

Errata

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HP References in this Manual

This manual may contain references to HP or Hewlett-Packard. Please note that Hewlett-Packard's former test and measurement, semiconductor products and chemical analysis businesses are now part of Agilent Technologies. We have made no changes to this manual copy. The HP XXXX referred to in this document is now the Agilent XXXX. For example, model number HP8648A is now model number Agilent 8648A.

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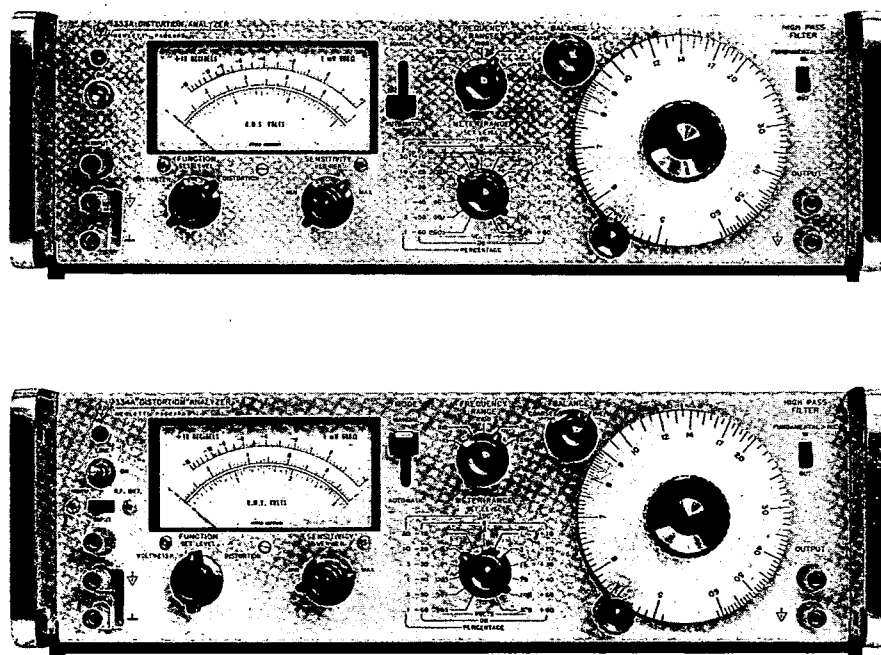
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OPERATING AND SERVICE MANUAL

DISTORTION ANALYZER 333A/334A



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PACKARD



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OPERATING AND SERVICE MANUAL

MODEL 333A/334A

DISTORTION ANALYZER

Serial Numbers:

333A: 1137A03146 and greater

334A: 1140A05641 and greater

Appendix C, Manual Backdating Changes, adapts this manual to lower serial numbers.

WARNING

To help minimize the possibility of electrical fire or shock hazards, do not expose this instrument to rain or excessive moisture.

Manual Part No. 00333-90008

Microfiche Part No. 00333-90058

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SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requirements. This is a Safety Class 1 instrument.

GROUND THE INSTRUMENT

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The instrument is equipped with a three-conductor ac power cable. The power cable must either be plugged into an approved three-contact electrical outlet or used with a three-contact to two-contact adapter with the grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet. The power jack and mating plug of the power cable meet International Electrotechnical Commission (IEC) safety standards.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.

DO NOT SERVICE OR ADJUST ALONE

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

DANGEROUS PROCEDURE WARNINGS

Warnings, such as the example below, precede potentially dangerous procedures throughout this manual. Instructions contained in the warnings must be followed.

WARNING

Dangerous voltages, capable of causing death, are present in this instrument. Use extreme caution when handling, testing, and adjusting.

SAFETY SYMBOLS

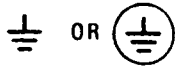
General Definitions of Safety Symbols Used On Equipment or In Manuals.



Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect against damage to the instrument.



Indicates dangerous voltage (terminals fed from the interior by voltage exceeding 1000 volts must be so marked).



Protective conductor terminal. For protection against electrical shock in case of a fault. Used with field wiring terminals to indicate the terminal which must be connected to ground before operating equipment.



Low-noise or noiseless, clean ground (earth) terminal. Used for a signal common, as well as providing protection against electrical shock in case of a fault. A terminal marked with this symbol must be connected to ground in the manner described in the installation (operating) manual, and before operating the equipment.



Frame or chassis terminal. A connection to the frame (chassis) of the equipment which normally includes all exposed metal structures.



Alternating current (power line).



Direct current (power line).



Alternating or direct current (power line).

WARNING

The WARNING sign denotes a hazard. It calls attention to a procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in injury or death to personnel.

CAUTION

The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product.

NOTE :

The NOTE sign denotes important information. It calls attention to procedure, practice, condition or the like, which is essential to highlight.

SECTION I

GENERAL INFORMATION

1-1. DESCRIPTION.

1-2. The Hewlett-Packard Models 333A and 334A Distortion Analyzers are solid state instruments for measuring distortion on ac voltages. The Models 333A and 334A include two control loops that automatically tune both legs of a bridge circuit which rejects the fundamental when the rejection circuit is initially set within the range of the loops. The 334A has a high impedance detector which operates from 550 kHz to greater than 65 MHz and provides the capability of monitoring the distortion of the amplitude modulation on an rf carrier.

1-3. Distortion levels of 0.1% to 100% full scale are measured in seven ranges for any fundamental frequency of 5 Hz to 600 kHz. Harmonics are indicated up to 3 MHz. The high sensitivity of these instruments requires only 0.3V rms for the 100% set level reference. The distortion characteristics can be monitored at the OUTPUT connectors with an oscilloscope, a true rms voltmeter, or a wave analyzer. The instruments are capable of an isolation voltage of 400 volts above chassis ground.

1-4. The voltmeter can be used separately for general purpose voltage and gain measurements. It has a frequency range of 5 Hz to 3 MHz (20 Hz to 500 kHz for 300 μ V range) and a voltage range of 300 μ V to 300 V rms full scale.

1-5. The AM detector included in the Model 334A is a broadband dc restoring peak detector consisting of a semiconductor diode and filter circuit. AM distortion levels as low as 0.3% can be measured on a 3 V to 8 V rms carrier modulated 30% in the standard broadcast band. Distortion less than 1% can be measured at the same level of the carrier up to 65 Mc.

1-6. ACCESSORY FEATURES.

1-7. The accessory available with the 333A and 334A Distortion Analyzers is a voltage divider probe, -hp- Model No. 10001A. The features of the probe are:

- a. 10 megohms shunted by 10 pF, giving 10:1 attenuation.
- b. DC to 30 MHz bandwidth.
- c. 2% division accuracy.
- d. 600 V peak input.
- e. 5 ns rise-time.

1-8. OPTION.

1-9. Option 01 is a standard -hp- Model 333A or 334A with a special meter and meter amplifier, compensated to permit response to VU (volume units) characteristics.

1-10 INSTRUMENT IDENTIFICATION.

1-11. Hewlett-Packard uses a two-section serial number. The first section (prefix) identifies a series of instruments. The last section (suffix) identifies a particular instrument within the series. If a letter is included with the serial number, it identifies the country in which the instrument was manufactured. If the serial prefix of your instrument differs from the one on the title page of this manual, a change sheet will be supplied to make this manual compatible with newer instruments or the backdating information in Appendix C will adapt this manual to earlier instruments. All correspondence with Hewlett-Packard should include the complete serial number.

Table 1-1. Specifications

MODEL 333A		Fundamental Input Greater Than 30 V			
DISTORTION MEASUREMENT RANGE					
Any fundamental frequency, 5 Hz to 600 kHz.					
Distortion levels of 0.1%-100% are measured full scale in 7 ranges.					
DISTORTION MEASUREMENT ACCURACY					
Harmonic measurement accuracy (full scale)					
Fundamental Input Less Than 30 V					
RANGE	$\pm 3\%$	$\pm 6\%$	$\pm 12\%$		
100%-0.3%	10 Hz 1 MHz	10 Hz 3 MHz			
0.1%	30 Hz 300 kHz	20 Hz 500 kHz	10 Hz 1.2 MHz		

Elimination Characteristics:			
Fundamental Rejection > 80 dB			
Second Harmonic Accuracy for a fundamental of:			
5 Hz to 20 Hz: better than +1 dB			
20 Hz to 20 kHz: better than ± 0.6 dB			
20 kHz to 100 kHz: better than -1 dB			
100 kHz to 300 kHz: better than -2 dB			
300 kHz to 600 kHz: better than -3 dB			

Table 1-1. Specifications (Cont'd)

Distortion Introduced by Instrument:
 > -70 dB from 5 Hz to 200 kHz
 > -64 dB from 200 kHz to 600 kHz

Meter indication is proportional to the average value of a waveform.

FREQUENCY CALIBRATION ACCURACY

Better than $\pm 5\%$ from 5 Hz to 300 kHz
 Better than $\pm 10\%$ from 300 kHz to 600 kHz

INPUT IMPEDANCE

Distortion Mode: $1\text{ M}\Omega \pm 5\%$ shunted by $< 70\text{ pF}$.

Voltmeter Mode:

$1\text{ M}\Omega \pm 5\%$ shunted by $< 30\text{ pF}$ (333A only),
 $1\text{ M}\Omega \pm 5\%$ shunted by $< 35\text{ pF}$ (334A only),
 1 to 300 V ranges; $1\text{ M}\Omega \pm 5\%$ shunted by $< 70\text{ pF}$,
 300 μV to 0.3 V ranges.

INPUT LEVEL FOR DISTORTION MEASUREMENTS

0.3 V rms for 100% set level (up to 300 V may be attenuated to set level reference). The minimum measurable distortion for floating operation on the X1 frequency range is 50dB below the fundamental.

DC ISOLATION

Signal ground may be $\pm 400\text{ Vdc}$ from external chassis.

VOLTMETER RANGE

300 μV to 300 V rms full scale (13 ranges),
 10 dB per range.

VOLTMETER FREQUENCY RANGE

5 Hz to 3 MHz (300 μV range: 20 Hz-500 kHz).

VOLTMETER ACCURACY:

RANGE	$\pm 2\%$	$\pm 5\%$
300 μV	30 Hz-300 kHz	20 Hz-500 kHz
1 mV-30 V	10 Hz-1 MHz	5 Hz-3 MHz
100 V-300 V	10 Hz-300 kHz	5 Hz-500 kHz

NOISE MEASUREMENTS

Voltmeter residual noise on the 300 μV range:
 $< 25\text{ }\mu\text{V rms}$ terminated in shielded 600 Ω ; $< 30\text{ }\mu\text{V rms}$ terminated in shielded 100 k Ω .

OUTPUT

For input frequencies from 20 Hz to 600 kHz,
 0.1 V rms $\pm 0.01\text{ V}$ open circuit for full scale meter deflection; 0.05 V rms $\pm 0.005\text{ V}$ into 2 k Ω for full scale meter deflection.

AUTOMATIC NULLING MODE

Set Level: At least 0.2 V rms.

Frequency Ranges:

X1, manual null tuned to less than 3% of set level; total frequency hold-in $\pm 0.5\%$ about true manual null.

X10 through X10K, manual null tuned to less than 10% of set level; total frequency hold-in $\pm 1\%$ about true manual null.

AUTOMATIC NULL ACCURACY

5 Hz to 100 Hz: Meter reading within 0 to +3 dB of manual null.

100 Hz to 600 kHz: Meter reading within 0 to +1.5 dB of manual null.

HIGH-PASS FILTER

3 dB point at 400 Hz with 18 dB per octave roll off. 60 Hz rejection $> 40\text{ dB}$. Normally used only with fundamental frequencies greater than 1 kHz.

POWER SUPPLY

100 V/120 V/220 V/240 V $+ 5\% - 10\%$, 48 - 66 Hz, approximately 4 watts.

MODEL 334A

Same as Model 333A except as indicated below:

AM DETECTOR

High impedance dc restoring peak detector with semi-conductor diode operates from 550 kHz to greater than 65 MHz. Broadband input. Maximum input; 40 V p-p ac or 40 V peak transient.

CARRIER FREQUENCY

550 kHz to 1.6 MHz: Distortion introduced by detector is $< 0.3\%$ for 3 to 8 volt carriers modulated 30%.

1.6 MHz to 65 MHz: Distortion introduced by detector is $< 1\%$ for 3 to 8 volts rms carriers modulated 30%.

NOTE

Distortion measurement at carrier levels as low as 1 volt may be made with reduced accuracy.

OPTION: 01

Indicating meter has VU characteristics conforming to FCC Requirements for AM, FM, and TV broadcasting.

SECTION II INSTALLATION

2-1. INTRODUCTION.

2-2. This section contains information and instructions necessary for the installation and shipping of the Models 333A/334A Distortion Analyzers. Included are initial inspection procedures, power and grounding requirements, installation information, and instructions for repackaging for shipment.

2-3. INSPECTION.

2-4. This instrument was carefully inspected both mechanically and electrically before shipment. It should be physically free of marks or scratches and in perfect electrical order upon receipt. To confirm this, the instrument should be inspected for physical damage in transit. Also check for supplied accessories, and test the electrical performance of the instrument using the procedure outlined in Paragraph 5-5. If there is damage or deficiency, see the warranty on the inside front cover of this manual.

2-5. POWER REQUIREMENTS.

2-6. The Model 333A/334A can be operated from any ac source of 100 V/120 V/220 V/240 V $\pm$ 5% - 10%, 48 - 66 Hz. With the instrument disconnected from the ac power source, move the slide (located on the rear panel) until the desired line voltage appears. Power dissipation is approximately 4 watts.

2-7. THREE-CONDUCTOR POWER CABLE.

2-8. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the instrument panel and cabinet be grounded. All Hewlett-Packard instruments are equipped with a three-conductor power cable, which, when plugged into an appropriate receptacle, grounds the instrument. The offset pin on the power cable three-prong connector is the ground wire.

2-9. INSTALLATION.

2-10. The Model 333A/334A is fully transistorized; therefore, no special cooling is required. However, the instrument should not be operated where the ambient temperature exceeds 55°C (131°F).

2-11. BENCH INSTALLATION.

2-12. The Model 333A/334A is shipped with plastic feet and tilt stand in place, ready for use as a bench instrument.

2-13. RACK INSTALLATION.

2-14. The Model 333A/334A may be rack mounted by using the 5" Rack Mount Kit (-hp- Part No. 5060-0775).

Instructions for the conversion are included with the kit. The rack mount for the Model 333A/334A is an EIA standard width of 19 inches. When mounted in a rack using the rack mount kit, additional support at the rear of the instrument should be provided if vibration or similar stress is likely.

2-15. REPACKAGING FOR SHIPMENT.

2-16. The following paragraphs contain a general guide for repackaging of the instrument for shipment. Refer to Paragraph 2-17 if the original container is to be used; 2-18 if it is not. If you have any questions, contact your local -hp- Sales and Service Office. (See Appendix B for office locations.)

NOTE

If the instrument is to be shipped to Hewlett-Packard for service or repair, attach a tag to the instrument identifying the owner and indicate the service or repair to be accomplished. Include the model number and full serial number of the instrument. In any correspondence, identify the instrument by model number, serial number, and serial number prefix.

2-17. If original container is to be used, proceed as follows:

a. Place instrument in original container if available. If original container is not available, a suitable one can be purchased from your nearest -hp- Sales and Service Office.

b. Ensure that container is well sealed with strong tape or metal bands.

2-18. If original container is not to be used, proceed as follows:

a. Wrap instrument in heavy paper or plastic before placing in an inner container.

b. Place packing material around all sides of instrument and protect panel face with cardboard strips.

c. Place instrument and inner container in a heavy carton or wooden box and seal with strong tape or metal bands.

d. Mark shipping container with "DELICATE INSTRUMENT," "FRAGILE," etc.

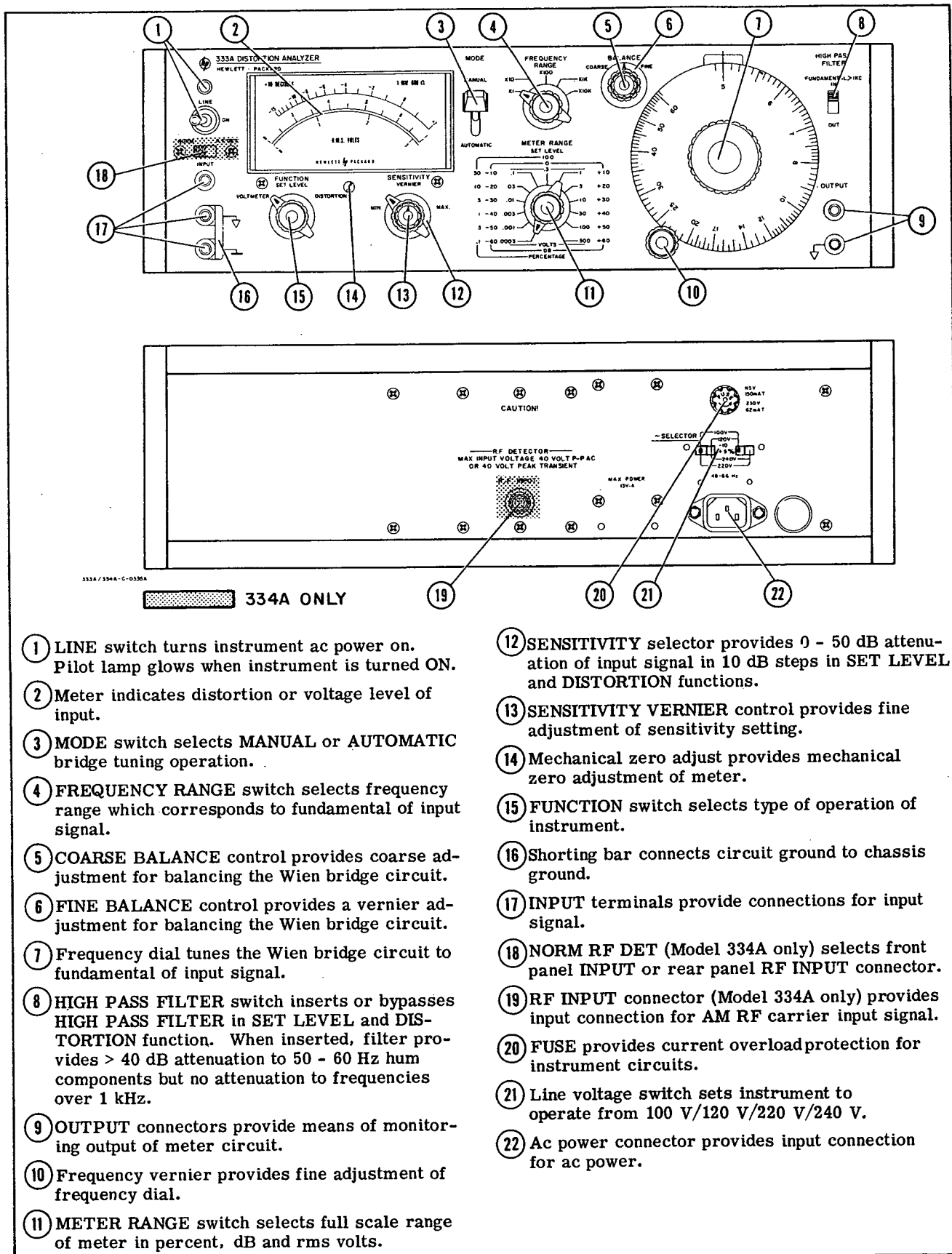


Figure 3-1. Front and Rear Panel Description

SECTION III

OPERATING INSTRUCTIONS

3-1. INTRODUCTION.

