JOHN FLUKE MFG. CO., INC.

P.O. Box 43210 Mountlake Terrace, Washington 98043

APRIL, 1969

MODEL 931B

RMS DIFFERENTIAL VOLTMETER

Rev. No. 1 10/18/71

Rev. No. 2 3/1/75

P/N 294306

WARRANTY

The JOHN FLUKE MFG. CO., INC.* warrants each instrument manufactured by them to be free from defects in material and workmanship. Their obligation under this Warranty is limited to servicing or adjusting an instrument returned to the factory for that purpose, and to making good at the factory any part or parts thereof; except tubes, fuses, choppers and batteries, which shall, within one year after making delivery to the original purchaser, be returned by the original purchaser with transportation charges prepaid, and which upon their examination shall disclose to their satisfaction to have been thus defective. If the fault has been caused by misuse or abnormal conditions of operations, repairs will be billed at a nominal cost. In this case, an estimate will be submitted before work is started, if requested.

If any fault develops, the following steps should be taken:

1. Notify the John Fluke Mfg. Co., Inc.,* 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 prepaid, and repairs will be made at the factory. If requested, an estimate will be made before the work begins, provided the instrument is not covered by the Warranty.

"The foregoing warranty is in lieu of all other warranties, express or implied, including but not limited to, any implied warranty of merchantability, fitness or adequacy for any particular purpose or use. Fluke shall not be liable for any special, incident or consequential damages."

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All shipments of John Fluke Mfg. Co., Inc.* instruments should be made via Railway Express**prepaid. The instrument should be shipped in the original packing carton, or if it is not available, use any suitable container that is rigid. 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

The instrument should be thoroughly inspected immediately upon receipt. 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 fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to John Fluke Mfg. Co., Inc.* Upon receipt of this report, you will be advised of the disposition of the equipment for repair or replacement. Include the model number, type number, and serial number when referring to this instrument for any reason.

The John Fluke Mfg. Co., Inc.* will be happy to answer all application questions which will enhance your use of this instrument. Please address your requests to: JOHN FLUKE MFG. CO., INC., P. O. Box 7428, SEATTLE, WASHINGTON 98133*.

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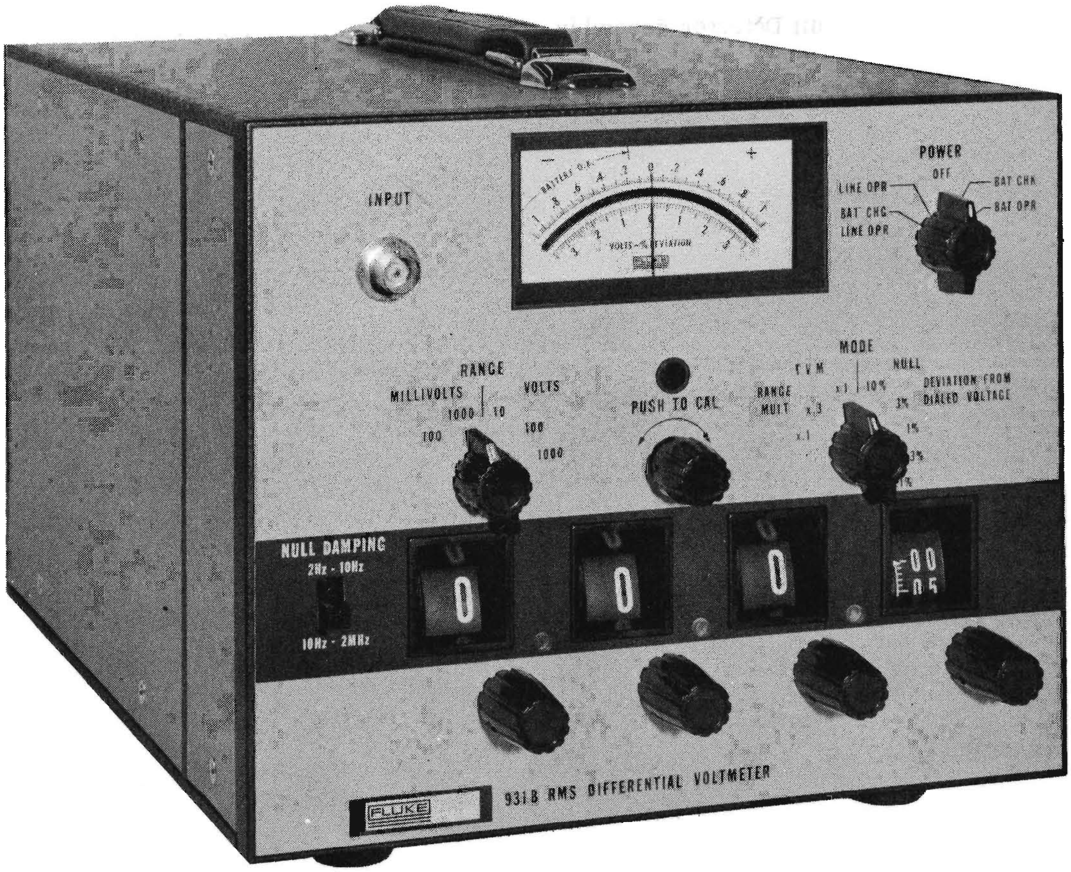


MODEL 931B RMS DIFFERENTIAL VOLTMETER

SECTION I

INTRODUCTION AND SPECIFICATIONS

1-1. INTRODUCTION

1-2. The Fluke Model 931B RMS Differential Voltmeter provides accurate true rms measurement of ac signals from 0.003 to 1100 volts ac at frequencies of 2 Hz to 2 MHz. A conventional (TVM) mode is included for rapid indication of the ac input rms value. Measurement accuracies to ±3% of end-scale are available on the TVM mode. The differential (NULL) mode provides a five digit in-line display of the ac input rms value. Location of the decimal point is accomplished automatically during the differential measurement. The meter end-scale is calibrated in percentage of dial settings for differential measurements, aiding in the measurement of deviations from a nominal value. A linear recorder output enables the instrument to be used as an rms ac to dc converter, as well as for production testing.

1-3. Since the instrument is an rms responding device instead of the average or peak responding, it is suitable for measurement and calibration of square, triangular, saw-tooth, and other non-sinusoidal waveforms. The instrument measures the true rms value of these waveforms regardless of the harmonic or phase variations in the harmonics.

1-4. The basic Model 931B contains a front panel BNC input and operates strictly from the available line power. Optional features are available for the instrument to provide a probe input and a rechargeable battery power source. The rechargeable battery option is identified as the -01 option and the probe input option is identified as the -02 option. The combination of both of these options is identified as the -03 option. A rear panel decal indicates which, if any, options are installed in the Model 931B.

1-5. The instrument is completely solid-state in design and packaged in a compact lightweight configuration for portable field or factory applications. The instrument is half rack, 19 inch standard, in size and is equipped with resilient feet and a tilt-down bail for bench-top use. Rack adapter kits are available for single or side-by-side mounting in a standard 19 inch relay rack. Single unit mounting is provided with the 881A-102 rack adapter kit while side-by-side mounting is provided with the 881A-103 rack adapter kit.

1-6. ELECTRICAL SPECIFICATIONS

DIFFERENTIAL (NULL) MODE

INPUT VOLTAGE RANGE
0.01 to 1100 volts rms in five ranges of 100 millivolts, 1000 millivolts, 10 volts, 100 volts, and 1000 volts, each with 10% overranging.

FREQUENCY RANGE
NULL DAMPING - 2 Hz to 10 Hz
Normal Mode - 10 Hz to 1 MHz

NULL RANGES
Meter end-scale calibrated in percentage of readout dial settings.

10%	(0.2% per scale division)
3%	(0.1% per scale division)
1%	(0.02% per scale division)
.3%	(0.01% per scale division)
.1%	(0.002% per scale division)

ACCURACY (at 23°C ±1°C)

NULL DAMPING (2 Hz - 10 Hz)*
2 Hz to 3 Hz
±1% of input, 0.01 to 1100 volts rms
3 Hz to 5 Hz
±0.5% of input, 0.01 to 1100 volts rms
5 Hz to 10 Hz
±0.2% of input, 0.01 to 1100 volts rms

NORMAL MODE (10 Hz - 2 MHz)
10 Hz to 20 kHz

±0.2% of input 0.01 to 1100 volts rms
30 Hz to 50 kHz
±(0.05% of input +0.005% of range), 0.01 to 500 volts rms
30 Hz to 20 kHz
±0.1% of input, 500 to 1100 volts rms
20 kHz to 50 kHz
±0.15% of input, 500 to 1100 volts rms
50 kHz to 100 kHz
±0.2% of input, 0.01 to 1100 volts rms
**100 kHz to 200 kHz
±0.5% of input, 0.01 to 1100 volts rms
**200 kHz to 500 kHz
±1.0% of input, 0.01 to 1100 volts rms
**500 kHz to 1 MHz
±3.0% of input, 0.01 to 1100 volts rms

*Voltages at frequencies above 10 Hz can be measured with the NULL DAMPING switch in the 2 - 10 Hz position without introducing any additional error, but the time required to obtain a reading when high resolution is required is excessive.

**Input voltages x frequency product should not exceed 1×10^8 Volt - Hertz.

CREST FACTOR
Ten or 1500 volts peak.

TEMPERATURE COEEFFICIENT OF ACCURACY
(0°C to 50°C)

2 Hz to 3 Hz	±0.1%/°C
3 Hz to 5 Hz	±0.05%/°C
5 Hz to 30 Hz	±0.025%/°C
30 Hz to 30 kHz	±0.0025%/°C
30 kHz to 50 kHz	±0.004%/°C
50 kHz to 200 kHz	±0.01%/°C
200 kHz to 1 MHz	±0.03%/°C

CONVENTIONAL (TVM) MODE

INPUT VOLTAGE RANGE
0.003 to 1100 volts rms in eleven end-scale ranges of 100 millivolts to 1000 volts in 1, 3 sequence, each with 10% overranging.

INPUT FREQUENCY RANGE
2 Hz to 2 MHz.

ACCURACY

10 Hz to 500 kHz	±3% of end-scale
2 Hz to 2 MHz	±8% of end-scale

CREST FACTOR
Ten at end-scale increasing proportionally to 30 at 1/3 scale or 1500 volts peak maximum.

GENERAL

INPUT
Model 931B or 931B-01
BNC connector mounted on front panel.
Model 931B-02 or 931B-03
Probe and 36 inch cable mounted to front panel.

INPUT IMPEDANCE
Model 931B and 931B-01
1 Megohm shunted by less than 8 pf at the front panel BNC connector.

Model 931B-02 and 931B-03
1 Megohm shunted by less than 7 pf at the probe tip.

SHORT TERM STABILITY
Better than 0.005% per hour and 0.02% per day without adjustment of the front panel PUSH TO CAL control.

LONG TERM STABILITY
Better than 0.01% for 30 days and 0.02% for 90 days, reset to zero during periodic adjustment of the front panel PUSH TO CAL control.

OVERLOAD PROTECTION
Transistor driver and relay protect the instrument from damage by overloads up to 1500 volt peak or 1000 volts rms on any range. The overload protection circuitry is automatically reset upon removal of the overload.

LINE REGULATION
Better than 0.0005% for a 10% line voltage change from the nominal.

DC RECORDER OUTPUT
Linear proportional to the meter deflection. Either one volt dc at end-scale (one kilohm output resistance) or adjustable from zero to one volt dc at end-scale. Accuracy of output (0°C to 50°C):

10 Hz to 500 kHz	±1% of end-scale.
2 Hz to 2 MHz	±5% of end-scale.

INPUT POWER
Model 931B and 931B-02
115/230 volts ac, 50 to 440 Hz, at approximately three watts.

Model 931B-01 and 931B-03
115/230 volts ac, 50 to 440 Hz, plus 22 hours minimum operation from fully-charged battery pack. Input power of 25 watts required for recharging of battery pack while operating the instrument.

1-7. ENVIRONMENTAL SPECIFICATIONS

OPERATING TEMPERATURE RANGE
0°C to 50°C.

STORAGE TEMPERATURE RANGE
Model 931B and 931B-02
40°C to +70°C.

SHOCK
Meets hammer blow requirements of MIL-T-945A.

VIBRATION
Meets all requirements of MIL-T-945A.

1-8. MECHANICAL SPECIFICATIONS

WEIGHT
Model 931B and 931B-02
11-1/2 pounds.

Model 931B-01 and 931B-03
15 pounds.

MOUNTING
Resilient feet provide for bench and portable use. For side-by-side EIA rack mounting of two instruments, use adapter kit 881A-103 which includes handle brackets and key plate. For EIA rack mounting of a single instrument, use adapter kit 881A-102 which includes brackets with handles.

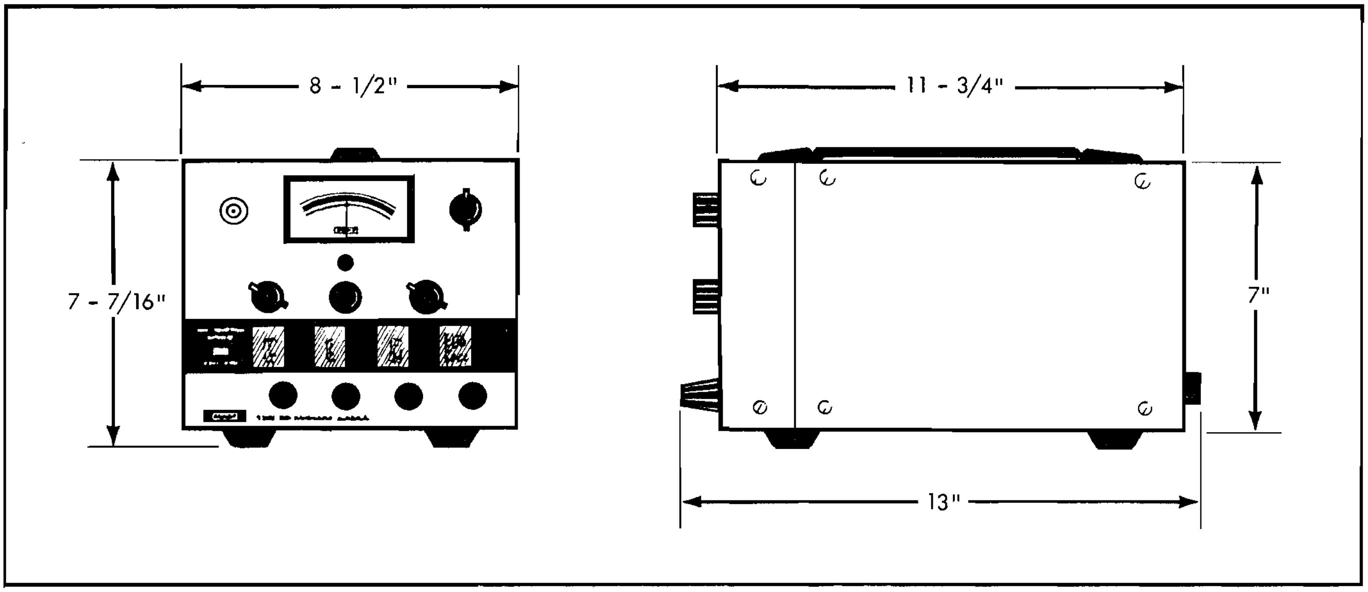


Figure 1-1. MODEL 931B OUTLINE DRAWING

SECTION II

OPERATING INSTRUCTIONS

2-1. INTRODUCTION

2-2. This section of the manual contains the information necessary for you to effectively operate your Model 931B RMS Differential Voltmeter. It is recommended that you thoroughly read and understand this section of the manual before attempting to operate your instrument.

2-3. Should any difficulties be encountered during the operation of your instrument please feel free to contact your nearest John Fluke Sales Representative or write directly to the John Fluke Mfg. Co., Inc., Box 7428 Seattle, Washington with a statement of your problem. A complete list of Sales Representatives is contained at the rear of this manual.

2-4. OPERATION FROM 115/230 VAC POWER

2-5. Input power from either a 115 or 230 volt ac power line can be used to operate the Model 931B. The instrument's input power transformer primary winding is comprised of two windings which, when connected in parallel, allow operation from 115 volts ac or, when connected in series, allow operation from 230 volts ac.

2-6. This instrument is usually shipped with the power transformer primary windings connected in parallel for operation from a 115 volt ac power line. However, if requested, the power transformer is wired for operation from a 230 volt ac power line during manufacture. A rear panel decal will indicate the required 115 or 230 volt ac power necessary to operate the instrument. To convert your instrument to either a 115 or 230 volt ac power input, perform the following steps:

a. Disconnect line power cord from line power and remove upper rear dust cover from instrument.

b. Locate the power transformer terminals on the rear panel and solder jumper wires in the desired 115 or 230 volt power configurations. A decal located on the power transformer illustrates the necessary connections.

c. Install the corresponding 115 or 230 volt 1/4 or 1/8 ampere AGC fuse in the rear panel fuseholder.

d. Replace the upper rear dust cover.

2-7. OPERATING FEATURES

2-8. All of the Model 931B controls, terminals, and indicators are illustrated and described in Figure 2-1.

2-9. PRELIMINARY OPERATING PROCEDURES

2-10. Connect the Model 931B line power cord to the available line power and proceed as follows:

WARNING!

The instrument's case is connected to the round pin on the three-prong connector of the line power cord. Whenever this instrument is operated from line power, ensure that this round pin is connected to a high quality earth ground.

a. Place the Model 931B controls to the following positions:

POWER	ON
RANGE	1000 VOLTS
MODE	TVM X1
NULL DAMPING	10Hz-2MHz
Readout dials	00.00

b. Allow the instrument's circuitry to stabilize for approximately one minute.

c. Press the PUSH TO CAL control and rotate as necessary to achieve a zero meter indication.

d. The desired rms measurements can now be performed. However, it recommended that the following Operational Test be performed to verify instrument operation.

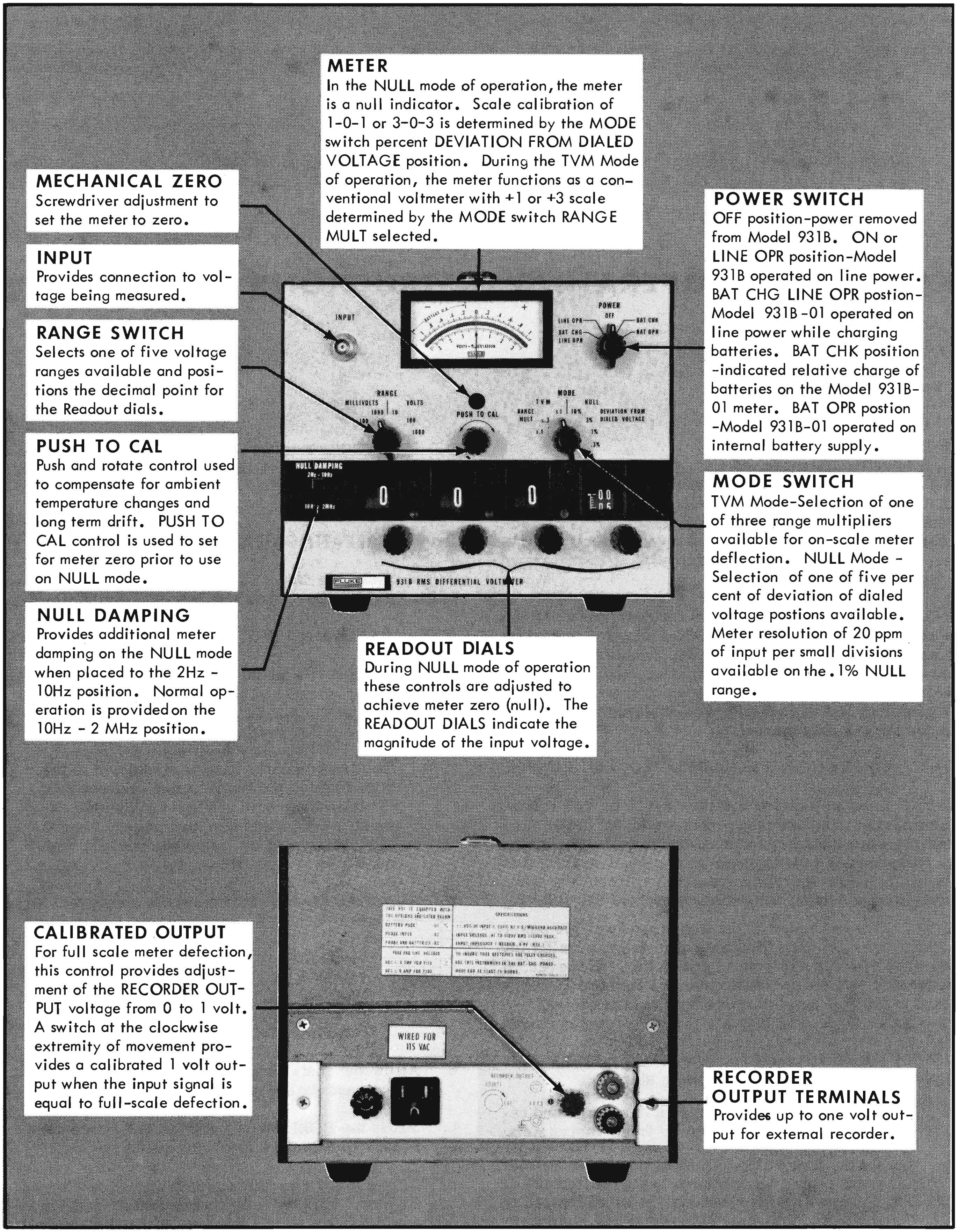


Figure 2-1. MODEL 931B FRONT AND REAR PANEL CONTROLS

2-11. OPERATIONAL TEST

2-12. The following information is provided for the operator to initially verify instrument operation. These tests will check relative instrument operation and are not intended as instrument performance checks. Should you wish to check the accuracy of the instrument against the specifications contained in Section I, refer to the Performance Checks described in Section IV of this manual.

2-13. To determine relative instrument operation, perform the operations described in paragraphs 2-9 and 2-10 and proceed as follows:

a. The decimal point should be illuminated between the two right hand Readout dials.

b. Place the RANGE switch to the 100 and then 10 VOLTS position, observing that the decimal point moves one place to the left as the range is decreased.

c. Place the RANGE switch to the 1000 MILLIVOLTS position, observing that the decimal point between the two right hand Readout dials is illuminated.

d. Place the RANGE switch to 100 MILLIVOLTS, observing that the decimal point moves one position to the left.

e. Connect a short bus-wire to the center connector of the BNC INPUT connector or the probe tip.

f. Whenever the bus-wire is touched, the meter pointer should deflect to the right.

g. Remove the bus-wire from the INPUT connector or probe.

h. Place the MODE switch to NULL 10%. The overload relay should be chattering and the meter pointer pinned at right full-scale.

i. Rotate the extreme right-hand Readout dial clockwise, observing that a zero meter indication is obtained at a dial setting between 03 to 50.

2-14. If the results of the Operational Test agree with the information given, it can be assumed that the instrument is operating normally and measurements can now be performed.

2-15. OPERATION AS A CONVENTIONAL RMS VOLTMETER

2-16. Conventional (TVM) rms measurements from 0.003 to 1100 volts ac at frequencies of 2 Hz to 2 MHz are available with the Model 931B. To operate the instrument as a conventional rms voltmeter, perform the operations described in the Preliminary Operating Procedures (paragraphs 2-9 through 2-10) and proceed as follows:

a. Ensure that the ac source to be measured has a ground reference and then apply the ac voltage to be measured to the INPUT of the Model 931B.

CAUTION!

Damage to the ac source, the Model 931B, or both may occur if the ac source is floating relative to earth ground.

b. Place the RANGE switch to the lowest voltage range possible while maintaining an on-scale meter deflection. Use the MODE switch X.3 and X.1 RANGE MULT positions to obtain a meter deflection greater than 1/3 of full-scale. The meter end-scale of 1 or 3 is determined by respective X1 or X.1 and X.3 position of the MODE switch.

c. The resulting meter deflection, multiplied by the product of the RANGE and MODE switch positions, is the rms value of the measured ac voltage.

Note!

If the meter pointer is observed to oscillate, such as is the case when measurements below 2 Hz are made, average the meter pointer excursions to determine the true rms value of the ac input voltage.

2-17. OPERATION AS A DIFFERENTIAL RMS VOLTMETER

2-18. An improved accuracy up to 60 times over that of the TVM mode is realized whenever the Model 931B is operated as a differential rms voltmeter. To operate the instrument as a differential rms voltmeter, proceed as follows:

a. Determine the relative value of the measured ac voltage by performing the TVM mode measurement described in paragraphs 2-15 and 2-16.

b. Place the NULL DAMPING switch to the 2 Hz-10 Hz or 10 Hz-2 MHz position which corresponds to the measured ac signal frequency.

c. Place the Readout dials to the TVM mode measurement value.

d. Place the MODE switch to the NULL 10% position and adjust the Readout dials for a zero meter indication. Meter deflection to the right indicates the measured ac voltage is greater than the Readout dial settings. Meter deflection to the left indicates the measured ac voltage is less than the Readout dial settings.

e. Place the MODE switch to successively higher NULL sensitivities and adjust the Readout dials for a zero meter deflection. The meter deflection on the NULL mode is scaled in terms of percentage of dialed voltage. Meter scale resolution for the .1% NULL range is 20 ppm of the measured ac voltage per small division.

f. The Readout dials digit value directly corresponds to the true rms value of the measured ac voltage.

Note!

Voltages smaller than 1/10 of full-scale are not normally measured on a given range since a lower range should be selected. For voltages less than 10 millivolts, measurements are made with a reduced accuracy. Refer to Figure 2-2 for typical accuracy specifications below 10 millivolts rms.

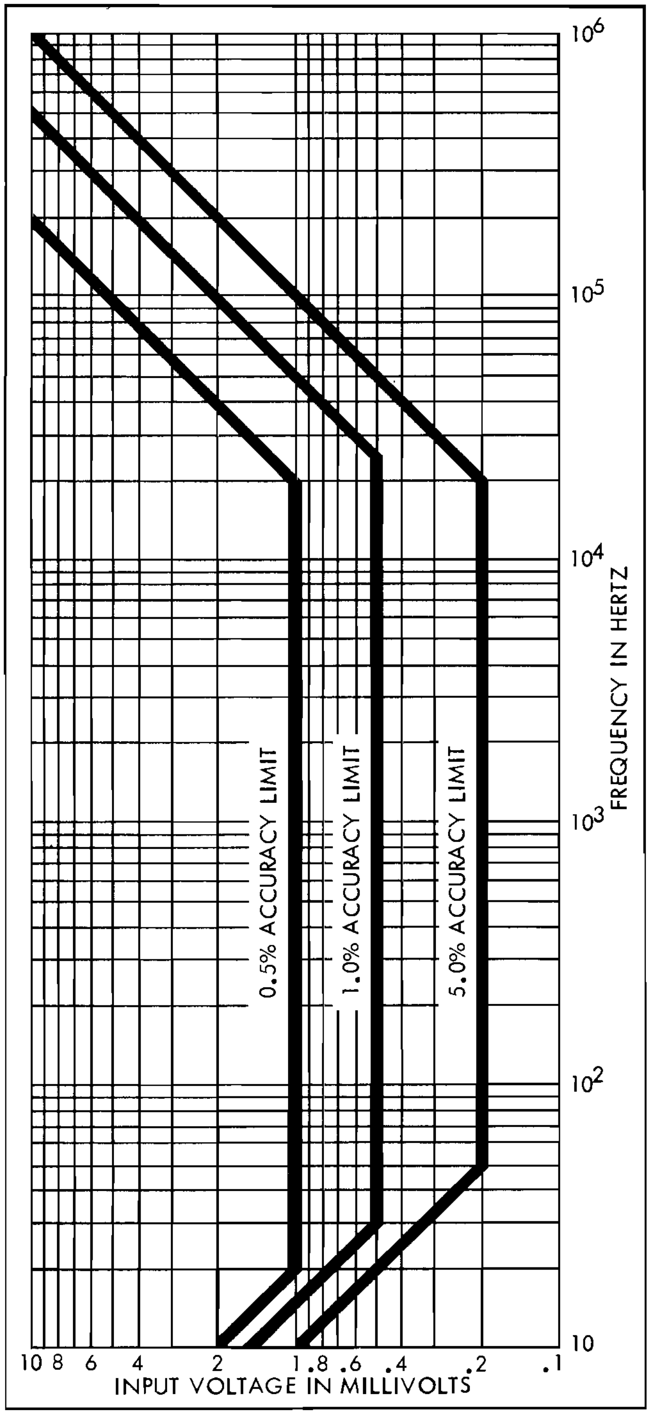


Figure 2-2. ACCURACY SPECIFICATIONS BELOW 10 MILLIVOLTS

2-19. RECORDER OUTPUT OPERATION

2-20. The Model 931B RECORDER OUTPUT can be used to drive a zero-center recorder to provide a record of the meter deflection. The RECORDER OUTPUT voltage is adjustable from zero to one volt dc for a full-scale meter deflection on the TVM mode. Since the low RECORDER OUTPUT terminal is grounded, as long as the instrument is operated with its power cord connected to line power, input isolation characteristics of the recorder can be disregarded. To use the RECORDER OUTPUT to drive a zero-center recorder, proceed as follows:

a. Connect the zero-center recorder input to the Model 931B RECORDER OUTPUT terminals.

b. Turn the recorder on and perform the Preliminary Operating Procedures described in paragraph 2-9 and 2-10.

c. Rotate the RECORDER OUTPUT ADJUST control maximum clockwise to provide a one volt dc output to the recorder for a full-scale TVM meter deflection. If a full-scale output of less than one volt is desired, apply a full-scale TVM input to the Model 931B and rotate the RECORDER OUTPUT ADJUST control counter-clockwise until the desired output level is obtained.

d. Apply the ac signal that is to be monitored to the INPUT of the Model 931B. The resulting meter excursions of the instrument are now recorded by the external recorder.

Note!

If the Model 931B is operated on the NULL mode, the RECORDER OUTPUT is proportional to the excursions of the monitored voltage above or below the Readout dial settings.

2-21. APPLICATIONS

2-22. MEASUREMENT OF VOLTAGE EXCURSIONS ABOUT A NOMINAL

2-23. Whenever the instrument is operated on the differential (NULL) mode, the meter end-scale is calibrated to be a known percentage of the Readout dial setting, thus providing rapid determination of voltage excursions about a nominal value. To measure voltage excursions about a nominal value, proceed as follows:

a. Determine the nominal value of the measured ac voltage using the TVM mode. Refer to paragraphs 2-15 and 2-16 for the TVM mode operating procedures.

b. Place the Readout dials to the nominal TVM mode value measured in step a and select the desired full-scale NULL sensitivity with the MODE switch.

c. The voltage excursions, in percent of the Readout dial settings, are now indicated by the meter deflection.

2-24. DBM MEASUREMENTS

2-25. The Model 931B, when used with a 600-ohm load, will function as an output meter. In this application the output to be measured must be terminated into a 600-ohm load and the Model 931B INPUT connected across the load. The Model 931B is then operated on the TVM or NULL mode and the resulting meter deflection or readout dial indication converted to DBM using the information provided in Figure 2-3. For DBM measurements on ranges above 100 MILLIVOLTS, multiply the voltages listed in Figure 2-3 by ten for each range and then add 20 dbm for each range.

INDICATED VOLTAGE (VOLTS AC)	DBM LEVEL FOR 100 MILLIVOLT RANGE (1 mw into 600Ω)
.00975	-38
.01227	-36
.01545	-34
.01946	-32
.02450	-30
.03088	-28
.03897	-26
.04887	-24
.06150	-22
.07746	-20
.09752	-18

Figure 2-3. 100 MILLIVOLT RANGE DBM CONVERSION TABLE

2-26. OPERATION AS AN AC TO DC CONVERTER

2-24. Whenever the Model 931B is operated on the TVM mode, the linear recorder output provides a dc voltage proportional to the meter deflection. This dc voltage can be monitored with a dc differential voltmeter, thus allowing the instrument to function as a true rms ac to dc converter.

2-28. OPERATING NOTES

2-29. GROUND LOOP CURRENTS

2-30. A potential difference often exists between different points of power system grounds. Consequently, current may flow from one power system ground through the Model 931B and the voltage source being measured to another power system ground. These ground loop currents should be avoided as they generate voltages that degrade measurement accuracy. To prevent these ground loop currents, operate the Model 931B from the same power line as the ac voltage source being measured or operate the instrument from battery power with its line power cord disconnected.

2-31. OVERLOAD PROTECTION

2-32. The Model 931B will withstand up to 1500 volts peak or 1000 volts rms on any voltage range. Input circuitry of the instrument is protected by a silicon diode and the thermocouples are protected by a transistor driver and relay. The overload relay is automatically reset upon removal of the overload. Should the instrument be subjected to prolonged overloads, excessive dissipation in the input circuitry and its protective device will result in thermally induced inaccuracies. These inaccuracies will take several minutes to subside after removal of the overload.

SECTION III

THEORY OF OPERATION

3-1. INTRODUCTION

3-2. The theory of operation for the Model 931B RMS Differential Voltmeter is contained in this section of the manual. Basic rms measurement principles are first discussed to initially orient the reader with the structure of the instrument circuitry. A functional block diagram analysis followed by a detailed circuit description of each particular block section is then discussed to completely describe the instrument circuitry.

3-3. Since this information can be an asset when used to troubleshoot the instrument, it is recommended that this section of the manual be thoroughly read and understood before attempting any maintenance on this instrument.

3-4. RMS MEASUREMENT PRINCIPLES

3-5. INTRODUCTION

3-6. The ac standards maintained by the National Bureau of Standards are comprised of a reference group of vacuum thermocouples and thermal voltage converters. These standards respond to the heating effect of an applied ac or dc signal which is then compared to the heating effect of a standard ac voltage. However, because of the theoretical uncertainty of intercomparison as a means of establishing an absolute standard, the resulting NBS test reports contain a basic uncertainty of ±100 ppm.

3-7. Because of the basic uncertainty involved in the NBS test reports, ac measurements made with an absolute accuracy of 0.1% or better can be considered to be highly accurate. The results of these ac measurements are usually expressed mathematically as the root-mean-square (rms) value. This rms value is equal to the amount of alternating current that will produce the same heating effect as an equal amount of dc current.

3-8. VACUUM THERMOCOUPLES

3-9. Vacuum thermocouples provide an excellent means for accurately sensing the rms value of an ac voltage since they respond only to the heating effect of the applied current. A vacuum thermocouple is comprised of an evacuated glass envelope containing a resistive heater element and an electrically isolated thermocouple junction. The thermocouple junction senses the temperature of the heater element and produces an output emf which is proportional to the temperature of the heater element. Since the temperature of the heater element is proportional to its dissipated power, which is in turn proportional to the square of the heater element current, the thermocouple junction output emf is nearly proportional to the square of the applied heater element input signal. Deviations from the approximate square law output characteristics are caused by the heater element temperature coefficient, radiation losses from the heater element, and other affects.

3-10. The ac-dc thermal transfer technique previously discussed in paragraphs 3-6 and 3-7 does not readily lend itself to direct reading instrumentation. However, the same measurement process may be performed continuously by using the differential connection of two vacuum thermocouples as illustrated in Figure 3-1. With this arrangement, the combined output of two thermocouples will be zero (null) when the ac input signal is equal to the dc reference. The comparison error at null will be quite small, however, off-null accuracy will be degraded by the approximate square-law characteristics of the vacuum thermocouples. In addition, relatively poor temperature coefficient matching and poor differential long term stability will also require that recalibration of the thermocouples be accomplished periodically to maintain an accurate null comparison over a long period of time.

3-11. The effects of these problems have been overcome in the Model 931B by first preceding the ac input

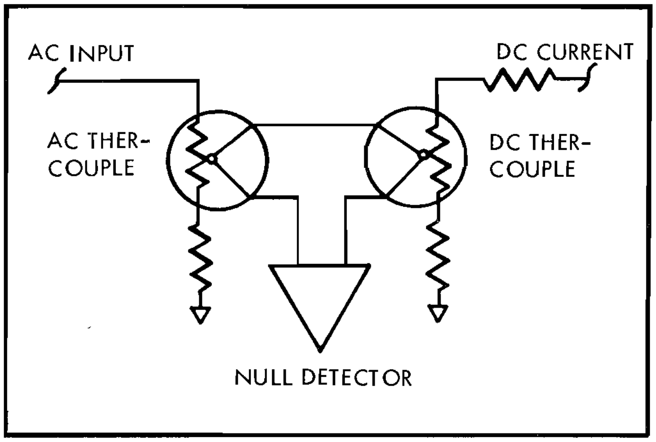


Figure 3-1. DIFFERENTIAL THERMOCOUPLE

to the thermocouple with a variable gain amplifier and secondly, by thermocouple calibration circuitry. Figure 3-2 illustrates a greatly simplified block diagram of the instrument's circuitry. The variable gain amplifier is used so that the measurement is always performed at the same input level to the thermocouples and since the gain of the ac amplifier is accurately known, the measured ac signal rms value can then be determined. The thermocouple calibration circuitry provides a means of eliminating the temperature and long-term drift characteristics of the thermocouples.

3-12. BLOCK DIAGRAM ANALYSIS

3-13. INTRODUCTION

3-14. The Model 931B circuitry is comprised of an input amplifier, a variable gain ac amplifier, two vacuum thermocouples, a null detector, a meter amplifier, a meter, calibration circuitry, and a power supply. A block diagram of the instrument's circuitry is illustrated in Figure 3-3.

3-15. CONVENTIONAL TVM MODE

3-16. When the Model 931B is operated on the conventional TVM mode, its circuitry is connected as illustrated in Figure 3-3. Input ac signals are amplified or attenuated by the input amplifier and applied to the following variable gain ac amplifier. Both the input and variable gain ac amplifiers are operational amplifiers and have a gain proportional to the ratio of feedback impedance to their input impedance. Gain of the input amplifier is controlled by one of four feedback networks selected with the RANGE switch for corresponding .1 to 100 volt ranges. The fifth or 1000 volt range is obtained by using the 100 volt range feedback network and passing the input amplifier output through a 10:1 attenuator. The gain of the variable gain ac amplifier is controlled by one of three feedback networks selected with the MODE switch. Gain progression of X.1, X.3, and X1 are used to provide a total of 15 overlapping voltage ranges for the instrument. The output of the variable gain ac amplifier is passed through the heater of TC1 which generates a dc output proportional to the heating effect of its heater signal, regardless of the waveform shape. The null detector then amplifies the output of TC1 and provides a dc current through R_S and the heater element of TC2 which is proportional to the rms value of the ac current through the heater of TC1. The meter amplifier senses the voltage drop across R_S and the heater of TC2, amplifies the signal, and drives the meter and recorder output.

3-17. DIFFERENTIAL NULL MODE

3-18. By placing the MODE switches of Figure 3-3 to the NULL position, the instrument circuitry is connected as a differential rms voltmeter. On this mode of operation, the input amplifier operates the same as on the TVM mode and amplifies or attenuates the input ac signal. Gain of the variable gain ac amplifier is now controlled by feedback through the Readout dial network and is inversely proportional to the Readout dial settings. The resulting output of the variable gain ac

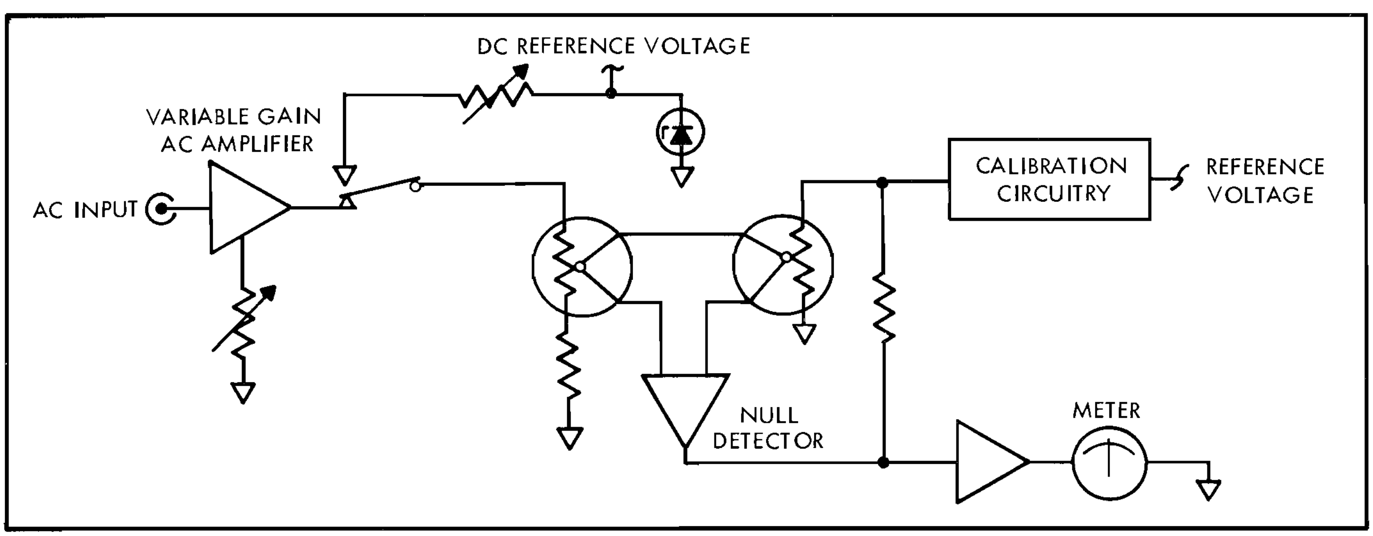


Figure 3-2. SIMPLIFIED MODEL 931B BLOCK DIAGRAM

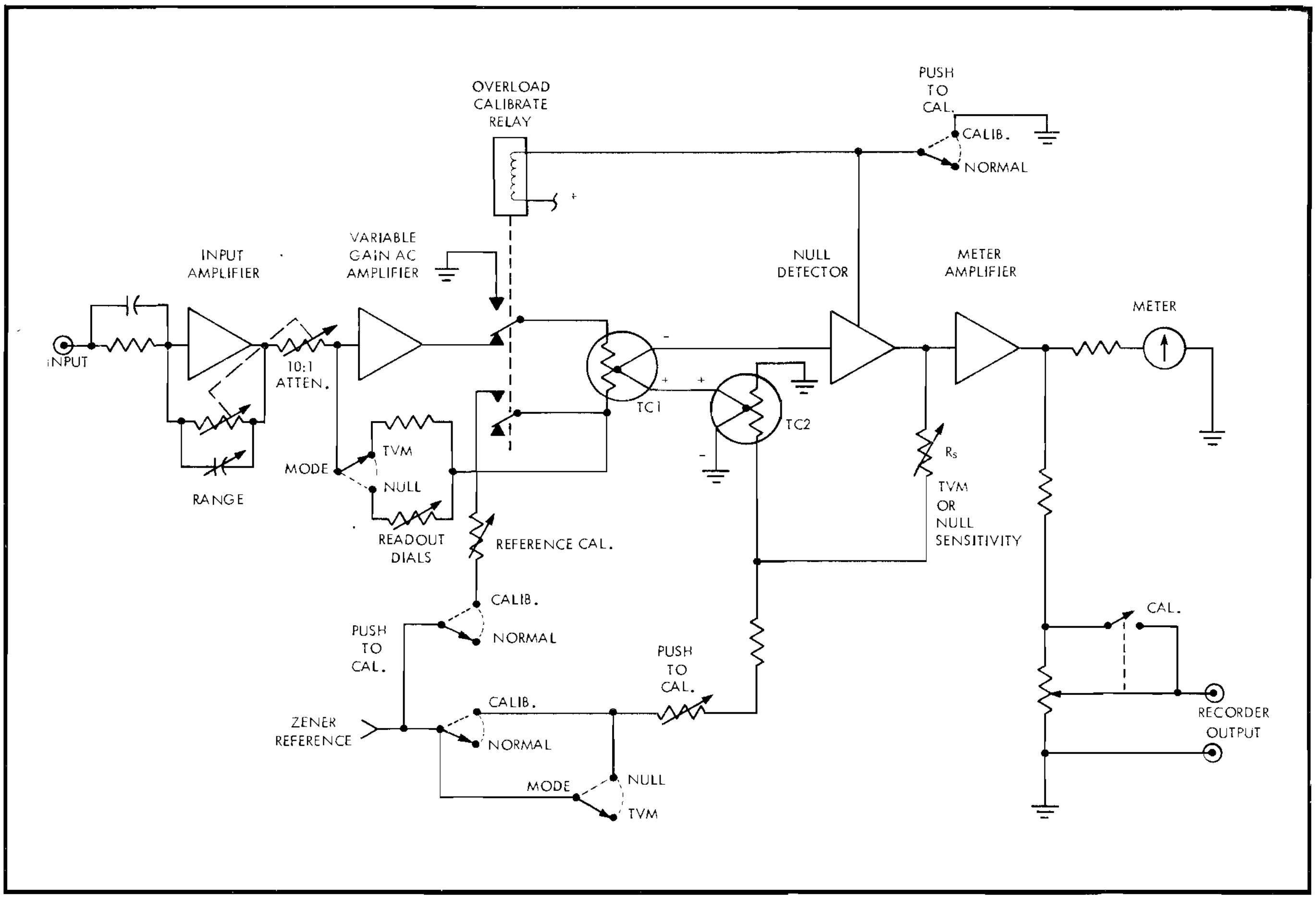


Figure 3-3. THE MODEL 931B FUNCTIONAL BLOCK DIAGRAM

amplifier is passed through the heater element of TC1 which generates a dc output that is in opposition to the established dc reference output of TC2. The dc reference for TC2 is derived from a zener reference voltage and the self-calibrate circuitry. The null detector then amplifies any resulting voltage difference between the two thermocouples and adds or subtracts a small amount of current to the reference current of TC2. The meter amplifier senses the polarity and magnitude of the voltage drop across R_S, amplifies the signal, and drives the meter and recorder output. The Readout dials are then adjusted until the output of TC1 matches the output of TC2 and a null condition is detected. The Readout dials digit indications are then directly proportional to the rms value of the measured ac signal.

