INSTRUCTION MANUAL

MODEL 1920

TRMS OPTION

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SECTION 1. GENERAL INFORMATION

1-1. INTRODUCTION

1-2. The Keithley Model 1920 is a True Root Mean Square (TRMS) AC plug-in option for the Models 192 and 191. The 1920 enables the 191 or 192 to measure the TRMS value of an AC signal. When the 1920 is installed in the Model 192 an AC+DC function is available. The Model 1920 has four ranges on which an AC signal can be measured. It is field installable.

1-3. Warranty Information

1-4. The warranty is given on the inside front cover of this manual. If there is a need to exercise the Warranty, contact the Keithley Representative in your area to determine the proper action to be taken. Keithley maintains complete repair and calibration facilities in the United States, West Germany, Great Britain, France, the Netherlands, Switzerland and Austria. Information concerning the application, operation or service of your instrument may be directed to the applications engineer at any of the above locations. *Check the inside front cover of this manual for addresses.*

1-5. Manual Addendums

1-6. Improvements or changes to the instrument that occur after printing of the manual will be explained on an addendum which will be attached to the inside back cover.

1-7. Safety Symbols and Terms

1-8. The symbol  on the instrument denotes that the user should refer to the operating instructions.

The symbol  on the instrument denotes that up to 500V may be present on the terminals.

The **WARNING** used in this manual explains dangers that could result in personal injury or death.

The **CAUTION** used in this manual explains hazards that could damage the instrument.

1-9. Specifications

1-10. Detailed specifications for the Model 1920 are given in Table 1-1.

TABLE 1-1
1920 Specifications

5-1/2 Digit Accuracy, +(% Rdg + Counts), 1 yr 18-28°C

Range	5-1/2 Digit RESOLUTION	20-50Hz*	DC, 50Hz-10kHz*	10K-20kHz*	20kHz-100kHz**
2V	10μV	1% + 100	0.25% + 100	0.35% + 300	1% + 500
20V	100μV	1% + 100	0.25% + 100	0.35% + 300	1% + 500
200V	1mV	1% + 100	0.25% + 100	0.35% + 300	1% + 500
700V	10mV	1% + 100	0.35% + 100	0.5% + 300	1% + 500

RESPONSE:	TRUE RMS
CREST FACTOR	3
AC + DC MODE:	Add 60 counts to specified accuracy (not available in Model 191)
MAXIMUM INPUT:	1000V Peak AC + DC, 2×10^7 V• Hz
SETTLING TIME:	0.5 sec to within 0.1% of change in reading
INPUT IMPEDANCE:	2M ohm shunted by less than 50pF.
TEMP. COEFFICIENT:	(0°-18°C and 28°-50°C): Less than 0.1 x applicable accuracy specification per °C below 50kHz; 0.2 x for 50kHz to 100kHz
3dB BANDWIDTH:	500kHz Typical
CMRR:	Greater than 60dB at 50 and 60Hz (1k ohm unbalanced)

* Above 2000 counts
** Above 20000 counts; 3% + 500 typical below 20000

SECTION 2. OPERATING INSTRUCTIONS

2-1. Operating Instructions for the Model 1920 installed in the Model 191 are as follows:

2-2. With the Model 1920 option, the Model 191 reads AC voltages from 10 microvolts/digit to 1000V. The instrument displays the True Root Mean Square (TRMS) value of an AC voltage. It has a frequency response of 20Hz to 100kHz.

2-3. The maximum reading is 199999. Overrange is indicated by (-) 1_ _ _ _ _, except on the 1000 volt range. The 700 volt range is selected with the 1000 volt button. On the 700 volt range, the display can read beyond the maximum allowable input voltage. Maximum allowable input: 1000V Peak AC + DC; 2×10^7 V•Hz. Use the Model 191 to measure AC voltage as follows:

CAUTION

Do not exceed maximum allowable input voltage. Instrument damage may occur.

A. Turn the power on with the ON/OFF pushbutton, and depress the ACV pushbutton.

B. Select the desired range from the 4 ranges available. The decimal point is positioned by the range pushbutton.

C. Ensure that the NULL pushbutton is out (light off) unless measurements are to be made as deviations from a preset value.

NOTE

Do not use NULL to zero the range. A small residual zero reading is normal. If NULL is used to zero this offset, readings in specified accuracy range will be low by the offset amount. This is because rms measurement signals add in a root mean square fashion and not linearly. The NULL function is a linear offset and not usable in TRMS measurements.

D. Connect the signal to be measured between the INPUT HI and LO binding posts. The binding posts accept wires, spade lugs or banana plugs for ease of connecting the circuit to be measured. Observe the displayed digits and decimal point.

E. For specified accuracy (pulse widths ≥10μs, peak voltage ≤1.5 x full scale) Figure 2-1 shows the allowable input signal vs. crest factor. The figure illustrates that for a crest factor of three the displayed reading must be less than 100,000 counts (1V on the 2V range). So long as the maximum input is not exceeded no damage will result in crest factors exceeding that shown in Figure 2-1, but accuracy will slowly degrade (For CF >3 but ≤10 typical accuracy is degraded by (CF-3) x 0.36% and peak signal must be less than 5 x full scale for that range).

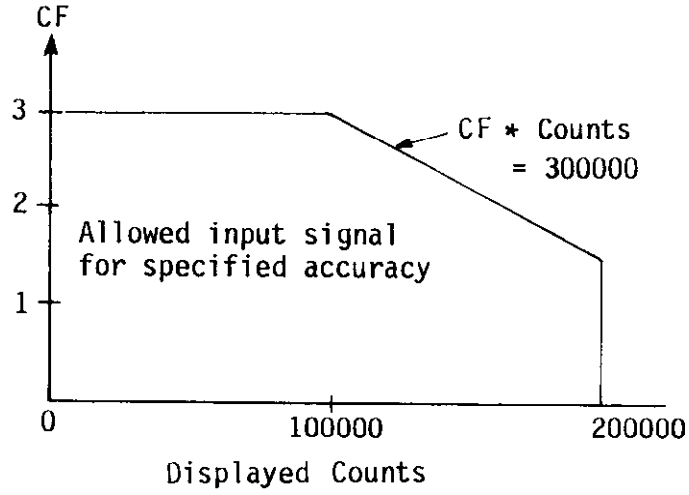


Figure 2-1. Crest Factor vs. Displayed Counts

2-4. Operating Instructions for the Model 1920 installed in the Model 192 are as follows:

2-5. With the Model 1920 option, the Model 192 reads AC voltages from 1 microvolt/digit to 1000V. The instrument displays the True Root Mean Square (TRMS) value of an AC voltage signal.