3-2. The Models 333A and 334A Distortion Analyzers measure total harmonic distortion of fundamental frequencies from 5 Hz to 600 kHz; harmonics up to 3 MHz are included. The sharp elimination characteristics (>80 dB), the low level of instrument induced distortion, and the meter accuracy of these instruments result in highly accurate measurement of low level harmonic distortion.

3-3. An rms calibrated voltmeter is inherent in the 333A and 334A. The voltmeter provides a full scale sensitivity of 300 μ volts rms (residual noise <25 μ volts). The voltmeter frequency range is from 5 Hz to 3 MHz except on the 0.0003 volt range, which is from 20 Hz to 500 kHz.

3-4. CONTROLS AND INDICATORS.

3-5. Figure 3-1 illustrates and describes the function of all front and rear panel controls, connectors, and indicators. The description of each component is keyed to the drawing included within the figure.

3-6. GENERAL OPERATING INFORMATION.

3-7. INPUT CONNECTIONS.

3-8. The input signal can be connected to the 333A and 334A through twisted pair leads or a shielded cable with banana plug connectors. Keep all test leads as short as possible to avoid extraneous pickup from stray ac fields. When measuring Low-level signals, ground loops may occur causing erroneous readings. Ground loops may be avoided by connecting the 333A/334A Distortion Analyzer to an appropriate isolation transformer to break the chassis ground from power supply ground. Connect all other instruments to one power strip with the three-prong connectors as close as possible.

3-9. VOLTMETER CHARACTERISTICS.

3-10. The RMS VOLTS markings on the meter face are based on the ratio between the average and effective (rms) values of a pure sine wave. The ratio of average to effective values in a true sine wave is approximately 0.9 to 1. When the meter is used to measure complex waves, the voltage indicated may not be the rms value of the signal applied. This deviation of meter indication exists because the ratios of average to effective values are usually not the same in a complex wave as in a sine wave. The amount of deviation depends on the magnitude and phase relation between the harmonics and fundamental frequency of the signal applied. Table 3-1 lists the deviation of the meter indication of a sine wave partly distorted by harmonics. As indicated in the table, harmonic content of less than 10% results in very small errors.

Table 3-1
Effect of Harmonics on Voltage Measurements

Input Voltage Characteristics	True RMS Value	Meter Indication
Fundamental = 100	100	100
Fundamental + 10% 2nd harmonic	100.5	100
Fundamental + 20% 2nd harmonic	102	100 - 102
Fundamental + 50% 2nd harmonic	112	100 - 110
Fundamental + 10% 3rd harmonic	100.5	96 - 104
Fundamental + 20% 3rd harmonic	102	94 - 108
Fundamental + 50% 3rd harmonic	112	90 - 116

NOTE

This chart is universal in application since these errors are inherent in all average-responding voltage-measuring instruments.

3-11. When making distortion measurements where the fundamental frequency is suppressed and the remainder of the signal is measured, the reading obtained on an average responding meter may deviate from the true total rms value. When the residual wave contains many inharmonically related sinusoids, the maximum error in the distortion reading is about 11 % (11 % of the measured distortion) low for distortion levels below 10 %.

EXAMPLE:

Measured Distortion	Maximum Error In Meter Indication	Total Distortion
2.5%	+0.11x0.025= 0.00027	0.025+0.0027= 0.0277 or 2.8%

This example represents the maximum possible error, and in most cases the error is less. In distortion measurements, the reading of an average-responding meter is sufficiently close to the rms value to be satisfactory for most applications.

3-12. OUTPUT TERMINALS.

3-13. The OUTPUT terminals provide a 0.1 V rms open circuit output for full scale meter deflection. These terminals can be used to monitor the output signal with an oscilloscope, a true rms voltmeter, or a wave analyzer. The combination of the distortion meter and oscilloscope provides more significant in-

formation about the device under test than the expression of distortion magnitude alone. Information obtained from the oscilloscope pattern is specific and reveals the nature of distortion which sometimes occurs at such low levels that it is difficult to detect in the presence of hum and noise. The impedance at the OUTPUT terminals is 2000 ohms, therefore, capacitive loads greater than 50 pF should be avoided to maintain the accuracy of meter readings.

3-14. OPERATING PROCEDURES.

3-15. INSTRUMENT TURN-ON.

- a. Set the 115-230 VAC switch to coincide with the line voltage in use. Turn switch to ON position. Pilot lamp will glow, indicating application of primary power.

3-16. ADJUSTMENT OF METER MECHANICAL ZERO.

3-17. The meter is properly zero-set when the pointer rests over the zero calibration mark and the instrument is in its normal operating environment and is turned off. Zero-set the meter as follows to obtain maximum accuracy and mechanical stability:

- a. Turn instrument on and allow it to operate for at least 20 minutes, to let meter movement reach normal operating temperature.
- b. Turn instrument off and allow 30 seconds for all capacitors to discharge.
- c. Rotate zero adjustment screw clockwise until pointer is left of zero and moving upscale.
- d. Continue rotating screw clockwise; stop when pointer is exactly at zero.
- e. When pointer is exactly over zero, rotate adjustment screw slightly counterclockwise to relieve tension on pointer suspension. If pointer moves off zero, repeat steps c through e, but make counterclockwise rotation less.

3-18. DISTORTION MEASUREMENT.



DO NOT EXCEED THE INPUT VOLTAGES LISTED BELOW TO PREVENT DAMAGING COMPONENTS ON A2 BOARD.

VOLTMETER FUNCTION -1V RANGE AND BELOW, AND DISTORTION ANALYZER FUNCTION - MAXIMUM SENSITIVITY.

1. 300 V ABOVE 100 Hz
2. 50 V ABOVE 1 kHz

3-19. MANUAL MODE.

- a. Turn instrument on and mechanically zero meter according to procedure in Paragraphs 3-15 and 3-16.

- b. Set NORM-R. F. DET. switch to NORM.
- c. Set FUNCTION switch to SET LEVEL.
- d. Set MODE switch to MANUAL.
- e. If fundamental frequency is 1 kHz or greater, set HIGH PASS FILTER switch to IN.
- f. Set SENSITIVITY selector to MIN. position, and rotate VERNIER control maximum counterclockwise.

NOTE

The bandwidth of the SENSITIVITY selector is reduced in the two extreme CCW positions (positions used with an input signal greater than 30 V).

- g. Set METER RANGE switch to SET LEVEL, and set BALANCE COARSE and FINE controls to center position.
- h. Connect signal to be measured to 333A/334A INPUT terminals.

WARNING

REMOVE SHORTING STRAP BETWEEN FRAME GROUND (⊥) AND CHASSIS GROUND (⋈) TERMINALS ON FRONT PANEL INPUT TERMINALS WHEN MEASURING DISTORTION BETWEEN TWO POINTS WHICH ARE DC OFFSET FROM GROUND POTENTIAL.

- i. Set SENSITIVITY selector to obtain meter indication greater than 1/3 full scale.
- j. Adjust SENSITIVITY VERNIER for full scale meter indication if making distortion measurement in percent; if making distortion measurement in dB adjust SENSITIVITY VERNIER for 0 dB meter indication.

NOTE

If unable to adjust for full scale or 0dB indication, (which indicates input signal is below 0.3 volts), set METER RANGE selector down-scale. Use this new setting as the 100% or 0dB SET LEVEL position, thus making the next range 30% or -10 dB, etc.

- k. Set FREQUENCY RANGE switch and frequency dial to fundamental frequency of input signal.
- l. Set FUNCTION switch to DISTORTION.
- m. Adjust frequency dial vernier and BALANCE COARSE and FINE controls for minimum

meter indication. Set METER RANGE switch down-scale as necessary to keep meter indication on scale.

- n. Repeat step m until no further reduction in meter indication can be obtained.
- o. Observe distortion either in percentage or dB, as indicated by meter deflection and METER RANGE switch setting. For example, if meter indicates 0.4 and METER RANGE setting is 1%, distortion measured is 0.4% of fundamental. Similarly, if meter indicates -6 dB and METER RANGE setting is -40 dB, distortion measured is -46 dB from fundamental.

NOTE

In MANUAL mode the accuracy of distortion measurements is affected by frequency stability of the input signal. An inaccuracy in distortion indications occurs when the frequency drift of the input signal exceeds the bandwidth of the rejection curve.

- p. If desired, rms voltage of input signal can be measured by setting FUNCTION switch to VOLTMETER, and setting METER RANGE switch to obtain an on-scale indication.

3-20. AUTOMATIC MODE.

- a. Perform steps a through l of Paragraph 3-19.
- b. Adjust frequency dial vernier and BALANCE COARSE and FINE controls for minimum meter indication.
- c. When meter indication is less than 10% of SET LEVEL indication, set MODE switch to AUTOMATIC. (If fundamental cannot be manually nulled below 10% of SET LEVEL indication, automatic mode cannot be used).
- d. Set METER RANGE switch down-scale to obtain on-scale meter indication.
- e. Observe distortion either in percentage or dB, as indicated by meter deflection and METER RANGE switch setting. For example, if meter indicates 0.4 and METER RANGE setting is 1%, distortion measured is 0.4% of fundamental. Similarly, if meter indicates -6 dB and METER RANGE setting is -40 dB, distortion measured is -46 dB from fundamental.
- f. If desired, rms voltage of input signal can be measured by setting FUNCTION switch to VOLTMETER, and setting METER RANGE switch to obtain an on-scale indication.

3-21. DISTORTION MEASUREMENT OF AM RF CARRIERS (334A only).



DO NOT EXCEED MAXIMUM INPUT VOLTAGES LISTED ON REAR PANEL.

- a. Turn instrument on and mechanically zero meter according to procedure in Paragraphs 3-15 and 3-16.
- b. Set NORM.-R. F. DET. switch to R. F. DET.
- c. Connect input signal to R. F. INPUT terminal on rear panel.
- d. Refer to Paragraph 3-19 for manual distortion measurement; refer to Paragraph 3-20 for automatic distortion measurement.

NOTE

If no meter deflection can be obtained with an RF input, diode A4CR1 should be checked. A spare diode is located on the outside of the A4 shield.

3-22. VOLTAGE MEASUREMENT.

- a. Turn instrument on and mechanically zero meter according to procedure in Paragraphs 3-15 and 3-16.
- b. Set NORM.-R. F. DET. switch to NORM.
- c. Set FUNCTION switch to VOLTMETER.
- d. Set METER RANGE switch to a range exceeding amplitude of signal to be measured.
- e. Connect signal to be measured to INPUT terminals.
- f. Set METER RANGE switch to give a reading as close to full scale as possible, and observe meter indication.
- g. The dB scale of the 333A/334A is calibrated in dBm, such that 0 dBm = 1 milliwatt dissipated by 600 ohms. Therefore, a dBm measurement must be made across 600 ohms. However, dB measurements across other impedances can be converted to dBm by use of the Impedance Correction Graph of Figure 3-3. For example: to convert a -30 dB reading across 200 ohms to dBm, locate the 200 ohm impedance line at the bottom of the graph. Follow the impedance line to the heavy black line, and read the meter correction at that point. The correction for 200 ohms is +5 dBm; thus the corrected reading is -25 dBm.

3-23. METER INDICATION.

3-24. The 333A/334A meter is calibrated to indicate in both dB and volts. It is interesting to note that the METER RANGE markings differ from most ac voltmeter range markings. On most ac voltmeters (600 ohms) 0 dB corresponds to the 1 volt range. This is not true in the case of the 333A/334A. Since the instrument is primarily a distortion analyzer, measurements are in dB (relative measurement) rather than in dBm (absolute measurement). Zero dB on the 333A/334A corresponds to 0.3 volt range rather than the 1 volt range. This allows a 10 dB greater dynamic range of distortion measurements.

3-25. If measurements are to be made in dBm, 10 dB must be subtracted from the METER RANGE setting. Thus 0 dB becomes the -10 dBm range for absolute power measurements. Zero dBm is equal to 1 milliwatt dissipated by any impedance and in this particular case is 600 ohms. The +10 DECIBELS marking on the meter face indicates that when voltmeter measurements are being made, the indication (METER RANGE plus meter indication) is 10 dB greater than when power (dBm) measurements are being made.

3-26. In short, when distortion and voltage measurements are being made, utilize the instrument METER RANGE and meter scale as they exist. For absolute power measurements in dBm, simply subtract 10 dB from the METER RANGE setting.

3-27. USE OF OUTPUT TERMINALS.

3-28. In VOLTMETER and SET LEVEL functions, the 333A/334A can be used as a low distortion, wide-band amplifier. A portion of the meter input (0.1 V rms open circuit for full scale meter deflection) is provided at the OUTPUT terminals.

3-29. In DISTORTION function, the distortion (0.1 V rms open circuit for full scale deflection) is provided at the OUTPUT terminals for monitoring purposes.

NOTE

The INPUT ∇ terminal and the OUTPUT ∇ terminal should not be connected directly together when making low level measurements. These terminals are isolated from each other by 1 ohm which reduces the effects of common mode voltages.

3-30. 333A/334A WITH OPTION 01.

3-31. Operating procedures for the 333A/334A with Option 01 are the same as for the standard instrument. The only difference between the standard and optional instrument is that the Option 01 has a special meter and meter amplifier which is compensated to respond to VU (volume unit) characteristics.

3-32. MANUAL NULLING.

3-33. Since the frequency and balance controls are rather sensitive in the MANUAL mode, the following information is supplied to simplify nulling the 333A/334A in the MANUAL mode. When nulling the 333A/334A in the MANUAL mode, connect the equipment as shown below and adjust the 333A/334A frequency and balance controls for the waveform shown in step a below. Additional waveforms are provided to simplify nulling.

- a.  No harmonic distortion. Frequency and balance adjustment correct.
- b.  Frequency and balance control improperly adjusted.
- c.  Frequency approximately correct; balance incorrect.
- d.  Balance approximately correct; frequency incorrect.
- e.  Second harmonic predominant; frequency and balance adjusted.
- f.  Second harmonic predominant; frequency and balance adjusted; phase changed.
- g.  Second harmonic predominant; frequency and balance adjusted; phase changed.
- h.  Third harmonic predominant.
- i.  Balance incorrect; meter reading off scale.
- j.  Frequency incorrect; meter reading off scale.

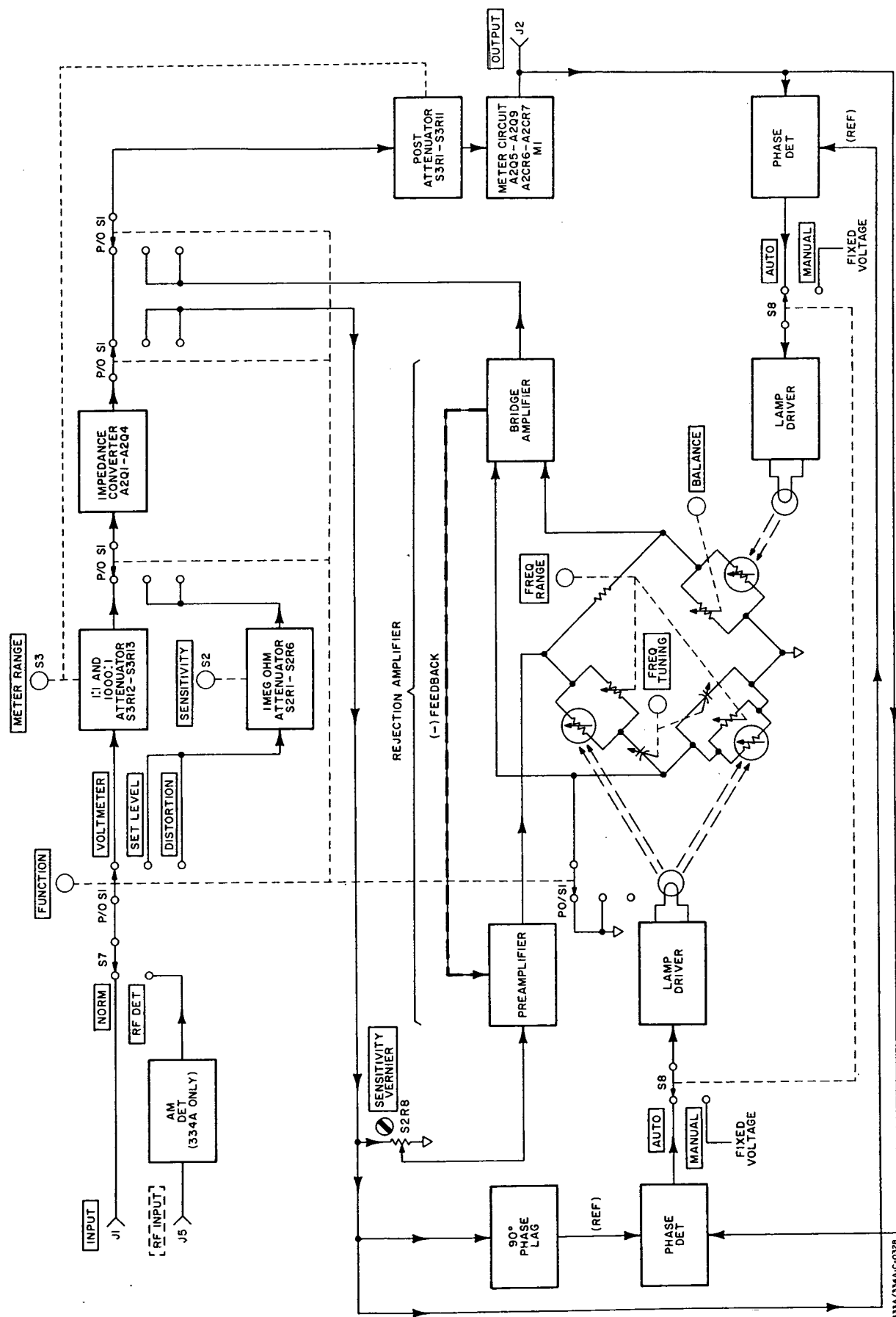


Figure 4-1. Block Diagram

SECTION IV

THEORY OF OPERATION

4-1. OVERALL DESCRIPTION.

4-2. Models 333A and 334A Distortion Analyzers include an impedance converter, a rejection amplifier, a metering circuit, and a power supply. The Model 334A also contains an AM detector. The impedance converter provides a low noise input circuit with a high input impedance independent of source impedance placed at the INPUT terminals. The rejection amplifier rejects the fundamental frequency of the input signal and passes the remaining frequency components on to the metering circuit for measuring distortion. The metering circuit provides visual indications of distortion and voltage levels on the front panel meter, M1. The AM detector (Model 334A only) detects the modulating signal from the RF carrier and filters all RF components from the modulating signal before it is applied to the impedance converter circuit.