3-19. CALIBRATION MODE

3-20. A characteristic of vacuum thermocouples is that their response tends to drift with time and temperature. Even though a pair of thermocouples may be carefully selected and matched, they drift independently and the accuracy with which comparisons are made is degraded.

3-21. The calibration circuitry contained in the Model 931B provides a means of adjusting the current flowing through the heater of TC2 until it matches a dc reference current that is passed through the heater of TC1. The dc reference current passed through the heater of TC1 during calibration is equal in heating effect to an ac current through its heater element when the Readout dials digit value is equal to the rms value of a measured ac voltage.

3-22. When the PUSH TO CAL control is depressed, the overload calibrate relay is energized, disconnecting the heater element of TC1 from the output of the variable gain ac amplifier and applying instead, a dc reference current through the heater of TC1. The null detector then detects any resulting difference between the outputs of TC1 and TC2 which is then displayed on the meter. The PUSH TO CAL control is then rotated to adjust the current through the heater of TC2 until a null is indicated on the meter and the output of TC2 matches the output of TC1.

3-23. CIRCUIT ANALYSIS

3-24. INTRODUCTION

3-25. The following paragraphs describe in detail the circuitry contained in the Model 931B. Functional schematic diagrams of the instrument circuitry are located at the rear of the manual.

3-26. INPUT AMPLIFIER

3-27. The Input Amplifier is comprised of five stages of direct coupled ac amplifiers forming an operational amplifier. Negative feedback networks are adjusted to be a precise multiple of the fixed R/C input network which result in the amplifier gain being a predictable inverse function of the selected RANGE.

3-28. Measured ac input voltages applied to the instrument are amplified or attenuated by the Input Amplifier comprised of Q101 through Q105. The input circuit of the amplifier is composed of R1 and C1 which maintains a high input impedance of one megohm shunted by less than seven pf. By placing this input R/C network in the probe on the probe version instruments, the input to the amplifier is effectively extended the length of the probe cable, thus eliminating the probe cable capacity. Overload protection for the Input Amplifier circuitry is provided by the diode CR101. Since the input summing junction is driven to zero volts by negative feedback, voltage excursions in excess of 0.7 volts constitute an overload and are shunted to ground by conduction of CR101. The input stage of Q101 is a field effect transistor (FET) utilized for its high input impedance and low noise features. The common-base stage of Q102 and the common-emitter stage of Q104 provide the necessary voltage gain of the input ac signal. Emitter followers Q103 and Q105 are used for impedance matching. Bias of Q102 and subsequently the remainder of the amplifier is adjusted with R105, adjustment H. High frequency compensation is provided by negative feedback from the collector of Q104 through C108 and the components selected by the RANGE switches S101C and S101D to the base of Q103. Bootstrap capacitor C110, located in the emitter-follower stage of Q103, provides for additional gain. External negative feedback networks selected by S101A and S101E control the forward gain of the Input Amplifier in 20 db decade steps. On the 100 MILLIVOLTS range, the feedback resistance R129 is selected, and the network compensated with C119. On the 1000 MILLIVOLTS range, the impedance of the selected feedback network is reduced to one-tenth the input impedance, resulting in one-tenth the forward gain. The 10 and 100 volt range feedback networks reduce the forward gain in a similar manner, thus providing four 10:1 steps of gain for the Input Amplifier. The 1000 volt range is provided by using the 100 volt range feedback network and passing the amplifier output through a 10:1 attenuator. The RANGE switch S101F provides the necessary circuit connections for the 10:1 attenuator comprised of R119 through R122. Variable resistor R121 provides calibration of the attenuation factor.

3-29. VARIABLE GAIN AC AMPLIFIER

3-30. The Variable Gain AC Amplifier is comprised of five stages of amplification forming an operational amplifier. Negative feedback, which is one of three fixed values on the TVM mode and a variable value on the NULL mode, controls the forward gain of the amplifier.

3-31. AC signals from the preceeding input amplifier are amplified by the Variable Gain AC Amplifier comprised of Q201 through Q207. The common-emitter stages of Q201 and Q203 provide the necessary voltage gain for the ac input signal. Emitter-followers Q202 and Q204 are used for impedance matching. The push-pull complementary amplifier stage of Q206 and Q207 provides a continuous ac signal through the normally closed contacts of K201 and the heater of TC1. Transistor Q205 establishes the bias level of the push-pull amplifier, and R222, adjustment P, provides symmetry adjustment. Variable resistor R204, adjustment M, provides bias adjustment for Q201 and subsequently the remainder of the amplifier circuitry. Low frequency compensation is provided by negative feedback from the emitter of Q204 to the emitter of Q201. Resistor R248 provides adjustment of the low frequency compensation. High frequency compensation is provided by negative feedback from the collector of Q203 through C206 and C207 to the base of Q202. External negative feedback networks, selected with the MODE switch S2E and S2F, control the forward gain of the amplifier. On the TVM mode, the value of the feedback network impedance is reduced by a factor of ten as the MODE switch progresses from X.1 to X1, resulting in a corresponding reduction in forward gain. During the NULL mode of operation, the feedback impedance is controlled by the Readout dial network and is inversely proportional to the Readout dial settings. The R/C networks in parallel with the heater element of TC1 provide overall frequency compensation for both the Input and Variable Gain AC Amplifiers. Compensation at 20 kHz is provided by selection of values for C218 and R233. Compensation at 500 kHz is provided by selection of values for C219 and R234.

3-32. VACUUM THERMOCOUPLES

3-33. Two differentially connected high vacuum thermocouples, designated TC201 and TC202, are used in the Model 931B to detect the rms value of the measured ac input signal. The heater element of TC201 is ac operated while the heater element of TC202 is dc operated.

3-34. TVM MODE. During the TVM mode of operation, the output of TC201 is amplified by the null detector which in turn produces a dc feedback current through the heater element of TC202 proportional to the rms value of the ac current through the heater element of TC201. This dc current flow through the heater of TC202 generates a voltage output opposing the output of T201. When the output of T202 equals the output of TC201, the null detector output and feedback is at a level proportional to the rms value of the measured ac signal, which is then indicated by the meter M1.

3-35. NULL MODE. On the NULL mode of operation, the heater element of TC202 is connected in series with the resistive network of R241 through R245 and R7 to a zener reference current of approximately 2 milliamperes by the MODE switch S2A. The output of the variable gain ac amplifier is then increased or decreased, as outlined in paragraph 3-31, until the output of TC201 is equal to the output of TC202. Deviations from the null condition are sensed by the null detector, whose output adds or subtracts slightly from the reference current through the heater element of TC202, to provide a meter indication of the deviation.

3-36. CALIBRATION. Upon initiation of the calibrate mode, the PUSH TO CAL switch S3 contacts are closed, performing the following functions:

a. S3A, located adjacent to the MODE switch S2B, places the null detector to maximum sensitivity.

b. S3B, located below the MODE switch S2D, places the meter amplifier bias to that of the NULL mode if the MODE switch is in any of its TVM positions.

c. S3C, located above the MODE switch S2A, applies a dc voltage to the heater element of TC202 derived from the reference zener if the MODE switch is in any of its TVM positions.

d. S3D, located adjacent to K201, applies a ground to the selenoid of K201 to energize the relay. K201A applies a ground to the heater of TC201, and K201B disconnects the heater of TC201 from the output of the variable gain ac amplifier.

e. S3E, located adjacent to the MODE switch S2C, disables the magnetic modulator zero suppression circuitry, if the MODE switch is in any of its TVM positions.

f. S3F, located above the MODE switch S2A, applies a dc voltage derived from the reference zener to the heater element of TC201.

The heater element of TC201 then receives a calibrated dc reference current, through the resistive divider of R235 through R240, which is equal in heating effect to an ac current when the Readout dial indications are equal to the rms value of a measured ac voltage. When the PUSH TO CAL switch contacts are closed, R7 is engaged and can be used to adjust the current through the heater of TC202 until its output matches the output of TC201. The null detector senses the output of the two thermocouples and causes the meter to indicate any unbalance between the two thermocouples. The PUSH TO CAL control is then rotated until the meter pointer indicates zero and the thermocouples are calibrated. The dc reference current for TC201 is calibrated with R236 and the selection of jumpers across R238 through R240. The dc current for TC202 is calibrated with R242 and R244.

3-37. NULL DETECTOR

3-38. The Null Detector is comprised of a magnetic modulator, a push-pull tuned-collector oscillator, a demodulator driver, a 5 kHz tuned-carrier amplifier, a synchronous demodulator, a dc amplifier and overload drive circuitry, and a meter amplifier.

3-39. PUSH-PULL TUNED-COLLECTOR OSCILLATOR. The Push-Pull Tuned-Collector Oscillator and Doubler, comprised of Q301 through Q303, Q308, and T301, produces a 2.5 kHz driving signal for the modulator, and a 5 kHz driving signal for the synchronous demodulator. Transistors Q301 and Q302 are connected in a push-pull tuned-collector configuration, thus providing a 2.5 kHz output to the modulator free from second-harmonic distortion. The tuned-collector circuit of T301 and C301 determines the oscillator operating frequency. Regenerate feedback is provided to the basis of Q301 and Q302 by the induced secondary voltages of T301. Capacitor C302 places the center-tapped secondary of T301 at ac ground. The 2.5 kHz signal induced in the associated output winding of T301 is applied to the magnetic modulator T302. Amplitude control of the output signal is provided by Q303, which peak detects drive current to the modulator across R303 and applies a control current to the basis of Q301 and Q302. Because the transistors Q301 and Q302 are connected in push-pull, their emitter signals developed across R313 are a full-wave rectified 2.5 kHz signal. Since this signal is unfiltered, it appears as a 5 kHz signal at the base of the demodulator driver Q308. Transistor Q308 amplifies the signal to provide a 5 kHz drive signal for the synchronous demodulator Q309.

3-40. MAGNETIC MODULATOR. The Magnetic Modulator consisting of T302 is a magnetic device using the principles of a saturable core to obtain amplification of the thermocouple outputs. Operation of the magnetic modulator is based upon the symmetrical saturation of the control winding by the 2.5 kHz driving signal from the push-pull tuned-collector oscillator. Absence of an input dc current through the control winding and the primary of T303 results in a minimum second-harmonic 5 kHz signal at T303. Presence of a control winding current unbalances the symmetrical saturation pattern, resulting in the generation of a 5 kHz signal in the primary of T303. The amplitude and phase of this 5 kHz signal is proportional to the magnitude and direction of the control winding current flow. Transformer T303 is tuned to 5 kHz and couples the resulting signal to the input of the 5 kHz tuned-carrier amplifier. Quick overload recovery is ensured due to the feedback through the windings associated with transistor zeners Q319 and Q320. The windings associated with Q306 provide suppression of less than 1/10 scale outputs from the magnetic modulator on the TVM mode of operation.

3-41. 5 kHz TUNED-CARRIER AMPLIFIER. The 5 kHz Tuned-Carrier Amplifier comprised of Q305 through Q307, L301, and T303 amplify the 5 kHz output of the magnetic modulator. Emitter feedback between Q307 and Q305 is used to prevent loading of the input circuitry. The tuned-series-resonate circuit of L301 and C306, located in the emitter circuit of Q305, provides frequency-sensitive negative-feedback from the emitter of Q307. At frequencies other than 5 kHz, the tuned circuit presents maximum impedance to the feedback signal and minimum gain for the carrier amplifier. At resonance, the tuned circuit impedance is minimum and maximum gain of the 5 kHz signal is provided.

3-42. SYNCHRONOUS DEMODULATOR. Transistor Q309 and R324 comprise a Synchronous Demodulator used to detect the amplitude and polarity information contained in the 5 kHz carrier signal. The Synchronous Demodulcator is driven in synchronism with the magnetic modulator driving signal. The resulting dc voltage is developed across R324 and filtered by C313 and R325 before being applied to the input of the dc amplifier.

3-43. DC AMPLIFIER. The DC Amplifier comprised of Q310 through Q314 provides sufficient gain of the dc voltage detected by the demodulator to drive the following meter amplifier. The differential pair of Q310 and Q311 amplify the input voltage at the base of Q310 in respect to ground. Additional amplification is provided with Q312 and Q313. Transistor Q314 provides a high impedance current drive at the amplifier output. During operation of the TVM mode, the output signal is developed across an output circuit comprised of CR1 which limits current flow in one direction through R10, R354 through R356, and the heater of TC202. Transistor zeners Q319 and Q320 function only on excessive inputs to provide quick overload recovery for the null detector. Resistor R356, adjustment W, provides adjustment of voltage developed from the magnetic modulator feedback. The voltage developed at the junction of R10 and R340 is then used to drive the following meter amplifier and indicate the magnitude of the measured ac signal. When the instrument is operated on the NULL mode, the diode CR1 is bypassed with the contacts of S2C to provide bi-directional current flow in the output circuit, and S2B places a shunt resistor of specified value in parallel with R354. Progression of the MODE switch from the 10% position to the .1% position results in an increase in shunt resistance and an increase in the meter amplifier input voltage. The meter then indicates that the ac current through the heater of TC201 is within the prescribed percent selected with the MODE switch. When the NULL DAMPING switch is placed to the 2 Hz-10 Hz position, during low frequency differential measurements with the instrument, capacitors C320 and C321 provide filtering of the shunt resistor voltage excursions to damp the meter indication.

3-44. OVERLOAD DRIVE CIRCUITRY. The Overload Drive Circuitry comprised of CR303, Q315, Q316, and K201 is used to prevent a shift in the ac thermocouple characteristics due to an excessive heater current. Consequently, ac input voltages of 1500 volts peak on any range will not affect the measurement accuracy of the instrument.

3-45. When the output voltage of the dc amplifier reaches approximately ten volts dc, diode CR303 conducts and forward biases the emitter-to-base junction of Q315. Conduction of Q315 also biases Q316 into conduction, which energizes the relay K201. With relay K201 energized, the input to the heater of TC201 is removed and excessive heating of the thermocouple is prevented. Upon the removal of the TC201 heater signal, the output of the thermocouples decreases, resulting in a decrease in the output of the dc amplifier. Diode CR303 is reversed-biases by this action, which in turn causes Q315 and Q316 to be driven into cut-off. Relay K201 is de-energized upon cut-off of Q316, and the ac signal is re-applied to the heater of TC201. If the overload condition persists, the overload relay will continue to energize and de-energize, thus preventing excessive heating of TC201.

3-46. METER AMPLIFIER. The Meter Amplifier comprised of Q317, Q318, Q321, and Q322 provides sufficient gain of the dc amplifier output to drive the front panel meter and recorder output circuitry. The differential pair of Q317 and Q318 amplify the input signal at the base of Q317 in respect to the base voltage of Q318. On the TVM mode of operation, negative feedback from the amplifier output is applied to the base of Q318. On the NULL mode, S2D provides a fixed-bias voltage at the base of Q318 to increase the amplifier operating point. Transistors Q321 and Q322 provide the required amplification of the output dc voltage used to drive the meter and recorder output circuitry. Resistor R342, adjustment V, provides adjustment of the differential-pair emitter voltages and subsequently the meter zero indication on the TVM mode. Resistor R347, adjustment X, provides adjustment of the base voltage for Q318 to allow Meter Amplifier zeroing on the NULL mode.

3-47. RECORDER OUTPUT CIRCUITRY

3-48. The Recorder Output Circuitry provides a dc output, adjustable from zero to one volt dc for a full-scale meter deflection, which can be used to drive a zero-center recorder or enable the instrument to be used as an rms to dc converter.

3-49. The recorder output voltage is developed across a divider network comprised of R361 through R363 and R38. Resistor R38 provides a means of adjusting the recorder output voltage from the rear panel. Switch S7 provides selection of a calibrated one volt full-scale output or a variable output. Rotation of R38 to its fully clockwise position places S7 to the CAL position to provide the calibrated recorder output. Rotation of R38 in the counter-clockwise direction places S7 to the VAR position, allowing adjustment of the recorder output voltage with R38. Resistor R362, adjustment Z, provides adjustment of the calibrated recorder output voltage.

3-50. REGULATED POWER SUPPLIES

3-51. The Regulated Power Supplies provide the ±14.5 volt dc operating voltages used throughout the Model 931B. Line regulation of the power supplies is better than 0.0005% for a 10% line voltage change.

3-52. Input power transformer T1 receives 115 volts ac or 230 volts ac, at 50 to 440 Hz, through the contacts of the POWER switch S1. The primary winding of T1 is constructed in such a manner to utilize 115 volts ac input, windings in parallel, or 230 volts ac, windings in series. Fuse F1 protects the instrument circuitry from overloads. The secondary voltage of T1 is half-wave rectified by CR104 and CR105 to provide the ±22 unregulated dc input voltages to the ±14.5 volt dc regulators. The positive rectifier output voltage is filtered by C122, R132, and C123 before being applied to the +14.5 volt dc regulator. The negative rectifier output voltage is filtered by C124, R133, and C125 before being applied to the -14.5 volt dc regulator. Input power to the regulators is supplied from the batteries BT1 and BT2 on instruments equipped with the -01 Option whenever the POWER switch is placed to the BAT OPR or BAT CHK position. Refer to Section VI for information concerning the options available with this instrument.

3-53. POSITIVE DC REGULATOR. The input dc voltage applied to the series-pass transistor Q109 is reduced to +14.5 volts dc and regulated in the following manner. A voltage proportional to the output voltage is developed at the base of differential amplifier Q114 by voltage divider R142, R143, and R144. A zener reference voltage established by CR106 is applied to the base of Q115, which is the other portion of the differential amplifier. Output voltage variations in respect to the zener reference voltage are then amplified and appear as an error signal at the collectors of Q114 and Q115. This error signal is amplified by the differential amplifier comprised of Q111 and Q112 and the output of Q111 used to control the conduction level of the series-pass transistor Q109. Variable resistor R143, adjustment L, provides setting of the regulator output voltage. Transistor Q106 is in the circuit to ensure that Q109 will initially conduct to provide the regulator operating voltages. Once Q109 conducts, Q106 is reversed-biased and effectively disconnected from the circuit. The value of R150 is factory selected to provide optimum current through CR106, thereby establishing a constant reference voltage for the regulator and the thermocouples used in the instrument.

3-54. NEGATIVE DC REGULATOR. The input voltage applied to the series-pass transistor Q108 is reduced to -14.5 volts dc and regulated in the following manner. A voltage proportional to the output voltage is developed at the base of amplifier Q110 by the divider R141 and R140. Output voltage variations are then amplified by Q110 and appear as an error signal at the base of Q107. The error signal is amplified by Q107 and the resulting Q107 collector signal used to control the conduction of the series-pass transistor Q108. Transistor Q113 is in the circuit to ensure that Q108 will initially conduct to provide the regulator operating voltages. Once Q108 conducts, Q113 is reversed-biased and effectively disconnected from the circuit.

SECTION IV

MAINTENANCE

4-1. INTRODUCTION

4-2. This manual section contains the information necessary for you to completely maintain your Model 931B RMS Differential Voltmeter. The information is contained under headings of "SERVICE INFORMATION, MAINTENANCE ACCESS, GENERAL MAINTENANCE, CALIBRATION PROCEDURES, TROUBLESHOOTING, and SELECTION OF COMPENSATING COMPONENTS." A list of the test equipment required for maintenance of this instrument is contained in Figure 4-1. If the recommended test equipment is not available, other instruments having equivalent specifications may be substituted.

4-3. Your instrument was completely tested and aligned before leaving the factory and should not require calibration during the first 90 days of operation. Should you wish to check the accuracy of the Model 931B against the specifications contained in Section I, the information contained in the Calibration Procedures (paragraphs 4-28 through 4-61) may be used. The Calibration Procedures are presented in such a manner, that by disregarding the adjustment information, they may serve as Instrument Performance Checks.

4-4. We recommend that you thoroughly read and understand this section of the manual before attempting any maintenance on your instrument.

4-5. SERVICE INFORMATION

4-6. Each instrument manufactured by the John Fluke Mfg. Co., Inc. is warranted for a period of one year upon delivery to the original purchaser. Complete warranty information is contained in the Warranty page located at the rear of this manual.

4-7. Factory authorized calibration and repair service for all Fluke instruments are available at various world wide locations. A complete list of factory authorized service centers is located at the rear of this manual. If requested, an estimate will be provided to the customer before any repair work is begun on instruments beyond their warranty period.

4-8. MAINTENANCE ACCESS

4-9. INTRODUCTION

4-10. The following procedures are to be used to gain access to various portions of the Model 931B. Normally it will only be necessary to perform the first procedure titled "ACCESS TO CALIBRATION ADJUSTMENTS" during the calibration of the instrument. However, if troubleshooting and repair of the instrument is required, access to particular portions of the circuitry is facilitated using the remaining procedures.

4-11. ACCESS TO CALIBRATION ADJUSTMENTS

4-12. To gain access to adjustment and compensating components contained in the instrument, proceed as follows:

a. Remove the six upper rear dust cover attaching screws and then slide the cover toward the rear of the instrument to remove it from the Model 931B.

b. Remove the eight left and right side panel attaching screws and remove the panels from the instrument. Access to all adjustments and the Variable Gain AC Amplifier compensating network components is now provided.

c. If compensation of the Input Amplifier circuitry is necessary, remove the two mounting screws from the labeled adjustment cover located on the left side of the instrument and remove the cover.

4-13. DIGIT ATTENUATOR ACCESS

4-14. To gain access to the Digit Attenuator, and other lower chassis components, proceed as follows:

EQUIPMENT	SPECIFICATIONS	RECOMMENDED INSTRUMENT
Oscillator	Frequency range of 10 Hz to 5 MHz. Short term stability of ±50 ppm/ min.	Hewlett Packard Model 651B
Function Generator	Square and sine wave output of 1 Hz to 50 kHz. Short term stability of ±50 ppm/min.	Hewlett Packard Model 3300A
AC Amplifier	Frequency range of 500 Hz to 800 kHz. Gain stability of ±50 ppm/min.	Krohn - Hite Model DCA - 10
Thermal Transfer Standard	AC to DC transfer accuracy of ±0.01% 5 Hz to 1 MHz, at voltages of 0.1 to 100 volts rms.	Fluke Model 540B with test report
DC Voltage Calibrator	Calibration accuracy of ±0.002%	Fluke Model 332B
DC Voltmeter	DC accuracy of ±0.2% (±0.005% if the Model 332B is not used).	Fluke Model 871A with 10k isolation probe.
50-Ohm Load	Resistive load	Tektronix 001-0049-00
Ratio Transformer	Accuracy of 1 to 10 ppm at 1 kHz	Gertsch Model 1011
Oscilloscope Plug In Unit	Calibrated sweep range: 1 msec/cm to 50 msec/cm Vertical sensitivity 50 mv/cm	Tektronix Model 545A with probe 1A1
Frequency Counter	Must be able to measure 2.5 kHz with an accuracy of 0.1% ± count.	Hewlett Packard Model 5245L
Autotransformer	0-135 volts ac up to 3 ampere	General Radio Model W5MT
Multimeter	AC and DC voltage, AC and DC current and resistance measurements with and accuracy of ±3%.	Fluke Model 853A
Voltage Divider	Minimum reactance at 5 MHz constructed of conformal coated metal film resistors	453 ohms, ±1%, 1/2 watt, 49.9 ohms, ±1%, 1/2 watt, 56.2 ohm, 1%, 1/2 watt

Figure 4-1. REQUIRED TEST EQUIPMENT

a. Remove the four bottom dust cover attaching screws.

b. Slide the cover toward the rear of the instrument and then remove the cover. Access to the Digit Attenuator, optional battery pack, ac power connector, recorder output components, and Readout dials is now provided.

4-15. RANGE SWITCH ACCESS

4-16. To gain access to the RANGE switch, proceed as follows:

a. Remove the upper dust cover using the procedure described in paragraph 4-12 step a.

b. Locate the Input Amplifier shield installed in the front left-hand corner of the instrument.

c. Remove the three shield mounting screws and remove the shield from the instrument. Access to the RANGE switch is now provided.

4-17. MODE SWITCH ACCESS

4-18. To gain access to the MODE switch, proceed as follows:

a. Remove the upper rear dust cover and right side panel from the instrument using the procedures contained in paragraph 4-12.

b. Remove the Null Detector PCB mounting screws and remove the PCB from the instrument. The PCB connecting wires are of sufficient length to allow removal of the PCB without disconnecting the wires. Access to the MODE switch is now provided.

4-19. PUSH TO CAL SWITCH ACCESS

4-20. To gain access to the PUSH TO CAL switch and other front panel components, proceed as follows:

a. Loosen the front panel control knob allen set-screws and remove the knobs from the instrument.

b. Remove the four attaching screws from the narrow side panels and remove the panels from the instrument.

c. Remove the six front panel corner attaching screws and slide the front panel forward slightly.

d. Disconnect the red and black INPUT wires located in the upper left corner of the front panel.

e. Slide the front panel forward until free of the instrument. Access to the PUSH TO CAL switch, POWER switch, Readout dials, input resistor R1, and the meter is now provided.

f. To gain access to R1, remove the two mounting screws from the cover located in the front left hand corner of the instrument and remove the cover.

Note!

Resistor R1 is located in the probe on the probe version instruments.

4-21. GENERAL MAINTENANCE

4-22. PERIODIC CLEANING

4-23. If it becomes necessary to clean the exterior of the instrument, use a cloth moistened with anhyndrous alcohol or Freon T. F. Degreaser, MS180 Miller-Stephenson Chemical Co., Inc. If either of these cleaning agents are not readily available, soap and water applied sparingly to a cloth, can be used to clean the exterior of the instrument.

4-24. The Model 931B is completely enclosed. Therefore, entry for dust, dirt, or lint to the interior of the instrument is not provided. However, if it becomes necessary to clean the interior of the instrument, a hot rinse, using distilled or deionized water, followed by a thorough drying should be used. Drying temperatures in excess of 160° F should be avoided.

CAUTION!

The use of solvents, particularly keytones, is not recommended because of the possible damage to dielectric materials used in the instrument.

4-25. FUSE REPLACEMENT

4-26. The only fuse in the Model 931B is located in a bayonet fuse holder mounted on the rear panel of the instrument. Correct values of this fuse for a 115 or 230 volt power line are as follows:

115 volt ac power line - 1/4A, AGC, fast acting
230 volt ac power line - 1/8A, AGC, fast acting

4-27. If your instrument contains a -01 or 03 option, additional fuses, F2 and F3, are installed in the rechargeable battery circuitry and protect the instrument's circuitry from overloads. Refer to the Section VI Option Information section for information pertaining to these fuses.

4-28. CALIBRATION PROCEDURES

4-29. INTRODUCTION

4-30. The Model 931B should be checked for calibration every 90 days or whenever repairs have been made to portions of the circuitry which will affect the calibration accuracy. In the event that the desired results of the calibration adjustments cannot be obtained, directions to the appropriate TROUBLESHOOTING or COMPENSATING paragraphs are given to enable rapid correction of the discrepancy.

4-31. Calibration of the instrument should be performed at an ambient room temperature of 71° F to 76° F (21.7° C to 24.4° C). Adjustment and test-point locations are illustrated in Figure 4-2.

4-32. CALIBRATION SIGNALS

4-33. Calibration of the Model 931B requires a 0.1 to 100 volt rms signal at frequencies of 2 Hz, 5 Hz, 500 Hz,

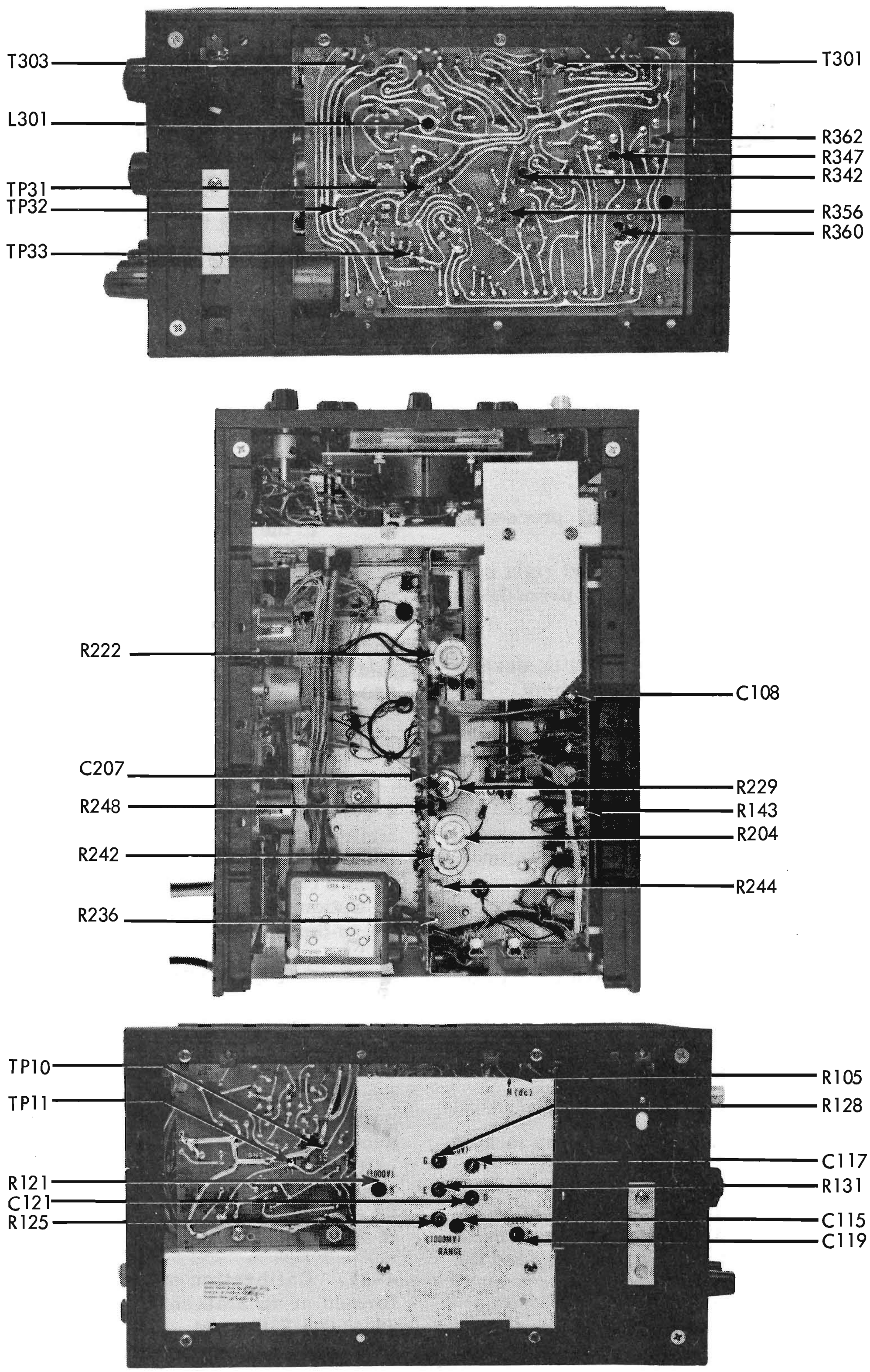


Figure 4-2. ADJUSTMENT AND TEST POINT LOCATIONS

20 kHz, 500 kHz, and 5 MHz. An ac source such as the one illustrated in Figure 4-3 can be used to obtain calibrated 1.0 to 100 volt rms signals, accurate to within ±0.01%, at frequencies from 5 Hz to 500 kHz. The 5 MHz 0.1 and 1.0 volt rms signals, accurate to within ±5%, can be obtained directly from the output of the oscillator described in Figure 4-1. A calibrated 0.1 volt rms signal, accurate to within ±0.01%, at frequencies of 20 kHz, 50 kHz, and 500 kHz can be obtained using the equipment connections and 10:1 divider illustrated in Figure 4-4 and performing the following steps:

a. Calibrate the Model 931B voltage ranges using the procedures described in paragraph 4-50 steps a through q.

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

Note!

The 10:1 divider output must be placed as close as possible to the Model 931B INPUT or loading of the divider by the connecting cable will occur.

c. Set the oscillator output frequency to 500 Hz and adjust its output level to obtain a null on the 100 MILLIVOLT differential mode of the Model 931B.

d. Perform a thermal transfer, adjusting only the output of the dc power supply. The dc power supply output is now set to provide an ac-dc transfer that will produce the desired 20 kHz, 50 kHz or 500 kHz 0.1 volt rms signal at the output of the 10:1 divider.

4-34. A calibrated one volt rms signal, accurate to within ±0.5%, at a frequency of 2 Hz can be obtained using the equipment connections illustrated in Figure 4-5 and performing the following steps:

a. Set the dc power supply output to 1.414 volts dc.

b. Set the oscilloscope input to dc and its vertical sensitivity to maximum.

c. Set the output frequency of the signal generator to 20 Hz and adjust the signal level to obtain a one volt rms indication on the Model 931B.

d. Adjust the oscilloscope vertical positioning control to intersect the positive peaks of the oscilloscope waveform with the CRT center grid line.

e. Change the signal generator output frequency to 2 Hz and adjust its output level until the positive peaks of the oscilloscope waveform intersect the CRT center grid line.

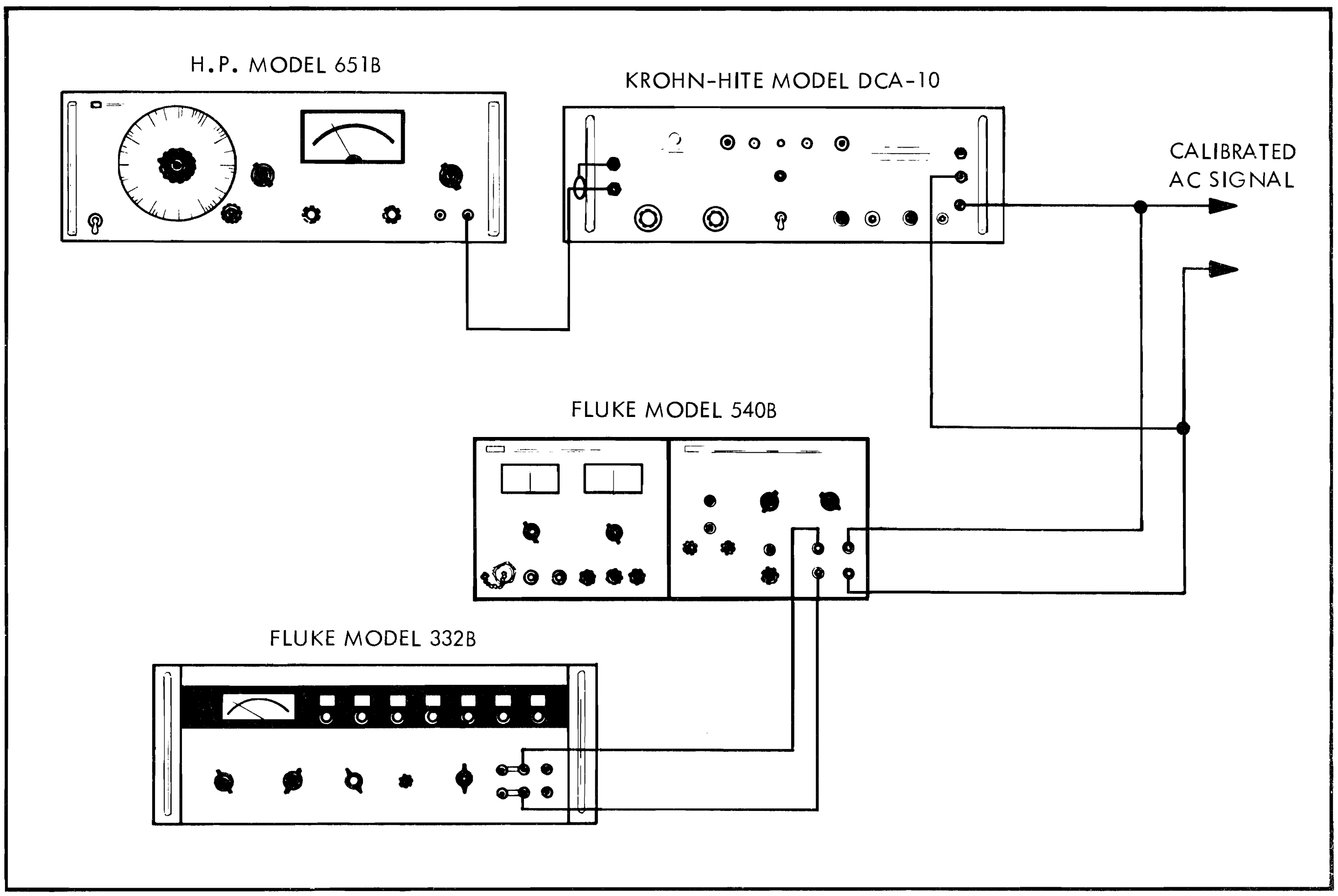


Figure 4-3. 5 Hz TO 500 kHz AC CALIBRATION SOURCE

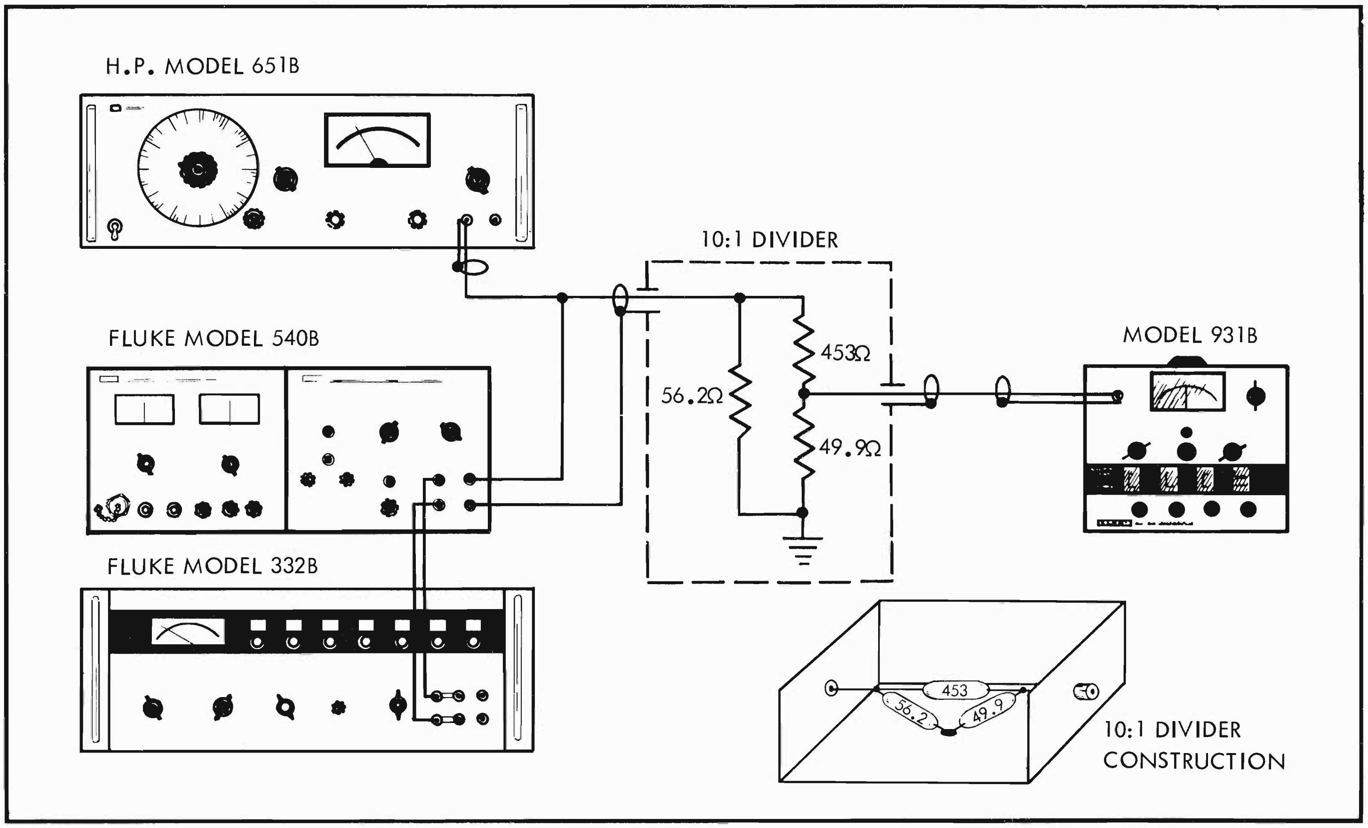


Figure 4-4. 20 kHz TO 500 kHz 0.1 VOLT RMS AC CALIBRATION SOURCE

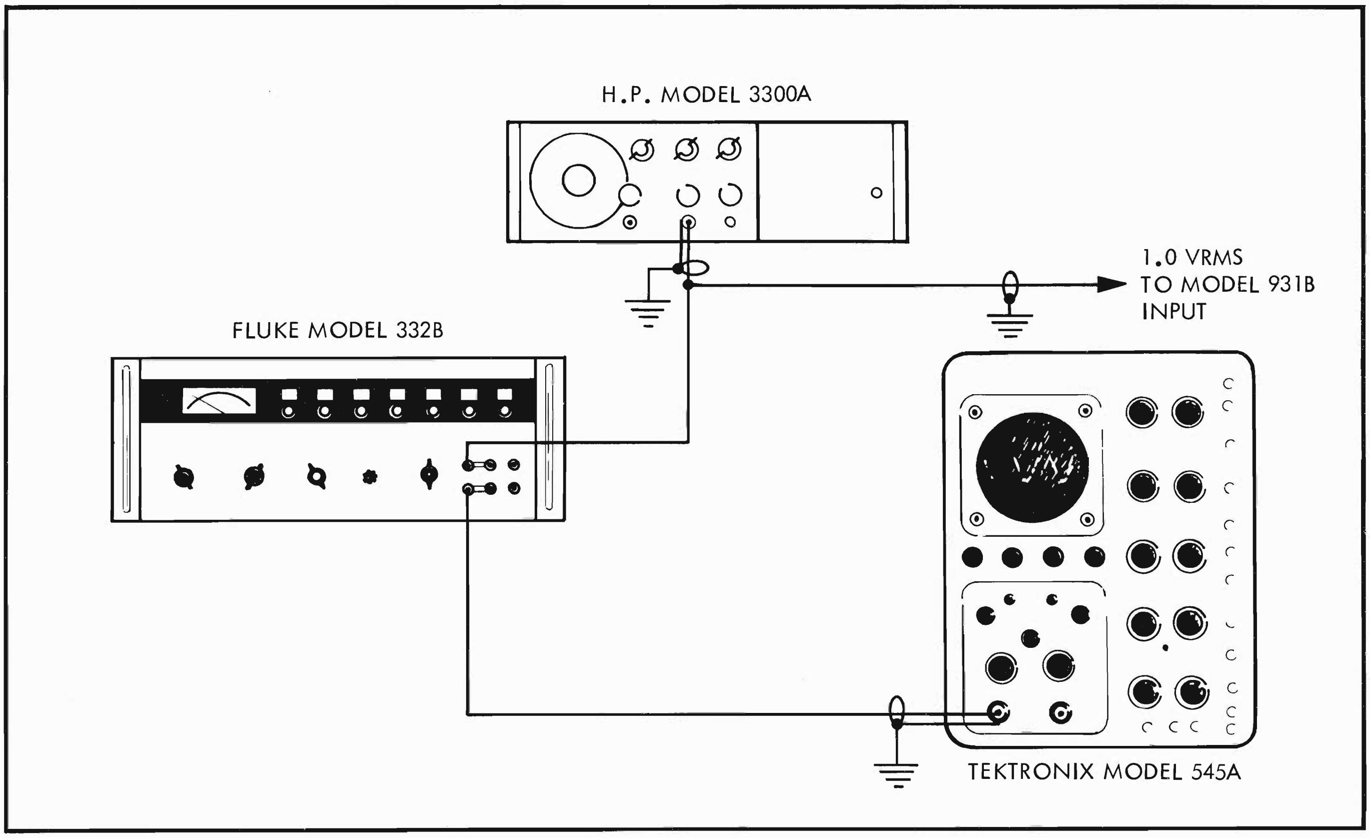


Figure 4-5. 2 Hz AC CALIBRATION SOURCE

f. A one volt rms signal at 2 Hz is now available at the input of the Model 931B.