2-6. The maximum reading is 199999. Overrange is indicated by OFLO. Maximum allowable input is 1000V Peak AC + DC; 2 x 10^7V•Hz. Use the Model 192 to measure AC or AC + DC voltages as follows:

CAUTION

Do not exceed maximum allowable input voltage. Instrument damage may occur.

A. TURN POWER ON with ON/OFF pushbutton.

B. Press the ACV button once to select the ACV (TRMS) function. Press the ACV button again and the 192 will measure the TRMS value of an AC + DC signal (AC signal superimposed with a DC level). The ACV and DCV LEDs will light simultaneously when the AC + DC function is enabled. Pressing the ACV button again will return the 192 to the ACV function. Pressing the DC button while in AC + DC returns the 192 the DCV function.

NOTE

The Model 192 will display "NO AC" if ACV is selected without the 1920 or 1910 ACV option. The AC + DC function is available only with C-4 and above software and Rev D and above Analog Board.

C. SELECT RANGE from the four ranges available. The decimal point is positioned by the range pushbutton. The 1000V range is selected with the 2000 button. If the 20MΩ button is inadvertently pressed when in ACV function, the 192 will set the range to 1000.

D. ZERO OFF unless measurements are to be made as deviations from a preset value.

NOTE

Do not use ZERO to zero the range. A small residual zero reading is normal. If ZERO is used, the residual voltage reading in specified accuracy range will be low by the amplitude of the zeroed residual voltage. This is because rms measurement signals add in a root mean square fashion and NOT linearly. THe ZERO function is a linear offset and not usable in TRMS measurements.

E. CONNECT INPUT to be measured between the HI ACV and LO binding posts.

F. TAKE READING.

G. For specified accuracy (pulse widths $\geq$10μs, peak voltage $\leq$1.5 x full scale) Figure 2-1 shows the allowable input signal vs. crest factor. The figure illustrates that for a crest factor of three the displayed reading must be less than 100,000 counts (1V on the 2V range). So long as the maximum input is not exceeded no damage will result in crest factors exceeding that shown in Figure 2-1, but accuracy will slowly degrade (For CF >3 but $\leq$10 typical accuracy is degraded by (CF-3) x 0.36% and peak signal must be less than 5 x full scale for that range).

SECTION 3. MAINTENANCE

3-1. The Model 1920 is a plug-in option that can be installed in your Model 191 or 192. Installation of the 1920 into your instrument is as follows.

WARNING

All service information is intended for qualified electronic maintenance personnel only.

3-2. INSTALLATION: (For use with Model 191)

A. Disconnect the line power cord of the Model 191 and remove all test leads from its input terminals for safety.

B. Turn the DMM bottom side up and loosen the four screws in the bottom cover.

C. Hold the top and bottom cover together to prevent their separation and turn the DMM over to the normal position. Remove the top cover.

D. Remove the RF shield by grasping it and FIRMLY lifting it away from the motherboard.

E. Carefully insert the connector of the 1920 into its mating receptacle on the 191 motherboard. Take note of the orientation of the 1920 into the 191 motherboard as shown in the figure below. Connect the brown wire of the 1920 to Pin 7 of the DCV switch, and connect the blue wire to Pin 9 of the ACV switch.

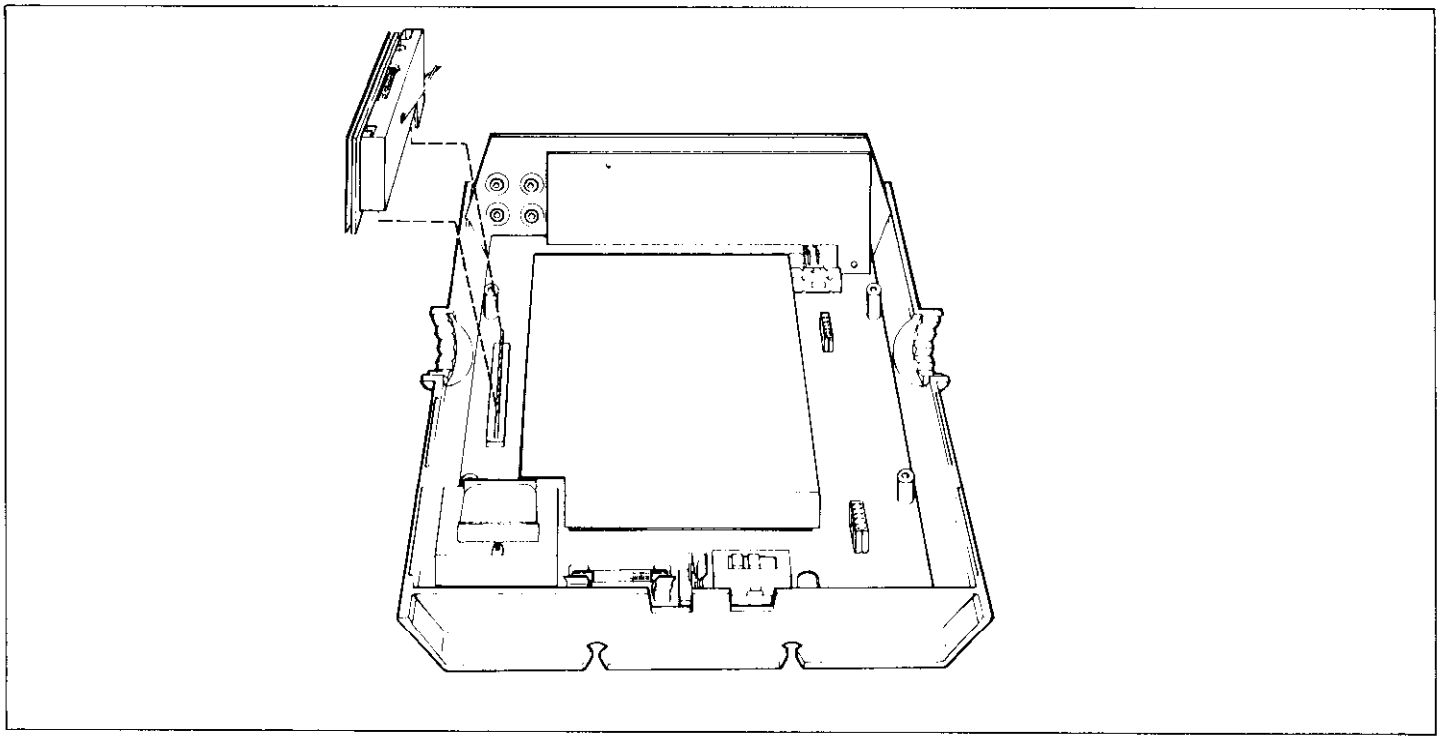
F. Replace the RF shield being careful not to pinch any wires.

