515A
Portable Calibrator

Instruction Manual

P/N 383026
December 1974
Rev. 2 11/75

FLUKE®

WARRANTY

Notwithstanding any provision of any agreement the following warranty is exclusive:

The JOHN FLUKE MFG. CO., INC., warrants each instrument it manufactures to be free from defects in material and workmanship under normal use and service for the period of 1-year from date of purchase. This warranty extends only to the original purchaser. This warranty shall not apply to fuses, disposable batteries (rechargeable type batteries are warranted for 90-days), or any product or parts which have been subject to misuse, neglect, accident, or abnormal conditions of operations.

In the event of failure of a product covered by this warranty, John Fluke Mfg. Co., Inc., will repair and calibrate an instrument returned to an authorized Service Facility within 1 year of the original purchase; provided the warrantor's examination discloses to its satisfaction that the product was defective. The warrantor may, at its option, replace the product in lieu of repair. With regard to any instrument returned within 1 year of the original purchase, said repairs or replacement will be made without charge. If the failure has been caused by misuse, neglect, accident, or abnormal conditions of operations, repairs will be billed at a nominal cost. In such case, an estimate will be submitted before work is started, if requested.

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If any failure occurs, the following steps should be taken:

1. Notify the JOHN FLUKE MFG. CO., INC., or nearest Service facility, giving full details of the difficulty, and include the model number, type number, and serial number. On receipt of this information, service data, or shipping instructions will be forwarded to you.

2. On receipt of the shipping instructions, forward the instrument, transportation prepaid. Repairs will be made at the Service Facility and the instrument returned, transportation prepaid.

SHIPPING TO MANUFACTURER FOR REPAIR OR ADJUSTMENT

All shipments of JOHN FLUKE MFG. CO., INC., instruments should be made via United Parcel Service or "Best Way"* prepaid. The instrument should be shipped in the original packing carton; or if it is not available, use any suitable container that is rigid and of adequate size. If a substitute container is used, the instrument should be wrapped in paper and surrounded with at least four inches of excelsior or similar shock-absorbing material.

CLAIM FOR DAMAGE IN SHIPMENT TO ORIGINAL PURCHASER

The instrument should be thoroughly inspected immediately upon original delivery to purchaser. All material in the container should be checked against the enclosed packing list. The manufacturer will not be responsible for shortages against the packing sheet unless notified immediately. If the instrument is damaged in any way, a claim should be filed with the carrier immediately. (To obtain a quotation to repair shipment damage, contact the nearest Fluke Technical Center.) Final claim and negotiations with the carrier must be completed by the customer.

The JOHN FLUKE MFG. CO., INC, will be happy to answer all applications or use questions, which will enhance your use of this instrument. Please address your requests or correspondence to: JOHN FLUKE MFG. CO., INC., P.O. BOX C9090, EVERETT, WASHINGTON 98206, ATTN: Sales Dept. For European Customers: Fluke (Holland) B.V., P.O. Box 5053, 5004 EB, Tilburg, The Netherlands.

*For European customers, Air Freight prepaid.

John Fluke Mfg. Co., Inc., P.O. Box C9090, Everett, Washington 98206

Rev. 6/81

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Section 1
Introduction & Specifications

1-1. INTRODUCTION

1-2. The Fluke Model 515A enables the field checking and/or calibration of the dc voltage, ac voltage and resistance ranges of high-accuracy voltmeters and multimeters. The Model 515A provides standards for dc voltage, ac voltage and resistance which maintain the basic accuracy over the temperature range of 23°C ±5°C. Self-contained batteries permit operation at sites remote from ac power, and also permit operating temperature of the unit to be maintained while in transit. Up to eight hours of battery operation is available from a single charge. The batteries are charged within the calibrator when connected to the ac line. A front-panel meter indicates the state of battery charge when in the battery-operated mode.

1-3. All instrument outputs are provided at a single set of terminals located on the front panel. Generally, connections to the instrument under test may be made one time for a complete series of tests. In addition, terminals are provided to allow guarding and shielding of test leads. Guarded connections reduce the effects of common mode voltages, while shielding reduces the effects of electrical noise. The front panel also contains all operating controls which are color-coded to simplify output voltage and resistance selection.

1-4. DC voltage outputs are selectable in the ranges of 0 - 999 microvolts (continuous), 100 millivolts to 1 volt in 100-millivolt steps, 1 volt to 10 volts in 1-volt steps, and 100 volts. AC voltages are selectable 1, 10 and 100V rms at 400 Hz, 10V rms at 4 kHz, and 10V rms at 50 kHz. Resistance is selectable at zero, 10, 100, 1K, 10K, 100K, 1M and 10M ohms. All pushbutton selection switches are mechanically interlocked so that only a single function can be selected.

1-5. Power source switching within the calibrator permits the unit to operate on 100V, 115V, 200V or 230V at 50 Hz to 440 Hz. The HI & LO front panel terminals are of solid copper to reduce the effects of thermal emf. In addition, the voltage outputs are fully protected against short circuit, and the resistance output will provide for the application of up to 200 milliwatts or 100V (dc or rms), whichever is less.

Resistance

Range:	10Ω through 10 MΩ in decade steps plus zero setting
Accuracy:	(@23°C ±5°C for 1 year; referred to zero ohms setting)
0Ω:	Residual Resistance; < 0.15Ω
10Ω – 100Ω:	±0.06%
1 kΩ – 1 MΩ:	±0.015%
10 MΩ:	±0.075%
Power Rating:	0.2 Watt or 100V (DC or RMS), whichever is less
Temperature Coefficient:	(0°C to 18°C, 28°C to 50°C); referred to residual resistance
0Ω:	< + 0.4%/°C
10Ω – 100Ω:	< ±10 ppm
1 kΩ – 1 MΩ:	< ±5 ppm
10 MΩ	< ±10 ppm

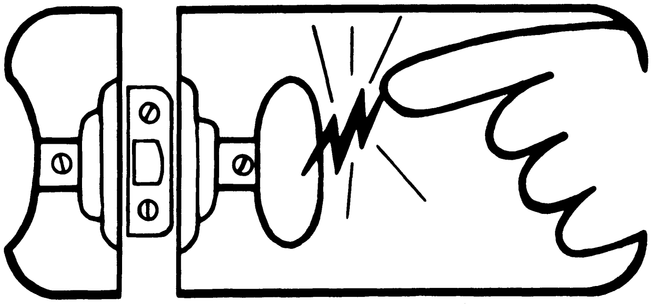
General

Size:	3½" H x 8½" W x 16" D
Weight:	13 lbs.
Operating Temperature:	0°C to 50°C
Storage Temperature:	–40°C to +50°C; to +60°C with batteries removed
Relative Humidity:	< 70%, 0°C to 45°C
Input Power:	100/115/200/230V ac, ±10%, < 10 Watts, 50 - 440 single phase or internal batteries. Eight hours operation from batteries when fully charged. Charging is automatic during line operation. Front panel meter indicates condition of charge and battery/line operation.
Output Connectors:	4 binding posts for HI, LO, GUARD and CHASSIS HI & LO terminals are solid copper
Shock:	15g., 11 msec half-sine wave
Vibration:	MIL-T-21200L Class 2 or Class 3
Altitude:	0 to 10,000 feet operating 50,000 feet non-operating

static awareness

A Message From

John Fluke Mfg. Co., Inc.



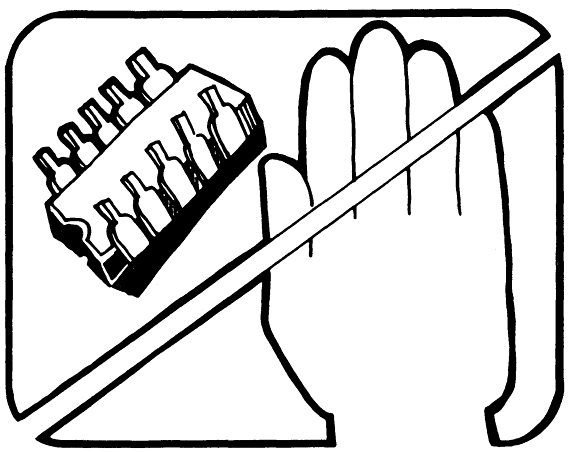
Some semiconductors and custom IC's can be damaged by electrostatic discharge during handling. This notice explains how you can minimize the chances of destroying such devices by:

1. Knowing that there is a problem.
2. Learning the guidelines for handling them.
3. Using the procedures, and packaging and bench techniques that are recommended.

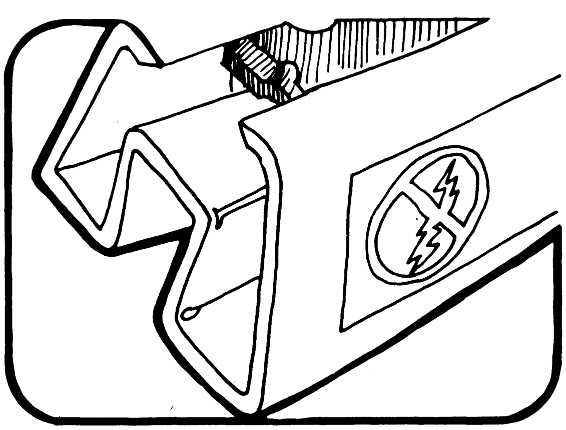
The Static Sensitive (S.S.) devices are identified in the Fluke technical manual parts list with the symbol

" "

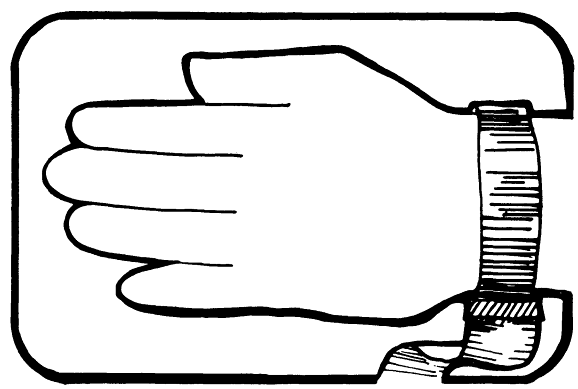
The following practices should be followed to minimize damage to S.S. devices.



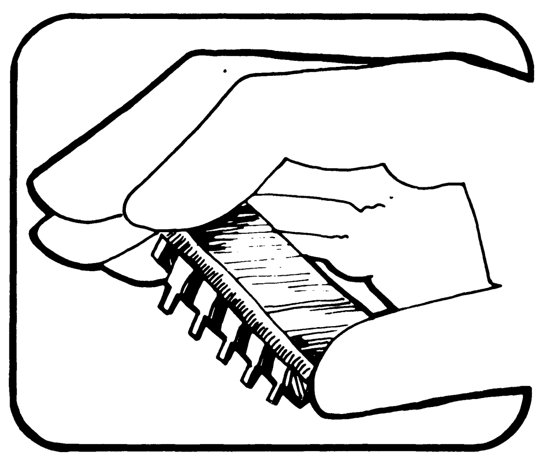
1. MINIMIZE HANDLING



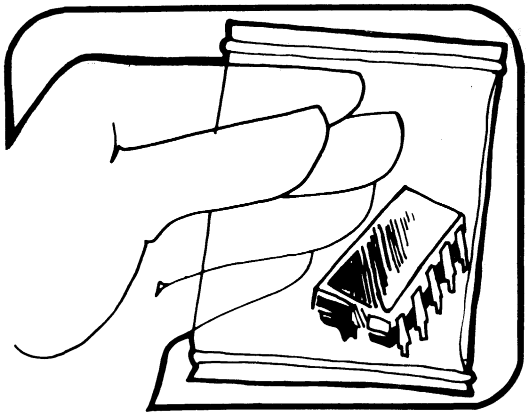
2. KEEP PARTS IN ORIGINAL CONTAINERS UNTIL READY FOR USE.



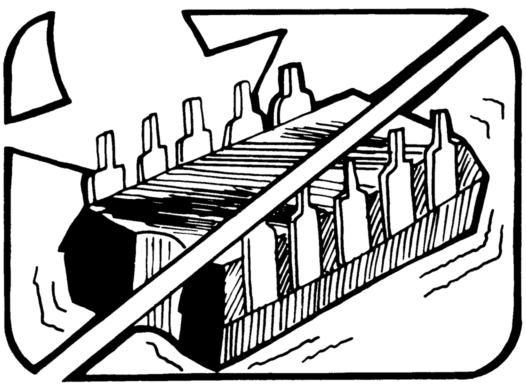
3. DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES. USE A HIGH RESISTANCE GROUNDING WRIST STRAP.



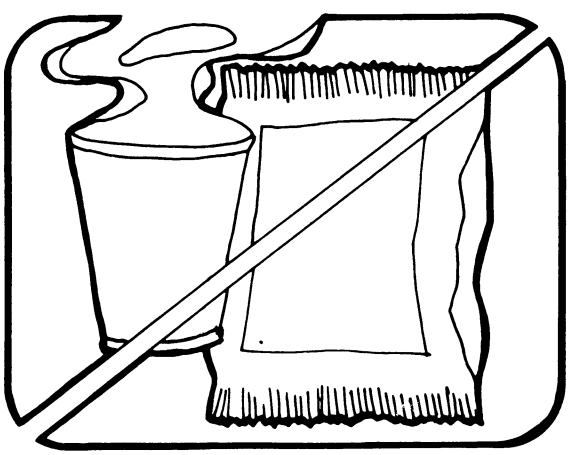
4. HANDLE S.S. DEVICES BY THE BODY



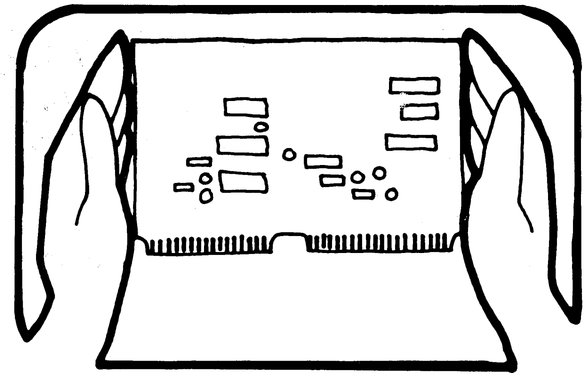
5. USE STATIC SHIELDING CONTAINERS FOR HANDLING AND TRANSPORT



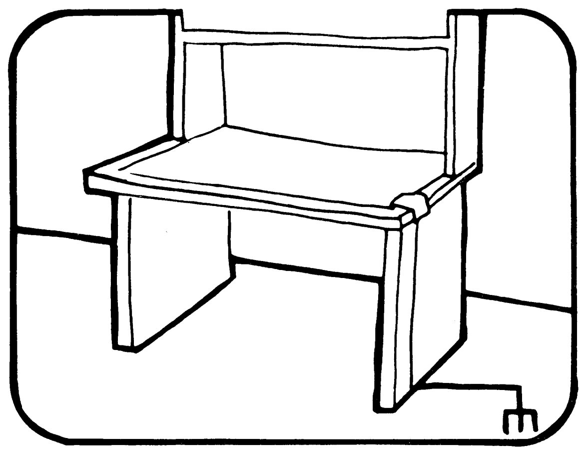
6. DO NOT SLIDE S.S. DEVICES OVER ANY SURFACE



7. AVOID PLASTIC, VINYL AND STYROFOAM® IN WORK AREA



8. WHEN REMOVING PLUG-IN ASSEMBLIES, HANDLE ONLY BY NON-CONDUCTIVE EDGES AND NEVER TOUCH OPEN EDGE CONNECTOR EXCEPT AT STATIC-FREE WORK STATION. PLACING SHORTING STRIPS ON EDGE CONNECTOR HELPS TO PROTECT INSTALLED SS DEVICES.



9. HANDLE S.S. DEVICES ONLY AT A STATIC-FREE WORK STATION
10. ONLY ANTI-STATIC TYPE SOLDER-SUCKERS SHOULD BE USED.
11. ONLY GROUNDED TIP SOLDERING IRONS SHOULD BE USED.

A complete line of static shielding bags and accessories is available from Fluke Parts Department, Telephone 800-526-4731 or write to:

JOHN FLUKE MFG. CO., INC.
PARTS DEPT. M/S 86
9028 EVERGREEN WAY
EVERETT, WA 98204

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Section 2
Operating Instructions

2-1. INTRODUCTION

2-2. This section contains operating instructions and applications information for the Model 515A. If any problem is encountered in operating the instrument, contact the nearest John Fluke Sales representative or write directly to John Fluke Mfg. Co., Inc. Please include the instrument serial number when writing.

2-3. INSTALLATION

2-4. The 515A is supplied with non-marring feet and tilt-down handle for bench or field use. Rack mounting kits are available for installation of the instrument in a standard 19-inch rack. Each kit contains necessary hardware and detailed installation instructions.

2-5. REPACKAGING FOR SHIPMENT

2-6. This instrument was packed and shipped in a foam-packed cardboard carton. If reshipment is required, the original container should be used, if available. Upon request, a new container can be obtained from the John Fluke Mfg. Co., Inc. Please include the instrument model number when requesting a new container.

2-7. INPUT POWER REQUIREMENTS

2-8. The 515A operates on 100, 115, 200 or 230 volts, 50 to 440 Hz ac power. To convert the instrument from one ac line voltage to another, turn the power off and then place the line power switches in the desired configuration, as shown in Figure 2-1. To gain access to the line power switches, remove the top dust cover and guard. When changing the line power configuration from 100V or 115V to 200V or 230V, change the line fuse, F1 from 1/4 amplere to 1/8 ampere, and vice versa. Also, change the line power marker on the rear panel to reflect the operating line voltage.

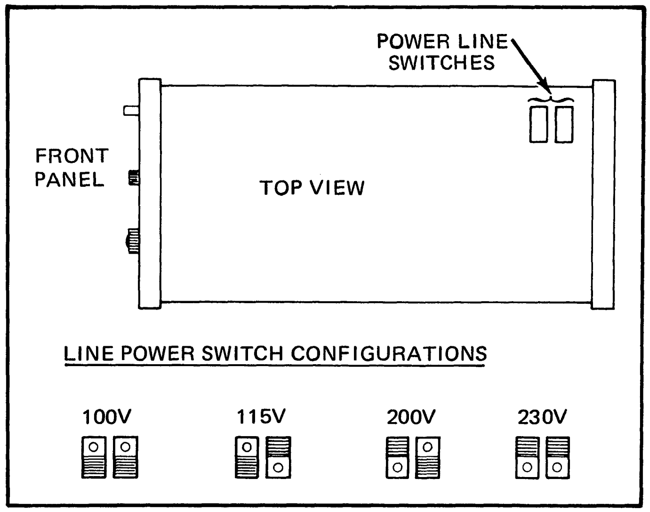


Figure 2-1. LINE POWER SWITCH LOCATIONS

WARNING

The ground pin on the three-prong power plug connects the instrument case to power ground. Insure that this pin is connected to a high-quality earth ground.

2-9. BATTERY OPERATION

2-10. The 515A contains rechargeable nickel-cadmium batteries which provide approximately eight hours of continuous operation remote from the ac power line. The batteries are protected from over-discharge, and are recharged whenever the 515A is operated from the ac power line. Charging time is approximately 18 hours from the fully discharged condition.

Section 3
Theory of Operation

3-1. INTRODUCTION

3-2. The theory of operation for the 515A Portable Calibrator is arranged under two major headings. First is the Overall Functional Description which discusses the overall operation of the instrument in terms of the functional relationship of the major circuits. Second is the Simplified Circuit Analysis which deals with the internal operation of each major circuit in more detail. Block diagrams and simplified circuit diagrams are included in this section, schematic diagrams are included at the rear of the manual in Section 8.

3-3. OVERALL FUNCTIONAL DESCRIPTION

3-4. The 515A portable calibrator self-contained power source allows field operations with immediate use at a new location without a warm-up period because the self-contained batteries power the calibrator during the transportation.

3-5. The 515A portable calibrator is shown in a simplified block diagram in Figure 3-1. The general operation of each major circuit is described in the following paragraphs.

3-6. Power is applied to the power supply (Main PCB) from either an external AC source or from the internal battery source. The AC input is controlled by two line switches so that any one of four possible AC voltages (110, 115, 200, 230) may be selected. Either the rectified AC input or the battery voltage is applied to the plus and minus 18 volt regulators for a controlled supply of ±18 VDC to all circuits.

3-7. The Battery Charger and Protection circuit (Battery Pack PCB) has an input from the transformer secondary anytime that AC is applied to the instrument. This input is rectified and applied to the batteries. If the AC input is removed while the power switch is on, the batteries automatically take over operation of the instrument. Fully charged batteries will operate the instrument for approximately eight hours. To prevent damage to the nickel-cadmium batteries a protection circuit removes the batteries from the power supply input when they discharge to the point that might result in damage to them. Since the batteries recover when the load is removed, they will reapply voltage to the instrument if the POWER switch is left ON. This results in a cycling action with the BATTERY LEVEL meter alternating between the BAT OK and OFF positions. This cycling is a normal function of the battery system and does not signify a failure.

3-8. The AC Generator (Main PCB) produces an extremely stable 10V rms, ac. The 10V ac is output directly at 400 Hz, 4 kHz and 50 kHz when selected by the output switching. The 10V ac is applied to the output transformer for use in generating the 1V ac or 100V ac outputs at 400 Hz and the 100V dc output. A +14.14214V dc reference voltage (V_{REF}) is used as the reference for the AC Generator and for the −18 volts regulated power supply.

3-9. When either the 1V ac or the 100V ac at 400 Hz or the 100V dc is selected by the switch positions, the 10V ac 400 Hz from the AC Generator is fed to the output transformer primary (Main PCB). The two AC voltages are taken directly from the transformer secondary and output via the output switching. If the 100V dc is selected, the 100 transformer output is routed to the 100 volt rectifier and regulator.

3-10. When selected the 100 volt rectifier and regulator (Main PCB) is input the 100V ac 400 Hz signal from the output transformer where it is rectified, regulated and output. Regulation is based on an input from the 10V dc regulator.

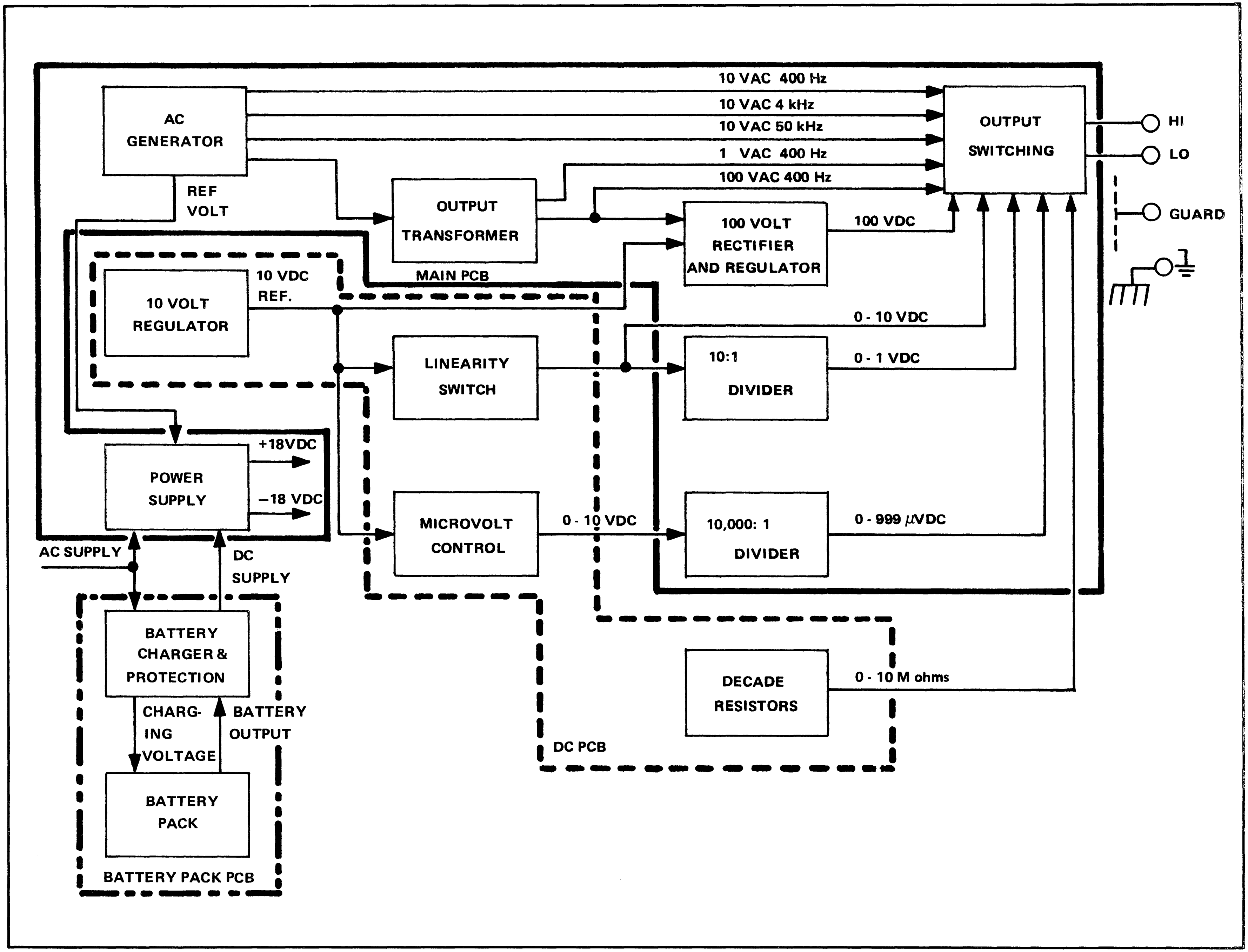


Figure 3-1. 515A SIMPLIFIED BLOCK DIAGRAM

3-11. The 10 volt regulator (DC PCB) provides a precision, temperature-compensated 10V dc. Outputs are provided to the 100 volt regulator, the linearity switch and the Microvolt Control when the individual circuit is selected for output.

3-12. The Linearity Switch (DC PCB) accepts the 10V dc from the regulator and divides it into eleven proportional steps for equal readings from zero to ten volts.

3-13. The output from the linearity switch is in turn divided by ten to the the 10:1 Divider Circuit (Main PCB) when the 1 volt dc scale is selected.

3-14. The Microvolt Control (DC PCB) and the 10,000:1 Divider (Main PCB) work in conjunction to provide the microvolt output selected by the front panel dial. If the microvolt function is selected, the regulated 10V dc is applied to the microvolt control circuitry where a portion equal to the dial setting is applied to the 10,000:1 Divider, resulting in a zero to 999 microvolt output.

3-15. The Decade Resistors (DC PCB) are precision resistors chosen by use of the Linearity Switch. It allows the operator to select the desired resistance for output to the output switching.

3-16. Output Switching (Main PCB) selects the desired output and places it on the output terminals.

3-17. SIMPLIFIED CIRCUIT ANALYSIS

3-18. Introduction

3-19. The following paragraphs contain a simplified circuit analysis of the blocks discussed previously on a functional level and illustrated in the Simplified block diagram, Figure 3-1. Each block description contains the name of the circuit board or boards on which it is physically located. Component designators referred to are found on the schematic diagrams located in Section 7.

3-20. Power Supply (Main PCB)

3-21. AC line power from A1J6 is applied to A1T1 through the POWER switch S1E and F and the line voltage selector switches S12 and S13. The primary of A1T1 consists of two windings which are interconnected for operation from either a 110, 115, 200 or 230 volt ac line. Both primary windings are completely shielded to reduce capacitive coupling between the power line and the floating circuitry in the instrument. The shield is connected to chassis ground and power line ground through the power cord. The secondary of A1T1 consists of two separate windings both of which are shielded to eliminate the generation of common mode signals that could appear at the OUTPUT terminals. This shield is connected to the guard. The center-tapped secondary winding provides ac power to rectifiers CR2 and CR3, CR4. The other secondary winding supplies ac power to the Battery Pack PCB and the meter, M1. Diodes CR1 & CR26 rectify the ac voltage present during line operation to provide a full-scale LINE OPR indication on M1. DS1 and DS2 function to limit the maximum current used by the Battery Pack PCB during charging of the batteries.

3-22. The ±18V Regulators produce low ripple operating voltages for the instrument. Input voltage to the regulators is derived from CR2 when the instrument is line-powered or from batteries if the line power is not applied and the instrument is turned on. The −18V Regulator receives its reference from the +14.14214V Reference Supply in the AC Generator. Reference voltage for the +18V Regulator is derived from the −18V Regulator.