4-3. BLOCK DIAGRAM DESCRIPTION.

(Refer to Figure 4-1)

4-4. DISTORTION MEASURING OPERATION.

4-5. For distortion measurement, the input signal is applied to the impedance converter (Assembly A2) through the FUNCTION selector, S1, and the one megohm attenuator. The one megohm attenuator is a voltage divider network which provides 50 dB attenuation in 10 dB steps. The desired level of attenuation is selected by the SENSITIVITY selector, S2. The impedance converter provides impedance matching and unity gain between the INPUT terminals and the input of the rejection amplifier.

4-6. The rejection amplifier consists of a preamplifier, a Wien bridge, and a bridge amplifier. The SENSITIVITY VERNIER control, at the input of the preamplifier, provides a set level signal to obtain a full scale reading on the meter for any voltage level at the input of the instrument. With the FUNCTION switch in the SET LEVEL position, a ground is applied to the Wien bridge circuit to allow a signal reference level to be set up on the meter. With the FUNCTION switch in the DISTORTION position, the Wien bridge is used as an interstage coupling network between the preamplifier and bridge amplifier. The Wien bridge is then tuned and balanced to reject the fundamental frequency of the applied input signal. Two automatic control loops consisting of two phase detectors, lamp drivers, lamps, and photocells provide fine tuning and balance in the AUTOMATIC MODE. The remaining frequency components are applied to the bridge amplifier and are measured as distortion by the metering circuit. Negative feedback from the bridge amplifier to the preamplifier narrows the rejection response of the Wien bridge.

4-7. The output of the rejection amplifier is applied to the metering circuit through the post-attenuator. The post-attenuator is used to limit the input signal

level applied to the metering circuit to 1 mV for full scale deflection. Sensitivity of the metering circuit is increased to 300 μ V for full scale deflection on the .0003 V range. The metering circuit provides a visual indication of the distortion level of the input signal. In addition to the indication provided by the meter, the OUTPUT terminals provide a means of monitoring the distortion components.

4-8. DISTORTION MEASUREMENT IN AM CARRIERS.

4-9. The Model 334A Distortion Analyzer contains an AM detector circuit for measuring envelope distortion in AM carriers. The input signal is applied to the input of the AM detector circuit where the modulating signal is recovered from the RF carrier. The signal is then applied to the impedance converter circuit through the one megohm attenuator and then through the same circuits previously described in the distortion measuring mode operation.

4-10. VOLTMETER OPERATION.

4-11. In the voltmeter mode of operation, the input signal is applied to the impedance converter circuit through the 1:1 and 1000:1 attenuator. The 1:1 attenuation ratio is used on the 0.0003 to 0.3 VOLTS ranges, and the 1000:1 attenuation ratio is used in the 1 to 300 VOLTS ranges. With the FUNCTION switch in the VOLTMETER position, the output of the impedance converter bypasses the rejection amplifier and is applied to the metering circuit through the post-attenuator (METER RANGE switch). Metering circuit sensitivity is increased from 1 mV for full scale deflection to 300 μ V on the .0003 V range, as it was in the distortion measuring operation. The function of the post-attenuator and metering circuit is the same for voltmeter operation as for the distortion measuring operation.

4-12. DETAILED CIRCUIT DESCRIPTION.

4-13. IMPEDANCE CONVERTER CIRCUIT. (Refer to Figure 7-2)

4-14. The input signal is applied to the impedance converter circuit through the 1:1 and 1000:1 attenuator S3R12 in voltmeter operation, and through the one megohm attenuator S2R1 through S2R6 in distortion operation. Capacitive dividers S2C1 through S2C10 in the attenuator keep the frequency response flat. The impedance converter is a low distortion, high input impedance amplifier circuit with gain independent of the source impedance placed at the INPUT terminals.

4-15. Instrument induced distortion of the signal being measured is minimized by keeping the input impedance and the gain of the impedance converter

linear. The input impedance is kept linear by use of local positive feedback from the source of A2Q1 to the gate of A2Q1 and to the protective diodes A2CR2 and A2CR3. Thus signals with a large source impedance can be measured accurately. Overall induced distortion is further minimized by a high open loop gain and 100% negative feedback. The high open loop gain is achieved by local positive feedback from the emitter of A2Q3 to the collector of A2Q2. Overall negative feedback from the emitter circuit of A2Q4 to the source of A2Q1 results in unity gain from the impedance converter.

4-16. The bias points of the transistors in the impedance converter are selected to minimize instrument induced distortion. A2Q1, an extremely low noise, high impedance field effect transistor, is the major component that makes linearity of the impedance converter independent of the signal source impedance.

4-17. REJECTION AMPLIFIER CIRCUIT. (Refer to Figures 7-3 and 7-5)

4-18. The rejection amplifier circuit consists of the preamplifier (A3Q1 thru A3Q3), the Wien bridge resistive leg and auto control loop (A5Q1 thru A5Q9 with associated lamp and photocell), the reactive leg and auto control loop (A5Q10 thru A5Q18 with associated lamp and photocell), and the bridge amplifier (A3Q4 thru A3Q6).

4-19. PREAMPLIFIER CIRCUIT.

4-20. The signal from the impedance converter is applied to the preamplifier, which is used during SET LEVEL and DISTORTION measuring operations. Negative feedback from the junction of A3R10 and A3R11 is applied to the junction of A3R2 and A3C2 to establish the operating point for A3Q1. Negative feedback from the emitter of A3Q3 is applied to the emitter of A3Q1 to stabilize the preamplifier. The preamplifier, like the impedance converter, is designed for high open loop gain and low closed loop gain to minimize instrument induced distortion.

4-21. WIEN BRIDGE CIRCUIT.

4-22. In the distortion measuring operation the Wien bridge circuit is used as a rejection filter for the fundamental frequency of the input signal. With the FUNCTION selector, S1, in the DISTORTION position, the Wien bridge is connected as an interstage coupling network between the preamplifier circuit and the bridge amplifier circuit. The bridge is tuned to the fundamental frequency of the input signal by setting the FREQUENCY RANGE selector, S4, for the applicable frequency range, and tuning the capacitors C4A through C4D. The bridge circuit is balanced by adjusting the COARSE balance control, R4, and the FINE balance control, R5. In the AUTOMATIC MODE fine tuning and balancing are accomplished by photoelectric cells which are in the resistive and reactive legs of the Wien bridge. The error signals for driving the photocells are derived by detecting the bridge output using the input signal as a reference.

4-23. When the Wien bridge is not tuned exactly to the frequency to be nulled, a portion of the fundamental

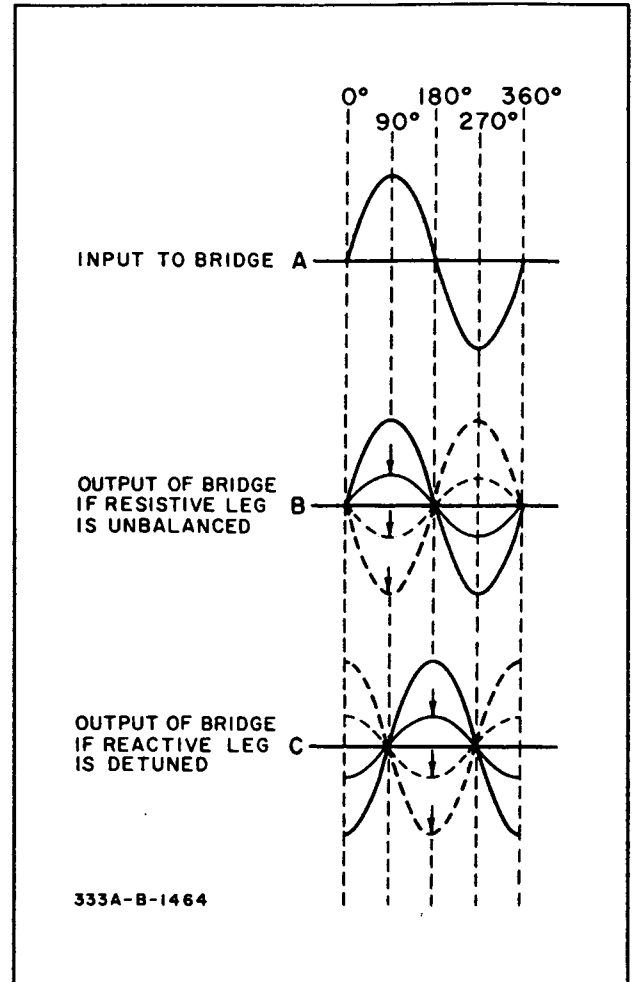


Figure 4-2. Bridge Waveforms

frequency will appear at the bridge output. The phase of this signal depends on which leg of the bridge is not tuned, or on the relative errors in tuning if neither is set correctly. The magnitude of the signal is proportional to the magnitude of the tuning error of either or both legs of the bridge.

4-24. Figure 4-2a shows a sinusoid input to the Wien bridge. If the resistive leg of the bridge is slightly unbalanced, the output of the bridge is very small, but has the waveform shown in Figure 4-2b and is in phase with the input. As the resistive leg is tuned, the signal approaches zero amplitude at null and then becomes larger, but 180° out of phase, if the null position is passed. When the resistive leg is correctly tuned and the reactive leg is tuned through null, a similar waveform is produced, Figure 4-2c. The only difference is that the reactive signal is 90° out of phase with the resistive signal.

4-25. When the bridge output is detected using the input signal as the reference, the error signals in phase or 180° out of phase with the reference develop a voltage that is used to vary the resistance in the resistive leg of the bridge, to tune it to the correct null position. Signals of the form in Figure 4-2c do not develop any voltage, as the resistive detector is insensitive to inputs differing from the reference by 90°.

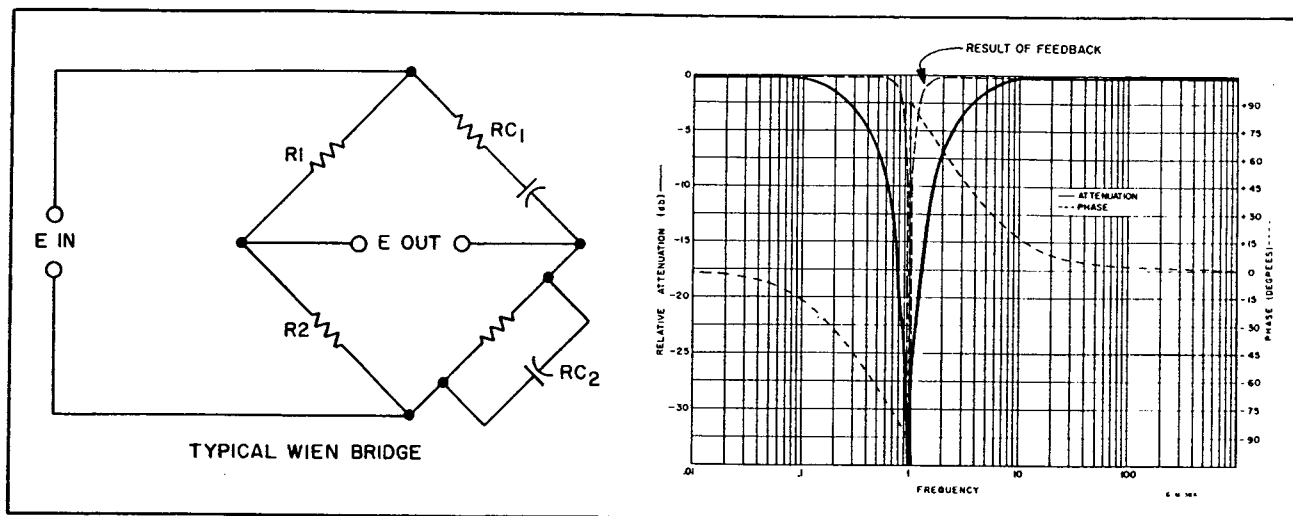


Figure 4-3. Wien Bridge Circuit and Rejection Characteristics

4-26. In an independent, but similar, control loop, the bridge input signal is shifted 90° and used as the reference signal for the detector. This detector develops control voltages to null the reactive leg of the bridge, but is insensitive to signals of the form in Figure 4-2b, which are caused by small tuning errors of the resistive branch.

4-27. The result is that the two control loops derive information from a common source and develop two independent control signals for nulling the two legs of the bridge. These control voltages are used to vary the brilliance of lamps, which in turn cause resistance changes in photocells that form part of the Wien bridge.

4-28. When the bridge circuit is tuned and balanced, the voltage and phase of the fundamental, which appears at junction of the series reactive leg (S4R1, 3, 5, 7, or 9 and C4A/B) and the shunt reactive leg (S4R11, 13, 15, 17, or 19, and C4C/D), is the same as at the midpoint of the resistive leg (A3R12 and A3R14). When these two voltages are equal and in phase, the fundamental frequency will not appear at the drain of the field effect transistor A3Q4. For frequencies other than the fundamental, the reactive leg of the Wien bridge offers various degrees of attenuation and phase shift which cause a voltage at the output points of the bridge. This difference voltage between the reactive leg and resistive leg is amplified by A3Q4, A3Q5, and A3Q6. Figure 4-3 illustrates a typical Wien bridge circuit and the rejection characteristics for it.

4-29. The Wien bridge circuit is designed to cover a continuous frequency range of over a decade for each position of the FREQUENCY RANGE selector S4. S4 provides coarse tuning of the reactive leg by changing the bridge circuit constants in five steps at 1 decade per step. For the automatic control loop, the reference voltage is taken from R6 at the input to the rejection amplifier and applied to the buffer amplifier A5Q7. The reference voltage is amplified and clipped by A5Q8 and A5Q9, and coupled to the detector A5Q4. The output of the metering circuit, which contains the fundamental frequency if either leg of the bridge is

untuned, is applied to the buffer amplifier A5Q1. It is amplified by A5Q2 and A5Q3 and coupled to the detector A5Q4.

4-30. Refer to Figure 4-4, partial schematic for detector operation. The discussion is applicable to both resistive and reactive detector circuits.

4-31. The signals from the error amplifier, (A5Q2 and A5Q3) will be equal and of opposite phase, and will cancel out each other when the detector, A5Q4, is off. However, when the positive half of the reference square wave gates A5Q4 on, the signal from the collector of A5Q3 will be shorted to ground. Thus the signal from the collector of A5Q2 will be coupled through the filter network to the base of A5Q5. If the signal from A5Q2 is in phase with the reference, the positive half of the signal will be passed, and if it is out of phase, the negative half will be passed.

4-32. The normal working voltage at A5TP3 is between 0 and -1 volt. The dc output of the filter network causes the voltage at A5TP3 to go in a positive direction (toward zero) for in phase error signals, and in a negative direction (toward -1 V) for out of phase error signals. The change in base voltage is then amplified by A5Q5 and lamp driver A5Q6. This will change the brilliance of lamp A6DS1, which will vary the resistance of A6V1 in the direction necessary to balance the resistive leg of the bridge.

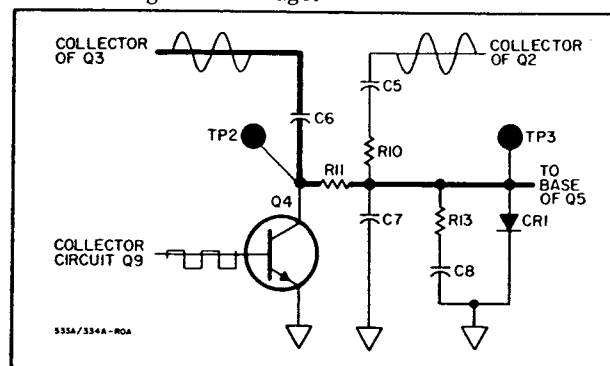


Figure 4-4. Auto Control Loop Detector

4-33. Refer to Figure 4-5 for the phase relationship of the bridge error signal and reference voltage at the base of A5Q4. The shaded portions of the error signals (b and c) indicate that part of the error signal which contributes to the dc lamp control voltage. As indicated in d, any error signal that is 90° out of phase with the reference does not affect the dc lamp control voltage, because equal amounts of the positive and negative portions are passed.