G. Calibrate the 1920 per the procedure located on Table 3-5.

H. Replace the top cover.

NOTE

Pin locations for the switches are shown on the decal on top of the RF shield.



WARNING

All service information is intended for qualified electronic maintenance personnel only.

3-3. INSTALLATION: (For use with Model 192)

A. Disconnect the line power cord of the Model 192 and remove all test leads from its input terminals for safety.

B. Remove two screws that hold the top cover to the rear panel and remove the cover.

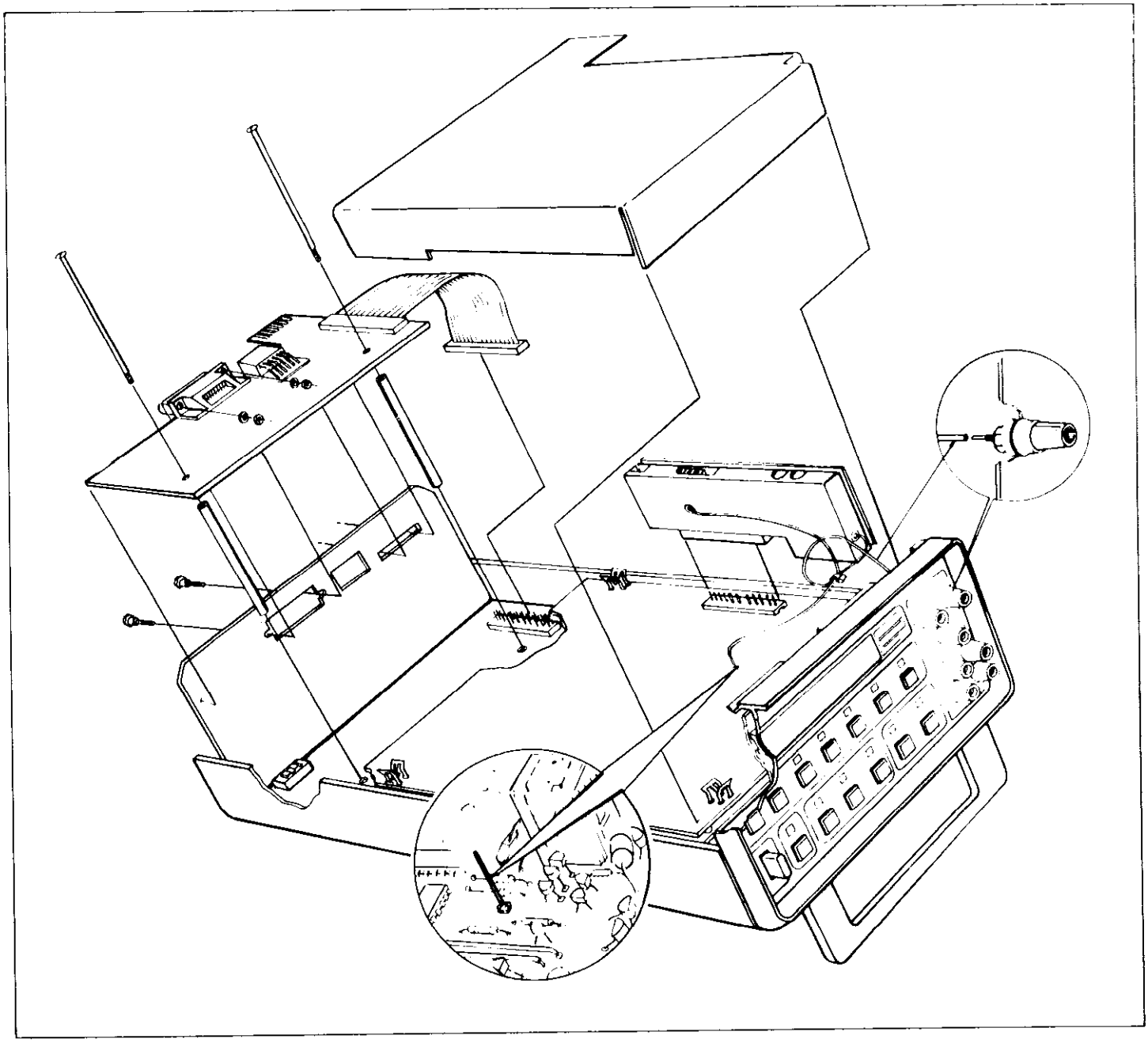
C. Remove the top shield from the Analog Board by grasping it and FIRMLY lifting it off, with a prying motion of the four retaining clips.

D. Carefully insert the connector of the 1920 into its mating receptacle on the Analog Board. Take note of the orientation of the 1920 onto the 192 Analog Board as shown in the figure below.

E. Connect the brown wire of the 1920 to P1014 on the Analog Board as shown in the figure below. Connect the blue wire to P1016 which is located on the ACV HI input terminal. This is also shown in the figure below.

F. Replace the shield to the Analog Board being careful not to pinch any wires when engaging the shield into the retaining clips.

G. Calibrate the 1920 per the procedure located on Table 3-4.



3-4. PERFORMANCE VERIFICATION

3-5. Performance verification may be performed upon receipt of the instrument to ensure that no damage or misadjustment has occurred during transit.

NOTE

For instruments that are still under warranty (less than 12 months since date of shipment), if the instrument's performance falls outside specifications at any point, contact your Keithley representative or the factory immediately.

3-6. RECOMMENDED TEST EQUIPMENT

3-7. Recommended test equipment for performance verification is listed in Table 3-1. Alternate test equipment may be used. However, if the accuracy of the alternate test equipment is not at least 4 times better than the instrument specifications, additional allowance must be made in the readings obtained.

TABLE 3-1
Recommended Test Equipment For Performance Verification

ITEM	DESCRIPTION	SPECIFICATION	MFR.	MODEL
A	AC Calibrator	0.1V, 1V, 10V, 100V ±0.022%	H-P	745A
B	High Voltage Amplifier (Used with Model 745A)	1000V ±0.04%	H-P	746A
C	DC Calibrator	1V ±0.002%	Fluke	343A

3-7. ENVIRONMENTAL CONDITIONS

3-8. All measurements should be made at an ambient temperature within the range of 18° to 28°C (65° to 82°F), and a relative humidity of less than 80%.

3-9. PERFORMANCE VERIFICATION PROCEDURE

3-10. Use the following procedure to verify the basic accuracy for AC voltage in the Model 191 or the Model 192.

WARNING

Performance verification should be performed by qualified personnel using accurate and reliable test equipment.

3-11. INITIAL CONDITIONS

3-12. Before beginning the verification procedure, the instrument must meet the following conditions:

A. If the instrument has been subject to extremes of temperature, allow sufficient time for internal temperatures to reach environmental conditions specified (18°-28°C). Typically, it takes one hour to stabilize a unit that is 10°C (18°F) out of the specified temperature range.