4-35. METER ZERO CHECK

4-36. With power removed from the Model 931B, proceed as follows:

a. Position the instrument horizontally (normal position) on the bench.

b. Adjust the meter mechanical zero screw, accessible from the front panel, until the meter pointer is at zero position. Back off the screw adjustment just enough to disengage the adjustment cam once the zero indication is obtained.

4-37. POWER SUPPLY CHECKS

4-38. The Power Supply Checks require the use of an autotransformer, an ac voltmeter, and a dc differential voltmeter. If the desired results of the following checks are not obtained, troubleshooting information is contained in paragraphs 4-67 through 4-69. To perform the checks, proceed as follows:

a. Remove the upper rear dust cover and side panels from the instrument and make the equipment connections illustrated in Figure 4-6.

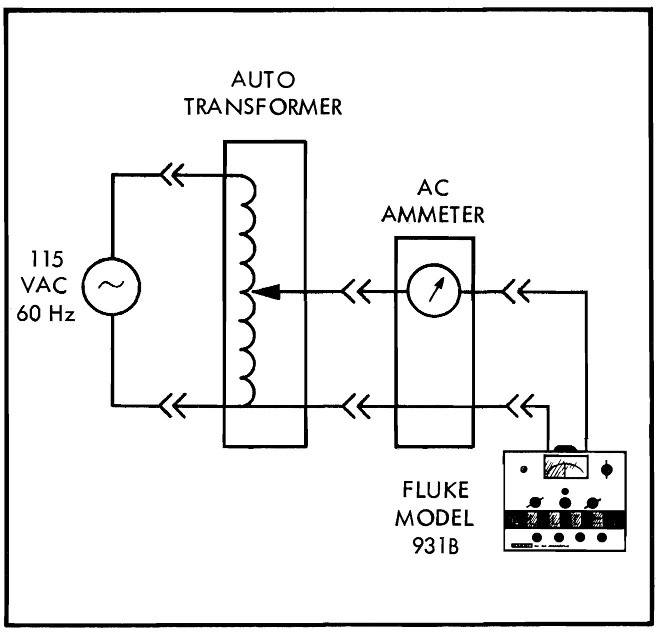


Figure 4-6. POWER SUPPLY CHECKS EQUIPMENT CONNECTIONS

b. Place the Model 931B controls to the following positions:

POWER	ON
MODE	NULL 10%
RANGE	100 MILLIVOLTS
NULL DAMPING	10 Hz - 2 MHz
Readout dials	0 0 0 07

c. Apply 115 volts, 50 to 440 Hz, through the autotransformer to the Model 931B.

d. Connect the input lead of the dc differential voltmeter to TP10 and the common lead to the nearest GRD point.

e. Adjust R143, adjustment L, until the voltage at TP10 is +14. 5 ±0. 004 volts dc.

f. Reduce the ac input voltage to 103. 5 volts ac with the autotransformer control. The voltage observed on the dc differential voltmeter should not vary.

g. Increase the ac input voltage to 126. 5 volts ac with the autotransformer control. The voltage observed on the dc differential voltmeter should not vary.

h. Return the ac input voltage to 115 volts ac with the autotransformer control.

i. Connect the dc differential voltmeter input to TP11, observing that the voltage is -13. 9 to -14. 6 volts dc.

j. Repeat steps f through h.

4-39. When the results of these checks agree with the information given, the power supplies contained in the instrument are functioning properly and the following calibration procedures can be performed.

4-40. AMPLIFIER BIAS CHECKS

4-41. The Amplifier Bias Checks require only the use of a dc differential with a 10K ohm isolation probe, which can be constructed as illustrated in Figure 4-7. If the results of the following checks cannot be obtained, troubleshooting information is contained in paragraphs 4-70 through 4-72. To perform the checks, proceed as follows:

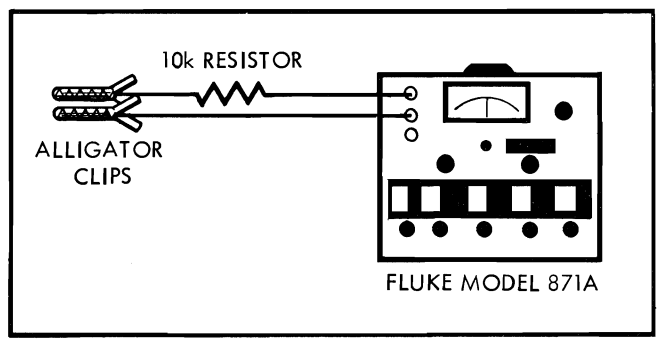


Figure 4-7. 10K ISOLATION PROBE

a. Place the Model 931B controls to the following positions:

POWER	ON
MODE	TVM X1
RANGE	100 MILLIVOLTS
NULL DAMPING	10 Hz - 2 MHz
Readout dials	10 00 00

b. Connect the input of the dc differential voltmeter to TP25 and its common lead to the nearest GRD point.

c. Adjust R105, adjustment H, until the voltage at TP25 is 0 ±0.02 volts dc.

d. Connect the dc differential voltmeter input to TP20 and adjust R204, adjustment M, until the voltage at TP20 is between +3.5 to +4 volts dc. This adjustment has a long time constant and will require patience.

e. Connect the dc differential voltmeter input to TP22 and adjust R222, adjustment P, until the voltage at TP22 is 0 ±0.02 volts dc.

4-42. When the results of these checks agree with the information given, the amplifier bias voltages are within tolerance and the following calibration procedures can be performed.

4-43. MODE SENSITIVITY CHECKS

4-44. The Mode Sensitivity Checks require the use of calibrated ac source, a ratio transformer, and a dc differential voltmeter. If the desired results of the following checks cannot be obtained, troubleshooting information is contained in paragraphs 4-70 through 4-72. To perform the checks, proceed as follows:

a. Place the Model 931B controls to the following positions:

POWER	ON
MODE	TVM X1
RANGE	100 MILLIVOLTS
NULL DAMPING	10 Hz - 2 MHz
RECORDER OUTPUT ADJUST	CAL
Readout dials	10 00 0

b. Connect the dc differential voltmeter input and common leads to the Model 931B RECORDER OUTPUT terminals.

c. Adjust R342, adjustment V, for a RECORDER OUTPUT of 0 ±0.5 millivolts.

d. Apply a 1 volt rms 500 Hz signal, from a calibration source, to the input of the ratio transformer.

e. Set the ratio transformer controls to provide an output voltage of 100 millivolts rms.

f. Apply the ratio transformer output to the Model 931B INPUT and place the MODE switch to the NULL .1% position.

g. Adjust R242 and R244 or the ac calibration source output for a zero meter indication ± one major division. Maximum allowable meter fluctuation is ± three small divisions.

h. Place the MODE switch to the NULL 10% position and adjust R347, adjustment X, for a RECORDER OUTPUT of 0 ±2 millivolts.

i. Set the ratio transformer controls to provide an output voltage of 110 millivolts and adjust R362, adjustment Z, for a RECORDER OUTPUT voltage of 1.0 ±0.002 volts dc.

j. Place the MODE switch to the TVM X1 position and set the ratio transformer controls to provide an output voltage of 100 millivolts.

k. Adjust R356, adjustment W, for a RECORDER OUTPUT voltage of 1.0 ±0.001 volts dc.

l. Repeat steps i through k until the specified results are simultaineously obtained.

m. With the RECORDER OUTPUT voltage at 1.0 ±0.001 volts dc from step k, adjust R360, adjustment Y, for a full-scale meter indication of 1 within ±1/2 of a small division.

4-45. When the results of these checks agree with the information given, the null detector and meter amplifier circuitry contained in the instrument are functioning properly, and the following calibration procedures can be performed.

4-46. 5 MHz RESPONSE CHECKS

4-47. The 5 MHz Response Checks require the use of a 5 MHz signal generator and a 10:1 divider. If the desired results of the following checks cannot be obtained, troubleshooting information is contained in paragraph 4-70 through 4-72. To perform the checks, proceed as follows:

a. Place the Model 931B controls to the following positions:

POWER	ON
MODE	TVM X1
RANGE	1000 MILLIVOLTS
NULL DAMPING	10 Hz - 2 MHz
Readout dials	10 0 0.0

b. Apply a 1.0 ±0.05 volt rms 5 MHz signal to the INPUT of the Model 931B.

c. Adjust C207, adjustment N, for the following meter indications:

BNC INPUT	PROBE INPUT
0.96 (±0.04 volts)	0.92 (±0.04 volts)

d. Place the RANGE switch to 100 MILLIVOLTS and apply a 1.0 ±0.05 volt rms 5 MHz signal to the input of a 10:1 divider.

e. Apply the 0.1 volt rms 5 MHz output of the 10:1 divider to the INPUT of the Model 931B. The 10:1 divider output must be directly connected to the Model 931B INPUT or loading of the divider will occur.

f. Adjust C108, adjustment J, for the following meter indications:

BNC INPUT	PROBE INPUT
0.92 (±0.04 volts)	0.88 (±0.04 volts)

4-48. When the results of these checks agree with the information given, the amplifier 5 MHz response is within tolerance and the following calibration procedures can be performed.

4-49. RANGE CHECKS

4-50. The Range Checks require the use of a calibrated ac source and a ratio transformer. If the desired results of the following checks are not obtained, troubleshooting or compensating adjustment information is contained in paragraphs 4-70 through 4-72 and paragraphs 4-79 through 4-87, respectively. To perform the checks, proceed as follows:

a. Place the Model 931B controls to the following positions:

POWER	ON
MODE	NULL .1%
RANGE	100 MILLIVOLTS
NULL DAMPING	10 Hz - 2 MHz
Readout dials	10 0.0 0

b. Apply a 10 volt rms 500 Hz signal, from a calibration source, to the input of the ratio transformer.

c. Set the ratio transformer controls to the positions that provide an output voltage of 0.1 volts rms.

d. Apply the ratio transformer output to the INPUT of the Model 931B and adjust R242 and R244 or the ac calibration source output for a meter indication of zero.

e. Place the RANGE switch to the 1000 MILLIVOLTS position and set the ratio transformer controls to provide an output voltage of 1.0 volt rms.

f. Adjust R125, adjustment C, for a meter indication of zero ±1.5 small divisions.

g. Place the RANGE switch to the 10 VOLTS position and set the ratio transformer controls to provide an output voltage that is equal to its input.

h. Adjust R131, adjustment E, for a meter indication of zero ±1.5 small divisions.

i. Set the ratio transformer controls to provide an output voltage of 0.1 volts rms.

j. Place the RANGE switch to the 100 MILLIVOLTS position, observing that a meter indication of zero ± two small divisions is obtained. If the desired result is not observed, repeat steps a through h.

k. Place the RANGE switch to the 10 VOLTS position.

l. Apply a 100 volt rms 500 Hz signal to the input of the ratio transformer and set the ratio transformer controls to provide an output voltage of 10 volts rms. If necessary, adjust the calibration source output level to obtain a meter indication of zero within ±1.5 small divisions on the Model 931B.

m. Place the RANGE switch to the 100 VOLTS position and set the ratio transformer controls to provide an output voltage that corresponds to its input.

n. Adjust R128, adjustment G, for a meter indication of zero ±1.5 small divisions.

o. Place the RANGE switch to the 1000 VOLTS position and set the Readout dials to 1 0 0. 0

p. Adjust R121, adjustment K, for a meter indication of zero ±1.5 small divisions.

q. Set the Readout dials to 10 0 0. 0 and repeat step m, observing that a meter indication of zero ± two small divisions is obtained. If the desired result is not observed, repeat steps m through q.

r. Apply the 50 kHz rms voltages on the ranges indicated in Figure 4-8 to the INPUT of the Model 931B and adjust the associated capacitor for a meter indication of zero ±1.5 small divisions.

50 kHz RMS INPUT VOLTAGE	MODEL 931B RANGE	ADJUSTMENT
100 mv	100 MILLIVOLTS	C119 - A
1000 mv	1000 MILLIVOLTS	C115 - B
10 v	10 VOLTS	C121 - D
100 v	100 VOLTS	C117 - F

Figure 4-8. 50 kHz RANGE ADJUSTMENTS

s. Perform the frequency response checks of Figure 4-9, observing that the specified zero meter indications are obtained.

4-51. When the results of these checks agree with the information given, the input ranges of the Model 931B are correctly calibrated, and the following calibration procedures can be performed.

4-52. DIGIT RATIO CHECKS

4-53. The Digit Ratio Checks require the use of a calibrated ac source and a ratio transformer. If the desired results of the following checks cannot be obtained, troubleshooting information is contained in paragraphs 4-76 through 4-78. To perform the checks, proceed as follows:

a. Place the Model 931B controls to the following positions:

MODEL 931B RANGE	INPUT RMS VOLTAGE	METER ZERO TOLERANCES 20 kHz (small divisions)	500 kHz (major divisions)
100 MILLIVOLTS	100 mv	±7.5 (.1% NULL)	±8 (1% NULL)
1000 MILLIVOLTS	1000 mv	±7.5 (.1% NULL)	±8 (1% NULL)
10 VOLTS	10 v	±7.5 (.1% NULL)	±8 (1% NULL)
100 VOLTS	100 v	±7.5 (.1% NULL)	±8 (1% NULL)

Figure 4-9. FREQUENCY RESPONSE CHECKS

POWER	ON
MODE	NULL .1%
RANGE	10 VOLTS
NULL DAMPING	10 Hz - 2 MHz
Readout dials	8.0 0 0

b. Apply a 10 volt rms 500 Hz signal, from a calibration source, to the input of the ratio transformer.

c. Apply the ratio transformer output to the Model 931B INPUT.

d. Perform the checks indicated in Figure 4-10.

MODEL 931B READOUT DIAL SETTING	RATIO TRANSFORMER SETTINGS	METER INDICATION
8.0 0 0	8 0 0 0 0	Set to 0*
4.0 0 0	4 0 0 0 0	0 ± .010
2.0 0 0	2 0 0 0 0	0 ± .015
1.0 0 0	1 0 0 0 0	0 ± .020
1.0 0 0	1 0 0 0 0	Set to 0*
1.1 0 0	1 1 0 0 0	0 ± .010
1.2 0 0	1 2 0 0 0	0 ± .010
1.4 0 0	1 4 0 0 0	0 ± .010
1.8 0 0	1 8 0 0 0	0 ± .010
1.0 0 0	1 0 0 0 0	Set to 0*
1.0 1 0	1 0 1 0 0	0 ± .010
1.0 2 0	1 0 2 0 0	0 ± .010
1.0 4 0	1 0 4 0 0	0 ± .010
1.0 8 0	1 0 8 0 0	0 ± .010
1.0 1 0	1 0 1 0 0	Set to 0*
1.0 0 10	1 0 0 1 0	Set to 0 R229(Q)
1.0 0 5	1 0 0 5 0	0 ± .010
1.0 0 1	1 0 0 1 0	0 ± .010

*Adjust R242 and R244 or ac calibration source.

Figure 4-10. DIGIT RATIO CHECKS

4-54. When the results of these checks agree with the information given, the Digit Attenuator is functioning properly, and the following low frequency checks can be performed.

4-55. LOW FREQUENCY CHECKS

4-56. The Low Frequency Checks require the use of an ac calibration source and a dc differential voltmeter with the 10K isolation probe illustrated in Figure 4-7. If the desired results of the following checks cannot be obtained, troubleshooting information is contained in paragraphs 4-70 through 4-72. To perform the checks, proceed as follows:

a. Place the Model 931B controls to the following positions:

POWER	ON
MODE	NULL 1%
RANGE	1000 MILLIVOLTS
NULL DAMPING	2 Hz - 10 Hz
Readout dials	10 0 0.0

b. Apply a one volt rms 2 Hz signal, from a low frequency calibration source, to the INPUT of the Model 931B. See paragraph 4-34.

c. Adjust R248 for a meter indication of -.5 ±2 major divisions.

d. Connect the input of the dc differential voltmeter to TP20 and its common lead to the nearest GRD point.

e. Adjust R204, adjustment M, until the voltage at TP20 is between 3.5 to 4.0 volts dc.

f. Repeat steps c and e until the specified results are simultaneously obtained.

g. Apply a one volt rms 5 Hz signal, from a calibration source, to the INPUT of the Model 931B, observing that the meter indicates zero ± one major division.

4-57. When the results of these checks agree with the information given, the Low Frequency Checks are within tolerance, and the final absolute calibration check can be performed.

4-58. ABSOLUTE CALIBRATION CHECKS

4-59. The following Absolute Calibration Checks require the use of a calibrated ac source. If the desired results of these checks are not obtained, troubleshooting information is contained in paragraphs 4-70 through 4-72.

4-60. ABSOLUTE CALIBRATION. To calibrate the instrument, proceed as follows:

a. Place the Model 931B controls to the following positions:

POWER	ON
MODE	NULL .1%
RANGE	10 VOLTS
NULL DAMPING	10 Hz - 2 MHz
Readout dials	10.0 0 0

b. Depress and rotate the PUSH TO CAL to the center of its adjustment range, which is five turns from either end-limit.

c. Apply a 10 volt rms 500 Hz signal, from a calibration source, to the Model 931B INPUT.

d. Adjust R242 and R244 for a meter deflection of zero ± one small division.

e. Depress the PUSH TO CAL control, taking care not to rotate it, and adjust R236 for a meter deflection of zero ± one small division. If the final setting of R236 occurs at an end limit of its adjustment range, perform the jumper wire selections contained in paragraph 4-61.

f. Upon release of the PUSH TO CAL control, a meter deflection of zero ±2.5 small divisions must be observed. If the specified results are not obtained, repeat the entire Absolute Calibration procedure.

4-61. JUMPER WIRE SELECTION. To correct the adjustment range of R236, proceed as follows:

a. Remove power from the Model 931B and reconnect any of the clipped CAL CUR jumper wires located on the Variable Gain AC Amplifier PCB. Refer to Figure 4-11 for location of the jumper wires.

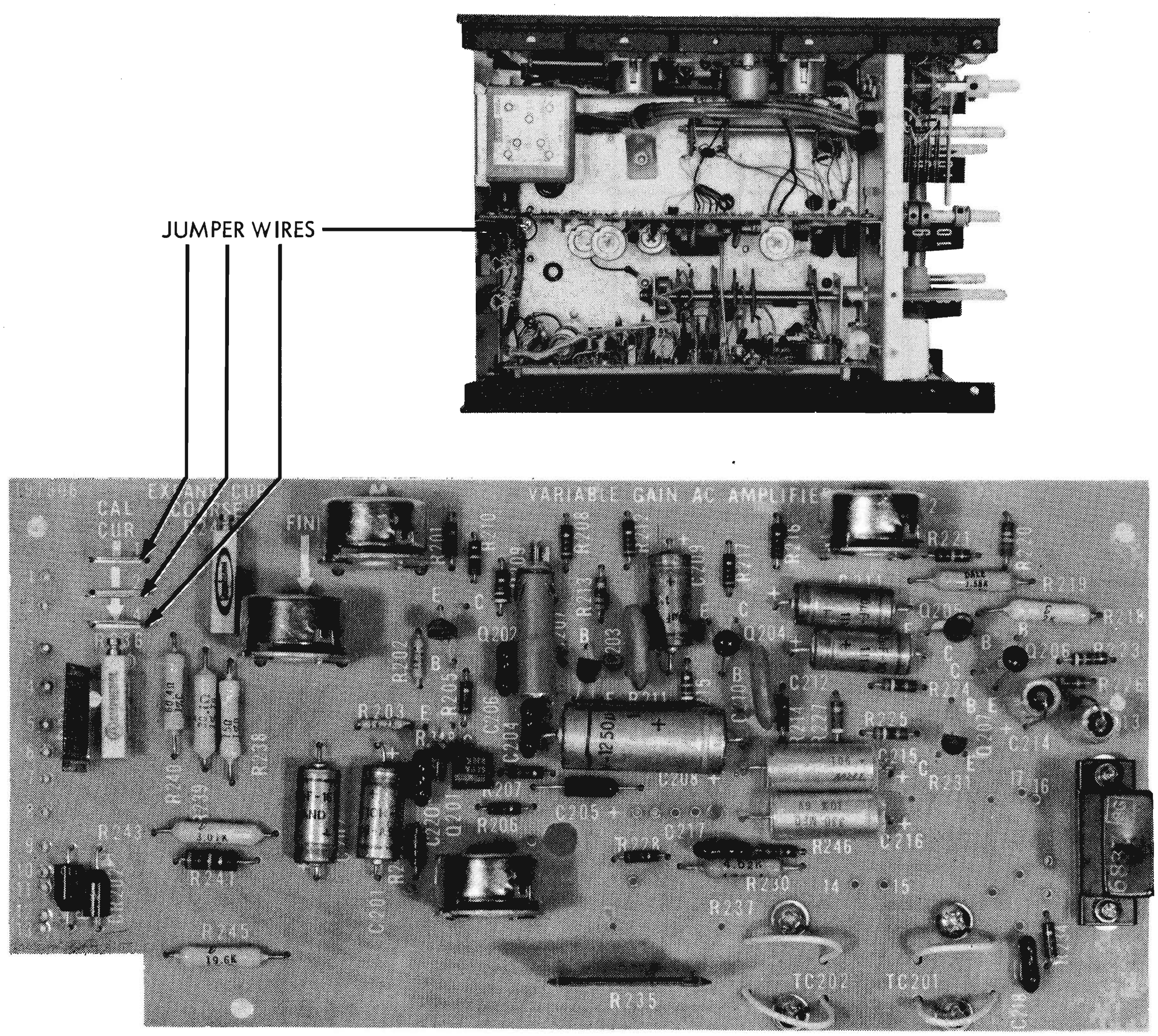


Figure 4-11. ABSOLUTE CALIBRATION JUMPER WIRE LOCATIONS

b. Energize the Model 931B and place its controls to the following positions:

POWER	ON
MODE	NULL .1%
RANGE	10 VOLTS
NULL DAMPING	2 Hz - 2 MHz
Readout dials	10.0 0 0

c. Depress and rotate the PUSH TO CAL control to the center of its adjustment range.

d. Adjust R236 fully clockwise.

e. Depress the PUSH TO CAL control, taking care not to rotate it, and adjust R242 and R244 for a meter deflection of zero ± one small division.

f. Apply a 10 volt rms 500 Hz signal, from a calibration source, to the Model 931B INPUT.

g. Rotate the Readout dials until a meter deflection of zero ± one small division is obtained.

h. Compare the Readout dials digit indication with the information provided in Figure 4-12 and cut the corresponding CAL CUR jumper wire.

READOUT DIAL INDICATION	CAL CUR JUMPER WIRE TO CUT
9.6841 to 9.7303	1, 2, 4
9.7303 to 9.7765	2, 4
9.7765 to 9.8227	1, 4
9.8227 to 9.8689	4
9.8689 to 9.9151	1, 2
9.9151 to 9.9613	2
9.9613 to 10.0075	1
10.0075 to 10.0537	NONE

Figure 4-12. CAL CUR JUMPER WIRE SELECTION

i. Perform the Absolute Calibration adjustments contained in paragraph 4-60.

4-62. When the results of the Absolute Calibration Checks agree with information given, the Model 931B is fully calibrated. The test equipment can now be disconnected from the instrument, and the upper rear dust cover and side panels installed.

4-63. TROUBLESHOOTING

4-64. INTRODUCTION

4-65. Troubleshooting of the Model 931B first begins by isolating the trouble to a particular portion of the instrument's circuitry such as the power supply, input amplifier, variable gain ac amplifier, null detector, or meter amplifier. The results of the Operational Test contained in Section II, when compared to known circuit functions, can be used to determine in which portion of the instrument's circuitry the trouble exists. The functional schematic diagrams contained at the rear of the manual will also aid in locating the source of trouble.

4-66. Once the trouble has been isolated to a particular portion of the instrument's circuitry, input and output signals or voltages of the particular circuit can be measured to determine the source of trouble. The following procedures outline a parameter check of each major circuit contained in the instrument.

4-67. POWER SUPPLY TESTS

4-68. The Power Supply Tests require the use of an ac voltmeter, an autotransformer, an oscilloscope, and a dc differential voltmeter. To perform the tests, proceed as follows:

a. Remove the upper rear dust cover and side panels from the Model 931B and make the equipment connections illustrated in Figure 4-13.

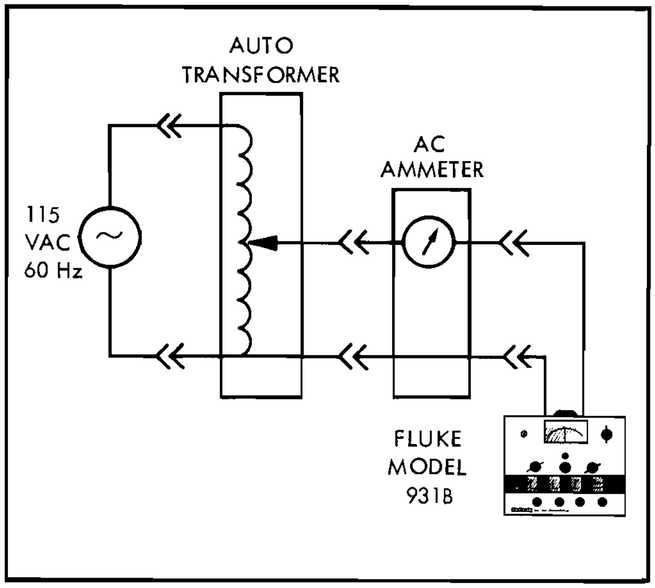


Figure 4-13. POWER SUPPLY TESTS EQUIPMENT CONNECTIONS

b. Place the Model 931B controls to the following positions:

POWER	ON
MODE	NULL 10%
RANGE	100 MILLIVOLTS
NULL DAMPING	10 Hz - 2 MHz
Readout dials	0 0.0 0

c. Apply 115 volts ac, 50 to 440 Hz, through the autotransformer to the Model 931B.

d. Connect the oscilloscope signal input to TP10 and connect its ground lead to the nearest GRD point. The signal observed on the oscilloscope CRT should not exceed a peak-to-peak amplitude of 14 millivolts.

e. Connect the oscilloscope input to TP11. The signal observed on the oscilloscope CRT should not exceed a peak-to-peak amplitude of 14 millivolts.

f. Connect the input lead of the dc differential voltmeter to TP10 and its common lead to the nearest GRD point. The voltage at TP10 should be ±14.5 volts dc.

g. Rotate R143, adjustment L, to each available limit, observing that the voltage at TP10 changes by at least 1.7 volts.

h. Adjust R143, adjustment L, for +14.5 ±0.004 volts dc at TP10.

i. Reduce the ac input to 103.5 volts ac with the autotransformer control. The voltage observed on the dc differential voltmeter should not vary.

j. Increase the ac input to 126.5 volts ac with the autotransformer control. The voltage observed on the dc differential voltmeter should not vary.

k. Return the ac input voltage to 115 volts ac with the autotransformer control.

l. Connect the dc differential voltmeter input to TP11, observing that the voltage is -13.9 to -14.6 volts dc.

m. Repeat steps i through j with the dc differential voltmeter connected to TP11.

n. Connect the dc differential voltmeter input to the wiring harness at terminal 2 or 3 of the Input Amplifier and Power Supply assembly. The voltage at terminal 2 and 3 should be +6.2 to +6.5 volts dc.

4-69. When the results of these tests agree with the information given, the Power Supply is operating properly, and the test equipment can be disconnected from the Model 931B.

4-70. INPUT AMPLIFIER AND VARIABLE GAIN AC AMPLIFIER TESTS

4-71. The Input Amplifier and Variable Gain AC Amplifier Tests require the use of a dc voltmeter with a 10K ohm isolation probe illustrated in Figure 4-7, an oscilloscope, a calibrated ac source, a ratio transformer, and a square wave generator. To perform the checks, proceed as follows:

a. Apply ac line power to the Model 931B and place its controls to the following positions:

POWER	ON
MODE	TVM X1
RANGE	100 MILLIVOLTS
NULL DAMPING	10 Hz - 2 MHz
Readout dials	10 0.0 0

b. Perform the bias voltage checks at the testpoints indicated in Figure 4-14 and, if necessary, adjust the appropriate adjustment to obtain the specified voltage. The final setting of these adjustments must not occur at the end limit of their adjustment range.

TEST POINT	SPECIFIED VOLTAGE	ADJUSTMENT
TP25	0 ±0.02 vdc	R105, adjustment H
TP20	+3.5 to +4.5 vdc	R204, adjustment M
TP22	0 ±0.02 vdc	R222, adjustment P

Figure 4-14. BIAS CHECKS

c. Apply a 10 volt rms 500 Hz signal, from a calibration source, to the input of the ratio transformer.

d. Set the ratio transformer controls to provide an output voltage of 0.1 volts rms.

e. Apply the ratio transformer output to the Model 931B INPUT.

f. Observe the signal present at TP12, TP21, and TP 24 with an oscilloscope. The peak-to-peak values should correspond to the waveforms contained in Figure 4-15.

g. Set the ratio transformer controls to provide an output voltage of 0.010 volts rms, and again observe the signals present at TP12, TP21 and TP 24 with an oscilloscope. The peak-to-peak signal levels should be 1/10 of the values illustrated in Figure 4-13.

h. Perform the range checks describe in Figure 4-16 at 500 Hz, observing that the signals at TP12, TP 21, and TP24 correspond to the specified peak-to-peak levels of Figure 4-15.

i. Repeat the range checks of Figure 4-16 at frequencies of 5 Hz, 50 kHz, and 500 kHz, observing that the signals at TP12, TP21, and TP24 are consistant with the 500 Hz checks.

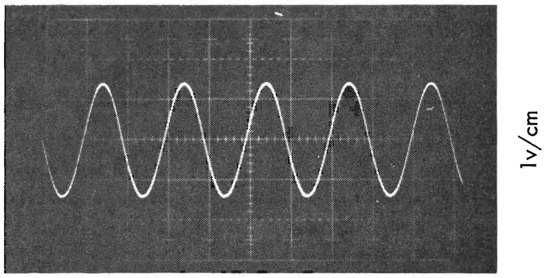
Note!

Complete frequency response checks are contained in paragraph 4-50 of the Calibration Procedures. These checks should be performed only after the instrument is determined to be fully operational.

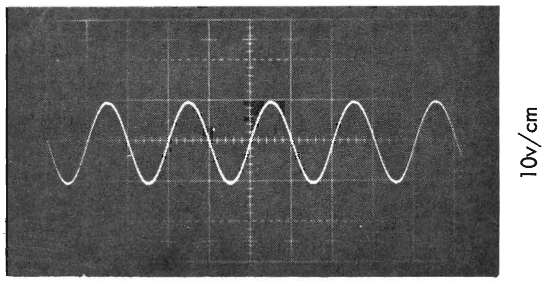
j. To check the amplifiers dynamic range for high crest factor waveforms, make the equipment connections illustrated in Figure 4-17 and place the RANGE switch to its 1000 MILLIVOLTS position.

k. Adjust the square wave generator output for a 10 volt peak-to-peak signal on the oscilloscope CRT.

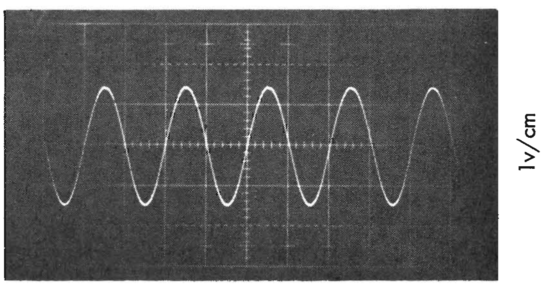
l. Adjust the squarewave generator output frequency, while simultaneously maintaining a 10 volt peak-to-



500 Hz .1 vrms input 1 msec/cm TP12



500 Hz .1 vrms input 1 msec/cm TP21



500 Hz .1 vrms input 1 msec/cm TP24

NOTE: All waveforms taken with an ac coupled oscilloscope using a 10:1 probe.

Figure 4-15. INPUT AND VARIABLE GAIN AC AMPLIFIER WAVEFORMS

peak output, for a one volt rms indication on the Model 931B.

m. Connect the oscilloscope input to TP24 of the Model 931B, observing that there is no clipping at the peaks of the waveform. If clipping is observed, the amplifiers have a limited dynamic range.

RANGE SWITCH	INPUT RMS VOLTAGE	MODE SWITCH	PEAK-TO-PEAK WAVEFORM LEVELS OF FIGURE 4-15
1000 mv	0.1	TVM X1	10%
	0.1	TVM X.1	100%
	0.3	TVM X.3	100%
	1.0	TVM X1	100%
10v	10.0	TVM X1	100%
100v	100.0	TVM X1	100%
1000v	100.0	TVM X1	10%

Figure 4-16. RANGE CHECKS

4-72. When the results of these checks agree with the information given, the Input Amplifier and Variable Gain AC Amplifier are functioning properly, and the test equipment can be disconnected from the Model 931B.

4-73. NULL DETECTOR TESTS

4-74. The Null Detector Tests require the use of a frequency counter, an oscilloscope, an ac source, a ratio transformer and a dc voltmeter. To perform the tests, proceed as follows:

a. Apply ac line power to the Model 931B and place its controls to the following positions:

POWER	ON
MODE	TVM X1
RANGE	1000 MILLIVOLTS
NULL DAMPING	10 Hz - 2 MHz
Readout dials	10 0 0.0

b. Connect the input of the frequency counter to TP30, observing that the counter indicates 2,500 Hz ±5 Hz. If necessary, adjust the tuning slug of T301, adjustment S, to obtain the correct frequency.

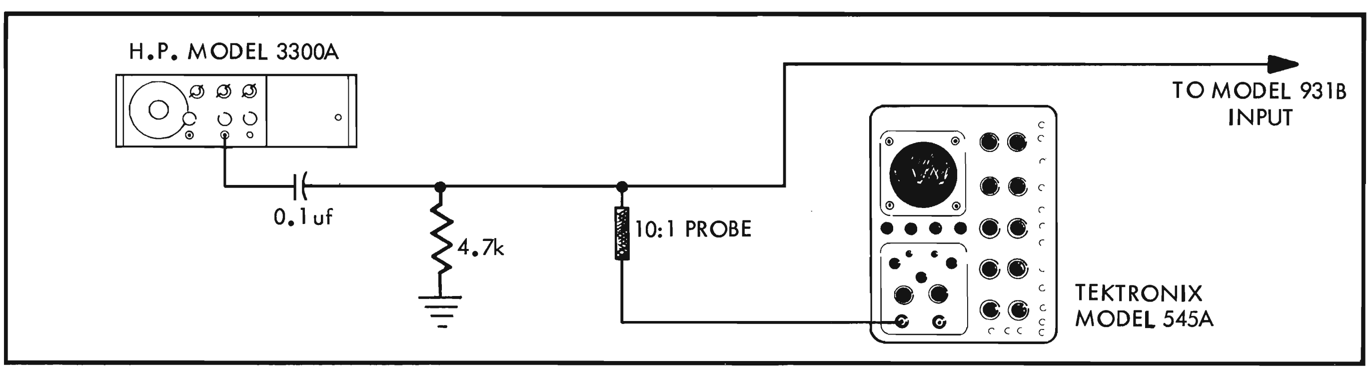


Figure 4-17. CREST FACTOR CHECK EQUIPMENT CONNECTIONS

c. Disconnect the frequency counter from the Model 931B.

d. Connect the oscilloscope input to TP31 and its external trigger input to TP30.

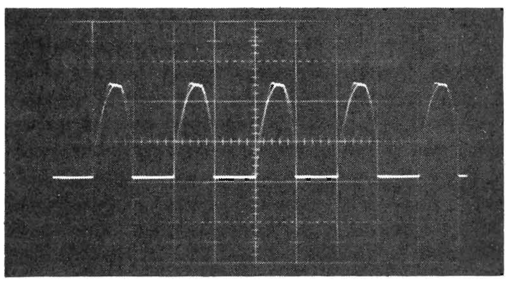
e. Apply a 10 volt rms 500 Hz signal, from a calibration source, to the input of the ratio transformer.

f. Set the ratio transformer output to 0.08 volts rms.

g. Apply the ratio transformer output to the Model 931B INPUT.

h. Short TP32 and TP33 to the nearest GRD point.

i. Set the ratio transformer output to provide an unsaturated 5 kHz carrier signal on the oscilloscope CRT. Figure 4-18 illustrates a typical unsaturated in-phase carrier signal.



2v/cm

500 Hz .08 vrms .1 msec/cm TP31

NOTE: Waveform taken with an ac coupled oscilloscope.

Figure 4-18. CARRIER AMPLIFIER WAVEFORM

j. Adjust the tuning slugs of T303 and L301, adjustments R and T, for a maximum positive carrier signal at TP31. The ratio transformer output may have to be reduced to prevent saturation as the maximum carrier level is approached.

k. Retune the slugs of T303 and L301 to obtain the in-phase carrier signal illustrated in Figure 4-18.

l. Remove the ground from TP32 and TP33 and set the ratio transformer output to one volt rms. The waveform observed at TP31 shall not exceed four volts peak-to-peak or replacement of T302 will be necessary.

m. Disconnect the oscilloscope from the Model 931B.

n. Connect the dc voltmeter input to TP32 and its common lead to the nearest GRD point. The voltage at TP32 should be +14 ±3.0 millivolts dc.

o. Connect the dc voltmeter input to TP33. The voltage at TP33 should be +7.1 ±0.8 volts dc.

p. Connect the dc voltmeter input to the base of Q304. The voltage should be +1.4 ±0.2 volts dc.

q. Remove the rms input to the Model 931B. The voltage at the base of Q304 should decrease to approximately zero volts dc.

r. Connect the dc voltmeter input to TP33. The voltage at TP33 should be -0.6 ±0.2 volts dc.

s. Apply the ratio transformer output to the Model 931B INPUT and set the ratio transformer output to 0.2 volts rms. The voltage at TP33 should be +1.8 ±0.3 volts dc.

t. Set the ratio transformer output to 1.5 volts rms. The voltage at TP33 should be +10 ±0.9 volts dc.

u. Set the ratio transformer output to 1.8 volts rms and then back to 1.5 volts rms. The overload relay should be activated only on the ratio transformer output setting of 1.8 volts rms.

v. Connect the dc voltmeter input to the base of Q317 and perform the checks indicated in Figure 4-19, observing that the specified voltages are obtained.

MODEL 931B RMS INPUT	Q317 BASE VOLTAGE (±0.1 vdc)
1.0	+2.0
0.2	+0.37
Ø	-0.06

Figure 4-19. METER AMPLIFIER INPUT VOLTAGE CHECKS

w. Connect the dc voltmeter input to the collector of Q322 and perform the checks indicated in Figure 4-20. If necessary, adjust the appropriate adjustment to obtain the specified results. The final setting of these adjustments must not occur at an end-limit of their adjustment range.

MODEL 931B RMS INPUT	Q322 COLLECTOR VOLTAGE (±0.03 vdc)	METER DEFLECTION	ADJUSTMENT
Ø	Ø	0	R342 - V
0.2	+0.43	.2	
1.0	+2.1	1.0	R360 - Y

Figure 4-20. METER AMPLIFIER TVM MODE OUTPUT CHECKS

x. Perform the NULL MODE checks indicated in Figure 4-21. If necessary, adjust the appropriate adjustment to obtain the specified results. The final setting of these adjustments must not occur at an end-limit of their adjustment range.