4-34. The operation of the reactive branch control loop is similar to that of the resistive branch. The

phase delay circuit, A5Q15, A5Q16, S4AF and S4C1 through S4C5, shifts the reference voltage 90° , as shown in Figure 4-5f. This makes the detector A5Q12 sensitive to components of the bridge error signal that are 90° out of phase (g and h). The output of the lamp driver, A5Q14, controls the brilliance of A6DS2, which varies the resistance of A6V2 through A6V5 to tune the branches of the reactive leg. Deck AR of the FREQUENCY RANGE switch, S4, switches A5R56 in parallel with A5R55 on the top three frequency ranges. A6DS2 will become brighter, and lower the resistance of A6V2 through A6V5, making variation

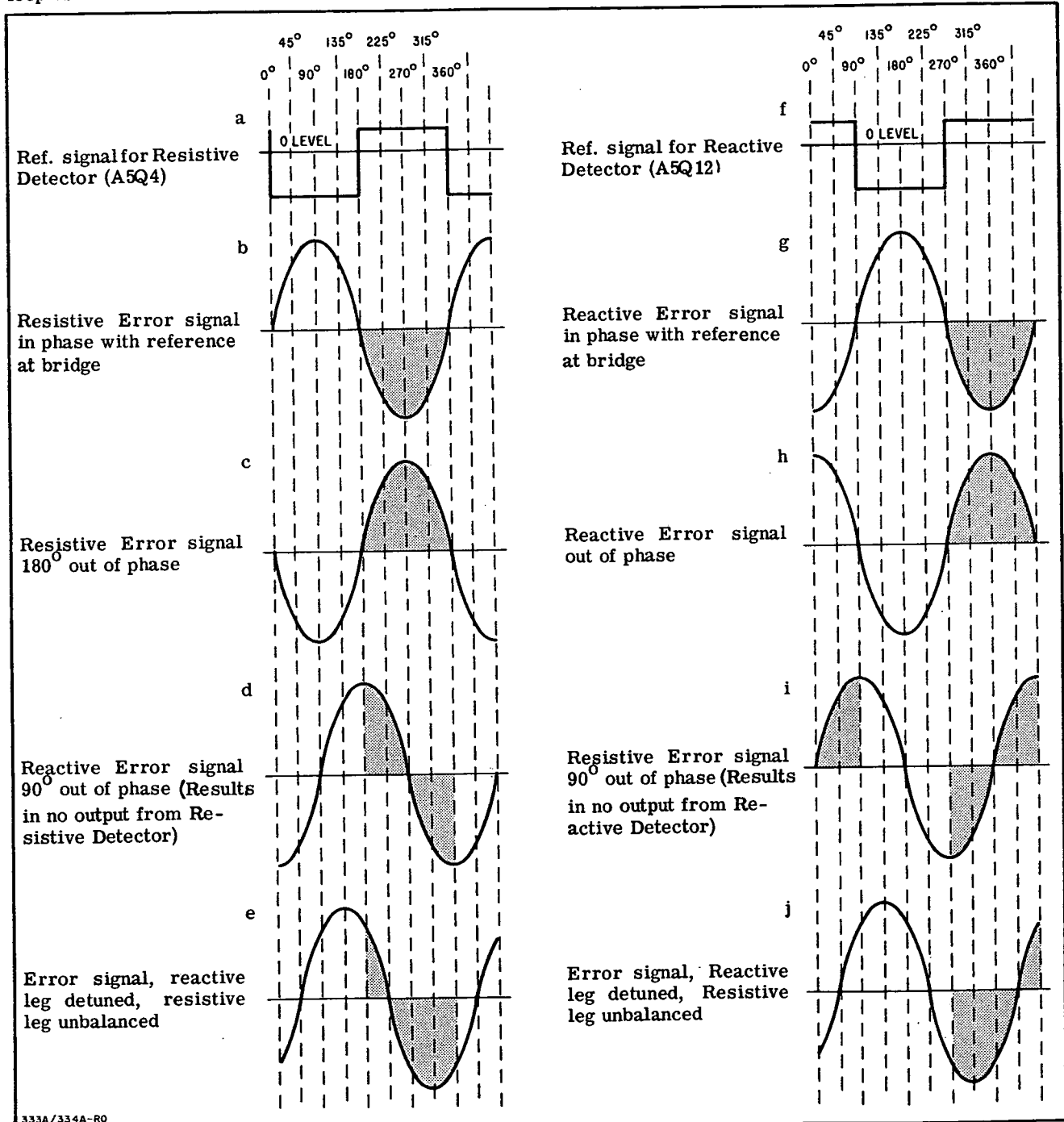


Figure 4-5. Reference and Error Phase Relationship

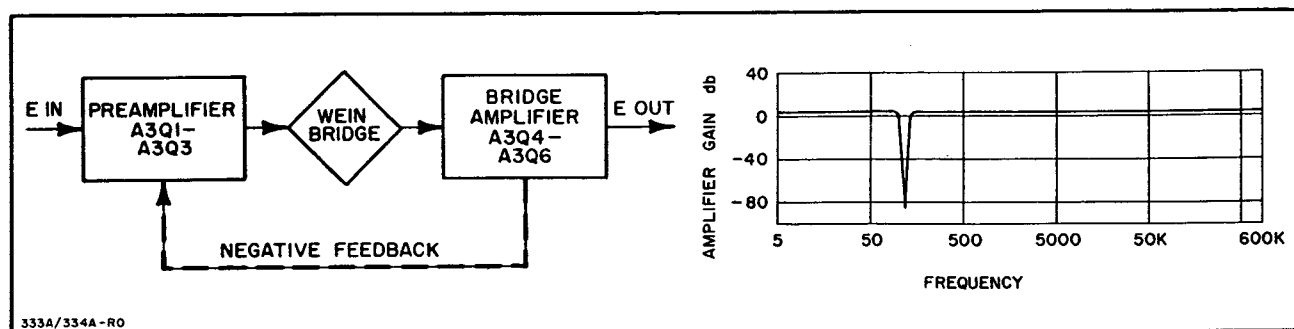


Figure 4-6. Rejection Amplifier Block Diagram and Typical Frequency Rejection Characteristic

in resistance less than on the two lower ranges. However, less variation in resistance is needed to tune the leg, because the impedance in the reactive leg becomes progressively less as the higher frequency ranges are selected.

4-35. Any error signal that is not an integral multiple of 90° is the result of the reactive leg of the bridge being detuned, and the resistive leg being unbalanced. For example, an error signal that is 45° out of phase (Figure 4-5e and j) will result in outputs from both resistive and reactive detectors to tune the bridge and reject the fundamental.

4-36. When the FUNCTION selector is set to the VOLTMETER or SET LEVEL position, the junction of the series and shunt reactive branches of the Wien bridge is connected to circuit ground through A3R19 by S1BF which disables the frequency rejection characteristic of the bridge circuit. With the bridge circuit disabled, the rejection amplifier circuit provides one dB of gain for the fundamental frequency and the harmonics. In the SET LEVEL operation, this signal is used to establish the SET LEVEL reference.

4-37. BRIDGE AMPLIFIER CIRCUIT.

4-38. The bridge amplifier circuit consists of three stages of amplification, A3Q4 through A3Q6. The first stage of amplification, A3Q4, is a field effect transistor which amplifies the difference signal between the gate and the source. The field effect transistor is selected for minimum noise performance with the high impedances of the Wien bridge circuit. The signal from the drain is applied to the two stage feedback amplifier A3Q5 and A3Q6. The output of A3Q6 is coupled to the meter circuit by the post attenuator S3R1 through S3R11. Negative feedback from the output of the bridge amplifier is applied to the preamplifier circuit to narrow the frequency rejection characteristic. It can be noted from the rejection characteristic (refer to Figure 4-3) for the bridge that the rejection of harmonic voltages is not constant. Typically the second harmonic is attenuated several dB more than the third harmonic and the third more than the fourth. The result of the negative feedback is illustrated by the rejection characteristic shown in dashed lines on the attenuation and phase characteristic of Figure 4-3. Figure 4-6 shows a simplified block diagram of the rejection amplifier with the typical frequency-rejection characteristic.

Refer to Figure 4-7, Bandwidth Versus Null Depth for further detail on the rejection characteristic.

4-39. HIGH PASS FILTER. (Refer to Figure 7-3).

4-40. The HIGH PASS FILTER is normally used when the fundamental of the input signal is greater than 1 kHz. In the voltmeter mode of operation, the filter is not used. In SET LEVEL and DISTORTION functions the filter presents >40 dB attenuation to 50 or 60 Hz hum components, but offers no attenuation to frequencies over 1 kHz. The filter assembly, A7, consists of A7C1, A7C2, and A7L1. The filter can be inserted or bypassed by the HIGH PASS FILTER switch, S9.

4-41. METER AMPLIFIER. (Refer to Figure 7-4)

4-42. The meter amplifier consists of the post attenuator, the meter amplifier circuit, and the meter rectifier circuit.

4-43. POST ATTENUATOR.

4-44. The post attenuator, S3R1 through S3R11, is a resistive network which attenuates the input signal in 10 dB steps. The attenuator is used in conjunction with either the input sensitivity attenuator or the 1000:1 attenuator to limit the signal level to the meter amplifier to 1 mV for full scale deflection on all ranges from 1 mV to 300 V full scale. The meter circuit sensitivity is increased to $300 \mu\text{V}$ for full scale deflection on the .0003V range by switching resistors A2R29 and A2R30 into the calibration network. Resistor A2R41 and capacitor A2C29 are also switched into the calibration network on the .0003V range to extend the passband of the amplifier.

4-45. METER AMPLIFIER CIRCUIT.

4-46. The meter amplifier circuit consists of a five stage amplifier circuit, A2Q5 through A2Q9, which develops the current for full scale meter deflection. Negative dc feedback from the emitter circuit of A2Q8 is applied to the base of A2Q5 to stabilize the dc operating point of the meter amplifier circuit and to minimize the tendency for dc drift due to ambient temperature changes. A2R51 and A2CR8 are electrically in the circuit only when the meter amplifier is overloaded. When the voltage on the emitter of A2Q9

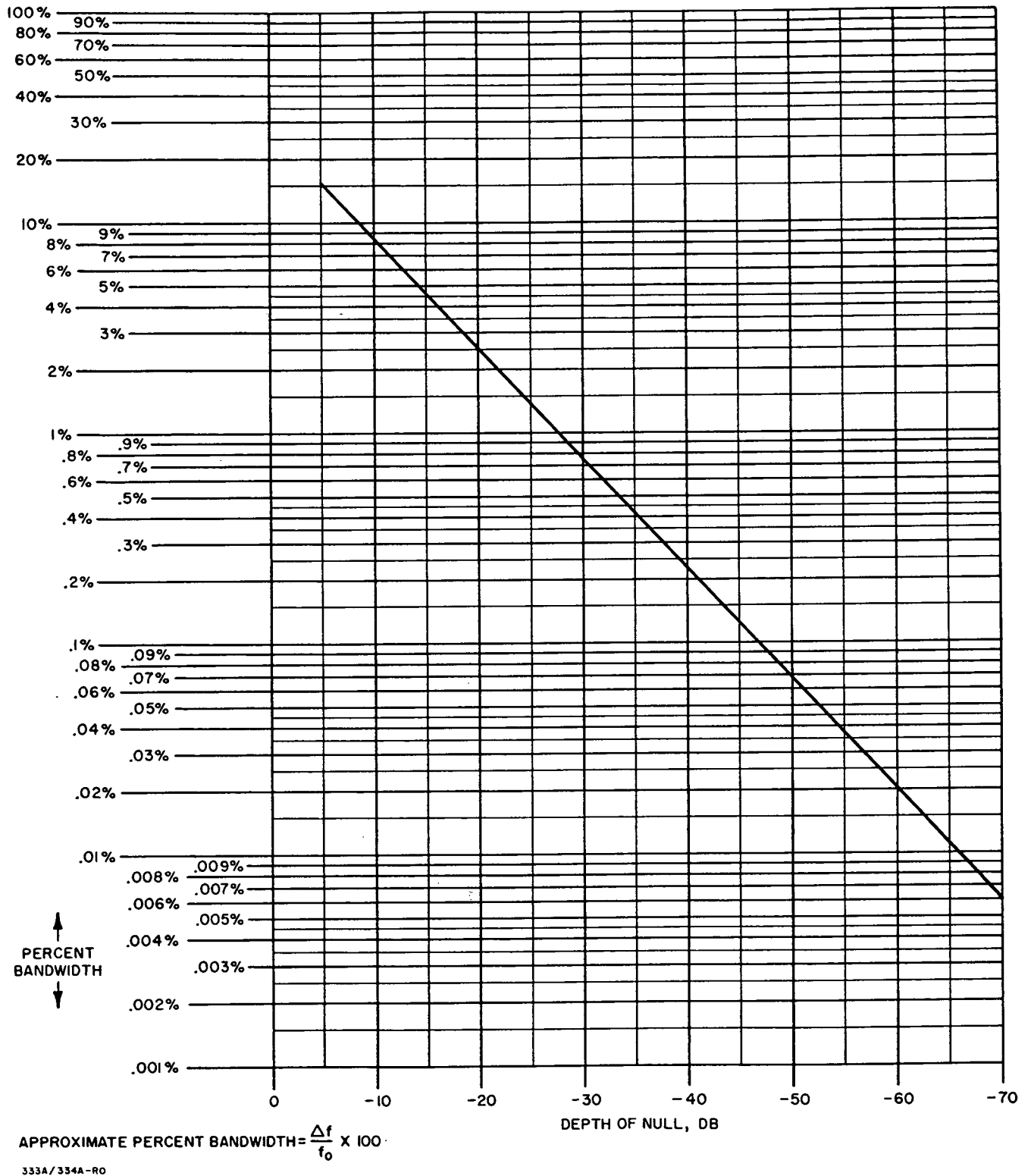


Figure 4-7. Bandwidth Versus Null Depth

becomes abnormally large during an overload, A2CR8 breaks down and provides a lower resistance charging path for A2C15, which reduces the transient recovery time of the meter amplifier. Negative ac feedback is applied from the collector circuit of A2Q9 to the emitter circuit of A2Q5. This feedback is used to ensure flat frequency response, to improve linearity, and to reduce the effect of variation of transistor parameters with environmental changes. In this manner, the calibration of the instrument is made dependent on high quality passive components.

4-47. METER RECTIFIER CIRCUIT.

4-48. The meter rectifier is connected in a bridge type configuration with a diode in each upper branch and a dc milliammeter connected across the midpoints of the bridge. The simplified meter rectifier is illustrated in Figure 4-8. The generator represented by A2Q5 through A2Q9 with the internal impedance R_o provides the meter, M1, with current for full scale deflection and develops a voltage across the calibration network, which closes the ac feedback loop. Capacitors A2C27 and A2C28 are used as coupling capacitors for the ac feedback loop, output signal to the OUTPUT connector, and the bridge error signal to the input of the automatic fine tuning loops. The mechanical inertia of the meter and A2C26 prevents the meter from responding to individual current pulses. Therefore, the meter indication corresponds to the average value of the current pulses rather than the peak value. The meter is calibrated to indicate the rms value of a sine wave. Resistor A2R45 impresses a fixed bias across diodes A2CR6 and A2CR7 (biasing them close to the barrier voltage) to make the meter amplifier response linear to large variations

in signal amplitude. The linearity of this type of circuit is also increased by including the meter circuit in the overall feedback loop.

4-49. POWER SUPPLY CIRCUIT. (Refer to Figure 7-6)

4-50. The power supply circuit consists of a +25 volt series regulated supply and a -25 volt series regulated supply which is the reference supply for the +25 volt supply.

4-51. The -25 volt regulated supply is of the conventional series regulator type. The amplifier A1Q5 is used to increase the loop gain of the circuit, thus improving voltage regulation. The positive feedback applied to the junction of A1R11 and A1R12 is used to further improve the line frequency suppression of the circuit.

4-52. The +25 volt regulated supply is of the conventional series regulator type and operates the same as the -25 volt regulated supply.

4-53. RF DETECTOR CIRCUIT. (334A only) (Refer to Figure 7-2)

4-54. The RF detector circuit consists of a rectifier, A4CR1, and filter circuit. The RF signal is applied to the circuit through the RF INPUT connector on the rear panel. The rectifier diode A4CR1 recovers the modulating signal from the RF carrier and the filter circuit removes any RF components before the signal is applied to the impedance converter circuit through the NORM-RF DET switch, S7.

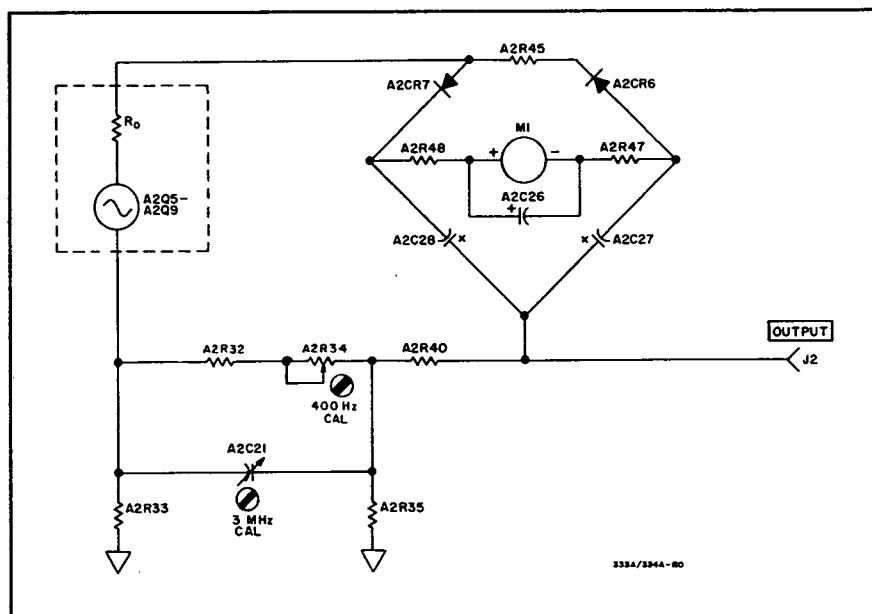


Figure 4-8. Simplified Metering Circuit

WARNING

These servicing instructions are for use by qualified personnel only. To avoid electrical shock, do not perform any servicing other than that contained in the operating instructions unless you are qualified to do so.

Table 5-1. Required Test Equipment

INSTRUMENT TYPE	SPECIFICATIONS	USE	RECOMMENDED MODEL
Voltmeter Calibrator	Voltage Range: 300 μ V to 300 V rms Accuracy: $\pm 0.2\%$ at 400 Hz	Performance Checks, Adjustment and Calibration	-hp- Model 738BR Voltmeter Calibrator
Test Oscillator	Voltage Range: 300 μ V to 3V Frequency Range: 10 Hz to 3 MHz	Performance Checks, Adjustment and Calibration	-hp- Model 652A Test Oscillator
Wave Analyzer	Bandwidth: 5 kHz to 600 kHz Dynamic Range: > 80 dB	Performance Checks	-hp- Model 310A Wave Analyzer
Electronic Counter	Functions: period, 1 sec. gate Accuracy: ± 2 counts	Performance Checks, Adjustment and Calibration	-hp- Model 5532A Electronic Counter
Multimeter	Voltage Range: 10mV to 1000VDC Accuracy: $\pm 1\% \pm (0.03\% \text{ readings} + 0.02\% \text{ Range})$ Worst Case	Adjustment and Calibration, Troubleshooting	-hp- Model 3465A Multimeter
Oscilloscope	Bandwidth: DC to 10 MHz Vertical: Dual Channel	Troubleshooting	-hp- Model 140A/1402A/1420A Oscilloscope
AC Voltmeter	Voltage Range: 100 μ V to 30V Frequency Range: 20 Hz to 4 MHz	Troubleshooting	-hp- Model 400F AC Voltmeter
Filter Box	Filtered Outputs: 500 Hz, 5 kHz 250 kHz, 600 kHz Output Distortion: < 80 dB	Performance Checks	White Model 2640 Filter Set
Power Supply	Output Voltage: ± 400 Vdc	Performance Checks	-hp- Model 6515A Power Supply
Signal Generator	Carrier Frequency: 1 MHz Modulation: External, upto 50%	Performance Checks (Model 334A only)	-hp- Model 606A Signal Generator
Oscillator	Voltage Range: 1V Frequency Range: 1 kHz Output: Floating, ± 400 Vdc	Performance Checks	-hp- Model 204C Oscillator
AC Probe	Input Impedance: 10 M Ω shunted by 10 pF	Troubleshooting	-hp- Model 11074A Voltage Divider Probe
Terminating Resistances	Feedthru: 50 $\Omega \pm 1\%$ and Feedthru: 600 $\Omega \pm 1\%$	Performance Checks Adjustment and Calibration	-hp- Model 11048B and -hp- Model 11095A
Shielded Loads	Resistance: 600 Ω and Resistance: 100 k Ω	Performance Checks	See Figure 5-7
Resistors	Fxd: 100 k $\Omega \pm 1\%$, 1/2 W and Fxd: 10 k $\Omega \pm 1\%$ 1/2 W Fxd: 500 k $\Omega \pm 1\%$, 1W	Performance Checks	-hp- Part No. 0727-0208 -hp- Part No. 0757-0215 -hp- Part No. 0730-0156

SECTION V MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains maintenance and service information for the 333A and 334A Distortion Analyzers. Included are Performance Checks, Adjustment and Calibration Procedures, and Troubleshooting Techniques.

5-3. REQUIRED TEST EQUIPMENT.

5-4. The equipment needed to properly maintain the Model 333A/334A is listed in Table 5-1. If the recommended model is not available, any instrument that has specifications equal to or better than the required specifications may be used.