B. Turn on the instrument and allow it to warm up for two hours before using it with the Model 192 and one hour before using it with the Model 191.

WARNING

Some procedures require the use of high voltage. Take care to prevent contact with live circuits which could cause electrical shock resulting in injury or death.

Performance Verification

RANGE	APPLIED INPUT AT 1kHz	ALLOWABLE READINGS For 191	For 192
2V	1.00000V	.99650V to 1.00350V	.99650V to 1.00350V
20V	10.0000V	9.9650V to 10.0350V	9.9650V to 10.0350V
200V	100.000V	99.650V to 100.350V	99.650V to 100.350V
700V	700.00V	696.55V to 703.45V	696.55V to 703.45V
	AT 20kHz		
2V	1.00000V	.99350V to 1.00650V	.99350V to 1.00650V
20V	10.0000V	9.9350V to 10.0650V	9.9350V to 10.0650V
200V	100.000V	99.350V to 100.650V	99.350V to 100.650V
	AT 100kHz		
2V	1.00000V	.98500V to 1.01500V	.98500V to 1.01500V
20V	10.0000V	9.8500V to 10.1500V	9.8500V to 10.1500V
200V	100.000V	98.500V to 101.500V	98.500V to 101.500V
	AT 30kHz		
700V	700.00V	688.00V to 712.00V	688.00V to 712.00V
	AT 20Hz		
20V	10.0000V	9.8900V to 10.1100V	9.8900V to 10.1100V
	AT 50Hz		
20V	10.0000V	9.8900V to 10.1100V	9.8900V to 10.1100V
	AC + DC Mode		
2V	+1.00000V DC		.99590V to 1.00410V
2V	-1.00000V DC		-.99590V to -1.00410

3-13. CALIBRATION

3-14. This section contains information necessary to calibrate the Model 1920 in your instrument (191 or 192). Calibration should be performed when any of the following conditions occur:

A. Annually
B. Installation of the 1920
C. Performance Verification indicates 1920 as out of specification

3-15. RECOMMENDED TEST EQUIPMENT

3-16. Recommended test equipment for calibration is listed in the following table. Alternate equipment may be used. However, the accuracy of the alternate equipment must be at least 4 times better than the Model 1920 specifications, or equal to the specifications listed in the Table below.

TABLE 3-3
Recommended Test Equipment For Calibration

ITEM	DESCRIPTION	SPECIFICATION	MFR.	MODEL
A	DC Calibrator	+1V ±.002%	Fluke	343A
B	AC Calibrator	0.1V, 1V, 10V, 100V ±0.022%	H-P	745A
C	High Voltage Amplifier (Used with Model 745A)	1000V ±0.04%	H-P	746A
D	Calibration Cover	--	Keithley	1913 (191)

3-17. ENVIRONMENTAL CONDITIONS

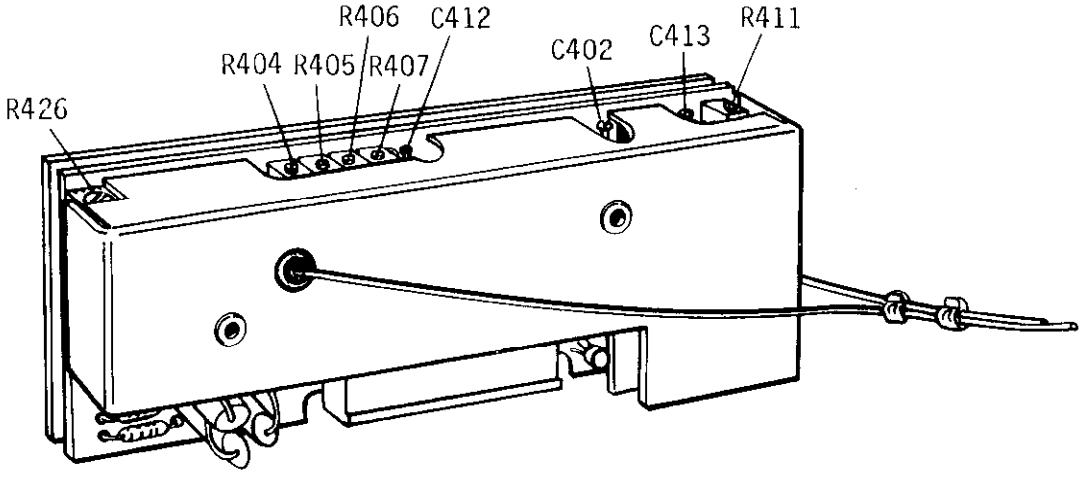
3-18. Calibration should be performed under laboratory conditions having an ambient temperature of 23 ±1°C, and a relative humidity of less than 70%. If the instrument has been subjected to temperatures outside of this range, or the higher humidity, allow two hours minimum for the instrument to stabilize at the specified environmental conditions before beginning the calibration procedure.

3-19. CALIBRATION PROCEDURE

3-20. Remove the top cover of your instrument and replace it with the appropriate calibration cover. With the calibration cover in place allow the internal temperature of the instrument to stabilize for two hours before performing the calibration.

WARNING

Some procedures require the use of high voltage. Take care to prevent contact with live circuits which could cause electrical shock resulting in injury or death.



Model 1920 Calibration Adjustments

TABLE 3-4
Model 1920 Installed in the 192
Calibration Procedure

STEP	RANGE	FUNCTION	APPLIED INPUT	ADJUSTMENT	READING
1	2	ACV + DCV	1.00000V DC	*Calibrator	1.00000 ±10 counts
2	2	ACV + DCV	-1.00000V DC	*R411	1.00000 ±20 counts
* ADJUSTMENT: Adjust the DC calibrator until the display reads 1.00000 ±10 digits. Reverse the leads and take note of the reading. Adjust R411 to 1/2 the difference (Example: Reading is 1.00400, adjust R411 to read 1.00200).					
3	Repeat Steps 1 and 2 until there is < 10 digits change in reading from + to -.				
4	2	ACV	1.00000V AC at 500Hz	R407	1.00000 ±10 counts
5	2	ACV	.10000V AC	R426	.10000 ±10 counts
6	Repeat Steps 4 and 5 until they are within tolerance.				

TABLE 3-4
Model 1920 Installed in the 192
Calibration Procedure (cont.)