3-23. +18V REGULATOR. The +18V Regulator consists of Q1 through Q3. Q1 is the series-pass element. Q2 and Q3 control the base current of Q1 to maintain the +18V dc output. Resistor R3 ensures intital turn-on of Q2 and Q3. The base of Q3 is referenced to the −18V Regulator through R10 and receives a sample of the +18V dc output through R8 and R9. Any change in the +18V dc output is therefore amplified by Q2 and Q3, which then alters the conduction of Q1 to maintain the regulated output. Variable resistor R9 allows adjustment of the +18V dc output.

3-24. −18V REGULATOR. The −18V Regulator consists of Q4 through Q6. Q4 is the series-pass element. Q5 and Q6 control the base current of Q4 to maintain the −18V dc output. R12 ensures intital turn-on of Q5 and Q6. The base of Q6 is referenced to the Reference Supply (V_{REF}) through R18, CR5, and CR6 and receives a sample of the −18V dc output through R17. CR5 and CR6 compensate for the voltage temperature coefficient at the base of Q6. Output voltage from this supply is therefore, dependent upon V_{REF} and the ratio of R17 to R16.

3-25. Battery Pack and Battery Charger and Protection (Battery Pack PCB)

3-26. The A3 Battery Pack PCB consists of the Battery Charger and Protection circuit on the PCB and two batteries, (BT1 and BT2) in the Battery Pack. This circuitry provides operation from the batteries in absence of line power, disconnects the batteries when they are in a low charge-state to prolong battery life and disconnects the batteries from the instrument circuitry and recharges them during line operation.

3-27. BATTERY OPERATION. When line power is removed and the POWER switch is ON, the batteries BT1 and BT2 are connected to the inputs of the ±18V Regulators through the Battery Charger and Protection circuit. The positive output of BT1 is applied through S1C to J5 where a divider consisting of R2, CR3 and R4 supplies the base of Q2 with a positive voltage. This voltage turns on Q2 which applies base current to Q1 and also turns it on. Conduction of Q1 applies the positive output BT1 through the series transistor Q3 to the input of the +18V Regulator. The diode connection of Q3 prevents reverse current flow from the +18V Regulator to the battery. The negative output of BT2 is applied through S1D to the series transistors Q5. Since a positive voltage is available at the emitter of Q4 through R8, Q4 is turned on in sequence with the conduction of Q1. This condition turns on Q5 and applies the negative output of BT2 through the series transistor Q6 to the input of the +18V Regulator. The diode connection of Q6 prevents reverse current flow from the −18V Regulator to the battery.

3-28. Should the batteries discharge to a state where they may be damaged, the series transistors Q1 and Q5 are automatically switched off. This is made possible through the use of zener diode CR3. As the output of BT1 decreases, the voltage at the base of Q2 reaches a point where the transistor can no longer furnish enough base current for Q1 to maintain conduction. Q1 is therefore cut-off and disconnects the output of BT1 from the +18V Regulator. Sharp cut-off for Q1 is ensured by R6 which provides some of the base current for Q2. Once the voltage at the collector of Q1 begins to drop, base current to Q2 is further reduced, this sharply cutting off Q1. Since the conduction of Q4 and Q5 is slaved to the conduction of Q1, as described in the preceding paragraph, the negative output of BT2 is also disconnected from the −18V Regulator.

3-29. Line Operation. When line power is applied, the batteries are disconnected from the ±18V Regulators and are recharged. Battery disconnection is caused by a −22V battery disconnect voltage produced by CR3, CR4 and C1. This voltage is applied to a divider consisting of R3 and R4 in the Battery Pack PCB. Presence of a negative voltage at the base of Q2 turns it off and causes Q1 to turn off. Since Q4 and Q5 are slaved to Q1, they are also turned off and both batteries are disconnected from the ±18V Regulators. Diodes CR4 and CR5 limit the maximum negative base to emitter voltage at Q2 and Q5 during line operation.

3-30. Charging of the batteries is provided through full-wave rectifier CR1 in the Battery Pack PCB. AC power for this rectifier is derived from the untapped secondary of T1. A2DS1 and DS2 function as a ballast to limit the maximum charging current. Zeners CR2 and CR6 in the Battery Pack PCB limit the maximum battery voltage during charging.

3-31. AC Generator (Main PCB)

3-32. The accurate 10V ac and 14.14214V dc outputs required are produced by the five circuits that make up the AC Generator. They consist of the oscillator, Peak AC to DC Converter, Sample and hold, Integrator, and the Reference Supply. All five circuits are located on the main PCB and are described individually in the following paragraphs.

3-33. Oscillator: The oscillator produces the constant amplitude 10V rms, fixed frequency output signal. It is a bridged "T" oscillator formed by input amplifier Q18 through Q24, voltage controlled resistor FET Q26, and output amplifier Q25, Q27, Q28. Output amplitude is precisely maintained at 10V rms by the integrator output voltage applied to Q26. Output frequency is dependent upon the component values in the bridged "T" feedback network.

3-34. Input amplifier Q18 through Q24 is the heart of the Oscillator. The differential pair of Q19 and Q21 receives two inputs derived from feedback networks connected to the Oscillator output. At 50 kHz the component values of R118, R119, C49, C50 and the setting of R95 determine the center output frequency. The 4 kHz frequency is controlled by the values of R122, R124, C51, C52 and the setting of R123. 400 Hz is controlled by R125, R128, C53, C54 and the setting of R127. The input to the base of Q21 is through the positive feedback network composed of R94 and R95. This feedback signal together with the conduction level of Q26 controls the output amplitude. Conduction of Q26 is dependent upon the voltage control signal applied to its gate. This signal is derived from the Integrator and is of such a level as to maintain the output signal at precisely 10V rms. Q18 and Q20 combine the collector signals of Q19 and Q20 in the appropriate phase so that the output signal to Q22 base is twice that of what is normally obtained from a differential input stage. The collector signal at Q23 is the first point at which a 10V rms signal is available. Emitter follower Q24 drives the following output stage of Q27 and Q28. AC current in Q23 and Q24 is minimized by bootstrapping R88 and the emitter load of Q24 through C35 to the output.

3-35. The output amplifier of Q25 and Q27, Q28 is a complementary output stage. Temperature compensation of the bias current for Q27 and Q28 is provided through Q25 and the divider network of R99 through R101. Variable resistor R100 allows adjustment of this bias current. Output amplifiers Q27 and Q28 produce the output signal of the instrument. Average output current is limited by Q33-34 and Q31-32, respectively. The output signal is specified to 10 mA above which clipping and distortion may result.

3-36. Peak AC to DC Converter: The Peak AC to DC Converter is a wide band amplifier which compares the amplitude of the output signal to V_{REF} and produces a dc voltage equal to four times any negative difference. The circuitry consists of input divider R37 through R42, operational amplifier U3, Q8, and differential amplifier Q9 and Q10. Q11 and Q12 are emitter follower stages.

3-37. The input divider R37 through R42 is driven at one end by the rms output signal and by V_{REF} at the other through S14. The center of this divider is applied to the input of U3. Except for a small interval of time during the negative most peak of the rms signal, a positive current is flowing into the input of the U3 amplifier; however, since the input resistance of U3 is extremely high and the current is of the proper polarity to forward bias CR9, it is conducted through CR9 and Q11 to –18V. When the peak of the rms signal is more negative than V_{REF}, the input current reverses direction and CR9 is cut-off. This signal condition is then amplified by U3 and Q8 through Q10, which produces an emitter current in Q12. The resulting current produces a voltage charge on C44 (with 400 Hz selected) that is four times the negative peak difference between the rms output and V_{REF}. When 4 kHz is selected C43 is charged. C42 is charged when 50 kHz is selected. Variable resistor R60 allows adjustment of the bias on CR9. R49 allows zero adjustment of the U3 amplifier input offset voltage.

3-38. Sample and Hold: The Sample and Hold circuit transfers the charge on C44, C43 or C42 to the input of the integrator. This circuit is operational only at 400 Hz & 4 kHz. It is disabled on output frequencies above 20 kHz because the overall detection is sufficiently fast without sample and hold. The circuitry consists of Schmitt Trigger Q13, Q14, inverter amplifiers Q7 and Q15, Q16, and FET gate Q17.

3-39. Positive excursions of the pulse wave form at the base of Q13 correspond to when CR9 in the Peak AC to DC Converter is cut-off and a negative peak difference signal is being stored on the selected capacitor, C44, C43 or C42. This positive going pulse is shaped by Schmitt Trigger Q13 and Q14. Normally, Q14 is conducting and Q13 is cut-off. Presence of a positive going input to Q13 turns it on and turns off Q14. The resulting positive pulse at the collector of Q14 subsequently has a duration equal to the conduction interval of Q13. This pulse is coupled through C29 and turns on inverter Q15, Q16. The conduction of Q15 and the clamping action of Q16 produces a positive pulse through C45 or C46 (depending on frequency) and CR13, which is applied to the gate of Q17. This positive pulse occurs at the trailing edge of the Schmitt Trigger pulse and turns on Q17. Conduction of Q17 then transfers the voltage charge on C44, C43 or C42, as selected, to C64, which is at the input of the integrator. The rectifier action of CR13 and C40 produces a zero volt turn on signal at the gate of Q17 in the absence of pulses from the Schmitt Trigger. This is necessary because the Schmitt Trigger of Q13 and Q14 is disabled on output frequencies above 20 kHz by switch position S11H. Inverter Q7 provides a positive pulse to Q17 which compensates for the small error caused by the gate to drain capacitance of Q17.

3-40. Integrator: The Integrator consisting of U4 and associated components produces an amplitude control voltage for the Oscillator that is dependent upon the error signal from Peak AC to DC Converter. U4 is a high gain, non-inverting amplifier whose input is derived from C64. Variable resistor R72 allows offset voltage compensation for U4. The network consisting of CR14 through CR16 and R78 functions as a clamping circuit which limits the maximum output voltage from U4. This circuit improves the recovery time of the Integrator upon initial turn-on.

3-41. Reference Supply: The Reference Supply produces an extremely stable reference voltage (V_{REF}) upon which the accuracy and stability of the AC Generator output is based. It consists of a high gain, high input impedance, differential amplifier U1 and a reference amplifier U2. The temperature coefficient of the base/emitter voltage for U2 is accurately matched to the temperature coefficient of the zener element through factory selection of R22 and R23. Output voltage of this supply is scaled to +14.14214V dc through selection of R30 and R31. Variable resistor R27 allows adjustment of V_{REF}. The adjustment range of R27 is compensated through jumper selection of R25 and R29. The resulting stable reference at the collector of U2 is applied to the non-inverting input of U1. The other input to U1 receives an equivalent voltage from the divider composed of R20 and R21. Any change in V_{REF} is sensed at the base of U2 which produces an amplified change at the non-inverting input to U1. This change then alters the conduction of U1 such that V_{REF} is maintained at +14.14214V dc.

3-42. Output Transformer (Main PCB)

3-43. The output transformer is only used when the 100V dc, 1V ac 400 Hz or 100V ac 400 Hz functions have been selected. The switch position picks either 1V ac or 100V ac at 400 Hz from the tranformer secondary and routes it to the HI and LO outputs for switch position 7(1V ac) or 9 (100V ac) or to the 100V dc Regulator for switch position 5 (100V dc).

3-44. 100Volt Rectifier and Regulator (Main PCB)

3-45. When the 100V dc output is selected one hundred volts AC 400 Hz is input from the output transformer. The AC is rectified by CR25 and applied to the emitter of Q29. The base is controlled by the collector current of Q30 whose base current is controlled by U5. Current limiting prevents damage to the equipment when the output is shorted. The +100V adjustment can be given additional range, if required, by removing jumper C, which parallels R142. If the U5 Op Amp is changed and the +100 adjustment does not have sufficient range reverse the status of R142 by removing or installing Jumper C, as required.

3-46. 10 Volt Regulator (DC PCB)

3-47. Reference amplifier U2 functions as the primary reference element for the supply. U2 is a silicon NPN transistor connected in series with a zener diode. Both devices are mounted on a common substrate and enclosed in a single envelope, thereby achieving extremely close thermal coupling. The reference voltage, V_I (See Figure 3-2) is the sum of the zener voltage, V_Z and the transistor base-to-emitter voltage, V_{be}. Temperature variations affecting V_Z are compensated for by corresponding changes in V_{be}. The result is a precision, temperature-compensated dc source.

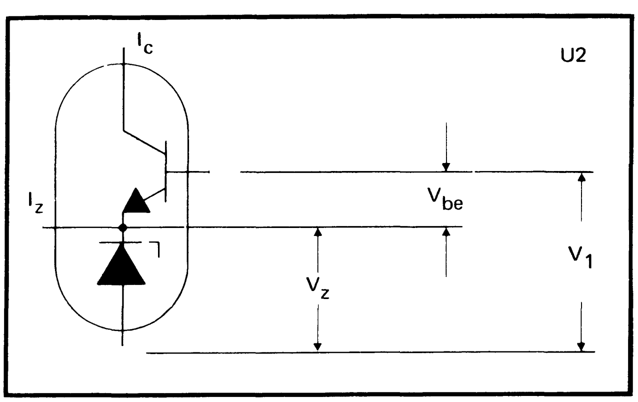


Figure 3-2. REFERENCE AMPLIFIER

3-48. Variations in the 10Volts are sensed at the base of U2, amplified, and applied to amplifier U1. The amplified output of U1 controls the conduction of Q1 to maintain a constant 10 volts. Potentiometer R11 (CAL) is the primary calibration adjustment and is set to provide exactly 10 volts at the regulator output.

3-49. Linearity Switch (DC PCB)

3-50. The Linearity Switch circuitry provides a voltage divider to output a linear portion of the regulated 10V dc. R12, R15, R18 and R21 form a constant output resistance ladder weighted ¼, 1/3, ½ and 1 respectively. By connecting various series and parallel combinations to the regulated 10V dc and common the desired proportional voltage is output on pin 8 with a source resistance of 300 ohms. The switching network insures that the source resistance remains 300 ohms regardless of the switch position or current flow. The fixed and variable resistors paralleling the ladder resistors provide calibration.

3-51. 10:1 Divider (Main PCB)

3-52. The output of the Linearity Ladder is input to the 10:1 Divider for outputs from zero to one volt in tenth of volt increments. R145 and R148 are the divider while R143 and R144 are used for calibration.

3-53. Microvolt Control (DC PCB) and 10,000:1 Divider (Main PCB)

3-54. The microvolt front panel control varies R32 on the DC PCB for a proportional output from zero to ten volts. The proportional voltage is now divided by ten thousand at R146 and R148 and the result, between 0 and 999 microvolts with a 0.2 microvolt resolution, is output through the output switching. R147 is a calibration adjustment.

3-55. Decade Resistors (DC PCB)

3-56. Seven precision resistor provide an output from ten ohms to ten megohms in increments of powers of ten. Only the 10 Megohm output is adjustable. A zero ohm output is available for determining residual resistance in the leads, connectors and test equipment.

3-57. Output Switching

3-58. The outputs are selected by the positioning of the function switches. The ten function switches are mechanically ganged so that only one can be depressed at any one time. The schematic is drawn with the 10V 50 kHz switch depressed. Switch contacts which are closed when the switch is open (not depressed) are drawn slanted to the right.

Section 4
Maintenance

4-1. INTRODUCTION

4-2. This section contains service and maintenance information for the Model 515A. The information is arranged under headings of "SERVICE INFORMATION, GENERAL MAINTENANCE, MAINTENANCE ACCESS, PERFORMANCE CHECKS, CALIBRATION PROCEDURES, COMPENSATING COMPONENT SELECTION, and TROUBLESHOOTING." Equipment required to service this instrument is listed in Table 4-1. If the recommended equipment is not available, substitute equipment having equivalent specification can be used.

4-3. SERVICE INFORMATION

4-4. Each instrument that is manufactured by the John Fluke Mfg. Co., Inc. is warranted for a period of one year upon delivery to the original purchaser. The WARRANTY is located at the front of the manual.

4-5. Factory authorized calibration and service for each Fluke product is available at various world-wide locations. A complete list of these authorized service centers is located at the rear of the manual. Shipping information is given in Section 2, paragraph 2-5. If requested, an estimate will be provided to the customer before any repair work is begun on instruments that are beyond the warranty period.

4-6. GENERAL MAINTENANCE

4-7. Cleaning

4-8. Periodically clean the 515A to remove accumulations of dust, grease or other contaminants using the following procedure:

a. Clean the front panel and exterior surfaces with anhydrous ethyl alcohol or a soft cloth dampened with a mild solution of detergent and water.

b. If cleaning of the interior is necessary use clean, dry air at low pressure (20 psi). If contaminants remain individual pcbs can be cleaned using warm water, however, any items likely to be affected by the water (batteries, meters, etc.) should be removed first. Excess water should be blown free with the clean dry air followed by a thorough drying. Do not use drying temperatures in excess of 50°C. If any solvent is used, such as freon, it should be kept clear of any switches or potentiometers since it removes lubrication and shortens the life span dramatically.

4-9. Fuse Replacement

4-10. Input line power to the instrument is overload protected by a fuse installed on the rear panel. The type and rating of the fuse is also indicated on the rear panel. If replacement is necessary, use only the type fuse specified on the decal for 115 or 230V ac line power.

Table 4-1; REQUIRED TEST EQUIPMENT

NOMENCLATURE	RECOMMENDED EQUIPMENT
Autotransformer	Variac
Multimeter	Fluke 8000A
Null Detector	Fluke 845
Voltage Divider	Fluke 720A
DC Voltage Standard/Null Detector	Fluke 335D
or	
DC Voltage Standard and Null Detector Combination	Fluke 332 or 343A and 845
Thermal Transfer Standard	Fluke 540B, A54-2 (Certified to ±0.04% at 50 kHz - 100 kHz)
Frequency Counter	Fluke 1900
Oscilloscope	Tektronix 543, 1A1, X10 Probe
Resistance Measuring System	ESI 242D
Resistive Loads	100, 1k and 931k ±2% (Useable to 100 kHz)
AC Differential Voltmeter	Fluke 931B
DC Differential Voltmeter	Fluke 885A
DC Reference Standard	Fluke 731B

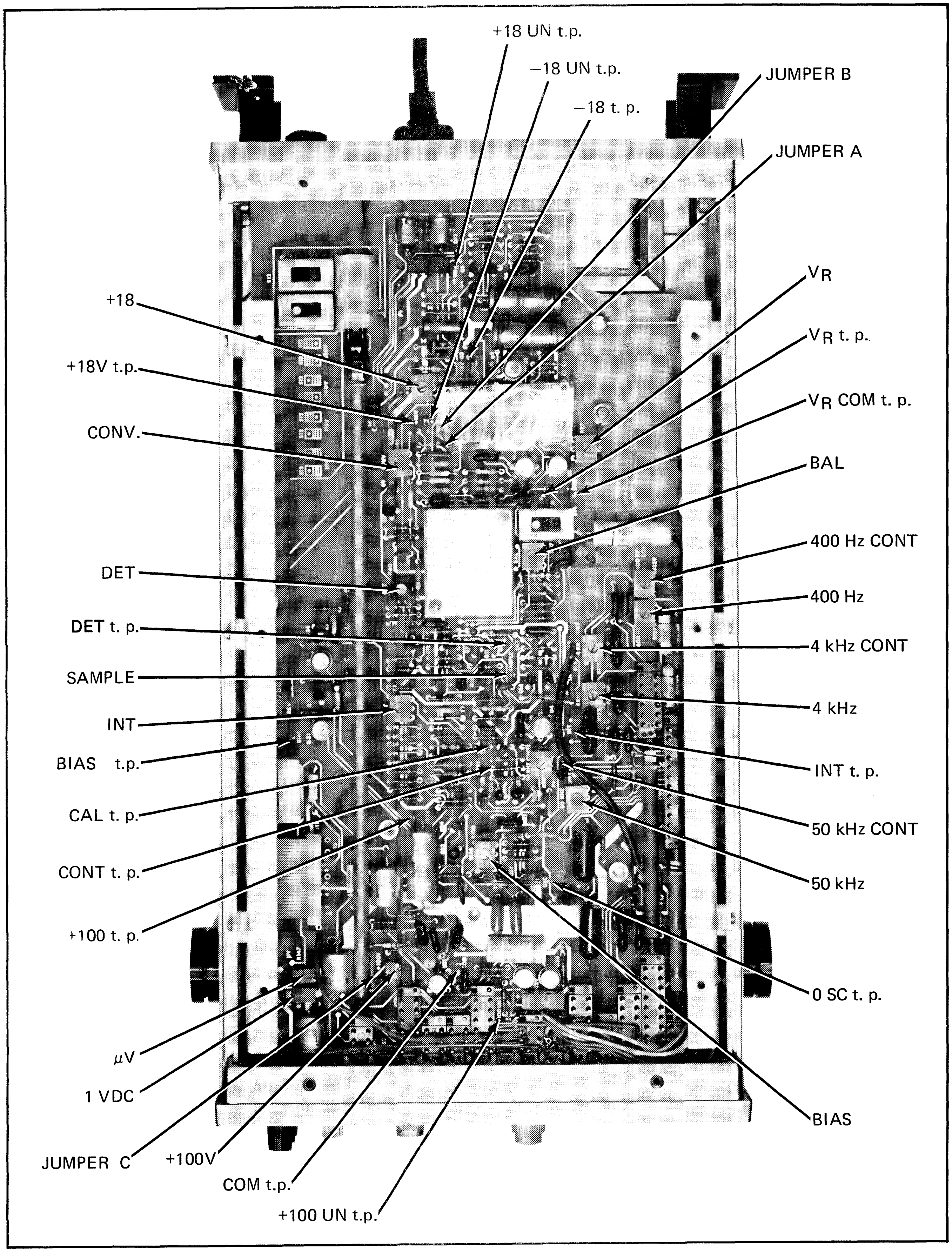


Figure 4-1 TOP VIEW.

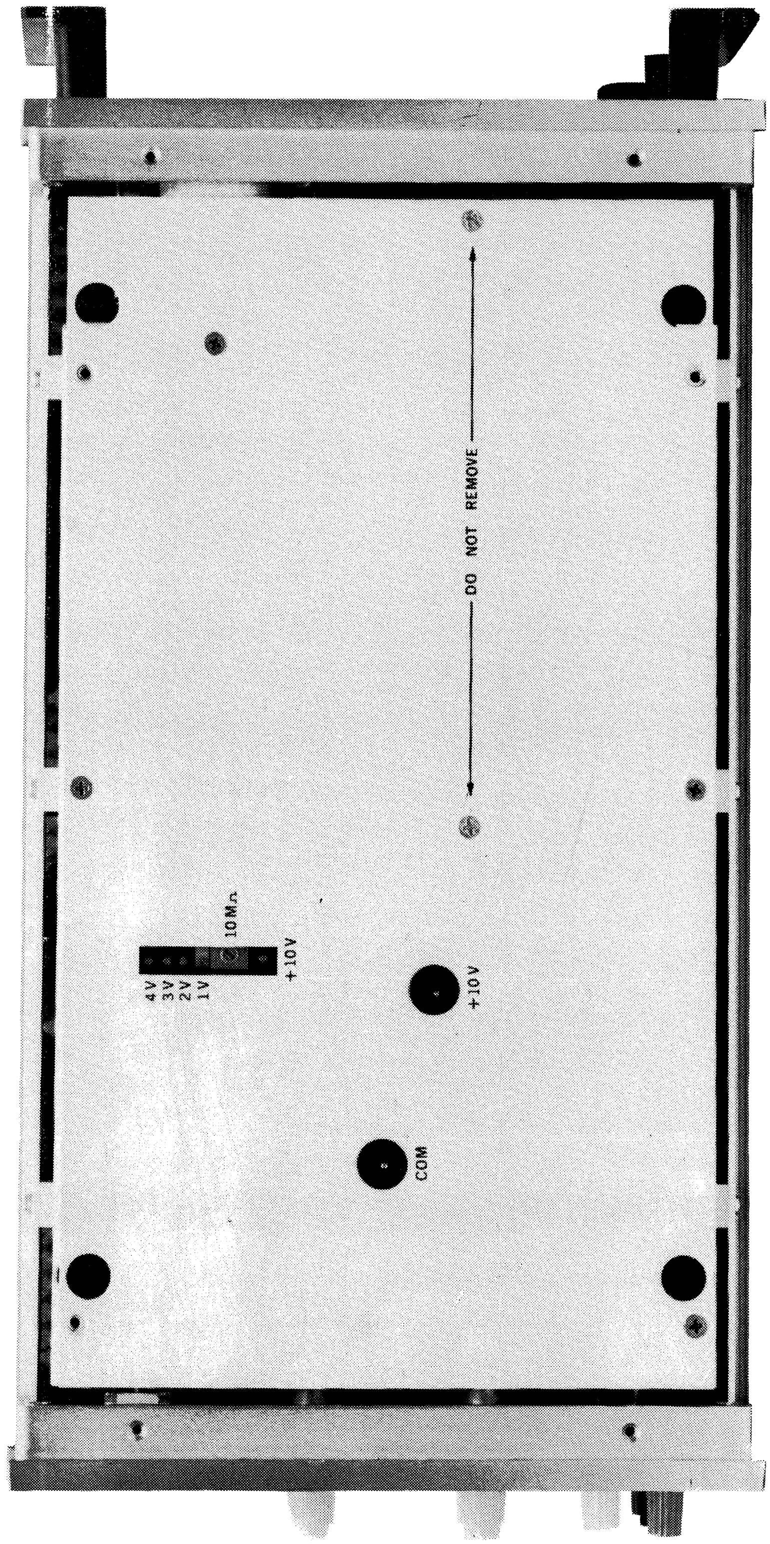


Figure 4-2. BOTTOM VIEW, GUARD INSTALLED

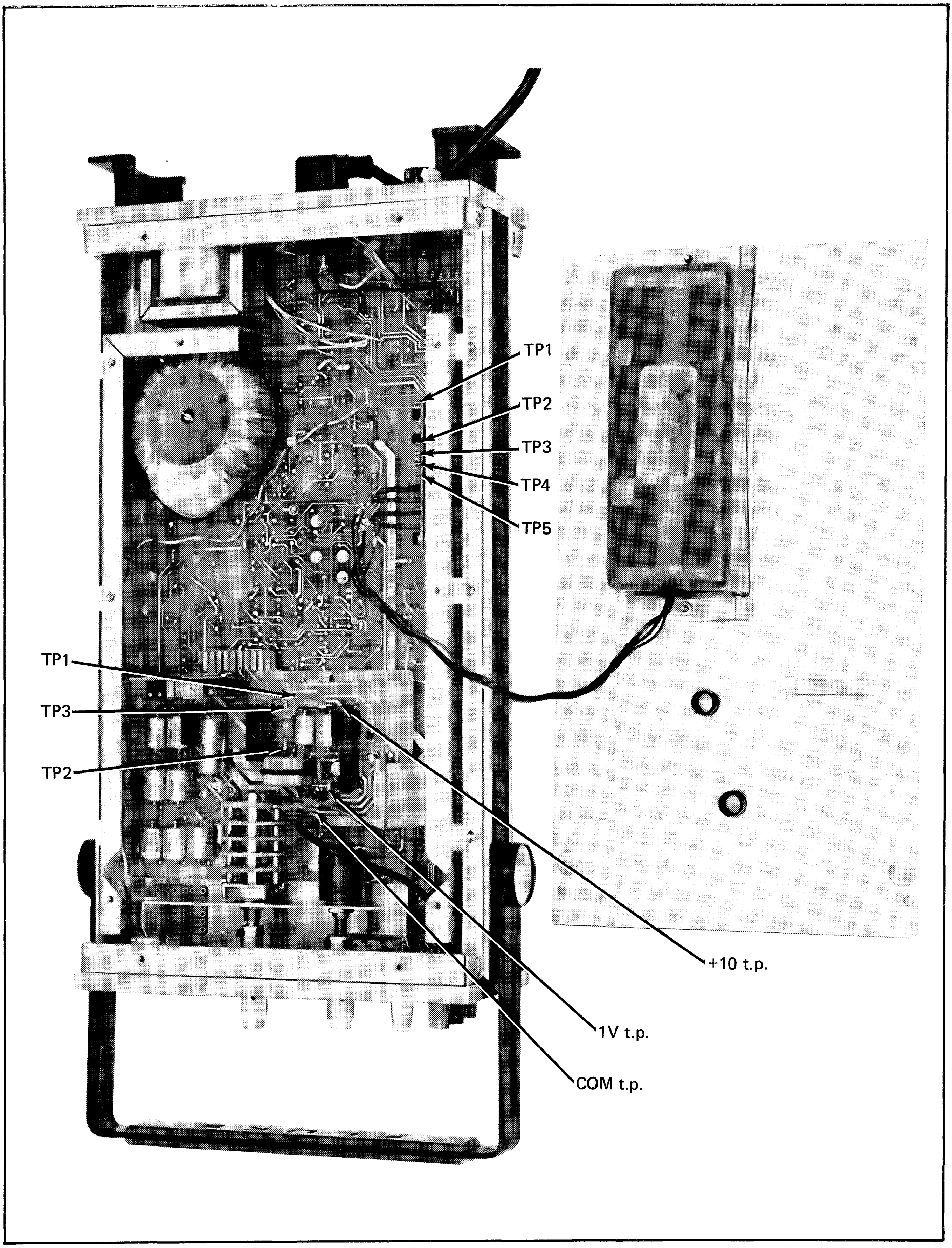


Figure 4-3. BOTTOM VIEW, GUARD REMOVED.

