931B

RMS Differential Voltmeter

Instruction Manual

FLUKE ®

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WARRANTY

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

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

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

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. JOHN FLUKE MFG. CO., INC., SHALL NOT BE LIABLE FOR ANY SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER IN CONTRACT, TORT, OR OTHERWISE.

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

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

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

SHIPPING TO MANUFACTURER FOR REPAIR OR ADJUSTMENT

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

CLAIM FOR DAMAGE IN SHIPMENT TO ORIGINAL PURCHASER

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

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

*For European customers, Air Freight prepaid.

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

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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 x 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.

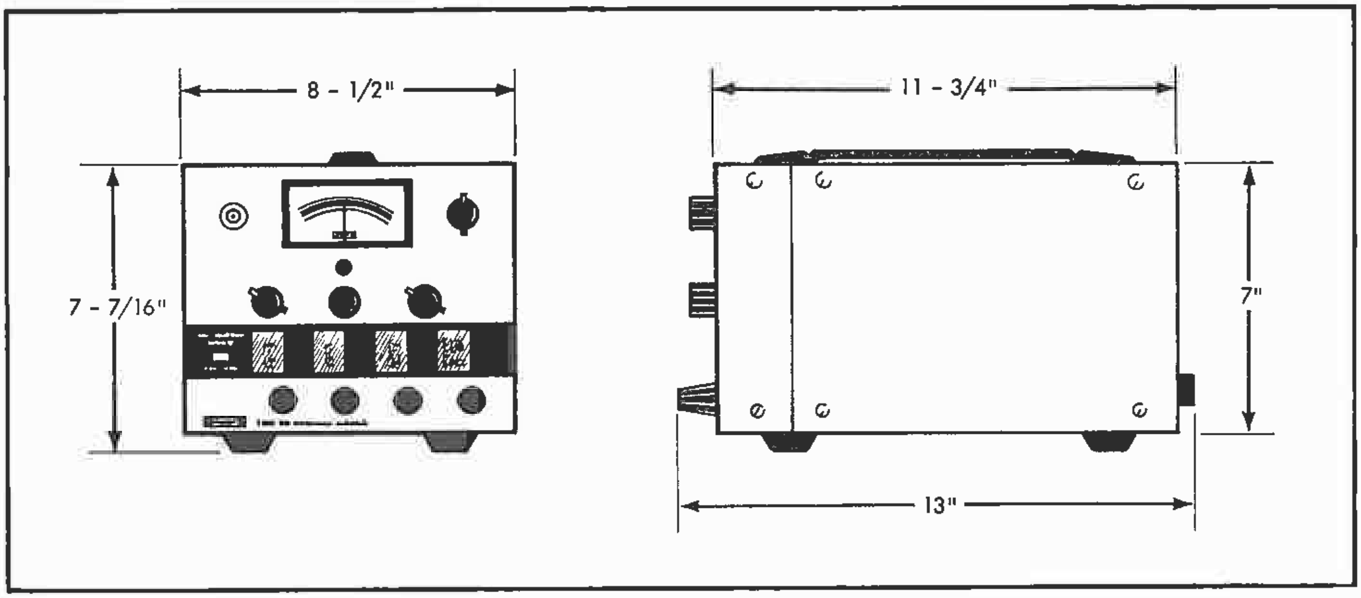
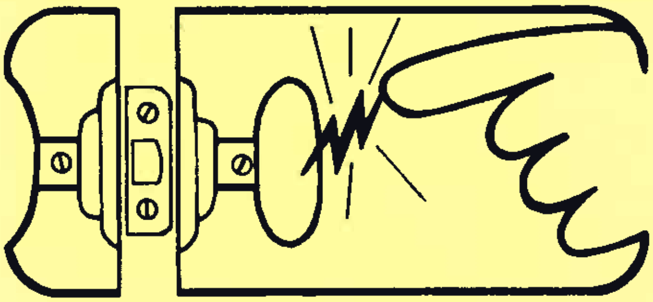


Figure 1-1. MODEL 931B OUTLINE DRAWING

static awareness

A Message From

John Fluke Mfg. Co., Inc.



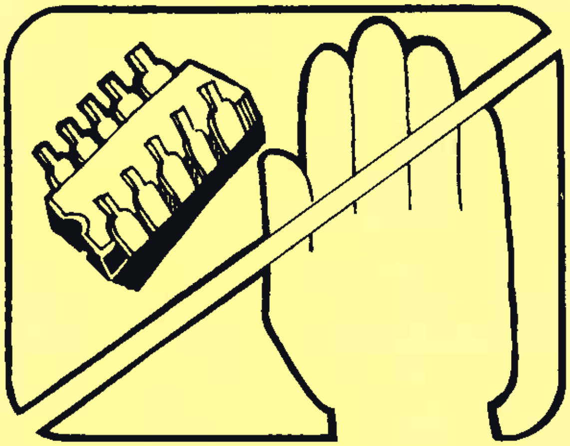
Some semiconductors and custom IC's can be damaged by electrostatic discharge during handling. This notice explains how you can minimize the chances of destroying such devices by:

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

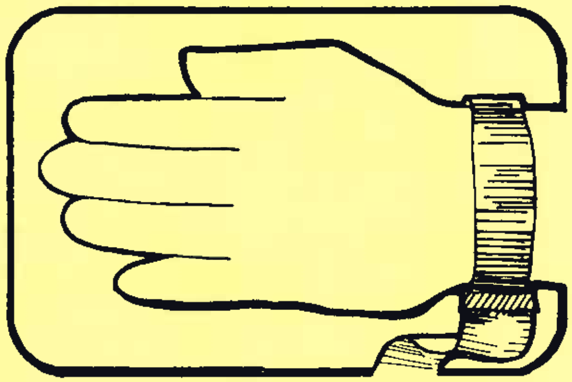
The Static Sensitive (S.S.) devices are identified in the Fluke technical manual parts list with the symbol

" "

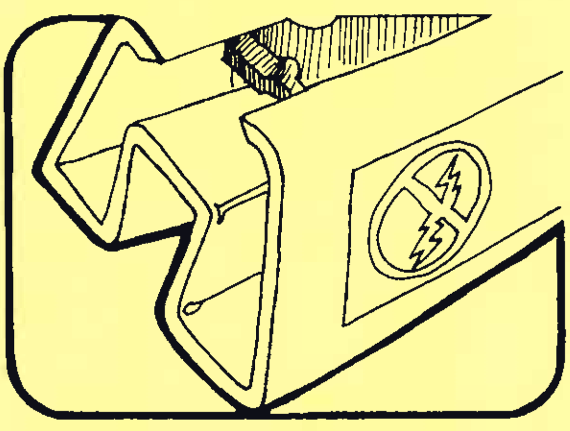
The following practices should be followed to minimize damage to S.S. devices.



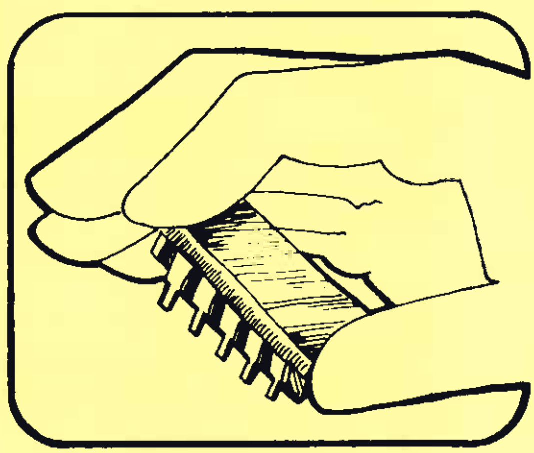
1. MINIMIZE HANDLING



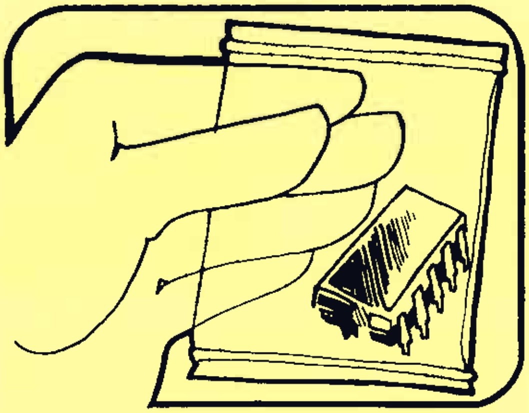
3. DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES



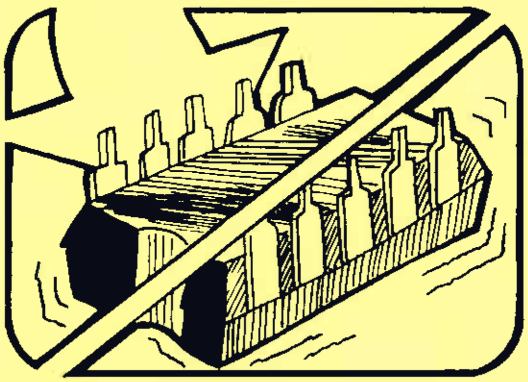
2. KEEP PARTS IN ORIGINAL CONTAINERS UNTIL READY FOR USE.



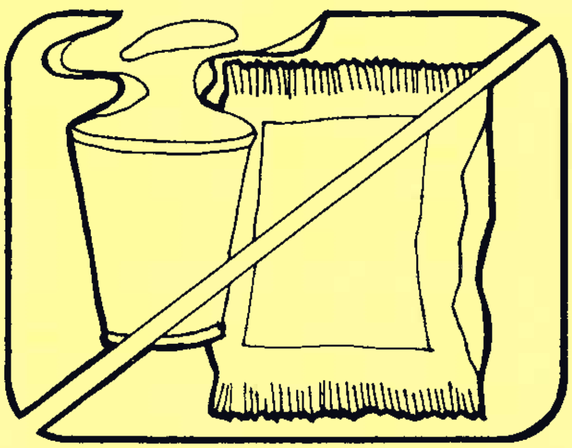
4. HANDLE S.S. DEVICES BY THE BODY



5. USE ANTI-STATIC CONTAINERS FOR HANDLING AND TRANSPORT



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



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

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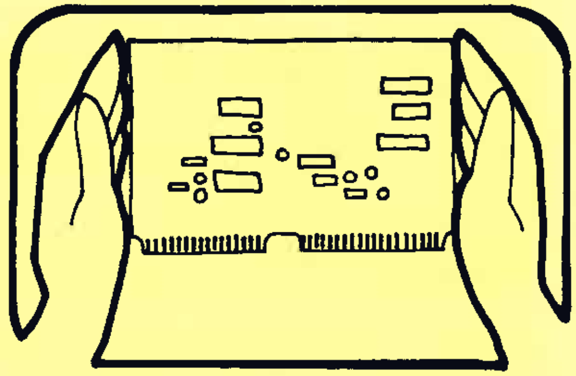
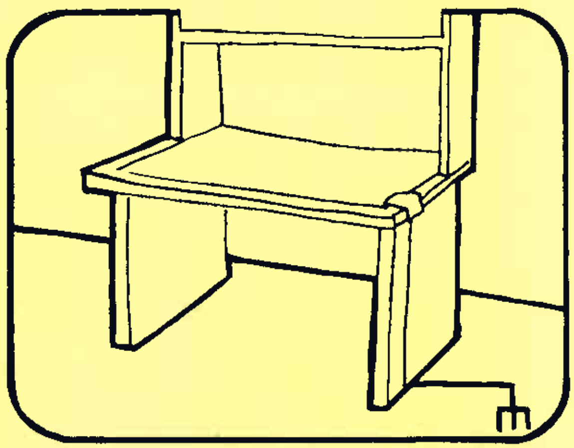
® Dow Chemical



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



9. HANDLE S.S. DEVICES ONLY AT A STATIC-FREE WORK STATION

10. ONLY ANTI-STATIC TYPE SOLDER-SUCKERS SHOULD BE USED.

11. ONLY GROUNDED TIP SOLDERING IRONS SHOULD BE USED.

Anti-static bags, for storing S.S. devices or pcbs with these devices on them, can be ordered from the John Fluke Mfg. Co., Inc.. See section 5 in any Fluke technical manual for ordering instructions. Use the following part numbers when ordering these special bags.

John Fluke Part No.	Description
453522	6" X 8" Bag
453530	8" X 12" Bag
453548	16" X 24" Bag
454025	12" X 15" Bag
Pink Poly Sheet	Wrist Strap
30"x60"x60 Mil	P/N TL6-60
P/N RC-AS-1200	$7.00
$20.00	

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.

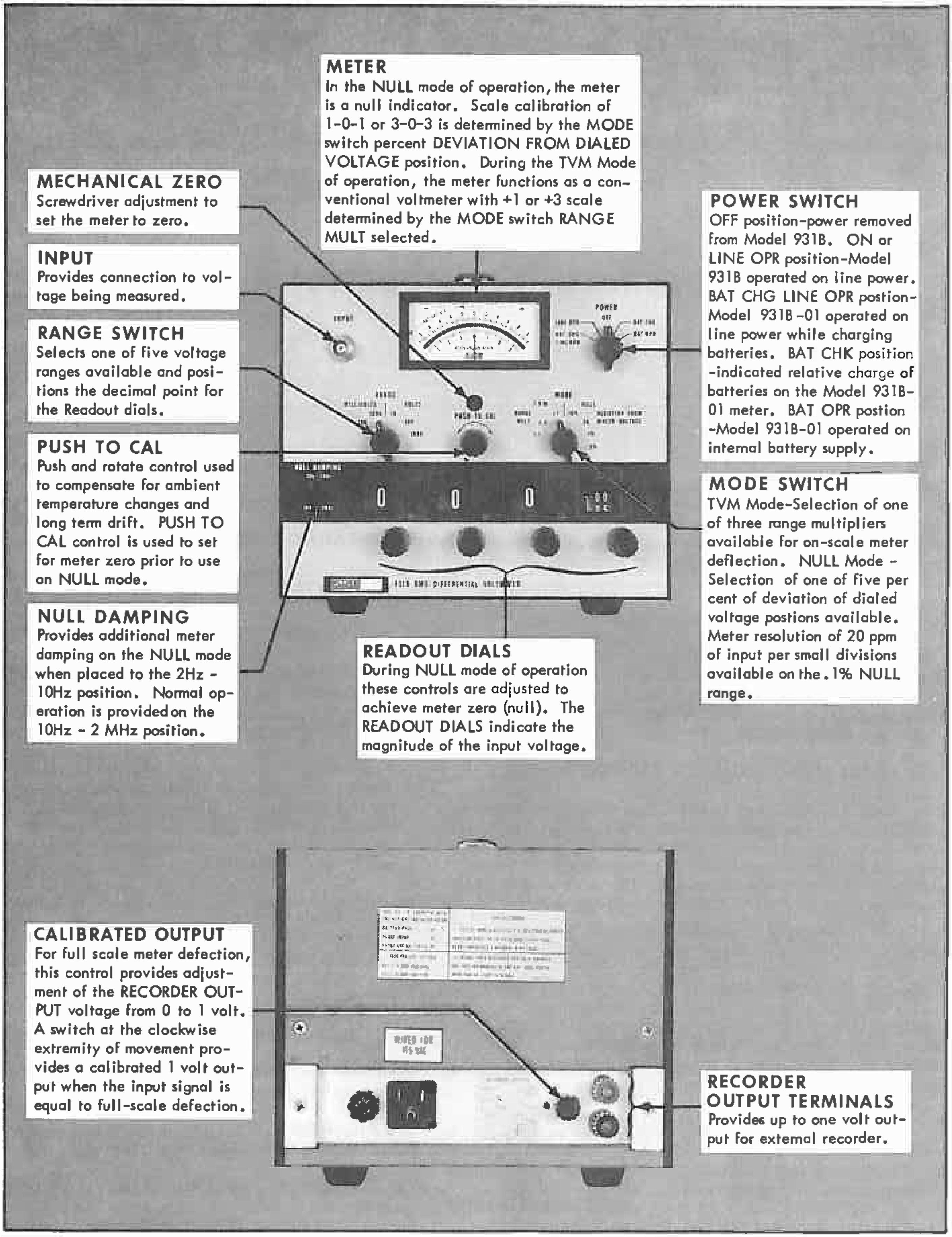


Figure 2-1. MODEL 931B FRONT AND REAR PANEL CONTROLS

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.