STEP	RANGE	FUNCTION	APPLIED INPUT	ADJUSTMENT	READING
7	20	ACV	10.0000V AC at 500Hz	R406	10.0000 ±10 counts
8	200	ACV	100.000V AC at 500Hz	R405	100.000 ±10 counts
9	2000 (700V AC Max)	ACV	500.00V AC	R404	500.00 ±10 counts
10	200	ACV	100.000V AC at 100kHz	C413 Caution: Use an insulated alignment tool	100.00 ±250 counts
11	2	ACV	1.00000V AC at 100kHz	C402	1.0000 ±50 counts
12	20	ACV	10.0000V AC at 100kHz	C407	10.0000 ±100 counts
13	Repeat Steps 10-12 until no change.				
14	Repeat Steps 1-12 to verify the readings.				

NOTE

High frequency (100kHz) measurements are sensitive to component location. Do not move or bend the components in the input area (C401, R403, etc.) Recalibration is necessary if these components are moved. If the 100V 100kHz cannot be brought into specification, refer to the troubleshooting section.

WARNING

Some procedures require the use of high voltage. Use an insulated alignment tool. Take care to prevent contact with live circuits which could cause electrical shock resulting in injury or death.

TABLE 3-5
Model 1920 Installed in the 191
Calibration Procedure

STEP	RANGE	FUNCTION	APPLIED INPUT	ADJUSTMENT	READING
1	2	ACV	100mV AC at 500Hz	R411	Minimum Reading
2	2	ACV	10mV AC at 500Hz	R411	Minimum Reading
3	2	ACV	1.00000V AC at 500Hz	R407	1.00000 ±10 counts
4	2	ACV	.10000V AC at 500Hz	R426	.10000 ±10 counts
5	Repeat Steps 3 and 4 until they are within specification.				
6	20	ACV	10.0000V AC at 500Hz	R406	10.0000 ±10 counts
7	200	ACV	100.000V AC at 500Hz	R405	100.000 ±10 counts
8	2000 (700, AC Max)	ACV	500.00V AC	R404	500.00 ±10 counts
9	200	ACV	100.000V AC at 100kHz	C413 Caution: Use an insulated alignment tool.	100.00 ±250 counts
10	2	ACV	1.00000V AC at 100kHz	C402	1.0000 ±50 counts
11	20	ACV	10.0000V AC at 100kHz	C407	10.0000 ±100 counts
12	Repeat Steps 9 thru 11 until no change.				
13	Repeat Steps 1 thru 11 to verify the readings.				

NOTE

High frequency (100kHz) measurements are sensitive to component location. Do not move or bend the components in the input area (C401, R403, etc.) Recalibration is necessary if these components are moved. If the 100V 100kHz cannot be brought into specification, refer to the troubleshooting section.

3-22. Troubleshooting

3-23. The troubleshooting instructions contained in this section are intended for qualified personnel having a basic understanding of analog and digital electronic principles and components used in precision electronic test equipment. Instructions have been written to assist in isolating the defective circuit or subcircuit. Isolation of the specific defective component has been left to the technician.

NOTE

For 1920's that are still under warranty (less than 12 months since date of shipment), if the 1920's performance is outside of specifications at any point, contact your Keithley representative or the factory before attempting troubleshooting or repair.

3-24. Troubleshooting Procedure

3-25. Table lists step by step checks of the major circuit blocks of the 1920. Follow Table 3-6 to locate the trouble.

NOTE

Performance Verification of the Model 1920 is necessary if any of the following occurs.

1) Removal/replacement of 1920
2) Removal/replacement of shields on the 1920

WARNING

Some procedures require the use of High Voltage. Take care to prevent contact with live circuits which could cause electrical shock resulting in injury or death.

TABLE 3-6
Model 1920 Troubleshooting (cont.)

STEP	ITEM/COMPONENT	REQUIRED CONDITION	REMARKS
1		Turn on Power. Select the AC function and 2V range.	
2	J1006, Pin 1	+5V <100mV AC noise	+5V supply
3	U401, Pin 7	+15V ±1V DC <100mV AC noise	+15V supply
4	U401, Pin 4	-15V ±1V DC <100mV AC noise	-15V supply
5		Apply 1 volt at 1kHZ	
6	U403, Pin 8 (Brown wire J1008)	1 volt DC	1920 Output
7	U401, Pin 6	1 volt AC at 1kHZ, no DC offset	U401 Output
8	Q408, Pins 2 and 5	+3V to +8V DC, within 10mV of each other	Differential Output of Q408
9	Q408, Pin 3	0V ± 25mV	Input summing junction

TABLE 3-6
Model 1920 Troubleshooting (cont.)

STEP	ITEM/COMPONENT	REQUIRED CONDITION	REMARKS
			(virtual ground)
10		Select 20V range and apply 10V AC at 1kHZ	If display overranges check Q406 and Q407 for gate drive and signal
11		Select 200V range and apply 100 V AC at 1kHZ	If display overranges check Q404 and Q405 for gate drive and signal
12		Select 700V range and apply 350V AC at 1kHZ	If display overranges check Q402 and Q403 for gate drive and signal
13		Select AC + DC function and the 2V range. Apply 1V DC	Check display for 1V if not, check Q401 and K401
14		Select AC apply 1V DC	Display approx. 0V if not, check Q401 K401, C401

NOTE

If the 100V 100kHz adjustment cannot be brought into specification, check the spacing between C401 and R403. If these components have been bent toward or away from each other, C413 may not have adequate calibration range. Moving C401 and R403 closer together increases the 100kHz response on all ranges. Check and adjust, if necessary.