4-11. Lamp Replacement

4-12. Two ballast lamps designated DS1 and DS2 that are part of the Battery charger are installed on the Main PCB. These lamps are soldered to 3 pins on the main PCB to hold them firmly in place. Access to the lamps is provided after removal of the top dust cover and guard. Replacement requires no special tools. If replacement is necessary, use only GE-757 (FLUKE PART NO. 175265) or equivalent.

4-13. MAINTENANCE ACCESS

4-14. The following procedure is to be used to gain access to the interior sections of the Model 515A.

4-15. Major Section Access

a. Turn off and disconnect the Model 515A. Remove the top dust cover and guard. Access is provided to all adjustments and test points shown in Figure 4-1.

b. Remove the bottom dust cover. Access is now provided to assemblies shown in Figure 4-2.

4-16. Plug-In Assembly Removal and Installation

a. Locate the assembly to be removed using Figure 4-3.

b. Disconnect any wiring and then remove mounting screws.

c. Remove the plug-in assembly using a gentle rocking motion and an even pulling force.

d. Install the plug-in assembly in its correct position using a gentle rocking motion and steady downward pressure. Ensure that each mating connector is correctly aligned during installation.

e. Reconnect any wiring disconnected in step c. Each wire is labeled with a number which corresponds to a connector on the PCB.

4-17. Battery Removal and Replacement

4-18. The batteries are installed on the inside of the bottom guard as shown in Figure 4-3. If replacement is necessary, the entire Battery Pack, FLUKE PART NO. 284356, should be replaced. Proceed as follows:

a. Disconnect the four wires labeled 1 through 4 from A3 Battery Pack PCB. Refer to Figure 4-3. for location.

b. Remove the screws which secure the Battery Pack to the bottom dust cover and then remove the Battery Pack.

c. Install a new Battery Pack, FLUKE PART NO. 284356, on the bottom dust cover using the mounting screws removed in step b.

d. Connect the four Battery Pack wires to the A3 Battery Pack PCB. Each wire is labeled with a number which corresponds to a connector on the PCB.

4-19. PERFORMANCE CHECKS

4-20. The following checks can be used to verify most electrical specifications on the Model 515A. Each check includes an introduction which states the objectives and lists the required test equipment. Refer to Table 4-1 for the recommended equipment.

4-21. Should a trouble be discovered, first determine that the instrument does not require calibration. If calibration does not correct the problem, troubleshoot the instrument and repair as necessary.

4-22. Preliminary Operation

a. Connect the power cord through an autotransformer to line power. Set the autotransformer output to 115V ac.

b. Set the POWER switch on the front panel to ON. The meter should indicate LINE OPR.

c. Set switches for 10V, 400 Hz output.

d. Allow the instrument to operate for at least 30 minutes.

4-23. Line and Load Regulation Checks

4-24. This check provides a means of verifying the line and load regulation performance. Line voltage changes should not cause output variations greater than 10 ppm under full load. No load to full load changes should not cause output variations greater than those given in Table 4-2. The following test equipment is required to perform these checks.

1. Autotransformer
2. AC Differential Voltmeter
3. 1k ±5% ½W
   931k ±1% ½W
   200k ±1% ½W

Table 4-2. LOAD REGULATION

APPLIED VOLTAGE AND FREQUENCY	LOAD REGULATION (ppm)	
10V ac 400 Hz	1k	40
10V ac 4 kHz	1k	40
10V ac 50 kHz	1k	80
100V ac 400 Hz	931k	150
100 V dc	200k	5

a. Perform the steps given in paragraph 4-22.

b. Connect the 1k load to the front panel HI and LO terminals.

c. Connect an ac digital or differential voltmeter to the front panel HI and LO terminals and record its indication.

d. Vary the autotransformer output setting from 102 to 128V ac, observing that theoutput voltage does not change more than ±100 uV.

e. Return the autotransformer setting to 115V ac and disconnect the 1k load from the OUTPUT terminals.

f. Record the terminal voltage between HI and LO with the ac digital or differential voltmeter.

g. Insure the 515A is set to 10V, 400 Hz. Reconnect the 1k load to the HI and LO terminals, observing that the output voltage does not change more than the limit specified in Table 4-2.

h. Repeat steps f and g for 4 kHz and 50 kHz.

i. Set the 515A to 100V ac 400 Hz.

j. Record the terminal voltage.

k. Connect the 931k Resistor to the terminals (This value of load is for use with an input Z=1.1MΩ, i.e., a Fluke 8400A). The output voltage should not change more than the limit specified in Table 4-2.

CAUTION!

100V ac present on the output terminals at this time.

l. Set the 515A to 100V dc.

m. Record the voltage between HI and LO with the dc digitaloor differential voltmeter.

n. Connect the 200 kΩ resistor to the terminals. (This value of load is for use with a dc voltmeter with an input R greater than 20 MΩ). The output voltage should not change more than limit in Table 4-2.

CAUTION!

100V dc present on the output terminals at this time.

o. Disconnect the test equipment from the front panel terminals.

4-25. Frequency Check

a. Connect the input of a frequency counter to the front panel OUTPUT terminals. Use the period mode if maximum resolution is desired.

b. Select the 10V ac 50 kHz function on the portable calibrator.

c. Verify the frequency is between 47.5 kHz and 52.5 kHz (19 to 21 μsec period)

d. Select the 10V ac 4 kHz function on theportable calibrator.

e. Verify the frequency is between 3.96 kHz and 4.04 kHz (247.5 to 252.5 μsec period).

f. Select the 10V ac 400 Hz function on the Portable Calibrator.

g. Verify the frequency is between 396 Hz and 404 Hz (2475 to 2525 μsec period).

4-26. AC Output Accuracy Check

4-27. The check provides a means of verifying the amplitude accuracies given in Table 4-3. It consists of two different methods; dc reference and thermal transfer. The test equipment required to perform these checks is listed at the beginning of each method.

4-28. DC REFERENCE: This method is the more limited of the two since the frequency response of the Peak AC to DC Converter is not checked.

TEST EQUIPMENT:

1. DC Voltage Standard / Null Detector

a. Turn off the Model 515A and remove the top dust cover.

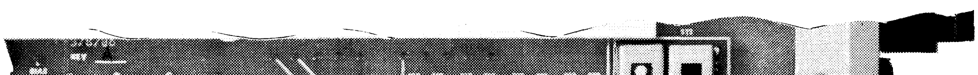
b. Make the equipment connections shown in Figure 4-4.

c. Set the dc voltage standard output to +14.14214V dc with a null detector sensitivity of 1V.

d. Turn on the Model 515A and allow it to operate for at least 30 minutes.

e. Increase the null detector sensitivity and record its indication. Maximum offset is +140 uV.

f. Turn off the Model 515A and disconnect the test equipment. Replace the upper dust cover. Within the limitation given above, all ac accuracies will now be within those listed in Table 4-3.



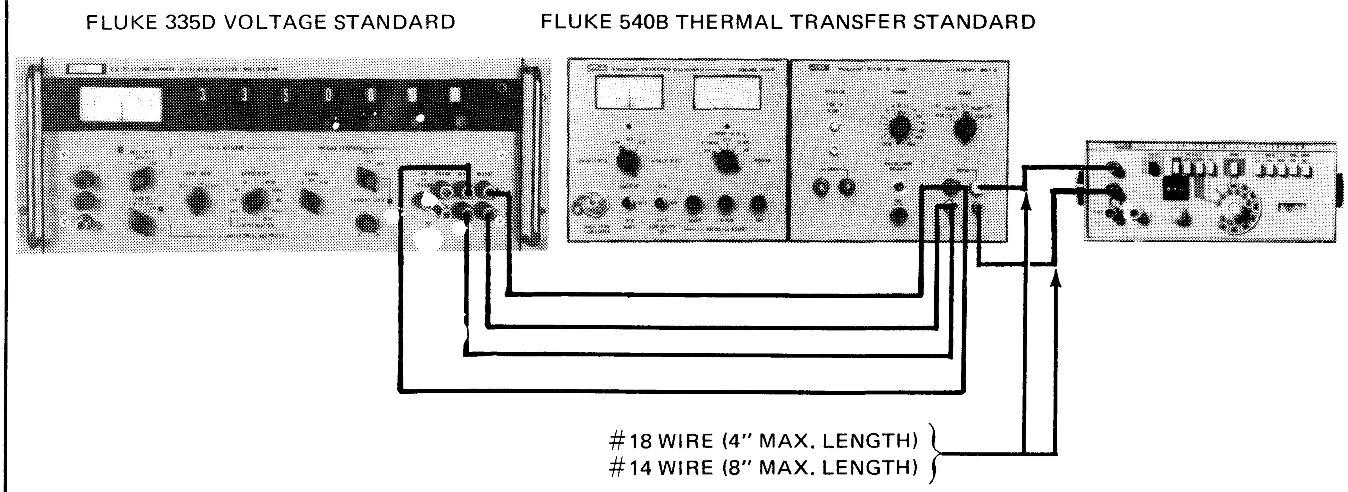


Figure 4-5. THERMAL TRANSFER EQUIPMENT CONNECTIONS

4-29. THERMAL TRANSFER: This method provides a better check than that in 4-28.

TEST EQUIPMENT:

1. DC Voltage Standard.
2. Thermal Transfer Standard (Certified to ±0.01% from 400 Hz to 50 kHz.

a. Make the equipment connections shown in Figure 4-5.

b. Set the dc voltage standard output to 10V dc.

c. Perform dc to ac transfer at 10V for 400 Hz, 4 kHz, and 50 kHz, observing that the thermal transfer amplitude accuracies given in Table 4-3 are achieved.

Table 4-3. OUTPUT AMPLITUDE ACCURACY

OUTPUT	TOLERANCE
10V ac 400 Hz	±0.04%
10V ac 4 kHz	±0.04%
10V ac 50 kHz	±0.1%

d. Because of current or loading limitations the Portable Calibrator 1 and 100 volt ranges cannot be verified by the thermal transfer method. If a precision verification of the ratio transformer outputs is required, standardize and use a 931B as a transfer standard. The 1V ac 400 Hz range should read 1V ±500 μV and the 100V ac 400 Hz range, 100V ±60 mV.

NOTE!

The 931B may be standardized against a stable AC source such as the Fluke 5200A. Use a Fluke 540B and a Fluke 335D to standardize the 5200A at 1 volt and 100 volts, 400 Hz.

4-30. Variable DC Voltage and Linearity Checks

a. Connect the equipment as shown in Figure 4-6. Insure the self-cal test for the Voltage Divider and calibration of the DC Transfer Standard against a standard cell is performed the same day, and prior to, the performance test. Zero the Null Detectors prior to starting the test.

b. Set the transfer standard for a 10 volt output.

c. Set the Voltage Standard to 11 volts and vary untill a null is obtained on Null Detector I. Monitor Detector I throughout the test, varying the voltage as required to maintain the null.

d. Select the 10V dc function on the Portable Calibrator and set the output multiplier switch to the X1 position. Set the voltage divider to 0.999999X.

e. Verify there is a null ±300μ volts on Null Detector II.

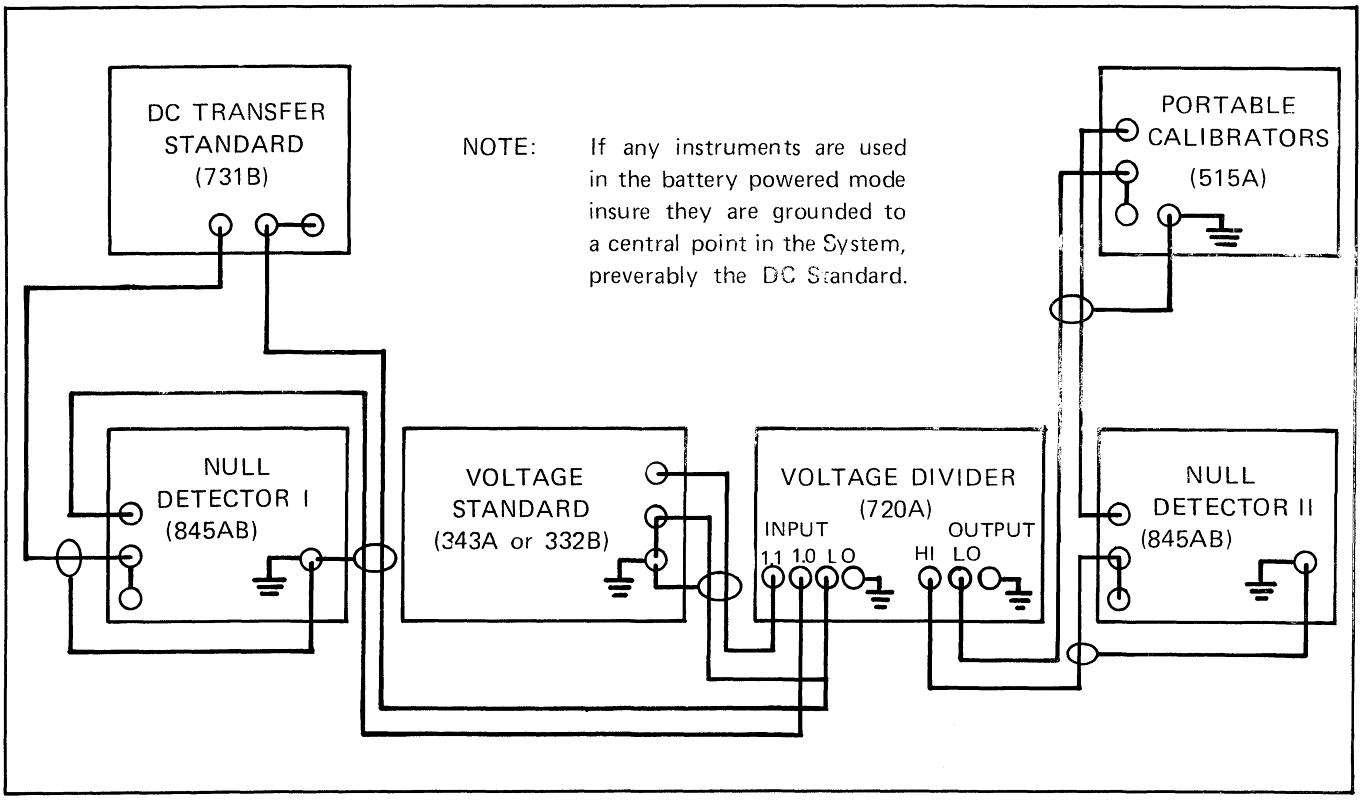


Figure 4-6. 10 VDC AND LESS TESTING.

f. Set the Output Multiplier switch and Voltage Divider to the figures shown in Table 4-4 and verify the reading on Null Detector II.

g. Select the 1V dc function on the Portable Calibrator and set the Output multiplier switch to X1.

Table 4-4. LINEARITY TESTS

OUTPUT MULTIPLIER SWITCH SETTING	VOLTAGE DIVIDER SETTING	NULL DETECTOR II READING
X . 9	.9000000	null ±270 μ volts
X . 8	.8000000	null ±240 μ volts
X . 7	.7000000	null ±210 μ volts
X . 6	.6000000	null ±180 μ volts
X . 5	.5000000	null ±150 μ volts
X . 4	.4000000	null ±120 μ volts
X . 3	.3000000	null ± 90 μ volts
X . 2	.2000000	null ± 60 μ volts
X.. 1	.100000	null ± 30 μ volts

h. Set the Voltage Divider to .1000000.

i. Verify a null ±30 μ volts on Null Detector II.

j. Select the μ volt function on the Portable Calibrator and set the μ volt counter to 000 μ volts.

NOTE

The μ volt dial reads 000 for both zero and 1000 μ volts. For a zero reading insure the dial is turned fully counter-clockwise against the stop. For a reading of 1000 μ volts the dial is turned clockwise past 999 until the dial reads 000.

k. Set the Voltage Divider to .0000000.

l. Verify null Detector II reads a null ±2 μ volts.

m. Disconnect the portable Calibrators HI input lead and connect it to the LO terminal.

n. Wait for thermals from the operators hands to subside and record the reading on Null Detector II. (Must be < 1 μV.)

o. Reconnect the Portable Calibrators leads as shown in Figure 4-6.

p. Wait for the thermals from the operators hands to subside and record the reading on Null Detector II.

q. Algebraically add the figures obtained in steps p and r. The result should be 0 ±2 μ volts.

r. Set the μ volt counter to 1000 μ volts and the Voltage Divider to 0001000.

s. Algebraically add the reading on Null Detector II and the reading obtained in step p. The result should be 0 ±2 μ volts.

t. Set the μ volt counter and Voltage Divider at 700 μ volts (.0000700), 500 μ volts (.0000500), 200 μ volts (.0000200) and 100 μ volts or (.0000100) in turn. At each setting the Algebraic sum of the Null Detector II reading and the thermal reading obtained in step p should be 0 ±2 μ volts.

4-31. 100 Volts DC Check

a. Connect the equipment as shown in Figure 4-7.

CAUTION!

The Transfer Standard and Null Detector I will be "floating" at +110 volts dc. Operate the Transfer Standard and Null Detector I under battery power if these type of units are available.

b. Select the 100V dc function on the Portable Calibrator.

c. Select a 10V dc output from the Transfer Standard.

d. Set the Voltage Standard to 110V dc initially and then adjust for a null ±5 μ volts on Null Detector I. Adjust the Voltage Standard as required during the test to maintain the null on Null Detector I.

e. Set the Voltage Divider to .999999X.

f. Verify Null Detector II reads a null ±3 millivolts.

4-32. Resistance Check

a. Connect the equipment as shown in Figure 4-8.

b. Select the ohms function on the 515A and set the Output Multiplier Switch to 0.

c. Determine the residual resistance with the Resistance Measurement System.

d. Verify the resistance values shown in Table 4-5 subtracting the residual resistance obtained in step c from the value read.

NOTE!

Through disuse the Output Multiplier Switch contacts may become contaminated and cause out-of-tolerance readings on the 10Ω range. Vigorously exercise the switch to remove these contaminants prior to verifying calibration of the 10 ohm range.

Table 4-5. RESISTANCE TOLERANCE

515A SETTING	TOLERANCE
0	Residual Resistance <150 mΩ
10	Reading minus Residual = 9.994 – 10.006 Ω
100	= 99.94 – 100.06 Ω
1K	= .99985K –1.000 15K Ω
10V	= 9.9985K – 10.0015K Ω
100K	=99.985K – 100.015K Ω
1000K	= 999.85K – 1000.15K Ω
10 M	= 9.9925 – 10.0075 MΩ

4-33. CALIBRATION PROCEDURES

4-34. Introduction

4-35. The Model 515A Portable Calibrator requires Calibration annually, or whenever repairs have been made which affect the electrical characteristics. Calibration should be performed after a 30 minute operating period and at an ambient temperature of 23°C ±1°.

4-36. All calibration test points and adjustments are shown in Figure 4-1 and 4-2. These calibrations points are accessible after removal of the top and bottom dust covers. and the top guard. Required test equipment is listed in Table 4-1.

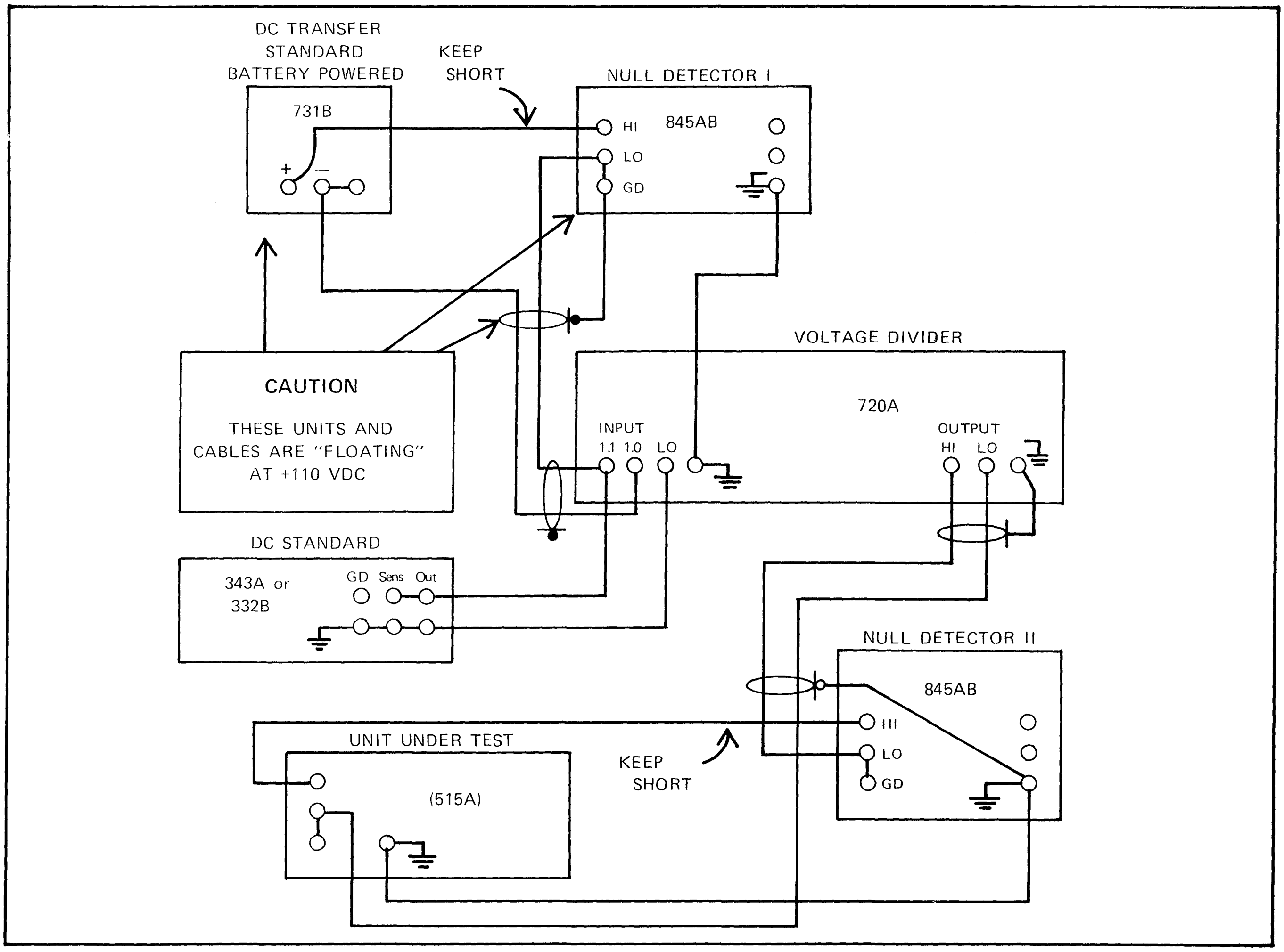


Figure 4-7. 100 VDC TESTING

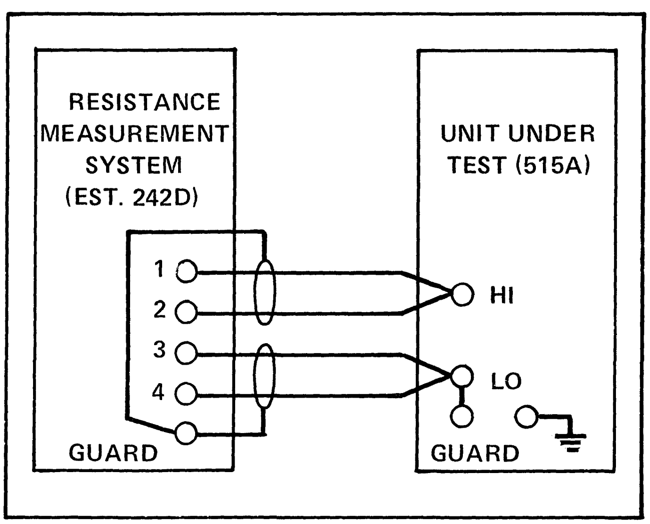


Figure 4-8. RESISTANCE CONNECTIONS

4-37. Regulator Alignment

a. Remove the top dust cover and guard. Adjustment and test point location are shown in Figure 4-1.

b. Connect the power cord through an auto-transformer to line power. Set the autotransformer output to 115V ac or the applicable supply voltage.

c. Turn on the Model 515A and allow it to operate for 30 minutes.

d. Connect the input of the voltmeter to +18V t.p. and circuit common.

e. Adjust +18V (R9) for +18 ±0.2V dc at +18V t.p.

f. Connect the dc voltmeter input to −18V t.p. observing that the voltage is −18 ±0.5V dc. There is no adjustment for the −18voltage.

g. Disconnect the dc voltmeter input from −18V t. p.

4-38. Reference Supply Alignment

a. Make the equipment connections shown in Figure 4-4.

b. Set the Voltage Standard output to +14.14214V dc with a Null Detector sensitivity of 1V.

c. Increase the null detector sensitivity and adjust.

V_R (R27) for a 0 ±70 μV indication on the null detector.

NOTE!

If this adjustment cannot be made, refer to paragraph 4-50 for range compensation of R27.

d. Disconnect the test equipment.

4-39. FET Bias

a. Connect the input of the voltmeter to CONT t.p. and circuit common. Select 50 kHz operation.

b. Adjust 50 kHz CONT (R90) for −2.5 ±0.2V dc at CONT t. p.

c. Disconnect the voltmeter input from CONT t.p.

4-40. Zero Set

a. Connect the voltmeter input to CONV. t. p. and circuit common at COM t. p.

b. Adjust CONV (R49) for 0 ±100 μV at CONV t. p.

c. Connect the dc voltmeter input to INT t.p. and circuit common at COM t. p.

d. Adjust INT. (R72) for 0 ±100 μV at INT t.p.

e. Disconnect the voltmeter from the instrument.

4-41. Output Bias

a. Connect a shorting jumper between CAL t. p. and circuit common.

b. Connect the input for the voltmeter to BIAS t. p. (+) and −18V t. p. (−).

c. Adjust BIAS (R100) for 90 - 100 mV dc between BIAS t.p. and −18V t.p.

d. Disconnect the voltmeter and shoring jumper from the instrument.

4-42. Detector Bias

a. Select the 10V ac 50 kHz function in the 515A.

b. Set the controls of a dc coupled oscilloscope to provide a .01V vertical sensitivity with an established 0V reference (Model 515A circuit common) on the display.

c. Connect the input through X10 probe to DET, t. p. Connect the probe ground clip to circuit common.

d. Adjust the oscilloscope sweep speed to view at least two complete cycles of the peaked waveform at DET TP.

e. Adjust DET (R60) until the peak of the waveform is at 100 ±10 mV in respect to circuit common. Use the 50 mV or 100 mV vertical sensitivity.

f. Select the 10V ac 4 kHz function and observe the amplitude of the peak. Readjust R60 if the signal is not 90 mV or greater.

g. Select the 10V ac 400 Hz function and observe the amplitude of the peak. Readjust R60 if the signal is not 90 mV or greater.

NOTE!