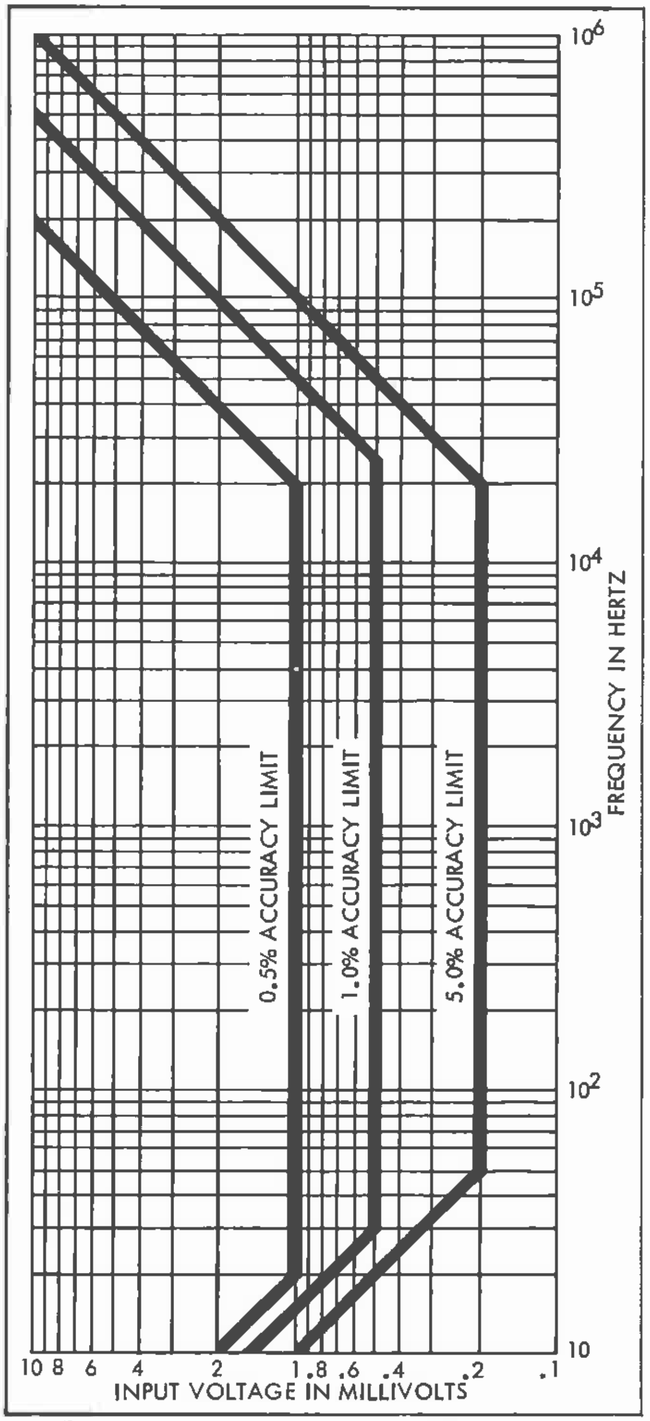


Figure 2-2. ACCURACY SPECIFICATIONS BELOW 10 MILLIVOLTS

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

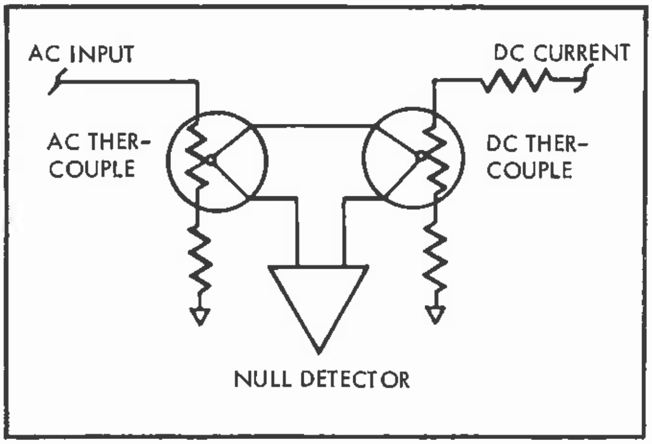


Figure 3-1. DIFFERENTIAL THERMOCOUPLE

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

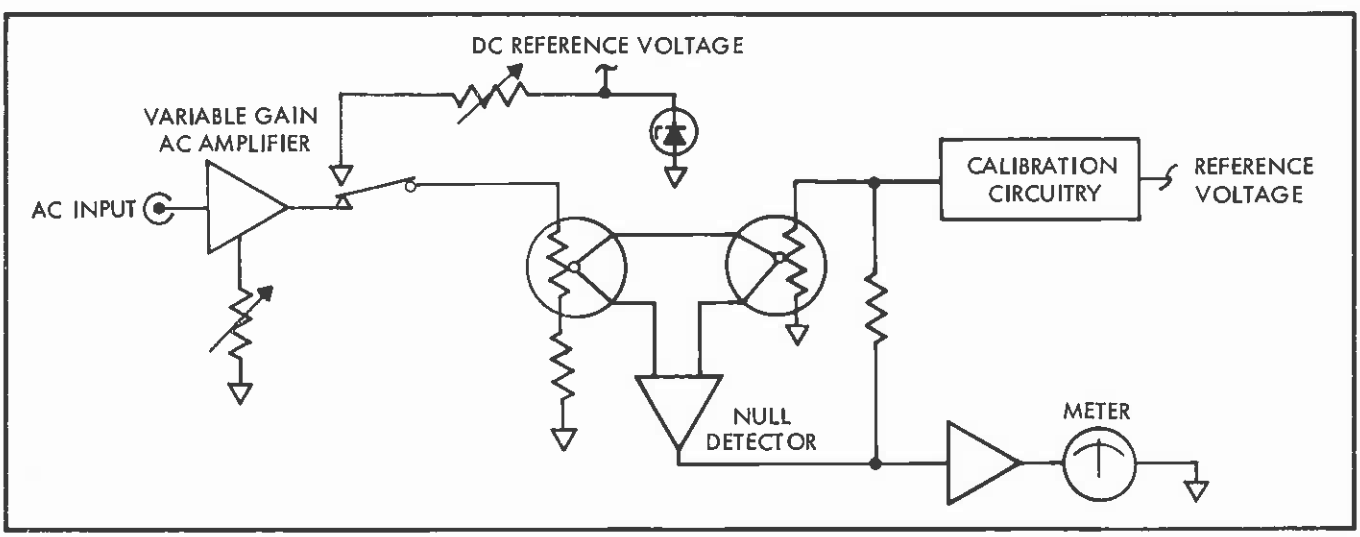


Figure 3-2. SIMPLIFIED MODEL 931B BLOCK DIAGRAM

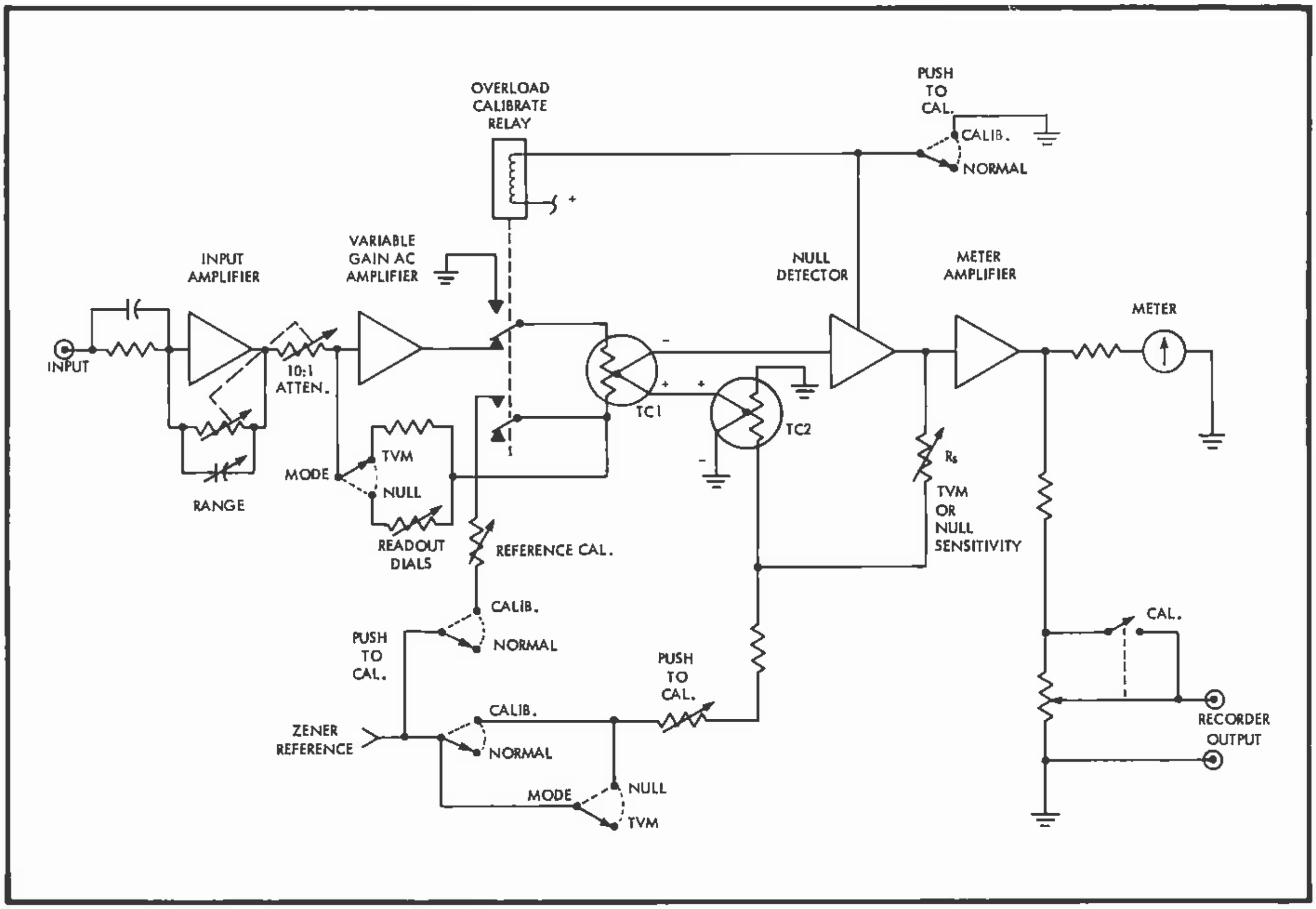


Figure 3-3. THE MODEL 931B FUNCTIONAL BLOCK DIAGRAM

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,

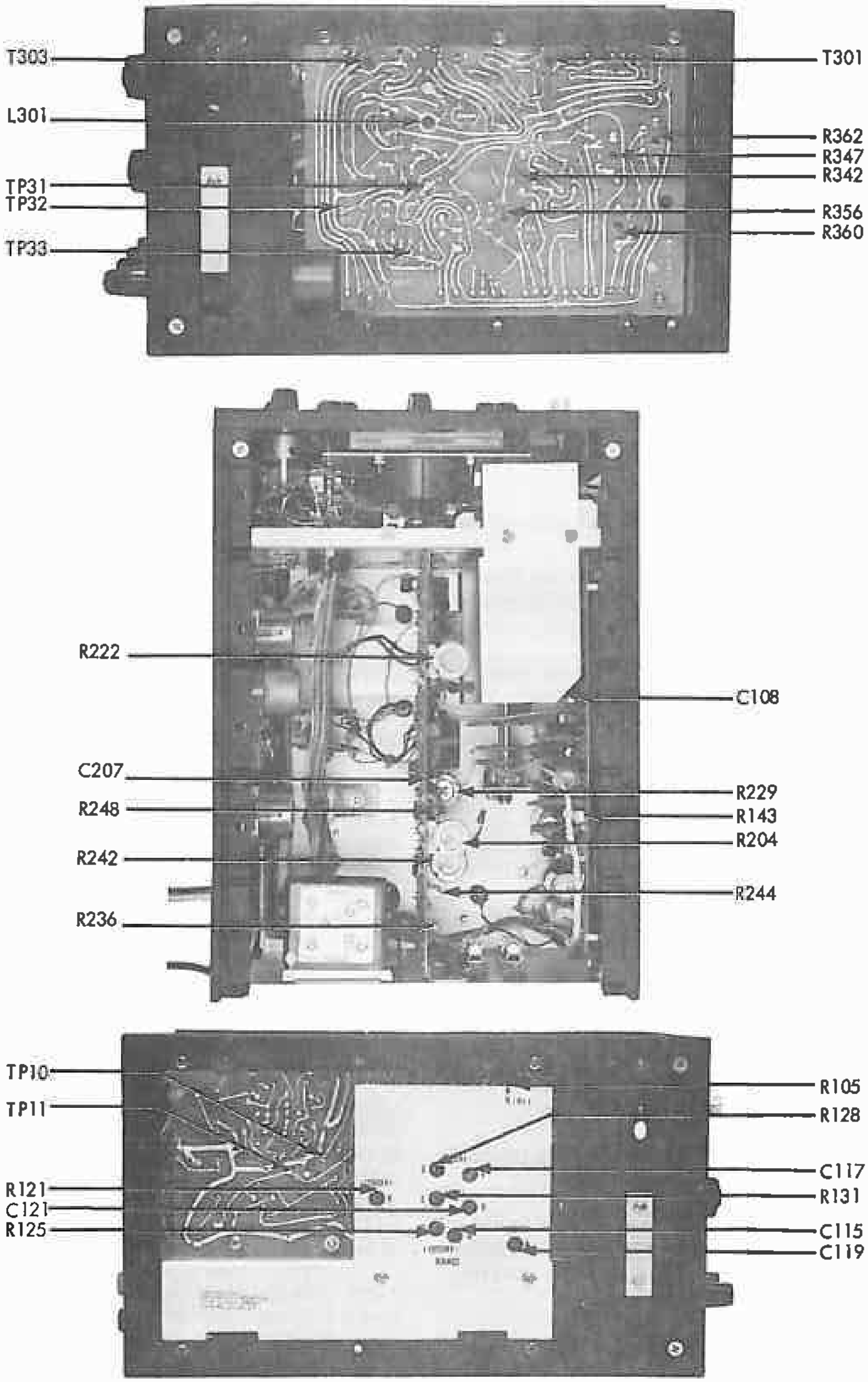


Figure 4-2. ADJUSTMENT AND TEST POINT LOCATIONS

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.