5-5. PERFORMANCE CHECKS.

5-6. The performance checks are in-cabinet procedures that can be used to verify instrument performance. These procedures can be used for periodic maintenance, to check specifications after a repair, or for incoming quality control inspection. Performance checks for both the 333A and 334A are provided. The performance checks are applicable to both instruments except where noted in paragraph heading.

5-7. The performance checks are made with the ac power cord connected to nominal line voltage (100V/120V/220V/240V, 48 to 66 Hz), MODE SWITCH to MANUAL, HIGH PASS FILTER to OUT, and NORM. - R. F. DET. switch to NORM, unless otherwise specified.

5-8. A Performance Check Test Card is provided at the end of this section for recording the performance of the instrument during the performance checks. The card may be removed from the manual and used as a permanent record of the incoming inspection or of a routine performance check. If the instrument fails to meet any of its specifications, perform the Adjustment and Calibration Procedures, Paragraph 5-23.

5-9. VOLTMETER ACCURACY AND FREQUENCY RESPONSE CHECK.

- Connect voltmeter calibrator to 333A/334A as shown in Figure 5-1. Test oscillator will be used later in check.
- Set 333A/334A FUNCTION switch to VOLT-METER.
- Set voltmeter calibrator for 400 Hz rms output.
- Check 333A/334A voltmeter full scale reading on all ranges against appropriate rms input from voltmeter calibrator. Voltmeter accuracy should be within $\pm 2\%$.
- Disconnect voltmeter calibrator.
- Connect 50 Ω output of test oscillator, terminated in 50 Ω , to 333A/334A.
- Set 333A/334A METER RANGE switch to 3 VOLTS.

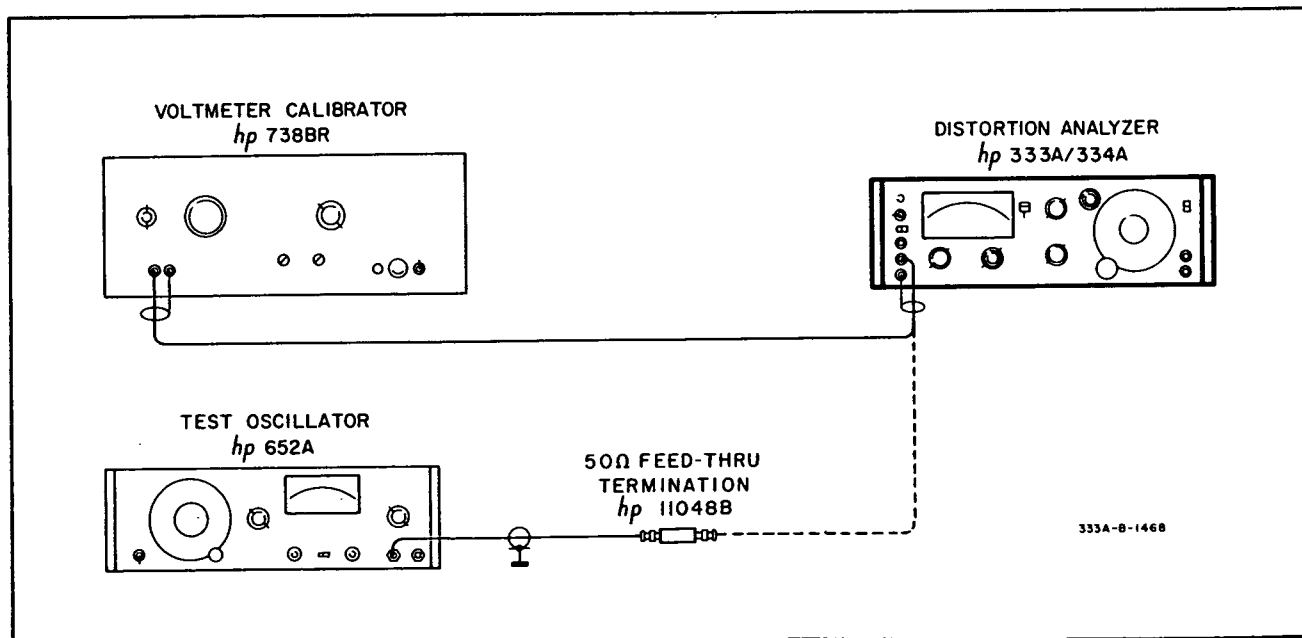


Figure 5-1. Voltmeter Accuracy and Frequency Response Check

Table 5-2. Voltmeter Frequency Response Check

FREQ.	3V RANGE METER INDICATION		FREQ.	0.0003V RANGE METER INDICATION	
	MIN.	MAX.		MIN.	MAX.
10 Hz	2.94 V	3.06 V	20 Hz	285 μ V	315 μ V
1 kHz	2.94 V	3.06 V	30 Hz	294 μ V	306 μ V
10 kHz	2.94 V	3.06 V	1 kHz	294 μ V	306 μ V
100 kHz	2.94 V	3.06 V	10 kHz	294 μ V	306 μ V
1 MHz	2.94 V	3.06 V	100 kHz	294 μ V	306 μ V
2 MHz	2.85 V	3.15 V	300 kHz	294 μ V	306 μ V
3 MHz	2.85 V	3.15 V	500 kHz	285 μ V	315 μ V

- h. Set test oscillator to 400 Hz, and adjust amplitude until 333A/334A meter indication is 3 V. Set reference on meter of test oscillator and use amplitude control to maintain set reference whenever frequency of oscillator is varied.
- i. Set test oscillator to each frequency listed in Table 5-2. At each respective frequency, 333A/334A meter reading should be within tolerances listed in table.
- j. Set 333A/334A METER RANGE switch to 0.0003 VOLTS.
- k. Set test oscillator to 400 Hz, and adjust amplitude until 333A/334A meter indication is 300 μ V. Set a reference on meter of test oscillator and use amplitude control to maintain set reference whenever frequency of oscillator is varied.
- l. Set test oscillator to each frequency listed in Table 5-4. At each respective frequency, 333A/334A meter reading should be within tolerances listed in table.

5-10. FUNDAMENTAL REJECTION CHECK.

- a. Connect test equipment to 333A/334A as shown in Figure 5-2. Set filter pass frequency to 500 Hz.

NOTE

The test oscillator output is filtered so that the input to the 333A/334A is a pure ac signal.

- b. Set 333A/334A controls as follows:
 FUNCTION VOLTmeter
 METER RANGE 1 VOLT
 MODE MANUAL
 FREQUENCY RANGE X100
 Frequency Dial. 5
- c. Set test oscillator frequency to 500 Hz, and adjust amplitude for indication of 1.0 volt on meter of 333A/334A.
- d. Set 333A/334A FUNCTION switch to SET LEVEL, and set METER RANGE to 0.3 V. Adjust SENSITIVITY controls for 0dB indication on 333A/334A meter.

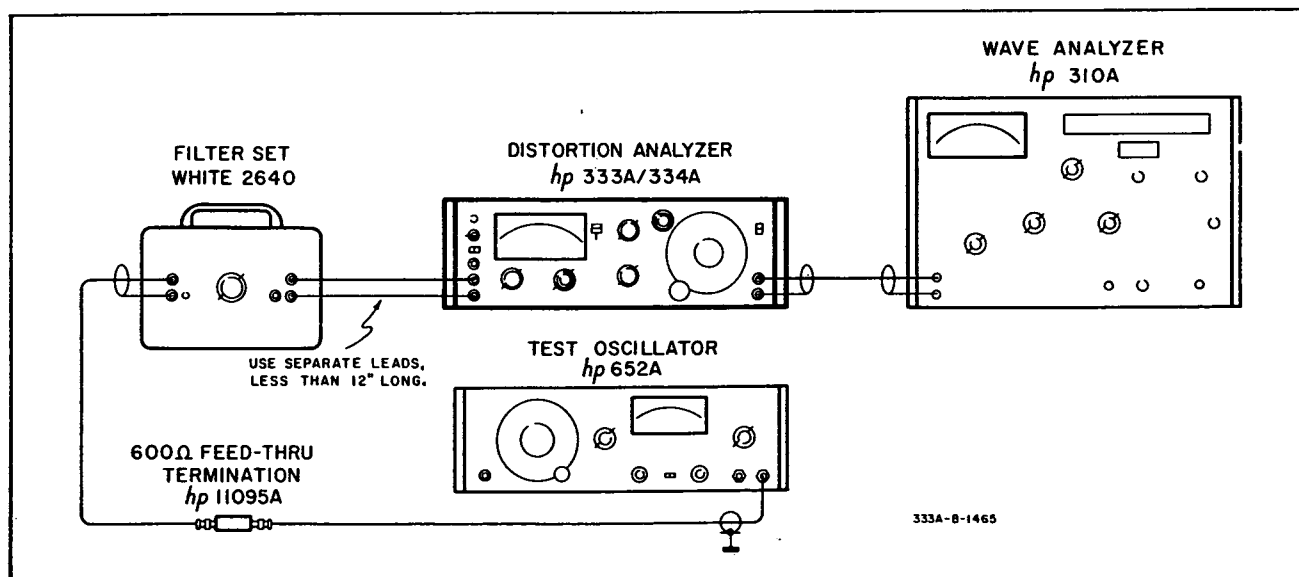


Figure 5-2. Fundamental Rejection Check

- e. Adjust wave analyzer controls for maximum reading (approximately 500 Hz), and use as 0dB reference.
- f. Set 333A/334A FUNCTION switch to DISTORTION.
- g. Adjust 333A/334A frequency dial vernier and BALANCE controls for minimum meter indication. When meter indication is less than 10% of SET LEVEL indication, set MODE switch to AUTOMATIC.
- h. Reduce 333A/334A METER RANGE switch setting as necessary to maintain on-scale meter indication.
- i. Observe wave analyzer meter, and reduce wave analyzer range setting as necessary to maintain on-scale meter indication.

— NOTE —

The 333A/334A OUTPUT is a 0 to 0.1 volt signal proportional to meter deflection, regardless of METER RANGE setting. Each decrease of the METER RANGE setting represents 10 dB fundamental rejection; therefore, the total fundamental rejection is the sum of the 333A/334A METER RANGE setting and the wave analyzer reading.

- j. The 333A/334A METER RANGE setting plus the wave analyzer reading should total more than -80 dB.
- k. Repeat steps b through j with 333A/334A and test equipment frequencies set to 5 kHz, 50 kHz, 250 kHz, and 600 kHz.

5-11. SECOND HARMONIC ACCURACY CHECK.

- a. Connect test oscillator 50Ω output, terminated in 50Ω load, to 333A/334A.
- b. Set 333A/334A controls as follows:
 FUNCTION SET LEVEL
 METER RANGE 0DB
 MODE MANUAL
 FREQUENCY RANGE X1
 Frequency Dial 15

- c. Set test oscillator frequency to 15 Hz at an amplitude of 1 volt.
- d. Adjust 333A/334A SENSITIVITY controls for 0dB indication on meter.
- e. Set 333A/334A FUNCTION switch to DISTORTION. Stepdown METER RANGE switch while adjusting frequency dial and vernier balance controls for best null indication on meter. Do not change frequency or balance settings after best null is obtained.
- f. Set 333A/334A FUNCTION switch to SET LEVEL, and set METER RANGE switch to 0dB.
- g. Set test oscillator frequency to 30 Hz, and adjust amplitude for 0dB indication on 333A/334A meter.
- h. Set 333A/334A FUNCTION switch to DISTORTION. Meter reading should not change more than +1 dB from 0dB reference.
- i. Repeat Steps b through h for each respective frequency and second harmonic listed in Table 5-3. 333A/334A meter readings should remain within tolerances listed in table.

Table 5-3. Second Harmonic Accuracy Check

333A/334A FREQUENCY	TEST OSCILLATOR FREQUENCY (Second Harmonic)	333A/334A TOLERANCES
10 kHz	20 kHz	<±0.6 dB
50 kHz	100 kHz	<-1.0 dB
200 kHz	400 kHz	<-2.0 dB
500 kHz	1 MHz	<-3.0 dB

5-12. INSTRUMENT INDUCED DISTORTION CHECK.

- a. Connect test equipment to 333A/334A as shown in Figure 5-3. Set filter pass frequency to 500 Hz.
- b. Set 333A/334A controls as follows:

FUNCTION SET LEVEL
 SENSITIVITY MAX.
 SENSITIVITY VERNIER MIN.
 METER RANGE 0DB
 MODE MANUAL
 FREQUENCY RANGE X100
 Frequency Dial 5

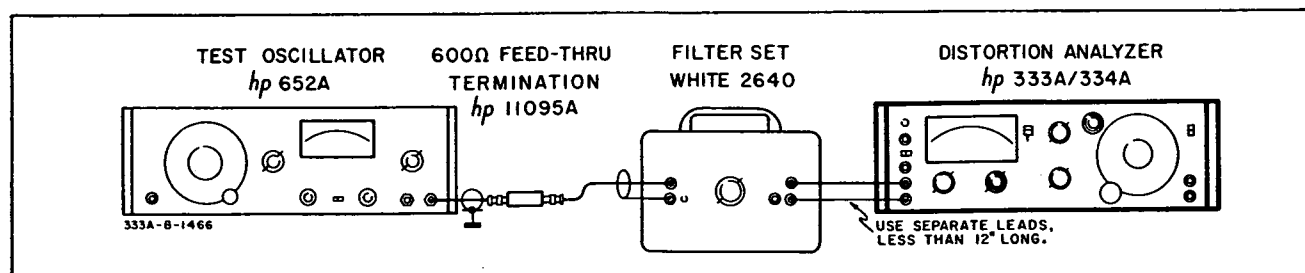


Figure 5-3. Instrument Induced Distortion Check

- c. Set test oscillator frequency to 500 Hz, and adjust amplitude for indication of +2 dB on 333A/334A meter.
- d. Set 333A/334A FUNCTION switch to DISTORTION.
- e. Adjust 333A/334A frequency dial vernier and BALANCE controls for minimum meter indication. When meter indication is less than 10% of SET LEVEL indication, set MODE switch to AUTOMATIC.
- f. Reduce 333A/334A METER RANGE setting as necessary to maintain on-scale meter indication.
- g. 333A/334A meter indication should be at least 70 dB below +2 dB reference.
- h. Repeat steps b through g with 333A/334A and test equipment frequencies set to 250 kHz and 600 kHz. 333A/334A meter indication should be at least 64 dB below +2 dB reference.

5-13. FREQUENCY CALIBRATION ACCURACY CHECK.

- a. Connect test equipment to 333A/334A as shown in Figure 5-4. Set electronic counter to read period.

NOTE

In this check, the 333A/334A frequency dial is held constant and the input frequency is varied

and monitored. If the dial is low, the input frequency will be high at null and vice versa.

- b. Set 333A/334A controls as follows:

FUNCTION SET LEVEL
SENSITIVITY MAX.
METER RANGE 0DB
MODE MANUAL
FREQUENCY RANGE X1
Frequency Dial 10

- c. Set test oscillator frequency to 10 Hz, and adjust amplitude for indication of +2 dB on 333A/334A meter.
- d. Set 333A/334A FUNCTION switch to DISTORTION.
- e. Do not adjust 333A/334A frequency controls. Adjust test oscillator frequency and 333A/334A BALANCE controls for minimum indication on 333A/334A meter.
- f. Repeat step e until best null is indicated on 333A/334A. Reduce METER RANGE setting as necessary to maintain on-scale meter indication.
- g. Electronic counter should indicate period of 100 msec $\pm$ 5 msec (10 Hz $\pm$ 5%).
- h. Set electronic counter to read frequency. Repeat Steps b through f for each frequency listed in Table 5-4. At each respective frequency setting, electronic counter should indicate that test oscillator frequency is within tolerances listed in table.

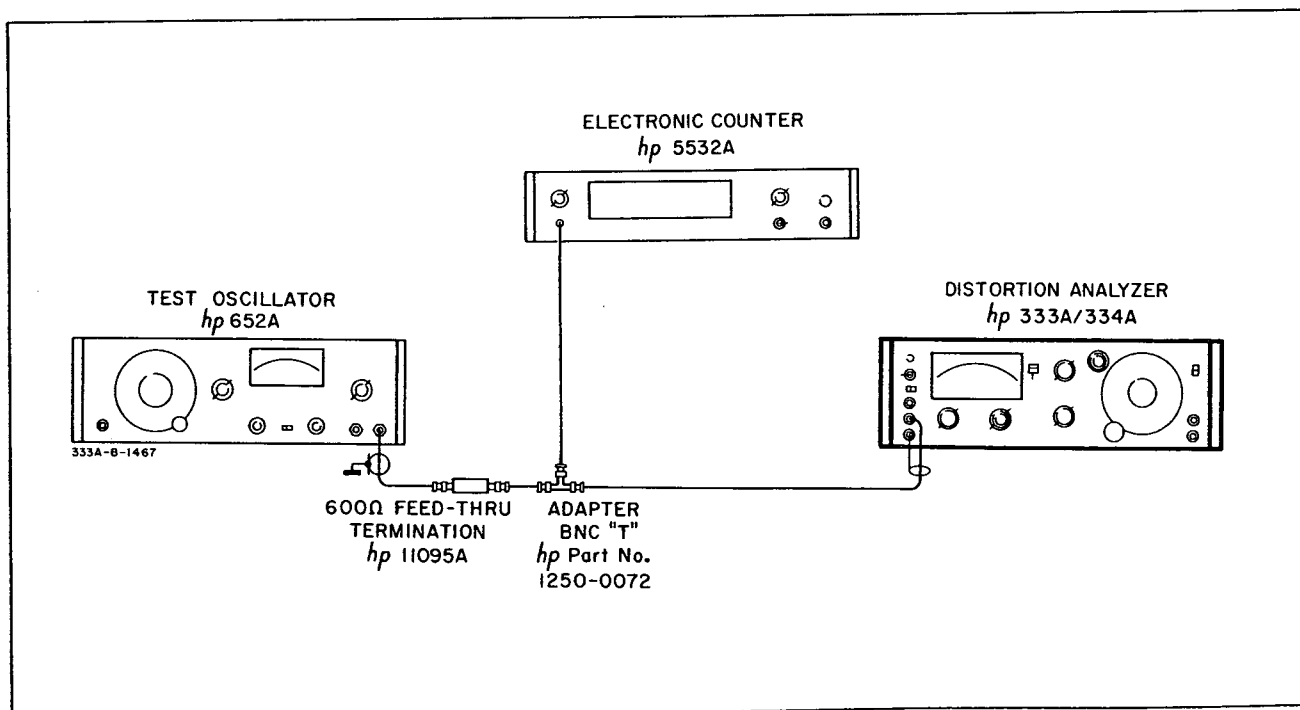


Figure 5-4. Frequency Calibration Accuracy Check

Table 5-4. Frequency Calibration Accuracy Check

333A/334A FREQUENCY	TEST OSCILLATOR FREQUENCY	ELECTRONIC COUNTER INDICATION
1 kHz	1 kHz	950 Hz to 1050 Hz
100 kHz	100 kHz	95 kHz to 105 kHz
200 kHz	200 kHz	190 kHz to 210 kHz
400 kHz	400 kHz	360 kHz to 440 kHz
600 kHz	600 kHz	540 kHz to 660 kHz

5-14. AUTOMATIC NULLING MODE CHECK.