If any adjustment is made, check previous steps to insure that all three readings are greater than 90 mv.

h. Disconnect the oscilloscope

4-43. Comparator Balance

a. Connect the input of an ac differential voltmeter to the front panel OUTPUT terminals.

b. Record the ac output voltage.

c. Switch S14 to the opposite position (white dot not showing) and record the ac voltmeter indication.

d. Adjust BAL (R37) for a maximum shift of 0 ±50 μV in output voltage of each setting of S14.

e. Set S14 to "white dot position" and disconnect the ac differential voltmeter.

4-44. Frequency Adjust

a. Connect the input of a frequency counter to the front panel OUTPUT terminals (Use period mode for maximum resolution.

b. Connect the input of the voltmeter to CONT t. p. (+) and circuit common.

c. Select the 10V ac 50 kHz function on the 515A.

d. Adjust 50 kHz (R95) for a frequency reading between 48.75 kHz and 51.25 kHz (19.5 to 20.5 μsec period).

e. Verify that CONT t. p. reads −2.5 to 0.2V dc. Adjust 50 kHz CONT (R90) if required and verify frequency is still within tolerance.

f. Select the 10V ac 4 kHz function.

g. Adjust 4 kHz (R123) for a frequency reading between 3.98 kHz and 4.02 kHz (248.75 to 251.25 μsec period).

h. Adjust 4 kHz control (R125) for −2.5 ±0.2V dc at CONT t. p. Verify the frequency is still within tolerance.

i. Select the 10V ac 400 Hz function.

j. Adjust 400 Hz (R127) for a frequency reading between 398 Hz and 402 Hz (2487.5 to 2512.5 μsec period).

k. Adjust 400 Hz CONT (R129) for −2.5 ±0.2V dc at TP CONT. Verify the frequency is still within tolerance.

4-45. Amplitude by Thermal Transfer

4-46. The Model 515A is now calibrated to meet amplitude accuracy specifications related to a dc reference accurate to ±15 ppm. If an amplitude accuracy related to a thermal transfer is required, perform the following procedure:

a. Make the equipment connections shown in Figure 4-5.

NOTE

Transfer accuracy of the thermal transfer standard must be certified to at least ±0.01% from 400 Hz to 50 kHz.

b. Set the dc Voltage Standard output to the 10V dc, and 515A to 10V −400 Hz.

c. Perform dc to ac transfer, observing the ac amplitude error.

d. Adjust BAL (R37) for a 10V rms output from the Model 515A.

e. Set 515A to 50 kHz and perform d.c. to a.c. transfer.

f. Adjust C74 (inside shield box, center of main PCB on top side) for 10V rms output.

g. Set 515A to 4 kHz and perform d.c. to a.c. transfer.

h. See that output is now 10V rms ±.01% of that at 400 Hz.

4-47. Variable DC Voltage and Linearity Calibration.

a. Connect the equipment as shown in Figure 4-6. Insure the self-cal test for the voltage divider and calibration of the DC Transfer Standard against a standard cell is performed the same day, and prior to the calibration procedure. Zero the Null Detectors. Insure the bottom dust cover is removed and the bottom guard installed on the Portable Calibrator. If the guard is not installed, air currents and hand capacity will effect the readings.

NOTE

The adjustments used in paragraph 4-47, unless specified otherwise, are through an access hole in the bottom guard, which must be installed. Low thermal leads should be used.

b. Set the Transfer Standard for a 11 volt output.

c. Set the Voltage Standard to 10 volts and vary until a null is obtained on Null Detector I. Monitor Null Detector I throughout the test, varying the voltage Standard as required to maintain the null.

d. Select the 10V dc function on the Portable Calibrator and set the output Multiplier switch to the X1 position. Set the voltage divider to 0.999999X.

e. Adjust +10V (R11) for a null ±10 μ volts on Null Detector II.

NOTE

The following linearity adjustments are highly interactive. If during adjustment the four controls cannot be brought into tolerance by the end of the fourth pass, recheck the 10-volt calibration and set the reading closer to a null.

f. Set the output multiplier switch to X.4 and the voltage divider to .4000000.

g. Adjust 4V (R14) for a null ±12 μ volts on Null Detector II.

h. Set the output multiplier switch to X.3 and the voltage divider to .300000.

i. Adjust 3V (R17) for a null ±9 μ volts on Null Detector II.

j. Set the Output Multiplier Multiplier Switch to X.2 and the voltage divider to .2000000.

k. Adjust 2V (R20) for a null ±6 μ volts on Null Detector II.

l. Set the Output Multiplier Switch to X.1 and the voltage Divider to .1000000.

m. Adjust 1V (R23) for a null ±3 μ volts on Null Detector II.

n. Repeat steps f through m until all eight steps can be performed to the listed tolerances without making any adjustments.

o. Set the Output Multiplier Switch to X.5, X.6, X.7, X.8 and X.9 in turn, verifying that Null Detector II reads a null ±150 μ volts, ±180 μ volts, ±210 μ volts ±240 μ volts or ±270 μ volts respectively. There are no adjustments for these readings, they are dependent upon the settings performed in the previous steps.

p. Select the 1V dc Function on the Portable Calibrator and set the output multiplier switch to X1.

q. Set the voltage divider to .1000000.

r. Adjust 1V dc (R144) on the top left front of the main pcb for a null ±1 μ volt on Null Detector II.

s. Select the μ volts function on the Portable Calibrator and set the μ volt counter to 000 μ volts.

NOTE

The μ volt dial reads 000 for both zero and 1000 μvolts. For a zero reading insure the dial is turned fully counter-clockwise against the stop. For a reading of 1000 μ volts, the dial is turned clockwise past 999 until the dial reads 000.

t. Set the voltage divider to .0000000.

u. Disconnect the Portable Calibrators HI input lead and connect it to the LO terminal.

v. Wait for thermals from the operators hands to subside and record the reading on Null Detector II. (Must be < 1 μ V.)

w. Reconnect the Portable Calibrators leads as shown in Figure 4-6.

x. Wait for the thermals from the operators hands to subside and record the reading on Null Detector II.

y. Algebraically add the figures obtained in steps v and x. The result should be 0 ±1 μ volts.

z. If the Algebraic sum does not equal a null ±1 μ volt mechanically adjust the potentiometer dial until it reads a null ±1 μ volt at the zero dial position.

NOTE

The pot can be mechanically served by loosening the set screws on the coupler that connect the shaft and the front panel counter, repositioning the pot, and retightening the set screws.

aa. Set the μ volt counter to 1000 μ volts and the Voltage Divider to .0001000.

ab. Algebraically add the reading on Null Detector II and the reading obtained in Step x. The result should be 0 ±2 μ volts. If not, adjust μ V (R147) on the top left front of the Main pcb until the algebraic sum equals 0 ±2 μ volts.

ac. Set the μ volt counter and Voltage Divider at 700 μ volts (.0000700), 500 μ volts (.0000500), 200 μ volts (.0000200) and 100 μ volts (.0000100) in turn. At each setting the Algebraic sum of the Null Detector II reading and the thermal reading obtained in step x should be 0 ± 2 μ volts.

NOTE !

There are no adjustments for the μ volt linearity dial. If the readings are not in tolerance, the Portable Calibrator requires repair.

4-48. 100 Volts DC Calibration

a. Connect the equipment as shown in Figure 4-7.

CAUTION!

The Transfer Standard and Null Detector I will be "floating" at +110 volts dc. Operate the transfer Standard and Null Detector I under battery power if these type of units are available.

b. Select the 100V dc function on the Portable Calibrator.

c. Select a 10V dc output from the Transfer Standard.

d. Set the voltage Standard to 110V dc initially and then adjust for a null ± 5 μ volts on Null Detector 1. Adjust the Voltage Standard as required during the test to maintin the null on Null Detector I.

e. Set the voltage divider to .999999X.

f. Adjust 100V (R141) on the top left front of the main pcb for a null ± 50 μ volts on Null Detector II.

4-49. Resistance Adjustments

a. Connect the equipment as shown in Figure 4-8.

b. Select the ohms function on the 515A and set the Output Multiplier Switch to 0.

c. Obtain the residual resistance with the Resistance Measurement System.

NOTE!

Through disuse, the Output Multiplier Switch contacts may become contaminated and cause out of tolerance readings at the 10Ω step. Vigorously exercise the switch to remove these contaminants prior to verifying calibration of 10 ohms.

d. Verify the resistance values shown in table 4-5, subtracting the residual resistance obtained in step c from the value read. There is no adjustment for settings 0 through 1 megohm. The 10 megohm value may be adjusted by varying 10 MΩ (R30 on the adjustment PCB) through the access slot in the bottom guard.

NOTE!

If a Resistance Measurement System is not available, the resistance can be measured by a comparison method. Check the reading of some known resistance with a precision DVM, such as a Fluke 8400, and then check the resistance of the Portable Calibrator.

4-50. COMPENSATING COMPONENT SELECTION

4-51. Replacement of U2(Main PCB) and associated matched components in the Reference Supply will require selection of jumpers A and B. These jumpers compensate the adjustment range of V_R (R27). Select of jumpers is done as follows:

a. Turn off the Model 515A and set V_R (R27) fully counterclockwise.

b. Locate jumpers A and B using Figure 4-1 and reconnect any cut jumpers.

c. Turn on the Model 515A and make the equipment connections shown in Figure 4-4.

d. Set the Voltage Standard output to +14.14214V dc with a null sensitivity of 1V.

e. Increase the null detector sensitivity and record the offset voltage.

f. Cut jumpers A and B per Table 4-6.

g. Adjust V_R (R27) for a 0 ± 70 μV indication on the null detector.

Table 4-6. A & B JUMPER SELECTION

OFFSET VOLTAGE V_R t.p.	CLIP JUMPER
0 to 0.00571	None
0.00572 to 0.01141	A
0.00142 to 0.01712	B
0.01713 to 0.02182	A & B

NOTE!

The Model 515A should be recalibrated using the procedures given in paragraph 4-33 through 4-49.

4-52. TROUBLESHOOTING

4-53. The following information is provided to assist in locating troubles in the Model 515A. It is recommended that the theory of operation in Section 3 be completely understood before attempting any troubleshooting.

4-54. Initial Troubleshooting

4-55. Troubleshooting begins by first performing a thorough inspection for improperly seated plug-in assemblies, loose wires, physically damaged parts, or other obvious problems. The next step is to insure that the instrument is being operated correctly, but fails to meet specifications. Performance checks especially designed for this purpose are given in paragraphs 4-19 through 4-32.

4-56. Once it is determined that a malfunction exists, all operating voltages should be checked as shown in Table 4-7 and Figure 4-1. During these checks, the instrument must be operated from nominal line power. The Rechargeable Battery Pack can be checked using the information in paragraph 4-66.

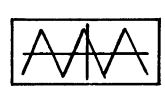
Table 4-7. OPERATING VOLTAGE CHECKS

TEST POINT	VOLTAGE (VDC)	CIRCUITRY CHECKED
+18 UN t.p.	+23V + 4V, −2V	AC INPUT (T1, CR2)
−18UN t.p.	−23V + 4V, −2V	AC INPUT (T1, CR2)
−18 t.p.	−18 ±0.5V	−18V REGULATOR (Refer to Para. 4-57)
+18 t. p.	+18 ±0.2V	+18V REGULATOR (Refer to Para. 4-57)
V_R t.p	+14.14214V	REFERENCE SUPPLY

4-57. +18V and −18V Regulators

4-58. The regulated power supplies are interconnected to each other and to V_R, the +14.14214V Reference Supply. A fault in one supply can cause all three to produce incorrect outputs at the same time. The −18V Regulator is referenced to V_R by R18 through CR5 & CR6. The +18V Regulator is referenced to the −18V by R10. But the V_R circuit is powered by the +18V Regulator. To facilitate locating a fault, interrupt this interconnection: If the +18V, −18V, and V_R are all low (the most common trouble) connect an external dc voltage of +14.0V between CR5 and CR6 to COM. Diode CR6 will be back-biased, thus the −18V Regu-

Table 4-8. AC GENERATOR CHECKS

CHECK POINT	NORMAL INDICATION	FAULT ANALYSIS
OSC t.p.	10V RMS	If abnormal check CONT t.p.
CONT t.p.	−2.5±0.2V dc	A. If OSC TP is high or low and TPV is ±0.6V, trouble is in the oscillator. B. Check INT t.p. If CONT t.p. is at some other voltage.
INT t.p	0 ±100 µV	A. If CONT t.p. is not +0.6 V and INT t.p. is +10 mV or more, trouble is in the INTEGRATOR. B. If CONT t.p. is more positive then −5V and INT t.p. is −10 mV or more, trouble is in the INTEGRATOR. C. If CONT t.p. is not +0.6V and INT t.p. is 0V or negative, trouble is in the peak AC to DC CONVERTER or SAMPLE AND HOLD. D. If CONT t.p. is more positive then −5V and INT t.p. is 0V or positive, trouble is in the Peak AC to DC CONVERTER or SAMPLE AND HOLD. E. If the waveform and peak voltage at SAMPLE t.p. is not as shown, the trouble is in the Peak AC to DC CONVERTER
		400 Hz – 250 mV 4 kHz – 200 mV 50 kHz– 50 mV

lator $+V_R$ interconnection is opened. Alternately, the end of R10 going to −18 volts can be opened and connected to an external −18V dc power supply.

4-59. AC Generator Checks

4-60. The voltage checks given in Table 4-8 and Figure 4-1 can be used to isolate a trouble to a major circuit. General troubleshooting of the major circuit should then reveal the exact source of trouble. Circuit voltages are given on the schematic diagram. Select the 10V ac 400 Hz function on the 515A

4-61. +100 DV Voltage

4-62. The voltage checks given in Table 4-9 and Figure 4-1 can be used to isolate troubles to a section of the +100 VDC circuit. Select the 100 Volt DC function on the 515A.

Table 4-9. 100V DC CHECKS

CHECK POINT (On Main PCB)	NORMAL INDICATION	FAULT ANALYSIS
+100UN t.p	120 to 130V dc (no load)	A. If +100 UN t.p. is low, check the bridge rectifier and input.
	105 - 115V (with 200kΩ load)	B. If normal, check +100V t.p.
+100V t.p.	100V dc	A. If +100V dc is high or low, check the +10V at pin 10, J11. B. If normal check Q29, Q30, U5, and the status of jumper C. *NOTE!* *If inexplicable readings occur during the DC voltage tests, confirm that J1 (DC PCB) J11 (Main PCB) is properly aligned on the connectors.* C. If normal check output switching network.

4-63. +10 Volts Checks

4-64. The voltage checks given in Table 4-10 and Figure 4-3 can be used to isolate troubles in the +10, +1 and μ volts circuits. If the output is not correct when any of these three voltages are selected, perform the steps in Table 4-10.

Table 4-10. 10 VOLT DC CHECKS

CHECK POINT (On DC PCB)	NORMAL INDICATION	FAULT ANALYSIS
+10V t.p.	+10V dc	A. If +10V t.p. is high or low proceed to +V t.p. B. If +10V t.p and both the +10 and +1 volt outputs faulty check the linearity circuits. C. If +10V t.p. and the +1 volt output are normal, while the +10 volt output is fault, check the output switching. D. If +10 t.p. and the +10 volt output is normal while the +1 volt output is faulty, check the 10:1 Divider and output switching.
+V t.p.	0.4V to 2V less than the regulated +18V. Dependent upon setting of linearity ladder. Voltage drop is smallest at end of ladder and increases to maximum at the center of the ladder	A. If +V t.p.is equal to the regulated +18 volts, no current is being drawn by the regulator and it is faulty. B. If voltage is more than 2V below the regulated +18V at +V t.p. check the supply path and check for excessive current being drawn by the the +10V Regulator, (Q1, V1, etc.)

4-65. Rechargeable Battery Pack

4-66. Operating voltages for the battery pack circuitry can be checked using the following procedure:

a. Connect the power cord through an autotransformer to line power. Set the autotransformer output to 0V. Battery meter must read in the green.

b. Make the voltage checks on the A3 Battery Pack PCB as shown in Table 4-11.

Table 4-11. BATTERY PCB CHECKS

TEST POINT (On Battery PCB)	NORMAL INDICATION (VCD)
TP 4	+19.2 to +25
TP 5	−19.2 to −25
TP 1	+0.1V ±.02V
TP3	0.2 to 0.4V less than TP4
TP2	+0.65 ±.05V

NOTE: Use output LO as circuit common.

c. Connect the dc voltmeter to A3TP 1 and slowly increase the autotransformer output. The voltage at TP1 should increase from +0.1V dc to approximately +25V dc at a line voltage between 30 and 90V ac.

d. Set the autotransformer output to 115V ac.

e. Connect the dc voltmeter input to A3TP2 and slowly decrease the autotransformer output. The voltage at TP2 should increase from −25V dc to +0.6V dc at a line voltage between 90 and 30V ac.

f. Turn off the Model 515A and disconnect the power cord.

g. Disconnect wire #1 from P1 on the A3 Battery Pack PCB.

h. Connect the output of a dc power supply set to +24V dc to P1 on the A3 Battery Pack PCB. Connect the power supply common to the LO terminal on the front panel.

i. Turn on the Model 515A and slowly decrease the power supply output until the meter on the front panel swings abruptly to the left.

j. Record the power supply output voltage. The Model 515A should turn-off at a power supply output between 18.5 and 19.5V dc.

k. Increase the power supply output until the meter on the front panel abruptly swings to the right. The Model 515A should turn on at a power supply output that is 1.2V above the value recorded in step j.

l. Turn off the Model 515A and disconnect the power supply. Reconnect wire #1 to P1 on the A3 Battery Pack PCB.

Section 5
Lists of Replaceable Parts

TABLE OF CONTENTS

5-1. INTRODUCTION

5-2. This section contains an illustrated parts breakdown of the instrument. Components are listed alphanumerically by assembly. Electrical components are listed by item number. Each listed part is shown in an accompanying illustration.

5-3. Parts lists include the following information:

a. Reference Designation or Item Number.

b. Description of each part.

c. Fluke Stock Number.

d. Federal Supply Code for Manufacturers (See (Appendix A for Code-to-Name list.)

e. Manufacturer's Part Number or Type.

f. Total Quantity per assembly of component.

g. Recommended Quantity: This entry indicates the recommending number of spare parts necessary to support one to five instruments for a period of two years. This list presumes an availability of common electronic parts at the maintenance site. For maintenance for one year or more at an isolated site, it is recommended that at least one in each assembly in the instrument be stocked. In the case of optional sub-assemblies, plug-ins, etc., that are not always part of the instrument, or are deviations from the basic instrument model, the REC QTY column lists the recommended quantity of the item in that particular assembly.

h. Use Code is provided to identify certain parts that have been added, deleted or modified during production of the instrument. Each part for which a use code has been assigned may be identified with a particular instrument serial number by consulting the Use Code Effectivity, paragraph 5-7.

5-4. HOW TO OBTAIN PARTS

5-5. Components may be ordered directly from the manufacturer by using the manufacturer's part number, or from the John Fluke Mfg. Co., Inc. factory or authorized representative by using the FLUKE STOCK NUMBER. In the event the part you order has been replaced by a new or improved part, the replacement will be accompanied by an explanatory note and installation instructions, if necessary.

5-6. To ensure prompt and efficient handling of your order, include the following information:

a. Quantity.

b. FLUKE Stock Number.

c. Description.

d. Reference Designation or Item Number.

e. Printed Circuit Board Part Number.

f. Instrument Model and Serial Number.

5-7. USE CODE EFFECTIVITY LIST

USE CODE	SERIAL NUMBER EFFECTIVITY

Table 5-1. FINAL ASSEMBLY

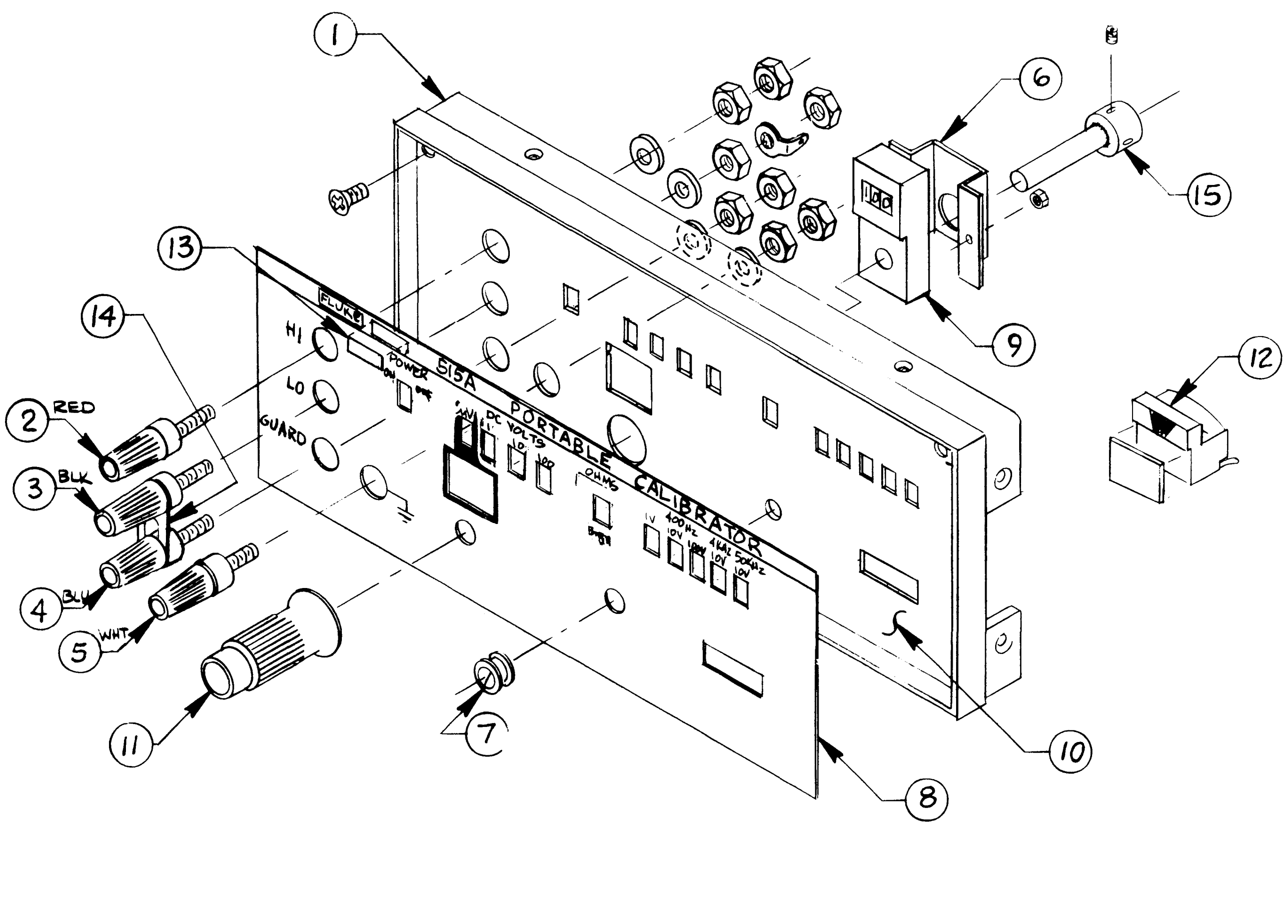
REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
	FINAL ASSEMBLY	515A	89536				
	Front Panel View (Figure 5-1)						
1	Bezel Frame	363093	89536	363093	1		
2	Binding Post, copper, red	380147	32767	825-65	1		
3	Binding Post, copper, black	380154	32767	825-45	1		
4	Binding Post, brass, blue	275578	32767	825-55	1		
5	Binding Post, brass, white	275586	32767	825-25	1		
6	Bracket	383133	89536	383133	1		
7	Bushing, Snap	160499	96881	422FF	1		
8	Decal Set	381038	89536	381038	1		
9	Dial, Digital	383141	89536	383141	1		
10	Front Panel	383034	89536	383034	1		
11	Knob Assembly	341396	89536	341396	1		
12	Meter, D'Arsonval	266494	82538	TS10	1		
13	Nameplate, S/N	393975	89536	393975	1		
14	Shorting link	190728	24655	0938-9751	1		
15	Shaft, Extension	381046	89536	381046	1		
	Rear Panel View (Figure 5-2)						
F1	Fuse, fast acting, ¼ amp	109314	71400	AGC	1		
XF1	Fuse, Holder	407775	75915	341-001 AL	1		
A1J5	Connector, AC, Power	284166	82389	EAC301	1		
A1T1	Xfmr, power	383208	89536	383208	1		
16	Bezel, frame	363093	89536	363093	1		
17	Foot, rear panel	391367	89536	391367	2		
18	Rear Panel	383042	89536	383042	1		
	Top View (Figure 5-3)						
A2	Main PCB Assembly (See Figure 5-6)	378786	89536	378786	1		

Table 5-1. FINAL ASSEMBLY, continued

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
19	Cable Assembly	384255	89536	384255	1		
20	Couple, Switch Extension	269670	89536	269670	3		
21	Guard, left side	383083	89536	383083	1		
22	Guard, right side	383091	89536	383091	1		
23	Side, chassis	383059	89536	383059	2		
24	Tube, switch extension	381053	89536	381053	1		
25	Tube, switch extension	381061	89536	381061	1		
26	Tube, switch extension	381079	89536	381079	1		
27	Wire Assembly	384354	89536	384354	1		
	Bottom View (Figure 5-4)						
A3	Battery Pack PCB Assembly (See Fig. 5-7)	307876	89536	307876	1		
A4	DC PCB Assembly (See Fig. 5-8)	378794	89536	378794	1		
T2	Xfmr, output	383190	89536	383190	1		
28	Dial Assembly	383174	89536	383174	1		
	Assembled View (Figure 5-5)						
29	Cover, bottom	383075	89536	383075	1		
30	Cover, top	383067	89536	383067	1		
31	Decal, bottom cover	381319	89536	381319	1		
32	Decal, knob, spun finish	285221	89536	285221	2		
33	Decal, side trim	363010	89536	363010	2		
34	Foot, bail, stand	292870	89536	292870	4		
35	Grip, handle	284836	89536	284836	2		
36	Guard, Bottom	383117	89536	383117	1		
37	Guard, Top	383109	89536	383109	1		
38	Handle	310045	89536	310045	1		
39	Insert, Non-skid Foot	104260	89536	104260	4		
40	Knob, femal half, black	309054	89536	309054	2		

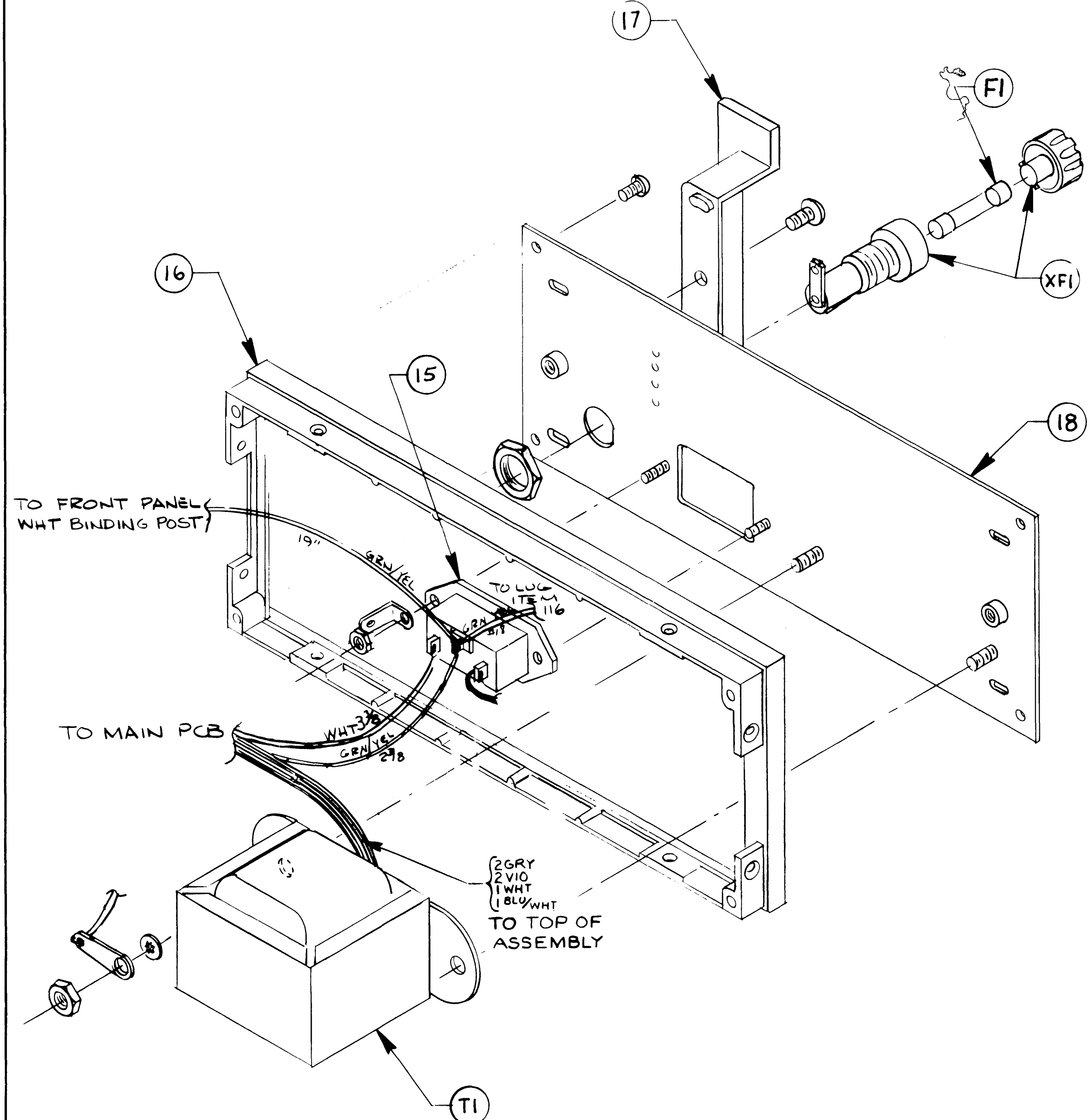
Table 5-1. FINAL ASSEMBLY, continued

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
41	Knob, male half, black	309047	89536	309047	2		
	Battery Pack Assembly	307900	89536	307900	1		
	Not illustrated - attached to inside of item 37						
BT1, BT2	Battery Pck (not illustrated)	284356	03508	PPS 1082	2		
	Cordset (not illustrated)	363481	70903	PH390	1		



NOTE: Components not marked with an Item Number are common hardware.