MODE SWITCH	MODEL 931B RMS INPUT	Q322 COLLECTOR VOLTAGE (±0.3 vdc)	METER DEFLECTION (±6 s.d.)	ADJUSTMENT
NULL 10%	1.0 1.1 0.9	Ø +2.1 -2.1	0 +1.0 -1.0	R347 - X R356 - W
NULL 3%	0.97 1.03	-1.96 +1.96	-3.0 +3.0	
NULL 1%	1.01 0.99	+2.1 -2.1	+1.0 -1.0	
NULL .3%	0.997 1.003	-1.96 +1.96	-3.0 +3.0	
NULL .1%	1.001 0.999	+2.1 -2.1	+1.0 -1.0	

Figure 4-21. METER AMPLIFIER NULL MODE OUTPUT CHECKS

y. Connect the dc voltmeter input and common leads to the RECORDER OUTPUT terminals.

z. Place the MODE switch to NULL 10%.

aa. Perform the checks described in Figure 4-22. If necessary, adjust the appropriate adjustment to obtain the specified results. The final adjustment setting must not occur at an end-limit of its adjustment range.

MODEL 931B RMS INPUT	RECORDER OUTPUT VOLTAGE (±.02v)	ADJUSTMENT
1.0 1.1	0 1.0	R362 - Z

Figure 4-22. RECORDER OUTPUT CHECKS

4-75. When the results of these checks agree with the information given, the Null Detector is functioning properly and the test equipment can be disconnected from the Model 931B.

4-76. DIGIT ATTENUATOR TESTS

4-77. The Digit Attenuator Tests require the use of a calibrated ac source and a ratio transformer. To perform the tests, proceed as follows:

a. Apply ac line power to the Model 931B and place its controls to the following positions:

POWER	ON
MODE	NULL 10%
RANGE	10 VOLTS
NULL DAMPING	10 Hz - 2 MHz
Readout dials	10.0 0 0

b. Apply a 10 volt rms 500 Hz signal, from a calibration source, to the ratio transformer.

c. Set the ratio transformer output to 10 volts rms.

d. Apply the ratio transformer output to the Model 931B INPUT. The Model 931B meter should indicate zero.

e. Slowly rotate the second from the left Readout dial to each digit position. The meter excursions between dial positions must be negative and then return quickly to the correct reading when the dial is firmly positioned.

f. Return the second dial to zero and place the MODE switch to the NULL 1% position. A meter deflection of zero should be obtained.

g. Slowly rotate the third from the left Readout dial to each digit position. The meter excursions between dial positions must be negative and then return quickly to the correct reading when the dial is firmly positioned.

h. If either of the Readout dials in steps e or f fail the test, check alignment of the star shaped rotor of that particular switch. The fixed tabs should be centered on the points of the star rotor when the dial is firmly positioned.

Note!

The switch contacts can be cleaned using Cranolin Contact Cleaner and Lubricant.

i. Place the RANGE switch to the 1000 MILLIVOLTS position and set the Readout dials to 777. 0.

j. Set the ratio transformer output to 0. 7777. The Model 931B meter will indicate negative full-scale.

k. Rotate the vernier Readout dial slowly to 77 and then back to 0., observing that the meter pointer moves linearily to 0 and back to negative full-scale. Abrupt shifts of the meter pointer indicate oscillations in the Variable Gain AC Amplifier. Refer to paragraph 4-70 for troubleshooting information concerning the Variable Gain AC Amplifier.

4-78. When the results of these tests agree with the information given, the Digit Attenuator is functioning properly, and the test equipment can be disconnected from the Model 931B.

4-79. SELECTION OF COMPENSATING COMPONENTS

4-80. INTRODUCTION

4-81. The replacement of a component on the A3 and A4 assemblies found to be defected during the course of troubleshooting may alter the adjustment range or frequency response characteristics of the Model 931B. Consequently, it may become necessary to replace certain selected components with new components of different values to bring the adjustment range or frequency response characteristics within tolerance. Complete instructions to determine the correct values of these selected components are contained in the following paragraphs.

4-82. CORRECTION OF INPUT AMPLIFIER ADJUSTMENT RANGE

4-83. Upon replacement of components associated with the Input Amplifier circuitry, it may be necessary to alter the value of capacitors C118, C134, and C139 to bring the 50 kHz adjustment range of the Input Amplifier within tolerance. To select the correct values of these capacitors, proceed as follows:

a. Remove C118, C134, and C139 from the A3 assembly. Refer to Figure 4-23 for locations.

b. Place the Model 931B controls as follows:

POWER	ON
MODE	NULL .1%
RANGE	10
NULL DAMPING	10 Hz - 2 MHz
Readout dials	10 0 0 0

c. Rotate C108, adjustment J, until all of its threaded shaft is exposed.

d. Apply a 10 volt rms 500 Hz signal, from a calibration source, to the INPUT of the Model 931B.

e. Adjust R131, adjustment E, for a center-zero meter indication ±1-1/2 small divisions.

f. Apply a one volt rms 500 Hz signal, from a calibration source, to the INPUT of the Model 931B and place the Readout dials to 1 0 0 0.

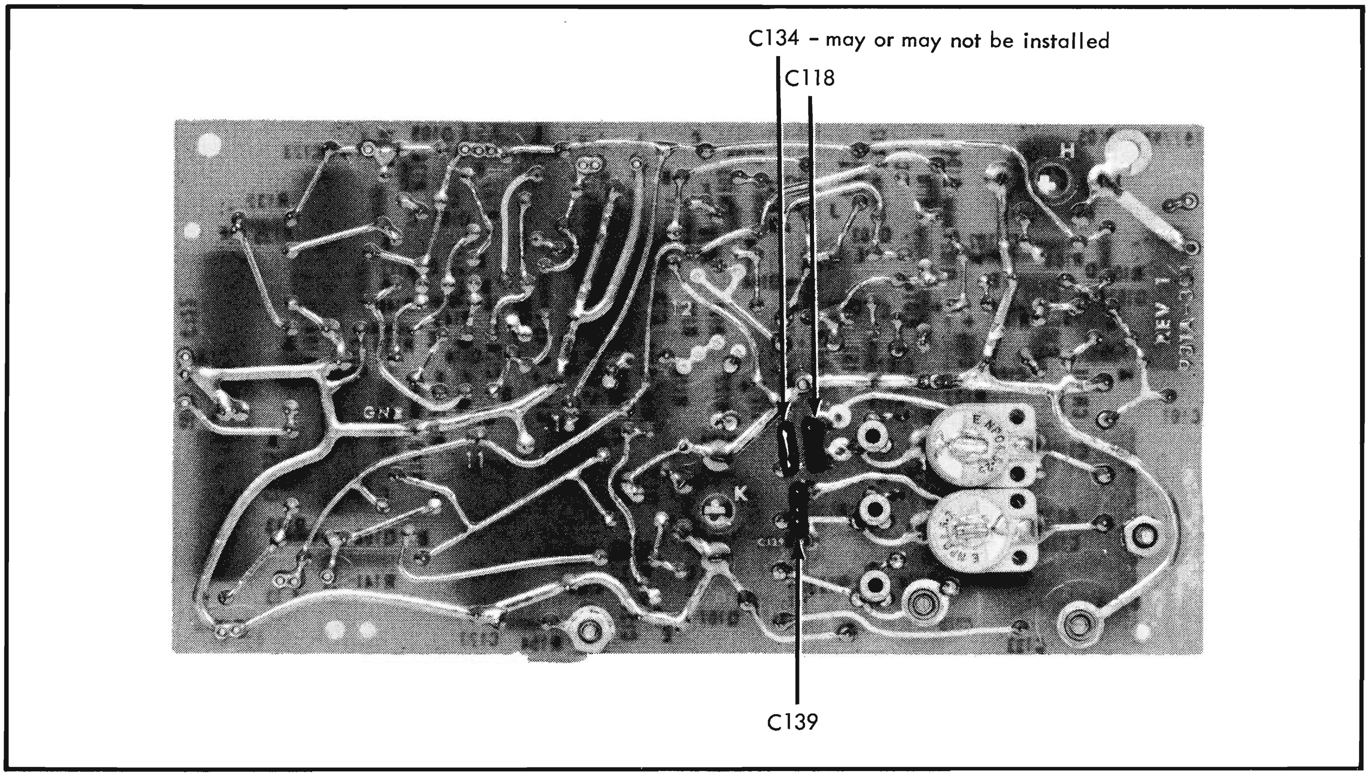


Figure 4-23. LOCATION OF COMPENSATING COMPONENTS

g. Adjust R242 and R244 for a center-zero meter indication.

h. Increase the calibration signal frequency to 50 kHz and adjust C121, adjustment D, for a center-zero meter indication ±1-1/2 small divisions. If the desired results cannot be obtained, rotate C121 to the center of its adjustment range.

i. Select a value, nominally 30 pf, for the padder capacitor C139 that will provide C121 with an adjustment range necessary to obtain the desired results of step h. Securely solder the selected capacitor C139 in its correct position illustrated in Figure 4-23.

j. Perform the adjustments described in paragraphs 4-43 through 4-45.

k. Place the Model 931B controls as follows:

POWER	ON
MODE	NULL . 1%
RANGE	100
NULL DAMPING	10 Hz - 2 MHz
Read dials	10 0 0 0

l. Apply a 100 volt rms 500 Hz signal, from a calibration source, to the input of the Model 931B and adjust R128, adjustment G, for a center-zero meter indication ±1-1/2 small divisions.

m. Increase the calibration signal frequency to 50 kHz and adjust C117, adjustment F, for a center-zero meter indication ±1-1/2 small divisions. If the desired results cannot be obtained, rotate C117 to the center of its adjustment range.

n. Place the MODE switch to NULL 10% and select a value, nominally 300 pf, for the padder capacitor C134 that will cause less than a ±. 1 meter deflection. Solder the selected capacitor C134 in its correct position illustrated in Figure 4-23.

o. Place the MODE switch to NULL . 1% and select a value, nominally 30 pf, for C118 that will cause a center-zero meter deflection ± five small divisions. Solder the selected capacitor in its correct position illustrated in Figure 4-23.

p. Adjust C117, adjustment F, for a center-zero meter indication ±1-1/2 small divisions.

q. Perform the frequency response checks contained in Figure 4-24, observing that the Model 931B meter deflection is within the specified limits. If these specified limits are not obtained, refer to paragraph 4-85 through 4-87 for selection of additional compensating networks.

4-84. When the results of these corrections agree with the information given, the instrument is ready for calibration using the procedures described in paragraphs 4-28 through 4-62.

4-85. SELECTION OF FREQUENCY COMPENSATING NETWORK COMPONENTS.

4-86. If the 20 kHz or 500 kHz frequency response checks of paragraphs 4-49 or 4-82 are not within their specified limits, it will be necessary to select values of the components used in the frequency compensating networks of Figure 4-25. To select the values of these components, proceed as follows:

a. Determine the area in need of compensation by performing the frequency response checks of Figure 4-24.

b. If the results of the 20 kHz checks are too low (-) remove R233, observing that a positive meter deflection occurs, and then use the information provided in Figure 4-26 to select a new value for R233.

Note!

If compensation is performed at 20 kHz, recheck the 50 kHz compensation described in paragraphs 4-82 through 4-84.

c. If the results of the 500 kHz checks are too high (+), the value of C218 will have to be increased. For example, if a -0.7% change is required, increase the value of C218 by 33 pf. Nominal values of C218 are as follows:

INPUT RMS VOLTAGE	MODEL 931B RANGE	METER DEFLECTION DEVIATION FROM CENTER-ZERO		
		20 kHz (NULL . 1%)	50 kHz (NULL . 1%)	500 kHz (NULL 10%)
100 mv	100 MILLIVOLTS	±7.5 s.d.	±1.5 s.d.	±8 m.d.
1 v	1000 MILLIVOLTS	±7.5 s.d.	±1.5 s.d.	±8 m.d.
10 v	10 VOLTS	±7.5 s.d.	±1.5 s.d.	±8 m.d.
100 v	100 VOLTS	±7.5 s.d.	±1.5 s.d.	±8 m.d.

Figure 4-24. FREQUENCY RESPONSE CHECKS

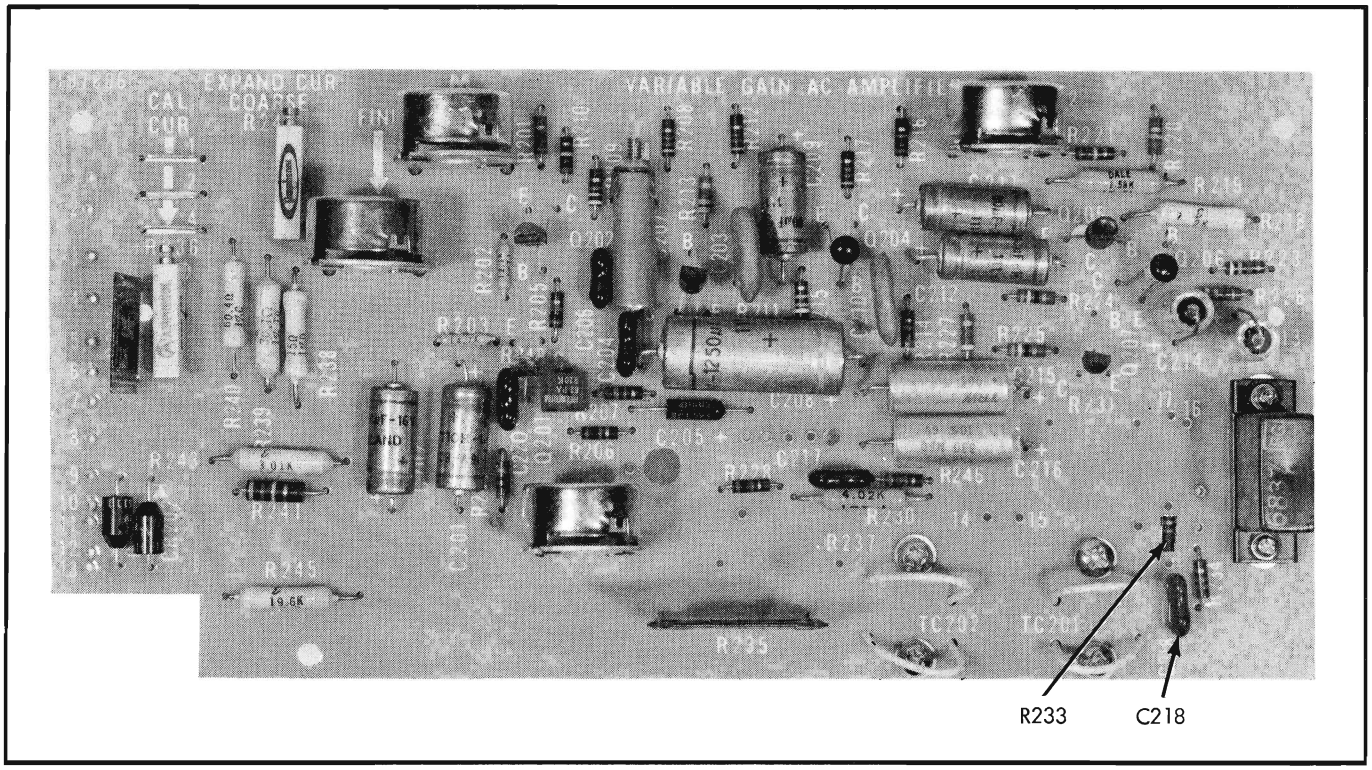


Figure 4-25. LOCATION OF COMPENSATING NETWORK COMPONENTS

BNC INPUT	PROBE INPUT	
33 to 47 pf	82 pf to 120 pf for a 5.6K value of R233.	39 pf to 82 pf for a 4.7K value of R233.

Note!

Compensation at 500 kHz must be started on the lower voltage ranges with at least a -0.5% resultant to bring the higher volt- age ranges within tolerance.

4-87. When the results of these corrections agree with information given, the instrument is ready for calibration using the procedures described in paragraphs 4-28 through 4-62.

POSITIVE METER DEFLECTION	R233 VALUE
+ 50 ppm	3K
+100 ppm	1.5K
+200 ppm	1K
+300 ppm	680K and increase value of C218 to 39 pf

Figure 4-26. 20 kHz NETWORK COMPENSATION

SECTION V

LIST OF REPLACEABLE PARTS

5-1. INTRODUCTION

5-2. This section of the manual contains a listing of replaceable components for this instrument. The first listing contains a complete breakdown of all the major assemblies followed by subsequent listings that itemize the components on each major assembly. An illustration accompanies each major assembly listing to aid in locating the listed components.

5-3. Assemblies and subassemblies are identified by a reference designation beginning with the letter A followed by a number (e.g., A1 etc.). Electrical components appearing on the schematic diagram are identified by their schematic diagram reference designation. Components not appearing on the schematic diagram are identified by index numbers on the grid illustrations. Flagnotes are used throughout the parts list and refer to special ordering explanations that are located in close proximity to the flagnotes.

5-4. COLUMN DESCRIPTIONS

a. The REF DESIG column indexes the item description to the associated illustration. In general the reference designations are listed under each assembly in alpha-numeric order. Subassemblies of minor proportions are sometimes listed with the assembly of which they are a part. In this case, the reference designations for the components of the subassembly may appear out of order.

b. The INDEX NO. column lists coordinates which locate the designated part on the associated grid illustrations.

c. The DESCRIPTION column describes the salient characteristics of the component. Indention of the description indicates the relationship to other assemblies, components, etc. In many cases it is necessary to abbreviate in this column. For abbreviations and symbols used, see the following page.

d. The ten-digit part number by which the item is identified at the John Fluke Mfg. Co. is listed in the STOCK NO. column. Use this number when ordering parts from the factory or authorized representatives.

e. The Federal Supply Code for the item manufacturer is listed in the MFR column. An abbreviated list of Federal Supply Codes is included in the Appendix.

f. The part number which uniquely identifies the item to the original manufacturer is listed in the MFR PART NO. column. If a component must be ordered by description, the type number is listed.

g. The TOT QTY column lists the total quantity of the items used in the instrument and reflects the latest Use Code. Second and subsequent listing of the same item are referenced to the first listing with the abbreviation REF. In the case of optional subassemblies, plug ins, etc. that are not always part of the instrument, or are deviations from the basic instrument model, the TOT QTY column lists the total quantity of the item in that particular assembly.

h. Entries in the REC QTY column indicate the recommended 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 of every part in the instrument be stocked. In the case of optional subassemblies, 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.

i. The USE CODE column identifies certain parts which have been added, deleted or modified during the 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 Serial Number Effectivity List at the end of the parts list. Sometimes when a part is changed, the new part can and should be used as a replacement for the original part. In this event a parenthetical note is added in the DESCRIPTION column.

5-5. HOW TO OBTAIN PARTS

5-6. Standard components have been used wherever possible. Standard components may be ordered directly from the manufacturer by using the manufacturer's part number, or parts may be ordered from the John Fluke Mfg. Co. factory or authorized representative by using the Fluke part 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.

5-7. You can insure prompt and efficient handling of your order to the John Fluke Mfg. Co. if you include the following information:

a. Quantity.

b. FLUKE Stock Number.

c. Description.

d. Reference Designation.

e. Instrument model and serial number.

Example; 2 each, 4805-177105, Transistors, 2N3565, Q107-108 for 845AR, s/n 168.

If you must order structural parts not listed in the parts list, describe the part as completely as possible. A sketch of the part showing its location to other parts of the instrument is usually most helpful.

5-8. LIST OF ABBREVIATIONS

ac	alternating current
Al	Aluminum
amp	ampere
assy	assembly
cap	capacitor
car flm	carbon film
C	centigrade
cer	ceramic
comp	composition
conn	connector
db	decibel
dc	direct current
dpdt	double-pole, double-throw
dpst	double-pole, single-throw
elect	electrolytic
F	fahrenheit
Ge	germanium
gmv	guaranteed minimum value
h	henry
Hz	hertz
hf	high frequency
IC	integrated circuit
if	intermediate frequency
k	kilohm
kHz	kilohertz
kv	kilovolt
lf	low frequency
MHz	megahertz
M	megohm
met flm	metal film
ua	microampere
uf	microfarad
uh	microhenry
usec	microsecond
uv	microvolt
ma	milliampere
mh	millihenry
m	milliohms
msec	millisecond
mv	millivolt
mw	milliwatt
na	nanoampere
nsec	nanosecond
nv	nanovolt
Ω	ohm
ppm	parts per million
piv	peak inverse voltage
p-p	peak to peak
pf	picofarad
plstc	plastic
p	pole
pos	position
P/C	printed circuit
rf	radio frequency
rfi	radio frequency interference
res	resistor
rms	root mean square
rtry	rotary
sec	second
sect	section
S/N	serial number
Si	silicon
scr	silicon controlled rectifier
spdt	single-pole, double-throw
spst	single-pole, single-throw
sw	switch
Ta	tantalum
tstr	transistor
tvm	transistor voltmeter
uhf	ultrahigh frequency
vtvm	vacuum tube voltmeter
var	variable
vhf	very high frequency
vlf	very low frequency
v	volt
va	voltampere
vac	volts, alternating current
vdc	volts, direct current
w	watt
ww	wire wound

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
		RMS DIFFERENTIAL VOLTMETER Figure 5-1	931B					
A1	D2-U3	Front Panel Assembly (See Figure 5-2)						
A2	D1-S5	Switch Panel Assembly (See Figure 5-3)	3158-197863 (931A-408)	89536	3158-197863	1		
A3	H3-Q5	Input Amplifier and Power Supply Assy. (See Figure 5-6)	1702-197798 (931A-401)	89536	1702-197798	1		
A4	I5-Q5	Variable Gain AC Amplifier Assembly (See Figure 5-7)	1702-197806 (931A-402)	89536	1702-197806	1		
A5	K5-R1	Null Detector Assembly (See Figure 5-8)	1702-197814 (931A-403)	89536	1702-197806	1		
F1	B3-P4	Fuse, Type AGC, fast act, 1/4 amp, 250v (for 115v operation) (Sheet 2 of 2)	5101-109314	71400	Type AGC	1	5	
F1	B3-P4	Fuse, Type AGC, fast act, 1/8 amp, 250v (for 230v operation) (Sheet 2 of 2)	5101-196790	71400	Type AGC	1	5	
J3	B4-T4	Binding post, red (sheet 2 of 2)	2811-142976	56474	DF31RC	1		
J4	B1-T4	Binding post, black (sheet 2 of 2)	2811-142984	58474	DF31BC	1		
P1	B3-Q3	Connector, male, 3 contact, snap-in (Sheet 2 of 2)	2109-160275	73586	M-1548-GS	1		
R38		Res, var, comp, 2.5k ±20%, 1/2w (not illustrated)	4701-192112	71450	VF-45	1		
T1	K1-N5	Transformer, power	5602-192690	89536	5602-192690	1		
XF1	B3-P4	Holder, fuse	2102-160846	75915	342004	1		
	B2-Q4	Bail (not illustrated)	3153-163386	89536	3153-163386	1		
	B2-P4	Bail, foot (not illustrated)	3151-169904	89536	3151-169904	2		
	J1-T3	Coupling, 5/8 inch.	2402-196881	89536	2402-196881	2		
	J1-T4	Coupling, 5/8 inch.	2402-196881	89536	2402-196881	REF		
	J1-U1	Coupling, 1/2 inch.	2402-198374	89536	2402-198374	1		
	I1-S5	Coupling, 1/4 inch. to 1/4 inch.	2402-104505	89536	2402-104505	1		
	B3-R4	Cover, bottom (not illustrated)	1406-167627	89536	1406-167627	1		
	J1-N5	Cover, side (sheet 2 of 2)	1406-167635	89536	1406-167635	2		
	J1-P3	Cover, side front (sheet 2 of 2)	1406-162164	89536	1406-162164	2		
	L1-P5	Cover, top (sheet 2 of 2)	1406-167619	89536	1406-167619	1		

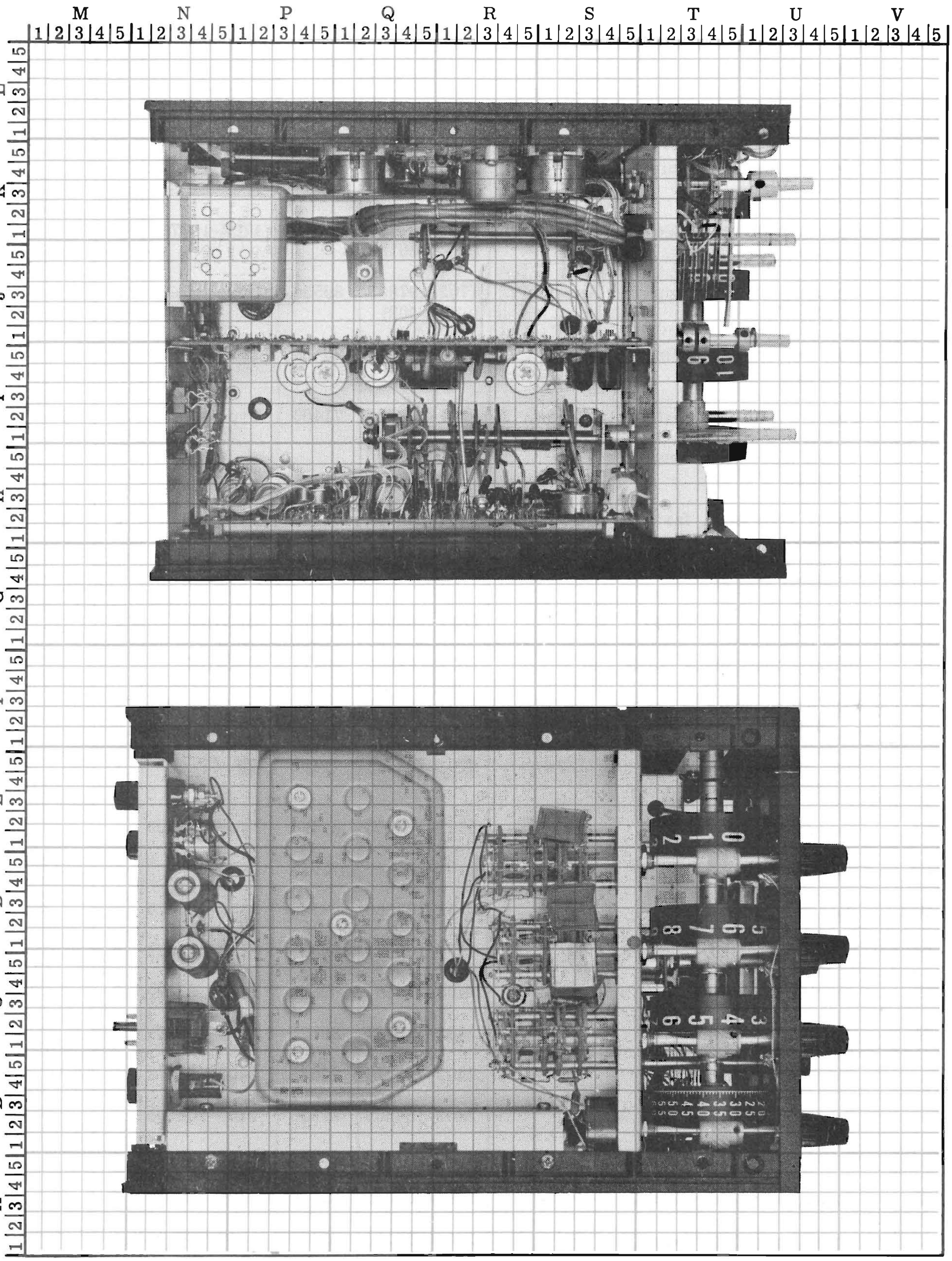


Figure 5-1. 931B RMS DIFFERENTIAL VOLTMETER (Sheet 1 of 2)

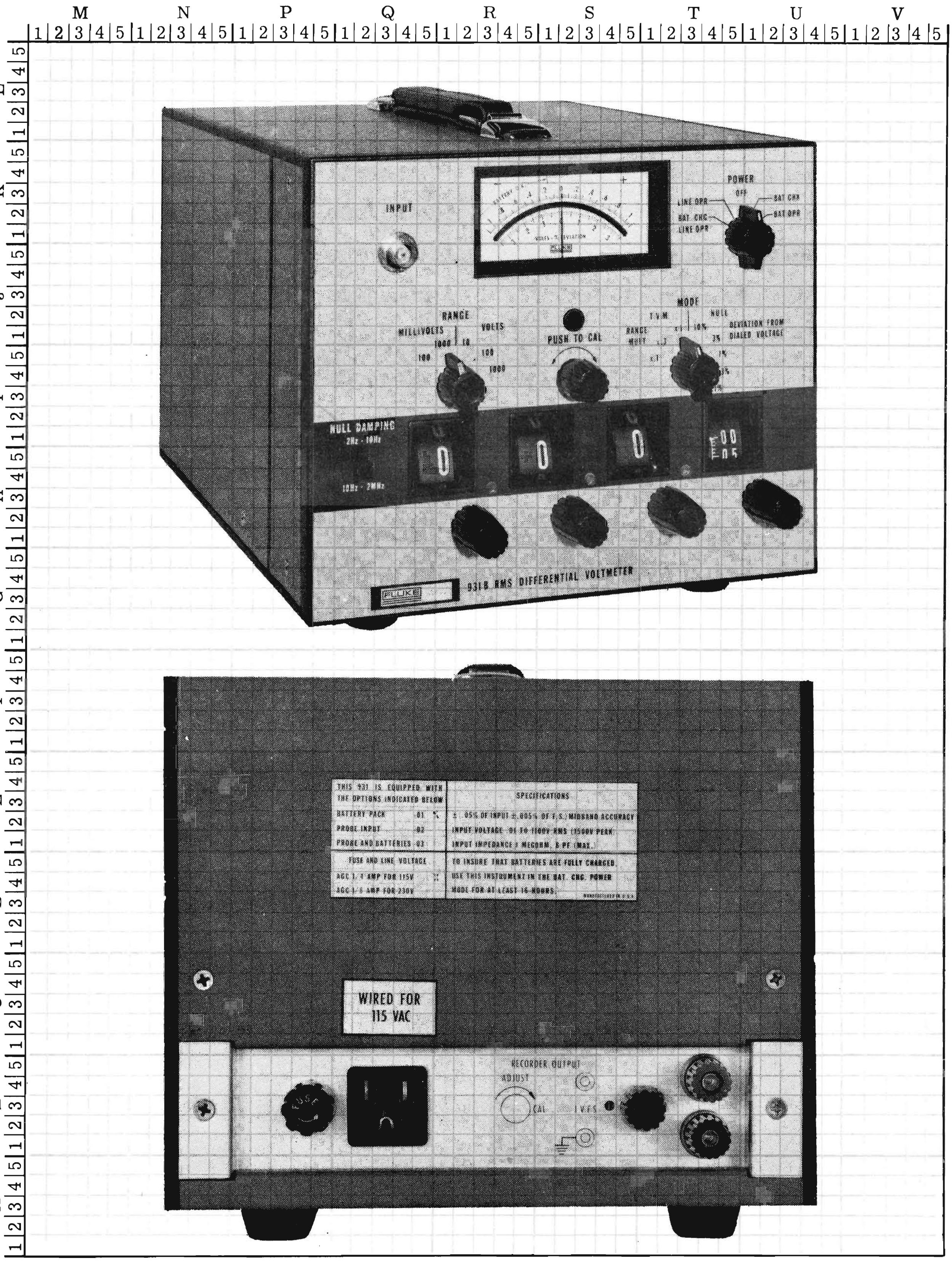


Figure 5-1. 931B RMS DIFFERENTIAL VOLTMETER (Sheet 2 of 2)

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
	C3-T4	Dial drum, 0-10	2403-162891	89536	2403-162891	3		
	D2-T4	Dial drum, 0-10	2403-162891	89536	2403-162891	REF		
	E2-T4	Dial drum, 0-10	2403-162891	89536	2403-162891	REF		
	B3-T4	Dial drum, 0-100	2403-162909	89536	2403-162909	1		
	K4-U2	Extension, shaft	2402-178038	20584	custom	1		
	A2-P3	Foot, rubber (sheet 2 of 2)	2819-103309	77969	9102-W	4		
	B2-T5	Gear, nylon	3155-154682	89536	3155-154682	4		
	L2-R1	Handle, black vinyl (sheet 2 of 2)	2404-101857	12136	919-415-173	1		
	B3-T1	Knob, RECORDER OUTPUT (sheet 2 of 2)	2405-190249	89536	2405-190249	2		
		Line cord (not illustrated)	6005-161638	91934	SVT-107-1	1		
	J1-U2	Shaft, cal pot	4711-197723	89536	4711-197723	1		
		Shaft, drum (not illustrated)	3153-171686	89536	3153-171686	1		
	I1-U2	Shaft, range switch	5108-197673	89536	5108-197673	1		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A1		**FRONT PANEL ASSEMBLY - Figure 5-2**						
DS1	C1-R3	Lamp, incandescent, 10v	3901-192120	08806	709	3	5	
DS2	C1-S1	Lamp, incandescent, 10v	3901-192120	08806	709	REF		
DS3	C1-Q4	Lamp, incandescent, 10v	3901-192120	08806	709	REF		
J1	J5-P2	Connector, female, coaxial Type BNC	2106-193250	91737	11823-1	1		
M1	K1-R2	Meter, 100-0-100 ua, 225Ω	2901-195156	89536	2901-195156	1		
S7	H3-N5	Switch, NULL DAMPING, slide	3156-240218	89536	3156-240218	1		
XDS1	B5-R2	Socket, lamp	2110-193037	95263	25-08-1	3		
XDS2	B5-S1	Socket, lamp	2110-193037	95263	25-08-1	REF		
XDS3	B5-Q4	Socket, lamp	2110-193037	95263	25-08-1	REF		
	I2-R3	Knob, CAL	2405-190249	89536	2405-190249	REF		
	G4-Q1	Knob, DIGIT	2405-158949	89536	2405-158949	4		
	G4-R3	Knob, DIGIT	2405-158949	89536	2405-158949	REF		
	G4-S4	Knob, DIGIT	2405-158949	89536	2405-158949	REF		
	G4-U1	Knob, DIGIT	2405-158949	89536	2305-158949	REF		
	I2-T1	Knob, MODE	2405-158956	89536	2405-158956	3		
	J5-T4	Knob, POWER	2405-158956	89536	2405-158956	REF		
	I2-P5	Knob, RANGE	2405-158956	89536	2405-158956	REF		
	J1-P1	*Panel decal	3156-240192	89536	3156-240192	1		
	E1-Q1	*Panel, finished	1406-197582	89536	1406-197582	1		
		*When ordering a front panel for the instrument, both the finished panel and the panel decal must be ordered.						

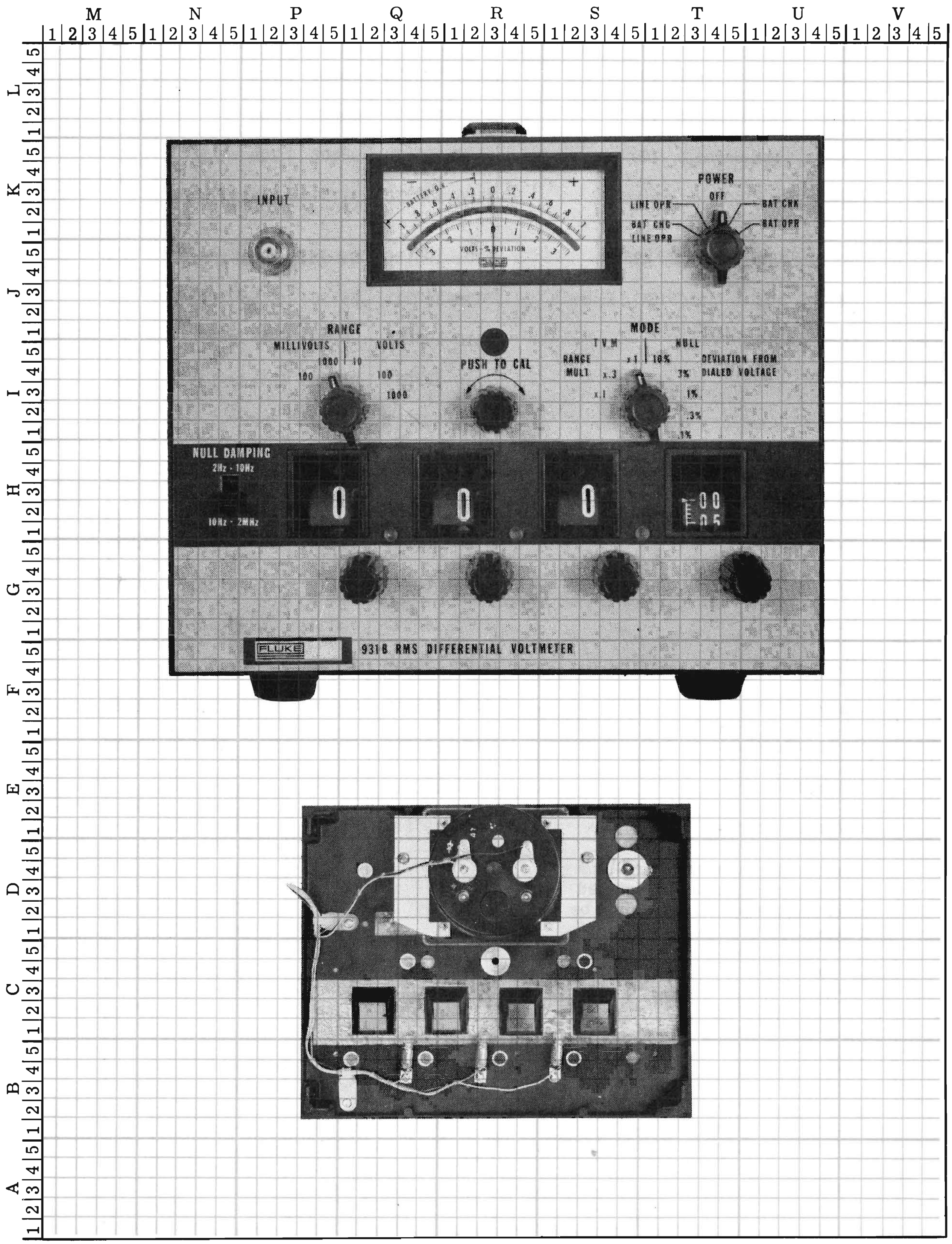


Figure 5-2. FRONT PANEL ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A2		**SWITCH PANEL ASSEMBLY -Figure 5-3**	3158-197863 (931A-408)	89536	3158-197863	REF		
A2A1	D2-Q1	Digit Switch Assembly (See Figure 5-4)	5110-197848 (931A-406)	89536	5110-197848	1		
A2A2	F1-T1	Mode Switch Assembly (See Figure 5-5)	5110-197855 (931A-407)	89536	5110-197855	1		
C1	G4-P1	Cap, matched pair, cer, 5.1 pf ±.25 pf, 500v (behind cover)	1501-199687	95275	VY10CA5-R1CA	1		
R1	G4-P1	Res, met flm 1.004M matched set (behind cover)	1					
R7	F5-R4	Res, var, comp, 5k ±20%, 1/2w	4701-195248	71450	VA-45	1		
S1	G5-T4	Switch, POWER, rotary, 2p, 2 pos, 1 sect	5105-180679	89536	5105-180679	1		
S3	F4-S4	Switch, CAL, leaf spring, 4p, spst, 2p, spdt	5106-198317	89536	5106-198317	1		

1 Resistors R1, R124, R126, R129 and R130 are factory matched. If replacement is required, an entire set, part number 4705-192849, must be ordered.