- a. Connect 50 Ω output of test oscillator, terminated in 50 Ω load, to 333A/334A INPUT terminal.
- b. Set 333A/334A controls as follows:
 FUNCTION SET LEVEL
 METER RANGE SET LEVEL
 MODE MANUAL
 FREQUENCY RANGE X1
 Frequency Dial 25
- c. Set test oscillator frequency to 25 Hz at an amplitude of 1 V.
- d. Adjust SENSITIVITY controls for +2 dB indication on 333A/334A meter.
- e. Set 333A/334A FUNCTION switch to DISTORTION.
- f. Adjust 333A/334A frequency dial vernier and BALANCE controls for minimum meter indication. Reduce METER RANGE setting as necessary to maintain on-scale meter reading. Note meter reading.
- g. Set 333A/334A FUNCTION and METER RANGE switch, respectively, to SET LEVEL. Then set FUNCTION switch to DISTORTION.
- h. Adjust 333A/334A frequency dial vernier and BALANCE controls for meter indication of less than 3% of set level (+2 dB).
- i. Set 333A/334A MODE switch to AUTOMATIC. Reduce METER RANGE setting as necessary to maintain on-scale meter reading. Meter reading should be within +3 dB -0dB of manually nulled reading obtained in step f.
- j. Repeat steps b through i with 333A/334A frequency dial set to 50, and test oscillator frequency set to 50 Hz.
- k. Set 333A/334A controls as follows:
 FUNCTION SET LEVEL
 METER RANGE SET LEVEL
 MODE MANUAL
 FREQUENCY RANGE X10
 Frequency Dial 50

- l. Set test oscillator frequency to 500 Hz, at an amplitude of 1 V.
- m. Adjust SENSITIVITY controls for +2 dB indication 333A/334A meter.
- n. Set 333A/334A FUNCTION switch to DISTORTION.
- o. Adjust 333A/334A frequency dial vernier and BALANCE controls for minimum meter indication. Reduce METER RANGE setting as necessary to maintain on-scale meter reading. Note meter reading.
- p. Set 333A/334A FUNCTION and METER RANGE switch, respectively, to SET LEVEL. Then set FUNCTION switch to DISTORTION.
- q. Adjust 333A/334A frequency dial vernier and BALANCE controls for meter indication of less than 10% of set level (± 2 dB).
- r. Set 333A/334A MODE switch to AUTOMATIC. Reduce METER RANGE setting as necessary to maintain on-scale meter reading. Meter reading should be within +1.5 dB -0dB of manually nulled reading obtained in step o.
- s. Repeat steps k through r with 333A/334A and test oscillator frequency set to 5 kHz, 50 kHz, and 500 kHz.

5-15. INPUT IMPEDANCE CHECK.**5-16. RESISTANCE CHECK.**

- a. Connect 50 Ω output of test oscillator, terminated in 50 Ω load, to 333A/334A INPUT terminals.
- b. Set 333A/334A controls as follows:
 FUNCTION VOLTMETER
 SENSITIVITY MAX.
 SENSITIVITY VERNIER MAX.
 METER RANGE 1 VOLT
- c. Set test oscillator frequency to 100 Hz, and adjust amplitude for indication of 1 volt on 333A/334A meter.
- d. Connect a 100 k Ω resistor in series with 333A/334A input.
- e. 333A/334A meter indication should be between 0.85 V and 0.95 V. This verifies an input resistance of 1 M $\Omega \pm 5\%$ in voltmeter function.
- f. Remove 100 k Ω resistor, and reconnect oscillator to 333A/334A.
- g. Set 333A/334A FUNCTION switch to SET LEVEL, and set METER RANGE switch to 0.1 VOLT.
- h. Adjust 333A/334A SENSITIVITY controls for meter indication of 0.1 V.

- i. Connect 100 k Ω resistor in series with 333A/334A input.
- j. 333A/334A meter indication should be between 85 mV and 95 mV. This verifies an input resistance of 1 M Ω $\pm$ 5% in set level and distortion functions.

5-17. CAPACITANCE CHECK.

- a. Connect 50 Ω output of test oscillator, terminated in 50 Ω load, and 10 k Ω resistor to 333A/334A as shown in Figure 5-5. Connect the resistor lead to the INPUT terminal of the 333A/334A, and insert the other lead directly into the 50 Ω load. Connect the ground lead from the 333A/334A to the outer shield of the 50 Ω load; do not use an adapter, as it would add capacitance.
- b. Set 333A/334A controls as follows:
 FUNCTION VOLTMETER
 SENSITIVITY MAX.
 SENSITIVITY VERNIER MAX.
 METER RANGE 1 VOLT
- c. Set test oscillator to 100 Hz and adjust amplitude for 333A/334A meter indication of 1V. Set a reference on meter of test oscillator and use amplitude control to maintain set reference whenever frequency of oscillator is varied.
- d. Increase frequency of test oscillator to 540 (455) kHz. 333A (334A) meter indication should be 0.707 V or greater, verifying an input capacitance of 30 (35) pF or less on 1 V range in voltmeter function.
- e. Set 333A/334A METER RANGE switch to 0.1 V range.
- f. Set test oscillator to 100 Hz and adjust amplitude for 333A/334A meter indication of 0.1V. Set a reference on meter of test oscillator and use amplitude control to maintain set reference whenever frequency of oscillator is varied.
- g. Increase frequency of test oscillator to 230 kHz. 333A/334A meter indication should be 70.7 mV or greater, verifying an input capacitance of 70 pF or less on 0.1 V range in voltmeter function.

- h. Set 333A/334A FUNCTION switch to SET LEVEL.
- i. Set test oscillator to 100 Hz and adjust amplitude for 333A/334A meter indication of 0.1 V. Set a reference on meter of test oscillator and use amplitude control to maintain set reference whenever frequency of oscillator is varied.
- j. Increase frequency of test oscillator to 230 kHz. 333A/334A meter indication should be 70.7 mV or greater, verifying an input capacitance of 70 pF or less in set level and distortion functions.

5-18. MINIMUM INPUT LEVEL CHECK.

- a. Connect 50 Ω output of test oscillator, terminated in 50 Ω load, to 333A/334A INPUT terminals.
- b. Set 333A/334A controls as follows:
 FUNCTION VOLTMETER
 SENSITIVITY MAX.
 SENSITIVITY VERNIER MAX.
 METER RANGE 0.3 VOLTS
- c. Set test oscillator to 400 Hz and adjust amplitude for 333A/334A meter indication of 0.3 V.
- d. Set 333A/334A FUNCTION switch to SET LEVEL.
- e. 333A/334A should indicate full scale or greater.

5-19. DC ISOLATION CHECK.

- a. Set the 6515A to zero output, and connect test equipment to 333A/334A as shown in Figure 5-6.

WARNING

REMOVE SHORTING BAR BETWEEN CHASSIS GROUND (∇) AND FRAME GROUND ($\perp$) ON 333A/334A INPUT TERMINALS.

- b. Set 333A/334A controls as follows:

FUNCTION VOLTMETER
 METER RANGE 1 VOLT

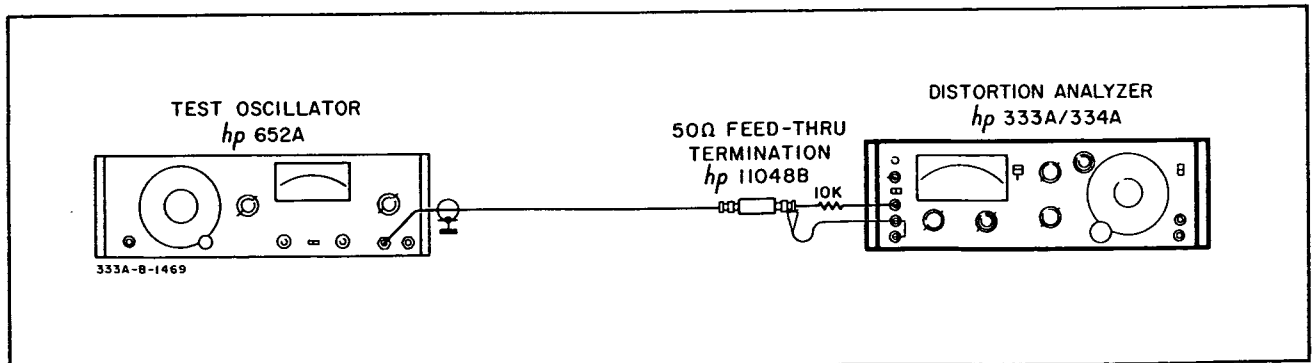


Figure 5-5. Capacitance Check

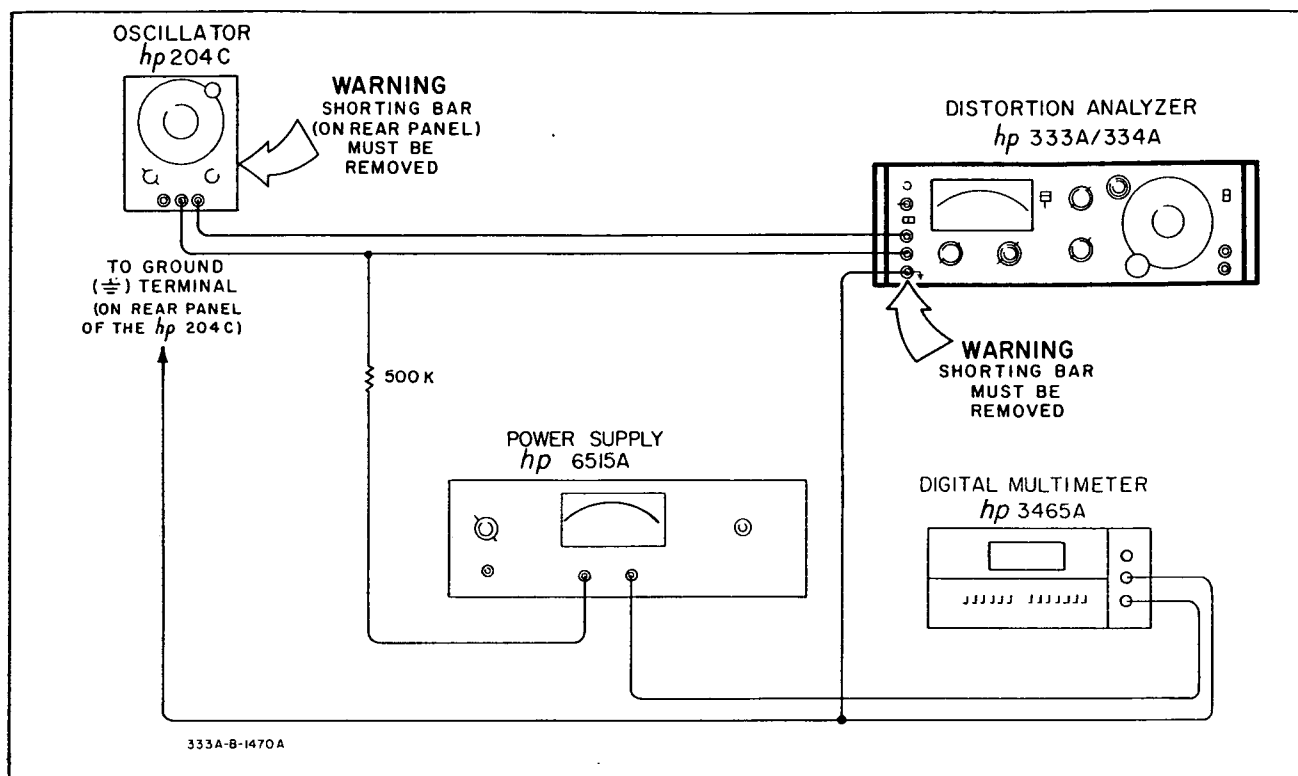


Figure 5-6. DC Isolation Check

- c. Set oscillator to 1 kHz, and adjust amplitude for 333A/334A meter indication of 0.9 V.
- d. Set power supply to ± 400 VDC. 333A/334A meter indication should not change. There should be approximately 0.27 mA indicated on the Multimeter's 1 mA range.

5-20. HIGH PASS FILTER CHECK.

- a. Connect 50 Ω output of test oscillator, terminated in 50 Ω load, to INPUT terminals of 333A/334A.
- b. Set 333A/334A controls as follows:
 FUNCTION SET LEVEL
 METER RANGE SET LEVEL
 HIGH PASS FILTER IN
- c. Set test oscillator to 5 kHz at an amplitude of 0.3 V. Set a reference on meter of test oscillator and use amplitude control to maintain set reference whenever frequency of oscillator is varied.
- d. Adjust 333A/334A SENSITIVITY controls for meter indication of 0dB.
- e. Set test oscillator to 1 kHz.
- f. Reading on 333A/334A meter should be within 0.5 dB of 0 dB setting.
- g. Set test oscillator to 60 Hz.

- h. Reading on 333A/334A meter should be at least 40 dB below 0 dB setting.

5-21. RESIDUAL NOISE CHECK.

- a. Connect a shielded 600 Ω load across 333A/334A INPUT terminals. (See Figure 5-7 for details on constructing shielded load). Be sure that shorting bar is connected between chassis ground and circuit ground on INPUT terminals.
- b. Set 333A/334A controls as follows:
 FUNCTION VOLTMETER
 METER RANGE 0.0003 VOLTS
- c. Meter should indicate less than 25 μ V.
- d. Remove 600 Ω load. Connect a shielded 100 k Ω load across INPUT terminals. (See Figure 5-7 for details on constructing shielded load).
- e. Meter should indicate less than 30 μ V.

5-22. AM DETECTOR CHECK (Model 334A only).

- a. Connect high frequency signal generator 50 Ω RF output to 334A R. F. INPUT terminal.
- b. Set 334A controls as follows:
 FUNCTION SET LEVEL
 NORM. - R. F. DET. R. F. DET.
 METER RANGE SET LEVEL
 MODE. MANUAL
 FREQUENCY RANGE X100
 Frequency Dial 10

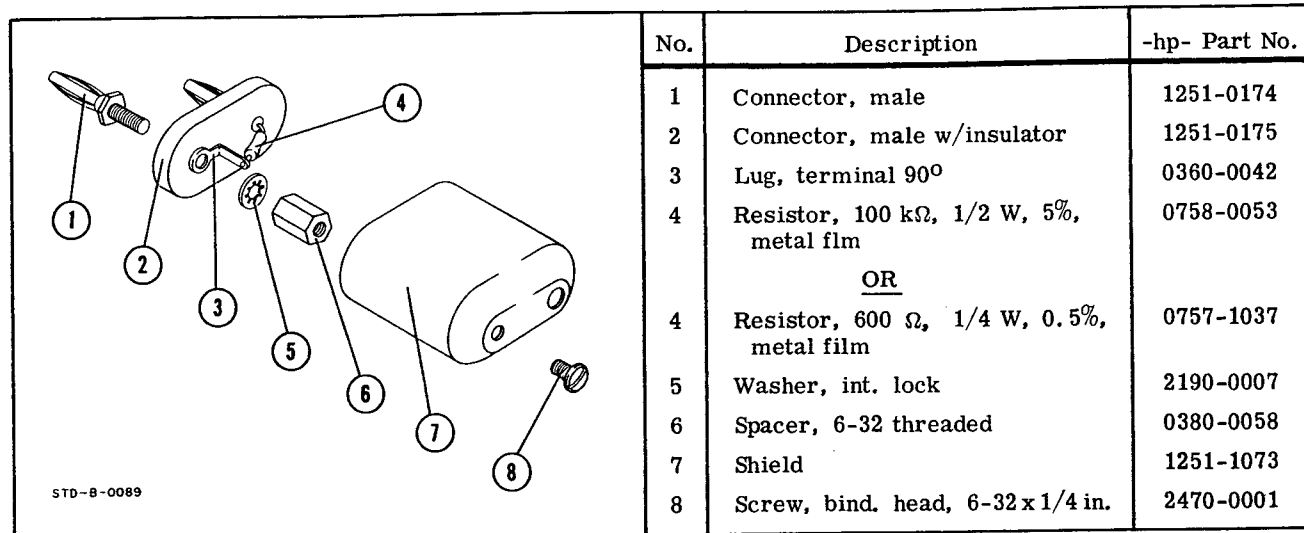


Figure 5-7. Shielded Load Assembly

- c. Set high frequency signal generator to 1 MHz at an amplitude of 3 V. Modulate high frequency signal generator output 30% at 1 kHz, using a test oscillator.
- d. Adjust 334A SENSITIVITY controls for 0dB meter indication.
- e. Set 334A FUNCTION switch to DISTORTION.
- f. Adjust 334A frequency dial vernier and balance controls for minimum meter indication.
- g. Distortion should be more than 40 dB below 0dB reference.

5-23. ADJUSTMENT AND CALIBRATION PROCEDURE.

5-24. The following is a complete adjustment and calibration procedure for the 333A and 334A. Before proceeding with these adjustments, the Performance Checks should be performed to determine whether adjustments are necessary. If your instrument does not meet the test limits specified in the following steps, refer to Troubleshooting Procedure, Paragraph 5-34. Adjustment locations are shown in Figure 5-8.

5-25. The adjustment and Calibration Procedure is performed with the ac power cord connected to nominal line voltage (115 V/230 V) 48 to 66 Hz, MODE

switch to MANUAL, HIGH PASS FILTER TO OUT, and NORM. -R. F. DET. switch to NORM, unless otherwise specified.

5-26. POWER SUPPLY AND BIAS ADJUSTMENTS.

- a. Remove top and bottom covers.
- b. Secure shorting bar between chassis ground and circuit ground INPUT terminals.
- c. Connect common lead of a dc voltmeter to either INPUT ground terminal.
- d. Perform the measurements and adjustments listed in Table 5-5.



DO NOT ALLOW PROBE TO SHORT A2TP1 TO GROUND. IF THIS HAPPENS, A2Q4 MAY BE DESTROYED.