SECTION 4. MODEL 1920 THEORY OF OPERATION

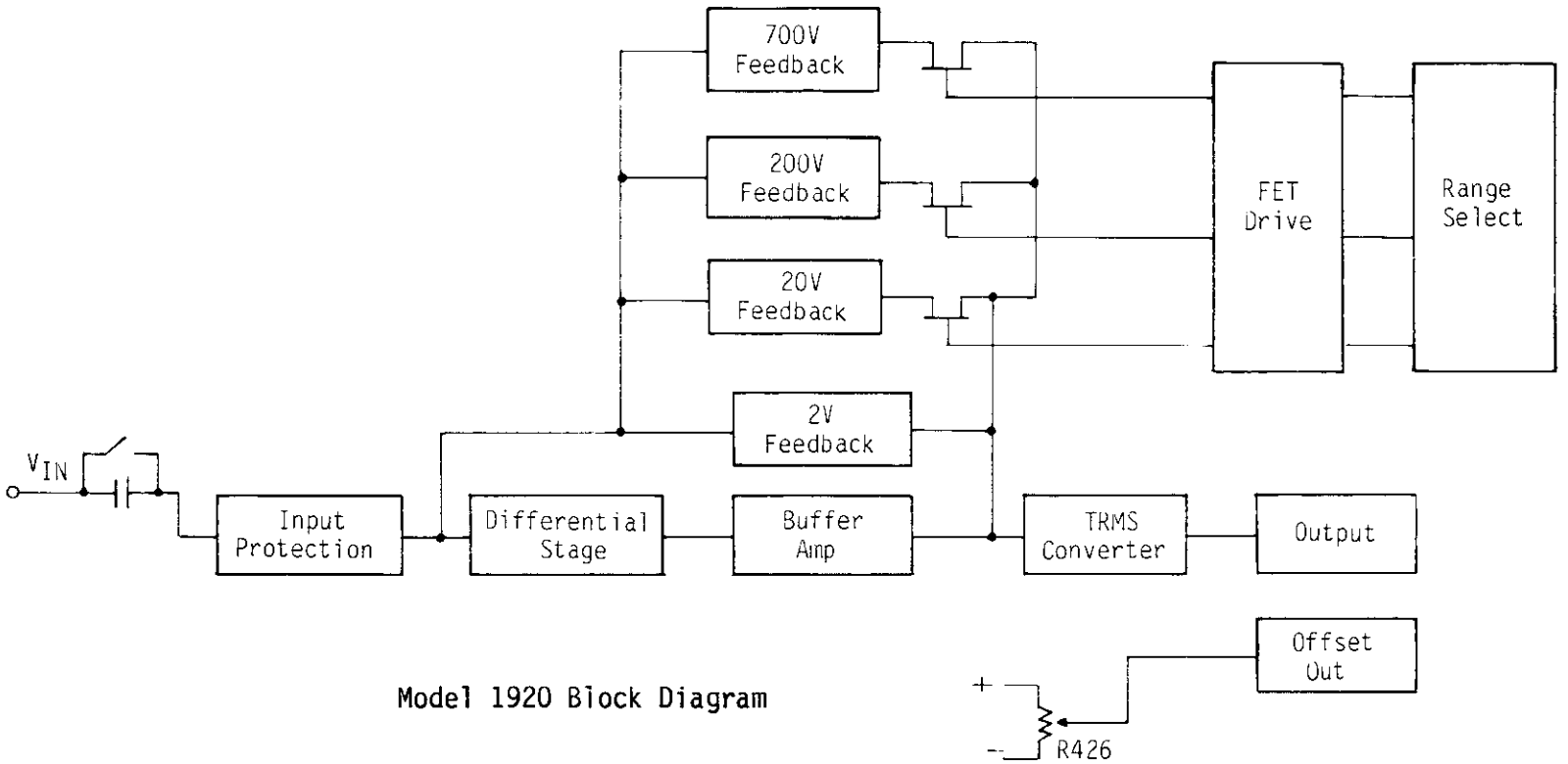
4-1. The Model 1920 is a plug in AC(+DC) to RMS converter with variable gain. The gain factor conditions the AC input voltage for application to the A/D converter.

4-2. The input signal is applied through C_{IN} (0.05μF) and R_{IN} (2MΩ) to Q408. For AC+DC operation C_{IN} is shorted by Relay K401. The two stage amplifier (op amp) is a variable gain inverting type with gain from-0.001 to-1 (see table below). The gain is selected accordingly by the double FET switches Q402-Q407. Two FETs are used for each range. They are configured in a T-type attenuator with the 10k resistors R413, R414 and R416 to effectively attenuate high frequency (100kHz) signals.

4-3. The op amp is a two stage amplifier. The first stage is configured around dual FET Q408. Q408 allows the reduction of input bias current. This reduction is necessary because an auto zero cycle is not possible on the AC or AC+DC functions. Any input bias current will show up as an input offset voltage. The second stage is configured around U401. The output of U401 is applied to the RMS converter U403. C409, C410 and R420 make up the two pole filter that is located at the output of U403. The output of U403 is a DC signal which is applied to the A/D converter. A small DC offset may be applied to the auto zero A/D input by adjusting R426. This allows compensation for the RMS converter's output offset.

TABLE 4-1
Ranging Information

Range	Gain	OP Amp Feedback Resistance	Engergized FETs
2V	1	2M	None
20V	1/10	(217k + R406) || 2M	Q406, Q407
200V	1/100	(19.6k + R405)|| 2M	Q404, Q405
700V	1/1000	(2.12k + R404)|| (19.6K + R405)|| 2M	Q402, Q403, Q404, Q405



Model 1920 Block Diagram

SECTION 5. REPLACEABLE PARTS

5-1. General

5-2. This section contains information for ordering replacement parts. The replaceable parts list is arranged in alphabetical order of the circuit designations of the components. A cross reference list of manufacturers containing their addresses is given in Table 5-1.

5-3. Ordering Information

5-4. To place an order or to obtain information concerning replacement parts contact your Keithley representative or the factory. See the inside front cover for addresses. When ordering, include the following information:

a. Instrument Model Number
b. Instrument Serial Number
c. Part Description
d. Circuit Designation (if applicable)
e. Keithley Part Number

5-5. Factory Service

5-6. If the instrument is to be returned to the factory for service, please complete the Service Form which follows this section and return it with the instrument.

5-7. Schematic and Component Layout

5-8. The Schematic and Component Layout follow this section.

TABLE 5-1
Cross Reference of Manufacturers

MFG Code	NAME AND ADDRESS	FEDERAL SUPPLY CODE
A-D	Analog Devices, Inc. Norwood, MA 02026	01121
BRN	Bourns, Inc. Riverside, CA 92507	80294

TABLE 5-1
Cross Reference of Manufacturers (cont.)

MFG Code	NAME AND ADDRESS	FEDERAL SUPPLY CODE
C-D	Cornell-Dubilier Newark, NJ 07101	14655
CLB	Centralab Division Milwaukee, WI 532021	71590
CLR	Clarostat Manufacturing Co. Dover, NH 03820	12697
DLE	Dale Electronics Columbus, NE 68601	91637
ECI	Electro-Cube, Inc. San Gabriel, CA 91776	14752
EFJ	E. F. Johnson Co. Waseca, MN 56093	74979
ERI	Erie Technological Products Erie, PA 16512	72982
INT	Intersil, Inc. Cupertino, CA 95014	32294
K-I	Keithley Instruments, Inc. Cleveland, Ohio 44139	80164
NAT	National Semi Corp. Santa Clara, CA 95051	27014
NIC	Nichicon Corp. Chicago, IL 60645	
NYT	Nytronics Components Group Darlington, SC 29532	83125
MEP	Mepco, Inc. Morristown, NJ 07960	80031

TABLE 5-1
Cross Reference of Manufacturers (cont.)

MFG Code	NAME AND ADDRESS	FEDERAL SUPPLY CODE
PRP	Precision Resistive Products Mediapolis, IA 53237	
SIL	Siliconix, Inc. Santa Clara, CA 95054	17856
STD	Standard Condenser Chicago, IL	97419
T-I	Texas Instruments, Inc. Dallas, TX 75231	01295

TABLE 5-2
Replaceable Parts List (cont.)