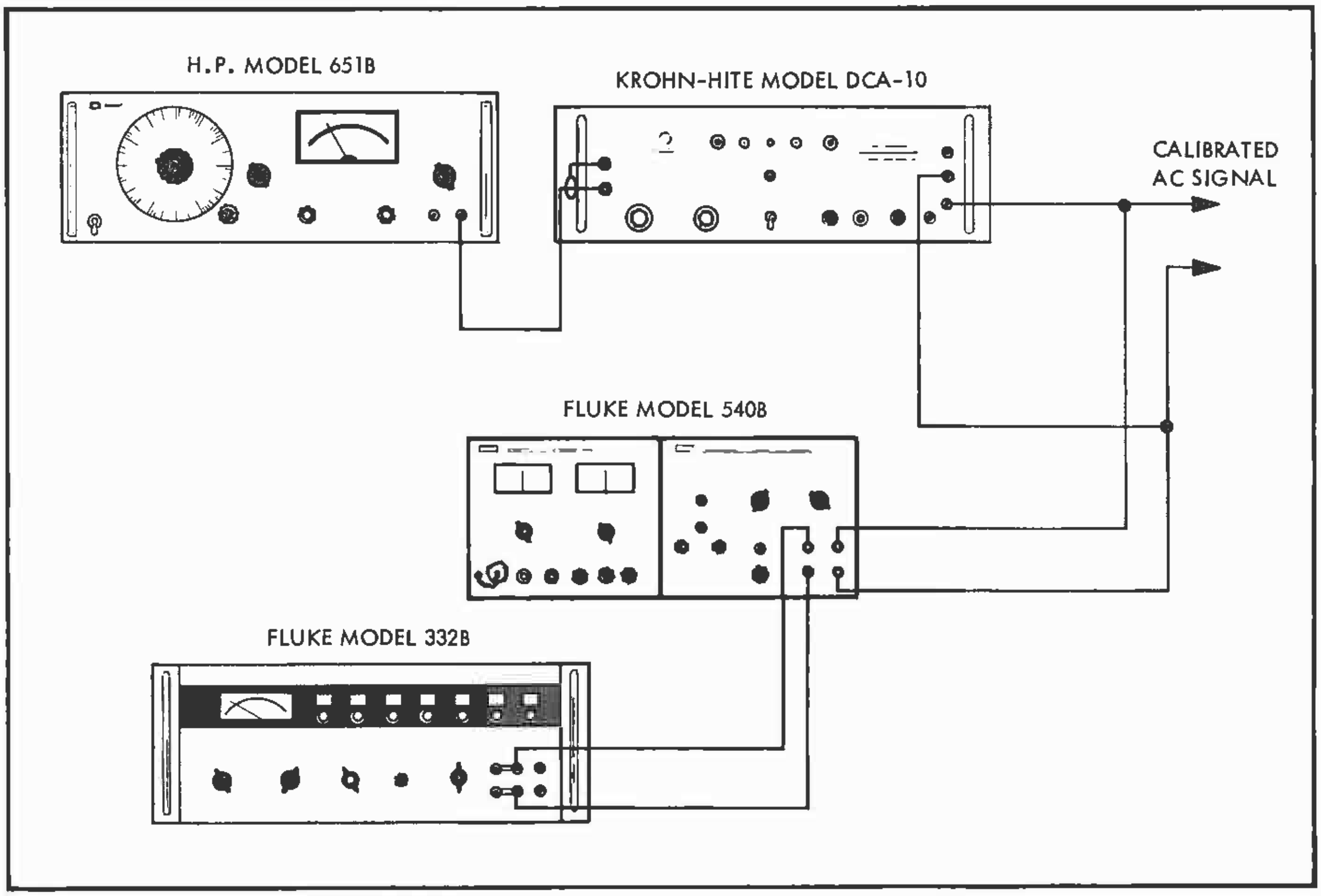


Figure 4-3. 5 Hz TO 500 kHz AC CALIBRATION SOURCE

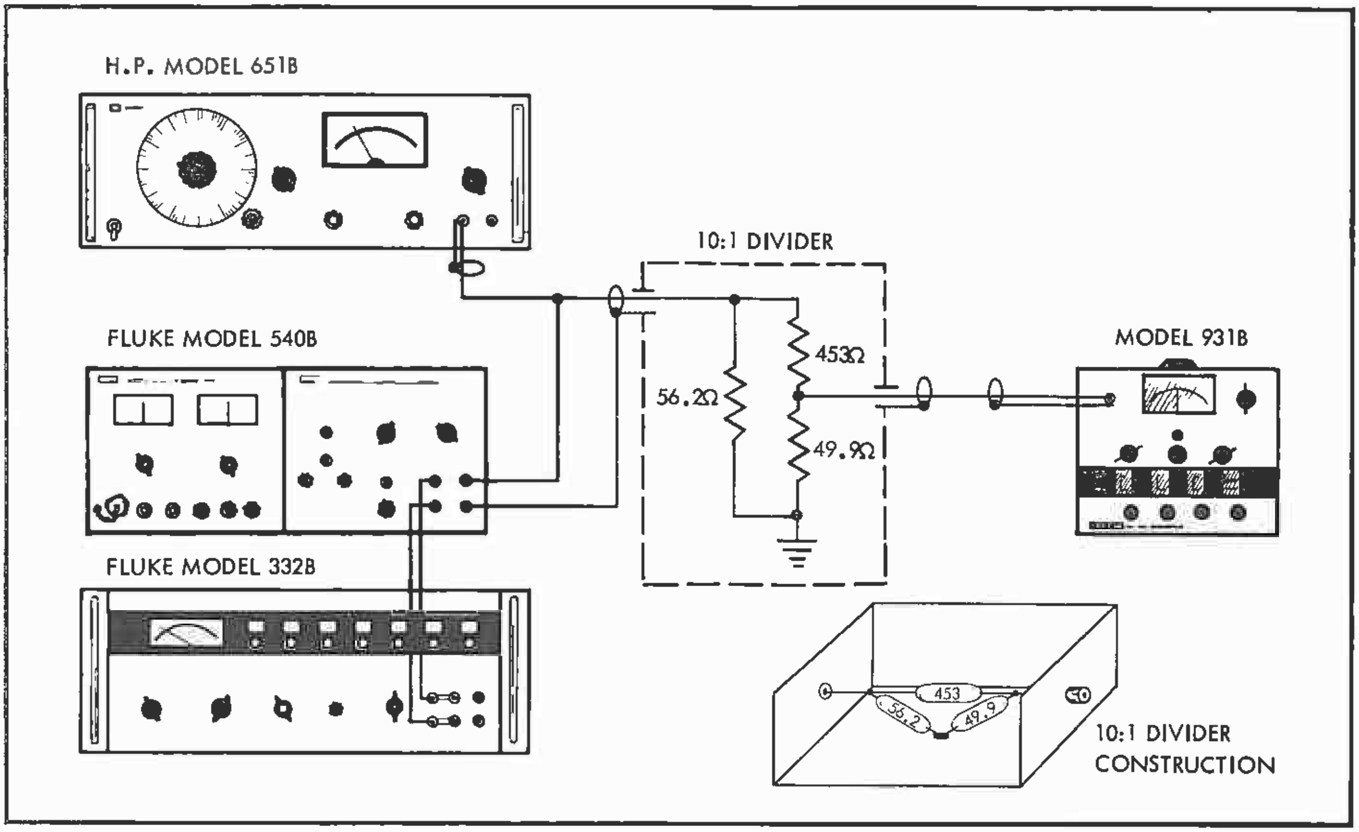


Figure 4-4. 20 kHz TO 500 kHz 0.1 VOLT RMS AC CALIBRATION SOURCE

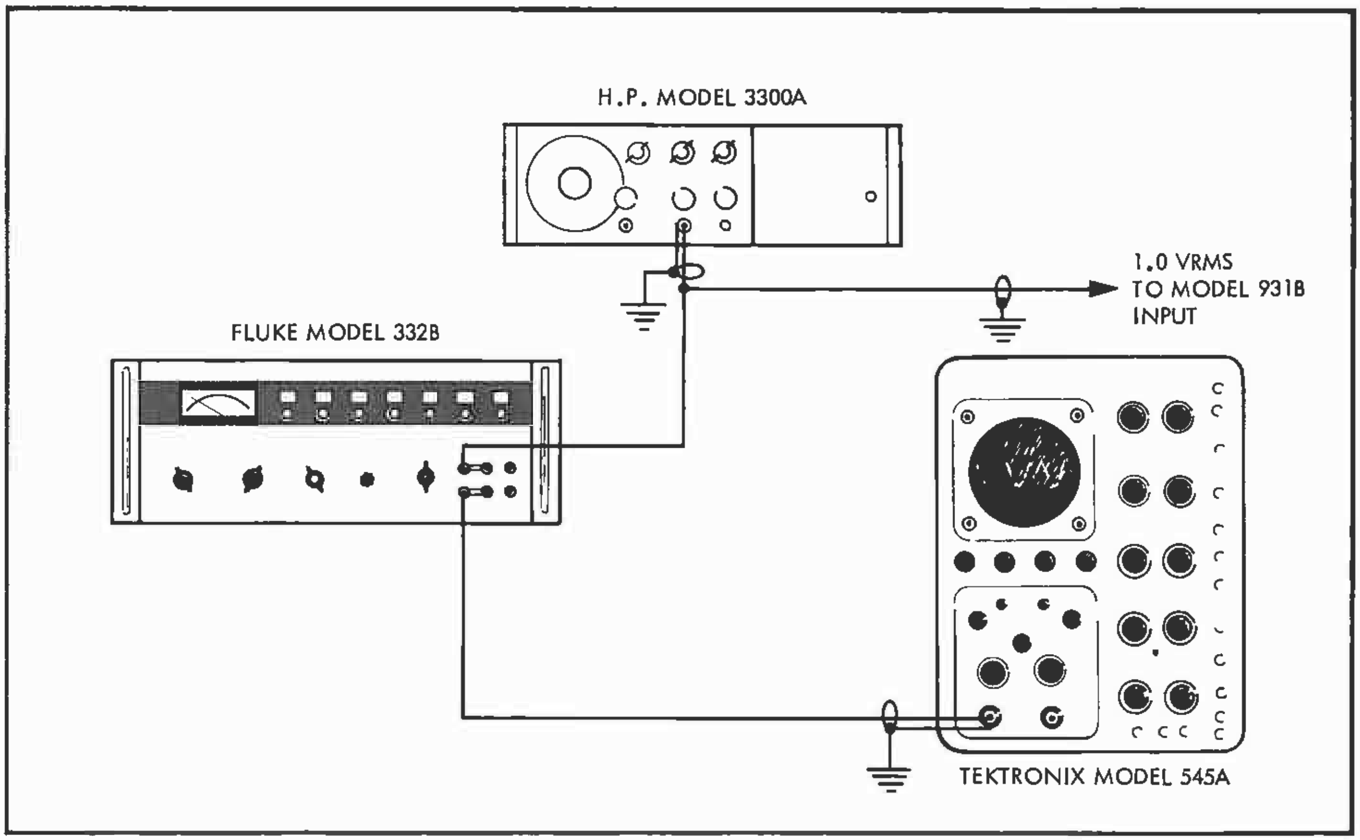


Figure 4-5. 2 Hz AC CALIBRATION SOURCE

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.

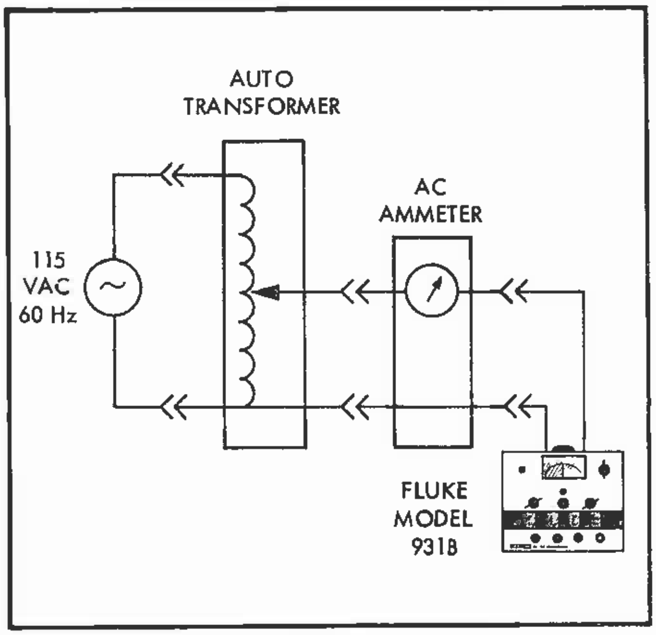


Figure 4-6. POWER SUPPLY CHECKS EQUIPMENT CONNECTIONS

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:

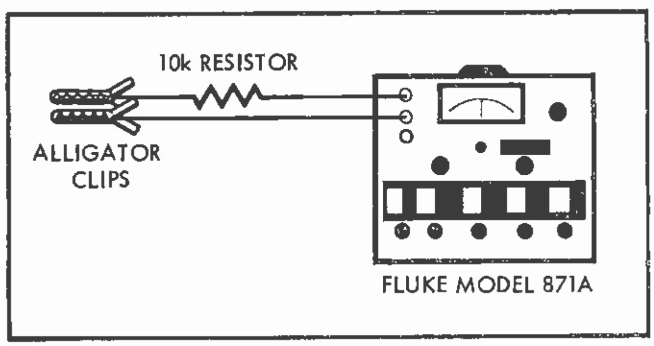


Figure 4-7. 10K ISOLATION PROBE

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.

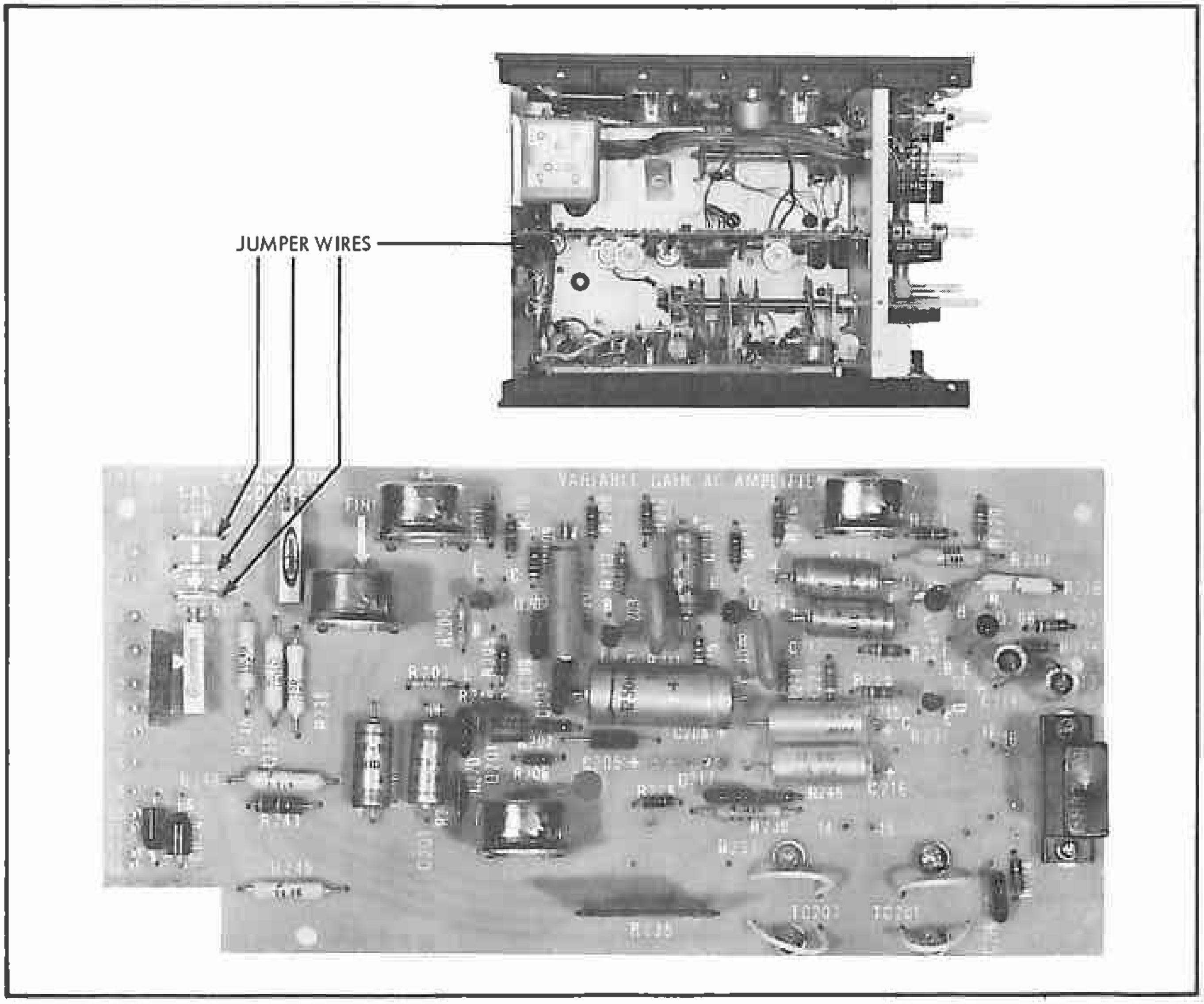


Figure 4-11. ABSOLUTE CALIBRATION JUMPER WIRE LOCATIONS

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.

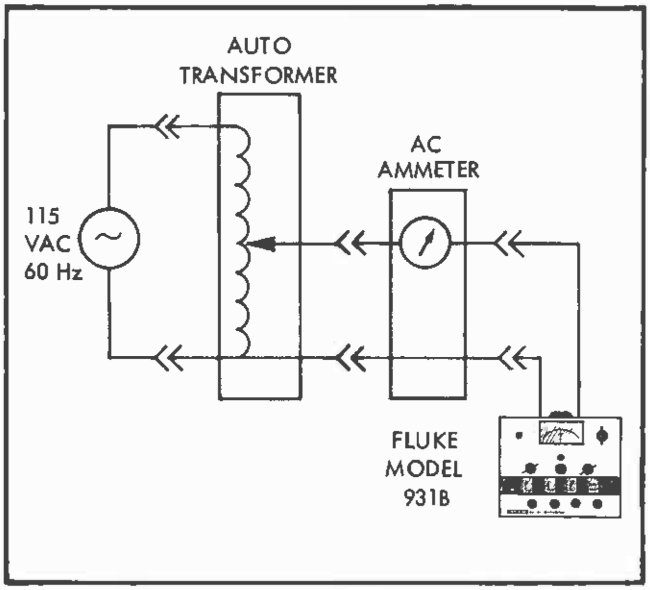


Figure 4-13. POWER SUPPLY TESTS EQUIPMENT CONNECTIONS

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.

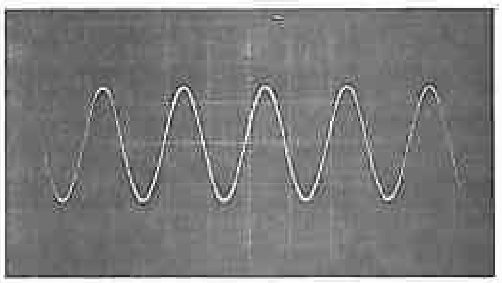
Note!

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.

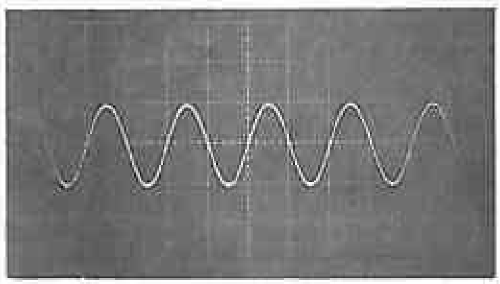
j. To check the amplifiers dynamic range for high crest factor waveforms, make the equipment connections illustrated in Figure 4-17 and place the RANGE switch to its 1000 MILLIVOLTS position.

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

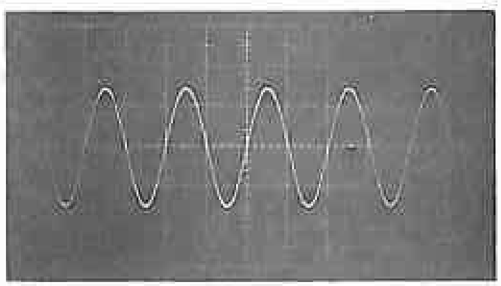
l. Adjust the squarewave generator output frequency, while simultaneously maintaining a 10 volt peak-to-



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%
10 v	10.0	TVM X1	100%
100 v	100.0	TVM X1	100%
1000 v	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.

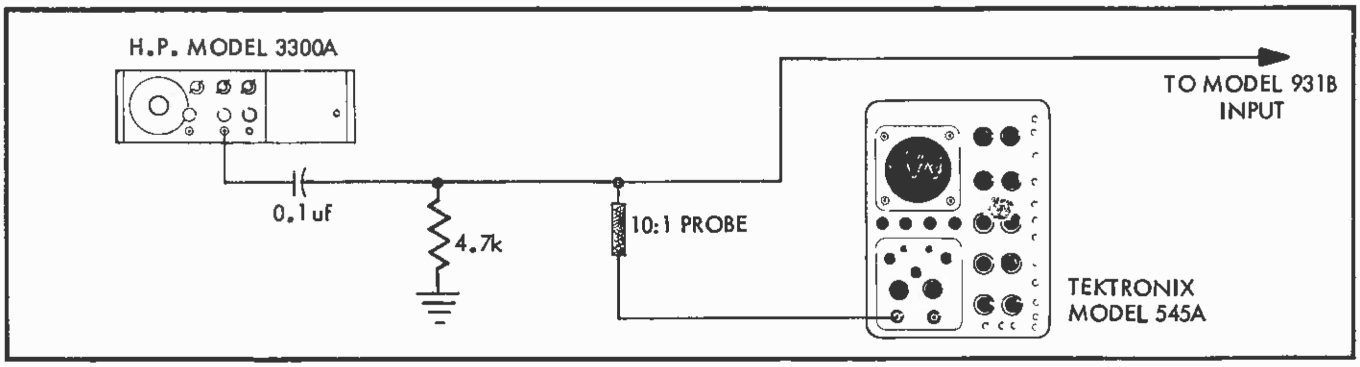


Figure 4-17. CREST FACTOR CHECK EQUIPMENT CONNECTIONS

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

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

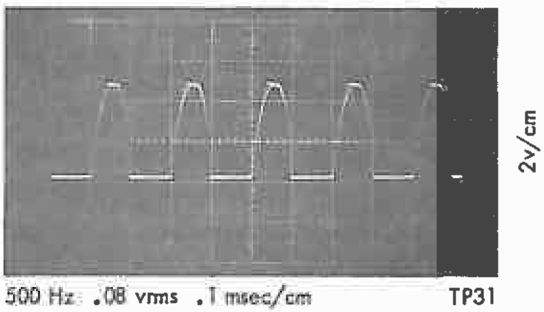
e. Apply a 10 volt rms 500 Hz signal, from a calibration source, to the input of the ratio transformer.