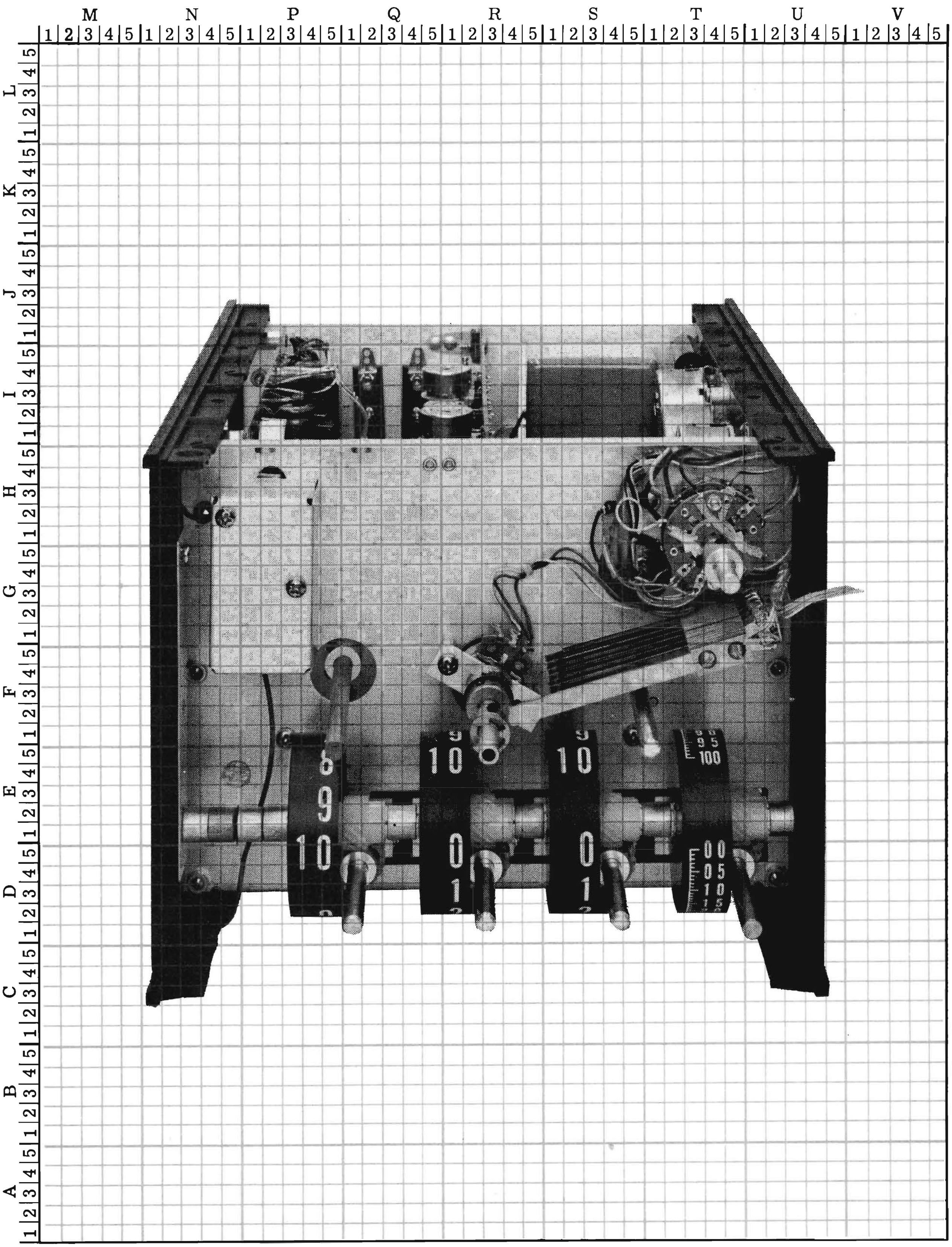


Figure 5-3. SWITCH PANEL ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A2A1		DIGIT SWITCH ASSEMBLY Figure 5-4	5110-197848 (931A-406)	89536	5110-197848	REF		
R11	I3-Q2	Res, ww, 10k matched set	2					
R12	I3-Q4	Res, ww, 5k matched set	2					
R13	H5-Q1	Res, met flm, 1k ±1%, 1/8w	4705-168229	75042	Type CEAT-O	3		
R14	H2-Q5	Res, ww, 2.5k matched set	2					
R15	H2-P5	Res, met flm, 332Ω ±1%, 1/8w	4705-192898	75042	Type CEAT-O	1		
R16	H1-Q2	Res, ww, 1.25k matched set	2					
R17		Res, met flm, 143Ω±1%, 1/8w (not illustrated)	4705-192906	75042	Type CEAT-O	1		
R18	H4-Q1	Res, met flm, 1k ±1%, 1/8w	4705-168229	75042	Type CEAT-O	REF		
R19		Res, met flm, 1k ±1%, 1/8w	4705-168229	75042	Type CEAT-O	REF		
R20	G5-Q5	Res, ww, 100k matched set	2					
R21	G4-Q2	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	3		
R22	F5-R1	Res, ww, 50k matched set	2					
R23	G3-Q2	Res, comp, 5.1k ±5%, 1/4w	4704-193342	01121	CB5125	2		
R24	F3-Q4	Res, ww, 25k matched set	2					
R25	F4-Q1	Res, comp, 2.4k ±5%, 1/4w	4704-193433	01121	CB2425	1		
R26	F3-Q2	Res, ww, 12.5k matched set	2					
R27		Res, comp, 1.2k ±5%, 1/4w (not illustrated)	4704-190371	01121	CB1225	3		
R28		Res, met flm, 1M ±.5%, 1/4w (not illustrated)	4705-198234	75042	Type CEB	1		
R29	F1-Q2	Res, comp, 100k ±5%, 1/4w	4704-148189	01121	CB1045	2		
R30	E5-R1	Res, met flm, 500k ±.25%, 1/4w	4705-198242	75042	Type CEB	1		
R31	E5-Q2	Res, comp, 51k ±5%, 1/4w	4704-193334	01121	CB5135	1		
R32	E2-Q5	Res, met flm, 250k ±1%, 1/4w	4705-198226	75042	Type CEB	1		
R33	E1-Q1	Res, comp, 24k ±5%, 1/4w	4704-193425	01121	CB2435	1		
R34		Res, met flm, 125k ±1%, 1/4w (not illustrated)	4705-198218	75042	Type CEB	1		
R35		Res, comp, 12k ±5%, 1/4w (not illustrated)	4704-159731	01121	CB1235	2		
R36	E1-Q4	Res, met flm, 49.9k ±1%, 1/2w	4705-182980	75042	Type CEC-TO	1		

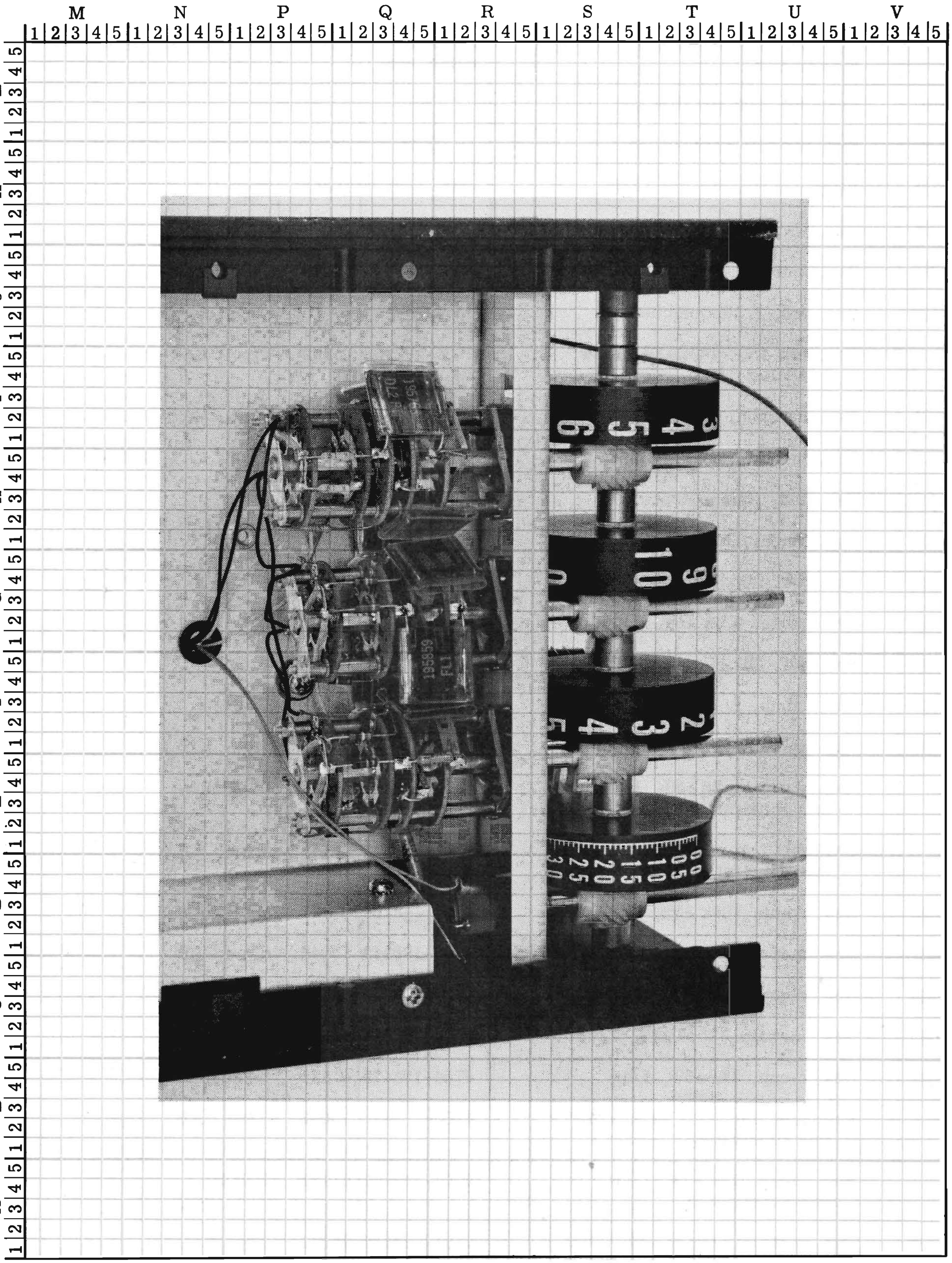


Figure 5-4. DIGIT SWITCH ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R37	D3-R3	Res, var, ww, 250Ω ±5%, 1w, 4th DIGIT	4702-244905	89536	4702-244905	1		
S4	H5-P4	Switch, 1st DIGIT, rotary, 11 pos, 5 sect	5105-198366	89536	5105-198366	1	1	
S5	G2-P5	Switch, 2nd DIGIT, rotary, 10 pos, 4 sect	5105-198325	89536	5105-198325	2		
S6	E5-P5	Switch, 3rd DIGIT, rotary, 10 pos, 4 sect	5105-198325	89536	5105-198325	REF		

2 These resistors are factory matched. If replacement is required, please give model, serial number, reference designation, and all markings from the resistor you are replacing.

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A2A2		**MODE SWITCH ASSEMBLY** **Figure 5-5**	5110-197855 (931A-407)	89536	5110-197855	REF		
C2	C4-K1	Cap, cer, .5 pf ±.25 pf, 500v	1501-174896	71590	Type TC2	1		A
C2	C4-K1	Cap, cer, 1 pf ±.25 pf, 500v	1501-105908	72982	331-000/ COKO/109C	1		B
C3	D4-K1	Cap, cer, 1pf ±.25 pf, 600v	1501-105908	72982	331-000/ COKO/109C	1		A
C3	D4-K1	Cap, cer, 1.5 pf ±.25 pf, 1000v	1501-178475	80183	10TCCV15-NPO	1		B
C4		Cap, mica, 33 pf ±5%, 500v (not illustrated)	1504-160317	04062	DM-15-330	3		
CR1	D3-H4	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	6		
R2	C4-K1	Res, met flm, 10.845k matched set	3					
R3	C3-K1	Res, met flm, 3.392k matched set	3					
R4	C5-K2	Res, comp, 470Ω ±5%, 1/4w	4704-147983	01121	CB4715	6		
R5	C3-K1	Res, met flm, 1.0355k matched set (not illustrated)	3					
R6	C5-K2	Res, comp, 110Ω ±5%, 1/4w	4704-193474	01121	CB1115	1		
R10	D4-H4	Res, comp, 2.2k ±5%, 1/4w	4704-148049	01121	CB2225	1		
S2	D2-K3	Switch, MODE, rotary, 8 pos	5105-198333	89536	5105-198333	1		

3 Resistors R2, R3 and R5 are factory matched. If replacement is required, an entire set, part number 4705-198168, must be ordered.

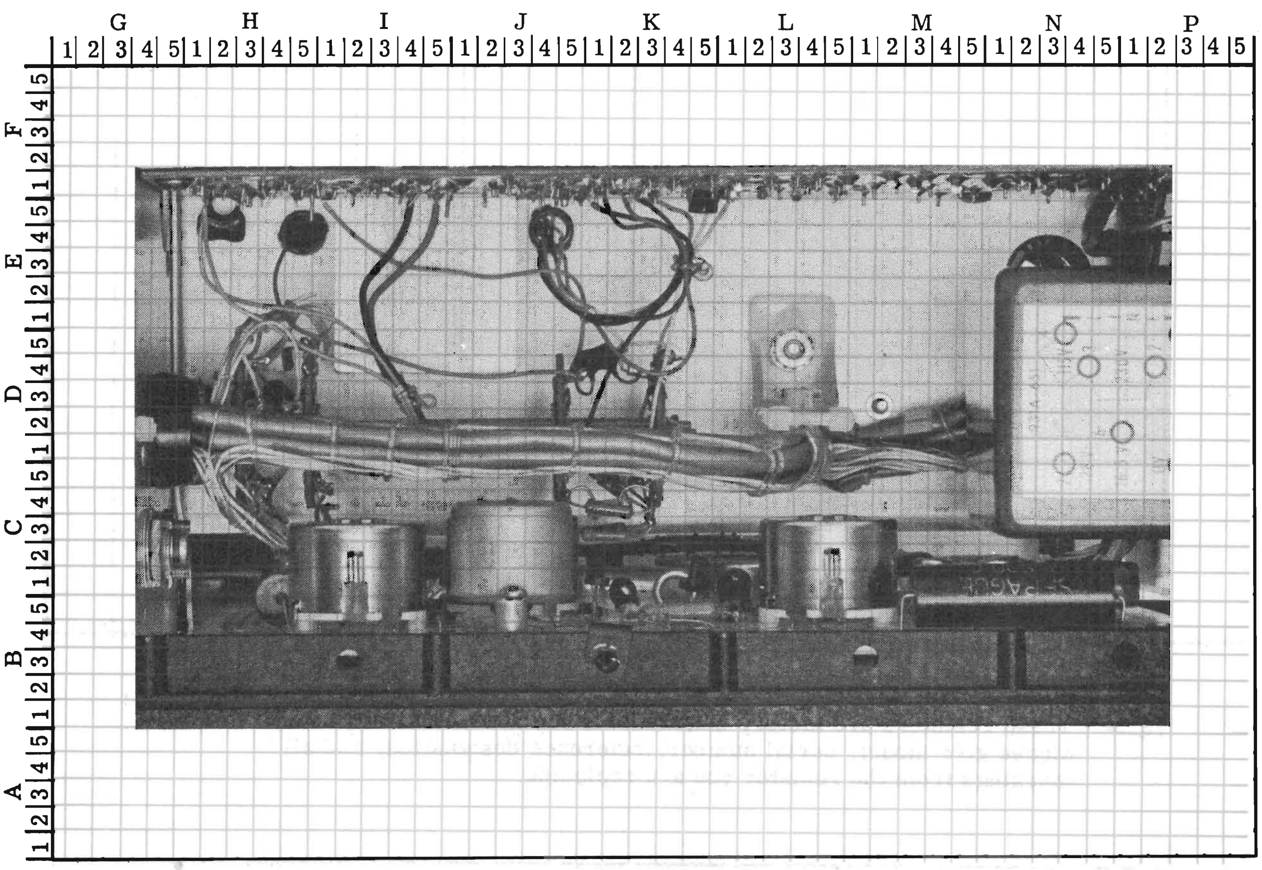


Figure 5-5. MODE SWITCH ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A3		**INPUT AMPLIFIER AND POWER SUPPLY ASSEMBLY - Figure 5-6**	1702-197798 (931A-401)	89536	1702-197798	REF		
C101	K3-S3	Cap, plstc, 2.2 uf ±20%, 250v	1507-222232	73445	C280AE/A2M2	1		
C102	K1-S1	Cap, mica, 22 pf ±5%, 500v	1504-148551	72136	DM-15-220	2		
C103	J1-S2	Cap, poly, 0.1 uf ±20%, 250v	1507-161992	73445	C280AE/ P100K	1		
C104	I5-R5	Cap, mica, 33 pf ±5%, 500v	1504-160317	72136	DM-15-330	REF		
C105	I3-R5	Cap, Ta, 10 uf ±20%, 15v	1508-160259	56289	150D106X9020 B2	4	1	
C106	I4-R4	Cap, mica, 39 pf ±5%, 500v (sheet 2 of 2)	1504-148544	72136	DM-15-390	3		
C107	I2-R4	Cap, mica, 22 pf ±5%, 500v	1504-148551	72136	DM-15-220	REF		
C108	H2-S3	Cap, var, .5-3 pf, 1,000v	1509-195982	73899	ST851	1		
C109	H4-S1	Cap, mica, 39 pf ±5%, 500v	1504-148544	72136	DM-15-390	REF		
C110	H5-T2	Cap, Ta, 10 uf ±20%, 15v	1508-160259	56289	150D106X9020 B2	REF		
C111	J2-S1	Cap, mica, 27 pf ±5%, 500v (sheet 2 of 2)	1504-177998	72136	DM-15-270	1		
C112	G4-R5	Cap, Ta, 10 uf ±20%, 15v	1508-160259	56289	150D106X9020 B2	REF		
C113	G5-R3	Cap, mica, 15 pf ±5%, 500v	1504-148569	72136	DM-15-150	1		
C114	I5-P4	Cap, cer, 22 pf ±5%, 50v	1501-217901	00656	C1-2	1		
C115	I2-P3	Cap, var, .8-10 pf, 250v	1509-193912	91293	JMC2950	2		
C116	I3-Q2	Cap, cer, 2,200 pf ±5%, 50v (sheet 2 of 2)	1501-217927	00656	MC605A22J	1		
C117	C4-T4	Cap, var, 4.5-25 pf, 500v (sheet 2 of 2)	1509-167007	72982	503-001	1		
C118	C4-S3	Cap, factory selected (sheet 2 of 2)	4					
C119	J4-P2	Cap, .8-10 pf, 250v	1509-193912	91293	JMC2950	REF		
C120		Cap, cer, 220 pf ±5%, 50v (not illustrated)	1501-217919	00656	MC505A221J	1		
C121	C1-T4	Cap, var, 1.5-7 pf, 500v (sheet 2 of 2)	1509-105973	72982	503NP01.5-7MMF	1		
C122	B4-S1	Cap, elect, 400 uf +50/-10%, 25v	1502-168153	73445	C437ARF400	7	1	
C123	C4-T1	Cap, elect, 400 uf +50/-10%, 25v	1502-168153	73445	C437ARF400	REF		
C124	B4-Q3	Cap, elect, 400 uf +50/-10%, 25v	1502-168153	73445	C437ARF400	REF		

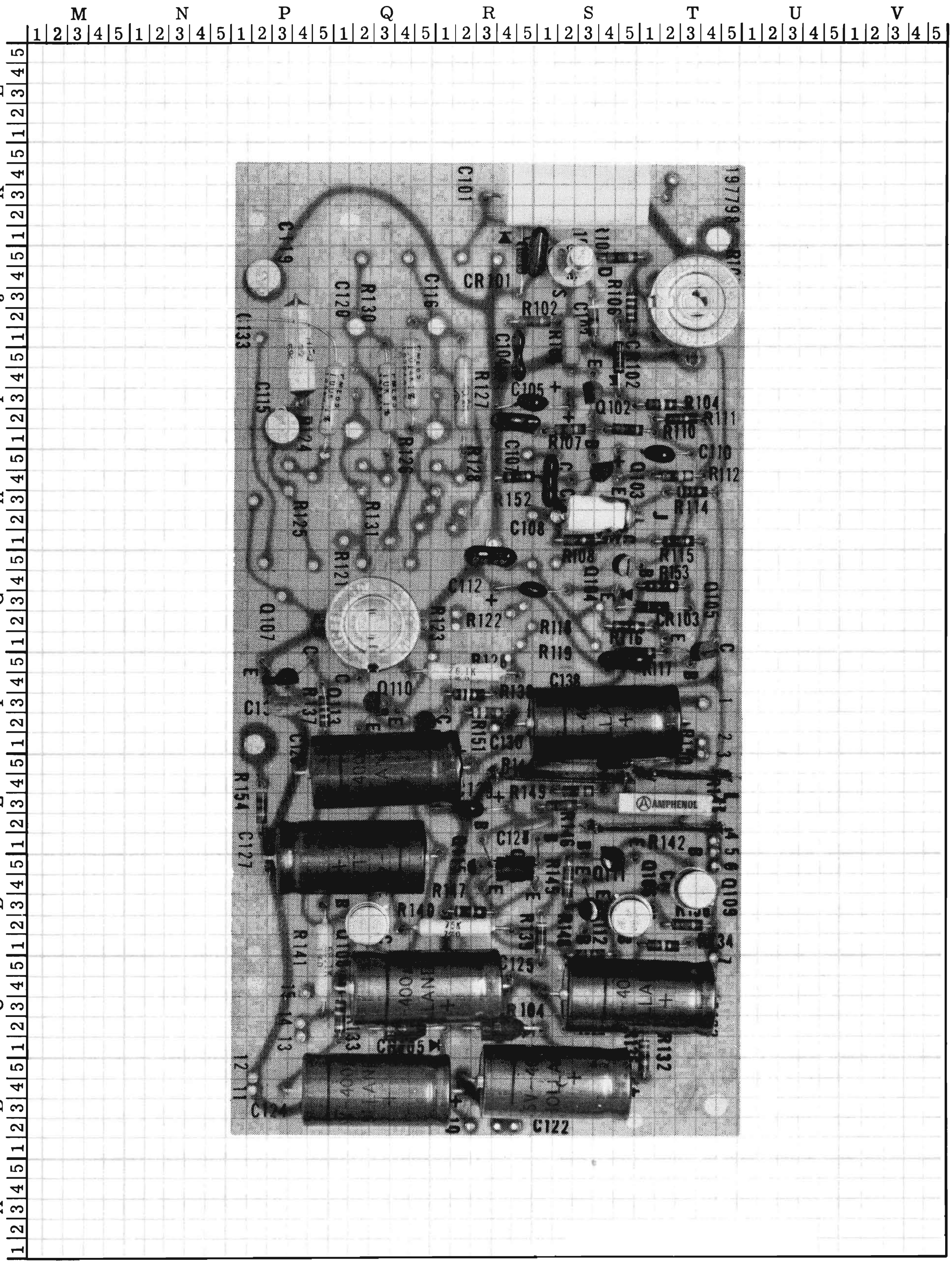


Figure 5-6. INPUT AMPLIFIER AND POWER SUPPLY ASSEMBLY (Sheet 1 of 2)

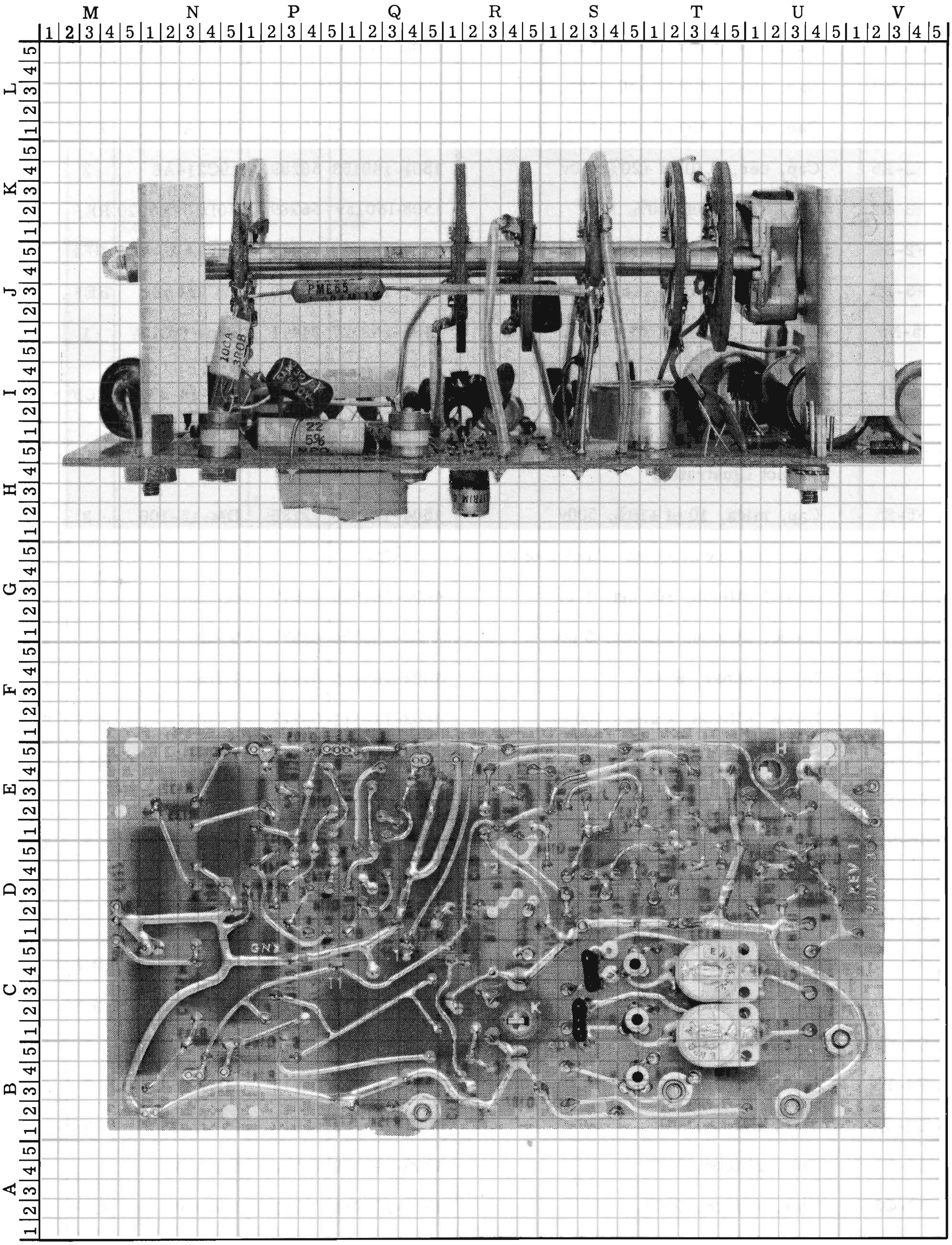


Figure 5-6. INPUT AMPLIFIER AND POWER SUPPLY ASSEMBLY (Sheet 2 of 2)

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
C125	C4-Q5	Cap, elect, 400 uf +50/-10%, 25v	1502-168153	73445	C437ARF400	REF		
C126	E5-Q3	Cap, elect, 400 uf +50/-10%, 25v	1502-168153	73445	C437ARF400	REF		
C127	D5-Q2	Cap, elect, 400 uf +50/-10%, 25v	1502-168153	73445	C437ARF400	REF		
C128	E2-R5	Cap, cer, 0.01 uf ±20%, 50v	1501-149153	56289	19C214A6	2		
C129	E3-R2	Cap, Ta, 10 uf ±20%, 15v	1508-160259	56289	150D106X9020B2	REF		
C130	F2-S4	Cap, elect, 400 uf +50/-10%, 25v	1502-168153	73445	C437ARF400	REF		
C131	F3-P3	Cap, cer, 0.01 uf ±20%, 50v	1501-149153	56289	19C214A6	REF		
C132	I5-N5	Cap, cer, 3 pf ±0.1%, 50v (sheet 2 of 2)	1501-209577	84411	Type 663UW	1		
C133	I4-P3	Cap, mica, 39 pf ±5%, 500v (sheet 2 of 2)	1504-148544	72136	DM-15-390	REF		
C134	C5-S4	Cap, factory selected (sheet 2 of 2) (not illustrated)	4					
C138	F5-S5	Cap, mica, 10 pf ±10%, 500v	1504-175216	72136	DM-15-100	2		
C139	C1-S2	Cap, factory selected (sheet 2 of 2)	4					
CR101	J5-R5	Diode, silicon, 100 ma, 1.5v	4802-161810	03877	SG5658	1	1	
CR102	I5-S4	Diode, silicon, 150 ma, 6 piv	4802-113308	03877	SG22	1	1	
CR103	G3-T1	Diode, zener, 9.4v	4803-180406	07910	1N758	1	1	
CR104	C2-R4	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF	2	
CR105	C2-Q4	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR106	E5-S4	Diode, zener, matched set	5					
Q101	J5-S3	Tstr, FET, N-channel	4805-192864	17856	FN-323	1	1	
Q102	I3-S3	Tstr, silicon, PNP	4805-195974	04713	2N3906	3	1	
Q103	H5-S4	Tstr, silicon, NPN	4805-218081	04713	MPS6520	6	2	
Q104	G5-S5	Tstr, silicon, NPN	4805-218081	04713	MPS6520	REF		
Q105	G1-T4	Tstr, silicon, NPN	4805-218081	04713	MPS6520	REF		
Q106	D2-S5	Tstr, germanium, NPN	4805-117127	95303	2N1304	1	1	
Q107	F4-P3	Tstr, silicon, PNP	4805-169375	04713	MPS3638	2	1	
Q108	D2-Q2	Tstr, silicon, NPN	4805-203489	07910	CDQ10656	3	1	
Q109	D4-T3	Tstr, silicon, PNP	4805-190389	04713	SM4144	1	1	
Q110	F3-Q3	Tstr, silicon, PNP	4805-195974	04713	2N3906	REF		
Q111	D5-S4	Tstr, silicon, NPN	4805-168708	03508	2N3391	16	4	
Q112	D3-S3	Tstr, silicon, NPN	4805-168708	03508	2N3391	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
Q113	F2-Q5	Tstr, silicon, PNP	4805-169375	04713	MPS3638	REF		
Q114, Q115	D5-R5	Tstr, silicon, NPN, attached pair	4805-168708	03508	2N3391	REF		
R101	J5-S5	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	2		
R102	J2-R5	Res, comp, 150Ω ±5%, 1/4w	4704-147934	01121	CB1515	1		
R103	J2-S3	Res, comp, 47Ω ±5%, 1/4w	4704-147892	01121	CB4705	1		
R104	I3-T2	Res, comp, 120k ±5%, 1/4w	4704-193458	01121	CB1245	2		
R105	J4-T3	Res, var, ww, 10k ±20%, 1-1/4w	4702-112862	71450	Type 110	2		
R106	J3-S5	Res, comp, 47k ±5%, 1/4w	4704-148163	01121	CB4735	3		
R107	I2-S2	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	3		
R108	H1-S3	Res, comp, 2.7M ±5%, 1/4w	4704-193490	01121	CB2755	1		
R109	I4-Q5	Res, comp, 33Ω ±5%, 1/4w (sheet 2 of 2)	4704-175034	01121	CB3305	3		
R110	I2-S5	Res, comp. 2.7k ±5%, 1/4w	4704-170720	01121	CB2725	2		
R111	I2-T3	Res, comp, 5.6k ±5%, 1/4w	4704-148080	01121	CB5625	2		
R112	H4-T2	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R113	J2-R4	Res, comp, 100k ±5%, 1/4w (sheet 2 of 2)	4704-148189	01121	CB1045	REF		
R114	H3-T3	Res, comp, 8.2k ±5%, 1/4w	4704-160796	01121	CB8225	6		
R115	H1-T2	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
R116	G2-S5	Res, comp, 10Ω ±5%, 1/4w	4704-147868	01121	CB1005	3		
R117	G1-T1	Res, comp, 2.7k ±5%, 1/4w	4704-170720	01121	CB2725	REF		
R118		Res, ww, 1k (not illustrated)	2					
R119		Res, ww, 2.5k (not illustrated)	2					
R120	F5-R3	Res, met flm, 26.1k ±1%, 1/2w	4705-208371	75042	Type CEC-TO	1		
R121	G3-Q2	Res, var, ww, 10k ±20%, 1-1/4w	4702-112862	71450	Type 110	REF		
R122		Res, ww, 750Ω (not illustrated)	2					
R123		Res, ww, 280.4Ω (not illustrated)	2					
R124	I3-P5	Res, met flm, 100k matched set	1					
R125	B4-S5	Res, var, comp, 1k ±30%, 1/2w (sheet 2 of 2)	4701-193060	73138	62P-RIK	1		
R126	I4-Q4	Res, met flm, 1.014k matched set	1					
R127	I4-R2	Res, met flm, 40.2k ±1%, 1/2w	4705-161059	75042	Type CEC-TO	1		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R128	C4-S5	Res, var, comp, 100k ±30%, 1/2w (sheet 2 of 2)	4701-193045	73138	62P-R100K	1		
R129	J3-P5	Res, met flm, 1.004M matched set (sheet 2 of 2)	1					
R130	I4-Q3	Res, met flm, 10k matched set	1					
R131	C2-S5	Res, var, comp, 100Ω ±30%, 1/2w	4701-193052	73138	62P-R100	1		
R132	C1-T1	Res, comp, 33Ω ±5%, 1/4w	4704-175034	01121	CB3305	REF		
R133	C2-Q1	Res, comp, 33Ω ±5%, 1/4w	4704-175034	01121	CB3305	REF		
R134	D1-T2	Res, comp, 27k ±5%, 1/4w	4704-148148	01121	CB2735	4		
R135	C2-S3	Res, comp, 33k ±5%, 1/4w	4704-148155	01121	CB3335	3		
R136	D2-T3	Res, comp, 220Ω ±5%, 1/4w	4704-147959	01121	CB2215	2		
R137	F3-P5	Res, comp, 18k ±5%, 1/4w	4704-148122	01121	CB1835	2		
R138	F3-R2	Res, comp, 180k ±5%, 1/4w	4704-193441	01121	CB1845	3		
R139	D1-S1	Res, comp, 3k ±5%, 1/4w	4704-193508	01121	CB3025	1		
R140	D2-R2	Res, met flm, 75k ±1%, 1/4w	4705-193961	75042	Type CEC-TO	1		
R141	D1-P5	Res, met flm, 68.1k ±1%, 1/2w	4705-161083	75042	Type CEC-TO	1		
R142	E2-T2	Res, ww, 20k, 1w	4707-131680	89536	4707-131680	1		
R143	E3-T2	Res, var, ww, 2k ±10%, 1w	4702-190355	02660	Type 2610	1		
R144	E4-S4	Res, ww, 15.6k	4707-195826	89536	4707-195826	1		
R145	D4-S2	Res, comp, 56k ±5%, 1/4w	4704-170738	01121	CB5635	2		
R146	E3-S2	Res, comp, 820Ω ±5%, 1/4w	4704-148015	01121	CB8215	1		
R147	D3-R2	Res, comp, 30k ±5%, 1/4w	4704-193417	01121	CB3035	1		
R148	D1-S3	Res, comp, 56k ±5%, 1/4w	4704-170738	01121	CB5635	REF		
R149	E4-S3	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R150	E4-T4	Res, ww, matched set	5					
R151	F2-R3	Res, comp, 330Ω ±5%, 1/4w	4704-147967	01121	CB3315	2		
R152	H4-R5	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
R153	G4-T2	Res, comp, 22Ω ±5%, 1/4w	4704-147884	01121	CB2205	1		
R154	E3-P2	Res, comp, 10Ω ±5%, 1/4w	4704-147868	01121	CB1005	REF		
S101	J5-T2	Switch, RANGE, rotary, 5 pos,	5105-198341	89536	5105-198341	1		

1 Resistors R1, R124, R126, R129 and R130 are factory matched. If replacement is required, an entire set, part number 4705-192849, must be ordered.

2 These resistors are factory matched. If replacement is required, please give model, serial number, reference designation, and all markings from the resistor you are replacing.

4 These components are factory selected. If replacement is required, replace with exact value. These parts may or may not be installed.

5 CR106, R150 and R237 are factory matched. If replacement is required, an entire set, part number 4807-197897, must be ordered.

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A4		**VARIABLE GAIN AC AMPLIFIER ASSEMBLY - Figure 5-7**	1702-197806 (931A-402)	89536	1702-197806	REF		
C201	H5-Q5	Cap, elect, 80 uf +50/-10%, 16v	1502-192914	73445	C426ARE80	6	1	
C202	I3-Q5	Cap, elect, 80 uf +50/-10%, 16v	1502-192914	73445	C426ARE80	REF		
C203	F3-S2	Cap, cer, .05 uf +80/-20%, 500v	1501-105676	56289	33C58B	2		
C204	G3-R4	Cap, mica, 100 pf ±5%, 500v	1504-148494	72136	DM-15-101	2		
C205	F5-R1	Cap, Ta, 5.6 uf ±10%, 35v	1508-198259	05397	K5R6C35K	1		A
C205	F5-R1	Cap, Ta, 10 uf ±20%, 6v	1508-106906	56289	150D106X-0006B2	1		B
C206	G4-S2	Cap, mica, 10pf ±10%, 500v	1504-175216	72136	DM-15-100	REF		
C207	G3-S4	Cap, var, 1-8 pf, 500v	1509-267906	72982	532-000	1		
C208	F4-R3	Cap, elect, 1,250 uf +50/-10%, 4v	1502-166330	73445	C437ARB1250	1	1	
C209	F1-S4	Cap, elect, 80 uf +50/-10%, 16v	1502-192914	73445	C426ARE80	REF		
C210	E2-R5	Cap, cer, .05 uf +80/-20%, 500v	1501-105676	56289	33C58B	REF		
C211	D3-S5	Cap, elect, 80 uf +50/-10%, 16v	1502-192914	73445	C426ARE80	REF		
C212	D2-S2	Cap, elect, 80 uf +50/-10%, 16v	1502-192914	73445	C426ARE80	REF		
C213	B2-R4	Cap, Ta, 68 uf ±10%, 15v	1508-182824	05397	K68C15K	2	1	
C214	B5-R5	Cap, Ta, 68 uf ±10%, 15v	1508-182824	05397	K68C15K	REF		
C215	D4-R2	Cap, Ta, 330 uf ±10%, 6v	1508-193011	05397	K330J6K	2	1	A
C215	D4-R2	Cap, elect, 400 uf ±50%, 4v	1502-187773	73445	C426ARB400	2		B
C216	D4-Q5	Cap, Ta, 330 uf ±10%, 6v	1508-193011	05397	K330J6K	REF		A
C216	D4-Q5	Cap, elect, 400 uf ±50%, 4v	1502-187773	73445	C426ARB400	REF		B
C217	E4-Q3	Cap, factory selected	4					
C218	B5-P3	Cap, factory selected	4					
C219	B4-Q2	Cap, factory selected	4					
C220	H3-R1	Cap, mica, 33 pf ±5%, 500v	1504-160317	72136	DM-15-330	REF		
CR201	K4-Q1	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR202	K3-Q1	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
K201	B1-Q3	Relay, 115 vac, dpdt	4504-218073	24446	3SBF-5-43-4-M-1	1	1	
Q201	H2-R3	Tstr, silicon, NPN	4805-218081	04713	MPS6520	REF		
Q202	H2-S3	Tstr, silicon, NPN	4805-218081	04713	MPS6520	REF		
Q203	F5-S1	Tstr, silicon, NPN	4805-218081	04713	MPS6520	REF		
Q204	E4-S3	Tstr, silicon, NPN	4805-159855	07910	CS23030	2	1	
Q205	C3-S4	Tstr, silicon, NPN	4805-168708	03508	2N3391	REF		
Q206	C1-S2	Tstr, silicon, NPN	4805-159855	07910	CS23030	REF		

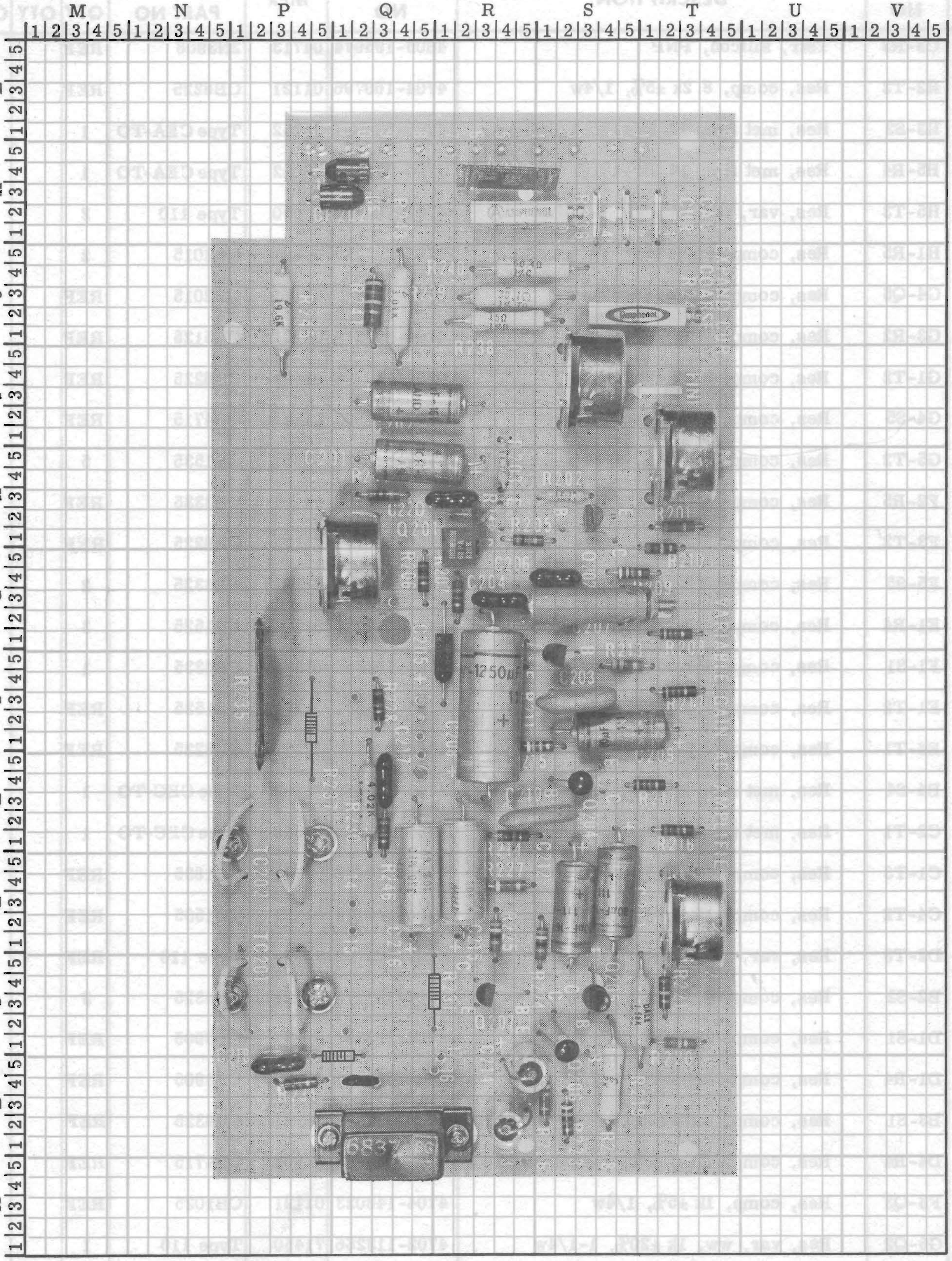


Figure 5-7. VARIABLE GAIN AC AMPLIFIER ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
Q207	C3-R3	Tstr, silicon, PNP	4805-195974	04713	2N3906	REF		
R201	H2-T2	Res, comp, 8.2k ±5%, 1/4w	4704-160796	01121	CB8225	REF		
R202	H3-S2	Res, met flm, 12.1k ±1%, 1/8w	4705-234997	75042	Type CEA-TO	1		
R203	H5-R4	Res, met flm, 14.7k ±1%, 1/8w	4705-226225	75042	Type CEA-TO	1		
R204	H5-T3	Res, var, ww, 5k ±5%, 1-1/4w	4702-163709	71450	Type 110	2		
R205	H1-R5	Res, comp, 200Ω ±5%, 1/4w	4704-193482	01121	CB2015	2		
R206	G4-Q5	Res, comp, 200Ω ±5%, 1/4w	4704-193482	01121	CB2015	REF		
R207	G3-R2	Res, comp, 5.1k ±5%, 1/4w	4704-193342	01121	CB5125	REF		
R208	G1-T2	Res, comp, 8.2k ±5%, 1/4w	4704-160796	01121	CB8225	REF		
R209	G4-S5	Res, comp, 470Ω ±5%, 1/4w	4704-147983	01121	CB4715	REF		
R210	G5-T2	Res, comp, 15k ±5%, 1/4w	4704-148114	01121	CB1535	5		
R211	F2-R5	Res, comp, 33k ±5%, 1/4w	4704-148155	01121	CB3335	REF		
R212	F3-T2	Res, comp, 8.2k ±5%, 1/4w	4704-160796	01121	CB8225	REF		
R213	F5-S5	Res, comp, 3.3k ±5%, 1/4w	4704-148056	01121	CB3325	2		
R214	E1-R4	Res, comp, 1.5k ±5%, 1/4w	4704-148031	01121	CB1525	3		
R215	F1-S1	Res, comp, 43k ±5%, 1/4w	4704-193367	01121	CB4335	1		
R216	E1-T2	Res, comp, 1.5k ±5%, 1/4w	4704-148031	01121	CB1525	REF		
R217	E4-T1	Res, comp, 8.2k ±5%, 1/4w	4704-160796	01121	CB8225	REF		
R218	B4-S4	Res, met flm, 2k ±1%, 1/2w	4705-151266	75042	Type CEC-TO	1		
R219	C2-T1	Res, met flm, 1.58k ±1%, 1/2w	4705-182543	75042	Type CEC-TO	1		
R220	C1-T3	Res, comp, 18k ±5%, 1/4w	4704-148122	01121	CB1835	REF		
R221	C4-T2	Res, comp, 15k ±5%, 1/4w	4704-148114	01121	CB1535	REF		
R222	D2-T3	Res, var, ww, 5k ±5%, 1-1/4w	4702-163709	71450	Type 110	REF		
R223	B2-S2	Res, comp, 4.3k ±5%, 1/4w	4704-193375	01121	CB4325	3		
R224	D1-S1	Res, comp, 39Ω ±5%, 1/4w	4704-193391	01121	CB3905	REF		
R225	D1-R4	Res, comp, 39Ω ±5%, 1/4w	4704-193391	01121	CB3905	REF		
R226	B3-S1	Res, comp, 4.3k ±5%, 1/4w	4704-193375	01121	CB4325	REF		
R227	D4-R4	Res, comp, 470Ω ±5%, 1/4w	4704-147983	01121	CB4715	REF		
R228	F3-Q3	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
R229	G5-Q2	Res, var, ww, 1k ±20%, 1-1/4w	4702-113266	71450	Type 110	1		
R230	E3-Q2	Res, met flm, 4.02k ±1%, 1/2w	4705-167478	75042	Type CEC-TO	1		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R231	C4-R1	Res, ww, 55.2Ω matched set	[2]					
R232	K4-R3	Res, ww, 3.2k ±1%	4707-195842	89536	4707-195842	1		
R233	B5-Q1	Res, factory selected	[4]					
R234	B4-P4	Res, factory selected	[4]					
R235	F3-P2	Res, ww, 63.7k	4707-195818	89536	4707-195818	1	1	
R236	K2-R5	Res, var, ww, 10k ±10%, 1w	4702-190348	02660	Type 2610	1		
R237	F2-P5	Res, selected, matched zener reference set	[5]					
R238	J2-R4	Res, met flm, 15Ω ±1%, 1/2w	4705-151050	75042	Type CEC-TO	1		
R239	J3-R4	Res, met flm, 30.1Ω ±1%, 1/2w	4705-198291	75042	Type CEC-TO	1		
R240	J4-R5	Res, met flm, 60.4Ω ±1%, 1/2w	4705-196691	75042	Type CEC	1		
R241	J3-Q3	Res, comp, 82k ±5%, 1/2w	4704-195966	01121	EB8235	1		
R242	I4-S4	Res, var, ww, 10k ±10%, 1-1/4w	4702-162115	71450	Type 110	1		
R243	J3-Q4	Res, met flm, 3.01k ±1%, 1/2w	4705-196709	75042	Type CEC	1		
R244	J2-T1	Res, var, ww, 1k ±10%, 1w	4702-190363	02660	Type 2610	1		
R245	J2-P3	Res, met flm, 19.6k ±1%, 1/2w	4705-159640	75042	Type CEC-TO	2		
R246	E1-Q3	Res, factory selected	[4]					
R247	H3-Q3	Res, comp, 10Ω ±5%, 1/4w	4704-147868	01121	CB1005	REF		
R248	H1-R2	Res, var, comp, 10k ±30%, 1/2w	4713-203844	73138	Type 62PA	1		
TC201 TC202	C5-P2 D5-P2	Thermocouple, vacuum, (matched pair)	5302-199679	11403	CS1707A	1	1	

[2] These resistors are factory matched. If replacement is required, please give model, serial number, reference designation, and all markings from the resistor you are replacing.