Figure 5-1. FRONT PANEL VIEW



NOTE: Components not marked with an Item Number are common hardware.

Figure 5-2. REAR PANEL VIEW

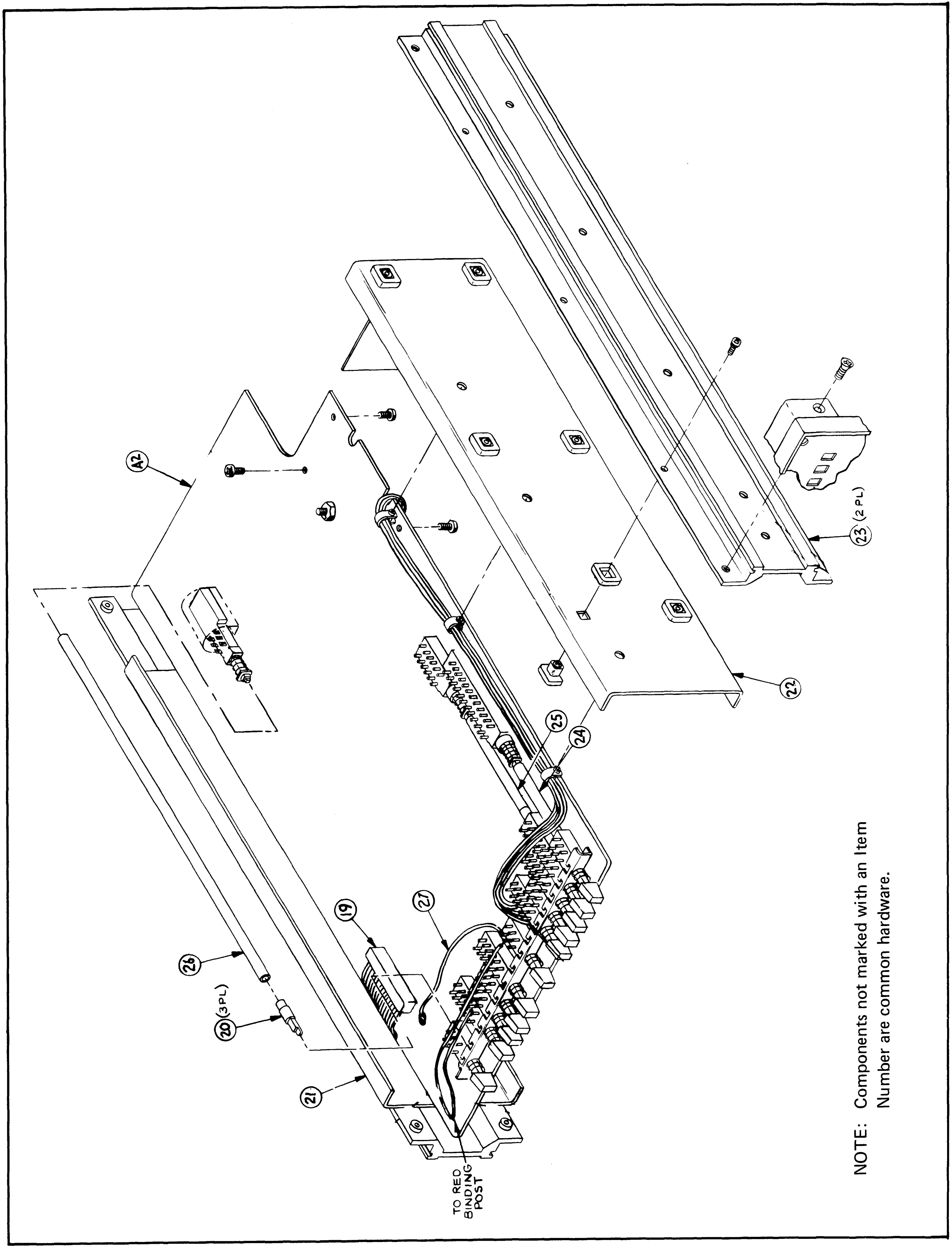


Figure 5-3. TOP VIEW

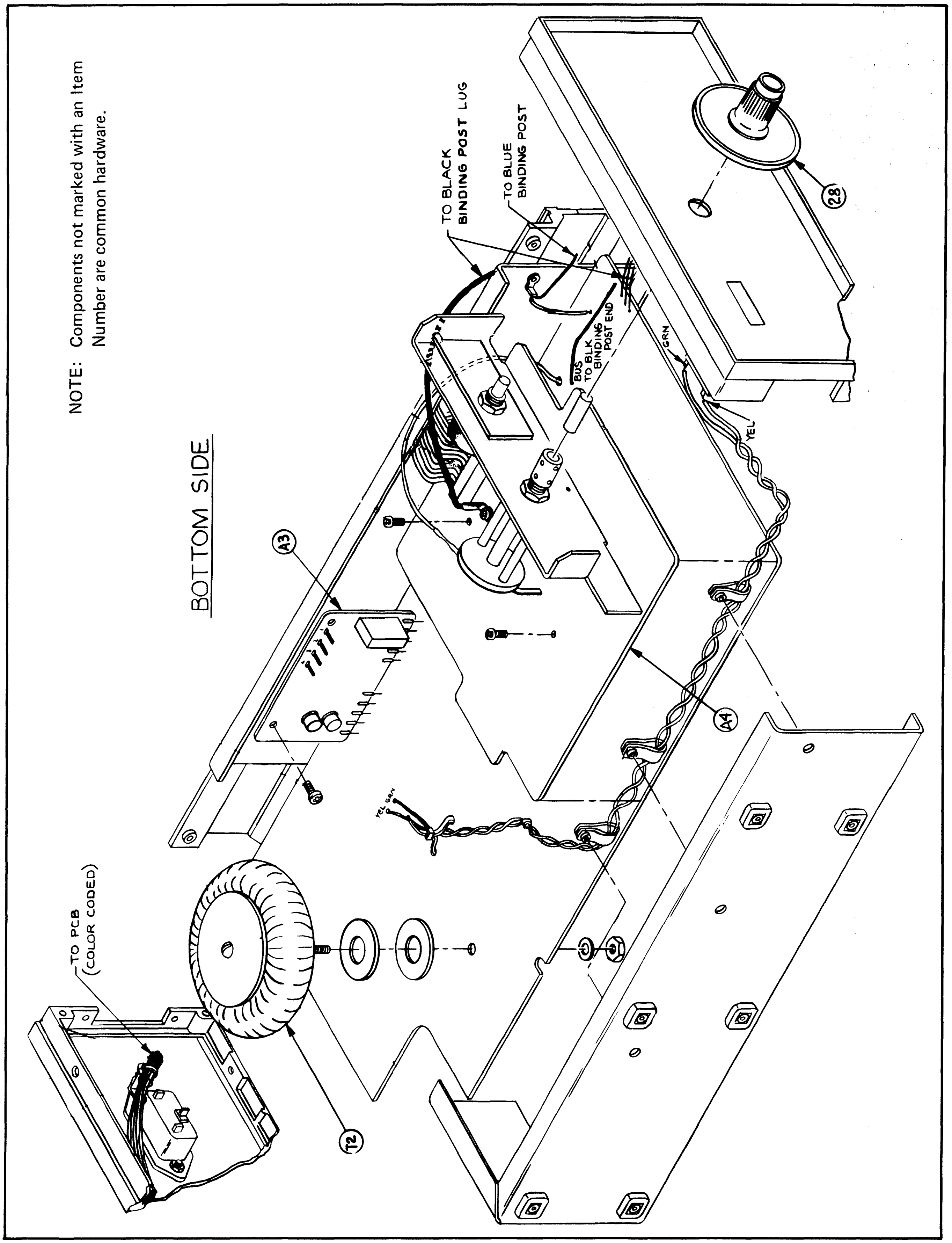
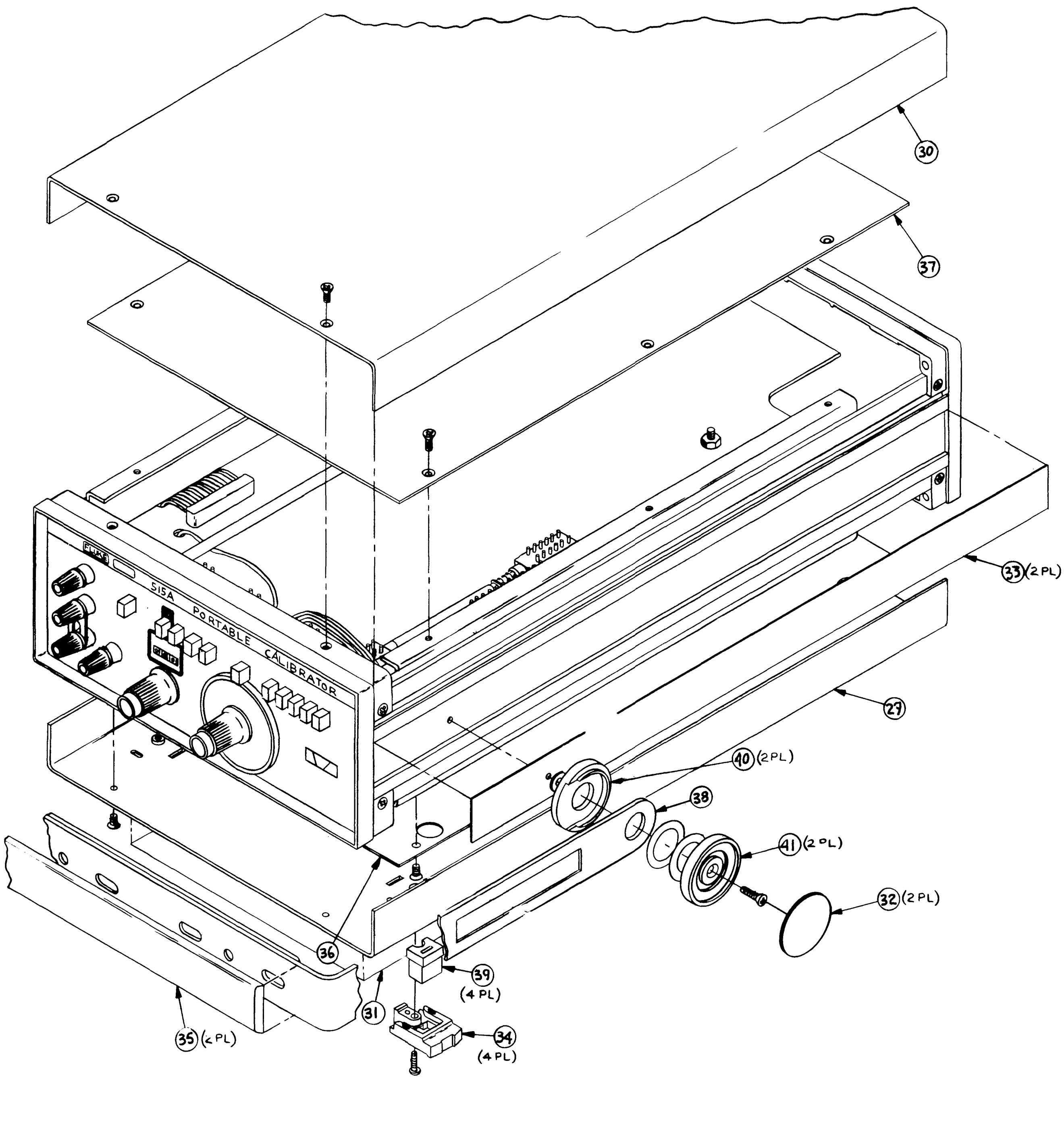


Figure 5-4. BOTTOM VIEW



NOTE: Components not marked with an Item Number are common hardware.

Figure 5-5. ASSEMBLED VIEW

Table 5-2. MAIN PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
	MAIN PCB ASSEMBLY	378786	89536	378786	REF		
	Figure 5-6						
C1	Cap, elect, 2 uF +75/–10%, 50V	105197	56289	30D205G050 BA4	1		
C2,C3	Cap, elect, 220 uF +100/–10%, 40V	178616	73445	ET221X040A01	2		
C4,C5, C9,C28, C32	Cap, Ta, 2.2 uF ±20%, 20V	161927	56289	196D225X0020	5		
C6,C8, C10, C12, C13, C14, C17, C20, C23	Cap, fxd cer, 0.05 uF +80/–20%, 25/50V	148924	32897	5855Y5U503Z	9		
C7,C35	Cap, Ta, 4.7 uF ±20%, 20V	161943	56289	196D475X0020	2		
C11, C18, C30	Cap, fxd mica, 33 pF ±5%, 500V	160317	72136	DM15E330J	3		
C15, C21, C22, C24, C25, C26, C34, C36, C64	Cap, fxd, cer, 0.01 uF ±20%, 100V	149153	56289	C023B101F103 M	9		
C16	Cap, fxd mica, 4 pF ±5%	190397	72136	DM15C040K	1		
C27, C59	Cap, fxd mica, 47 pF ±5%, 500V	148536	72136	DM15E470J	2		
C29	Cap, fxd, cer, 180 pF ±10%, 1KV	105890	71590	BB60181KS3N	1		
C31	Cap, fxd, cer, 20 pF ±10%, 500V	106369	32897	831-000T2H0-200	1		
C33	Cap, fxd, mica, 22 pF ±5%, 500V	148551	71236	DM15C220J	1		
C37, C38	Cap, mylar, 0.22 uF ±10%, 250V	194803	73445	C280AE/A220K	2		

Table 5-2. MAIN PCB ASSEMBLY, continued

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
C40, C48	Cap, Ta, 3.3 uF ±10%, 15V	182808	56289	150D330X9015	2		
C41	Cap, fxd, cer, 3.3 pF ±10%, 500V	106377	32897	861-000T2H0-3R3	1		
C42, C61	Cap, fxd, cer, 0.025 uF ±20%, 100V	168435	56289	C023B101H253 MU	2		
C43, C44	Cap, fxd, cer, 0.05 uF ±20%, 100V	149161	56289	55C23A1	2		
C45	Cap, fxd, mica, 270 pF ±5%, 500V	148452	14655	CD15FD271J03	1		
C46	Cap, fxd, mica, 3000 pF ±5%, 500V	161786	71236	DM19F302J	1		
C47	Cap, Ta, 0.33 uF ±5%, 20V	271338	56289	150D033X5020 A2	1		
C49, C50	Cap, fxd, mica, 270 pF, ±1%, 500V	179010	14655	CD15F271J2			
C51, C52	Cap, fxd, mica, 3300 pF ±5%, 500V	148320	14655	C019FB32J	2		
C53, C54	Cap, fxd, met polycarbonate, 0.033 uF ±5%, 100V	310474	01281	X463UW33351	2		
C55	Cap, fxd, met polycarbonate, 5 uF ±10%, 50V	313254	84411	X463UW5059.50	1		
C57	Cap, fxd, plstc, 1 uF ±20%, 200V	106450	84411	TYPE X6635	1		
C58	Cap, fxd, mica, 5 pF ±10%, 500V	148577	72136	DM15C050K	1		
C60	Cap, fxd, mica, 2 pF ±5%, 500V	175208	72136	DM15E020J	1		
C62	Cap, fxd, mica, 56 pF ±5%, 500V	148528	14655	DC15F560J	1		
C63	Cap, plstc, 0.0047 uF ±20%, 200V	106054	56289	192P47202	1		
C66	Cap, fxd mylar, 0.15 uF ±10%, 200V	222620	14655	DMF1P15	1		
C67, C68	Cap, Ta, 330 uF ±10%, 6V	193011	56289	150D337X9006 S2	2		
C70	Cap, plstc, 2.2 uF ±10%, 10CV	306522	73445	C280MCH/A2 M2	1		
C71	Cap, fxd, met polycarbonate, 0.033 uF ±10% 100V	288894	84411	X463UW.03391	1		
C72, C73	Cap, elect, 10 uF +50/–10%, 25V	170266	25403	ET100X025A2	2		

Table 5-2. MAIN PCB ASSEMBLY, continued

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
C74	Cap, var, cer, 1.7 - 10 pF 250V	321109	73899	DVJ302A	1		
CR1, CR7, CR26	Diode, Rectifier, 1 amp, 100 piv	116111	05277	1N4817	3		
CR2	Rectifier, bridge, 2 amp, 100V	296509	09423	FB100	1		
CR3 thru CR6, CR13, CR14, CR15, CR17, CR18, CR20, CR21, CR22, CR24	Diode, Hi-speed, switch	203323	03508	DHD1105	13		
CR8	Diode, Si, 75 mA, 25 piv	348177	03508	DA2429	1		
CR9	Diode, Hi-speed switching	256339	28480	5082-2900	1		
CR10, CR11, CR12	Diode Ge, 80 mA, 100 piv	149187	93332	1N270	3		
CR16, CR19	Diode, zener, 6.2V	180497	07910	1N753	2		
CR25	Rectifier, bridge, 2 amp, 600V	341008	09423	FB600	1		
DS1, DS2	Lamp, incandesant, 28V, 80 mA	175265	08806	757	2		
L1	Ferrite tube, choke core	321182	02114	56-590-65-4B	1		
Q1, Q33	Xstr, Si, PNP	269076	95303	2N4037	2		
Q2,Q4, Q12 thru Q16, Q24, Q25, Q28, Q34	Xstr, Si, NPN	218396	04713	2N3904	11		

Table 5-2. MAIN PCB ASSEMBLY, continued

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
Q3,Q19 Q21	Xstr, Si, NPN	218081	04713	MPS6520	3		
Q5,Q7 thru Q10, Q27, Q32	Xstr, Si, PNP	195974	04713	2N3906	7		
Q6,Q11 Q18, Q20	Xstr, Si, PNP	229898	04713	MPS6522	4		
Q17, Q26	Xstr, Si, N-channel FET	261388	04713	SPF179	2		
Q22, Q23	Xstr, Si, PNP	225599	12040	2N4250	2		
Q29	Xstr, Si, PNP	266619	07263	2N4888	1		
Q30	Xstr, Si, NPN	370684	04713	MPS-A42	1		
Q31	Xstr, Si, NPN	150359	95303	2N3053	1		
R1,R4, R13, R101	Res, fxd, comp, 6.8K ±5%, ¼W	148098	01121	CB6825	4		
R2	Res, met film, 6.98K ±1%, 1/8W	261685	91637	MFF1-8	1		
R3,R7, R16, R68	Res, fxd, comp, 1.8K ±5%, ¼W	175042	01121	CB1825	4		
R5, R14, R19	Res, fxd, comp, 270 ±5%, ¼W	160804	01121	CB2715	3		
R6, R15	Res, fxd, comp, 180K ±5%, ¼W	193441	01121	CB1845	2		
R8	Res, met film, 54.9K ±1%, 1/8W	271353	91637	MFF1-85492	1		
R9, R95, R123, R127	Res, var, 10K ±10%, ½W	309674	11236	360T103A	4		
R10	Res, met film 63.4K ±1%, 1/8W	235382	91637	MFF1-8	1		

Table 5-2. MAIN PCB ASSEMBLY, continued

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
R11, R75, R76, R84, R88	Res, fxd, comp, 22K ±5%, ¼W	148130	01121	CB2235	5		
R12, R97	Res, fxd, comp, 5.6K ±5%, ¼W	148080	01121	CB5625	2		
R17	Res, met film, 57.6K ±1%, 1/8W	289116	91637	MFF1-8	1		
R18	Res, met film, 45.3K ±1%, 1/8W	234971	91637	MFF1-845R32F	1		
R20	Res, met film, 51.1K ±1%, 1/8W	309757	91637	MFF1-8	1		
R21	Res, met film, 49.9K ±1%, 1/8W	293456	91637	MFF1-8	1		
R22, R23, R30, R31 and U2	Ref Amp Assy	397869	89536	397869	1		
R24	Res, met film, 2.49K ±1%, 1/8W	309732	91637	MFF1-8	1		
R25	Res, met film, 1.05K ±1%, 1/8W	293530	91637	MFF1-8	1		
R26	Res, met film, 107 ±1%, 1/8W	309716	91637	MFF1-8	1		
R27	Res, var, 100 ±10%, ½W	275735	11236	360T101A	1		
R28	Res, met film, 200 ±1%, 1/8W	309724	91637	MFF1-8	1		
R29	Res, met film, 10 ±1%, 1/8W	268789	91637	MFF1-8	1		
R37	Res, var, 20 ±20%, ½W	275727	11236	360T200B	1		
R38	Res, met film, 40.2 ±1%, 1/8W	245373	91637	MFF1-8	1		
R39	Res, met film, 100 ±1%, 1/8W	168195	91637	MFF1-81000F	1		
R40, R41	Res, network, 14K, 14K	293506	18612	310865	1		
R42	Res, met film, 33.2 ±1%, 1/8W	199950	91637	MFF1-8	1		
R43, R54, R57, R64	Res, fxd comp, 100K ±5%, ¼W	148189	01121	CB1045	4		

Table 5-2. MAIN PCB ASSEMBLY, continued

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
R44, R45, R93, R152, R156	Res, fxd, comp, 1K ±5%, ¼W	148023	01121	CB1025	5		
R46	Res, met film, 13.7K ±1%, 1/8W	236752	91637	MFF1-8	1		
R47, R74	Res, met film, 453 ±1%, 1/8W	267393	91637	MFF1-8	2		
R48, R73	Res, met film, 1M ±1%, 1/8W	268797	91637	MFF1-8	2		
R49, R72	Res, var, 1M ±10%, ½W	276691	11236	360T105A	2		
R52	Res, fxd, comp, 2.4M ±5%, ¼W	221945	01121	CB2455	1		
R53	Res, fxd, comp, 470K ±5%, ¼W	188441	01121	CB4745	1		
R55, R58, R70, R111, R112	Res, fxd, comp, 47K ±5%, ¼W	148163	01121	CB4735	5		
R56	Res, fxd, comp, 360K ±5%, ¼W	234690	01121	CB3645	1		
R59	Res, fxd, comp, 12K ±5%, ¼W	159731	01121	CB1235	1		
R60	Res, var, 1000 ±10%, ½W	275750	11236	360T102A	1		
R61	Res, fxd, comp, 27K ±5%, ¼W	148148	01121	CB2735	1		
R62, R85, R99	Res, fxd, comp, 8.2K ±5%, ¼W	160796	01121	CB8225	3		
R63	Res, fxd, comp, 100 ±5%, ¼W	147926	01121	CB1015	1		
R65, R67, R78, R87, R91, R92, R149, R150	Res, fxd, comp, 10K ±5%, ¼W	148106	01121	CB1035	8		
R66	Res, fxd, comp, 91 ±5%, ¼W	221887	01121	CB9105	1		
R69	Res, fxd, comp, 820K ±5%, ¼W	220541	01121	CB8245	1		

Table 5-2. MAIN PCB ASSEMBLY, continued

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
R71	Res, fxd, comp, 6.2K ±5%, ¼W	221911	01121	CB6225	1		
R77	Res, fxd, comp, 2.2M ±5%, ¼W	198390	01121	CB2255	1		
R79	Res, fxd, comp, 36K ±5%, ¼W	221929	01121	CB3635	1		
R80, R81	Res, met film, 1K ±1%, 1/8W	168229	91637	MFF1-81991F	1		
R82, R83	Res, met film, 1.47K ±1%, 1/8W	293654	91637	MFF1-8	2		
R86	Res, fxd, comp, 510 ±5%, ¼W	218032	01121	CB5115	1		
R89	Res, met film, 4.53K ±1%, 1/8W	260331	91637	MFF1-8	1		
R90	Res, var, 1K	393728	89536	393728	1		
R94, R118, R122, R196	Res, met film, 41.2K ±1%, 1/8W	289538	91637	MFF1-8	4		
R98	Res, fxd, comp, 4.7K ±5%, ¼W	148072	01121	CB4725	1		
R100	Res, var, 2K ±10%, ½W	309666	11236	360T202A	1		
R102, R104	Res, fxd, comp, 5.6 ±5%, ¼W	208033	01121	CB56G5	2		
R103	Res, fxd, deposited, carbon, 0.50 ±5%, ¼W	381954	80031	CR251-45P.5TS	1		
R105, R106	Res, met film, 30.1 ±1%, 1/8W	296665	91637	MFF1-830R1J	2		
R110	Res, fxd, comp, 56K ±5%, ¼W	170738	01121	CB5635	1		
R114	Res, fxd, comp, 2.7 ±5%, ¼W	246744	01121	CB2705	1		
R115	Res, fxd, comp, 1M ±5%, ¼W	182204	01121	CB1055	1		
R116	Res, fxd, comp, 390K ±5%, ¼W	193383	01121	CB3945	1		
R117	Res, fxd, comp, 2.2M ±5%, ¼W	198390	01121	CB2255	1		
R119	Res, met film, 2.55K ±1%, 1/8W	325498	91637	MFF1-8	1		
R120	Res, fxd, comp, 51K ±5%, ¼W	193334	01121	CB5135	1		
R121	Res, fxd, comp, 620 ±5%, ¼W	221903	01121	CB6215	1		
R124, R128	Res, met film, 2.43K ±1%, 1/8W	312637	91637	MFF1-8	2		

Table 5-2. MAIN PCB ASSEMBLY, continued

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
R125, R129	Res, var, 500 ±10%, ½W	325613	11236	360T500A	2		
R130	Res, fxd, comp, 10 ±5%, ¼W	147868	01121	CB1005	1		
R131	Res, fxd, comp, 4.3K ±5%, ¼W	193375	01121	CB4325	1		
R132	Res, fxd, comp, 30K ±5%, ¼W	193417	01121	CB3035	1		
R133	Res, fxd, comp, 68K ±5%, ¼W	148171	01121	CB6835	1		
R134	Res, fxd, comp, 560K ±5%, ¼W	220533	01121	CB5645	1		
R135	Res, fxd, comp, 22M ±5%, ¼W	221986	01121	CB2265	1		
R136, R137	Res, met film, 49.9K ±1%, 1/8W	268821	91637	MFF1-849R92F	2		
R138, R139	Res, divider set	384677	89536	384677	1		
R140	Res, met film, 71.5K ±1%, 1/8W	291435	91637	MFF1-871R5	1		
R141	Res, var, 100 ±10%, 0.5W	381913	32997	3299W1-101	1		
R142	Res, met film, 57.6 ±1%, 1/8W	305946	91637	MFF1-857R6	1		
R143	Res, met film, 681K ±1%, 1/8W	381517	91637	MFF1-8	1		
R144, R147	Res, var, 200K ±10%, 0.5W	381921	32997	3299W1-204	2		
R145, R148	Res, driver, set	384685	89536	384685	1		
R146	Res, met film, 3.24M ±1%, ½W	394478	91637	MFF1-2	1		
R151	Res, fxd, comp, 75 ±5%, ¼W	246736	01121	CB7505	1		
R153	Res, met film, 200K ±1%, 1/8W	261701	91637	MFF1-8	1		
R154, R155	Res, fxd, comp, 7.5K ±5%, ¼W	193326	01121	CB7525	2		
R157	Res, comp, 11 ±5%, ¼W	221861	01121	CB1105	1		
S1	Switch, power (Rear portion)	381129	89536	381129	1		
S1 thru S11	Switch Assy. pushbutton (Front Module)	381095	89536	381095	1		
S10	Switch, pushbutton (Rear portion)	381103	89536	381103	1		

Table 5-2. MAIN PCB ASSEMBLY, Continued.