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.



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	10.000

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.

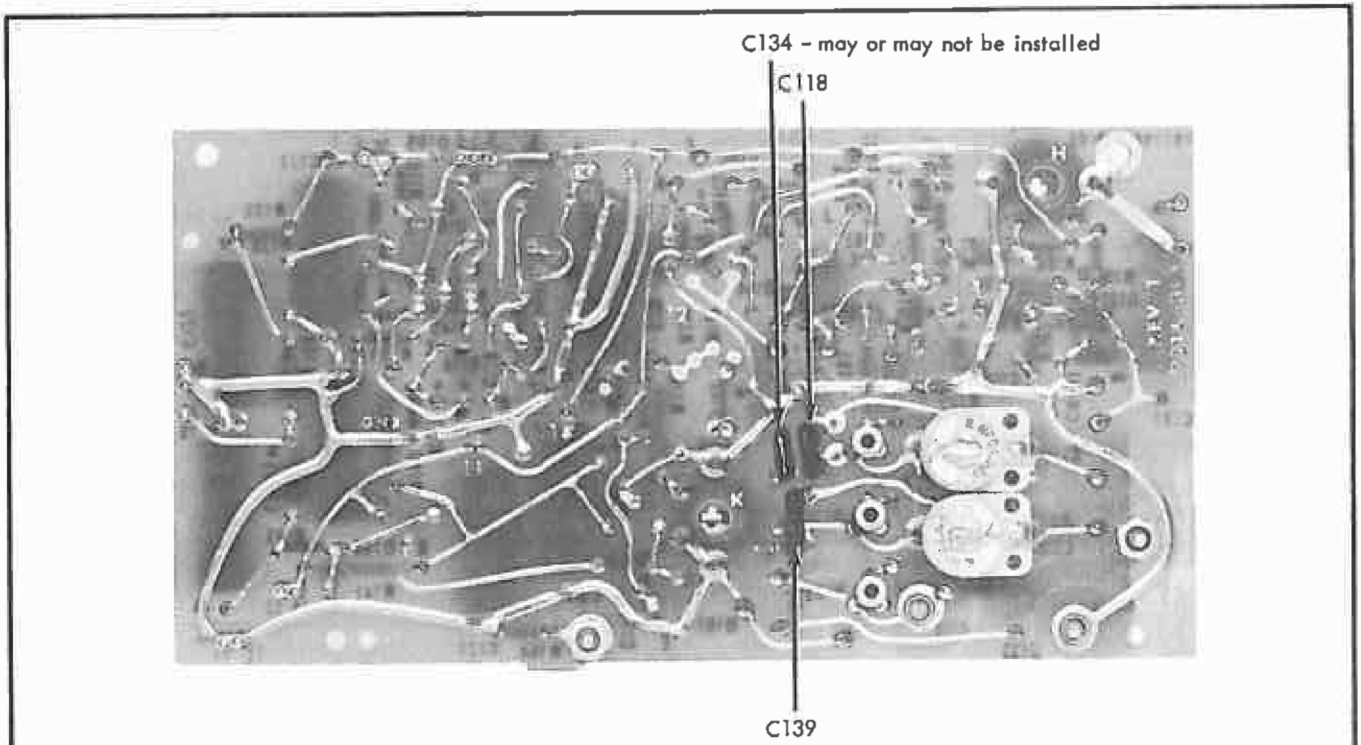


Figure 4-23. LOCATION OF COMPENSATING COMPONENTS

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

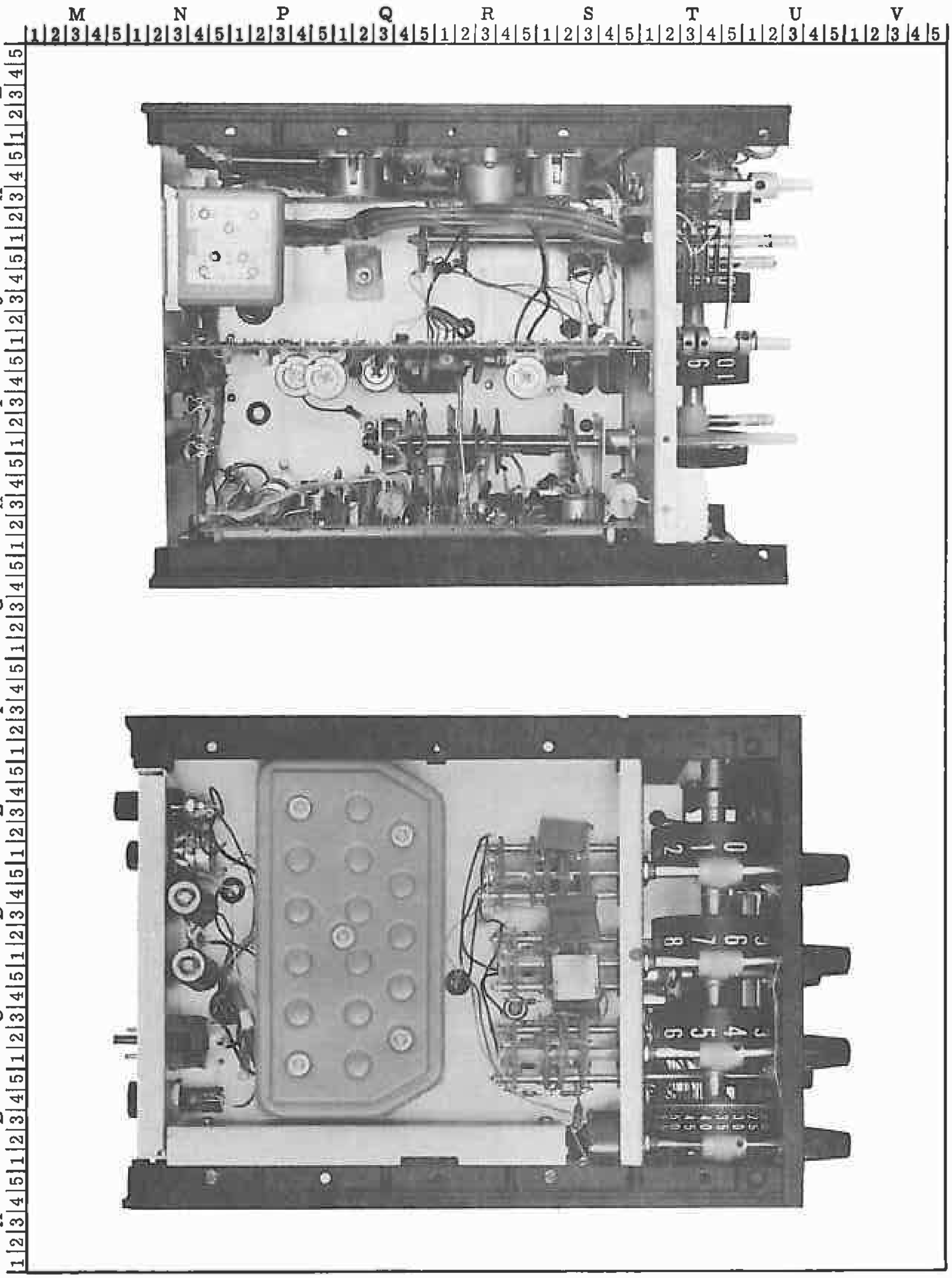


Figure 5-1. 931B RMS DIFFERENTIAL VOLTMETER (Sheet 1 of 2)

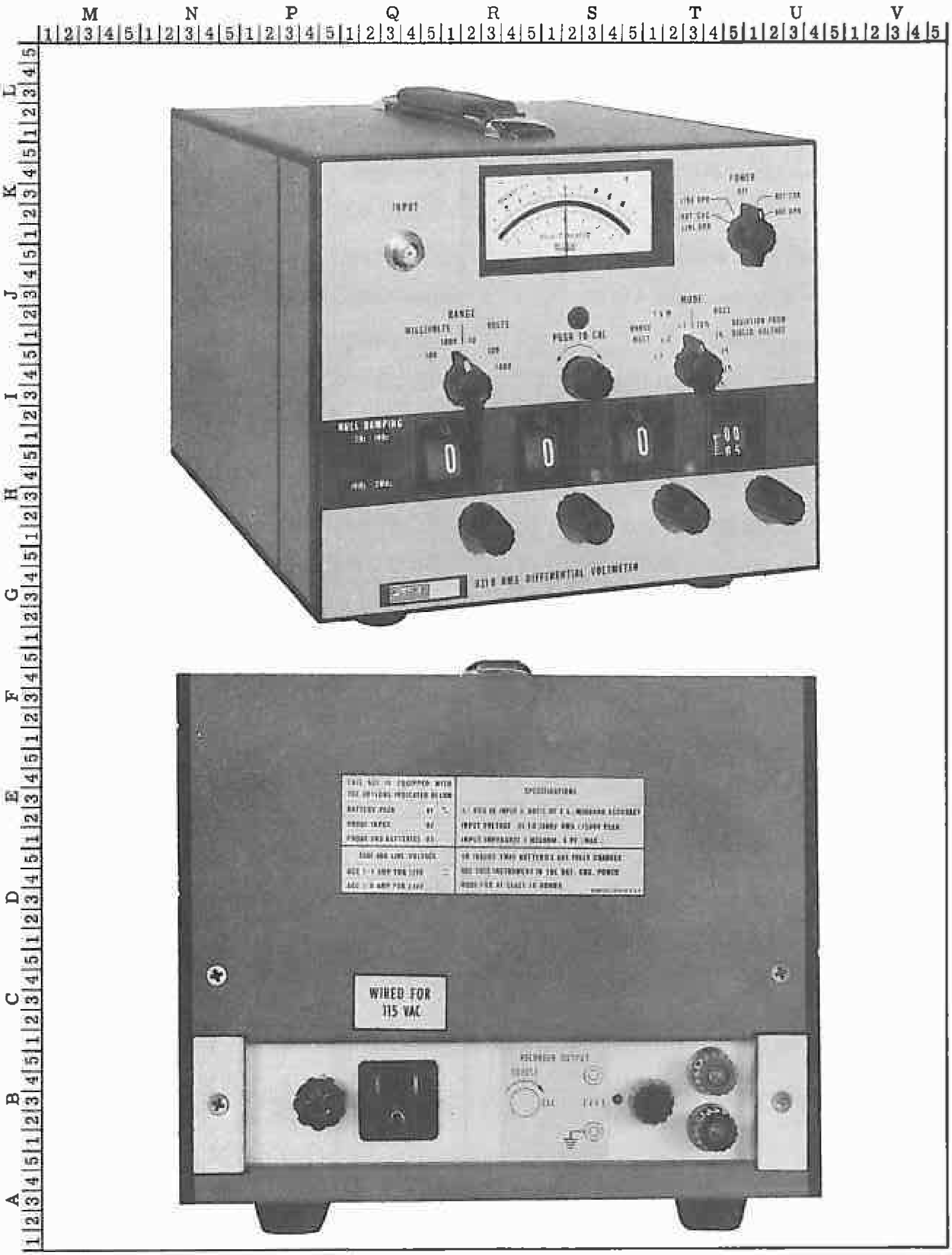


Figure 5-1. 931B RMS DIFFERENTIAL VOLTMETER (Sheet 2 of 2)

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.						

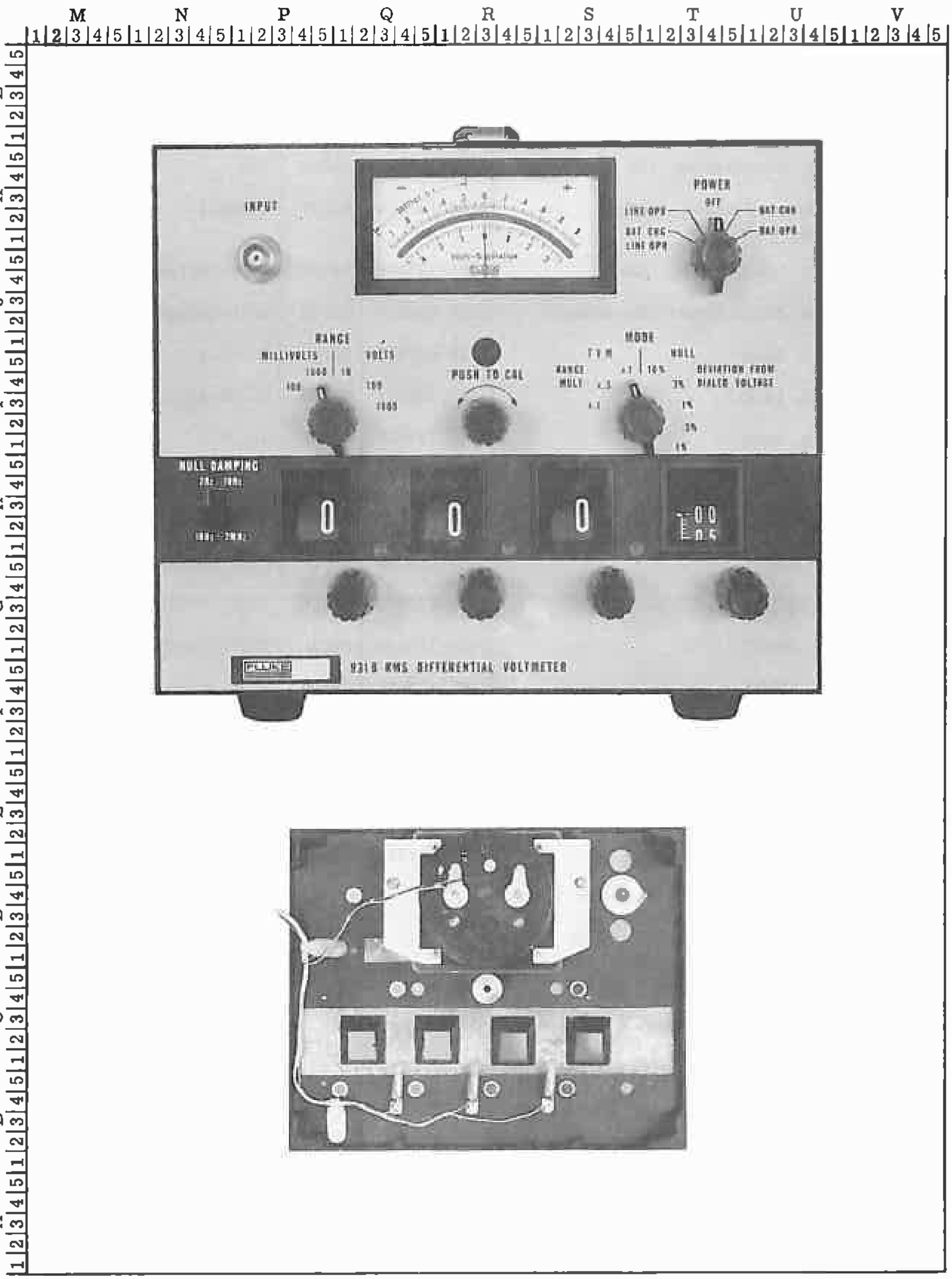


Figure 5-2. FRONT PANEL ASSEMBLY

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.