[4] These components are factory selected. If replacement is required, replace with exact value. These parts may or may not be installed.

[5] CR106, R150 and R237 are factory matched. If replacement is required, an entire set, part number 4807-197897, must be ordered.

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A5		**NULL DETECTOR ASSEMBLY** Figure 5-8	1702-197814 ([illegible]A-403)	39536	1702-197814	REF		
C301	J4-V1	Cap, poly, 0.1 uf ±10%, 50v	1507-150318	84411	194P1049R5	1		
C302	G4-T4	Cap, Ta, 39 uf ±20%, 6v	1508-163915	06751	TSD2-6-396	1		
C303	F3-U4	Cap, Ta, 15 uf ±20%, 6v	1508-161935	06751	TSD1-6-156	2	1	
C304	B5-S4	Cap, poly, 0.047 uf ±10%, 50v	1507-150300	84411	194P4739R5	2		
C305	C3-R2	Cap, poly, 0.047 uf ±20%, 250v	1507-162008	73445	C280AE/P47K	5		
C306	C3-S3	Cap, poly, 0.047 uf ±10%, 50v	1507-150300	84411	194P4739R5	REF		
C307	E2-R5	Cap, cer, 180 pf ±10%, 500v	1501-105890	71590	BB60181KS3N	1		
C308	K3-U5	Cap, poly, 0.047 uf ±20%, 250v	1507-162008	73445	C280AE/P47K	REF		
C309	K2-U1	Cap, Ta, 15 uf ±20%, 6v	1508-161935	06751	TSD1-6-156	REF		
C310	H5-T1	Cap, poly, 0.047 uf ±20%, 250v	1507-162008	73445	C280AE/P47K	REF		
C311	E1-R1	Cap, poly, 0.047 uf ±20%, 250v	1507-162008	73445	C280AE/P47K	REF		
C312	B5-P5	Cap, Ta, 6.8 uf ±10%, 35v	1508-182782	05397	K6R8C35K	1		
C313	C1-Q3	Cap, elect, 80 uf +50/-10%, 16v	1502-192914	73445	C426ARE80	REF		
C314	C4-P4	Cap, poly, 0.047 uf ±20%, 250v	1507-162008	73445	C280AE/P47K	REF		
C315	I1-P5	Cap, poly, 0.47 uf ±20%, 250v	1507-184366	73445	C280AE/ P470K	2		
C316	I3-S4	Cap, Ta, 1 uf ±20%, 35v	1508-161919	06751	TSD1-35-105	1		
C317	G2-S1	Cap, Ta, 150 uf +20/-15%, 15v	1508-160945	56289	109D157C201-5TO	2		
C318	F4-R2	Cap, Ta, 150 uf +20/-15%, 15v	1508-160945	56289	109D157C201-5TO	REF		
C319	G5-N3	Cap, poly, 0.47 uf ±20%, 250v	1507-184366	73445	C280AE/P470K	REF		
C320	F1-N2	Cap, Ta, 33 uf ±10%, 10v	1508-182832	05397	K33C10K	2	1	
C321	E1-N3	Cap, Ta, 33 uf ±10%, 10v	1508-182832	05397	K33C10K	REF		
CR301	D4-T4	Diode, silicon, 200 ma, 25 piv	4802-190272	93332	1N456A	1	1	
CR302	F4-U3	Diode, germanium, 80 ma, 35 piv	4802-163907	93332	1N279	1	1	
CR303	E4-P2	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR304	F5-Q2	Diode, zener	4808-325472	15818	1N823	2		D
CR305	H2-P1	Diode, zener	4808-325472	15818	1N8[illegible]	REF		D
L301	[illegible]	Transformer, resonator #2	5602-197962	89536	560[illegible]	1		
Q301	[illegible]	Tstr, silicon, NPN	4805-203489	07910	CD[illegible]	REF		
Q302	I5-U3	Tstr, silicon, NPN	4805-203489	07[illegible]	CDQ[illegible]	REF		
Q303	G1-U1	Tstr, silicon, NPN	4805-168708	[illegible]	2N33[illegible]	REF		

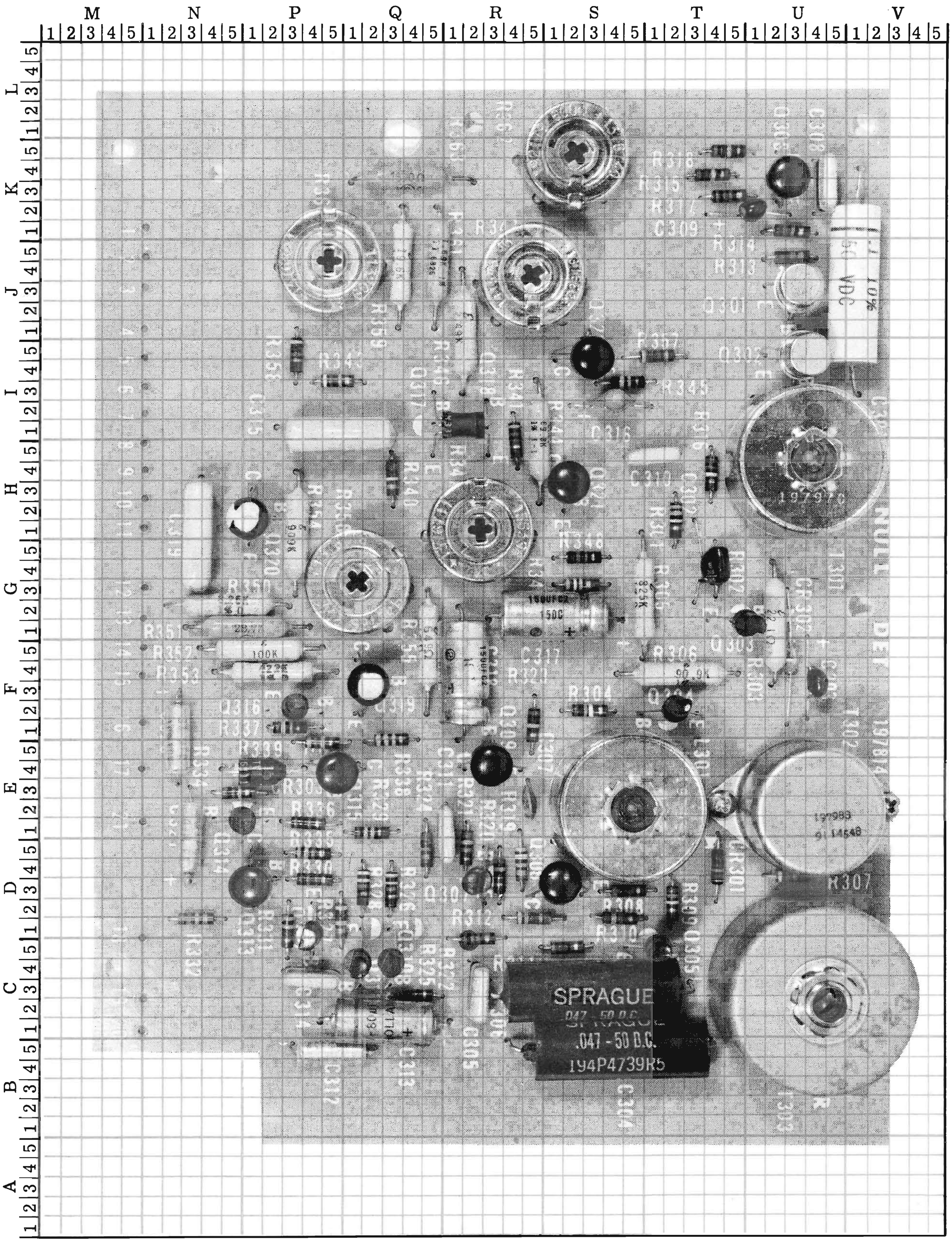


Figure 5-8. NULL DETECTOR ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
Q304	F2-T2	Tstr, silicon, NPN	4805-168708	03508	2N3391	REF		
Q305	C5-T1	Tstr, silicon, NPN	4805-168708	03508	2N3391	REF		
Q306	D3-S1	Tstr, silicon, PNP	4805-203364	07263	2N3638	7	2	
Q307	D3-R2	Tstr, silicon, NPN	4805-168708	03508	2N3391	REF		
Q308	K4-U3	Tstr, silicon, PNP	4805-203364	07263	2N3638	REF		
Q309	E4-R3	Tstr, silicon, PNP	4805-203364	07263	2N3638	REF		
Q310	C4-Q3	Tstr, silicon, NPN	4805-168708	03508	2N3391	REF		
Q311	C4-Q1	Tstr, silicon, NPN	4805-168708	03508	2N3391	REF		
Q312	D1-P4	Tstr, silicon, NPN	4805-168708	03508	2N3391	REF		
Q313	D3-P1	Tstr, silicon, PNP	4805-203364	07263	2N3638	REF		
Q314	E1-P1	Tstr, silicon, NPN	4805-168708	03508	2N3391	REF		
Q315	E4-P5	Tstr, silicon, PNP	4805-203364	07263	2N3638	REF		
Q316	F2-P3	Tstr, silicon, NPN	4805-168708	03508	2N3391	REF		
Q317 Q318	I1-R2	Tstr, silicon, NPN, attached pair	4805-168708	03508	2N3391	REF		
Q319	F3-Q2	Tstr, silicon, PNP, selected	4805-193904	89536	4805-193904	2	1	C
Q320	H2-P1	Tstr, silicon, PNP, selected	4805-193904	89536	4805-193904	REF		C
Q321	H4-S2	Tstr, silicon, PNP	4805-203364	07263	2N3638	REF		
Q322	I5-S3	Tstr, silicon, PNP	4805-203364	07263	2N3638	REF		
R301	H2-T2	Res, comp, 330k ±5%, 1/4w	4704-192948	01121	CB3345	1		
R302	G4-T4	Res, comp, 39Ω ±5%, 1/4w	4704-193391	01121	CB3905	REF		
R303	G1-U2	Res, met flm, 22.1Ω ±1%, 1/2w	4705-151472	75042	Type CEC-TO	1		
R304	F2-S3	Res, comp, 180k ±5%, 1/4w	4704-193441	01121	CB1845	REF		
R305	G3-T1	Res, met flm, 825k ±1%, 1/2w	4705-151308	75042	Type CEC-TO	1		
R306	F4-T3	Res, met flm, 90.9k ±1%, 1/2w	4705-162974	75042	Type CEC-TO	1		
R307	D4-U3	Res, comp, 47k ±5%, 1/4w	4704-148163	01121	CB4735	REF		
R308	D3-S5	Res, comp, 1M ±5%, 1/4w	4704-182204	01121	CB1055	1		
R309	D2-T2	Res, comp, 180k ±5%, 1/4w	4704-193441	01121	CB1845	REF		
R310	D1-S4	Res, comp, 6.8k ±5%, 1/4w	4704-148098	01121	CB6825	3		
R311	C5-S2	Res, comp, 15Ω ±5%, 1/4w	4704-147876	01121	CB1505	2		
R312	D2-R5	Res, comp, 4.3k ±5%, 1/4w	4704-193375	01121	CB4325	REF		
R313	J5-U3	Res, comp, 220Ω ±5%, 1/4w	4704-147959	01121	CB2215	REF		
R314	K1-U3	Res, comp, 5.6k ±5%, 1/4w	4704-148080	01121	CB5625	REF		
R315	K4-T4	Res, comp, 15k ±5%, 1/4w	4704-148114	01121	CB1535	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R316	H4-T4	Res, comp, 120k ±5%, 1/4w	4704-193458	01121	CB1245	REF		
R317	K3-T5	Res, comp, 1.2k ±5%, 1/4w	4704-190371	01121	CB1225	REF		
R318	K5-T5	Res, comp, 15k ±5%, 1/4w	4704-148114	01121	CB1535	REF		
R319	D4-R5	Res, comp, 39k ±5%, 1/4w	4704-188466	01121	CB3935	1		
R320	D4-R3	Res, comp, 6.8k ±5%, 1/4w	4704-148098	01121	CB6825	REF		
R321	D5-R2	Res, comp, 6.8k ±5%, 1/4w	4704-148098	01121	CB6825	REF		
R322	C5-R2	Res, comp, 1.2k ±5%, 1/4w	4704-190371	01121	CB1225	REF		
R323	F1-R5	Res, comp, 15k ±5%, 1/4w	4704-148114	01121	CB1535	REF		
R324	D5-Q5	Res, comp, 12k ±5%, 1/4w	4704-159731	01121	CB1235	REF		
R325	C3-Q5	Res, comp, 15Ω ±5%, 1/4w	4704-147876	01121	CB1505	REF		
R326	D3-Q3	Res, comp, 470Ω ±5%, 1/4w	4704-147983	01121	CB4715	REF		
R327	D1-Q1	Res, comp, 47k ±5%, 1/4w	4704-148163	01121	CB4735	REF		
R328	D3-Q2	Res, comp, 470Ω ±5%, 1/4w	4704-147983	01121	CB4715	REF		
R329	E1-Q2	Res, comp, 27k ±5%, 1/4w	4704-148148	01121	CB2735	REF		
R330	D4-P4	Res, comp, 2.2k ±5%, 1/4w	4704-148049	01121	CB2225	1		
R331	D1-P3	Res, comp, 3.3k ±5%, 1/4w	4704-148056	01121	CB3325	REF		
R332	D2-N3	Res, comp, 68k ±5%, 1/4w	4704-148171	01121	CB6835	1		
R334	E3-N5	Res, comp, 22k ±5%, 1/4w	4704-148130	01121	CB2235	1		
R335	D5-P4	Res, comp, 330Ω ±5%, 1/4w	4704-147967	01121	CB3315	REF		
R336	E1-P4	Res, comp, 1.5k ±5%, 1/4w	4704-148031	01121	CB1525	REF		
R337	F1-P3	Res, comp, 27k ±5%, 1/4w	4704-148148	01121	CB2735	REF		
R338	F1-Q3	Res, comp, 33k ±5%, 1/4w	4704-148155	01121	CB3335	REF		
R339	E5-P4	Res, comp, 82k ±5%, 1/4w	4704-188458	01121	CB8235	1		
R340	H4-Q3	Res, comp, 150k ±5%, 1/4w	4704-182212	01121	CB1545	1		
R341	I1-R4	Res, comp, 8.2k ±5%, 1/4w	4704-160796	01121	CB8225	REF		
R342	H2-R2	Res, var, ww, 1.5k ±10%, 1-1/4w	4702-156398	71450	Type 110	1		
R343	I4-P5	Res, comp, 91k ±5%, 1/4w	4704-193300	01121	CB9135	1		
R344	I1-R5	Res, met flm, 69.8k ±1%, 1/2w	4705-162057	75042	Type CEC-TO	1		
R345	I4-S5	Res, comp, 27k ±5%, 1/4w	4704-148148	01121	CB2735	REF		
R346	J1-R2	Res, met flm, 2.49k ±1%, 1/2w	4705-193995	75042	Type CEC-TO	1		
R347	J4-R4	Res, var, ww, 1k ±20%, 1-1/4	4702-111575	71450	Type 110	1		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R348	G5-S3	Res, comp, 5.1k ±5%, 1/4w	4704-193342	01121	CB5125	1		
R349	G3-S2	Res, comp, 390k ±5%, 1/4w	4704-193383	01121	CB3945	1		
R350	G2-N5	Res, met flm, 8.25k ±1%, 1/2w	4705-192492	75042	Type CEC-TO	1		
R351	G1-P1	Res, met flm, 28.7k ±1%, 1/2w	4705-193987	75042	Type CEC-TO	1		
R352	F5-P2	Res, met flm, 100k ±1%, 1/2w	4705-151316	75042	Type CEC-TO	1		
R353	F4-P2	Res, met flm, 422k ±1%, 1/2w	4705-198283	75042	Type CEC-TO	1		
R354	H1-P3	Res, met flm, 909k ±1%, 1/2w	4705-159483	75042	Type CEC-TO	1		
R355	F5-Q5	Res, met flm, 649Ω ±1%, 1/2w	4705-150730	75042	Type CEC-TO	1		
R356	G4-Q1	Res, var, ww, 200Ω ±20%, 1-1/4w	4702-144766	71450	Type 110	1		
R357	I5-T1	Res, comp, 470Ω ±5%, 1/4w	4704-147983	01121	CB4715	REF		
R358	I5-P3	Res, comp, 7.5k ±5%, 1/4w	4704-193326	01121	CB7525	1		
R359	J4-Q3	Res, met flm, 19.6k ±1%, 1/2w	4705-159640	75042	Type CEC-TO	REF		
R360	J5-P4	Res, var, ww, 6k ±5%, 1-1/4w	4702-113209	71450	Type 110	1		
R361	J4-Q5	Res, met flm, 1.69k ±1%, 1/2w	4705-194001	75042	Type CEC-TO	2		
R362	L1-S2	Res, var, ww, 600Ω ±5%, 1-1/4w	4702-192179	71450	Type 110	1		
R363	K4-Q4	Res, met flm, 1.69k ±1%, 1/2w	4705-194001	75042	Type CEC-TO	REF		
T301	H5-U5	Transformer, oscillator	5602-197970	89536	5602-197970	1		
T302	E2-U4	Transformer, modulator	5602-197988	89536	5602-197988	1		
T303	C3-U4	Transformer, resonator #1	5602-197954	89536	5602-197954	1		A
T303	C3-U4	Transformer, resonator #1	5602-228148	89536	5602-228148	1		B

5-9. SERIAL NUMBER EFFECTIVITY

5-10. A Use Code column is provided to identify certain parts that have been added, deleted, or modified during production of the Model 931B. 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 List below. All parts with no code are used on all instruments with serial numbers above 1044. New codes will be added as required by instrument changes.

USE CODE	EFFECTIVITY
No Code	Model 931B, serial number 1044 and on.
A	Model 931B, serial number 1044 thru 1341.
B	Model 931B, serial number 1342 and on.
C	Model 931B, serial number 123 to 1933.
D	Model 931B, serial number 1934 and on.

SECTION VI

ACCESSORY AND OPTION INFORMATION

6-1. INTRODUCTION

6-2. This section of the manual contains information pertaining to the accessories and options available for your instrument.

6-3. ACCESSORY INFORMATION

6-4. The accessory information, if applicable, will contain details concerning accessories that may be used with this particular instrument.

6-5. OPTION INFORMATION

6-6. Each of the options available for this instrument, if any, are described separately under headings containing the option number. The option descriptions contain applicable operating and maintenance instructions and field installation procedures. - A complete list of replaceable parts for each option is contained at the end of that option description.

OPTION INFORMATION

RECHARGEABLE BATTERY PACK (OPTION-01) FOR THE MODEL 931B RMS DIFFERENTIAL VOLTMETER

6-1. INTRODUCTION

6-2. The Model 931B can be equipped with a rechargeable battery pack upon installation of the 931B-7001 Option Kit. Upon installation of this kit, the instrument is identified as a Model 931B-01 on its rear panel decal.

6-3. OPERATING INSTRUCTIONS

6-4. To operate the Model 931B-01 on battery power, proceed as follows:

a. Place the POWER switch to the BAT CHK position and wait for ten seconds, observing that the meter deflects within the BATTERY OK region.

Note!

Battery manufacturers recommend that nickel-cadmium batteries should not be stored for extended periods of time without recharging at least every 90 days. Storage temperatures below 25°C are recommended.

b. If the batteries are adequately charged, place the POWER switch to the BAT OPR position and proceed with the desired measurement using the procedures outlined in Section II of the Model 931B manual.

WARNING!

Whenever the round pin on the line power cord is not connected to earth ground, the instrument's chassis is at the common INPUT terminal potential.

c. If the batteries are not adequately charged, connect the line power cord to available line power and place the POWER switch to the BAT CHG LINE OPR position. After approximately 16 hours the batteries should be fully charged. Measurements may also be performed with the instrument while the batteries are being charged.

6-5. CIRCUIT DESCRIPTION

6-6. When the POWER switch S1E and D is placed to the BAT OPR position, input power to the series regulators is supplied from BT1 and BT2. Operation of the regulators is the same as described in Section III of the Model 931B manual to provide the operating voltages for the instrument.

6-7. Charging of BT1 and BT2 is provided when the POWER switch is placed to the BAT CHG LINE OPR position. Switch S1C applies 28 volts ac from the secondary of T1 through the voltage dropping resistors R8 and R9 to the half-wave rectifiers CR201 and CR202. The resulting dc voltage is then used to charge the batteries BT1 and BT2. Fuses F2 and F3 protect the instrument circuitry from overloads.

6-8. An indication of relative battery charge is available on the meter M1, when the POWER switch is placed to the BAT CHK position. Switch S1G and F place the meter M1 between the +14.5 volt dc regulator output and the output of BT1. An indication of the relative battery charge under a load condition is then available from the meter. Resistor R39 functions as a meter multiplier.

6-9. MAINTENANCE INSTRUCTIONS

6-10. The batteries contained in the Model 931B-01 may require changing when 48 hours of charging will no longer result in a satisfactory battery check. To replace the batteries contained in the instrument, proceed as follows:

Note!

Zero deflection of the meter during battery check or abrupt failure of the instrument during battery operation may be caused by failure of the battery fuses.

a. Invert the instrument and remove the lower dust cover.

b. Remove the five screws that secure the battery pack cover and remove the cover.

c. Unsolder the connecting wires from the defective nickle-cadmium cells and remove the cells.

Note!

Nickle-cadmium cells when heated or discharged rapidly may give off hydrogen gas. Use care when soldering connections on the cells and when disposing of the cells.

d. Install the replacement 1.2 volt nickle-cadmium cells observing proper polarity of the connections.

e. Replace the plastic battery pack cover and secure it with the five screws.

f. Replace the lower dust cover and check the batteries using the procedure outlined in paragraph 6-3.

6-11. PARTS LIST

6-12. The following list of parts are peculiar only to the 01 Option.

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
		RMS DIFFERENTIAL VOLTMETER RECHARGEABLE BATTERY OPTION (see Figure 5-1)	931B-01					
		ADD the following components:						
		Battery pack	3158-198135	89536	3158-198135	1		
BT1,		Battery, nickel-cadium, 1.2v	4002-160390	06860	1.2SCL	26		
XBT1, XBT2		Holder, battery	3155-198093	89536	3155-198093	2		
F2, F3		Fuse, Type AGC, fast act, 1/2 amp, 250v	5101-153858	71400	Type AGC	2	5	
R8	C5-N4	Res, power, 100Ω ±5%, 25w	4706-190736	75042	Type 2D	2		
R9	D3-N4	Res, power, 100Ω ±5%, 25w	4706-190736	75042	Type 2D	REF		
XF1	I3-N3	Holder, fuse	2102-103283	71400	4405	2		
XF2	I1-N3	Holder, fuse	2102-103283	71400	4405	REF		
A1		**FRONT PANEL ASSEMBLY (see Figure 5-2)**						
		CHANGE the following components to:						
M1	E4-R3	Meter, 100-0-100 ua, 325Ω	2901-208967	89536	2901-208967	1		
	J3-R1	Panel decal	3156-240226	89536	3156-240226	1		
A2		**SWITCH PANEL ASSEMBLY (see Figure 5-3)**	3158-198119 (931AB-402)	89536	3158-198119	1		
		ADD the following component:						
R39	H3-U1	Res, comp, 39k ±5%, 1/4w	4704-188466	01121	CB3935	1		
		CHANGE the following component to:						
S1	G5-T4	Switch, POWER, rotary, 2p, 2 pos, 1 sect	5105-198358	89536	5105-198358	1		

OPTION INFORMATION

PROBE INPUT (OPTION-02) FOR THE MODEL 931B RMS DIFFERENTIAL VOLTMETER

6-1. INTRODUCTION

6-2. The Model 931B can be equipped with a probe input upon installation of the 931B -7002 Option Kit. Upon installation of this kit, the instrument is identified as a Model 931B-02 on its rear panel decal.

6-3. OPERATING INSTRUCTIONS

6-4. Operation of the instrument with a probe input involves attaching the short ground clip on the probe to a common circuit point and then sampling the circuit voltage with the probe tip. Applicable operating instructions are contained in Section II of the Model 931B manual.

6-5. CIRCUIT DESCRIPTION

6-6. Whenever the probe assembly is installed in the instrument, the input attenuator network of R1 and C1 are located in the probe assembly. The range feedback resistors are then matched to the probe assembly. Input capacity of the instrument is then reduced to less than 7 pf at the probe tip.

6-7. MAINTENANCE INSTRUCTIONS

6-8. Troubleshooting and calibration of the instrument with a probe input remains the same as the basic model instrument. Applicable maintenance instructions are contained in Section IV of the Model 931B manual.

6-9. PARTS LIST

6-10. The following list of parts are peculiar only to the Probe Option Kit.

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
		RMS DIFFERENTIAL VOLTMETER PROBE INPUT OPTION	931B-02					
		ADD the following components:						
		Probe Assembly 1	2906-238808	89536	2906-238808	1		
C1		Cap, matched pair, cer, 5.6 pf (inside probe)	1					
R1		Res, met flm, 1.004M, matched set	1					
		Ground lead	6002-221408	89536	6002-221408	1		
		Panel connector collar	3153-200493	89536	3153-200493	1		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
		RMS DIFFERENTIAL VOLTMETER RECHARGEABLE BATTERY OPTION (see Figure 5-1)	931B-01					
		ADD the following components:						
		Battery pack	3158-198135	89536	3158-198135	1		
BT1,		Battery, nickel-cadium, 1.2v	4002-160390	83740	C1.2T	26		
XBT1, XBT2		Holder, battery	3155-198093	89536	3155-198093	2		
F2, F3		Fuse, Type AGC, fast act, 1/2 amp, 250v	5101-153858	71400	Type AGC	2	5	
R8	C5-N4	Res, power, 100Ω ±5%, 25w	4706-190736	75042	Type 2D	2		
R9	D3-N4	Res, power, 100Ω ±5%, 25w	4706-190736	75042	Type 2D	REF		
XF1	I3-N3	Holder, fuse	2102-103283	71400	4405	2		
XF2	I1-N3	Holder, fuse	2102-103283	71400	4405	REF		
A1		**FRONT PANEL ASSEMBLY (see Figure 5-2)**						
		CHANGE the following components to:						
M1	E4-R3	Meter, 100-0-100 ua, 325Ω	2901-208967	89536	2901-208967	1		
	J3-R1	Panel decal	3156-240226	89536	3156-240226	1		
A2		**SWITCH PANEL ASSEMBLY (see Figure 5-3)**	3158-198119 (931AB-402)	89536	3158-198119	1		
		ADD the following component:						
R39	H3-U1	Res, comp, 39k ±5%, 1/4w	4704-188466	01121	CB3935	1		
		CHANGE the following component to:						
S1	G5-T4	Switch, POWER, rotary, 2p, 2 pos, 1 sect	5105-198358	89536	5105-198358	1		

ACCESSORY INFORMATION

MODEL A90 CURRENT SHUNT

6-1. INTRODUCTION

6-2. The Model A90 Current Shunt is designed for use with any high-impedance ac or dc voltmeter capable of accurately measuring 100 millivolts. Six Fluke precision wire wound and strip resistors provide a 100 millivolt full-scale output for each of six pushbutton current ranges: 0.1, 1, 10, 100, and 1000 milliamperes and 10 amperes (ac or dc). Basic accuracy is specified over a frequency range of dc to 4 kHz for the 10 ampere range and dc to 10 kHz for the milliampere ranges.

6-3. The instrument is supplied in half-rack case so that it may be conveniently mounted side-by-side with other half-rack instruments in a standard 19-inch rack. A carrying handle detents into custom non-marring feet and serves as a tilt-up bail for bench use.

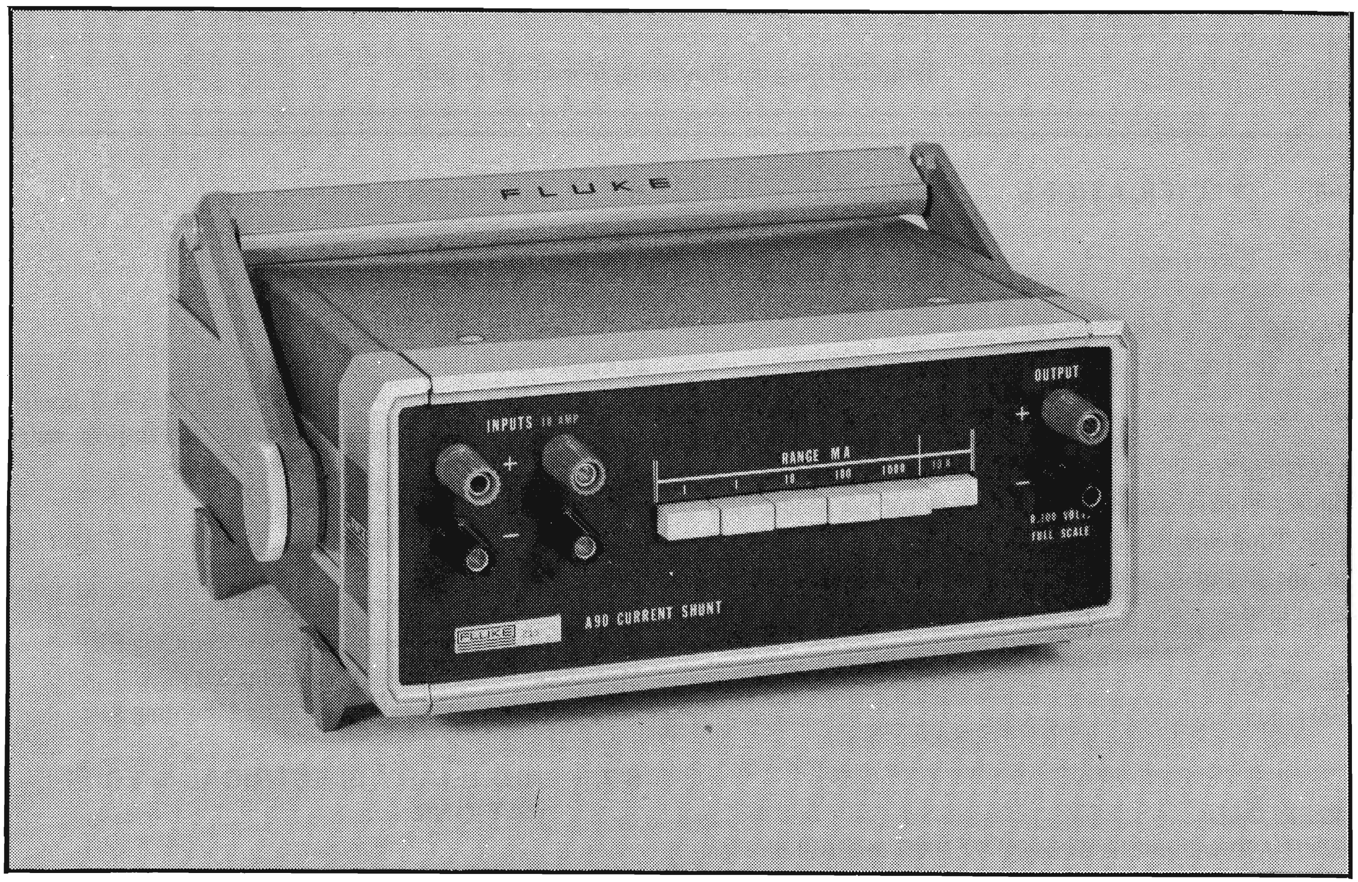
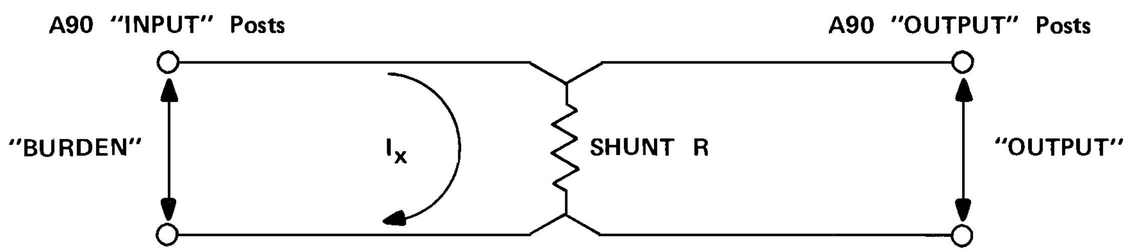


Figure 6-1. MODEL A90 CURRENT SHUNT

Table 6-1. ACCURACY OF A90 (1 year, 15°C - 35°C)

RATED CURRENT RANGE	E BURDEN (APPROX.)	SHUNT R	"OUTPUT" AT RATED CURRENT	"OUTPUT" ACCURACY AS % OF CURRENT INPUT	
				DC ONLY	DC TO 10 KHZ AC
0.1 ma	100 mv	1 kΩ	100 mv	±0.1%	±0.1%
* 0.1 ma	100 mv	1 kΩ	100 mv	+0.0% –0.2%	+0.0% –0.2%
1.0 ma	100 mv	100Ω	100 mv	±0.1%	±0.1%
10 ma	100 mv	10Ω	100 mv	±0.1%	±0.1%
100 ma	102 mv	1Ω	100 mv	±0.1%	±0.1%
1A	120 mv	0.1Ω	100 mv	±0.1%	±0.2%
10A	300 mv	0.01Ω	100 mv	±0.2%	±0.3% (to 4 kHz)

* With 1 MΩ Input R Voltmeter.
When Input R is ⩾10 MΩ, use non-asterisked 0.1 ma specification.



Simplified diagram illustrating terms used in table.

6-4. SPECIFICATIONS

6-5. Electrical

RANGE
0.1, 1, 10, 100, and 1000 milliamps and 10 amperes.

ACCURACY
Table 6-1 gives accuracy specifications for the Model A90 only. Total current measurement accuracy is also dependent on the accuracy and input impedance of the voltmeter being used.

SENSITIVITY
100 millivolts full scale.

OVERLOAD
Model A90 will not be damaged by 100% overload on each range below 10 amperes or by 50% overload on the 10 ampere range.

6-6. Mechanical

CURRENT SELECTION
Pushbutton, each range.

CONNECTORS
Positive (+) and negative (–) INPUT and OUTPUT binding posts with separate input posts for 10 ampere range.

DIMENSIONS
The Model A90 outline drawing is shown in Figure 6-2.

RACK MOUNTING KITS (OPTIONAL)
MEE-7014: Side-by-side Half-rack Mounting Kit
MEE-7006: Center Rack Mounting Kit
MEE-7013: Left or right of center Mounting Kit.

6-7. AUXILIARY ELECTRICAL SPECIFICATIONS

6-8. Tables 6-2 through 6-6 provide accuracy specifications for the Model A90 when used with Fluke Models

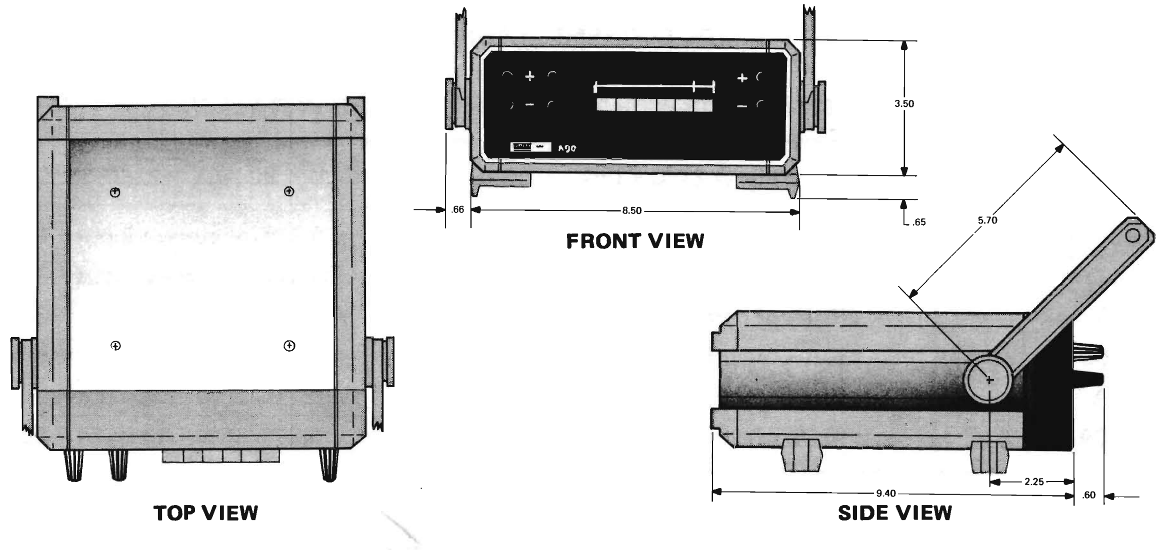


Figure 6-2. MODEL A90 OUTLINE DRAWING

Table 6-2. A90/8100A ACCURACY. 30 days, @ 23°C ±5°C.

DC ACCURACY

CURRENT RANGE	SPECIFICATION
0.1 ma	±(0.12% of current input + 0.1 ua)
1.0 ma	±(0.12% of current input + 1.0 ua)
10 ma	±(0.12% of current input + 10 ua)
100 ma	±(0.12% of current input + 0.1 ma)
1A	±(0.12% of current input + 1.0 ma)
10A	±(0.22% of current input + 10 ma)

AC ACCURACY

CURRENT RANGE	30 Hz — 50 Hz	50 Hz — 10 kHz
0.1 ma	+(0.5% of current input + 1.0 ua) —(0.7% of current input + 1.0 ua)	+(0.2% of current input + 0.5 ua) —(0.4% of current input + 0.5 ua)
1.0 ma	±(0.6% of current input + 10 ua)	±(0.3% of current input + 5.0 ua)
10 ma	±(0.6% of current input + 0.1 ma)	±(0.3% of current input + 50 ua)
100 ma	±(0.6% of current input + 1.0 ma)	±(0.3% of current input + 0.5 ma)
1A	±(0.7% of current input + 10 ma)	±(0.4% of current input + 5.0 ma)
10A	±(0.8% of current input + 100 ma)	±(0.5% of current input + 50 ma)*

*10A specified to 4 kHz only.

For:	DC CURRENT		AC CURRENT	
	V_r =	1v	V_r =	1v
	V_{dfs} =	±.1000	V_{dfs} =	.1000

Table 6-3. A90/8300A ACCURACY

DC CURRENT ACCURACY

MEASUREMENTS WITHOUT MV/OHMS OPTION INSTALLED

CURRENT RANGE	24 hr @ 23°C ±1°C	90 days @ 23°C ±5°C
0.1 ma	±(0.1% of current input + 0.1 ua)	±(0.11% of current input + 0.3 ua)
1.0 ma	±(0.1% of current input + 1.0 ua)	±(0.11% of current input + 3.0 ua)
10 ma	±(0.1% of current input + 10 ua)	±(0.11% of current input + 30 ua)
100 ma	±(0.1% of current input + 0.1 ma)	±(0.11% of current input + 0.3 ma)
1A	±(0.1% of current input + 1.0 ma)	±(0.11% of current input + 3.0 ma)
10A	±(0.2% of current input + 10 ma)	±(0.21% of current input + 30 ma)

V_r = 10 VDC
V_{dfs} = 0.1000 (Readout also will display "DC +" or "DC –").

MEASUREMENTS WITH MV/OHMS OPTION (8300A-02) INSTALLED

CURRENT RANGE	90 days @ 23°C ±5°C
0.1 ma	±(0.11% of current input + 0.01 ua)
1.0 ma	±(0.11% of current input + 0.1 ua)
10 ma	±(0.11% of current input + 1.0 ua)
100 ma	±(0.11% of current input + 10 ua)
1A	±(0.11% of current input + 0.1 ma)
10A	±(0.21% of current input + 1.0 ma)

V_r = 100 MV (0.1v)
V_{dfs} = 100.000 (Readout will also display MV DC + or MV DC–)

AC CURRENT ACCURACY
MEASUREMENTS WITH AC OPTION 8300A-01 INSTALLED
90 days @ 23°C ±5°C using AC Zero control periodically.

CURRENT RANGE	30 Hz – 50 Hz	50 Hz – 10 kHz
0.1 ma	+(0.5% of current input + 0.05 ua) –(0.7% of current input + 0.05 ua)	+(0.1% of current input + 0.05 ua) –(0.3% of current input + 0.05 ua)
1.0 ma	±(0.6% of current input + 0.5 ua)	±(0.2% of current input + 0.5 ua)
10 ma	±(0.6% of current input + 5.0 ua)	±(0.2% of current input + 5.0 ua)
100 ma	±(0.6% of current input + 50 ua)	±(0.2% of current input + 50 ua)
1A	±(0.7% of current input + 0.5 ma)	±(0.3% of current input + 0.5 ma)
10A	±(0.8% of current input + 5.0 ma)	±(0.4% of current input + 5.0 ma)*

V_r = 1 VAC
V_{dfs} = .10000 (Readout will also display "AC")
*10A specified to 4 kHz only.