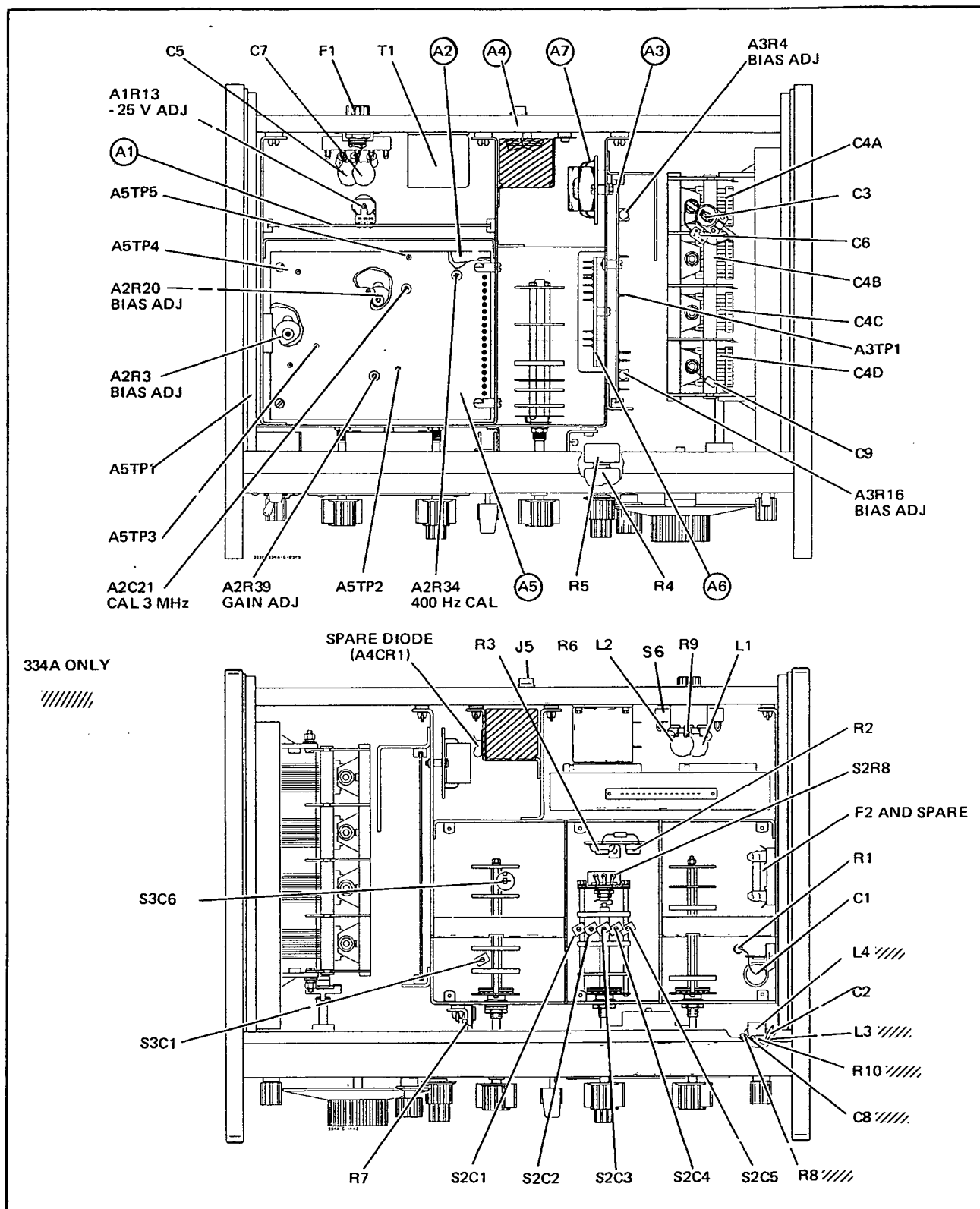
5-27. VOLTMETER GAIN ADJUSTMENTS.

- a. Connect voltmeter calibrator to 333A/334A as shown in Figure 5-1.
- b. Set Distortion Analyzer controls as follows:
FUNCTION VOLTMETER
METER RANGE 0.001 VOLTS

Table 5-5. Power Supply and Bias Adjustments

MEASUREMENT POINT	VOLTAGE LIMITS	ADJUSTMENT	REGULATION (vary line voltage between 103.5 and 126.5 VAC)
Any violet wire	-25 V ± 0.5 V	A1R13	-25 V ± 0.25 V
Any red wire	+25 V ± 1.0 V	None*	+25 V ± 1.0 V
A2 TP1	-11.3 V	A2R3	-11.3 V ± 0.1 V
A2 TP2	+8.2 V ± 0.5 V	A2R20	+8.2 V ± 0.5 V
A3 TP1	+2.65 V ± 0.2 V	A3R4	+2.65 V ± 0.2 V
A3 TP2	-19.5 V ± 0.5 V	A3R16	-19.5 V ± 0.5 V

* Referenced to -25 volt supply; -25 volt supply must be adjusted first.



- c. Set voltmeter calibrator to 1 mV rms output at 400 Hz.
- d. Adjust A2R34 (400 Hz CAL.) for a meter indication of 1.0 mV.
- e. Set Voltmeter Calibrator to 0.3 mV rms output. Set 333A/334A METER RANGE switch to 0.0003 VOLTS.
- f. The meter should indicate $300 \mu\text{V} \pm 6 \mu\text{V}$ ($\pm 2\%$). If necessary, change value of A2R30* to set reading within these limits. Typical values for this resistor are from 150Ω to 300Ω . Increasing resistance decreases the meter reading, and vice versa.

5-28. VOLTMETER FREQUENCY RESPONSE ADJUSTMENT.

- a. Connect test oscillator to 333A/334A as shown in Figure 5-1.

NOTE

Cover plate (Item 33 in Figure 6-1) must be in place before performing these adjustments.

- b. Set 333A/334A controls as follows:
FUNCTION VOLTMETER
METER RANGE 0.0003 VOLTS
- c. Set test oscillator to 400 Hz, and adjust amplitude for 333A/334A meter indication of $300 \mu\text{V}$. Set a reference on meter of test oscillator and use amplitude control to maintain set reference whenever frequency of oscillator is varied.
- d. Set test oscillator frequency to 20 Hz.
- e. 333A/334A meter should indicate $300 \mu\text{V} \pm 15 \mu\text{V}$. If reading exceeds these limits, change value of A2C30*. Typical values for this capacitor are between $10 \mu\text{F}$ and $50 \mu\text{F}$.
- f. Set 333A/334A METER RANGE switch to 1 VOLT.
- g. Disconnect test oscillator, and connect voltmeter calibrator to 333A/334A as shown in Figure 5-6.
- h. Set voltmeter calibrator to 0.9 V rms at 400 Hz. Note 333A/334A meter reading.
- i. Disconnect voltmeter calibrator and connect test oscillator to 333A/334A.
- j. Set test oscillator frequency to 400 Hz, and adjust amplitude so that 333A/334A meter reading is same as in step h. Set a reference on meter of test oscillator and use amplitude control to maintain set reference whenever frequency of oscillator is varied.

- k. Set test oscillator frequency to 2 MHz, and attenuate output by 40 dB, maintaining reference set in step j.
- l. Set 333A/334A METER RANGE switch to 0.01 VOLTS.
- m. Adjust A2R39 for 333A/334A meter indication of 9 mV.
- n. Set test oscillator frequency to 3 MHz.
- o. Adjust A2C21 for 333A/334A meter indication of 9 mV.

NOTE

Adjustments of A2R39 and A2C21 interact. Therefore, it may be necessary to repeat the two adjustments to bring both within tolerance.

- p. Set 333A/334A METER RANGE switch to .3 VOLTS.
- q. Disconnect test oscillator, and connect voltmeter calibrator to 333A/334A.
- r. Set voltmeter calibrator to 0.3V rms at 400 Hz. Note 333A/334A meter reading.
- s. Disconnect voltmeter calibrator, and connect test oscillator to 333A/334A.
- t. Set test oscillator frequency to 400 Hz, and adjust amplitude until 333A/334A meter indication is same as in step r. Set a reference on meter of test oscillator and use amplitude control to maintain set reference whenever frequency of oscillator is varied.
- u. Set test oscillator frequency to 2.5 MHz.
- v. Adjust S3C6 for 333A/334A meter indication of 0.3 V.
- w. Set 333A/334A METER RANGE switch to 3 VOLTS.
- x. Set test oscillator frequency to 200 kHz, and increase amplitude by 20 dB, maintaining reference set in step t.
- y. Adjust S3C1 for 333A/334A meter indication of 3 V.

5-29. BRIDGE BALANCE ADJUSTMENT.



MAINTAIN THE LEAD DRESS TO C3 AND THE TUNING CAPACITOR, C4. ANY CHANGE IN LEAD DRESS WILL CAUSE A CHANGE IN CAPACITANCE.

- a. Connect test equipment to 333A/334A as shown in Figure 5-4.
- b. Set 333A/334A controls as follows:
FUNCTION SET LEVEL

SENSITIVITY VERNIER MIN.
 SENSITIVITY 1 step counterclockwise
 METER RANGE SET LEVEL
 MODE MANUAL
 FREQUENCY RANGE X1K
 Frequency Dial 60

- c. Turn slot on trimmer capacitor C3 parallel with side casting of instrument.
- d. Set test oscillator frequency to 60 kHz, and adjust amplitude for indication of +2 dB on 333A/334A meter.
- e. Set 333A/334A COARSE and FINE BALANCE controls to center of range.
- f. Set 333A/334A FUNCTION switch to DISTORTION.
- g. Adjust test oscillator frequency vernier control and C3 for definite null indication on meter of 333A/334A. Reduce METER RANGE setting as necessary to maintain on-scale reading.
- h. Observe electronic counter indication. If test oscillator frequency is not between 57 kHz and 63 kHz, 333A/334A frequency dial is out of tolerance. Follow steps below to bring frequency dial within tolerance:
 - 1) Set 333A/334A controls as in step b. Set test oscillator frequency for electronic counter indication of 60.00 kHz, and adjust amplitude for indication of +2 dB on meter of 333A/334A.
 - 2) Set 333A/334A COARSE and FINE BALANCE controls to center of range.
 - 3) Adjust 333A/334A frequency dial vernier control for definite null.
 - 4) Remove knob from frequency dial. Do not change tuning capacitor, C4, setting.
 - 5) Loosen retaining screws in frequency dial plate, and slip dial until 60 is directly under mark on indicator. Be careful not to change C4 setting.
 - 6) Tighten retaining screws and replace knob.

5-30. SENSITIVITY SWITCH CALIBRATION.

- a. Connect test oscillator to 333A/334A as shown in Figure 5-1.

NOTE

Selector positions for the SENSITIVITY selector will be referred to as follows: MIN = Position 1, next step = Position 2, etc., to MAX = Position 6.

- b. Set Distortion Analyzer controls as follows:

FUNCTION SET LEVEL
 METER RANGE 0.01 VOLTS
 SENSITIVITY Position 5
 SENSITIVITY VERNIER MAX.
- c. Set test oscillator frequency to 400 Hz, adjust amplitude for indication of 9 mV on 333A/334A meter.
- d. Set a reference on meter of test oscillator and use amplitude control to maintain set reference whenever frequency of oscillator is varied.
- e. Set test oscillator frequency to 100 kHz.
- f. Adjust S2C5 for 333A/334A meter indication of 9 mV.
- g. Set 333A/334A SENSITIVITY switch to each position listed in Table 5-6, and increase test oscillator output by 10 dB for each respective decrease in SENSITIVITY switch position. Adjust appropriate capacitor for 333A/334A meter indication of 9 mV at each setting.

NOTE

When switching the SENSITIVITY positions, be careful not to move SENSITIVITY VERNIER control from MAX. position.

5-31. ADJUSTMENT OF FACTORY SELECTED COMPONENTS.

5-32. Certain components in the Model 333A/334A are individually selected to compensate for varying circuit parameters. These components are designated by an asterisk (*) on the schematic and in the parts list, and the typical value is shown. Table 5-7 describes the function of the factory selected components and lists their value ranges.

5-33. TROUBLESHOOTING PROCEDURES.

5-34. This section contains procedures designed to assist in the isolation of malfunctions. These procedures are based on a systematic analysis of the instrument circuits in an effort to localize the prob-

Table 5-6. Sensitivity Switch Calibration

SENSITIVITY Switch	TEST OSCILLATOR OUTPUT (Increase)	ADJUST FOR 9 mV
Position 4	+10 dB	S2C4
Position 3	+20 dB	S2C3
Position 2	+30 dB	S2C2
Position 1	+40 dB	S2C1

lem. These operations should be undertaken only after it has been established that the difficulty cannot be eliminated by the Adjustment and Calibration Procedures. An investigation should also be made to insure that the trouble is not a result of conditions external to the 333A/334A.

5-35. Conduct a visual check of the 333A/334A for possible burned or loose components, loose connections, or any other obvious condition which might suggest a source of trouble.



THE 333A/334A CONTAINS VERY HIGH IMPEDANCE, HIGH FREQUENCY CIRCUITS. CONTAMINATION OF THE SWITCHES, CIRCUIT BOARDS OR TUNING CAPACITOR WILL CAUSE HIGH IMPEDANCE LEAKAGE PATHS AND SUBSEQUENT DETERIORATION OF THE PERFORMANCE OF THE INSTRUMENT. AVOID TOUCHING ANY OF THESE CIRCUITS WITH THE BARE FINGERS, AS SKIN OILS ARE EXTREMELY CONTAMINATING.

5-36. Table 5-8 contains a list of typical front panel and internal trouble symptoms, as well as the probable cause of trouble. If the instrument malfunction cannot be located through use of the table, refer to Paragraphs 5-38 through 5-44.

5-37. Trouble in the Model 333A/334A can generally be isolated to circuits of one of the two principle instrument functions-voltmeter or distortion. In order for the distortion function to operate properly, the voltmeter function must operate properly. Therefore, troubleshoot the voltmeter function first to assure that it works normally before attempting to locate a trouble in the distortion function.

5-38. TROUBLESHOOTING VOLTMETER FUNCTION.

5-39. Follow the steps below to troubleshoot the voltmeter function:

a. Set 333A/334A controls as follows:

FUNCTION VOLTMETER
METER RANGE. 1 VOLT
Connect a 1 V rms, 1 kHz signal to 333A/
334A INPUT TERMINALS.

b. Measure ac output of impedance converter at A2-pin 4 for approximately 1 mV rms (Use 10 M Ω /10 pF impedance probe). If proper signal is present, proceed to step c; if not proceed to step d.

c. Measure ac input to meter amplifier at A2-pin 6 for approximately 1 mV rms. If proper signal is present, check meter amplifier circuit. (See schematic diagram of Fig-

Table 5-7. Factory Selected Components

COMPONENT	FUNCTION	VALUE		
		Low	Normal	High
A2C22*	Sets range of A2C21	0 pF	47 pF	47 pF
A2C23*	Adjusts meter frequency response in 2 MHz region	100 pF	240 pF	320 pF
A2C30*	Adjusts meter frequency response in 20 Hz region	10 μ F	22 μ F	50 μ F
A2C29*	Adjusts meter flatness on 0.0003 V range at 300 kHz	0 pF	390 pF	680 pF
A2R30*	Adjusts meter amplifier gain on 0.0003 V range at 400 Hz.	150 Ω	300 Ω	300 Ω
A3C11*	Adjusts bridge amplifier frequency response in 1 MHz to 3 MHz region	56 pF	127 pF	127 pF
A3R17*	Adjusts gain of rejection amplifier	1 k Ω	2 k Ω	3 k Ω
C9*	Adjusts tracking of frequency dial	0 pF	2.2 pF	6.8 pF
R3*	Adjusts range of S2R8	0 Ω	390 Ω	390 Ω
S3R14*	Adjusts flatness of 1000:1 attenuator in 2 MHz to 3 MHz region	7.5 Ω	10 Ω	10 Ω
S4R6* through S4R26*	Must be individually matched to be $\pm 1/4\%$	--	--	--

Table 5-8. Troubleshooting Aid

SYMPTOM	PROBABLE CAUSE
1. FRONT PANEL SYMPTOMS	
A. No meter deflection with signal at input; ON lamp not illuminated. (ALL FUNCTIONS).	Check Fuse (F1).
B. No meter deflection with signal at input; Output normal. (All FUNCTIONS).	Check M1.
C. Will not null manually; VOLTMETER and SET LEVEL FUNCTIONS normal.	Check A4AF, C4A-D, C3, R4, R5, A6DS1, and A6V1.
D. No SENSITIVITY VERNIER control in SET LEVEL mode.	Check R2, R3, and S2R8.
E. BALANCE controls erratic. (DISTORTION FUNCTION only).	Check R4 and R5.
F. No meter deflection with RF input. (R. F. DET. only).	Check diode A4CR1. Spare diode located on outside of A4 shield.
G. Low meter reading with input signal frequency below 1 kHz. (Set Level Function only).	Check to see if high pass filter is in the OUT position.
2. INTERNAL ADJUSTMENT SYMPTOMS	
A. Insufficient -25 volts adjustment with A1R13, measured at any violet wire.	Check A1C1, A1C11, A1CR3, A1CR4, A1CR7 and A1Q4 through A1Q6.
B. +25 volts supply out of specs, measured at any red wire.	Check -25 volts (see Symptom 2-A above), A1C2, A1C6, A1CR1, A1CR2 and A1Q1 through A1Q3.
C. Insufficient bias adjustment with A2R3, measured at A2TP1.	Check -25 volts (see Symptom 2-A above), A2C4, A2C14 and A2Q1 through A2Q4.
D. Insufficient bias adjustment with A2R20, measured at A2TP2.	Check -25 volts (see Symptom 2-A above), +25 volts (see Symptom 2-B above), A2C15, A2Q5 through A2Q9.
E. Insufficient 400 Hz adjustment with A2R34.	Check +8.2 volts bias (see Symptom 2-D above), check for -4 Vdc at + meter terminal and Check M1.
F. Insufficient gain adjustment with A2R39.	Check A2Q5 through A2Q9, and A2C23.
G. Insufficient 3 MHz calibration adjustment with A2C21.	Check A2C22. (Increasing value of capacitor will decrease meter reading).
H. Insufficient bias adjustment with A3R4, measured at A3TP1.	Check -25 volts (see Symptom 2-A above), +25 volts (see Symptom 2-B above), A3C1, A3C6 and A3Q1 through A3Q3.
J. Insufficient bias adjustment with A3R16, measured at A3TP2.	Check -25 volts (see Symptom 2-A above), A3C7, and A3Q4 through A3Q6. Change A3R17. (Increasing value of resistor will increase voltage at A3TP2.)

ure 7-4 for ac and dc voltage levels on meter amplifier). If proper signal is not present, check post attenuator.

- d. Measure ac input to impedance converter at A2-pin 1 for approximately 1 mV rms. If proper signal is present, check impedance converter and power supply. (See appropriate schematic diagrams for ac and dc voltage levels in impedance converter and power supply). If proper signal is not present, check input attenuator and FUNCTION switch.

5-40. TROUBLESHOOTING DISTORTION FUNCTION.

5-41. Follow the steps below to troubleshoot the distortion function by first troubleshooting the rejection amplifier and then the automatic control circuit.

5-42. REJECTION AMPLIFIER.

- a. Set 333A/334A controls as follows:

FUNCTION VOLTMETER
MODE MANUAL
METER RANGE 3 VOLTS
SENSITIVITY MAX.
SENSITIVITY VERNIER MAX.
FREQUENCY RANGE X1K
Frequency Dial 5
Connect a 1 kHz signal to 333A/334A INPUT, and adjust amplitude for 0dB indication 333A/334A meter.

- b. Set 333A/334A FUNCTION to SET LEVEL.

333A/334A meter should indicate between +0.5 dB and +0.8 dB, verifying gain in rejection amplifier. If sufficient gain is present, check Wien bridge circuit. If sufficient gain is not present, proceed with the following steps.