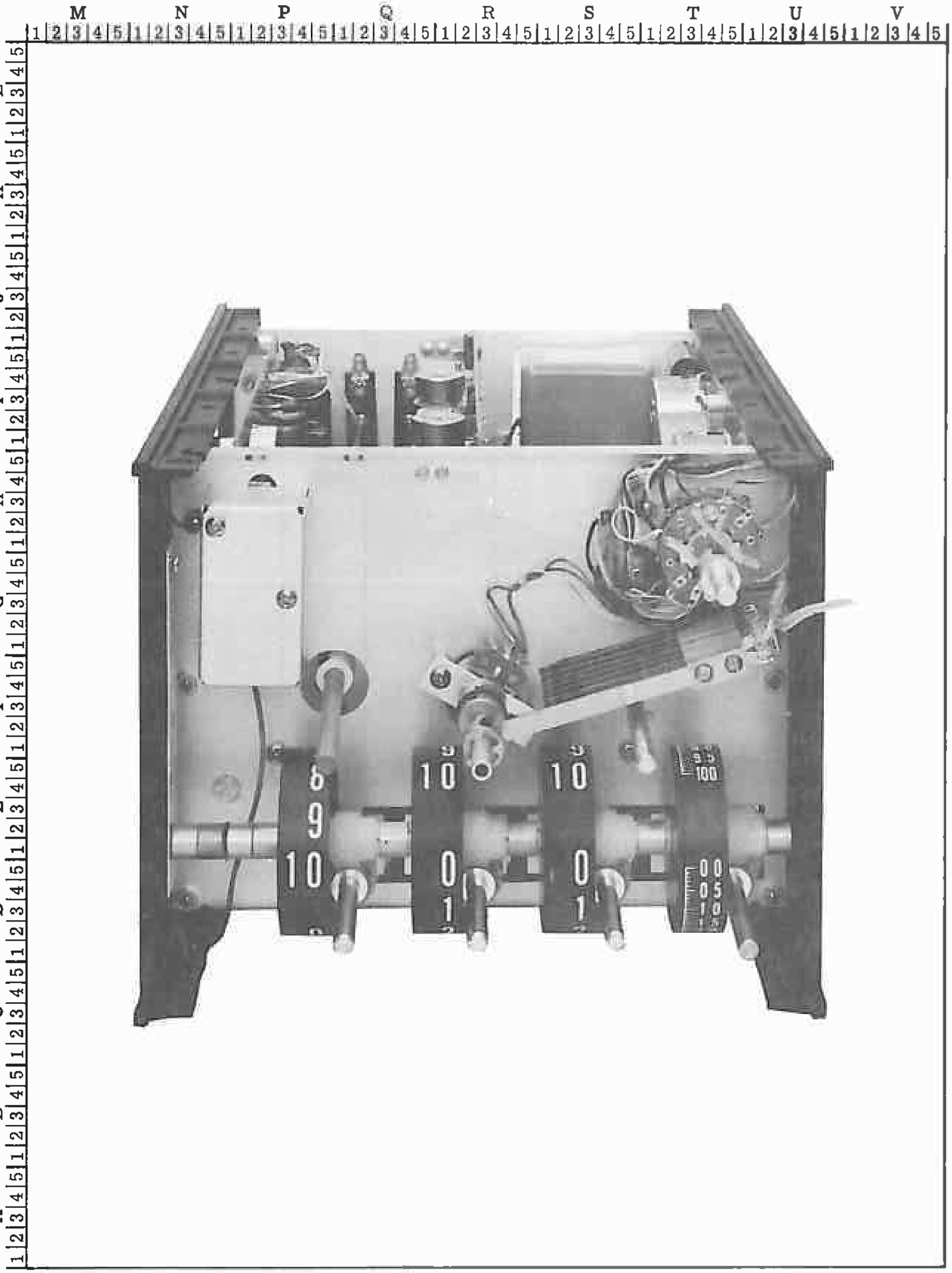


Figure 5-3. SWITCH PANEL ASSEMBLY

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		

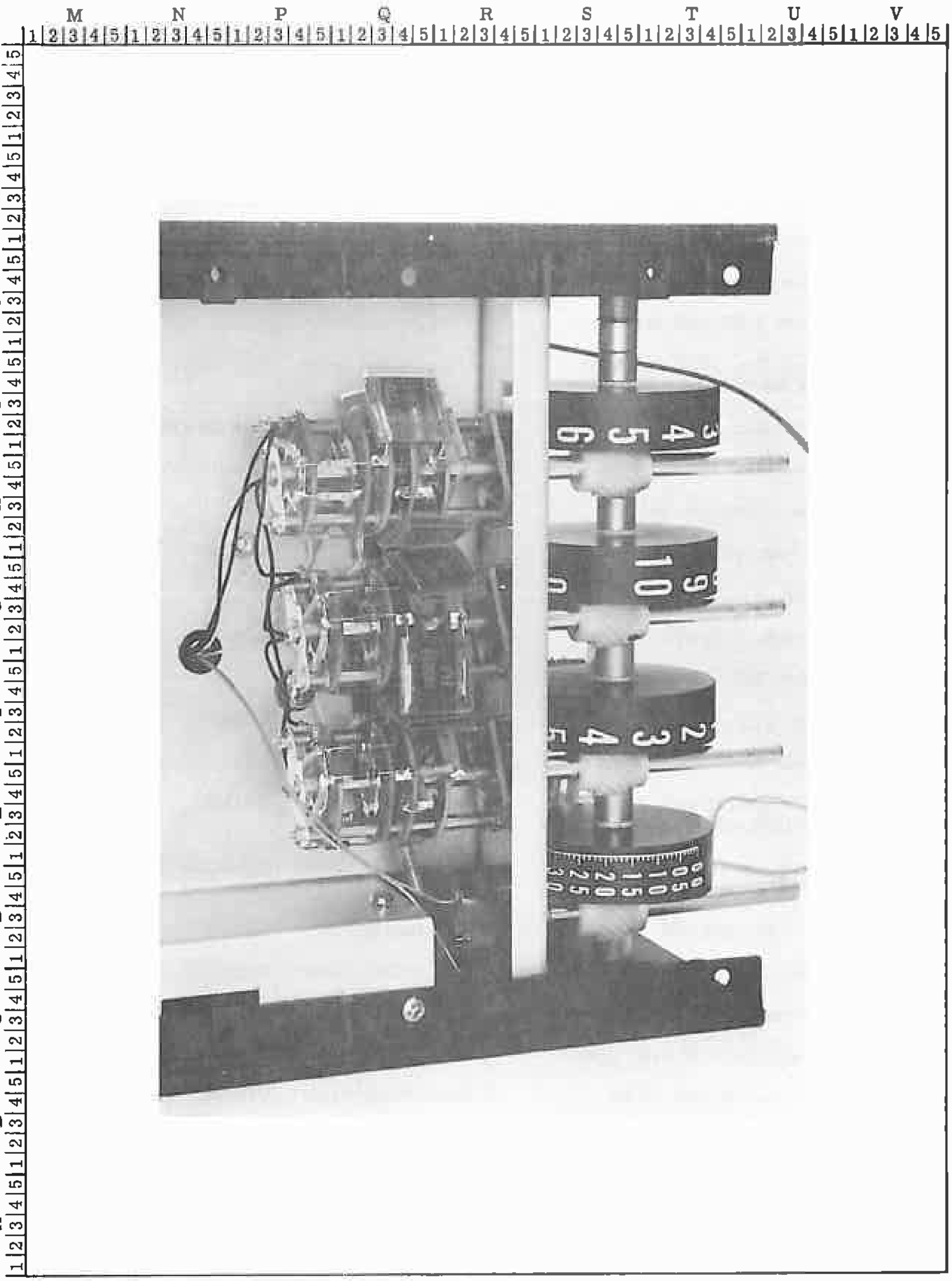


Figure 5-4. DIGIT SWITCH ASSEMBLY

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.

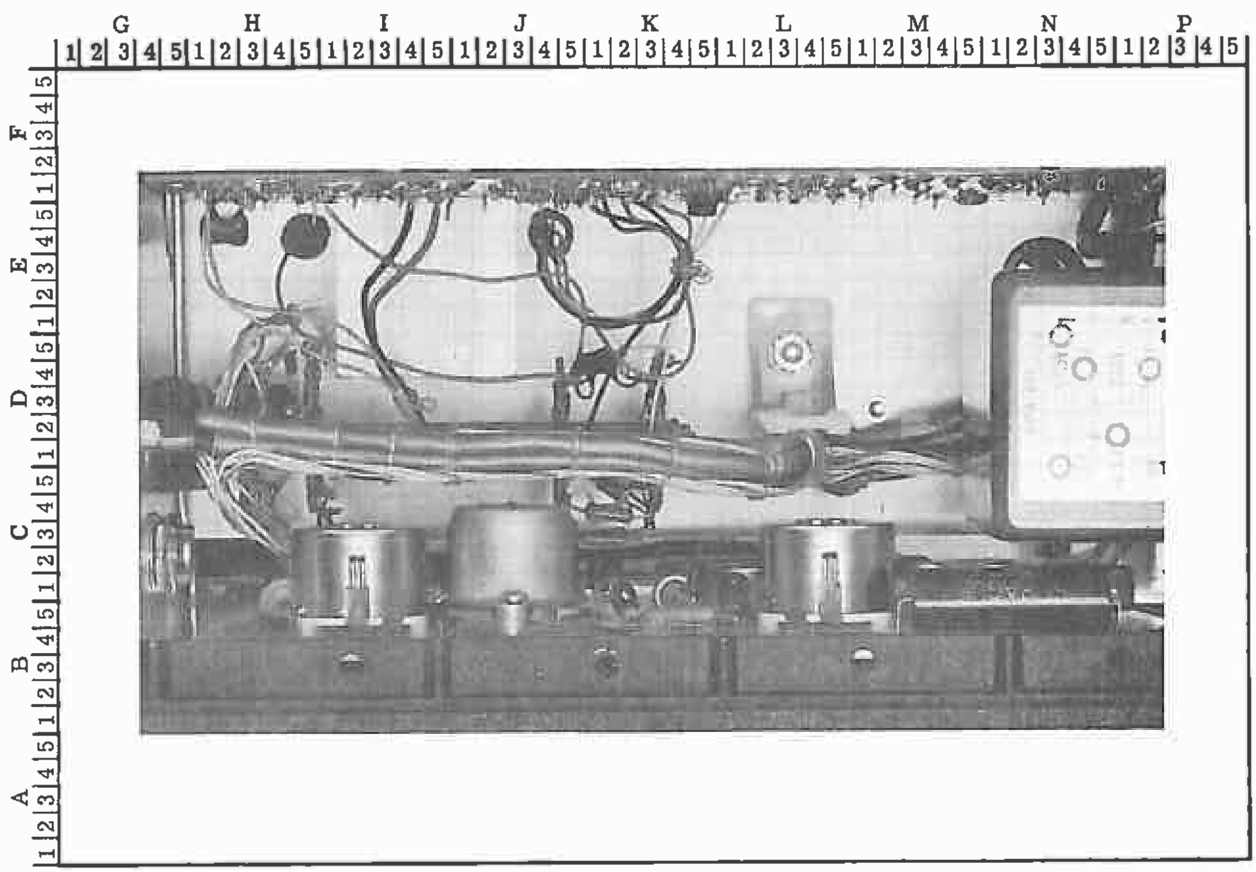


Figure 5-5. MODE SWITCH ASSEMBLY

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		

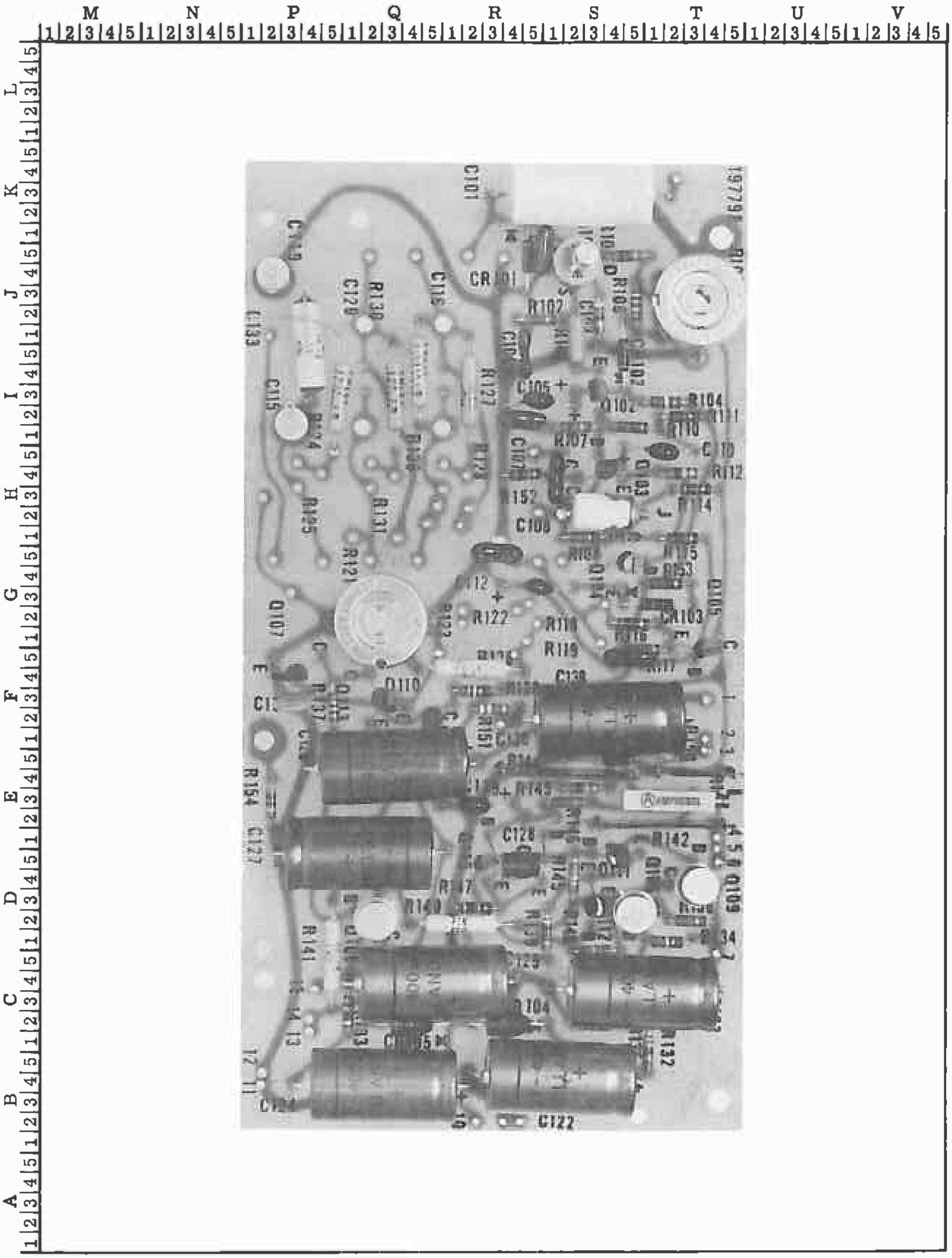
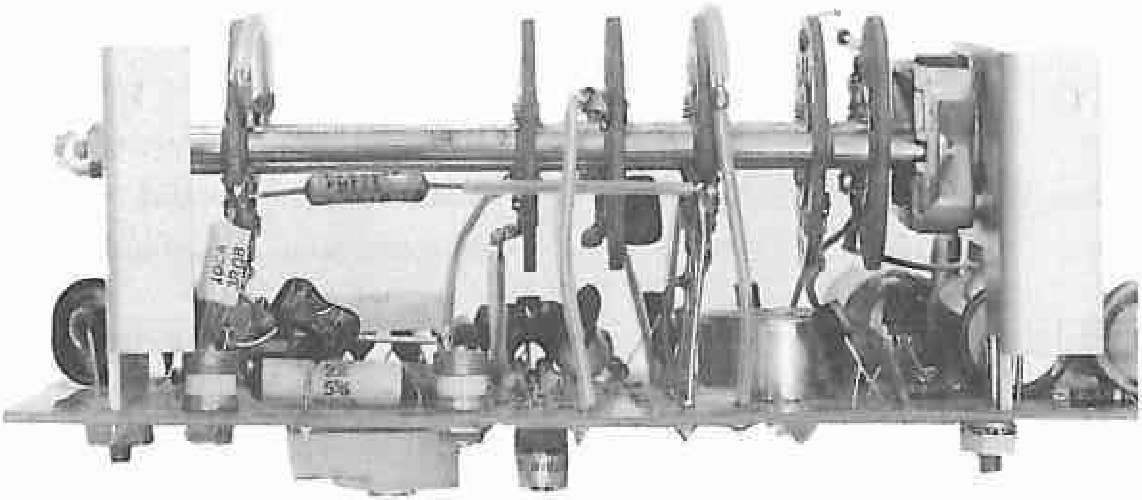


Figure 5-6. INPUT AMPLIFIER AND POWER SUPPLY ASSEMBLY (Sheet 1 of 2)



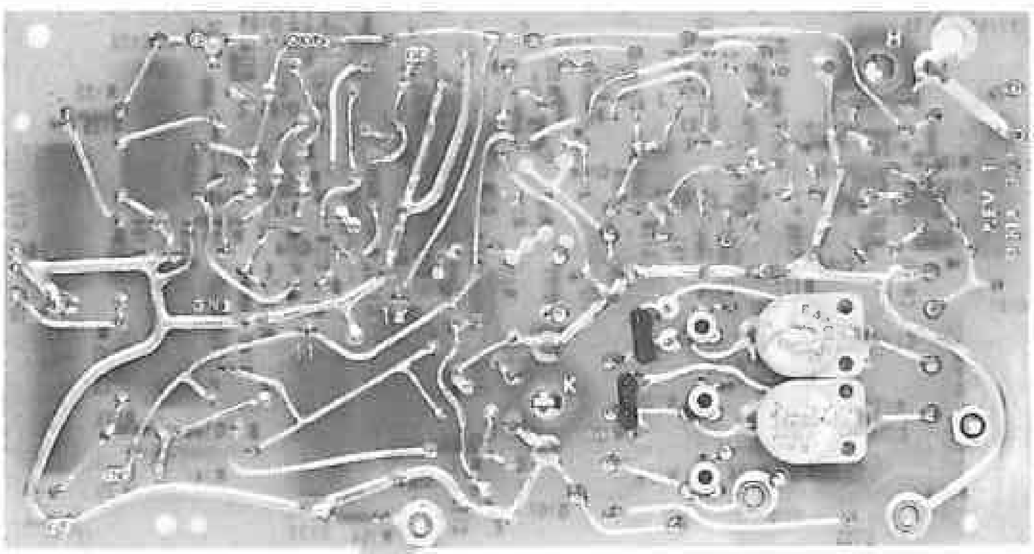


Figure 5-6. INPUT AMPLIFIER AND POWER SUPPLY ASSEMBLY (Sheet 2 of 2)