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
S11	Switch, pushbutton (Rear portion)	381111	89536	381111	1		
S12, S13, S14	Switch, slide DPDT	234278	82389	XW1649	3		
U1	IC, Op- Amp	271502	12040	LM301A	1		
U3,U4	IC, Op-Amp	284760	12040	LM308H	2		
U5	IC, Op-Amp	288928	12040	LM308AH	1		
	Cable (515A-4403)	384792	89536	385792	1		
	Cable (515A-4404)	391219	89536	391219	1		
	Heat sink, double	312405	98978	RU67B2U	1		
	Heat sink, single	312413	98978	RU67B1U	1		
	Insulator, pwr switch	383158	89536	383158	1		
	Pushbutton, grey	369546	71590	J52305-T31753	10		
	Shield	307744	89536	307744	1		
	Socket, xstr	285262	07233	133-23-92-039	3		

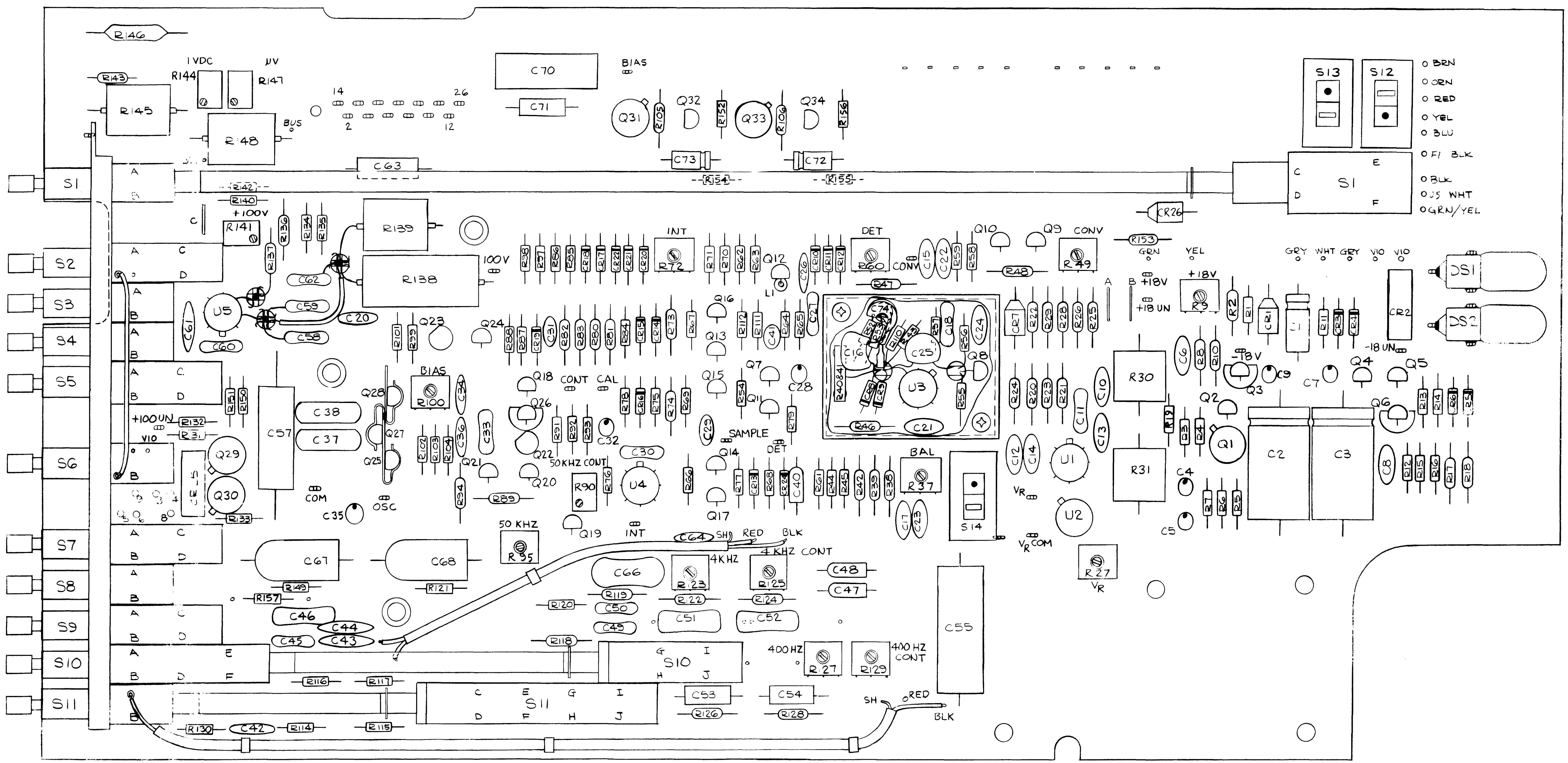


Figure 5-6. MAIN PCB ASSEMBLY

Table 5-3. BATTERY PACK PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
	BATTERY PACK PCB ASSEMBLY	307876	89536	307876	REF		
	Figure 5-7						
CR1	Diode, bridge rectifier	296509	51605	FB100	1		
CR2, CR6	Diode, zener, 36V	284364	12969	UZ8736	2		
CR3	Diode, zener, 18.5V ±2%	309450	15818	TD333379	1		
CR4, CR5	Diode, Si, Hi-speed switch	203323	07910	TD8253	2		
Q1, Q4	Xstr, Si, PNP	195974	04713	2N3906	2		
Q2, Q5	Xstr, Si, NPN	218396	04713	2N3904	2		
Q3, Q6	Xstr, Ge, PNP	148619	01295	2N1303	2		
R1,R10	Res, comp, 1M ±5%, ¼W	182204	01121	CB1055	2		
R2	Res, comp, 15K ±5%, ¼W	148114	01121	CB1535	1		
R3	Res, comp, 27K ±5%, ¼W	148148	01121	CB2735	1		
R4	Res, comp, 150K ±5%, ¼W	182212	01121	CB1545	1		
R5	Res, comp, 30K ±5%, ¼W	193417	01121	CB3035	1		
R6, R7	Res, comp, 330K ±5%, ¼W	192948	01121	CB3315	2		
R8	Res, comp, 56K ±5%, ¼W	170738	01121	CB5635	1		
R9	Res, comp, 68K ±5%, ¼W	148171	01121	CB6835	1		
	Amp pins	267500	00779	86144-2	4		
	Connector, receptacle	267617	00779	85863-5	10		

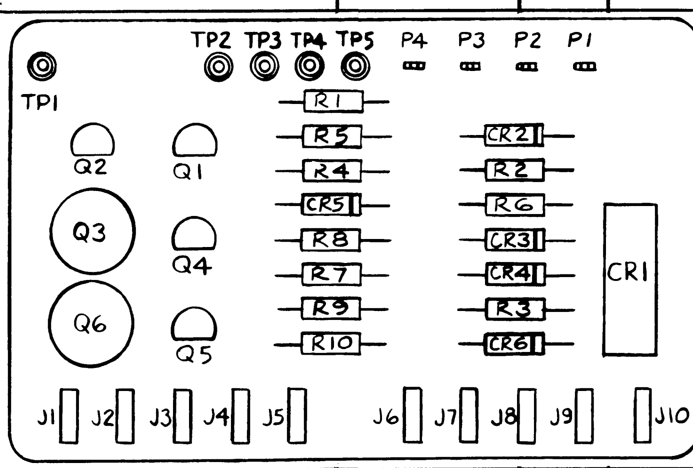


Figure 5-7. BATTERY PACK PCB ASSEMBLY

Table 5-4. DC PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
	DC PCB ASSEMBLY	378794	89536	378794	REF		
	Figure 5-8						
A5	ADJ, PCB Assembly (See Table 5-5)	384651	89536	384651	1		
C1, C3	Cap, Ta, 1 uF ±20%, 35V	161919	56289	196D105X0035	2		
C2	Cap, fxd, mica, 100 pF ±5%, 500V	148494	71263	DM15F101J	1		
C4	Cap, plstc, 0.1 uF ±10%, 250V	161992	73445	C280AE/A100K	1		
CR1	Diode, FET, current reg	348482	17856	E505	1		
CR2	Diode, zener, 5.6V	277236	07910	1N752A	1		
Q1	Xstr, Si, NPN	218396	04713	2N3904	1		
R1	Res, fxd, comp, 100 ±5%, ¼W	147926	01121	CB1015	1		
R2	Res, ww, card, 4.22K ±0.5%, ½W	311761	89536	311761	1		
R3	Res, ww, card, 10K ±0.5%, ½W	195776	89536	195776	1		
R4	Res, ww, card, 1.27K ±0.1%, ½W	341628	89536	341628	1		
R5 thru R10	[1]						
R12, R15, R18, R21	Res, set, linearity ladder	384669	89536	384669	1		
R13	Res, met film, 182K ±1%, 1/8W	241091	91637	MFF1-8	1		
R16	Res, met film, 215K ±1%, 1/8W	289470	91637	MFF1-8			
R19	Res, met film, 365K ±1%, 1/8W	289520	91637	MFF1-8	1		
R22	Res, fxd, met film, 715K ±1%, 1/8W	236836	91637	MFF1-87153F	1		
R24	Res, ww, card, 10 ±0.01%, ½W	384370	89536	384370	1		
R25	Res, ww, Herm, 100 ±0.01%, ½W	384552	89536	384552	1		
R26	Res, ww, Herm, 1K ±0.01%, ½W	384560	89536	384560	1		
R27	Res, ww, Herm 10K ±0.01%, ½W	384578	89536	384578	1		
R28	Res, ww, Herm, 100K ±0.01%, ½W	384586	89536	384586	1		
R29	Res, ww, Herm, 1M ±0.01%, 1W	384594	89536	384594	1		
R31	Res, met film, 9.980M ±0.1%	380972	01281	AR90	1		

Table 5-4. DC PCB ASSEMBLY, continued

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
R32	Res, var, ww, 5K ±5%, 2W	295626	80294	35095-9-502	1		
S1	Switch, linearity	381137	89536	381137	1		
U1	IC, Operational Amplifier	284760	12040	LM308H	1		
U2	[1]						
	Bracket, pot and SW	383125	89536	383125	1		
	Coupler	103838	89536	103838	1		
	Plate, Pot	405142	89536	405142	1		
	[1] If U2 or any of the Resistors R5 thru R10 require replacement the pcb must be returned to the factory for integration into the circuit and recalibration.						

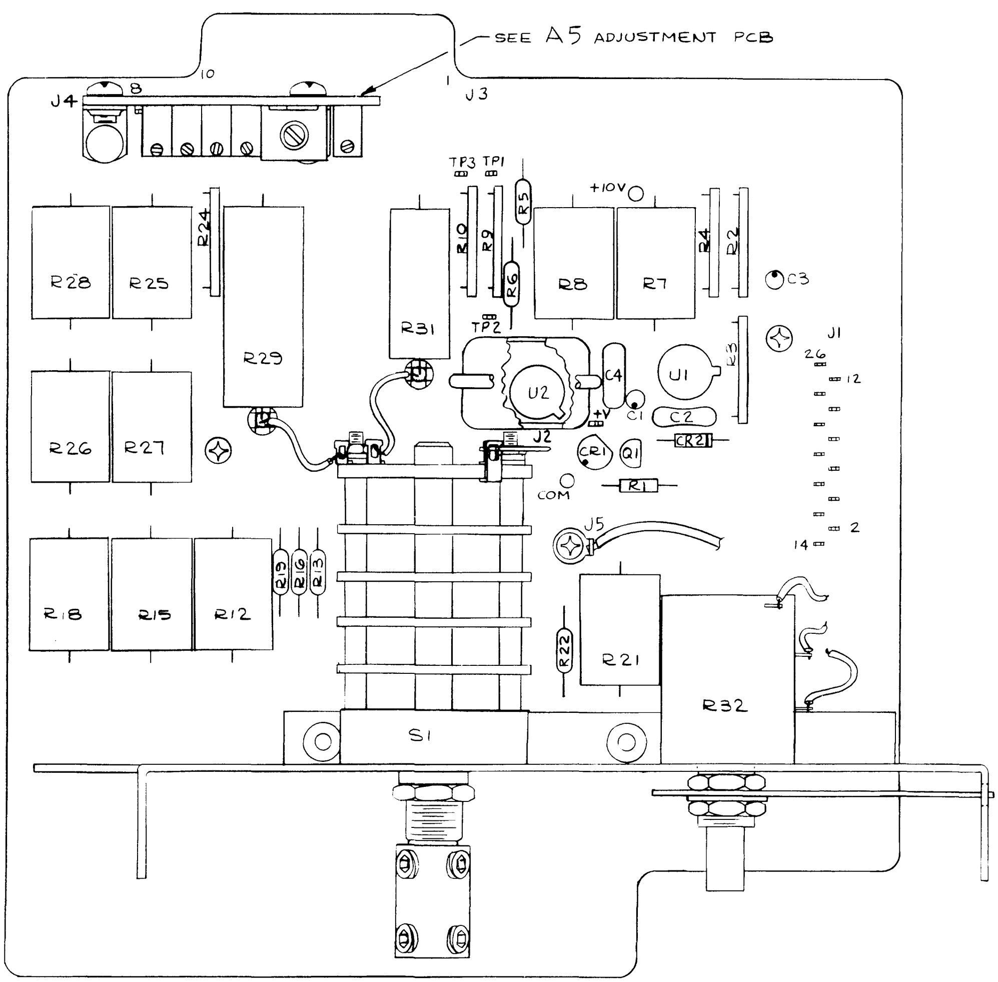


Figure 5-8. DC PCB ASSEMBLY

Table 5-5. ADJUSTMENT PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
	ADJUSTMENT PCB ASSEMBLY	384651	89536	384651	REF		
	Figure 5-9						
R11	Res, var, cermet, 10 ±30%, ¾W	186205	73138	78PR10	1		
R14, R17	Res, var, cermet, 50K ±10%, ½W	330688	80031	ET34P503	2		
R20	Res, var, cermet, 100K ±20%, ½W	268581	71450	190PC104B	1		
R23	Res, var, cermet, 200K ±20%, ½W	381509	80031	ET34P204	1		
R30	Res, var, cermet, 50K ±10%, ½W	288290	71450	360S503A	1		
	Connector, PCB Mount	267617	00779	95863-5	8		

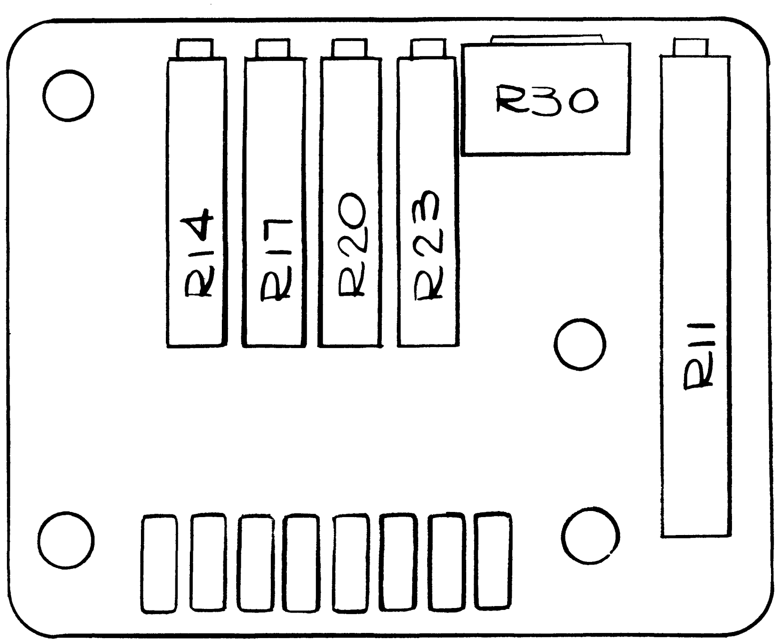


Figure 5-9. ADJUSTMENT PCB ASSEMBLY

Section 6
Option & Accessory Information

6-1. INTRODUCTION

6-2. This section of the manual contains information pertaining to the options and accessories available for the 515A Portable Calibrator. Each of the options and accessories are described under separate major headings containing the Model or Option number. The option descriptions contain applicable operating and maintenance instructions and field installation procedures.

6-3. ACCESSORIES

6-4. Front Panel Dust Cover (M03-203-700)

6-5. The front panel dust cover is a molded plastic snap-on accessory which fits over the front panel of the 515A. The dust cover provides protection fro the front panel controls and is useful when storing or transporting the Portable Calibrator.

6-6. Side-by-Side Rack Mount (M00-200-618)

6-7. Use the following procedure to install two 515A Portable Calibrators side-by-side in a standard 19-inch equipment rack. For an illustration of the mounting procedure, refer to Figure 6-1.

a. Remove the decals from the handle connectors and remove the handles from the instruments.

b.1 Remove the metal decal trim from the side of the instruments.

c. Remove the bottom cover and guard from the instruments.

d. Connect the two instruments together and attach the rack ears as shown in Figure 6-1.

e. Replace the bottom cover and guard.

6-8. Offset Rack Mounting (M00-200-619)

6-9. Use the following procedure to install one 515A Portable Calibrator in the offset configuration. For an illustration of the mounting procedure, refer to Figure 6-2.

a. Remove the decals from the handle connectors and remove the handle from the instrument.

b. Remove the metal decal trim from the side of the instrument.

c. Assemble the offset connector.

d. Attach the two rack ear connectors to the instrument positioning the offset connector either right or left, as desired.

6-10. OPTIONS

6-11. There are no options available for the 515A Portable Calibrator.

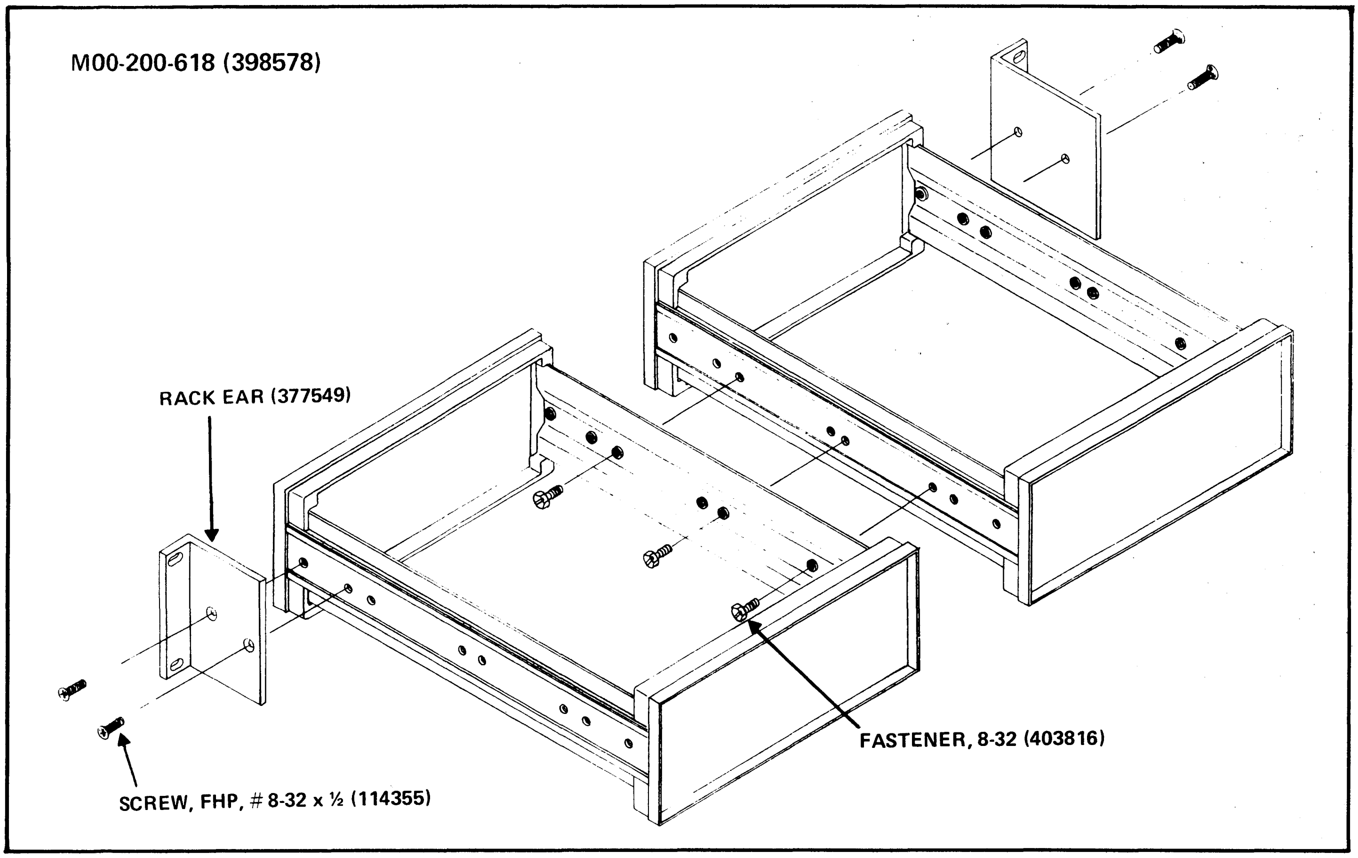


Figure 6-1. SIDE-BY-SIDE RACK MOUNTING

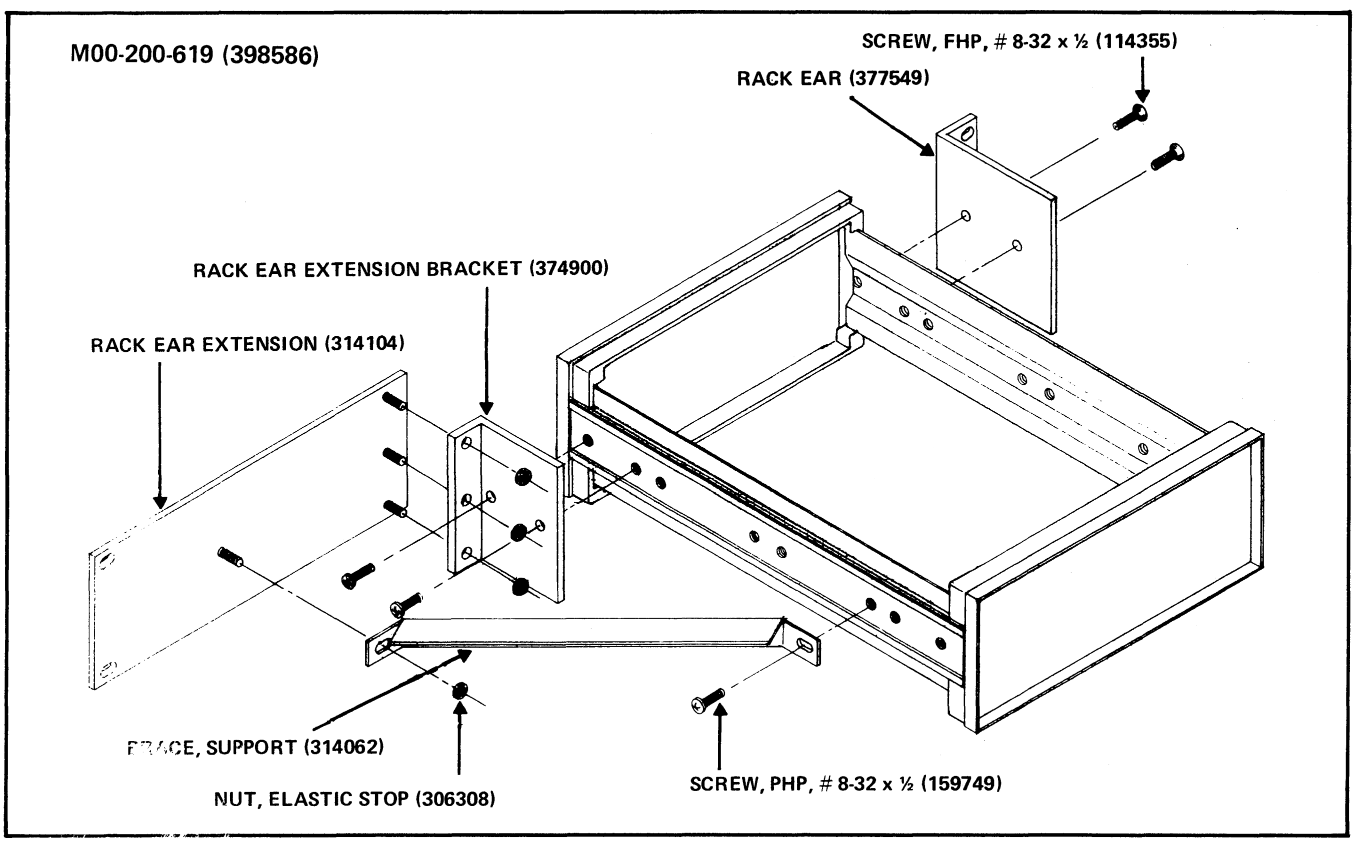


Figure 6-2. OFFSET RACK MOUNTING

Section 7
General Information

7-1. This section of the manual contains generalized user information as well as supplemental information to the List of Replaceable Parts contained in Section 5.