Table 6-4. A90/9500A SPECIFICATIONS

ACCURACY WHEN UNKNOWN CURRENT IS 20% OR MORE OF A90 CURRENT RANGE. (23°C ±1°C)

CURRENT RANGE	20 Hz – 50 Hz	50 Hz – 10 kHz
0.1 ma	+(0.3% of current input + 0.02 ua) –(0.5% of current input + 0.02 ua)	+(0.05% of current input + 0.015 ua) –(0.25% of current input + 0.015 ua)
1.0 ma	±(0.4% of current input + 0.2 ua)	±(0.15% of current input + 0.15 ua)
10 ma	±(0.4% of current input + 2.0 ua)	±(0.15% of current input + 1.5 ua)
100 ma	±(0.4% of current input + 20 ua)	±(0.15% of current input + 15 ua)
1A	±(0.5% of current input + 0.2 ma)	±(0.25% of current input + 0.15 ma)
10A	±(0.6% of current input + 2.0 ma)	±(0.35% of current input + 1.5 ma)*

ACCURACY WHEN UNKNOWN CURRENT IS BETWEEN 10% AND 20% OF A90 CURRENT RANGE.

A90 INPUT (% OF CURRENT RANGE)	% OF INPUT ABSOLUTE ACCURACY 20 Hz – 50 Hz @ 23°C ±1°C FOR A90 CURRENT RANGE				
	0.1 ma		1 ma – 100 ma	1A	10A
	+	–			
10-11%	0.53%	0.73%	± 0.63%	±0.73%	±0.83%
12-14%	0.50%	0.70%	± 0.60%	±0.70%	±0.80%
15-17%	0.47%	0.67%	± 0.57%	±0.67%	±0.77%
18-20%	0.44%	0.64%	± 0.54%	±0.64%	±0.74%

A90 INPUT (% OF CURRENT RANGE)	% OF INPUT ABSOLUTE ACCURACY 50 Hz – 10 kHz @23°C ±1°C FOR A90 CURRENT RANGE				
	0.1 ma		1 ma – 100 ma	1A	10A*
	+	–			
10-11%	0.23%	0.43%	±0.33%	±0.43%	±0.53%
12-14%	0.20%	0.40%	±0.30%	±0.40%	±0.50%
15-17%	0.17%	0.37%	±0.27%	±0.37%	±0.47%
18-20%	0.13%	0.33%	±0.23%	±0.33%	±0.43%

V_r = .1v

V_{dfs} = .10000

TC = 0.005% of current input/°C 20 Hz –50 Hz
0.004% of current input/°C 50 Hz – 10 kHz

*10A is specified to 4 kHz only.

8100A, 8300A, 9500A, 891A, 893A, and 931B. Table 6-7 gives V_r and V_{dfs} for each of the voltmeters listed in the tables in addition to various other Fluke voltmeters, where

V_r = Voltage range to be used on the voltmeter
and V_{dfs} = Nominal voltmeter reading with full-scale current in A90 shunt.

6-9. INSTALLATION

6-10. There are three rack-mount kits available, at additional cost, for use with the Model A90. Kit MEE-7014 allows the Model A90 to be mounted side-by-side with another half-rack instrument in a standard 19-inch rack. Kit MEE-7006 supplies hardware necessary to mount the

Table 6-5. A90/891A AND 893A ACCURACY (Sheet 1 of 2)

WITH 891A AND 893A – DC ACCURACY		
CURRENT RANGE	@ 23°C ±2°C	@ 15°C –35°C
0.1 ma	±(0.11% of current input + 0.02 ua)	±(0.12% of current input + 0.02 ua)
1.0 ma	±(0.11% of current input + 0.2 ua)	±(0.12% of current input + 0.2 ua)
10 ma	±(0.11% of current input + 2.0 ua)	±(0.12% of current input + 2.0 ua)
100 ma	±(0.11% of current input + 20 ua)	±(0.12% of current input + 20 ua)
1A	±(0.11% of current input + 0.2 ma)	±(0.12% of current input + 0.2 ma)
10A	±(0.21% of current input + 2.0 ma)	±(0.22% of current input + 2.0 ma)
V_r = 1v V_{dfs} = 0.10000		

WITH 893A – AC ACCURACY @ 23°C ±2°C	
CURRENT RANGE	50 Hz – 10 kHz
0.1 ma	+(0.05% of current input + 0.025 ua) –(0.25% of current input + 0.025 ua)
1.0 ma	±(0.15% of current input + 0.25 ua)
10 ma	±(0.15% of current input + 2.5 ua)
100 ma	±(0.15% of current input + 25 ua)
1A	±(0.25% of current input + 0.25 ma)
10A	±(0.35% of current input + 2.5 ma)*

WITH 893A – AC ACCURACY @ 15°C –35°C		
CURRENT RANGE	5 Hz – 10 Hz	10 Hz – 20 Hz
0.1 ma	+(1.0% of current input + 0.25 ua) –(1.2% of current input + 0.25 ua)	+(0.5% of current input + 0.1 ua) –(0.7% of current input + 0.1 ua)
1.0 ma	±(1.1% of current input + 2.5 ua)	±(0.6% of current input + 1.0 ua)
10 ma	±(1.1% of current input + 25 ua)	±(0.6% of current input + 10 ua)
100 ma	±(1.1% of current input + 0.25 ua)	+(0.6% of current input + 0.1 ma)
1A	±(1.2% of current input + 2.5 ma)	±(0.7% of current input + 1.0 ma)
10A	±(1.3% of current input + 25 ma)	±(0.8% of current input + 10 ma)

893A – AC ACCURACY @ 15°C –35°C.		
CURRENT RANGE	20 Hz – 50 Hz	50 Hz – 10 kHz
0.1 ma	+(0.15% of current input + 0.025 ua) –(0.35% of current input + 0.025 ua)	+(0.1% of current input + 0.025 ua) –(0.3% of current input + 0.025 ua)
1.0 ma	±(0.25% of current input + 0.25 ua)	±(0.2% of current input + 0.25 ua)
10 ma	±(0.25% of current input + 2.5 ua)	±(0.2% of current input + 2.5 ua)
100 ma	±(0.25% of current input + 25 ua)	±(0.2% of current input + 25 ua)
1A	±(0.35% of current input + 0.25 ma)	±(0.3% of current input + 0.25 ma)
10A	±(0.45% of current input + 2.5 ma)	±(0.4% of current input + 2.5 ma)*

Table 6-5. A90/891A AND 893A ACCURACY (Sheet 2 of 2)

V_r = 1v (AC or DC)
V_{dfs} = 0.10000

*10A is specified to 4 kHz only.

Table 6-6. A90/931B SPECIFICATIONS

ACCURACY WHEN UNKNOWN CURRENT IS 10% OR MORE OF A90 CURRENT RANGE

CURRENT RANGE	% OF INPUT ABSOLUTE ACCURACY 2 Hz – 3 Hz	3 Hz – 5 Hz	5 Hz – 30 Hz	SPECIFICATIONS 30 Hz – 10 kHz
0.1 ma	+1.0% −1.2%	+0.5% −0.7%	+0.2% −0.4%	+(0.05% of current input + 5 na) −(0.25% of current input + 5 na)
1.0 ma	±1.1%	±0.6%	±0.3%	±(0.15% of current input + 50 na)
10 ma	±1.1%	±0.6%	±0.3%	±(0.15% of current input + 0.5 ua)
100 ma	±1.1%	±0.6%	±0.3%	±(0.15% of current input + 5 ua)
1A	±1.2%	±0.7%	±0.4%	±(0.25% of current input + 50 ua)
10A	±1.3%	±0.8%	±0.5%	±(0.35% of current input + 0.5 ma)*
TC=	±0.1%/°C	±0.05%/°C	±0.025%/°C	±0.0025%/°C

V_r = 100 MV
V_{dfs} = 100.000

*10A is specified to 4 kHz only.

Table 6-7. "V_r" AND "V_{dfs}" FOR VOLTMETERS OF TABLES 6-2 THROUGH 6-6

VOLTMETER	"V_r"	"V_{dfs}"
8300A (Without MV/Ohms)	10v	.010
8100A, 871A, 873A, 881A, 883A, 885A, 887A, 891A, 893A	1v	.100
801, 803, 801B, 803B, 803D, 821A, 823A, 825A	0.5v	.100
9500A, 910A	0.1v	.100
8300A (With MV/Ohms), 931A, 931B	100 MV	100.0

V_r = Voltage range to be used on the voltmeter.
V_{dfs} = Nominal voltmeter reading with full-scale current in A90 shunt.

instrument in the center of the rack. Kit MEE-7013 supplies two different sized rack ears so that the instrument can be mounted to the left or to the right of rack center.

6-11. OPERATING INSTRUCTIONS

6-12. A description of Model A90 controls and terminals is given in Figure 6-3.

6-13. Equipment Connections

6-14. It is recommended that the Model A90 always be used in the "LO" lead as shown in Figure 6-4A. When used in the "HI" lead, as shown in Figure 6-4B, the distributed capacitance, C_{DIST}, loads the source. When connected in the "HI" lead, the voltmeter guard should either be connected as shown or else the voltmeter should be battery operated.

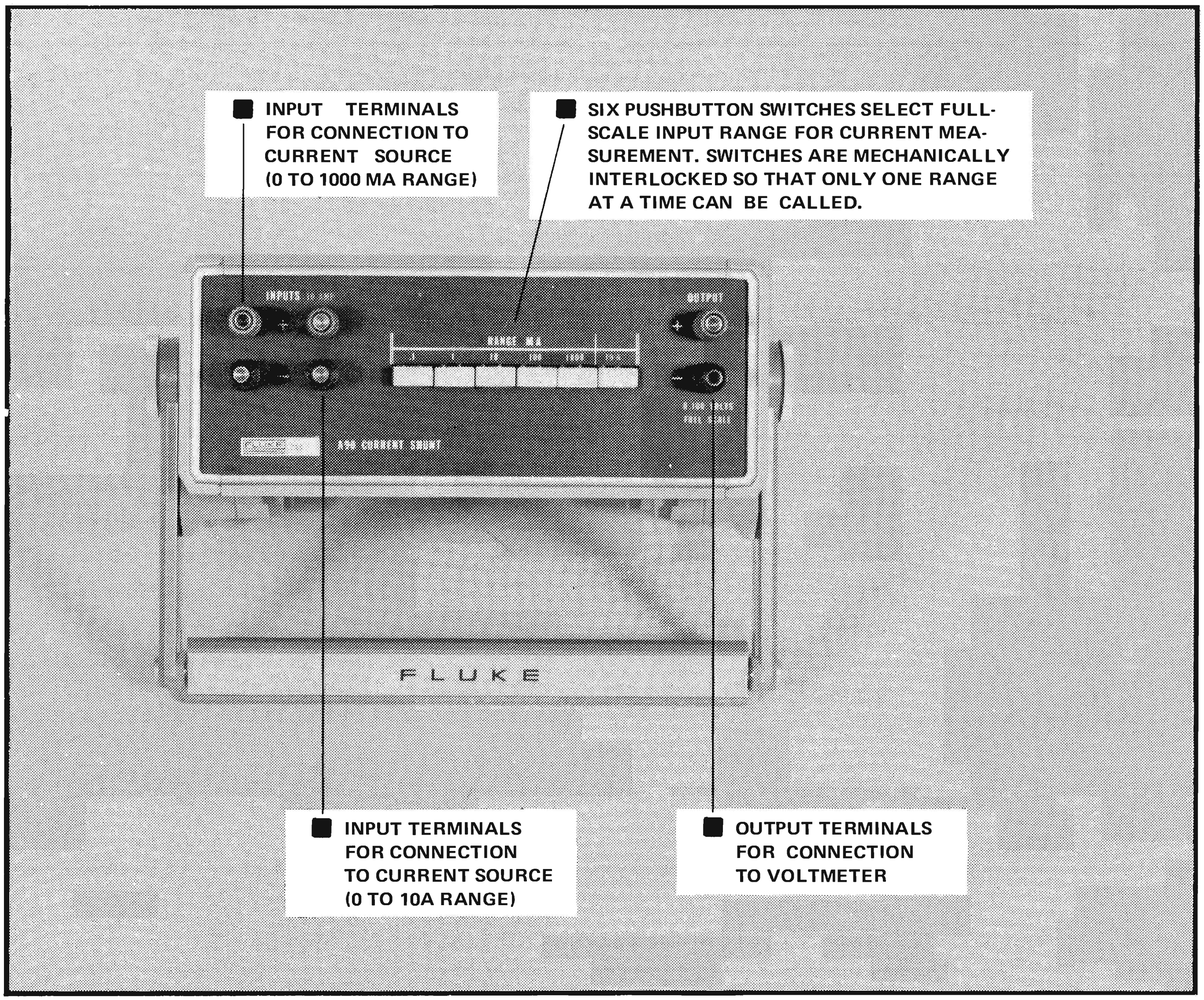


Figure 6-3. MODEL A90 CONTROLS AND TERMINALS.

6-15. At high ac currents, performance of the A90 may depend upon the manner in which the current leads are connected to the input binding posts. Optimum performance is obtained when the input current leads are twisted.

6-16. Voltmeter Impedance

6-17. The input impedance of the voltmeter which is used with the Model A90 is significant with regard to total measurement accuracy. As indicated in the specifications, Model A90 measurement accuracy is derated for voltmeters having finite input impedance. As the voltmeter input capacity increases, the Model A90 response rolls off at the high end; and as the voltmeter input resistance decreases, the response shifts downward, resulting in negative measurement errors.

6-18. Combining Model A90 And Voltmeter Specifications

6-19. Combined specifications for the A90 when used with various Fluke voltmeters is given in Tables 6-2 through 6-6. When the A90 is used with other voltmeters, the following information may be used to combine specifications.

6-20. Equation 1 (Figure 6-5) is used to combine A90 and voltmeter specifications for overall accuracy. The "W" term is taken from Table 6-1, and the "X", "Y" and "Z" terms are taken from voltmeter specifications (data sheets). All Fluke voltmeter specifications, except the Model 910A, contain the "X" term; they usually list the "Y" term and occasionally the "Z" term. Model 910A accuracy specifi-

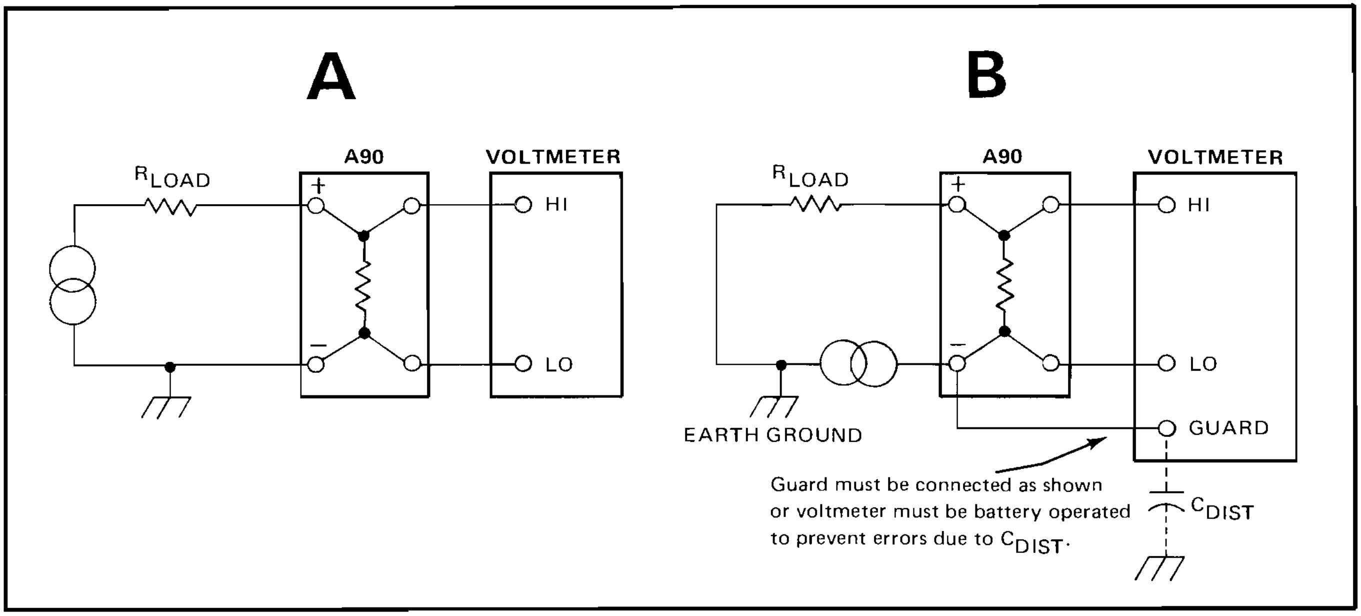


Figure 6-4. EQUIPMENT CONNECTIONS FOR CURRENT MEASUREMENT.

EQUATION 1. COMBINING A-90 SPECIFICATION WITH VOLTMETER SPECIFICATION.

A-90 Specification (from Table 6-1)

$\pm$ W %

Voltmeter Specification (from Voltmeter Data Sheet)

$\pm$ (X % of input + Y % of range + Z uv)

Vr = Lowest voltmeter range that will measure 100 MV

$$= + \left[(W + X) \text{ \% of current input} + \frac{Vr}{0.1} \times \left(Y + \frac{Z}{10000} \right) \text{ \% of current range} \right]$$

EXAMPLE 1: Accuracy using 10 ma DC A-90 range with 891A.

A-90 Specification (from Table 6-1)

$\pm$ 0.1 %

891A Specification (from 891A Data Sheet)

$\pm$ (0.01 % of input + 0.001 % of range + 10 uv)

Vr = 1.0 (891A's 1v DC Range)

$$= \pm \left[(0.1 + 0.01) \text{ \% of current input} + \frac{1.0}{0.1} \times \left(0.001 + \frac{10}{10{,}000} \right) \text{ \% of current range} \right]$$

$$= \pm \left[0.11\text{\% of current input} + 0.02\text{\% of current range} \right]$$

$$= \pm \left[0.11\text{\% of current input} + 2 \text{ ua} \right]$$

Figure 6-5. EQUATION 1 – COMBINING A90 AND VOLTMETER SPECIFICATIONS (Sheet 1 of 2)

EXAMPLE 2: Accuracy using 0.1 ma AC A-90 range with 873A at 1 kHz.

Model 873A has 1 megohm input impedance in its AC mode so separate accuracy statements are required for positive and negative limits of error for measurements made on the A-90's 0.1 ma range.

Positive Limit of Error

A-90 Specification — 873A Specification

$$+\ 0.0\ \% \qquad \pm\ 0.2\ \%\ \text{of input}\ +\ 25\ \text{uv}$$

"Vr" is 873A's 1v AC Range

No "Y" Term In Spec.

$$= +\left[(0.0 + 0.2)\ \%\ \text{of current input} + \frac{1}{0.1} \times \left(0 + \frac{25}{10000}\right)\ \%\ \text{of current range}\right]$$

$$= +\left[\ 0.2\%\ \text{of current input} + 0.025\%\ \text{of current range}\ \right]$$

Negative Limit of Error

$$= -\left[(0.2 + 0.2)\ \%\ \text{of current input} + 0.025\%\ \text{of current range}\right]$$

$$= -\left[0.4\%\ \text{of current input} + 0.025\%\ \text{of current range.}\right]$$

Figure 6-5. EQUATION 1 – COMBINING A90 AND VOLTMETER SPECIFICATIONS (Sheet 2 of 2)

cation consists of "Y" term only. If "X", "Y", or "Z" do not appear in a voltmeter accuracy specification, it should be treated as a zero in Equation 1. The voltmeter must be used on the lowest range that can measure 100 millivolts. This range is assigned the symbol "V_r" in Equation 1. V_r is always stated as volts, i.e., 100 millivolt range equals 0.1 volts for V_r.

6-21. Equation 2 (Figure 6-6) may be used to convert the voltmeter voltage reading to current.

6-22. THEORY OF OPERATION

6-23. The schematic diagram of the Model A90 is located at the back of the manual. In the milliampere ranges, current is directed through the appropriate shunt resistor by switches S1A through S5A, and the corresponding output voltage is connected to the output terminals through switches S1 through S5, decks B and C. In 10 ampere range, the input current is applied directly to the shunt resistor, and the output voltage is connected to the output terminals through switch S6.

6-24. All shunt resistors are four-terminal shunts or are connected in a four-terminal switching arrangement so that lead resistance does not affect measurement accuracy.

6-25. MAINTENANCE

6-26. The following paragraphs contain instructions for cleaning and calibrating the Model A90.

6-27. Cleaning

6-28. The instrument should be cleaned periodically to remove dust, grease, and other contamination. The following procedure should be adhered to when cleaning the instrument:

a. Remove loose contamination with low-pressure, clean, dry air.

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

CAUTION!

Do not use aromatic hydrocarbons or chlorinated solvents on the front panel, because they will react with the Lexan binding posts.

$$I_x = I_r \times \frac{V_d}{V_{dfs}}$$

Where:
- I_x = magnitude of unknown current in units of A90 "RANGE" used. (i.e. ma or amps).
- I_r = A90 Rated Current "RANGE".
- V_d = Voltmeter reading.
- V_{dfs} = Nominal Voltmeter reading with rated current flowing in A90. "V_{dfs}" and "V_r" are tabulated in Table 6-7 for each voltmeter listed in Tables 6-2 through 6-6. Note that "V_{dfs}" multiplies or divides "V_d" by powers of 10 so it is simple to manipulate.

EQUATION 2. CONVERTING VOLTAGE READINGS TO CURRENT

Example: An 8100A reads =.0643 when used with an A90 in the 10 ma range. What current is flowing?

- I_r = 10 ma (A90 "Rated Current Range")
- V_d = .0643 (Voltmeter reading)
- V_{dfs} = .1000 (From Table 6-7)

Answer: $I_x = 10 \text{ ma} \times \frac{.0643}{.1000} = 6.43 \text{ ma}$

Figure 6-6. Equation 2 – CONVERTING VOLTAGE READINGS TO CURRENT

6-29. Test Equipment

6-30. Test equipment required for calibration and testing of the Model A90 is shown in Table 6-8. If the recommended equipment is not available, other equivalent equipment may be used.

Table 6-8. LIST OF TEST EQUIPMENT

NAME	RECOMMENDED EQUIPMENT
Constant Current Source	Fluke Model 382A
DC Differential Voltmeter	Fluke Model 895A or 885A
Low-Thermal Leads	
4-Terminal Ohmmeter	Fluke Model 8300A with Option -02

6-31. Calibration

6-32. PRELIMINARY CHECKS. Make the resistance checks shown in Table 6-9. Values are approximate since check is intended to show only gross errors, such as defective or open resistors.

6-33. .1 MA AND 1 MA RANGE CHECKS. Connect the ohmmeter and A90, as shown in Figure 6-7, for 4-terminal resistance measurements, and perform the following steps:

a. Set the A90 to the .1 MA range. The ohmmeter should indicate between 1.00050 and 0.99950 kilohms. If the measured resistance is not within these limits, the .1 MA shunt, R6, is defective and must be replaced.

b. Set the A90 to the 1 MA range. The ohmmeter should indicate between 100.07 and 99.93 ohms. If the measured resistance is not within these limits, the 1 MA shunt, R5, is defective and must be replaced.

6-34. 10 MA, 100 MA, AND 1000 MA RANGE CHECKS. Connect the constant current generator, differential voltmeter, and A90 as shown in Figure 6-8 and perform the following steps:

a. Set the A90 to the 10 MA range.

b. Set the differential voltmeter controls as follows:

RANGE	1 Volt
NULL Sensitivity	100 μV
Readout Dials	0.100000

Table 6-9. RESISTANCE CHECKS

OHMMETER CONNECTIONS	MODEL A90	
	RANGE	APPROXIMATE RESISTANCE (OHMS)
INPUT Terminals	.1 MA	1000
	1 MA	100
	10 MA	10
	100 MA	1
	1000 MA	0.1
	10A	∞
INPUT (10A Terminals)	10A	0.01
OUTPUT Terminals	10A	0.01
	1000 MA	0.1
	100 MA	1
	10 MA	10
	1 MA	100
	.1 MA	1000

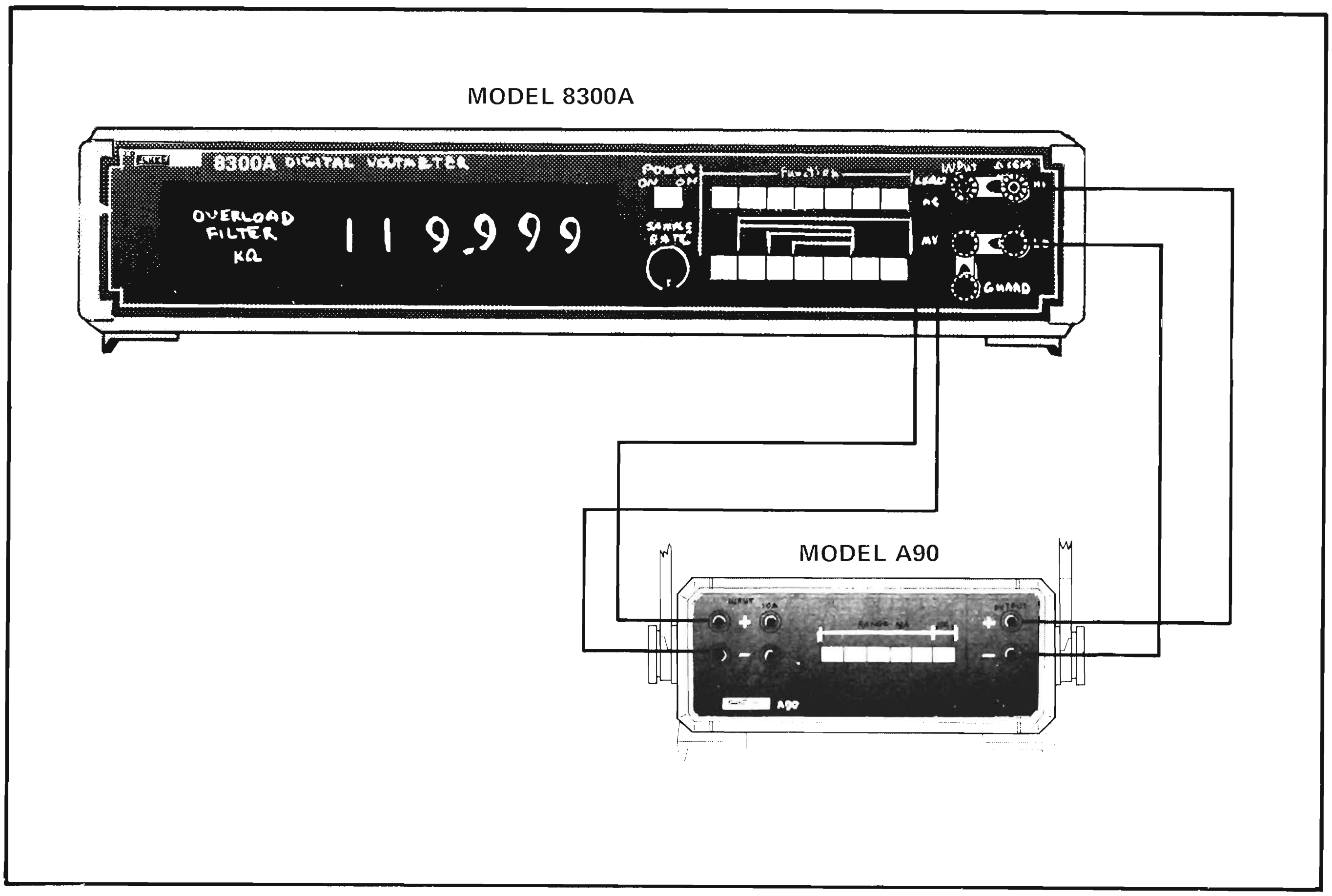


Figure 6-7. EQUIPMENT CONNECTIONS – .1 MA AND 1 MA RANGE CHECKS

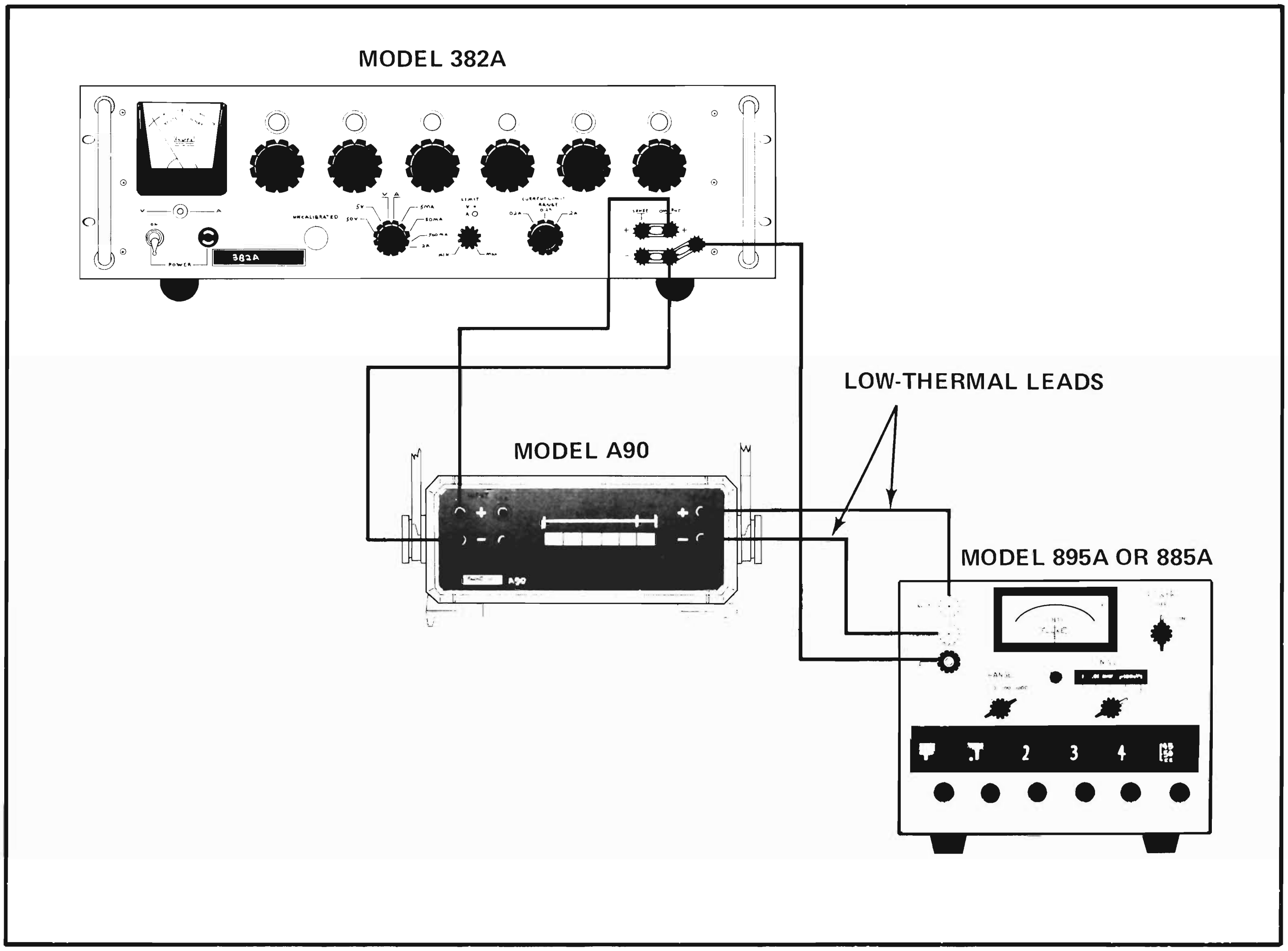


Figure 6-8. EQUIPMENT CONNECTIONS – 10 MA, 100 MA, AND 1000 MA RANGE CHECKS

c. Set the constant current generator for 10.0000 milliamperes output. The differential voltmeter should indicate null within ±80 micorvolts. If the voltmeter does not indicate within these limits, the 10 MA shunt, R4, is defective and must be replaced.

d. Change the A90 range to 100 MA and the constant current generator output to 100 milliamperes. The differential voltmeter should indicate null within ±80 microvolts. If the voltmeter does not indicate within these limits, the 100 MA shunt, R3, is defective and must be replaced.

e. Change the A90 range to 1000 MA and the constant current generator output to 1000 milliamperes. The differential voltmeter should indicate null within ±80 microvolts. If the +80 microvolt limit is not met, the 1000 MA shunt, R2, should be replaced. If the –80 microvolt limit is not met, R2 is low in ohmic value and can be trimmed to its desired value by carefully removing a small amount of material from the edge of the shunt using a whetstone.

6-35. 10 AMPERE RANGE CHECK. Connect equipment as shown in Figure 6-8, leaving the constant current generator temporarily disconnected from the A90, and perform the following steps:

a. Set the differnetial voltmeter controls as follows:

RANGE	1 Volt
NULL Sensitivity	100 μV
Readout Dials	0.00000

The voltmeter should indicate less than ±4 microvolts of thermal offset. If more than ±4 microvolts of offset is observed, check for cold solder joints or possible thermal generators in the test setup. When thermal offset has been reduced to within ±4 microvolts, proceed to step (b).

b. Connect the constant current generator to the 10 AMP binding posts of the A90 and set the A90 to the 10A range.

c. Set the differential voltmeter controls as follows:

RANGE	1 Volt
NULL Sensitivity	100 μV
Readout Dials	.020000

d. Set the constant current generator output to 2 amperes. The voltmeter should indicate null within ±80 microvolts. If the +80 microvolt limit is not met, the 10 ampere shunt, R1, should be replaced. If the −80 microvolt limit is not met, R1 is low in ohmic value and can be trimmed to its desired value by carefully removing a small amount of material from the edge of the shunt using a whetstone.

6-36. LIST OF REPLACEABLE PARTS

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
		CURRENT SHUNT – Figure 6-9	A90					
		Shunt PCB Assembly (See Figure 6-9)	A90-403	89536	A90-403	1		
J1, J2, J5		Binding post, red, +	275552	89536	275552	3		
J3, J4, J6		Binding post, black –	275560	89536	275560	3		
		Cover, bottom	224360	89536	224360	1		
		Cover, top	224352	89536	224352	1		
		Foot	230037	89536	230337	4		
		Handle, carrying	231423	89536	231423	1		
		Panel, front	A90-208	89536	A90-208	1		
		Panel, rear	A90-209	89536	A90-209	1		

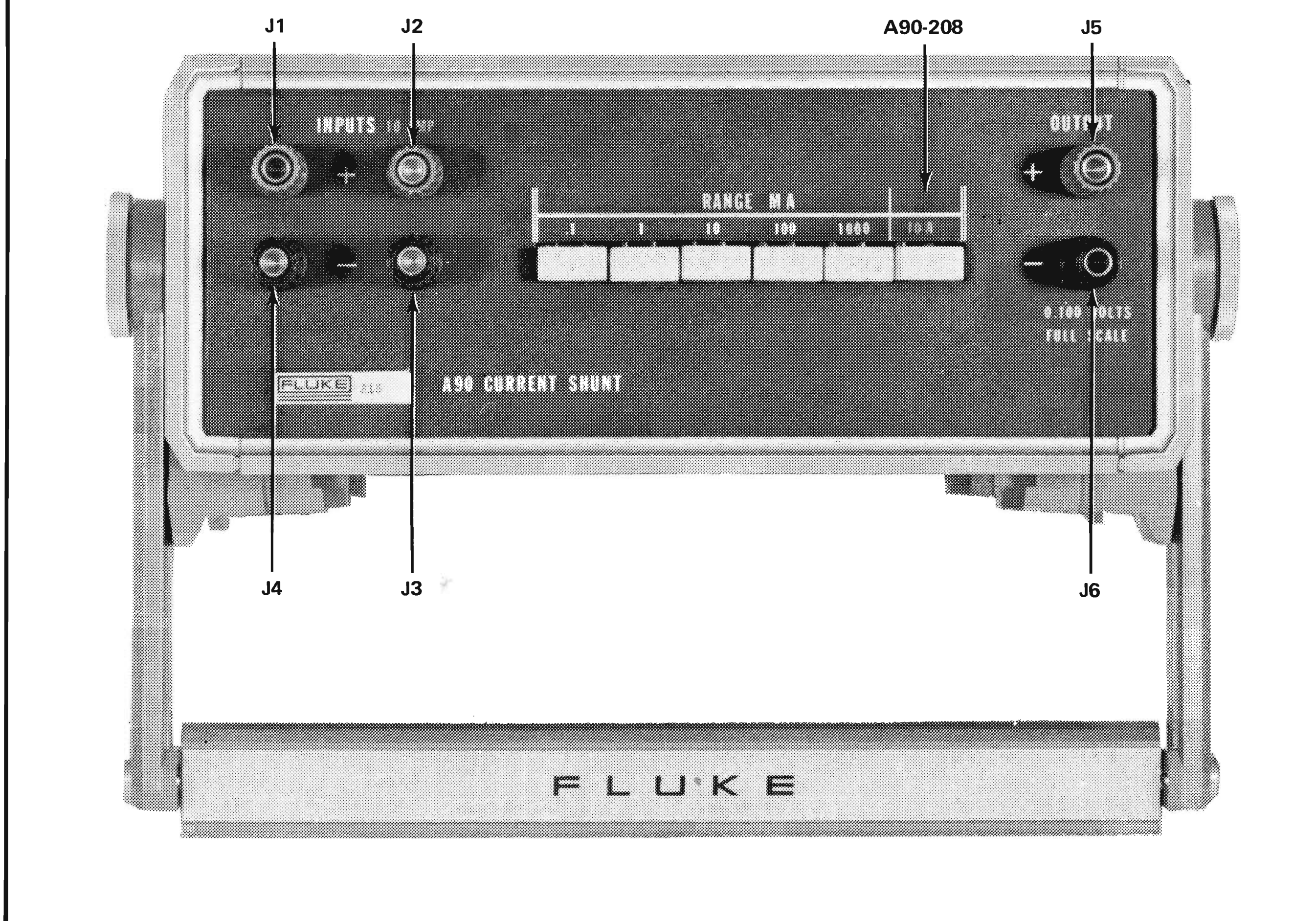


Figure 6-9. MODEL A90 CURRENT SHUNT (Sheet 1 of 2)

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
		SHUNT PCB ASSEMBLY — Figure 6-9	A90-403	89536	A90-403	REF		
R1		Res, ww, 0.010Ω ±0.2%, 1w	34-4022	89536	34-4022	1		
R2		Res, ww, 0.10Ω ±0.1%, 1w	224121	89536	224121	1		
R3		Res, ww, 1.0Ω ±0.1%, ½w	224089	89536	224089	1		
R4		Res, ww, 10Ω ±0.1%, ½w	224071	89536	224071	1		
R5		Res, ww, 100Ω ±0.03%, ½w	155846	89536	155846	1		
R6		Res, ww, 1 KΩ ±0.04%, ½w	131706	89536	131706	1		
S1 thru S6		Switch assembly, RANGE MA	A90-802	89536	A90-802	1		

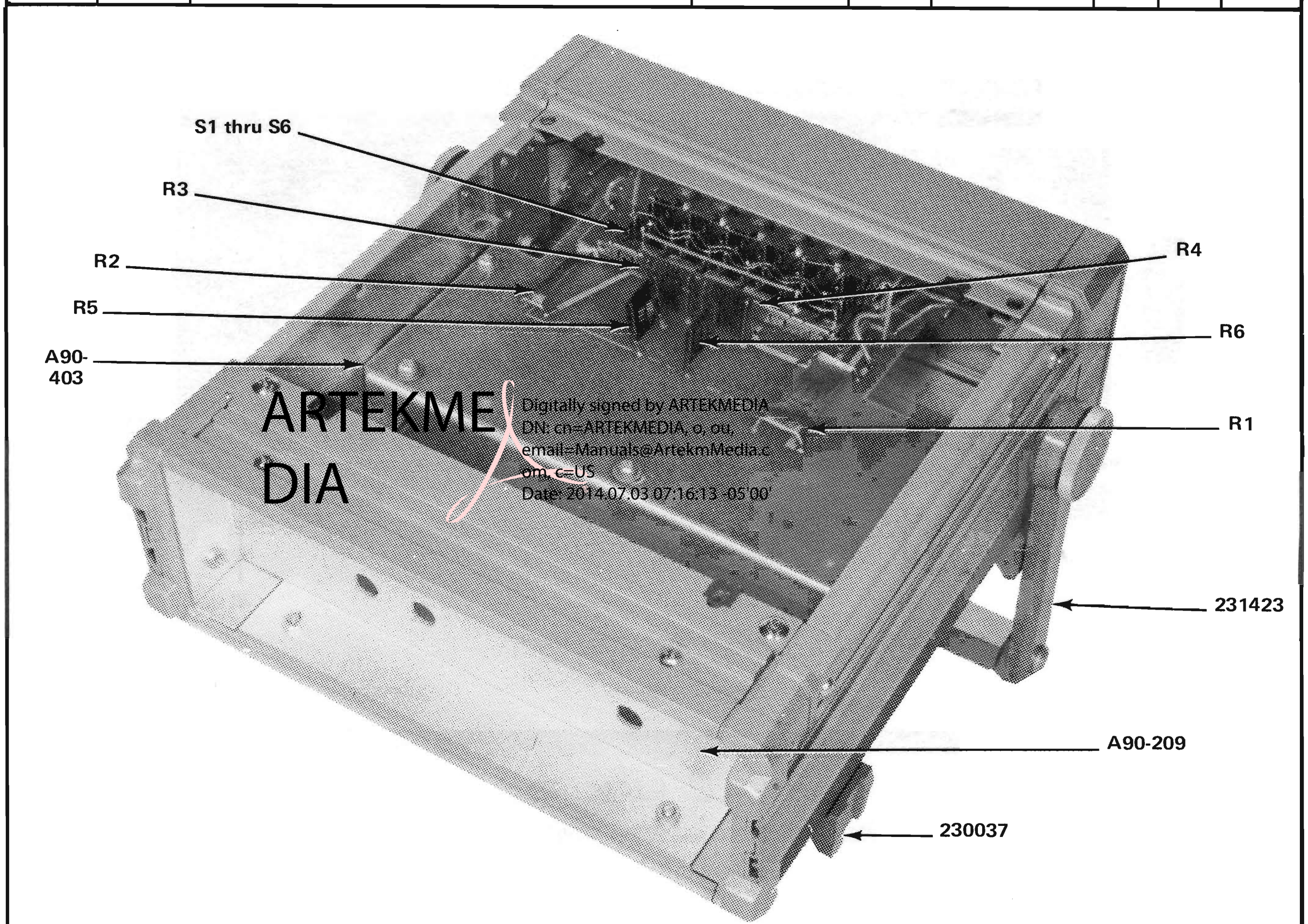
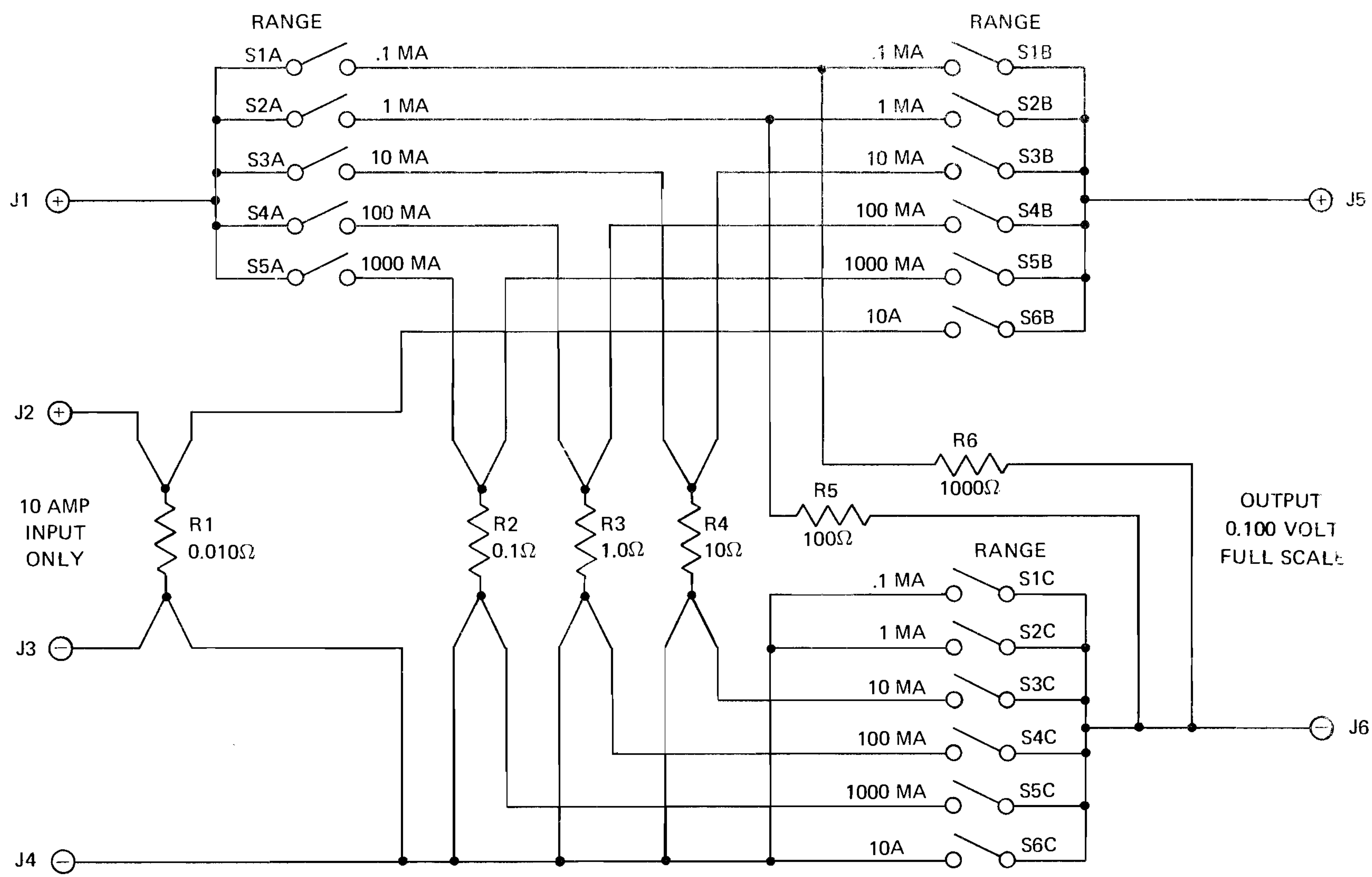


Figure 6-9. MODEL A90 CURRENT SHUNT (Sheet 2 of 2)



FUNCTIONAL SCHEMATIC DIAGRAM	
MODEL A90 CURRENT SHUNT	
SER. NO. 123 & ON	REV. a
FLUKE JOHN FLUKE MFG. CO., INC. P.O. Box 7428 Seattle, Washington 98133	

Appendix A

Federal Supply Code for Manufacturers

A-1. CODE TO NAME

A-2. The following five digit code numbers are listed in numerical sequence along with the manufacturer's name and address to which the code has been assigned. The Federal Supply Code has been taken from Cataloging Handbook H 4-2, Code to Name.