Circuit Desig.	Description	Schematic Location	PC-Board Item No./Location	Mfr. Code	Mfr. Desig.	Keithley Part No.
C401	.05μF, 1000V, Metal Poly	A4	5/E2	STD	CAPACPLYE2020	C-285-.05
C402	.25pF to 1.5pF, 2000V Trimmer	C3	6/E2	EFJ	273-0001-002	31863A
C403	1μF, 16V, Alum Elect	B3	7/E2	NIC	50VKBID	C-325-1.0
C404	1μF, 16V, Alum Elect	B4	8/E2	NIC	50VKBID	C-325-1.0
C405	330pF, 500V, Poly	C1	9/D2	CLB	CPR330J	C-138-330pF
C406	30pF, 500V, Mica	C2	10/D2	C-D	DC10ED00J3	C-236-30pF
C407	.25pF to 1.5pF, 2000V, Trimmer	C3	11/D2	K-I	273-0001-002	31863A
C408	1μF, 50V, Metal Poly	F4	12/C3	ECI	625B	C-335-1.0
C409	1μF, 50V, Metal Poly	F5	13/C3	ECI	625B	C-335-1.0
C410	1μF, 50V, Metal Poly	F5	14/C3	ECI	625B	C-335-1.0
C411	33pF, 500V, Mica	D4	15/D2	C-D	DC10ED300J3	C236-33pF
C412	6.8pF, 50V, Tube Cer	D4	100/D2	ERI	301-000C0 H015	C-282-6.8pF
C413	.25pF to 1.5pF, 2000V, Trimmer	B4	101/E2	K-I	273-0001-002	31863A
C414	.75pF, 600V, Tube Cer	B4	102/E2	CRL	R1CC20	C-77-0.75pF
CR401	Diode, Diffused Silicon	B2	22/E3	T-I	IN914	RF-28
CR402	Diode, Diffused Silicon	B5	23/E2	T-I	IN914	RF-28
CR403	Diode, Diffused Silicon	C5	24/E2	T-I	IN914	RF-28
K401	Relay	B2, A4	53/E3			RL-69

TABLE 5-2
Replaceable Parts List (cont.)

Circuit Desig.	Description	Schematic Location	PC-Board Item No./Location	Mfr. Code	Mfr. Desig.	Keithley Part No.
L401	100µH Choke	A3	17/D2	NYT	SWD-100	CH-14
L402	100µH Choke	A3	18/D3	NYT	SWD-100	CH-14
Q401	Transistor, PNP	B2	34/E3	A-D	AD-820	TG-84
Q402	N-Channel JFET (selected)	D2	35/D2	K-I		TG-128
Q403	N-Channel JFET	E2	36/D2	INT	ITE4392	TG-77
Q404	N-Channel JFET (selected)	D2	37/D2	K-I		TG-128
Q405	N-Channel JFET	E2	38/D2	INT	ITE4392	TG-77
Q406	N-Channel JFET (selected)	D3	39/D2	K-I		TG-128
Q407	N-Channel JFET	E3	40/D2	INT	ITE4392	TG-77
Q408	Dual N-Channel JFET	C4	41/E2	SIL	E411	TG-118
R401	1k, 1%, 1/2W, mtf	B4	57/F2	DLE	MFF-1/2	R-94-1k
R402	1k, 1%, 1/2W, mtf	B4	58/F2	DLE	MFF-1/2	R-94-1k
R403	2M, .5%, 1W, mtf	B4	59/E2	DLE	MFF-1/2-31	R-303-2M
R404	Pot, 100Ω, 10%, 3/4W	C2	60/D2	BRN	3600, GP100	RP-89-100
R405	Pot, 1k, 10%, 3/4W	C2	61/D2	BRN	3600, GP1000	RP-89-1k
R406	Pot, 10k, 10%, 3/4W	C3	62/D2	BRN	3600, GP10000	RP-89-10k
R407	Pot, 1k, 10%, 3/4W	F5	63/D2	BRN	3600, GP1000	RP-89-1k
R408	2.12k, .5%, 1/8W, mtf	C2	64/D2	DLE	MFF 1/8	R-246-2.12k
R409	19.6k, .5%, 1/8W, mtf	C2	65/D2	DLE	MFF-1/8	R-246-19.6k
R410	217k, .5%, 1/8W, mtf	C3	66/D2	DLE	MFF-1/8	R-246-217k
R411	Pot, 10k, 10%, 3/4W	D5	67/E2	BRN	3600, GP10000	RP-89-10k

TABLE 5-2
Replaceable Parts List (cont.)