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	150D106X9020 B2	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		

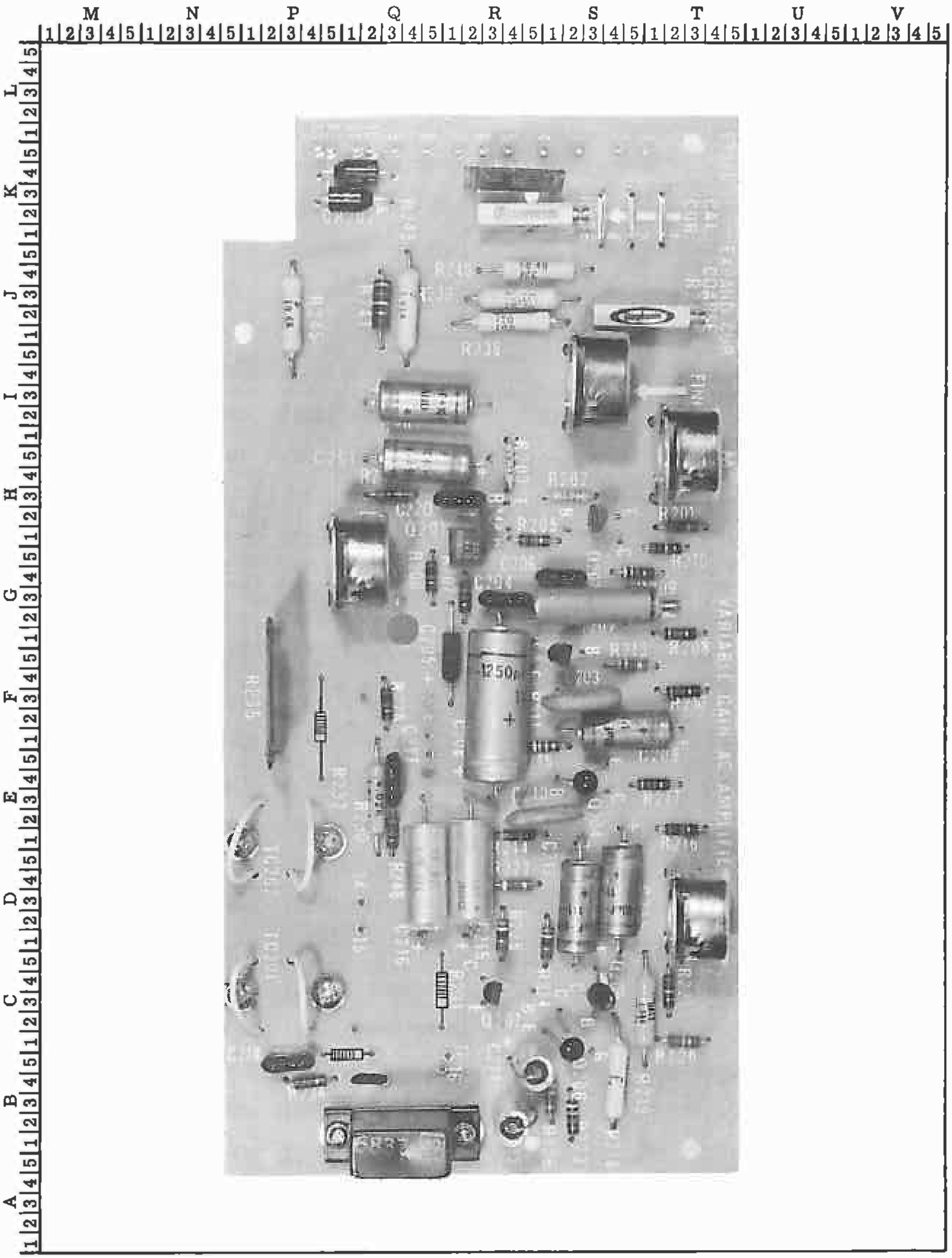


Figure 5-7. VARIABLE GAIN AC AMPLIFIER ASSEMBLY

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, co.np, 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 (931A-403)	89536	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	F3-Q2	Diode, zener	4808-325472	15818	1N823	2		D
CR305	H2-P1	Diode, zener	4808-325472	15818	1N823	REF		D
L301	E2-T1	Transformer, resonator #2	5602-197962	89536	5602-197962	1		
Q301	J3-U3	Tstr, silicon, NPN	4805-203489	07910	CDQ10656	REF		
Q302	I5-U3	Tstr, silicon, NPN	4805-203489	07910	CDQ10656	REF		
Q303	G1-U1	Tstr, silicon, NPN	4805-168708	03508	2N3391	REF		