00213	Sage Electronics Corp. Rochester, New York
00327	Welwyn International, Inc. Westlake, Ohio
00656	Aerovox Corp. New Bedford, Massachusetts
00686	Film Capacitors Passaic, New Jersey
00779	AMP Inc. Harrisberg, Pennsylvania
01121	Allen-Bradley Co. Milwaukee, Wisconsin
01281	TRW Semiconductors Lawndale, California
01295	Texas Instruments, Inc. Semiconductor Components Div. Dallas, Texas
01686	RCL Electronics Inc. Manchester, New Hampshire
01730	Deleted
01884	Dearborn Electronics Inc. Orlando, Florida
02114	Ferroxcube Corp. Saugerties, New York
02606	Replaced by 15801
02660	Amphenol-Borg Elect. Corp. Broadview, Illinois
02799	Arco Capacitors, Inc. Torrence, California
03508	General Electric Co. Semiconductor Products Syracuse, New York
03614	Replaced by 71400
03651	Replaced by 44655
03797	Eldema Corp. Compton, California
03877	Transitron Electronic Corp. Wakefield, Massachusetts
03888	Pyrofilm Resistor Co., Inc. Cedar Knolls, New Jersey
03911	Clairex Corp. New York, New York
03980	Muirhead Instruments, Inc. Mountainside, New Jersey
04009	Arrow Hart and Hegemen Electronic Company Hartford, Connecticut
04062	Replaced by 72136
04202	Replaced by 81312
04217	Essex Wire Corp. Wire & Cable Div. Anaheim, California
04221	Aemco, Div. of Midtex Inc. Mankato, Minnesota
04222	Aerovox Corp. (H-Q) Myrtle Beach, South Carolina
04645	Replaced by 75376
04713	Motorola Semiconductor Products Inc. Phoenix, Arizona
05082	Replaced by 94154
05236	Jonathan Mfg. Co. Fullerton, California
05277	Westinghouse Electric Corp. Semiconductor Dept. Youngwood, Pennsylvania
05278	Replaced by 43543
05397	Union Carbide Corp. Electronics Div. Cleveland, Ohio
05279	Southwest Machine & Plastic Co. Los Angeles, California
05397	Union Carbide Corp. Electronics Div. New York, New York
05571	Sprague Electric Co. Pacific Div. Los Angeles, California
05574	Viking Industries Chaisworth, California
05704	Alac, Inc. Glendale, California
05820	Wakefield Engineering Ind. Wakefield, Massachusetts
06001	General Electric Company Capacitor Department Irmo, South Carolina
06136	Replaced by 63743
06473	Amphenol Space & Missile Sys. Chatsworth, California
06555	Beede Electrical Instrument Co. Penacook, New Hampshire
06739	Electron Corp. Littletown, Colorado
06743	Clevite Corp. Cleveland, Ohio
06751	Semcor Div., Components, Inc. Phoenix, Arizona
06860	Gould National Batteries Inc. City of Industry, California
06980	Varian-Eimac San Carlos, California
07115	Replaced by 14674
07138	Westinghouse Electric Corp., Electronic Tube Division Elmira, New York
07256	Silicon Transistor Corp. Garden City, New York
07263	Fairchild Semiconductor Div. of Fairchild Camera & Instrument Corp. Mountain View, California
07344	Bircher Co., Inc. Rochester, New York
07792	Lerma Engineering Corp. Northampton, Massachusetts
07910	Teledyne Corp. (Continental Device) Hawthorne, California
08225	Industro Transistor Corp. Long Island City, New York
08530	Reliance Mica Corp. Brooklyn, New York
08792	Discontinued
08806	General Electric Co. Miniature Lamp Dept. Cleveland, Ohio
08863	Nylomatic Corp. Norrisville, Pennsylvania
08988	Skottie Electronics Inc. Archbald, Pennsylvania
09353	C and K Components Watertown, Massachusetts
09423	Scientific Components, Inc. Santa Barbara, California
09922	Burndy Corp. Norwalk, Connecticut
11236	CTS of Berne Berne, Indiana
11237	Chicago Telephone of Calif., Inc. (CTC) Paso Robles, California
11358	Discontinued
11403	Best Products Co. Chicago, Illinois

11503 Keystone Mfg.
Div. of Avis Industrial Corp.
Warren, Michigan

11726 Qualidyne Corp.
Santa Clara, California

12014 Chicago Rivet & Machine Co.
Bellwood, Illinois

12040 National Semiconductor Corp.
Danburry, Connecticut

12060 Diodes, Inc.
Chatsworth, California

12136 Philadelphia Handle Co.
Camden, New Jersey

12323 Presin Co., Inc.
Shelton, Connecticut

12327 Freeway Washer & Stamping Co.
Cleveland, Ohio

12400 Replaced by 75042

12617 Hamlin Inc.
Lake Mills, Wisconsin

12697 Clarostat Mfg. Co.
Dover, New Hampshire

12749 James Electronics
Chicago, Illinois

12856 Micrometals
Sierra Madre, California

12954 Dickson Electronics Corp.
Scottsdale, Arizona

12969 Unitrode Corp.
Watertown, Massachusetts

13103 Thermalloy Co.
Dallas, Texas

13511 Amphenol Corp.
Los Gatos, California

13606 Sprague Electric Co.
Transistor Div.
Concord, New Hampshire

13839 Replaced by 23732

14099 Semtech Corp.
Newbury Park, California

14193 California Resistor Corp.
Santa Monica, California

14298 American Components, Inc.
Conshohocken, Pennsylvania

14655 Cornell-Dubilier Electronics
Newark, New Jersey

14674 Discontinued, see 16299

14752 Electro Cube Inc.
San Gabriel, California

14869 Replaced by 96853

15636 Elec-Trol Inc.
Northridge, California

15801 Fenwal Electronics Inc.
Framingham, Massachusetts

15818 Amelco Semiconductor
Div. of Teledyne Inc.
Mountain View, California

15849 USECO, Inc.
Mt. Vernon, New York

15898 International Business
Machines (IBM)
Essex Junction, Vermont

15909 Replaced by 17870

16299 Corning Glass
Raleigh, North Carolina

16332 Replaced by 28478

16473 Cambridge Scientific Ind. Inc.
Cambridge, Maryland

16742 Paramount Plastics
Downey, California

16758 Delco Radio
Div. of General Motors
Kokomo, Indiana

17001 ITT Cannon
Santa Ana, California

17069 Circuit Structures Lab.
Upland, California

17856 Siliconix, Inc.
Sunnyvale, California

17870 Daven-Div of Thomas A. Edison
Ind. – McGraw - Edison Co.
Manchester, New Hampshire

18083 Deleted

18178 Vactec Inc.
Maryland Heights, Missouri

18612 Vishay Intertechnology
Inc.
Malvern, Pennsylvania

18736 Voltronics Corp.
Hanover, New Jersey

19429 Discontinued, use 89536

19451 Perine Machinery & Supply Co.
Seattle, Washington

19701 Electra Mfg. Co.
Independence, Kansas

20584 Enochs Mfg. Co.
Indianapolis, Indiana

20891 Self-Organizing Systems,
Inc.
Dallas, Texas

22767 ITT Semiconductors
Div. of ITT
Palo Alto, California

23050 Product Comp. Corp.
Mount Vernon, New York

23732 Tracor
Rockville, Maryland

23880 Stanford Applied Engrng.
Santa Clara, California

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

24248 Southco
Div. of South Chester Corp.
Lester, Pennsylvania

24655 General Radio Co.
West Concord, Massachusetts

24759 Lenox-Fugle Electronics
Plainfield, New Jersey

25403 Amperex Electronic Corp.
Semiconductor & Receiving
Tube Division
Slatersville, Rhode Island

27014 National
Semiconductor
Corp.
Santa Clara, California

27264 Molex Products
Downers Grove, Illinois

28425 Bohannon Industries
Fort Worth, Texas

28478 Deltrol Controls,
Corp.
Milwaukee, Wisconsin

28480 Hewlett Packard
Co.
Palo Alto, California

28520 Heyman Mfg. Co.
Kenilworth, New Jersey

29083 Monsanto, Co., Inc.
Santa Clara, California

30323 Illinois Tool
Works, Inc.
Chicago, Illinois

32539 Mura Corp.
Great Neck, New York

32767 Griffith Plastic
Products Co.
Burlingame, California

32879 Advanced Mechanical
Components
Northridge, California

32897 Erie Technological
Products, Incorporated
Frequency Control Div.
Carlisle, Pennsylvania

33173 General Electric
Co., Tube Dept.
Owensboro, Kentucky

34333 Silicon General
Westminister, California

34335 Advanced Micro
Devices,
Sunnyvale, California

37942 Mallory, P. R. & Co., Inc.
Indianapolis, Indiana

42498 National Company
Melrose, Massachusetts

43543 Nytronics Inc.
Transformer Co. Div.
Alpha, New Jersey

44655 Ohmite Mfg. Co.
Skokie, Illinois

49671 Radio Corp. of America
New York, New York

49956 Raytheon Company
Lexington, Maine

53021 Sanamo Electric Co.
Springfield, Illinois

55026 Simpson Electric Company
Chicago, Illinois

56289 Sprague Electric Co.
North Adams, Massachusetts

58474 Superior Electric Co.
Bristol, Connecticut

60399 Torrington Mfg. Co.
Torrington, Connecticut

62460 Deleted

63743 Ward Leonard Electric Co.
Mount Vernon, New York

64834 West Mfg. Co.
San Francisco, California

65092 Weston Instruments Inc.
Newark, New Jersey

66150 Winslow Tele-Tronics Inc.
Asbury Park, New Jersey

70563 Amperite Company
Union City, New Jersey

70903 Belden Mfg. Co.
Chicago, Illinois

71002 Birnbach Radio Co., Inc.
New York, New York

71236 "ELMENCO"
Willimantic, Connecticut

71400 Bussmann Mfg.
Div. of McGraw - Edison Co.
Saint Louis, Missouri

71450 CTS Corp.
Elkhart, Indiana

71468 ITT Cannon Electric Inc.
Los Angeles, California

71482 Clare, C. P. & Co.
Chicago, Illinois

71590 Centralab
Div. of Globe Union Inc.
Milwaukee, Wisconsin

71707 Coto Coil Co., Inc.
Providence, Rhode Island

71744 Chicago Miniature Lamp Works
Chicago, Illinois

71785 Cinch Mfg. Co. & Howard
B. Jones Div.
Chicago, Illinois

72005 Driver, Wilber B., Co.
Newark, New Jersey

72092 Replaced by 06980

72136 Electro Motive Mfg. Co.
Willimantic, Connecticut

72259 Nytronics Inc.
Berkeley Heights, New Jersey

72354 Deleted

72619 Dialight Corp.
Brooklyn, New York

72653 G. C. Electronics
Rockford, Illinois

72665 Replaced by 90303

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

72928 Gudeman Co. (Gulton
Industries)
Chicago, Illinois

72982 Erie Tech. Products Inc.
Erie, Pennsylvania

73138 Beckman Instruments Inc.
Helipot Division
Fullerton, California

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

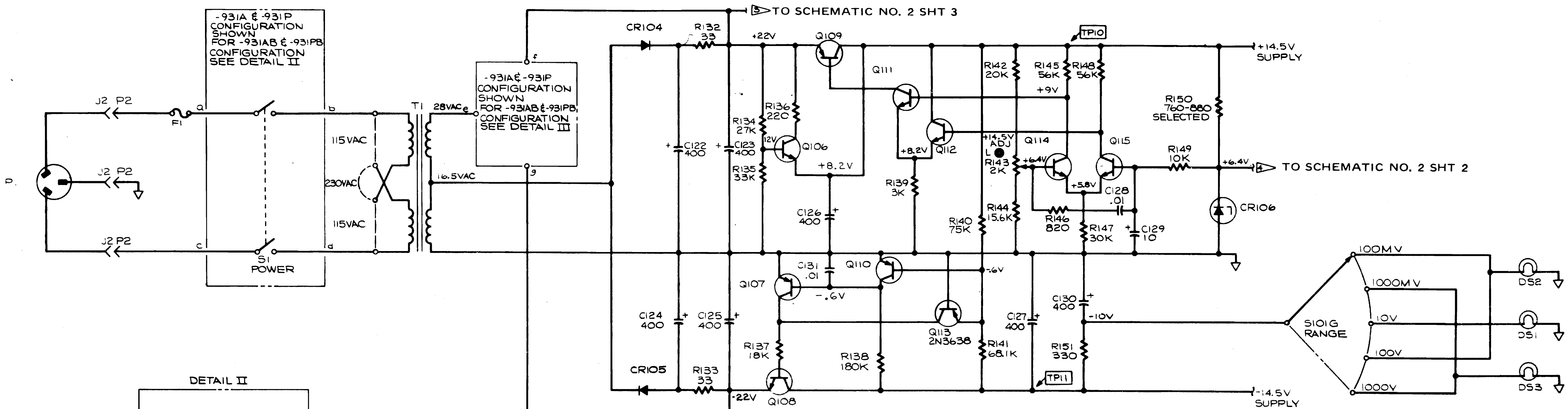
73445 Amperex Electronic Corp.
Hicksville, New York

73559 Carling Electric Inc.
Hartford, Connecticut

73586 Circle F Industries
Trenton, New Jersey

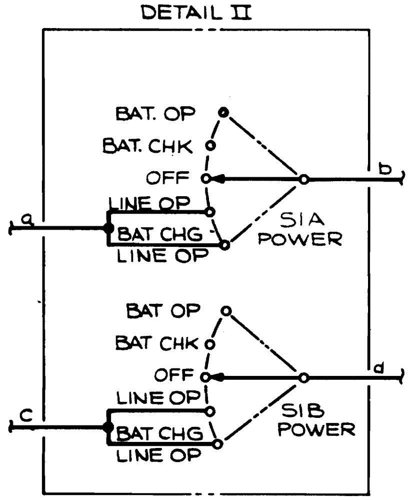
73734 Federal Screw Products, Inc.
Chicago, Illinois

73743	Fischer Special Mfg. Co. Cincinnati, Ohio
73899	JFD Electronics Co. Brooklyn, New York
73949	Guardian Electric Mfg. Co Chicago, Illinois
74199	Quam Nichols Co. Chicago, Illinois
74217	Radio Switch Corp. Marlboro, New Jersey
74276	Signalite Inc. Neptune, New Jersey
74306	Piezo Crystal Co. Carlisle, Pennsylvania
74542	Hoyt Elect. Instr. Works Penacook, New Hampshire
74970	Johnson, E. F., Co. Waseca, Minnesota
75042	IRC Inc. (Div. of TRW) Philadelphia, Pennsylvania
75376	Kurz-Kasch, Inc. Dayton, Ohio
75382	Kulka Electric Corp. Mount Vernon, New York
75915	Littlefuse Inc. Des Plaines, Illinois
76854	Oak Mfg. Co. Crystal Lake, Illinois
77342	Potter & Brumfield Div. of Amer. Machine & Foundry Princeton, Indiana
77969	Rubbercraft Corp. of Calif. LTD. Torrance, California
78189	Shakeproof Div. of Illinois Tool Works Elgin, Illinois
78277	Sigma Instruments, Inc. South Braintree, Massachusetts
78488	Stackpole Carbon Co. Saint Marys, Pennsylvania
78553	Tinnerman Products Cleveland, Ohio
79136	Waldes Kohinoor Inc. Long Island City, New York
79497	Western Rubber Company Goshen, Indiana
79963	Zierick Mfg. Corp. New Rochelle, New York
80031	Mepco Div. of Sessions Clock Co. Morristown, New Jersey
80145	API Instruments Co. Chesterland, Ohio
80183	Sprague Products North Adams, Massachusetts
80294	Bourns Inc. Riverside, California
80583	Hammarlund Co., Inc. Mars Hill, North Carolina
80640	Stevens, Arnold Inc. Boston, Massachusetts
81073	Grayhill Inc. La Grange, Illinois
81590	Korry Mfg. Co. Seattle, Washington
81312	Winchester Electronics Div. of Litton Industries Oakville, Connecticut
81439	Therm-O-Disc Inc. Mansfield, Ohio
81483	International Rectifier Corp. Los Angeles, California
81741	Chicago Lock Corp. Chicago, Illinois
82305	Palmer Electronics South Gate, California 90280
82389	Switchcraft Inc. Chicago, Illinois
82415	Price Electric Corp. Frederick, Maryland
82872	Roanwell Corp. New York, New York
82877	Rotron Mfg. Co., Inc. Woodstock, New York
82879	ITT Wire & Cable Div. Pawtucket, Rhode Island
83003	Varo Inc. Garland, Texas
83298	Bendix Corp. Electric Power Division Eatontown, New Jersey
83330	Smith, Herman H., Inc. Brooklyn, New York
83478	Rubbercraft Corp. of America New Haven, Connecticut
83594	Burroughs Corp. Electronic Components Div. Plainfield, New Jersey
83740	Union Carbide Corp. Consumer Products Div. New York, New York
84171	Arco Electronics, Inc. Great Neck, New York
84411	TRW Ogallala, Nebraska
86577	Precision Metal Products Stoneham, Massachusetts
86684	Radio Corp. of America Electronic Components & Devices Harrison, New Jersey
86689	Deleted
87034	Marco-Oak Inc. Anaheim, California
88245	Litton Products Inc. Van Nuys, California
88419	Use 14655
88690	Replaced by 04217
89536	Fluke, John Mfg. Co., Inc. Seattle, Washington
89730	Replaced by 08806
90201	Mallory Capacitor Co. Indianapolis, Indiana
90215	Best Stamp & Mfg. Co Kansas City, Missouri
90211	Square D Co. Chicago, Illinois
90303	Mallory Battery Co. Tarrytown, New York
91293	Johanson Mfg. Co. Boonton, New Jersey
91407	Replaced by 58474
91502	Associated Machine Santa Clara, California
91506	Augat Attleboro, Mass.
91637	Dale Electronics Inc. Columbus, Nebraska
91662	Elco Corp. Willow Grove, Pennsylvania
91737	Gremar Mfg Co., Inc. (ITT) Woburn, Massachusetts
91802	Industrial Devices, Inc. Edgewater, New Jersey
91836	King's Electronics Tuckahoe, New York
91929	Honeywell Inc. Micro Switch Div. Freeport, Illinois
91934	Miller Electric Co., Inc. Pawtucket, Rhode Island
93332	Sylvania Electric Products Semiconductor Products Div Woburn, Massachusetts
94145	Replaced by 49956
94154	Tung-Sol Div. of Wagner Electric Corp. Newark, New Jersey
95146	Alco Electronics Products Inc. Lawrence, Massachusetts
95263	Leecraft Mfg. Co. Long Island City, New York
95264	Replaced by 98278
95275	Vitramon Inc. Bridgeport, Connecticut
95303	Radio Corp. of America Solid State & Receiving Tube Div. Cincinnati, Ohio
95354	Methode Mfg. Corp. Rolling Meadows, Illinois
95712	Dage Electric Co., Inc. Franklin, Indiana
95987	Weckesser Co. Inc. Chicago, Illinois
96733	San Fernando Electric Mfg. Co. San Fernando, California
96853	Rustrak Instrument Co. Manchester, New Hampshire
96881	Thomson Industries, Inc. Manhasset, New York
97540	Master Mobile Mounts Div. of Whitehall Electronics Corp. Los Angeles, California
97913	Industrial Electronic Hdware Corp. New York, New York
97945	White, S. S. Co. Plastics Div. New York, New York
97966	Replaced by 11358
98094	Replaced by 49956
98159	Rubber-Teck, Inc. Gardena, California
98278	Microdot Inc. Pasadena, California
98291	Sealectro Corp. Conhex Div. Mamaroneck, New York
98388	Accurate Rubber & Plastics Culver City, California
98743	Replaced by 12749
98925	Deleted
99120	Plastic Capacitors, Inc. Chicago, Illinois
99217	Southern Electronics Corp. Burbank, California
99392	STM Oakland, California
99515	Marshall Industries Capacitor Div. Monrovia, California
99779	Barnes Corp. Lansdowne, Pennsylvania
	Toyo Electronics (R-Ohm Corp.) Irvine, California 92664
	National Connector Minneapolis, Minn. 55436

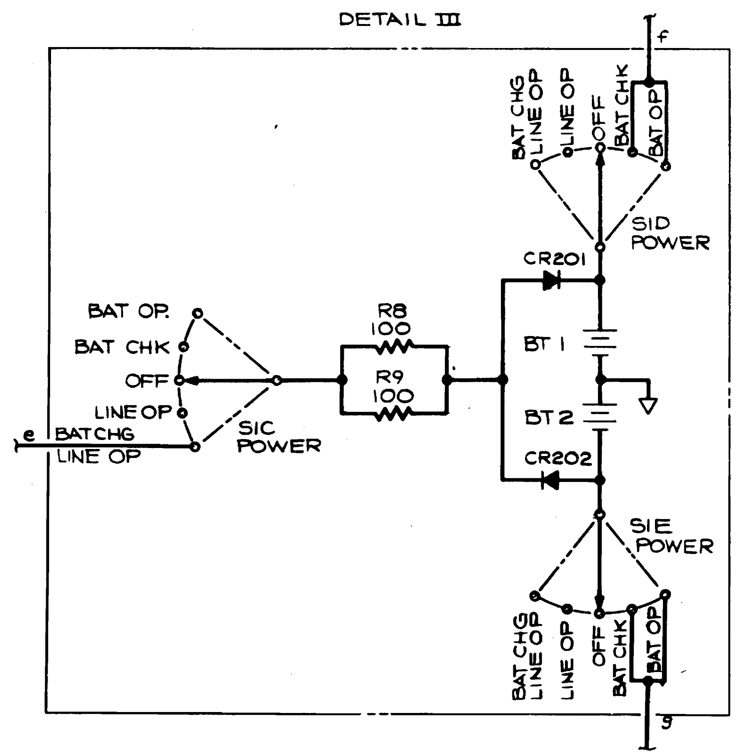


REGULATED POWER SUPPLIES

DETAIL II



DETAIL III



NOTES:

1. UNLESS OTHERWISE NOTED, RESISTANCES ARE IN OHMS AND ALL CAPATICANCES ARE IN MICROFARADS
2. ● INDICATES INTERNAL ADJUSTMENT (LETTER IDENTIFICATION)
3. TP12 IDENTIFIES TEST POINT (NUMBER IDENTIFICATION
4. ALL FLAGNOTES WITH LIKE NUMBERS ARE CONNECTED
5. VOLTAGES NOTED ARE APPROXIMATE VALUES FOR TROUBLE SHOOTING ONLY, NOT FOR CALIBRATION. MODE SWITCH IN TVM POSITION, NO A.C. SIGNAL IN. 115VAC POWER
6. * FACTORY SELECTED COMPONENTS. MAY BE OMITTED

REFERENCE DESIGNATIONS:

CHASSIS ASSY
C1-4, CR1, M1, R1-39, S1-7, T1
401 BOARD
C101-136, CR101-106, Q101-115, R101-153, S101
402 BOARD
C201-220 CR201-202, K201, Q201-207, R201-247, TC201-202
403 BOARD
C301-319, CR301-303, L301, Q301-322, R301-322, 334-363; T301-302

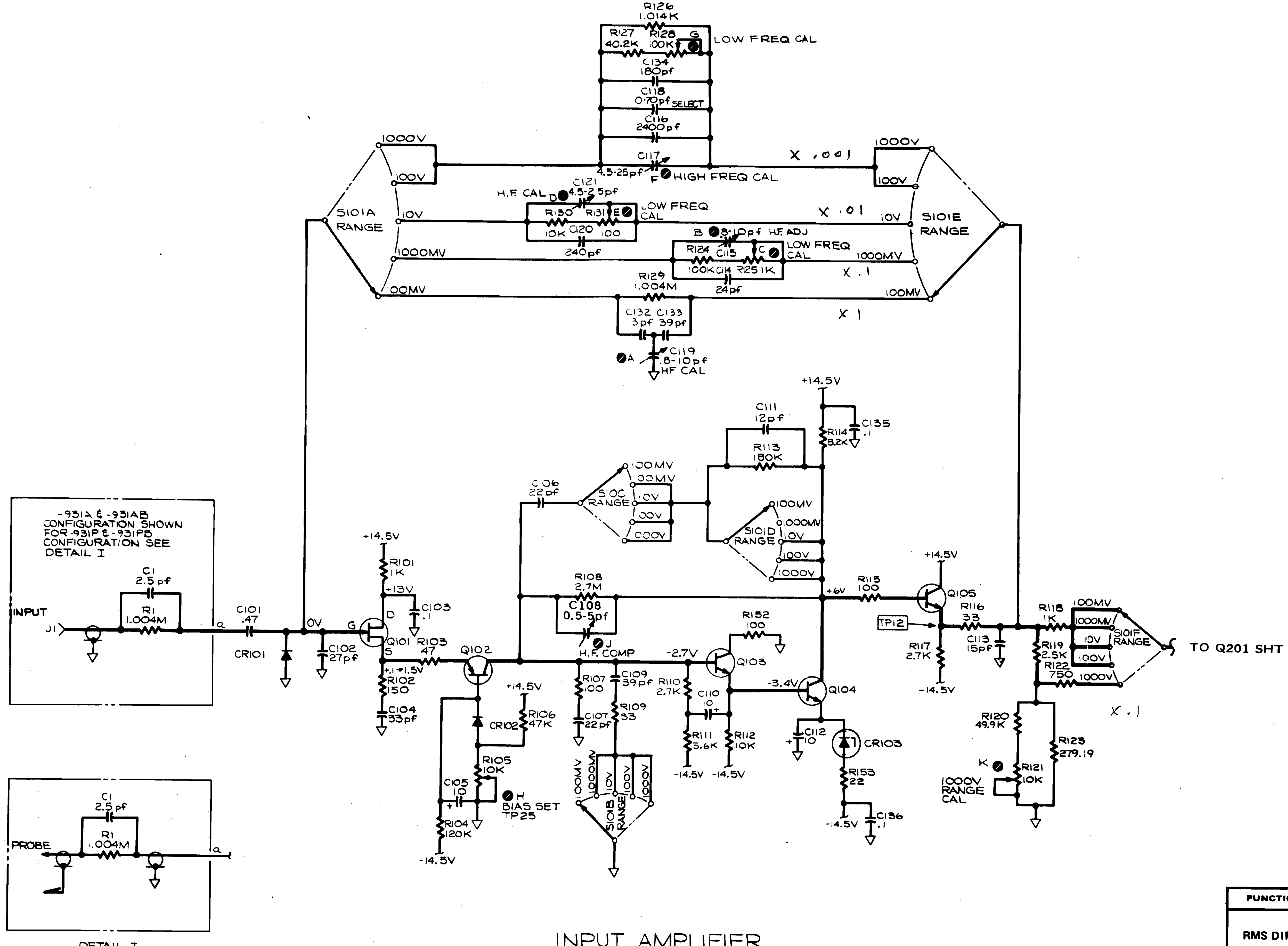
FUNCTIONAL SCHEMATIC DIAGRAM

MODEL 931B
RMS DIFFERENTIAL VOLTMETER

SCHEMATIC NO. 1

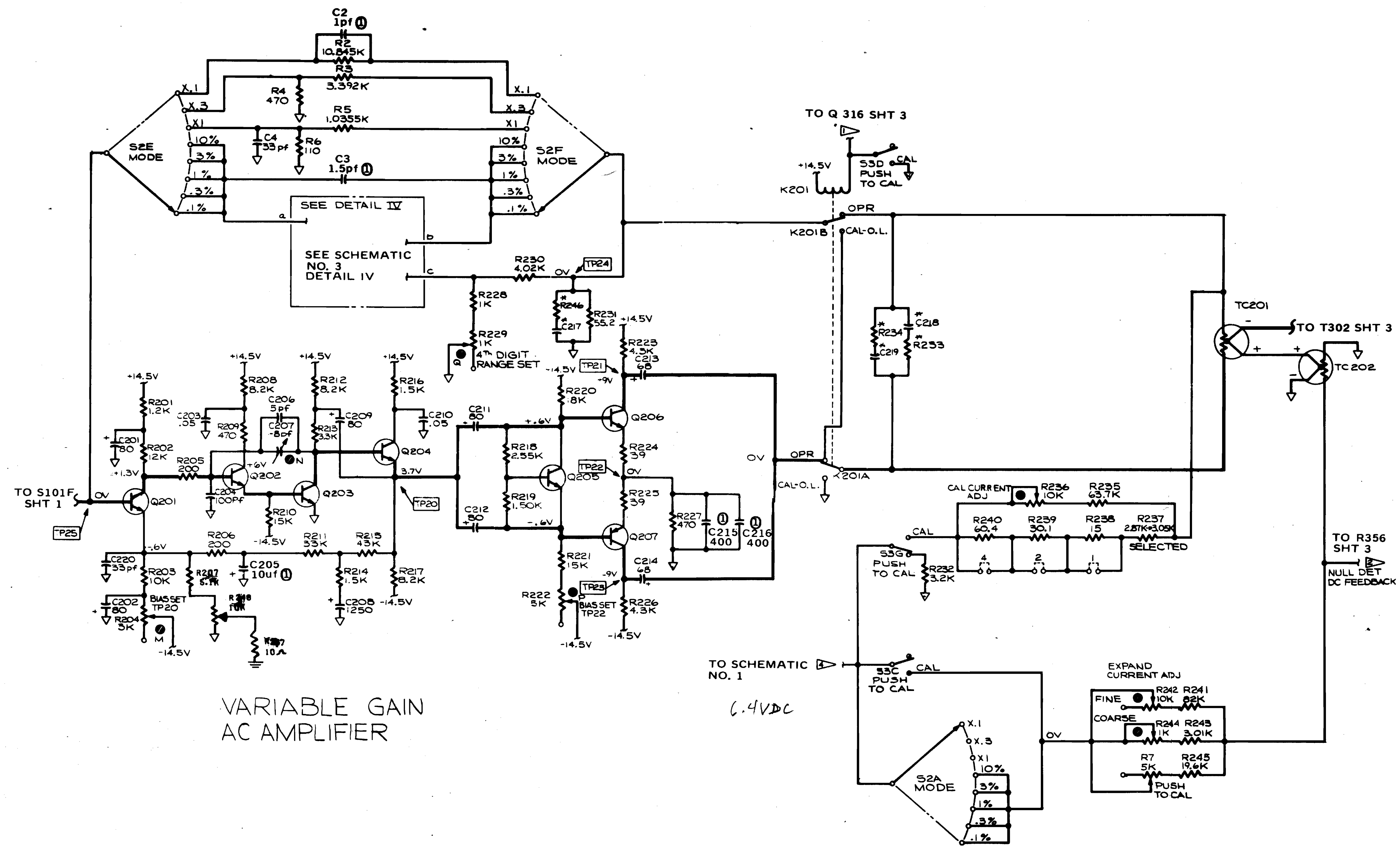
SER. NO. 123 & ON — REV. a

FLUKE JOHN FLUKE MFG. CO., INC.
P.O. Box 7428 Seattle, Washington 98133



INPUT AMPLIFIER

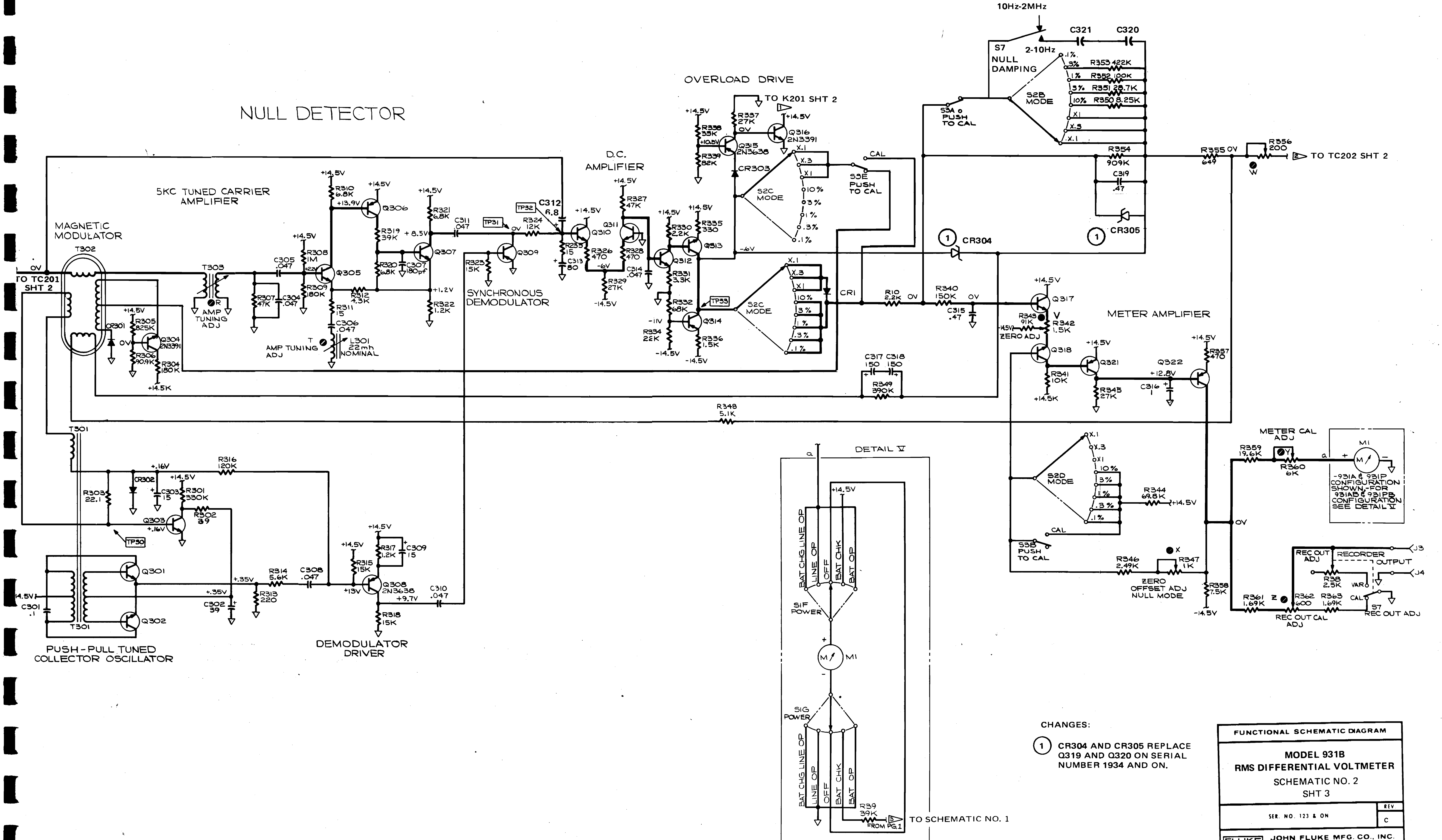
FUNCTIONAL SCHEMATIC DIAGRAM
MODEL 931B RMS DIFFERENTIAL VOLTMETER
SCHEMATIC NO. 2 SHT 1
SER. NO. 123 & ON — REV. b
FLUKE JOHN FLUKE MFG. CO., INC. P.O. Box 7428 Seattle, Washington 98133



VARIABLE GAIN
AC AMPLIFIER

CHANGES:
① For S/N 1044 thru 1341:
C2 Was 0.5pf
C3 Was 1.0pf
C205 Was 5.6uf
C215 & C216 Were 330uf

FUNCTIONAL SCHEMATIC DIAGRAM
MODEL 931B RMS DIFFERENTIAL VOLTMETER
SCHEMATIC NO.2 SHT 2
SER NO 123 & ON — REV C
FLUKE JOHN FLUKE MFG. CO., INC. P.O. Box 7428 Seattle, Washington 98133



CHANGES:

1 CR304 AND CR305 REPLACE Q319 AND Q320 ON SERIAL NUMBER 1934 AND ON.

FUNCTIONAL SCHEMATIC DIAGRAM

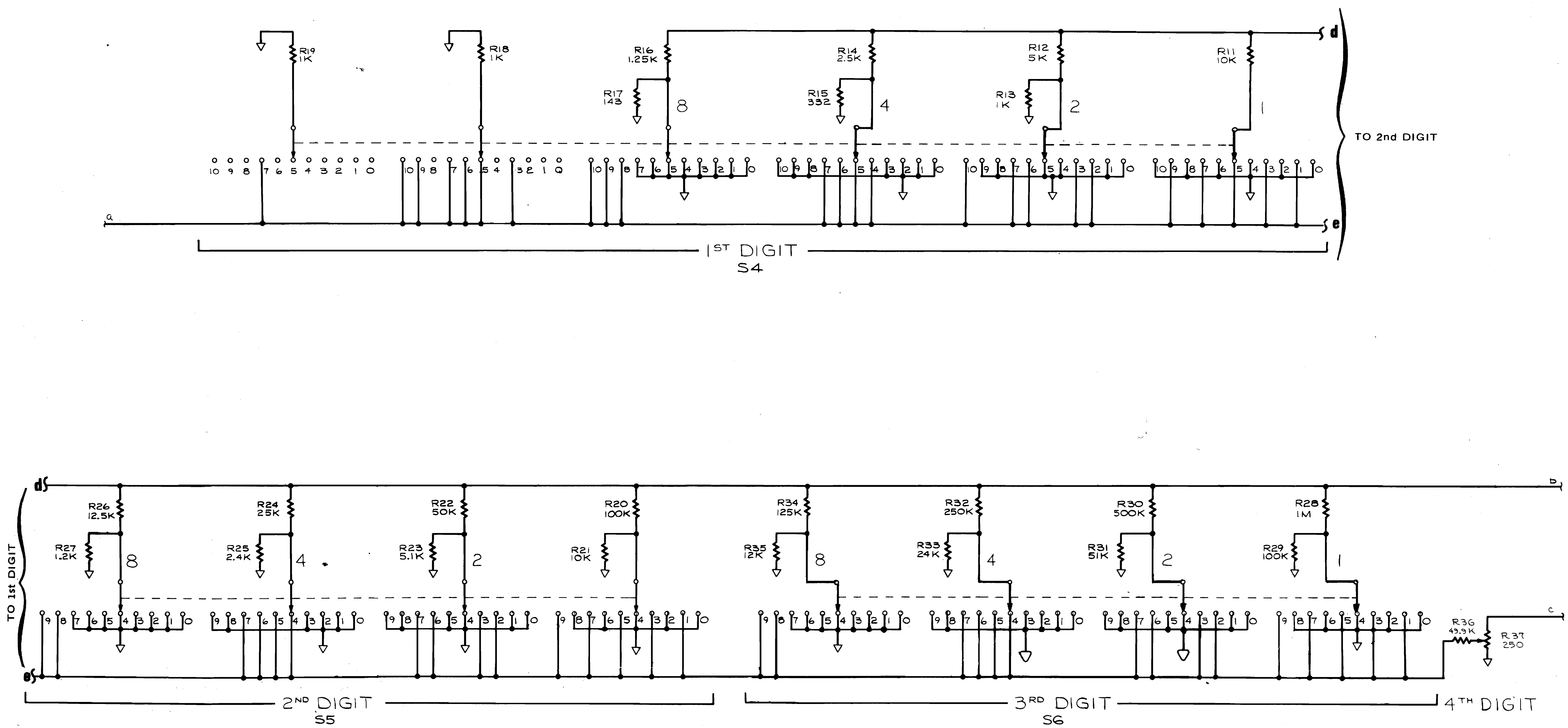
MODEL 931B
RMS DIFFERENTIAL VOLTMETER

SCHEMATIC NO. 2
SHT 3

SER. NO. 123 & ON

REV C

FLUKE JOHN FLUKE MFG. CO., INC.
P O Box 7428 Seattle Washington 98133



FUNCTIONAL SCHEMATIC DIAGRAM

MODEL 931B
RMS DIFFERENTIAL VOLTMETER
SCHEMATIC NO. 3
DETAIL IV

SER. NO. 123 & ON — REV b

FLUKE JOHN FLUKE MFG. CO., INC.
P.O. Box 7428 Seattle Washington 98133