List of Abbreviations and Symbols

A or amp	ampere
ac	alternating current
af	audio frequency
a/d	analog-to-digital
assy	assembly
AWG	american wire gauge
B	bel
bcd	binary coded decimal
°C	Celsius
cap	capacitor
ccw	counterclockwise
cer	ceramic
cermet	ceramic to metal(seal)
ckt	circuit
cm	centimeter
cmrr	common mode rejection ratio
comp	composition
cont	continue
crt	cathode-ray tube
cw	clockwise
d/a	digital-to-analog
dac	digital-to-analog converter
dB	decibel
dc	direct current
dmm	digital multimeter
dvm	digital voltmeter
elect	electrolytic
ext	external
F	farad
°F	Fahrenheit
FET	Field-effect transistor
ff	flip-flop
freq	frequency
FSN	federal stock number
g	gram
G	giga (10^9)
gd	guard
Ge	germanium
GHz	gigahertz
gmv	guaranteed minimum value
gnd	ground
H	henry
hd	heavy duty
hf	high frequency
Hz	hertz
IC	integrated circuit
if	intermediate frequency
in	inch(es)
intl	internal
I/O	input/output
k	kilo (10^3)
kHz	kilohertz
kΩ	kilohm(s)
kV	kilovolt(s)
lf	low frequency
LED	light-emitting diode
LSB	least significant bit
LSD	least significant digit
M	mega (10^6)
m	milli (10^{-3})
mA	milliampere(s)
max	maximum
mf	metal film
MHz	megahertz
min	minimum
mm	millimeter
ms	millisecond
MSB	most significant bit
MSD	most significant digit
MTBF	mean time between failures
MTTR	mean time to repair
mV	millivolt(s)
mv	multivibrator
MΩ	megohm(s)
n	nano (10^{-9})
na	not applicable
NC	normally closed
(-) or neg	negative
NO	normally open
ns	nanosecond
opnl ampl	operational amplifier
p	pico (10^{-12})
para	paragraph
pcb	printed circuit board
pF	picofarad
pn	part number
(+) or pos	positive
pot	potentiometer
p-p	peak-to-peak
ppm	parts per million
PROM	programmablle read-only memory
psi	pound-force per square inch
RAM	random-access memory
rf	radio frequency
rms	root mean square
ROM	read-only memory
s or sec	second (time)
scope	oscilloscope
SH	shield
Si	silicon
serno	serial number
sr	shift register
Ta	tantalum
tb	terminal board
tc	temperature coefficient or temperature compensating
tcxo	temperature compensated crystal oscillator
tp	test point
u or μ	micro (10^{-6})
uhf	ultra high frequency
us or μs	microsecond(s) (10^{-6})
uut	unit under test
V	volt
v	voltage
var	variable
vco	voltage controlled oscillator
vhf	very high frequency
vlf	very low frequency
W	watt(s)
ww	wire wound
xfmr	transformer
xstr	transistor
xtal	crystal
xtlo	crystal oscillator
Ω	ohm(s)
μ	micro (10^{-6})

Federal Supply Codes for Manufacturers

D9816
Westermann Wilhelm Augusta-Anlage
Mannheim-Nackarau Germany

00199
Marcon Electronics Corp
Kearny, New Jersey

00213
Nytronics Comp. Group Inc.
Darrlingon, South Carolina

00327
Welwyn International Inc.
Westlake, Ohio

00656
Aerovox Corp.
New Bedford, Massachusetts

00686
Film Capacitors Inc.
Passaic, New Jersey

00779
AMP, Inc.
Harrisburg, Pennsylvania

01121
Allen Bradley Co.
Milwaukee, Wisconsin

01281
TRW Electronics & Defense Sector
Lawndale, California

01295
Texas Instruments Inc.
Semiconductor Group
Dallas,Texas

01537
Motorola Communications &
Electronics Inc.
Franklin Park, Illinois

01686
RCL Electronics/Shallcross Inc.
Electro Components Div.
Manchester, New Hampshire

01884
Sprague Electric Co.
(Now 56289)

01961
Varian Associates Inc.
Pulse Engineering Div.
Convoy, Connecticut

02111
Spectrol Electronics Corp.
City of Industry, California

02114
Amperex Electronic Corp.
Ferrox Cube Div.
Saugerties, New York

02131
General Instrument Corp.Government
Systems Div.
Westwood, Massachusetts

02395
Sonar Radio Corp.
Hollywood, Florida

02533
Leigh Instruments Ltd.
Frequency Control Div.
Don Mills, Ontario, Canada

02606
Fenwal Labs
Division of Travenal Labs
Morton Grove, Illinois

0266
Bunker Ramo-Eltra Corp.
Amphenol NA Div.
Broadview, Illinois

02735
RCA-Solid State Div.
Somerville, New Jersey

02799
Arco Electronics Inc.
Chatsworth, California

03508
General Electric Co.
Semiconductor Products& Batteries
Auburn, New York

03797
Genisco Technology Corp.
Eltronics Div.
Rancho Dominquez, Calif.

03877
Gilbert Engineering Co.Inc
Incon Sub of Transitron
Electronic Corp.
Glendale, Arizona

03888
KDI Electronics Inc.
Pyrofilm Div.
Whippany, New Jersey

03911
Clairex Corp.
Clairex Electronics Div.
Mount Vernon, New York

03980
Muirhead Inc.
Mountainside, New Jersey

04009
Cooper Industries, Inc.
Arrow Hart Div.
Hartford, Connecticut

04217
Essex International Inc.
Wire & Cable Div.
Anaheim, California

04221
Midland-Ross Corp.
Midtex Div.
N. Mankato, Minnesota

04222
AVX Corp.
AVX Ceramics Div.
Myrtle Beach, S. Carolina

04423
Telonic Berkley Inc.
Laguna Beach, California

04713
Motorola Inc.
Semiconductor Group
Phoenix, Arizona

05236
Jonathan Mfg. Co.
Fullerton, California

05245
Corcom Inc.
Libertyville, Illinois

05276
ITT Pomona
Electronics Div.
Pomona, California

05277
Westinghouse Elec. Corp.
Semiconductor Div.
Youngwood, Pennsylvania

05397
Union Carbide Corp.
Materials Systems Div.
Cleveland. Ohio

05571
Sprague Electric Co.
(Now 56289)

05574
Viking Connectors Inc
Sub of Criton Corp.
Chatsworth, Calif.

05820
EG & G Wakefield Engineering
Wakefield, Massachusetts

05972
Loctite Corp.
Newington, Connecticut

06001
General Electric Co.
Electric Capacitor Product Section
Columbia, S. Carolina

06141
Fairchild Weston Systems Inc.
Data Systems Div.
Sarasota, Florida

06192
La Deau Mfg. Co.
Glendale, California

06229
Electrovert Inc.
Elmsford, New York

06383
Panduit Corp.
Tinley Park, Illinois

06473
Bunker Ramo Corp.
Amphenol NA Div.
SAMS Operation
Chatsworth, California

06555
Beede Electrical Instrument
Penacook, New Hampshire

06665
Precision Monolithics
Sub of Bourns Inc.
Santa Clara, California

06666
General Devices Co. Inc.
Indianapolis, Indiana

06739
Electron Corp.
Littleton, Colorado

06743
Gould Inc.
Foil Div.
Eastlake, Ohio

06751
Components Inc.
Semcor Div.
Phoenix, Arizona

06776
Robinson Nugent Inc.
New Albany, Indiana

06915
Richco Plastic Co.
Chicago, Illinois

06961
Vernitron Corp.
Piezo Electric Div.
Bedford, Ohio

06980
Varian Associates Inc.
Eimac Div.
San Carlos, California

07047
Ross Milton Co., The
Southampton, Penna.

07138
Westinghouse Electric Corp.
Industrial & Government
Tube Div.
Horseheads, New York

07233
Benchmark Technology Inc.
City of Industry, Calif.

07239
Biddle Instruments
Blue Bell, Penna.

07256
Silicon Transistor Corp.
Sub of BBF Inc.
Chelmsford, Massachusetts

07261
Avnet Corp.
Culver City, California

07263
Fairchild Camera & Instrument
Semiconductor Div.
Mountain View, California

07344
Bircher Co. Inc., The
Rochester, New York

Federal Supply Codes for Manufacturers (cont)

07557
Campion Co. Inc.
Philadelphia, Penna.

07597
Burndy Corp.
Tape/Cable Div.
Rochester, New York

07716
TRW Inc. (Can use 11502)
IRC Fixed Resistors/
Burlington
Burlington, Iowa

07792
Lerma Engineering Corp.
Northampton, Massachusetts

07810
Bock Corp.
Madison, Wisconsin

07933
Raytheon Co.
Semiconductor Div.
Mountain View, Calif.

08235
Industro Transistor Corp.
Long Island City, New York

08261
Spectra-Strip
An Eltra Co.
Garden Grove, Calif.

08530
Reliance Mica Corp.
Brooklyn, New York

08718
ITT Cannon Electric
Phoenix Div.
Phoenix, Arizona

08806
General Electric Co.
Minature Lamp Products
Cleveland, Ohio

08863
Nylomatic
Fallsington, Penna.

08988
Skottie Electronics Inc.
Archbald, Pennsylvania

09021
Airco Inc.
Airco Electronics
Bradford, Penna.

09023
Cornell-Dublier Electronics
Fuquay-Varina, N. Carolina

09214
General Electric Co.
Semiconductor Products Dept.
Auburn, New York

09353
C and K Components Inc.
Newton, Massachusetts

09423
Scientific Components Inc.
Santa Barbara, California

09579
CTS of Canada, Ltd
Streetsville, Ontario

09922
Burndy Corp.
Norwalk, Connecticut

09969
Dale Electronics Inc.
Yankton, South Dakota

09975
Burroughs Corp.
Electronics Components
Detroit, Michigan

10059
Barker Engineering Corp.
Kenilworth, New Jersey

10389
Illinois Tool Works Inc.
Licon Div.
Chicago, Illinois

10582
CTS of Asheville
Skyland, N. Carolina

11236
CTS Corp.
Berne Div.
Berne, Indiana

11237
CTS Corp of California
Paso Robles Div.
Paso Robles, California

11295
ECM Motor Co.
Schaumburg, Illinois

11358
Columbia Broadcasting System
CBS Electronic Div.
Newburyport, Massachusetts

11403
Vacuum Can Co.Best Coffee Maker Div.
Chicago, Illinois

11502
TRW Inc.
TRW Resistive Products Div.
Boone, North Carolina

11503
Keystone Columbia Inc.
Freemont, Indiana

11532
Teledyne Relays Teledyne
Industries Inc.
Hawthorne, California

11711
General Instrument Corp.
Rectifier Div.
Hicksville, New York

11726
Qualidyne Corp.
Santa Clara, California

12014
Chicago Rivet & Machine Co.
Naperville, Illinois

12040
National Semiconductor Corp.
Danbury, Connecticut

12060
Diodes Inc.
Northridge, California

12136
PHC Industries Inc.
Formerly Philadelphia Handle Co.
Camden, New Jersey

12300
AMF Canada Ltd.
Potter-Brumfield
Guelph, Ontario, Canada

12323
Practical Automation Inc.
Shelton, Connecticut

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Freeway Corp.
Cleveland, Ohio

12443
Budd Co.,The
Plastics Products Div.
Phoenixville, Pennsylvania

12581
Hitachi Metals Inernational Ltd.
Hitachi Magna-Lock Div.
Big Rapids, Missouri

12615
US Terminals Inc.
Cincinnati, Ohio

12617
Hamlin Inc.
Lake Mills, Wisconsin

12697
Clarostat Mfg. Co. Inc.
Dover, New Hampshire

12749
James Electronic Inc.
Chicago, Illinois

12856
MicroMetals Inc.
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12881
Metex Corp.
Edison, New Jersey

12895
Cleveland Electric Motor Co.
Cleveland, Ohio

12954
Microsemi Corp.
Components Group
Scottsdale, Arizona

12969
Unitrode Corp.
Lexington, Massachusetts

13050
Potter Co.
Wesson, Mississippi

13103
Thermalloy Co., Inc.
Dallas, Texas

13327
Solitron Devices Inc.
Tappan, New York

13511
Bunker-Ramo Corp.
Amphenol Cadre Div.
Los Gatos, California

13606
Sprague Electric Co.
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13689
SPS Technologies Inc.
Hatfield, Pennsylvania

13919
Burr-Brown Research Corp.
Tucson, Arizona

14099
Semtech Corp.
Newbury Park, California

14140
McGray-Edison Co.
Commercial Development Div.
Manchester, New Hampshire

14193
Cal-R-Inc.
Santa Monica, California

14298
American Components Inc.
an Insilco Co. RPC Div.
Conshohocken, Pennsylvania

14298
ACIC Inc.
Sub of Insilco Corp.
Research Triangle Park, NC

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Wells Electronics Inc.
South Bend, Indiana

14482
Watkins-Johnson Co.
Palo Alto, California

14552
Microsemi Corp.
Santa Ana, California

14655
Cornell-Dublier Electronics
Div. of Federal Pacific
Electric Co. Govt Cont Dept.
Newark, New Jersey

Federal Supply Codes for Manufacturers (cont)

14704
Crydom Controls
(Division of Int Rectifier)
El Segundo, California

14752
Electro Cube Inc.
San Gabriel, California

14936
General Instrument Corp.
Discrete Semi Conductor Div.
Hicksville, New York

14949
Trompeter Electronics
Chatsworth, California

15412
Amtron
Midlothian, Illinois

15542
Scientific Components Corp.
Mini-Circuits Laboratory Div.
Brooklyn, New York

15636
Elec-Trol Inc.
Saugus, California

15782
Bausch & Lomb Inc.
Graphics & Control Div.
Austin, Texas

15801
Fenwal Eletronics Inc.
Div. of Kidde Inc.
Framingham, Massachusetts

15818
Teledyne Inc. Co.
Teledyne Semiconductor Div.
Mountain View, California

15849
Useco Inc.
(Now 88245)

15898
International Business
Machines Corp.
Essex Junction, Vermont

16245
Conap Inc.
Olean, New York

16258
Space-Lok Inc.
Burbank, California

16352
Codi Corp.
Linden, New Jersey

16469
MCL Inc.
LaGrange, Illinois

16473
Cambridge Scientific Industries
Div. of Chemed Corp.
Cambridge, Maryland

16733
Cablewave Systems Inc.
North Haven, Connecticut

16742
Paramount Plastics
Fabricators Inc.
Downey, California

16758
General Motors Corp.
Delco Electronics Div.
Kokomo, Indiana

17069
Circuit Structures Lab
Burbank, California

17117
Electronic Molding Corp.
Woonsocket, Rhode Island

17338
High Pressure Eng. Co. Inc.
Oklahoma City, Oklahoma

17545
Atlantic Semiconductors Inc.
Asbury Park, New Jersey

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Angstrohm Precision, Inc.
Hagerstown, Maryland

17856
Siliconix Inc.
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E G & Gvactee Inc.
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18324
Signetics Corp.
Sacramento, California

18520
Sharp Electronics Corp.
Paramus, New Jersey

18542
Wabash Inc.
Wabash Relay & Electronics Div.
Wabash, Indiana

18565
Chomerics Inc.
Woburn, Massachusetts

18612
Vishay Intertechnology Inc.
Vishay Resistor Products Group
Malvern, Pennsylvania

18632
Norton-Chemplast
Santa Monica, California

18677
Scanbe Mfg. Co.
Div. of Zero Corp.
El Monte, California

18736
Voltronics Corp.
East Hanover, New Jersey

18927
GTE Products Corp.
Precision Material Products
Business Parts Div.
Titusville, Pennsylvania

19315
Bendix Corp., The
Navigation & Control Group
Terboro, New Jersey

19451
Perine Machinery & Supply Co..
Kent, Washington

19613
Minnesota Mining & Mfg. Co.
Textool Products Dept.
Electronic Product Div.
Irving, Texas

19647
Caddock Electronics Inc.
Riverside, California

19701
Mepco/Centralab Inc.
A N. American Philips Co.
Mineral Wells, Texas

20584
Enochs Mfg. Inc.
Indianapolis, Indiana

20891
Cosar Corp.
Dallas, Texas

21317
Electronics Applications Co.
El Monte, California

21604
Buckeye Stamping Co.
Columbus, Ohio

21845
Solitron Devices Inc.
Semiconductor Group
Rivera Beach, Florida

22526
DuPont, EI DeNemours & Co. Inc.
DuPont Connector Systems
Advanced Products Div.
New Cumberland, Pennsylvania

22767
ITT Semiconductors
Palo Alto, California

22784
Palmer Inc.
Cleveland, Ohio

23050
Product Comp. Corp.
Mount Vernon, New York

23732
Tracor Applied Sciences Inc.
Rockville, Maryland

23880
Stanford Applied Engineering
Santa Clara, California

23936
William J. Purdy Co.
Pamotor Div.
Burlingame, California

24347
Penn Engineering Co.
S. El Monte, California

24355
Analog Devices Inc.
Norwood, Massachusetts

24444
General Semiconductor
Industries, Inc.
Tempe, Arizona

24655
Genrad Inc.
Concord, Massachusetts

24759Lenox-Fugle Electronics Inc.
South Plainfield, New Jersey

24796
AMF Inc.
Potter & Brumfield Div.
San Juan Capistrano, Calif.

24931
Specialty Connector Co.
Greenwood, Indiana

25088
Siemen Corp.
Isilen, New Jersey

25099
Cascade Gasket
Kent, Washington

25403
Amperex Electronic Corp.
Semiconductor & Micro-Circuit Div.
Slatersville, Rhode Island

25706
Daburn Electronic & Cable Corp.
Norwood, New Jersey

26629
Frequency Sources Inc.
Sources Div.
Chelmsford, Massachusetts

26806
American Zettler Inc.
Irvine, California

27014
National Semiconductor Corp.
Santa Clara, California

27167
Corning Glass Works Corning
Electronics
Wilmington, North Carolina

27264
Molex Inc.
Lisle, Illinois

27440
Industrial Screw Products
Los Angeles, California

Federal Supply Codes for Manufacturers (cont)

27745
Associated Spring Barnes Group Inc.
Syracuse, New York

27956
Relcom (Now 14482)

28198
Positronic Industries
Springfield, Missouri

28213
Minnesota Mining & Mfg. Co.
Consumer Products Div.
3M Center
Saint Paul, Minnesota

28425
Serv-O-Link
Euless, Texas

28478
Deltrol Corporation
Deltrol Controls Div.
Milwaukee, Wisconsin

28480
Hewlett Packard Co.
Corporate HQ
Palo Alto, California

28484
Emerson Electric Co.
Gearmaster Div.
McHenry, Illinois

28520
Heyco Molded Products
Kenilworth, New Jersey

29083
Monsanto Co.
Santa Clara, California

29604
Stackpole Components Co.
Raleigh, North Carolina

29907
Omega Engineering Inc.
Stamford, Connnecticut

30035
Jolo Industries Inc.
Garden Grove, California

30146
Symbex Corp.
Painesville, Ohio

30148
AB Enterprise Inc.
Ahoskie, North Carolina

30161
Aavid Engineering Inc.
Laconia, New Hampshire

30315
Itron Corp.
San Diego, California

30323
Illinois Tool Works Inc.
Chicago, Illinois

30800
General Instrument Corp.
Capacitor Div.
Hicksville, New York

31019
Solid State Scientific Inc.
Willow Grove, Pennsylvania

31091
Alpha Industries Inc.
Microelectronics Div.
Hatfield, Pennsylvania

31323
Metro Supply Company
Sacramento, California

31448
Army Safeguard Logistics Command
Huntsville, Alabama

31746
Cannon Electric
Woodbury, Tennessee

31827
Budwig
Ramona, California

31918
ITT-Schadow
Eden Prairie, Minnesota

32293
Intersil
Cupertino, California

32539
Mura Corp.
Westbury, Long Island, N.Y.

32559
Bivar
Santa Ana, California

32767
Griffith Plastics Corp.
Burlingame, California

32879
Advanced Mechanical Components
Northridge, California

32897
Murata Erie North America Inc.
Carlisle Operations
Carlisle, Pennsylvania

32997
Bourns Inc.
Trimpot Div.
Riverside, California

33096
Colorado Crystal Corp.
Loveland, Colorado

33173
General Electric Co.
Owensboro, Kentucky

33246
Epoxy Technology Inc.
Billerica, Massachusetts

33297
NEC Electronics USA Inc.
Electronic Arrays Inc. Div.
Mountain View, California

33919
Nortek Inc.
Cranston, Rhode Island

34333
Silicon General Inc.
Garden Grove, California

34225
Advanced Micro Devices
Sunnyvale, California

34359
Minnesota Mining & Mfg. Co.
Commercial Office Supply Div.
Saint Paul, Minnesota

34371
Harris Corp.
Harris Semiconductor
Products Group
Melbourne, Florida

34649
Intel Corp.
Santa Clara, California

34802
Electromotive Inc.
Kenilworth, New Jersey

34848
Hartwell Special Products
Placentia, California

35009
Renfrew Electric Co. Ltd.
IRC Div.
Toronto, Ontario, Canada

36665
Mitel Corp.
Kanata, Ontario, Canada

37942
Mallory Capacitor Corp.
Sub of Emhart Industries
Indianapolis, Indiana

39003
Maxim Industries
Middleboro, Massachusetts

40402
Roderstein Electronics Inc.
Statesville, North Carolina

42498
National Radio
Melrose, Massachusetts

43543
Nytronics Inc.(Now 53342)

44655
Ohmite Mfg. Co.
Skokie, Illinois

49671
RCA Corp.
New York, New York

49956
Raytheon Company
Executive Offices
Lexington, Massachusetts

50088
Thomson Components-Mostek Corp.
Carrollton, Texas

50120
Eagle-Picher Industries Inc.
Electronics Div.
Colorado Springs, Colorado

50157
Midwest Components Inc.
Muskegon, Mississippi

50541
Hypertronics Corp.
Hudson, Massachusetts

50579
Litronix Inc.
Cupertino, California

51167
Aries Electronics Inc.
Frenchtown, New Jersey

51372
Verbatim Corp.
Sunnyvale, California

51406
Murata Erie, No. America Inc.
(Also see 72982)
Marietta, Georgia

51499
Amtron Corp.
Boston, Massachusetts

51605
CODI Semiconductor Inc.
Kenilworth, New Jersey

51642
Centre Engineering Inc.
State College, Pennsylvania

51791
Statek Corp.
Orange, California

51984
NEC America Inc.
Falls Church, Virginia

52063
Exar Integrated Systems
Sunnyvale, California

52072
Circuit Assembly Corp.
Irvine, California

52152
Minnesota Mining & Mfg.
Saint Paul, Minnesota

52333
API Electronics
Haugpauge,Long Island,New York

Federal Supply Codes for Manufacturers (cont)

52361
Communication Systems
Piscataway, New Jersey

52525
Space-Lok Inc.
Lerco Div.
Burbank, California

52531
Hitachi Magnetics
Edmore, Missouri

52745
Timco
Los Angeles, California

52763
Stettner-Electronics Inc.
Chattanooga, Tennessee

52769
Sprague-Goodman Electronics Inc.
Garden City Park, New York

52771
Moniterm Corp.
Amatrom Div.
Santa Clara, California

52840
Western Digital Corp.
Costa Mesa, California

53021
Sangamo Weston Inc.
(See 06141)

53217
Technical Wire Products Inc.
Santa Barbara, California

53342
Opt Industries Inc.
Phillipsburg, New Jersey

53944
Glow-Lite
Pauls Valley, Oklahoma

54294
Shallcross Inc.
Smithfield, North Carolina

54453
Sullins Electronic Corp.
San Marcos, California

54473
Matsushita Electric Corp.
(Panasonic)
Secaucus, New Jersey

54583
TDK
Garden City, New York

54869
Piher International Corp.
Arlington Heights, Illinois

54937
DeYoung Mfg.
Bellevue, Washington

54590
RCA Corp.
Electronic Components Div.
Cherry Hill, New Jersey

55026
American Gage & Machine Co.
Simpson Electric Co. Div.
Elgin, Illinois

55112
Plessey Capacitors Inc.
(Now 60935)

55261
LSI Computer Systems Inc.
Melville, New York

55285
Bercquist Co.
Minneapolis, Minnesota

55576
Synertek
Santa Clara, California

55680
Michicon/America/Corp.
Schaumburg, Illinois

56282
Utek Systems Inc.
Olathe, Kansas

56289
Sprague Electric Co.
North Adams, Massachusetts

56365
Square D Co.
Corporate Offices
Palatine, Illinois

56375
DAL Industries Inc.
Wescorp Div.
Mountain View, California

56481
Shugart Associates
Sub of Xerox Corp.
Sunnyvale, California

56708
Zilog Inc.
Campbell, California

56856
Vamistor Corp. of Tennessee
Sevierville, Tennessee

56880
Magnetics Inc.
Baltimore, Maryland

57026
Endicott Coil Co. Inc.
Binghamton, New York

57053
Gates Energy Products
Denver, Ohio

58014
Hitachi Magnalock Corp.
(Now 12581)

58104
Simco
Atlanta, Georgia

58474
Superior Electric Co.
Bristol, Connecticut

59124
KOA-Speer Electronics Inc.
Bradford, Pennsylvania

59640
Supertex Inc.
Sunnyvale, California

59660
Tusonix Inc.
Tucson, Arizona

59730
Thomas and Betts Corp.
Iowa City, Iowa

59831
Semtronics Corp.
Watchung, New Jersey

60395
Xicor Inc.
Milpitas, California

60399
Torin Engineered Blowers
Div. of Clevepak Corp.
Torrington, Connecticut

60705
Cera-Mite Corp.
(formerly Sprague)
Grafton, Wisconsin

60935
Westlake Capacitor Inc.
Tantalum Div.
Greencastle, Indiana

61804
M/A Com Inc.
Burlington, Massachusetts

61857
SAN-O Industrial Corp.
Bohemia, Long Island, NY

61935
Schurter Inc.
Petaluma, California

62351
Apple Rubber
Lancaster, New York

62793
Lear Siegler Inc.
Energy Products Div.
Santa Ana, California

63743
Ward Leonard Electric Co.Inc.
Mount Vernon, New York

64154
Lamb Industries
Portland, Oregon

64155
Linear Technology
Milpitas, California

64834
West M G Co.
San Francisco, Calif.

65092
Sangamo Weston Inc.
Weston Instruments Div.
Newark, New Jersey

65940
Rohm Corp & Whatney
Irvine, California

65964
Evox Inc.
Bannockburn, Illinois

66150
Entron Inc.
Winslow Teltronics Div.
Glendale, New York

66608
Bering Industries
Fremont, California

70290
Almetal Universal Joint Co.
Cleveland, Ohio

70485
Atlantic India Rubber Works Inc.
Chicago, Illinois

70563
Amperite Company
Union City, New Jersey

70903
Belden Corp.
Geneva, Illinois

71002
Birnbach Co. Inc.
Farmingdale, New York

71034
Bliley Electric Co.
Erie, Pennsylvania

71183
Westinghouse Electric Corp.
Bryant Div.
Bridgeport, Connecticut

71400
Bussman Manufacturing
Div. McGraw-Edison Co.
St. Louis, Missouri

71450
CTS Corp.
Elkhart, Indiana

71468
ITT Cannon Div. of ITT
Fountain Valley, California

71482
General Instrument Corp.
Clare Div.
Chicago, Illinois

Federal Supply Codes for Manufacturers (cont)

71590
Mepco/Centralab
A North American Philips Co.
Fort Dodge, Iowa

71707
Coto Corp.
Providence, Rhode Island

71744
General Instrument Corp.
Lamp Div/Worldwide
Chicago, Illinois

71785
TRW Inc.
Cinch Connector Div.
Elk Grove Village, Illinois

71984
Dow Corning Corp.
Midland, Michigan

72005
AMAX Specialty Metals Corp.
Newark, New Jersey

72136
Electro Motive Mfg. Corp.
Florence, South Carolina

72228
AMCA International Corp.
Continental Screw Div.
New Bedford, Massachusetts

72259
Nytronics Inc.
New York, New York

72619
Amperex Electronic Corp.
Dialight Div.
Brooklyn, New York

72653
G C Electronics Co.
Div. of Hydrometals Inc.
Rockford, Illinois

72794
Dzus Fastner Co. Inc.
West Islip, New York

72928
Gulton Industries Inc.
Gudeman Div.
Chicago, Illinois

72982
Murata Erie N. America Inc.
Erie, Pennsylvania

73138
Beckman Industrial corp.
Helipot Div.
Fullerton, California

73168
Fenwal Inc.
Ashland, Massachusetts

73293
Hughes Aircraft Co.
Electron Dynamics Div.
Torrance, California

73445
Amperex Electronic Corp.
Hicksville, New York

73559
Carlingswitch Inc.
Hartford, Connecticut

73586
Circle F Industries
Trenton, New Jersey

73734
Federal Screw Products Inc.
Chicago, Illinois

73743
Fischer Special Mfg. Co.
Cold Spring, Kentucky

73893
Microdot
Mt. Clemens, Mississippi

73899
JFD Electronic Components
Div. of Murata Erie
Oceanside, New York

73905
FL Industries Inc.
San Jose, California

73949
Guardian Electric Mfg. Co.
Chicago, Illinois

74199
Quam Nichols Co.
Chicago, Illinois

74217
Radio Switch Co.
Marlboro, New Jersey

74306
Piezo Crystal Co.
Div. of PPA Industries Inc.
Carlisle, Pennsylvania

74542
Hoyt Elect.Instr. Works Inc.
Penacook, New Hampshire

74840
Illinois Capacitor Inc.
Lincolnwood, Illinois

74970
Johnson EF Co.
Waseca, Minnesota

75042
TRW Inc.
IRC Fixed Resistors
Philadelphia, Pennsylvania

75297
Litton Systems
Kester Solder Div.
Chicago, Illinois

75376
Kurz-Kasch Inc.
Dayton, Ohio

75378
CTS Knights Inc.
Sandwich, Illinois

75382
Kulka Electric Corp.
(Now 83330)
Mount Vernon, New York

75915
Tracor Littlefuse
Des Plaines, Illinois

76854
Oak Switch Systems Inc.
Crystal Lake, Illinois

77122
TRW Assemblies & Fasteners Group
Fastener Div.
Moutainside, New Jersey

77342
AMF Inc.
Potter & Brumfield Div.
Princeton, Indiana

77542
Ray-O-Vac Corp
Madison, Wisconsin

77638
General Instrument Corp.
Rectifier Div.
Brooklyn, New York

77900
Shakeproof Lock Washer Co.
(Now 78189)

77969
Rubbercraft Corp. of CA Ltd.
Torrance, California

78189
Illinois Tool Works Inc.
Shakeproof Div.
Elgin, Illinois

78277
Sigma Instruments Inc.
South Braintree, Mass.

78290
Struthers Dunn Inc.
Pitman, New Jersey

78553
Eaton Corp.
Engineered Fastener Div.
Cleveland, Ohio

78592
Stoeger Industries
South Hackensack, New Jersey

79136
Waldes Kohinoor Inc.
Long Island City, New York

79497
Western Rubber Co.
Goshen, Indiana

79727
C - W Industries
Southampton, Pennsylvania

79963
Zierick Mfg. Corp.
Mount Kisco, New York

80009
Tektronix
Beaverton, Oregon

80031
Mepco/Electra Inc.
Morristown, New Jersey

80032
Ford Aerospace & Communications Corp.
Western Development
Laboratories Div.
Palo Alto, California

80145
LFE Corp.
Process Control Div.
Clinton, Ohio

80183
Sprague Products
(Now 56289)

80294
Bourns Instruments Inc.
Riverside, California

80583
Hammerlund Mfg. Co. Inc.
Paramus, New Jersey

80640
Computer Products Inc.
Stevens-Arnold Div.
South Boston, Mass.

81073
Grayhill Inc.
La Grange, Illinois

81312
Litton Systems Inc.
Winchester Electronics Div.
Watertown, Connecticut

81439
Therm-O-Disc Inc.
Mansfield, Ohio

81483
International Rectifier Corp.
Los Angeles, California

81590
Korry Electronics Inc.
Seattle, Washington

81741
Chicago Lock Co.
Chicago, Illinois

82227
Airpax Corp.
Cheshire Div.
Cheshire, Connecticut

82240
Simmons Fastner Corp.
Albany, New York

Federal Supply Codes for Manufacturers (cont)