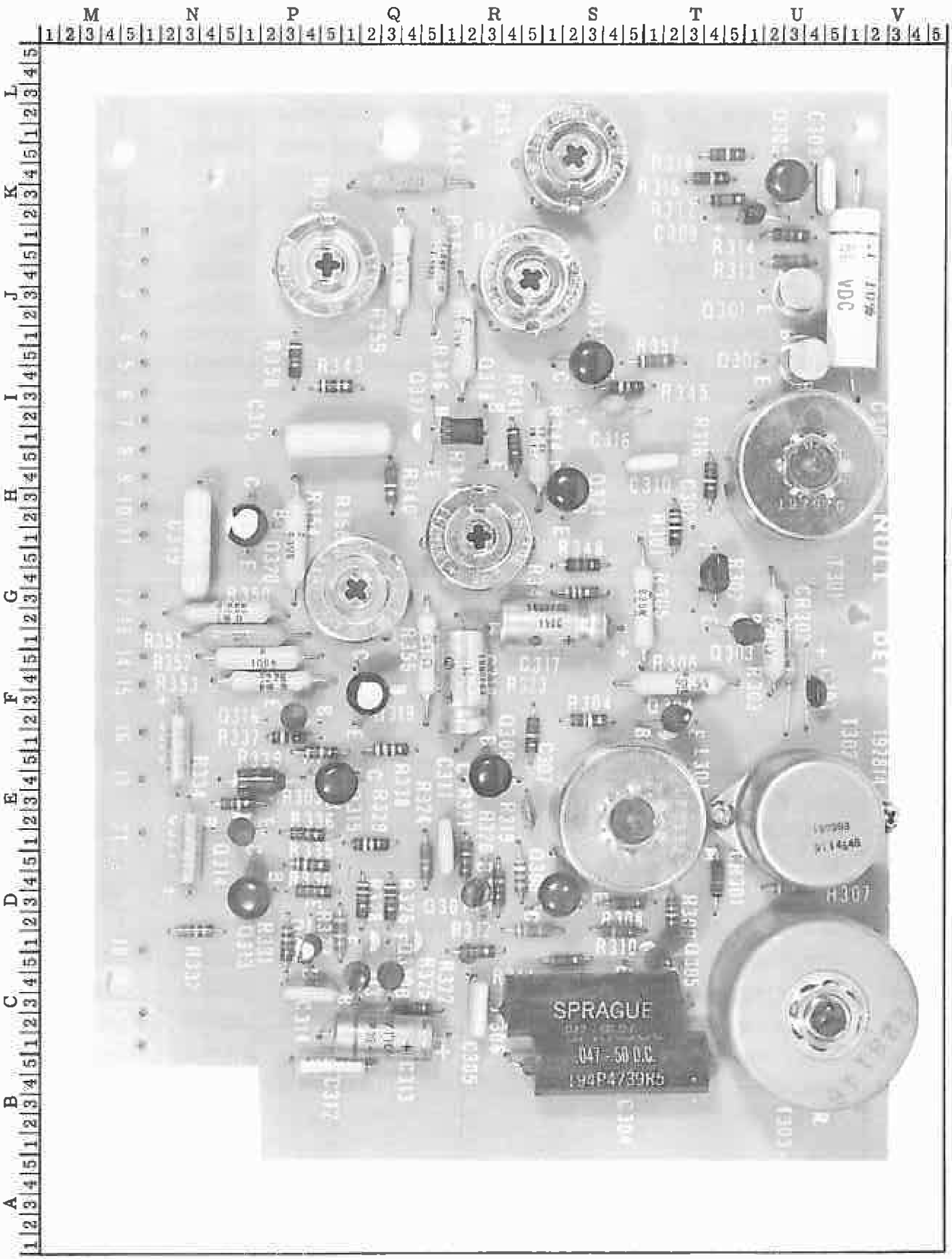


Figure 5-8. NULL DETECTOR ASSEMBLY

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		

Section 7

General Information

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

List of Abbreviations and Symbols

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

00213
Nytronics Comp. Group Inc.
Subsidiary of Nytronics Inc.
Formerly Sage Electronics
Rochester, New York

00327
Welwyn International, Inc.
Westlake, Ohio

00656
Aerovox Corp.
New Bedford, Massachusetts

00686
Film Capacitors, Inc.
Passaic, New Jersey

00779
AMP Inc.
Harrisburg, Pennsylvania

01121
Allen-Bradley Co.
Milwaukee, Wisconsin

01281
TRW Electronic Comp.
Semiconductor Operations
Lawndale, California

01295
Texas Instruments, Inc.
Semiconductor Group
Dallas, Texas

01537
Motorola Communications &
Electronics Inc.
Franklin Park, Illinois

01686
RCL Electronics Inc.
Manchester, New Hampshire

01730
Replaced by 73586

01884
Use 56289
Sprague Electric Co.
Dearborn Electronic Div
Lockwood, Florida

02114
Ferroxcube Corp.
Saugerties, New York

02131
General Instrument Corp.
Harris ASW Div.
Westwood, Maine

02395
Rason Mfg. Co.
Brooklyn, New York

02533
Snelgrove, C.R. Co., Ltd.
Don Mills, Ontario, Canada
M3B 1M2

02606
Fenwal Labs
Div. of Travenal Labs.
Morton Grove, Illinois

02660
Bunker Ramo Corp., Conn Div.
Formerly Amphenol-Borg
Electric Corp.
Broadview, Illinois

02799
Areo Capacitors, Inc.
Chatsworth, California

03508
General Electric Co.
Semiconductor Products
Syracuse, New York

03614
Replaced by 71400

03651
Replaced by 44655

03797
Eldema Div.
Genisco Technology Corp.
Compton, California

03877
Transistron Electronic Corp.
Wakefield, Massachusetts

03888
KDI Pyrofilm Corp.
Whippany, New Jersey

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

03980
Muirhead Inc.
Mountainside, New Jersey

04009
Arrow Hart Inc.
Hartford, Connecticut

04062
Replaced by 72136

04202
Replaced by 81312

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

04221
Aemco, Div. of
Midtex Inc
Mankato, Minnesota

04222
AVX Ceramics Div.
AVX Corp.
Myrtle Beach, Florida

04423
Telonic Industries
Laguna Beach, California

04645
Replaced by 75376

04713
Motorola Inc. Semiconductor
Products
Phoenix, Arizona

04946
Standard Wire & Cable
Los Angeles, California

05082
Replaced by 94988

05236
Jonathan Mfg. Co.
Fullerton, California

05245
Components Corp. now
Corcom, Inc.
Chicago, Illinois

05277
Westinghouse Electric Corp.
Semiconductor Div.
Youngwood, Pennsylvania

05278
Replaced by 43543

05279
Southwest Machine &
Plastic Co.
Glendora, California

05397
Union Carbide Corp.
Materials Systems Div.
New York, New York

05571
Use 56289
Sprague Electric Co.
Pacific Div.
Los Angeles, California

05574
Viking Industries
Chatsworth, California

05704
Replaced by 16258

05820
Wakefield Engineering Inc
Wakefield, Massachusetts

06001
General Electric Co.
Electronic Capacitor &
Battery Products Dept.
Columbia, South Carolina

06136
Replaced by 63743

06383
Panduit Corp
Tinley Park, Illinois

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

06555
Beede Electrical Instrument Co.
Penacook, New Hampshire

06739
Electron Corp.
Littleton, Colorado

06743
Clevite Corp.
Cleveland, Ohio

06751
Components, Inc. Semcor Div
Phoenix, Arizona

06860
Gould Automotive Div.
City of Industry, California

06961
Vernitron Corp., Piezo
Electric Div.
Formerly Clevite Corp., Piezo
Electric Div
Bedford, Ohio

06980
Eimac Div.
Varian Associates
San Carlos, California

07047
The Ross Milton Co
South Hampton, Pennsylvania

07115
Replaced by 14674

07138
Westinghouse Electric Corp.,
Electronic Tube Div
Horsehead, New York

07233
TRW Electronic Components
Cinch Graphic
City of Industry, California

07256
Silicon Transistor Corp.
Div. of BBF Group Inc.
Chelmsford, Massachusetts

07261
Aumet Corp.
Culver City, California

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

07344
Bircher Co., Inc.
Rochester, New York

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

07792
Lerma Engineering Corp.
Northampton, Massachusetts

07910
Teledyne Semiconductor
Formerly Continental Device
Hawthorne, California

07933
Use 49956
Raytheon Co
Semiconductor Div. HQ
Mountain View, California

08225
Industro Transistor Corp.
Long Island City, New York

08261
Spectra Strip Corp
Garden Grove, California

08530
Reliance Mica Corp.
Brooklyn, New York

08806
General Electric Co
Miniature Lamp Products Dept
Cleveland, Ohio

08863
Nylomatic Corp
Norrisville, Pennsylvania

08988
Use 53085
Skottie Electronics Inc
Archbald, Pennsylvania

09214
G E Co Semi-Conductor
Products Dept
Power Semi-Conductor
Products OPN Sec
Auburn, New York

09353
C and K Components
Watertown, Massachusetts

09423
Scientific Components, Inc.
Santa Barbara, California

09922
Burndy Corp.
Norwalk, Connecticut

09969
Dale Electronics Inc.
Yankton, S. Dakota

10059
Barker Engineering Corp.
Formerly Amerace, Amerace
ESNA Corp.
Kenilworth, New Jersey

11236
CTS of Berne
Berne, Indiana

11237
CTS Keene Inc
Paso Robles, California

11358
CBS Electronic Div.
Columbia Broadcasting System
Newburyport, Minnesota

11403
Best Products Co.
Chicago, Illinois

11503
Keystone Columbia Inc.
Warren, Michigan

11532
Teledyne Relays
Hawthorne, California

11711
General Instrument Corp.
Rectifier Division
Hicksville, New York

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

12300
Potter-Brumfield Div.
AMF Canada LTD.
Guelph, Ontario, Canada

12323
Presin Co., Inc.
Shelton, Connecticut

12327
Freeway Corp. formerly
Freeway Washer & Stamping Co.
Cleveland, Ohio

12443
The Budd Co. Polychem Products
Plastic Products Div.
Bridgeport, Pennsylvania

12615
U.S. Terminals Inc.
Cincinnati, Ohio

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., Inc.
Dallas, Texas

13327
Solitron Devices Inc.
Tappan, New York

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

13606
Use 56289
Sprague Electric Co.
Transistor Div.
Concord, New Hampshire

13839
Replaced by 23732

14099
Semtech Corp.
Newbury Park, California

14140
Edison Electronic Div.
Mc Gray-Edison Co.
Manchester, New Hampshire

14193
Cal-R-Inc. formerly
California Resistor, Corp
Santa Monica, California

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

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

14752
Electro Cube Inc.
San Gabriel, California

14869
Replaced by 96853

14936
General Instrument Corp.
Semi Conductor Products Group
Hicksville, New York

15636
Elec-Trol Inc
Saugus, California

15801
Fenwal Electronics Inc.
Div. of Kidde Walter and Co., Inc.
Framingham, Massachusetts

15818
Teledyne Semiconductors,
formerly Amelco Semiconductor
Mountain View, California

15849
Litton Systems Inc. Useco Div.
formerly Useco Inc.
Van Nuys, California

15898
International Business
Machines Corp.
Essex Junction, Vermont

15909
Replaced by 14140

16258
Space-Lok Inc.
Burbank, California

16299
Corning Glass
Electronic Components Div.
Raleigh, North Carolina

16332
Replaced by 28478

16473
Cambridge Scientific Ind.
Div. of Chemed Corporation
Cambridge, Maryland

16742
Paramount Plastics
Fabricators, Inc.
Downey, California

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

17001
Replaced by 71468

17069
Circuit Structures Lab.
Burbank, California

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

17545
Atlantic Semiconductors, Inc.
Asbury Park, New Jersey

17856
Siliconix, Inc.
Santa Clara, California

17870
Replaced by 14140

18178
Vactec Inc.
Maryland Heights, Missouri

18324
Signetics Corp.
Sunnyvale, California

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

18736
Voltronics Corp.
Hanover, New Jersey

18927
GTE Sylvania Inc.
Precision Material Group
Parts Division
Titusville, Pennsylvania

19451
Perine Machinery & Supply Co.
Seattle, Washington

19701
Electro-Midland Corp.
Mepco-Electra Inc.
Mineral Wells, Texas

20584
Enochs Mfg. Inc.
Indianapolis, Indiana

20891
Self-Organizing Systems, Inc.
Dallas, Texas

21604
Bucheye Stamping Co.
Columbus, Ohio

21845
Solitron Devices Inc.
Transistor Division
Riveria Beach, Florida

22767
ITT Semiconductors
Palo Alto, California

23050
Product Comp Corp.
Mount Vernon, New York

23732
Tracor Inc.
Rockville, Maryland

23880
Stanford Applied Engrng.
Santa Clara, California

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

24248
Replaced by 94222

24355
Analog Devices Inc.
Norwood, Massachusetts

24655
General Radio
Concord, Massachusetts

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

25088
Siemen Corp.
Isilen, New Jersey

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

27014
National Semiconductor Corp.
Santa Clara, California

27264
Molex Products
Downers Grove, Illinois

28213
Minnesota Mining & Mfg. Co.
Consumer Products Div.
St. Paul, Minnesota

28425
Serv-/-Link formerly
Bohannan Industries
Fort Worth, Texas

28478
Deltrol Controls Div.
Deltrol Corporation
Milwaukee, Wisconsin

28480
Hewlett Packard Co.
Corporate HQ
Palo Alto, California

28520
Heyman Mfg. Co.
Kenilworth, New Jersey

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

29604
Stackpole Components Co.
Raleigh, North Carolina

30148
AB Enterprise Inc.
Ahoskie, North Carolina

30323
Illinois Tool Works, Inc.
Chicago, Illinois

31091
Optimax Inc.
Colmar, Pennsylvania

32539
Mura Corp.
Great Neck, New York

32767
Griffith Plastic Corp.
Burlingame, California

32879
Advanced Mechanical
Components
Northridge, California

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

32997
Bourns Inc.
Trimpot Products Division
Riverside, California

33173
General Electric Co.
Products Dept.
Owensboro, Kentucky

34333
Silicon General
Westminister, California

34335
Advanced Micro Devices
Sunnyvale, California

34802
Electromotive Inc
Kenilworth, New Jersey

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

42498
National Radio
Melrose, Massachusetts

43543
Nytronics Inc.
Transformer Co. Div.
Geneva, New York

44655
Ohmite Mfg. Co.
Skokie, Illinois

49671
RCA Corp
New York, New York

49956
Raytheon Company
Lexington, Massachusetts

50088
Mostek Corp.
Carrollton, Texas

50579
Litronix Inc.
Cupertino, California

51605
Scientific Components Inc.
Linden, New Jersey

53021
Sangamo Electric Co.
Springfield, Illinois

54294
Cutler-Hammer Inc. formerly
Shallcross, A Cutler-Hammer Co.
Selma, North Carolina

55026
Simpson Electric Co.
Div. of Am. Gage and Mach. Co.
Elgin, Illinois

56289
Sprague Electric Co
North Adams, Massachusetts

58474
Superior Electric Co.
Bristol, Connecticut

60399
Torin Corp. formerly
Torrington Mfg. Co.
Torrington, Connecticut

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

64834
West Mfg. Co.
San Francisco, California

65092
Weston Instruments Inc.
Newark, New Jersey

66150
Winslow Tele-Tronics Inc.
Eaton Town, New Jersey

70485
Atlantic India Rubber Works
Chicago, Illinois

70563
Amperite Company
Union City, New Jersey

70903
Belden Corp.
Geneva, Illinois

71002
Birnback Radio Co., Inc
Freeport, New York

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

71450
CTS Corp.
Elkhart, Indiana

71468
ITT Cannon Electric Inc.
Santa Ana, California

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

71590
Centrelab Electronics
Div. of Globe Union Inc.
Milwaukee, Wisconsin

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

71744
Chicago Miniature Lamp Works
Chicago, Illinois

71785
TRW Electronics Components
Cinch Connector Operations Div.
Elk Grove Village
Chicago, Illinois

72005
Wilber B. Driver Co.
Newark, New Jersey

72092
Replaced by 06980

72136
Electro Motive Mfg. Co.
Williamantic, Connecticut

72259
Nytronics Inc.
Pelham Manor, New Jersey

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

72653
G.C. Electronics
Div. of Hydrometals, Inc.
Brooklyn, New York

72665
Replaced by 90303

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

72928
Gulton Ind. Inc
Gudeman Div.
Chicago, Illinois

72982
Erie Tech. Products Inc.
Erie, Pennsylvania

73138
Bechman Instrument Inc.
Helipot Division
Fullerton, California

73293
Hughes Aircraft Co.
Electron Dynamics Div
Torrance, California

73445
Amperex Electronic Corp.
Hicksville, New York

73559
Carling Electric Inc.
West 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.
Components Corp.
Brooklyn, New York

73949
Guardian Electric Mfg. Co.
Chicago, Illinois

74199
Quan Nichols Co.
Chicago, Illinois

74217
Radio Switch Corp.
Marlboro, New Jersey

74276
Signalite Div.
General Instrument Corp.
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
TRW Electronics Components
IRC Fixed Resistors
Philadelphia, Pennsylvania

75376
Kurz-Kasch Inc.
Dayton, Ohio

75378
CTS Knights Inc.
Sandwich, Illinois

75382
Kulka Electric Corp.
Mount Vernon, New York

75915
Littlefuse Inc.
Des Plaines, Illinois

76854
Oak Industries Inc.
Switch Div.
Crystal Lake, Illinois

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

77638
General Instrument Corp.
Rectifier Division
Brooklyn, New York

77969
Rubbercraft Corp. of CA. LTD.
Torrance, California

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

78277
Sigma Instruments, Inc.
South Braintree, Massachusetts

78488
Stackpole Carbon Co.
Saint Marys, Pennsylvania

78553
Eaton Corp. Engineered
Fastener Div.
Tinnerman Plant
Cleveland, Ohio

79136
Waldes Kohinoor Inc.
Long Island City, New York

79497
Western Rubber Company
Goshen, Indiana

79963
Zierick Mfg. Corp.
Mt. Kisko, New York

80031
Electro-Midland Corp.
Mepco Div.
A North American Phillips Co.
Norristown, New Jersey

80145
LFE Corp., Process Control Div.
formerly API Instrument Co.
Chesterland, Ohio

80183
Use 56289
Sprague Products
North Adams, Massachusetts

80294
Bourns Inc., Instrument Div.
Riverside, California

80583
Hammarlund Mfg. Co., Inc.
Red Bank, New Jersey

80640
Arnold Stevens, Inc
South Boston, Massachusetts

81073
Grayhill, Inc.
La Grange, Illinois

81312
Winchester Electronics
Div. of Litton Industries Inc.
Oakville, Connecticut

81483
Therm-O-Disc Inc.
Mansfield, Ohio

81483
International Rectifier Corp.
Los Angeles, California

81590
Korry Mfg. Co.
Seattle, Washington

81741
Chicago Lock Co.
Chicago, Illinois

82305
Palmer Electronics Corp.
South Gate, California

82389
Switchcraft Inc.
Chicago, Illinois

82415
North American Phillips
Controls Corp.
Frederick, Maryland

82872
Roanwell Corp.
New York, New York

82877
Rotron Inc.
Woodstock, New York

82879
ITT Royal Electric Div.
Pawtucket, Rhode Island

83003
Varo Inc.
Garland, Texas

83058
The Carr Co., United Can Div.
of TRW
Cambridge, Massachusetts

83298
Bendix Corp.
Electric Power Div.
Eatontown, New Jersey

83330
Herman H. Smith, Inc.
Brooklyn, New York

83478
Rubbercraft Corp.
of America, Inc.
West Haven, Connecticut

83594
Burroughs Corp.
Electronic Components Div.
Plainfield, New Jersey

83740
Union Carbide Corp.
Battery Products Div.
formerly Consumer Products Div.
New York, New York

84171
Arco Electronics
Great Neck, New York

84411
TRW Electronic Components
TRW Capacitors
Ogallala, Nebraska

84613
Fuse Indicator Corp.
Rockville, Maryland

84682
Essex International Inc.
Industrial Wire Div.
Peabody, Massachusetts

86577
Precision Metal Products
of Malden Inc.
Stoneham, Massachusetts

86684
Radio Corp. of America
Electronic Components Div.
Harrison, New Jersey

86928
Seastrom Mfg. Co., Inc.
Glendale, California

87034
Illuminated Products Inc.
Subsidiary of Oak Industries Inc.
Anahiem, California

88219
Gould Inc.
Industrial Div.
Trenton, New Jersey

88245
Litton Systems Inc.
Useco Div.
Van Nuys, California

88419
Cornell-Dubilier Electronic Div.
Federal Pacific Co.
Fuquay-Varian, North Carolina

88486
Plastic Wire & Cable
Jewitt City, Connecticut

88690
Replaced by 04217

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

89730
G.E. Co., Newark Lamp Works
Newark, New Jersey

90201
Mallory Capacitor Co.
Div. of P.R. Mallory Co., Inc.
Indianapolis, Indiana

90211
Use 56365
Square D Co.
Chicago, Illinois

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

90303
Mallory Battery Co.
Div. of Mallory Co., Inc.
Tarrytown, New York

91094
Essex International Inc.
Suglex/IWP Div.
Newmarket, New Hampshire

91293
Johanson Mfg. Co.
Boonton, New Jersey

91407
Replaced by 58474

91502
Associated Machine
Santa Clara, California

91506
Augat Inc
Attleboro, Massachusetts

91637
Dale Electronics Inc.
Columbus, Nebraska

91662
Elco Corp.
Willow Grove, Pennsylvania

91737
Use 71468
Gremar Mfg. Co., Inc.
ITT Cannon/Gremar
Santa Ana, California

91802
Industrial Devices, Inc.
Edgewater, New Jersey

91833
Keystone Electronics Corp
New York, New York

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

91929
Honeywell Inc.
Micro Switch Div
Freeport, Illinois

91934
Miller Electric Co., Inc.
Div. of Aunet
Woonsocket, Rhode Island

92194
Alpha Wire Corp.
Elizabeth, New Jersey

93332
Sylvania Electric Products
Semiconductor Products Div.
Woburn, Massachusetts

94145
Replaced by 49956

94154
Use 94988
Wagner Electric Corp.
Tung-Sol Div.
Newark, New Jersey

94222
Southco Inc. formerly
South Chester Corp.
Lester, Pennsylvania

95146
Alco Electronic Products Inc.
Lawrence, Massachusetts

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

95264
Replaced by 98278

95275
Vitramon Inc.
Bridgeport, Connecticut

95303
RCA Corp.
Receiving Tube Div
Cincinnati, Ohio

95348
Gordo's Corp.
Bloomfield, New Jersey

95354
Methode Mfg. Corp
Rolling Meadows, Illinois

95712
Bendix Corp.
Electrical Components Div.
Microwave Devices Plant
Franklin, Indiana

95987
Weckesser Co. Inc.
Chicago, Illinois

96733
San Fernando Electric Mfg. Co.
San Fernando, California

96853
Gulton Industries Inc.
Measurement and Controls Div.
formerly Rustrak Instruments Co.
Manchester, New Hampshire

96881
Thomson Industries, Inc.
Manhasset, New York

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

97913
Industrial Electronic
Hardware Corp.
New York, New York

97945
Penwall Corp.
SS White Industrial Products Div.
Piscataway, New Jersey

97966
Replaced by 11358

98094
Replaced by 49956

98159
Rubber-Teck, Inc.
Gardena, California

98278
Malco A Microdot Co., Inc.
Connector & Cable Div.
Pasadena, California

98291
Sealectro Corp.
Mamaroneck, New York

98388
Royal Industries
Products Div.
San Diego, California

98743
Replaced by 12749

98925
Replaced by 14433

99120
Plastic Capacitors, Inc.
Chicago, Illinois

99217
Bell Industries Elect.
Comp. Div.
formerly Southern Elect. Div
Burbank, California

99392
STM
Oakland, California

99515
ITT Jennings Monrovia Plant
Div. of ITT Jennings formerly
Marshall Industries Capacitor Div.
Monrovia, California

99779
Use 29587
Bunker-Ramo Corp.
Barnes Div.
Landsdowne, Pennsylvania

99800
American Precision Industries Inc.
Delevan Division
East Aurora, New York

99942
Centrelab Semiconductor
Centrelab Electronics Div. of
Globe-Union Inc.
El Monte, California

Toyo Electronics
(R-Ohm Corp.)
Irvine, California

National Connector
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Dacca 3, Bangladesh
Tel 257249 or 255776

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Fluke (Belgium) S A /N V
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Tel 26680

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Manuel Montt 024 - Of D
Casilla 16228, Santiago 9, Chile
Tel 44940, TLX 240301
Attn Intronica Chile

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Bogota DE, Colombia SA
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Edificio "Jerico"
Ave 12 de Octubre #2285 y
Ave Orellana (Planta Baja)
Quito, Ecuador
Tel 529684, TLX (393) 2865

Proteco Coasin Cia, Ltda
Calderon 103 y Malecon
Casilla #9733
Guayaquil, Ecuador
Tel 526093

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Tel 312079, TLX FJ2347

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B P No 31
78530 BUC, France
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Rapifax (089) 9605166

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Schmidt & Co (H K) Ltd
28th Fl Wing on Centre
111 Connaught Road
Central Hong Kong
Tel 5-455644
TLX 74766

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P O Box 906
Reykjavik, Iceland
Tel 24120, TLX 2133

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33/44-A Raj Mahl Vilas Extension
Bangalore 560 080, India
Tel 33139, TLX (953) 0845741

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Shantiniketan, Office No 6
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Tel 434032 447541

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98 Nehru Place
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Tel 640380, TLX (95) 314890

Hinditron Services Pvt Ltd
Srinath Complex, 5th Floor
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Sarojini Devi Road
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Tel 821117, TLX (953) 0155 575

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P T Dwi Tunggal Jaya Sakti
Kebayoran Baru
Jakarta Selatan, Indonesia
Tel 716374, TLX 45305

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Naven County Meath, Ireland
Tel (46) 23577, TLX (851) 3182

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R D T Electronics Engineering Ltd
P O Box 75
46, Sokolov Street
Ramat Hasharon 47235, Israel
Tel (3) 483216, TLX (922) 32143

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Via Pelizza da Volpedo 59
20092 Cinisello Balsamo
Milan, Italy
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00143 Rome, Italy
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Sistrel S p A
Via Cinto
Parco S Paolo
80126 Naples, Italy
Tel (81) 7679700

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Shinbashi Bldg.
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Tel (03) 434-0181, TLX 2424331

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Nairobi, Kenya, East Africa
Tel 331955, TLX 22639

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C P O Box 8446
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Jung-ku
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Beirut, Lebanon
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PDR Yemen ■
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Karakoy Istanbul, Turkey
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TLX (821) 23353

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Tel: (02) 736-2888
TLX: (790) 25887

Australia, Mount Waverley
Elmeasco Instruments Pty Ltd
Tel: 03-233-4044
TLX: 36206

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Elmeasco Instruments Pty Ltd.
Tel: (07) 229-3161

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TLX: 01135589 FLKE BR

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Allan Crawford Associates Ltd
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Chile, Santiago
Intronica Chile Ltda
Tel: 44940
TLX: 240301

China, Beijing
Beijing Radio Research Institute
Tel: 445612

Colombia, Bogota
Sistemas E Instrumentacion, Ltda.
Tel: 232-45-32
TLX: 45787 COASN CO

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Tage Olsen A/S
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TLX: 35293 TOAS SK

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Edificio "Jerico"
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TLX: 2865 Protec Ed

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Hinditron Services Pvt. Ltd.
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TLX: 031 4890 SRMP IN

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Spark Radio & Electronics Corp
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TLX: 54318

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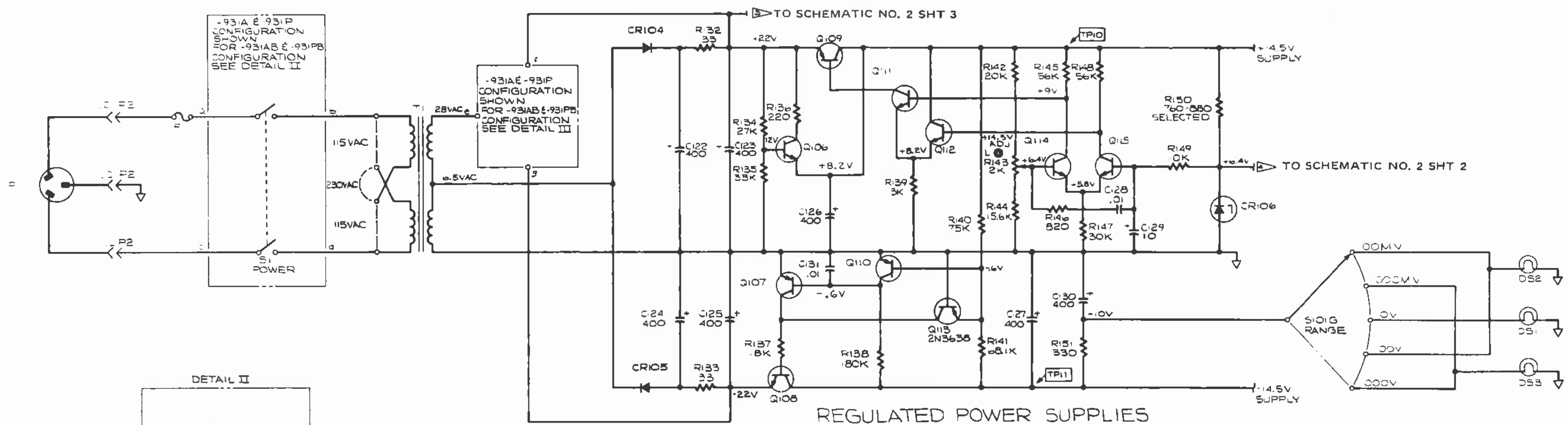
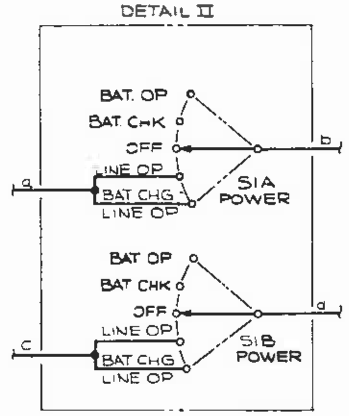
Litho in U.S.A. 1/83