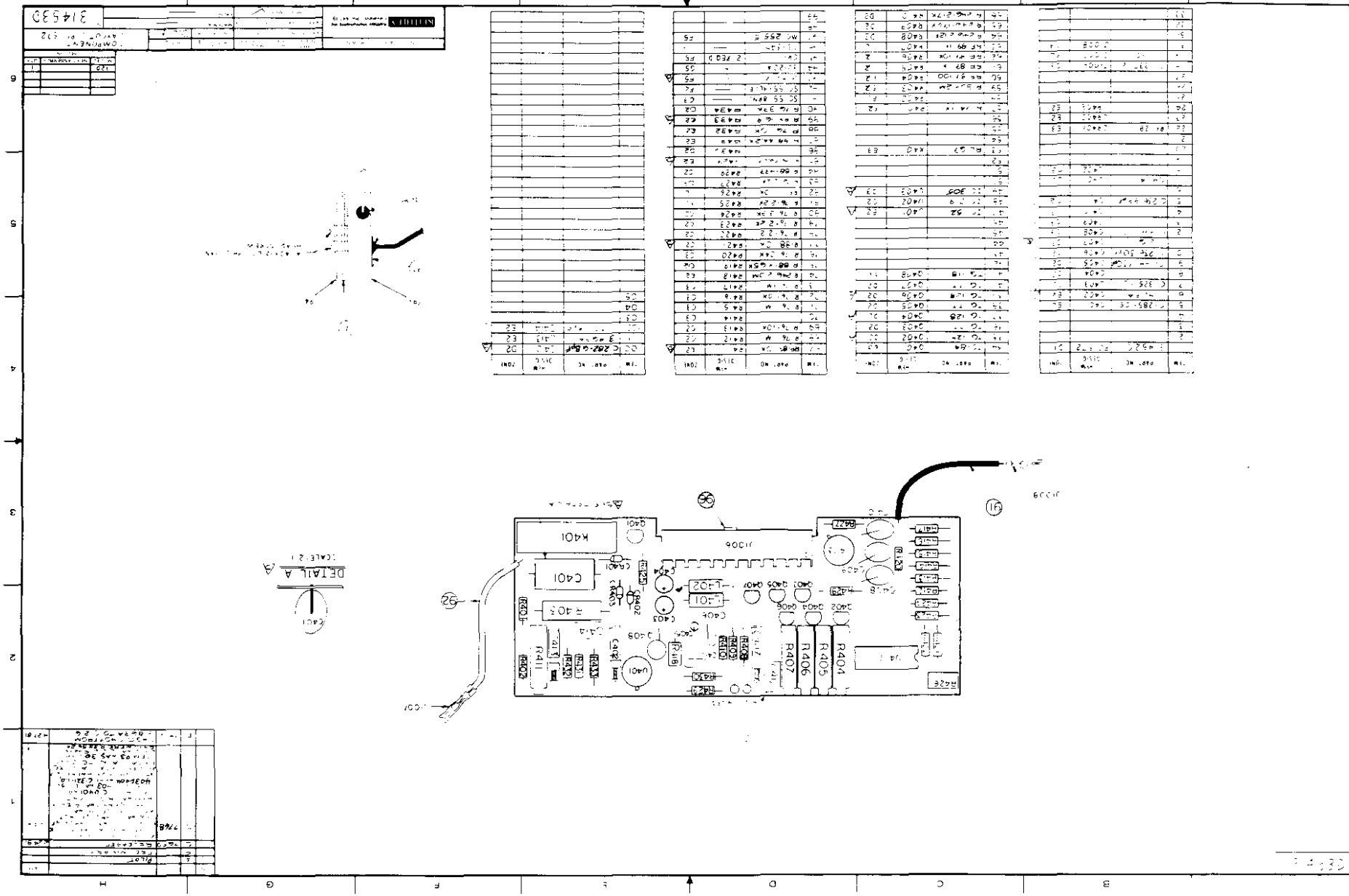
Circuit Desig.	Description	Schematic Location	PC-Board Item No./Location	Mfr. Code	Mfr. Desig.	Keithley Part No.
R412	1M, 5%, 1/4W, Carb	D2	68/C2	MEP	CR25*	R-76-1M
R413	10k, 5%, 1/4W, Carb	D2	69/C2	MEP	CR25*	R-76-10k
R414	10k, 5%, 1/4W, Carb	D3	70/C3	MEP	CR25*	R-76-10k
R415	1M, 5%, 1/4W, Carb	D3	71/C3	MEP	CR25*	R-76-1M
R416	10k, 5%, 1/4W, Carb	D3	72/C3	MEP	CR25*	R-76-10K
R417	1M, 5%, 1/4W Carb	D3	73/C3	MEP	CR25*	R-76-1M
R418	2M, .5%, 1/8W, mtf	C4	74/E2	DLE	MFF-1/8	R-246-2M
R419	3.65k, 1%, 1/8W, mtf	D4	75/D2	PRP	**	R-88-3.65k
R420	24k, 5%, 1/4W, Carb	F5	76/C3	MEP	CR25*	R-76-24k
R421	10k, 1%, 1/8W, mtf	F2	77/C2	PRP	**	R-88-10k
R422	2.2Ω, 5%, 1/4W, Carb	G2	78/C2	MEP	CR25*	R-76-2.2
R423	2.2k, 5%, 1/4W, Carb	F4	79/C2	MEP	CR25*	R-76-2.2k
R424	3.3k, 5%, 1/4W, Carb	G4	80/C2	MEP	CR25*	R-76-3.3k
R425	2.2k, 5%, 1/4W, Carb	A2	81/E2	MEP	CR25*	R-76-2.2k
R426	Pot, 10k, 10%, 1/2W.	F2	82/C2	BRN	3386H-1-103	RP-111-10k
R427	2.2k, 5%, 1/4W. Carb	F5	83/D3	MEP	DR25*	R-76-2.2k
R428	499Ω, 1%, 1/8W, mtf	E5	84/D2	PRP	**	R-88-499
R429	56.2k, .5%, 1/8W, mtf	C4	85/E2	DLE	MFF-1/8	R-246-56.2k
R430	56.2k, .5%, 1/8W, mtf	C4	86/D2	DLE	MFF-1/8	R-246-56.2k
R431	44.2k, 1%, 1/8W, mtf	C5	87/E2	PRP	**	R-88-44.2k
R432	10k, 5%, 1/4W, Carb	C5	88/E2	MEP	CR25*	R-76-10k
R433	16.9Ω, 1%, 1/8W, mtf	C5	89/E2	PRP	**	R-88-16.9
R434	33k, 5%, 1/4W, Carb	D4	90/D2	MEP	CR25*	R-76-33k

CR25* Manufacturers Designation includes parts description e.g. CR25 33k, 5%, 1/4W, Carb for R434

** Manufacturers Designation is GP1/4, 1%, T100, Resistance value

TABLE 5-2
Replaceable Parts List (cont.)

Circuit Desig.	Description	Schematic Location	PC-Board Item No./Location	Mfr. Code	Mfr. Desig.	Keithley Part No.
U401	Monolithic JFET	D4	47/E2	NAT	LF356H	IC-152
U402	Voltage Quad Comparator	F3,4	49/D3	NAT	LM339	IC-219
U403	TRMS to DC Converter	E5	49/D3	A-D	AD536AK	IC-305


R401
C401
R403
R407
R406
R405
R404
J1006
DETAIL A
SCALE: 2:1

KEITHLEY INSTRUMENTS, INC.
28775 AURORA ROAD
CLEVELAND, OHIO 44139

SERVICE FORM

MODEL NO._____ SERIAL NO._____ P.O. NO._____ DATE_____ R-

NAME _____ PHONE _____

COMPANY _____

ADDRESS _____ CITY _____ STATE _____ ZIP_____

1. Describe problem and symptoms using quantitative data whenever possible (enclose readings, chart recordings, etc.) _____

_____

_____ (Attach additional sheets as necessary).

2. Show a block diagram of your measurement system including all instruments connected (whether power is turned on or not). Also describe signal source.

3. List the positions of all controls and switches on both front and rear panels of the instrument. _____

_____

4. Describe input signal source levels, frequencies, etc. _____

_____

_____

5. List and describe all cables used in the experiment (length, shielding, etc.).

_____

_____

6. List and describe all other equipment used in the experiment. Give control settings for each. _____

_____

_____

7. Environment:
   Where is the measurement being performed? (Factory, controlled laboratory, out-of-doors, etc.) _____
   What power line voltage is used? _____ Variation? _____ Frequency? _____
   Ambient temperature? _____°F. Variation? ____°F. Rel. Humidity? _____
   Other _____

8. Additional Information. (If special modifications have been made by the user, please describe below.) _____

_____

_____ REV 0774