82305
Palmer Electronics Corp.
South Gate, California

82389
Switchcraft Inc.
Sub of Raytheon Co.
Chicago, Illinois

82415
Airpax Corp
Frederick Div.
Frederick, Maryland

82872
Roanwell Corp.
New York, New York

82877
Rotron Inc.
Custom Div.
Woodstock, New York

82879
ITT
Royal Electric Div.
Pawtucket, Rhode Island

83003
Varo Inc.
Garland, Texas

83014
Hartwell Corp.
Placentia, California

83055
Signalite Fuse Co.
(Now 71744)

83058
TRW Assemblies & Fasteners Group
Fasteners Div.
Cambridge, Massachusetts

83259
Parker-Hannifin Corp.
O-Seal Div.
Culver City, California

83298
Bendix Corp.
Electric & Fluid Power Div.
Eatonville, New Jersey

83315
Hubbell Corp.
Mundelein, Illinois

83330
Kulka Smith Inc.
A North American Philips Co.
Manasquan, New Jersey

83478
Rubbercraft Corp. of America
West Haven, Connecticut

83553
Associated Spring Barnes Group
Gardena, California

83740
Union Carbide Corp.
Battery Products Div.
Danbury, Connecticut

84171
Arco Electronics
Commack, New York

84411
American Shizuki
TRW Capacitors Div.
Ogallala, Nebraska

84613
FIC Corp.
Rockville, Maryland

84682
Essex Group Inc.
Peabody, Massachusetts

85367
Bearing Distributing Co.
San Fransisco, California

85372
Bearing Sales Co.
Los Angeles, California

85480
W. H. Brady Co.
Industrial Product
Milwaukee, Wisconsin

85932
Electro Film Inc.
Valencia, California

86577
Precision Metal Products Co.
Peabody, Massachusetts

86684
Radio Corp. of America
(Now 54590)

86928
Seastrom Mfg. Co. Inc.
Glendale, California

87034
Illuminated Products Inc.
(Now 76854)

88219
GNB Inc.
Industrial Battery Div.
Langhorne, Pennsylvania

88245
Winchester Electronics
Litton Systems-Useco Div.
Van Nuys, California

88486
Triangle PWC Inc.
Jewitt City, Connecticut

88690
Essex Group Inc.
Wire Assembly Div.
Dearborn, Michigan

89020
Amerace Corp.
Buchanan Crimptool Products Div.
Union, New Jersey

89265
Potter-Brumfield
(See 77342)

89536
John Fluke Mfg. Co., Inc.
Everett, Washington

89597
Fredericks Co.
Huntingdon Valley, Penna.

89709
Bunker Ramo-Eltra Corp.
Amphenol Div.
Broadview, Illinois

89730
General Electric
Lamp Div.
Newark, New Jersey

90201
Mallory Capacitor Co.
Sub of Emhart Industries Inc.
Indianapolis, Indiana

90215
Best Stamp & Mfg. Co.
Kansas City, Missouri

90303
Duracell Inc.
Technical Sales & Marketing
Bethel, Connecticut

91094
Essex Group Inc.
Suflex/IWP Div.
Newmarket, New Hampshire

91247
Illinois Transformer Co.
Chicago, Illinois

91293
Johanson Mfg. Co.
Boonton, New Jersey

91462
Alpha Industries Inc.
Logansport, Indiana

91502
Associated Machine
Santa Clara, California

91506
Augat Inc.
Attleboro, Massachusetts

91507
Froeliger Machine Tool Co.
Stockton, California

91637
Dale Electronics Inc.
Columbus, Nebraska

91662
Elco Corp.
A Gulf Western Mfg. Co.
Connector Div.
Huntingdon, Pennsylvania

91737
ITT Cannon/Gremar
(Now 08718)

91802
Industrial Devices Inc.
Edgewater, New Jersey

91833
Keystone Electronics Corp.
New York, New York

91836
King's Electronics Co. Inc.
Tuckahoe, New York

91929
Honeywell Inc.
Micro Switch Div.
Freeport, Illinois

91934
Miller Electric Co.
Woonsocket, Rhode Island

91984
Maida Development Co.
Hampton, Virginia

91985
Norwalk Valve Co.
S. Norwalk, Connecticut

92914
Alpha Wire Corp.
Elizabeth, New Jersey

93332
Sylvania Electric Products
Semiconductor Products Div.
Woburn, Massachusetts

94144
Raytheon Co.
Microwave & Power Tube Div.
Quincy, Massachusetts

94222
Southco Inc.
Concordville, Pennsylvania

94988
Wagner Electric Corp.
Sub of Mcgraw-Edison Co.
Whippany, New Jersey

95146
Alco Electronic Products Inc.
Switch Div.
North Andover, Massachusetts

95263
Leecraft Mfg. Co.
Long Island City, New York

95275
Vitramon Inc.
Bridgeport, Connecticut

95303
RCA Corp.
Receiving Tube Div.
Cincinnati, Ohio

95348
Gordo's Corp.
Bloomfield, New Jersey

95354
Methode Mfg. Corp.
Rolling Meadows, Illinois

Federal Supply Codes for Manufacturers (cont)

95573
Campion Laboratories Inc.
Detroit, Michigan

95712
Bendix Corp.
Electrical Comp. Div.
Franklin, Indiana

95987
Weckesser Co. Inc.
(Now 85480)

96733
SFE Technologies
San Fernando, California

96853
Gulton Industries Inc.
Measurement & Controls Div.
Manchester, New Hampshire

96881
Thomson Industries Inc.
Port Washington, New York

97525
EECO Inc.
Santa Ana, California

97540
Whitehall Electronics Corp.
Master Mobile Mounts Div.
Fort Meyers, Florida

97913
Industrial Electronic
Hardware Corp.
New York, New York

97945
Pennwalt Corp.
SS White Industrial Products
Piscataway, New Jersey

97966
CBS
Electronic Div.
Danvers, Massachusetts

98094
Machlett Laboratories Inc.
Santa Barbara. California

98159
Rubber-Teck Inc.
Gardena, California

98278
Malco A Microdot Co.
South Pasadena, California

98291
Sealectro Corp.
BICC Electronics
Trumbill, Connecticut

98372
Royal Industries Inc.(Now 62793)

98388
Lear Siegler Inc.
Accurate Products Div.
San Deigo, California

99120
Plastic Capacitors Inc.
Chicago, Illinois

99217
Bell Industries Inc.
Elect. Distributor Div.
Sunnyvale, California

99378
ATLEE of Delaware Inc.
N. Andover, Massachusetts

99392
Mepco/Electra Inc.
Roxboro Div.
Roxboro, North Carolina

99515
Electron Products Inc.
Div. of American Capacitors
Duarte, California

99779
Bunker Ramo- Eltra Corp.
Barnes Div.
Lansdown, Pennsylvania

99800
American Precision Industries
Delevan Div.
East Aurora, New York

99942
Mepco/Centralab
A North American Philips Co.
Milwaukee, Wisconsin

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Tempe, AZ 85282
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Tucson
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Irvine, CA 92714
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2020 N. Lincoln Street
Burbank, CA 91504
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(619) 292-7656

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14180 East Evans Ave.
Aurora, CO 80014
(303) 695-1000

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John Fluke Mfg. Co., Inc.
Glen Locken East
41-C New London Turnpike
Glastonbury, CT 06033
(203) 659-3541

DC, Washington
(301) 770-1570

FL, Clearwater
(813) 799-0087

Miami
(305) 462-1380

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Orlando, FL 32803
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(813) 251-9211

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Marietta, GA 30067
(404) 953-4747

IL, Chicago
John Fluke Mfg. Co., Inc.
1150 West Euclid Ave.
Palatine, IL 60067
(312) 705-0500

IN, Indianapolis
John Fluke Mfg. Co., Inc.
8777 Purdue Rd.
Suite 101
Indianapolis, IN 46268
(317) 875-7870

LA, Baton Rouge
(504) 924-1203

New Orleans
(504) 455-0814

MA, Boston
John Fluke Mfg. Co., Inc.
Middlesex Tech Center
900 Middlesex Turnpike
Building 8
Billerica, MA 01821
(617) 663-2400

MD, Baltimore
(301) 792-7060

Rockville
John Fluke Mfg. Co., Inc.
5640 Fishers Lane
Rockville, MD 20852
(301) 770-1570

MI, Detroit
John Fluke Mfg. Co., Inc.
33031 Schoolcraft
Livonia, MI 48150
(313) 522-9140

MN, Bloomington
John Fluke Mfg. Co., Inc.
1801 E. 79th St., Suite 9
Bloomington, MN 55420
(612) 854-5526

MO, St. Louis
John Fluke Mfg. Co., Inc.
11756 Borman Drive
Suite 160
St. Louis, MO 63146
(314) 993-3805

NC, Greensboro
John Fluke Mfg. Co., Inc.
1310 Beaman Place
Greensboro, NC 27408
(919) 273-1918

NJ, Paramus
John Fluke Mfg. Co., Inc.
P.O. Box 930
Paramus, NJ 07653-0930
West 75 Century Road
Paramus, NJ 07652
(201) 262-9550

NM, Albuquerque
(505) 881-3550

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John Fluke Mfg. Co., Inc.
4515 Culver Road
Rochester, NY 14622
(716) 323-1400

OH, Cleveland
John Fluke Mfg. Co., Inc.
7830 Freeway Circle
Middleburg Heights, OH 44130
(216) 234-4540

Dayton
John Fluke Mfg. Co., Inc.
5450 Far Hills Avenue
Suite 111
Kettering, OH 45429
(513) 436-2224

OK, Northeast
(918) 749-0190

OR, Portland
(503) 227-2042

PA, Philadelphia
John Fluke Mfg. Co., Inc.
200 Lindenwood Drive
Malvern, PA 19355
(215) 647-9550

Pittsburgh
(412) 261-5171

TX, Austin
(512) 459-3344

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John Fluke Mfg. Co., Inc.
1801 Royal Lane
Suite 307
Dallas, TX 75229
(214) 869-0311

El Paso
(915) 533-3508

Houston
(713) 240-5995

San Antonio
John Fluke Mfg. Co., Inc.
10417 Gulfdale
San Antonio, TX 78216
(512) 340-0498

UT, Salt Lake City
(801) 268-9331

WA, Seattle
John Fluke Mfg. Co., Inc.
5020 148th Ave. N.E.
Suite #110
Redmond, WA 98052
(206) 881-6966

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Navy	(714) 863-9031, CA (301) 770-1570, MD
USAF	(513) 436-2224, OH (512) 340-2621, TX
Security	(301) 770-1570, MD

Service Center Areas

CA, Burbank (213) 849-4641
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CO, Denver (303) 695-1000
FL, Orlando (305) 896-4881
IL, Chicago (312) 705-0500
MD, Rockville (301) 770-1576
NJ, Paramus (201) 262-9550
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WA, Everett (206) 356-5560

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Fluke Asia Ltd.
Shun Tak Centre, Room 1501
200 Connaught Road
Central, Hong Kong
Tel: 852 5 482116
TLX: (780) 87058 FLUKE
FAX: (852) 5-479863

Australia ●
Elmeasco Instruments Pty, Ltd.
P.O. Box 30
Concord, N.S.W. 2137
Australia
Tel: 61-2-736-2888
TLX: (790) 25887 A/B: ELSCOAA 25887
FAX: 61-2-733663

Elmeasco Instruments Pty, Ltd.
P.O. Box 623
12 Maroondah Highway
Ringwood, Victoria 3134
Australia
Tel: 61-3-879-2322
TLX: (790) 30418 A/B: ELTENTAA 30418
FAX: (61) (3) 879-4310

Elmeasco Instruments Pty, Ltd.
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Salisbury, Queensland 4107
Australia
Tel: 61-7-875-1444
TLX: (790) 44062 A/B: ELMQLDAA44062

Elmeasco Instruments Pty, Ltd.
P.O. Box 154
Prospect, South Australia 5082
Tel: 61-8-344-9000 TLX: (790) A/B:87519

Elmeasco Instruments Pty, Ltd.
P.O. Box 413
Scott House
46-48 Kings Park Road
West Perth, Western Australia 6005
Australia
Tel: 61-9-481-1500
TLX: (790) 94765 A/B: ASECSAA 94765
FAX: (61) (9) 322-2075

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Gerate GmbH & Co.
Vertrieb KG
Obachgasse 28
1220 Vienna, Austria
Tel: 43-222-25-36-26
TLX: (847) 134759
FAX: 43-222-25-72-75

Bahrain ●
Basma W.L.L.
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Manama, Bahrain
Tel: 973-251364; TLX: (955) 9003
FAX: (965) 245218

Bangladesh ●
Motherland Corporation
24 Hatkhola Road, Tikatuli
Dacca-3, Bangladesh
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Cable: "MOTHERLAND" DACCA

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Industrial & Electro-Acoustic Systems
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The Netherlands
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Tlx: 35000 phtc nl
Fax: 040-785651

Bolivia ●
Coasin Bolivia S.R.L.
Casilla 7295
La Paz, Bolivia
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TLX: (336) 3233 COALAP BV
Cable: COALAP

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ATP/Hi-Tek Eletronica Ltda.
Al. Amazonas 422,
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Sao Paulo, Brazil
Tel: 55-11-421-5477;
TLX: (391) 1171413 HITK BR

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Negara Brunei Darussalam
Tel: 673-2-23109 or 23557
TLX: (799) BU 2265 RANKOC

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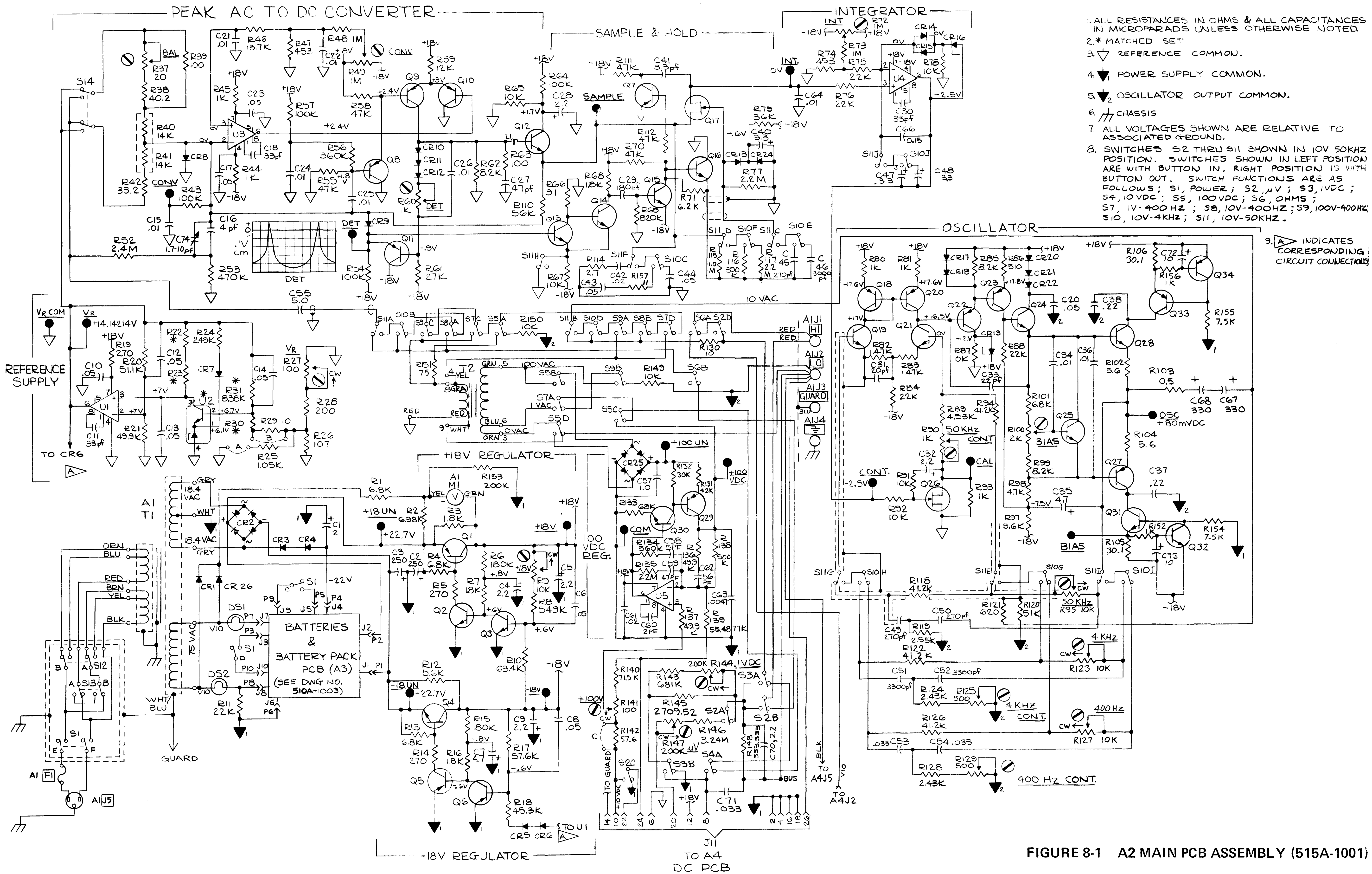
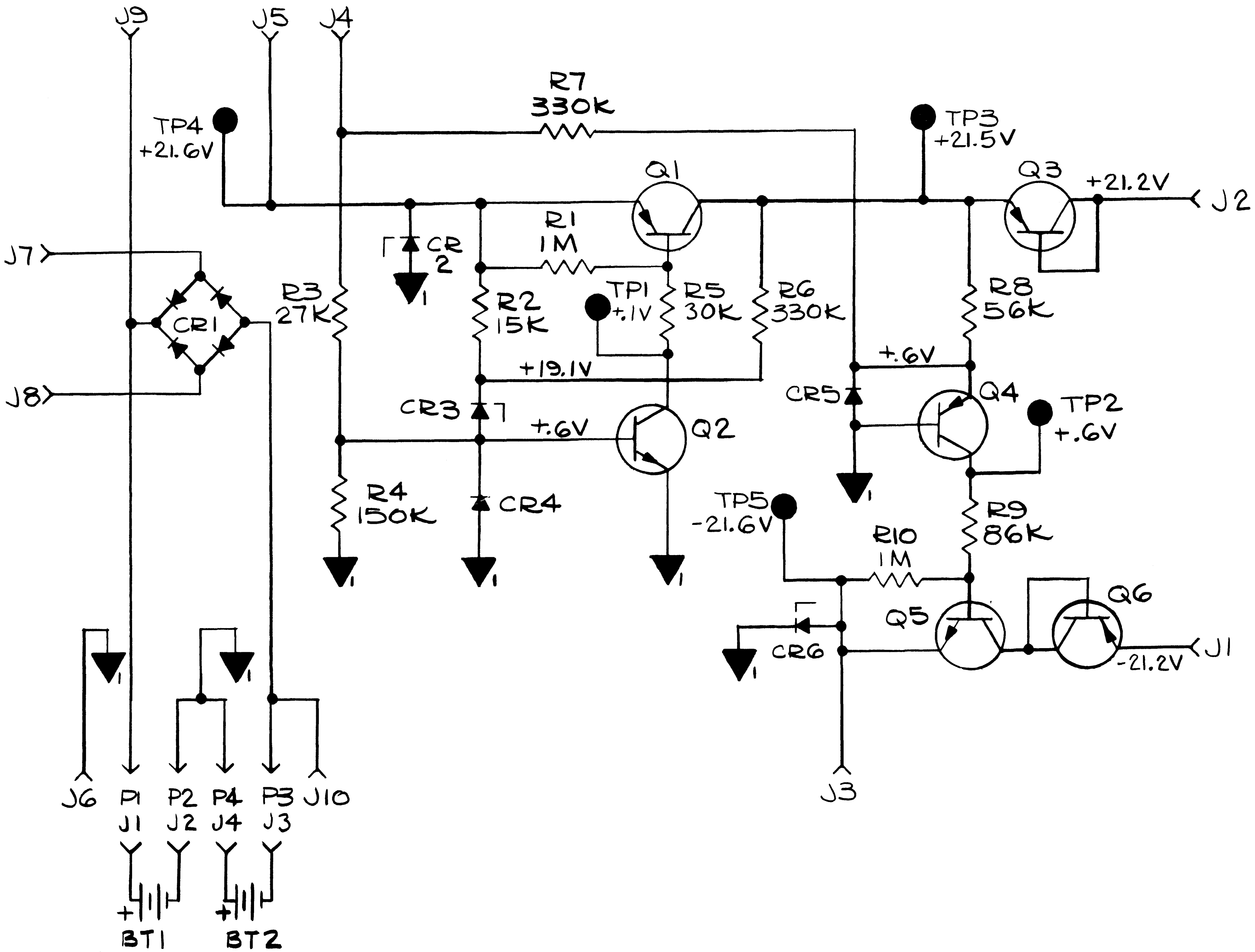
Section 8

Schematic Diagrams



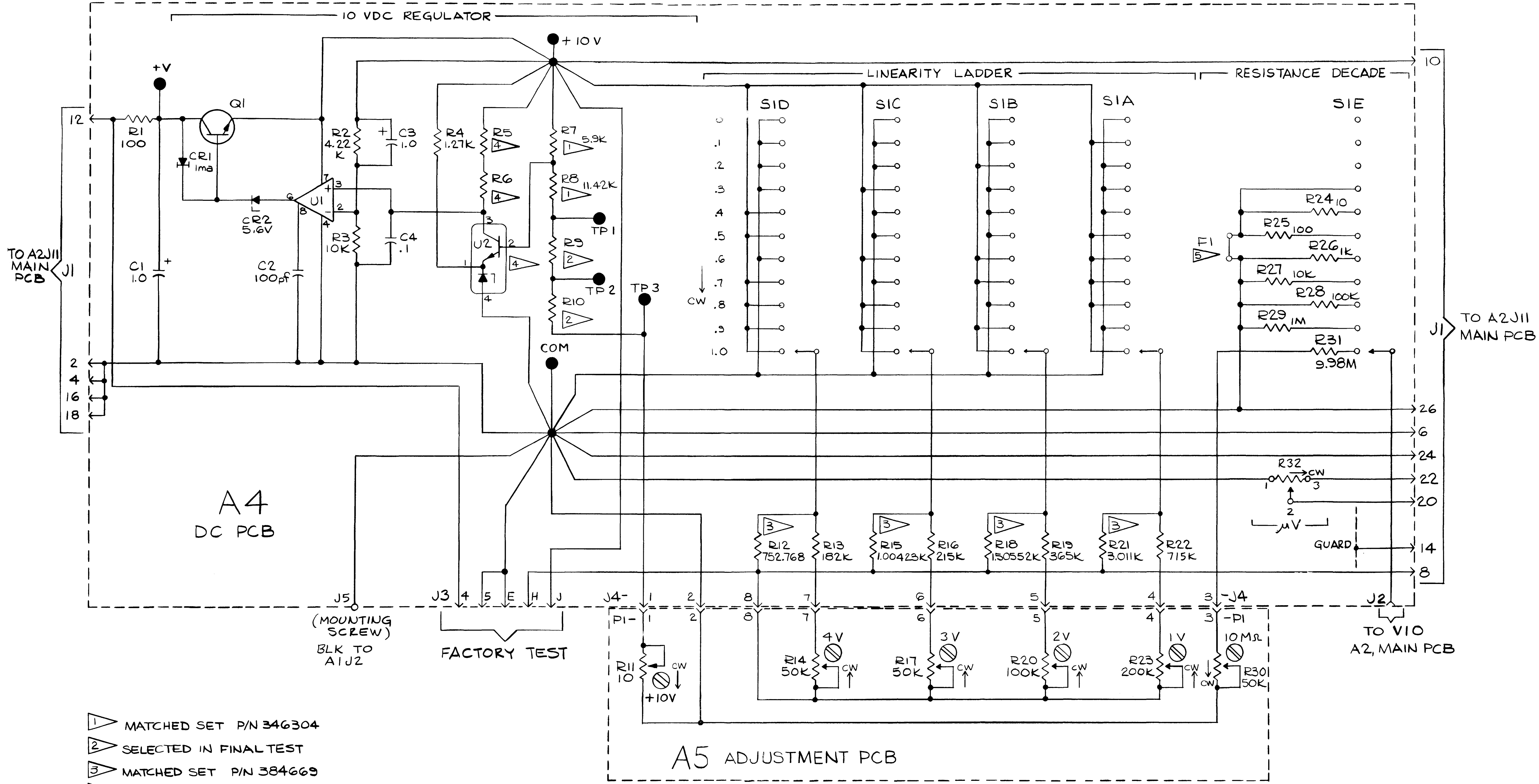
1. ALL RESISTANCES IN OHMS & ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE NOTED.
2. * MATCHED SET
3. ▽ REFERENCE COMMON.
4. ▼ POWER SUPPLY COMMON.
5. ▼2 OSCILLATOR OUTPUT COMMON.
6. CHASSIS
7. ALL VOLTAGES SHOWN ARE RELATIVE TO ASSOCIATED GROUND.
8. SWITCHES S2 THRU S11 SHOWN IN 10V 50KHZ POSITION. SWITCHES SHOWN IN LEFT POSITION ARE WITH BUTTON IN. RIGHT POSITION IS WITH BUTTON OUT. SWITCH FUNCTIONS ARE AS FOLLOWS; S1, POWER; S2, μV; S3, 1VDC; S4, 10 VDC; S5, 100VDC; S6, OHMS; S7, 1V-400 HZ; S8, 10V-400HZ; S9, 100V-400HZ; S10, 10V-4KHZ; S11, 10V-50KHZ.
9. A INDICATES CORRESPONDING CIRCUIT CONNECTIONS.

FIGURE 8-1 A2 MAIN PCB ASSEMBLY (515A-1001)



1. ALL RESISTANCES IN OHMS & ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE NOTED.
2. PCB VOLTAGES MEASURED DURING BATTERY OPERATION.
3. LAST CR, CR6
   LAST R, R10
   LAST Q, Q6
4. POWER SUPPLY COMMON

FIGURE 8-2 A3 BATTERY PACK PCB ASSEMBLY
(510A-1003)



1. MATCHED SET P/N 346304
2. SELECTED IN FINAL TEST
3. MATCHED SET P/N 384669
4. SELECTED P/N 346270
5. PCB FUSE. REPLACE WITH #34 AWG WIRE.
6. ALL RESISTANCES IN OHMS & ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE NOTED.
7. A4: LAST C, C4
   LAST R, R32

FIGURE 8-3 A4 DC AND A5 ADJUSTMENT PCB ASSEMBLY (515A-1002 & 515A-1003)