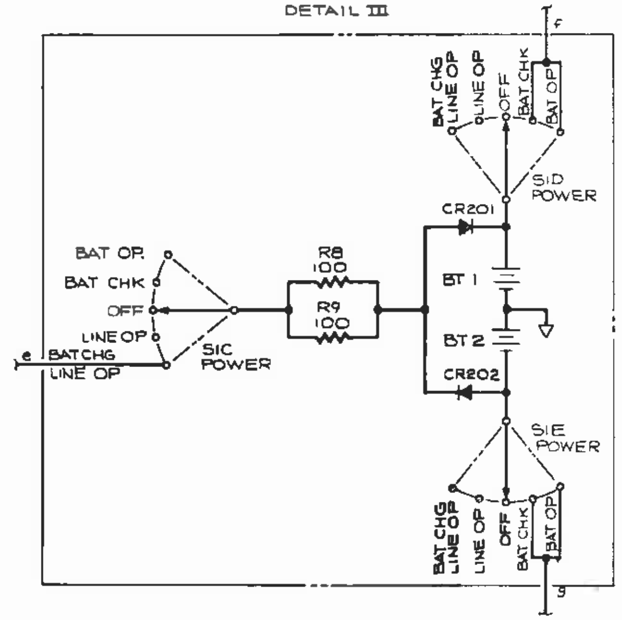


REGULATED POWER SUPPLIES

DETAIL II



DETAIL III



NOTES:

1. UNLESS OTHERWISE NOTED, RESISTANCES ARE IN OHMS AND ALL CAPACITANCES 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

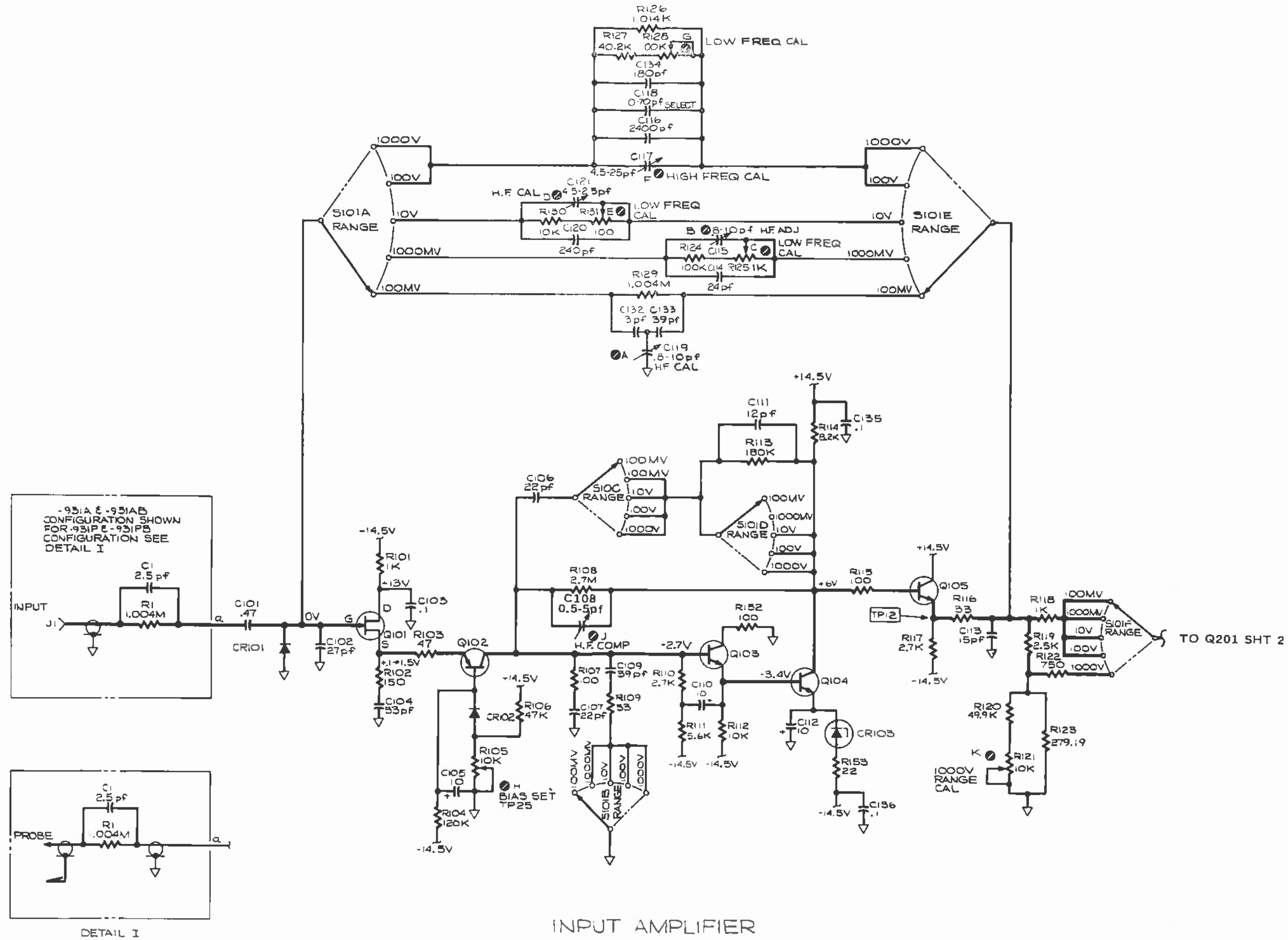
FUNCTIONAL SCHEMATIC DIAGRAM

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

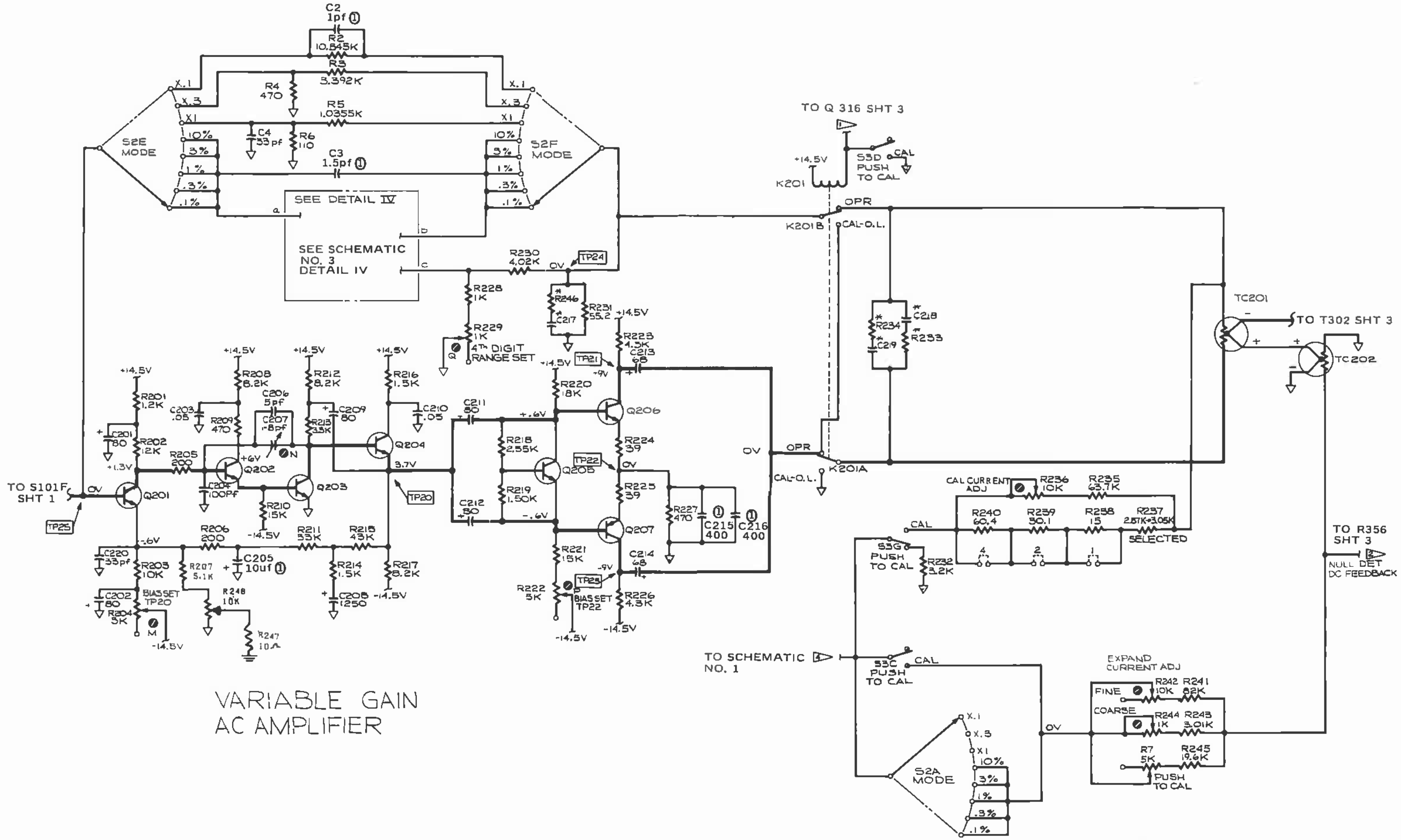
FUNCTIONAL SCHEMATIC DIAGRAM

MODEL 931B
RMS DIFFERENTIAL VOLTMETER

SCHEMATIC NO 2
SHT 1

REV b

FLUKE JOHN FLUKE MFG CO., INC



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

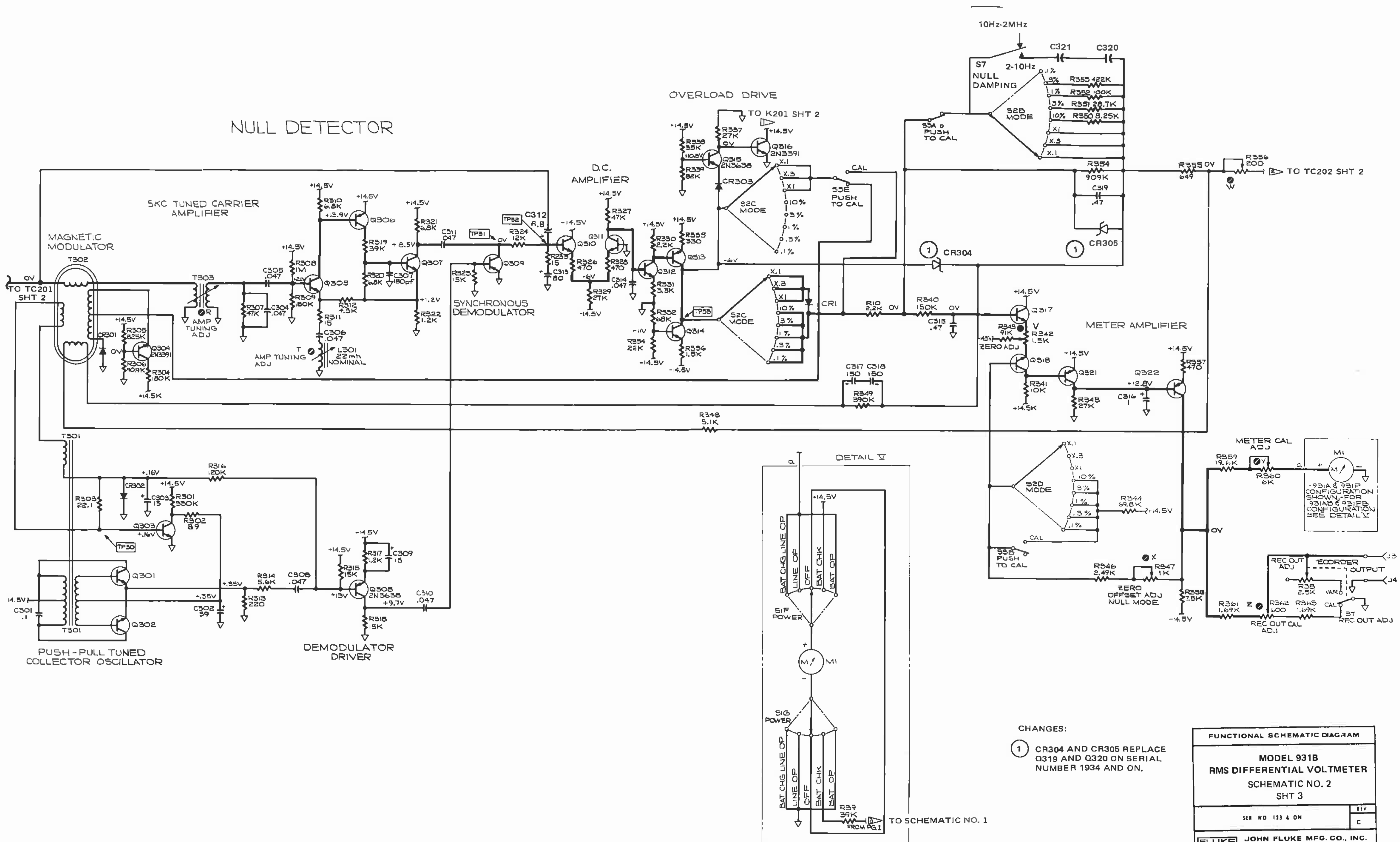
FUNCTIONAL SCHEMATIC DIAGRAM

MODEL 931B
RMS DIFFERENTIAL VOLTMETER

SCHEMATIC NO.2
SHT 2

SER NO 133 & ON | REV C

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



CHANGES:

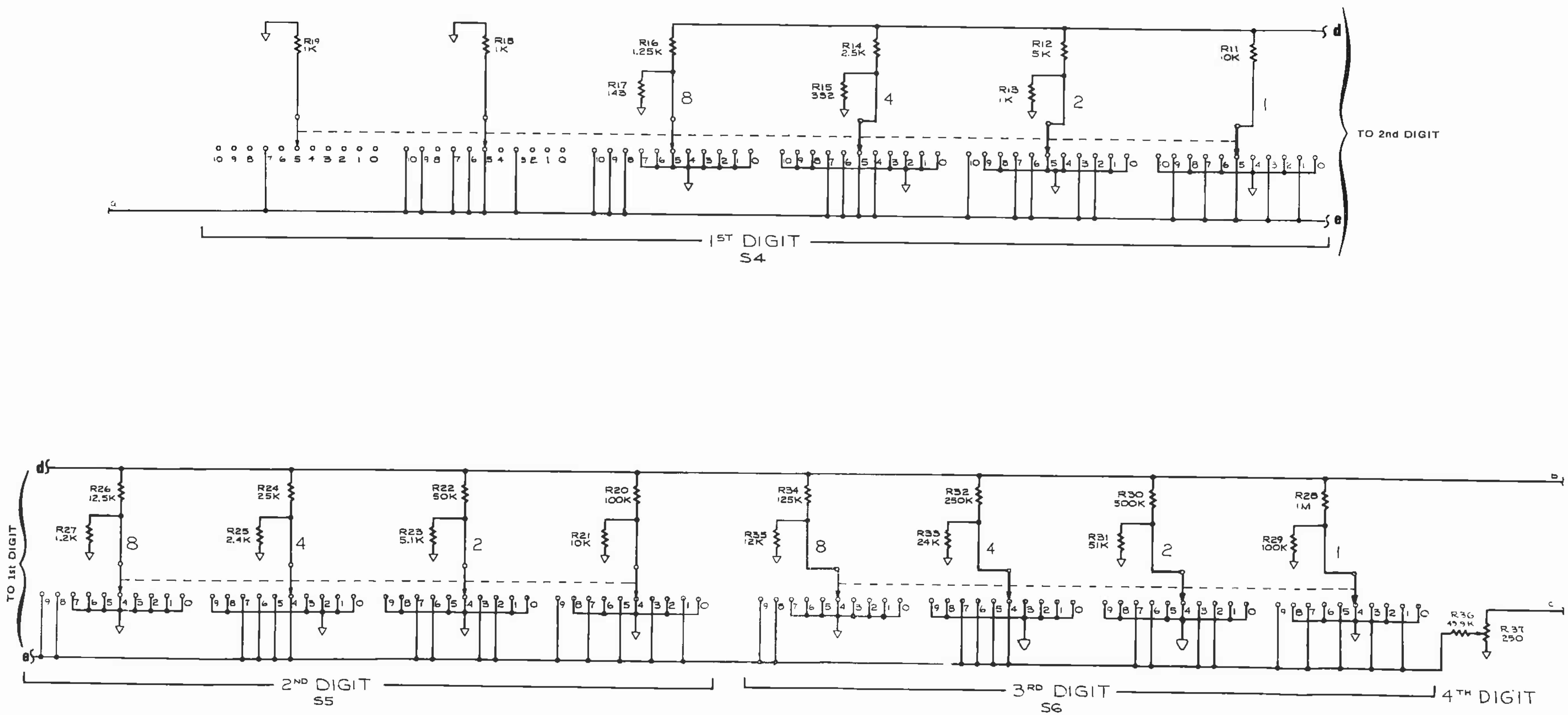
(1) CR304 AND CR305 REPLACE Q319 AND Q320 ON SERIAL NUMBER 1934 AND ON.

FUNCTIONAL SCHEMATIC DIAGRAM

MODEL 931B
RMS DIFFERENTIAL VOLTMETER
SCHEMATIC NO. 2
SHT 3

SER NO 133 & 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

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