- c. Set amplitude of 1 kHz input signal to .3V rms. Measure ac signal at A3-pin 7 for approximately 185 mV rms (use a 10 M Ω /10 pF impedance probe). This voltage will increase to approximately 2.4 V in distortion mode at null. If proper voltage is present, proceed to step d; if not, go to step f.
- d. Measure ac output of rejection amplifier at A3-pin 2 for approximately 0.32 V rms. If proper voltage is present, check high pass filter and switch, and check function and meter range switch connections. If proper voltage is not present, go to step e.
- e. Measure ac signal at A3-pin 8 for approximately 315 mV rms (use a 10 M Ω /10 pF probe, and be sure that Wien bridge is detuned with 1 kHz input and 333A/334A frequency at 5 kHz). If proper voltage is present, check A3Q4 through A3Q6 and associated circuitry. If proper voltage is not present, check Wien bridge circuit.
- f. Measure ac input to rejection amplifier at A3-pin 1 for approximately 0.29 V rms. If proper voltage is present, check A3Q1 through A3Q3 and associated circuitry. If proper

Table 5-8. Troubleshooting Aid (Cont'd)

SYMPTOM	PROBABLE CAUSE
3. AUTOMATIC MODE INOPERATIVE	
A. No indication of square wave reference voltage (frequency of fundamental of the input signal) at A5TP1 and A5TP4.	Check A5Q7.
B. No indication of square wave at A5TP4. A5TP1 normal square wave indication.	Check A5Q15 through A5Q18, and A5Q12.
C. No indication of square wave at A5TP1. A5TP4 normal square wave indication.	Check A5Q8, A5Q9, and A5Q4.
D. No bridge error signal at A5TP2 or A5TP5.	Check A2R50 and A5Q1.
E. No indication of "chopped" sine wave (frequency of fundamental of the input signal) at A2TP2. A5TP2 normal.	Check A5Q2 thru A5Q4.
F. No indication of "chopped" sine wave at A5TP5, A5TP2 indication normal.	Check A5Q10 thru A5Q12.
G. Normal indication at A5TP1, TP2, TP4 and TP5.	Check A5Q5, A5Q6, A5Q13, and A5Q14.
H. Drifts off null on any one frequency range.	Check for open capacitor (S4C1-C5) on frequency range with problem.

voltage is not present, check sensitivity vernier and check function switch connections.

5-43. AUTOMATIC CONTROL CIRCUIT.

5-44. The automatic control circuit is made up of two control loops—resistive and reactive—that are identical with the exception of the 90° phase lag circuit in the reactive loop. The following steps list a procedure for checking the resistive loop only; however, the same general procedure can be used to check the reactive loop. Refer to the schematic diagram of Figure 7-5 for circuit voltages and waveforms, as well as the 333A/334A control settings.

- a. Check waveform at A5TP1. If proper waveform is present, proceed to step b; if not go to step f.
- b. Check waveform at A5TP2. If proper waveform is present, proceed to step c; if not go to step e.
- c. Measure dc voltage at A5—pin 17 for approximately +16V (manual mode). Set FUNCTION to DISTORTION, and manually null the input signal. Set MODE to AUTOMATIC, turn BALANCE COARSE control fully counterclockwise and check for approximately +20 Vdc at A5—pin 17. Then turn BALANCE COARSE control fully clockwise and check for approximately +12 Vdc at A5—pin 17. If proper voltages are present, check photoresistors as outlined in Paragraph 5-46. If proper voltages are not present, go to step d.
- d. Measure dc voltage at A5TP3 for approximately -0.5 V (manual mode). Set MODE to AUTOMATIC, turn BALANCE COARSE control fully counterclockwise and check for approximately -1 Vdc at A5TP3, then turn BALANCE COARSE control fully clockwise and check for 0 Vdc at A5TP3. If proper voltages are present, check A5Q6. If proper voltages are not present, check A5Q5 and check MODE switch connections.
- e. Check waveform at A5—pin 16. If proper waveform is present, check A5Q1 through A5Q4 and associated circuitry. If proper waveform is not present, check A2R50.
- f. Check waveform at negative side of A5C10. If proper waveform is present, check A5Q7 through A5Q9 and associated circuitry. If proper waveform is not present, check R6.

5-45. PHOTORESISTOR CHECK AND ADJUSTMENT (A6V1 thru A6V5).

5-46. The following steps give a procedure for checking, and if necessary, adjusting the photoresistors in the Wien bridge balancing circuit. Paragraph 5-48 tells how to check the resistance of each individual photoresistor. If a photoresistor is not within tolerance, adjust the resistance of it according to the steps in Paragraph 5-48.

5-47. PHOTORESISTOR CHECK.

- a. Turn 333A/334A off, and set MODE to MANUAL and FREQUENCY RANGE to X1K.
- b. Disconnect all wires to A6 board except to pins 6, 7, and 8 (lamp drive voltage connections).
- c. Turn 333A/334A on, and check value of photoresistors at pins listed in Table 5-9. Allow a tolerance of $\pm 20\%$ on values.

Table 5-9. Photoresistor Check

PHOTORESISTOR	PINS (A6)	RESISTANCE
V1	9, 10	30 k Ω
V2	2, 3	15 k Ω
V3	1, 10	15 k Ω
V4	3, 4	150 k Ω
V5	5, 10	150 k Ω

- d. If any resistance value is out of tolerance, refer to Paragraph 5-48. If all values are within tolerance, reconnect wires to A6 board. (See Figure 7-1 for wire color code diagram of A6 board).

5-48. PHOTORESISTOR ADJUSTMENT.

NOTE

If the photoresistors are adjusted, perform the Bridge Balance Adjustment, Paragraph 5-30.

- a. Turn 333A/334A off, and set MODE to MANUAL and FREQUENCY to X1K.
- b. Disconnect all wires to A6 board except to pins 6, 7, and 8 (lamp drive voltage connections).
- c. Remove A6 board mounting screw (access to mounting screw is through hole in A3 board). Remove screw which holds plastic cover to A6 board, and remove plastic cover.
- d. Adjust resistance of photoresistors by repositioning individual photoresistor around light source. If resistance is low, move photoresistor away from light source; if resistance is high, move photoresistor closer to light source. After repositioning a photoresistor, replace plastic cover on A6 boards so that photoresistor is not affected by outside light. Then measure resistance of photoresistor.
- e. If an individual photoresistor cannot be adjusted within tolerance, replace the photoresistor.
- f. After adjusting photoresistors, replace screw securing plastic cover to A6 board and replace A6 mounting screw. Reconnect wires to A6 board (See Figure 7-1 for wire color code diagram of A6 board).

5-49. SERVICING ETCHED CIRCUIT BOARDS.

5-50. The Model 333A has six-etched circuit boards and the Model 334A has seven. Use caution when removing them to avoid damaging mounted components. The -hp- part number for the assembly is marked on the circuit board to identify it. Refer to Section VI for parts replacement and -hp- part number information.

5-51. The etched circuit boards are of the plated-through type. The electrical connection between the two sides of the board is made by a layer of metal plated through the component hole. When working on these boards, observe the following rules:

- a. Use a low-heat (25 to 30 watts) small-tip soldering iron, and a small diameter rosin core solder.
- b. Remove circuit components by placing the soldering iron on the component lead on either side of the board, and pulling up on the lead. If a component is obviously damaged, clip leads off as close to the component as possible and then remove leads with a soldering iron.



EXCESSIVE HEAT CAN CAUSE THE CIRCUIT AND BOARD TO SEPARATE OR CAUSE DAMAGE TO THE COMPONENTS.

- c. Clean component lead hole by heating the hole with the iron and inserting a wooden toothpick. Remove the toothpick after the solder has cooled and insert the new component lead.
- d. To replace components, shape new leads and insert them in lead holes. Reheat the soldering

iron and add a small amount of new solder as required to insure a good electrical connection.

- e. Clean excessive flux from the connection and adjoining area.

5-52. SERVICING ROTARY SWITCHES.

5-53. The 333A/334A has five rotary type switches FUNCTION, SENSITIVITY, FREQUENCY RANGE, MODE, and METER RANGE. When working on these switches, observe the following rules:

- a. Use a low-heat (25 to 50 watts) small-tip soldering iron, and a small diameter rosin core solder.
- b. When replacing components, attempt to dress them as nearly to their original alignment as possible.
- c. Clean excessive flux from the connection and adjoining area.
- d. After cleaning the switch, apply a light coat of lubriplate to the switch detent balls. DO NOT apply lubricant to the switch contacts or allow lubricant to contaminate components.

5-54. ISOLATING THE IMPEDANCE CONVERTER.

5-55. A problem can be isolated to the Impedance Converter by making two distortion measurements with the SENSITIVITY control in two adjacent positions and the VERNIER control adjusted to compensate for this. If the meter reading differs by more than 3 dB between the two positions of the SENSITIVITY control, and the lower reading is in the more counterclockwise position, then the Impedance Converter is attenuating higher level signals. A possible interference with this test may come from the automatic mode circuitry. Disconnect power supply pins 4 and 5 on A5 assembly to disable the automatic mode circuitry for this test.

PERFORMANCE CHECK TEST CARD

Hewlett-Packard Model 333A/334A
Distortion Analyzer
Serial No. _____

Test performed by _____
Date _____

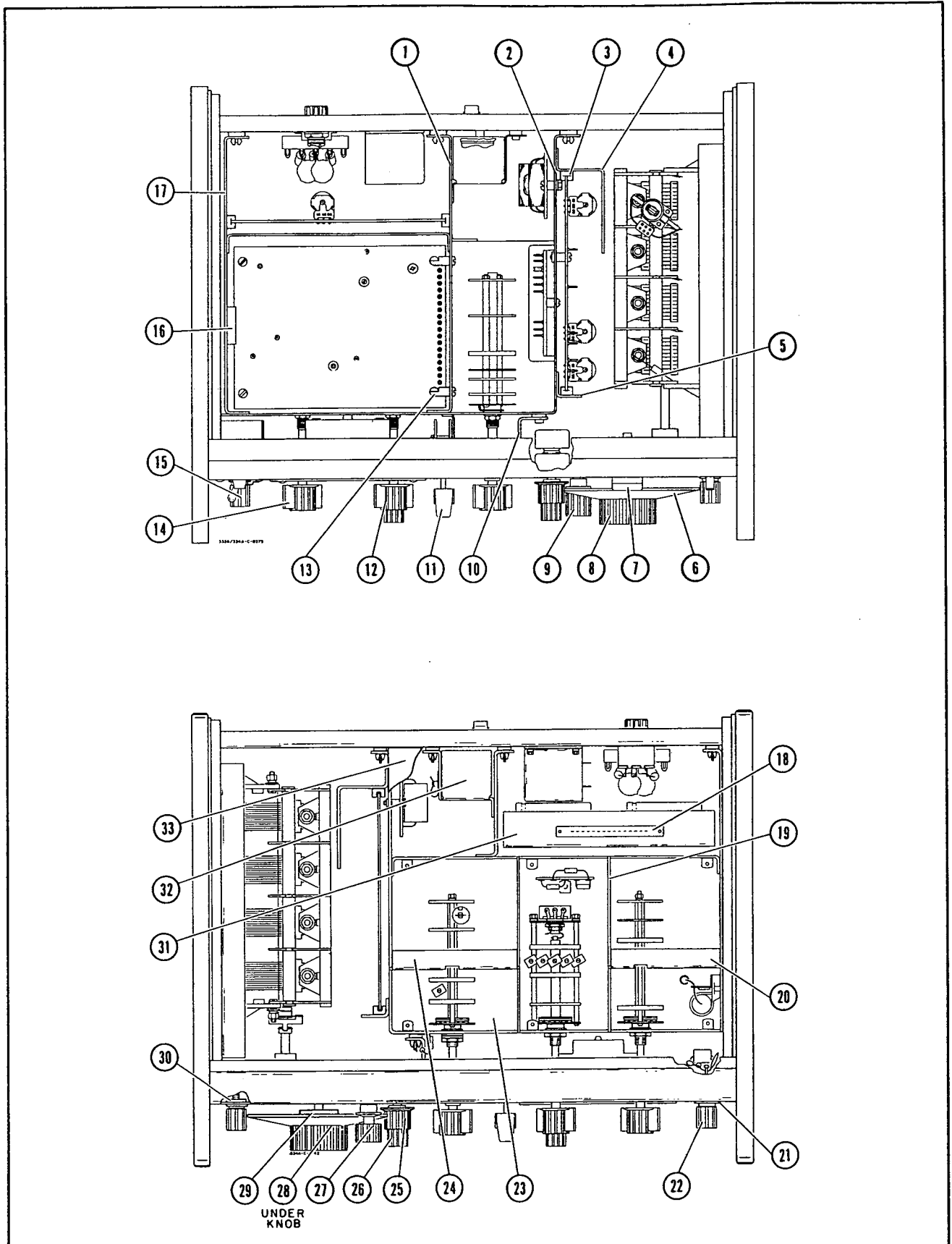
DESCRIPTION	CHECK
1. Voltmeter Accuracy and Frequency Response Check: Accuracy Check .0003 V .001 V	<u>Indication</u> <u>Min.</u> 294 μV 0.98 mV <u>Max.</u> 306 μV 102 mV
2. Fundamental Rejection Check: 500 Hz, 5 kHz, 50 kHz, 250 kHz, 600 kHz	<u>Specification</u> > -80 dB <u>Indication</u>
3. Second Harmonic Accuracy Check: 15 Hz 10 kHz 50 kHz 200 kHz 500 kHz	<u>Specification</u> <u>Indication</u> < +1.0 dB < $\pm$ 0.6 dB < -1.0 dB < -2.0 dB < -3.0 dB
4. Instrument Induced Distortion Check: 500 Hz 250 kHz 600 kHz	<u>Specification</u> <u>Indication</u> > -70 dB > -64 dB > -64 dB
5. Frequency Calibration Accuracy Check: 10 Hz 1 kHz 100 kHz 200 kHz 400 kHz 600 kHz	<u>Specification</u> <u>Indication</u> 95 msec to 105 msec 950 Hz to 1050 Hz 95 kHz to 105 kHz 190 kHz to 210 kHz 360 kHz to 440 kHz 540 kHz to 660 kHz
6. Automatic Nulling Mode Check: 25 Hz, 50 Hz 500 Hz, 5 kHz, 50 kHz, 500 kHz	<u>Specification</u> <u>Indication</u> Within +3 dB -0 dB of manual null Within +1.5 dB -0 dB of manual null
7. Input Impedance Check: Resistance Check, Voltmeter Resistance Check, Set Level Capacitance Check, Voltmeter 1 V .1 V Capacitance Check, Set Level .1 V	<u>Specification</u> <u>Indication</u> 1 MΩ $\pm$5% 1 MΩ $\pm$5% < 30 pF (333A) < 35 pF (334A) < 70 pF < 70 pF
8. Minimum Input Level Check: 0.3 V	<u>Specification</u> <u>Indication</u> 100% set level
9. DC Isolation Check: 333A/334A Meter Power Supply Ammeter	<u>Specification</u> <u>Indication</u> No change in indication No indication

PERFORMANCE CHECK TEST CARD (CONT'D)

		<u>Indication</u>	
9. Accuracy Check (Cont'd)		<u>Min.</u>	<u>Max.</u>
.003 V	2.94 mV		3.06 mV
.01 V	9.8 mV		10.2 mV
.03 V	29.4 mV		30.6 mV
.1 V	98 mV		102 mV
.3 V	.294 V		.306 V
1	.98 V		1.02 V
3	2.94 V		3.06 V
10	9.8 V		10.2 V
30	29.4 V		30.6 V
100	98.0 V		102.0 V
300	294.0 V		306.0 V
Frequency Response Check, 3 V range		<u>Min.</u>	<u>Max.</u>
10 Hz	2.94 V		3.06 V
1 kHz	2.94 V		3.06 V
10 kHz	2.94 V		3.06 V
100 kHz	2.94 V		3.06 V
1 MHz	2.94 V		3.06 V
2 MHz	2.85 V		3.15 V
3 MHz	2.85 V		3.15 V
Frequency Response Check, .0003 V range		<u>Min.</u>	<u>Max.</u>
20 Hz	285 μ V		315 μ V
30 Hz	294 μ V		306 μ V
1 kHz	294 μ V		306 μ V
10 kHz	294 μ V		306 μ V
100 kHz	294 μ V		306 μ V
300 kHz	294 μ V		306 μ V
500 kHz	285 μ V		315 μ V
10. High Pass Filter Check:		<u>Specification</u>	<u>Indication</u>
60 Hz Rejection		> 40 dB	
11. Residual Noise Check:		<u>Specification</u>	<u>Indication</u>
600 Ω Load		< 25 μ V	
100 k Ω Load		< 30 μ V	
12. AM Detector Check (Model 334A only)		<u>Specification</u>	<u>Indication</u>
Distortion		> -40 dB	

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- a. Instrument model number.
- b. Instrument serial number.
- c. Description of the part.
- d. Function and location of the part.



P/O Figure 6-1. Mechanical Parts

INDEX NO.	-hp- PART NO.	TQ	DESCRIPTION
(1)	00331-00104	1	Gusset - Center
(2)	00331-04301	1	Plate - Panel
(3)	5040-0601	4	Glide - Plastic
(4)	00331-01202	1	Bracket - PC Board Mount, Rear
(5)	00331-01203	1	Bracket - PC Mount
(6)	00333-04001	1	Dial Plate
(7)	5040-5158	1	Indicator - Dial
(8)	0370-0160	1	Knob - Round black
(9)	0370-0025	1	Knob - Round black vernier
(10)	00331-01201	1	Bracket - Support
(11)	0370-0046	1	Knob - Lever Switch black
(12)	0370-0113	1	Knob - Skirted Bar black
(13)	0380-0200	2	Standoff - Hinged
(14)	0370-0112	3	Knob - Skirted Bar black
(15)	1510-0091	4	Binding Post Assembly red
(16)	00333-01202	1	Bracket - PC Mounting
(17)	00331-00103	1	Gusset - Side
(18)	1251-0135	1	Connector - Printed Circuit 15 pin
(19)	00331-00601	2	Shield - Divider
(20)	00331-00602	1	Shield - SW Function
(21)	0340-0099	5	Insulator - Binding Post
(22)	1510-0534	5	Binding Post Assembly
(23)	00331-00101	1	Deck
(24)	00331-00603	1	Shield - SW Range
(25)	0370-0117	1	Knob - Skirted black
(26)	0370-0114	2	Knob - Round Red vernier
(27)	5040-0669	1	Disc. Assembly - Vernier drive
(28)	61B-40D-4	1	Plate - Frequency Dial
(29)	5020-0630	1	Hub - Dial
(30)	0340-0100	4	Insulator - Binding Post
(31)	00331-01204	1	Bracket - Mounting
(32)	00332-00602	1	Shield - RF Det.
(33)	00331-04102	1	Cover - Plate

P/O Figure 6-1. Mechanical Parts

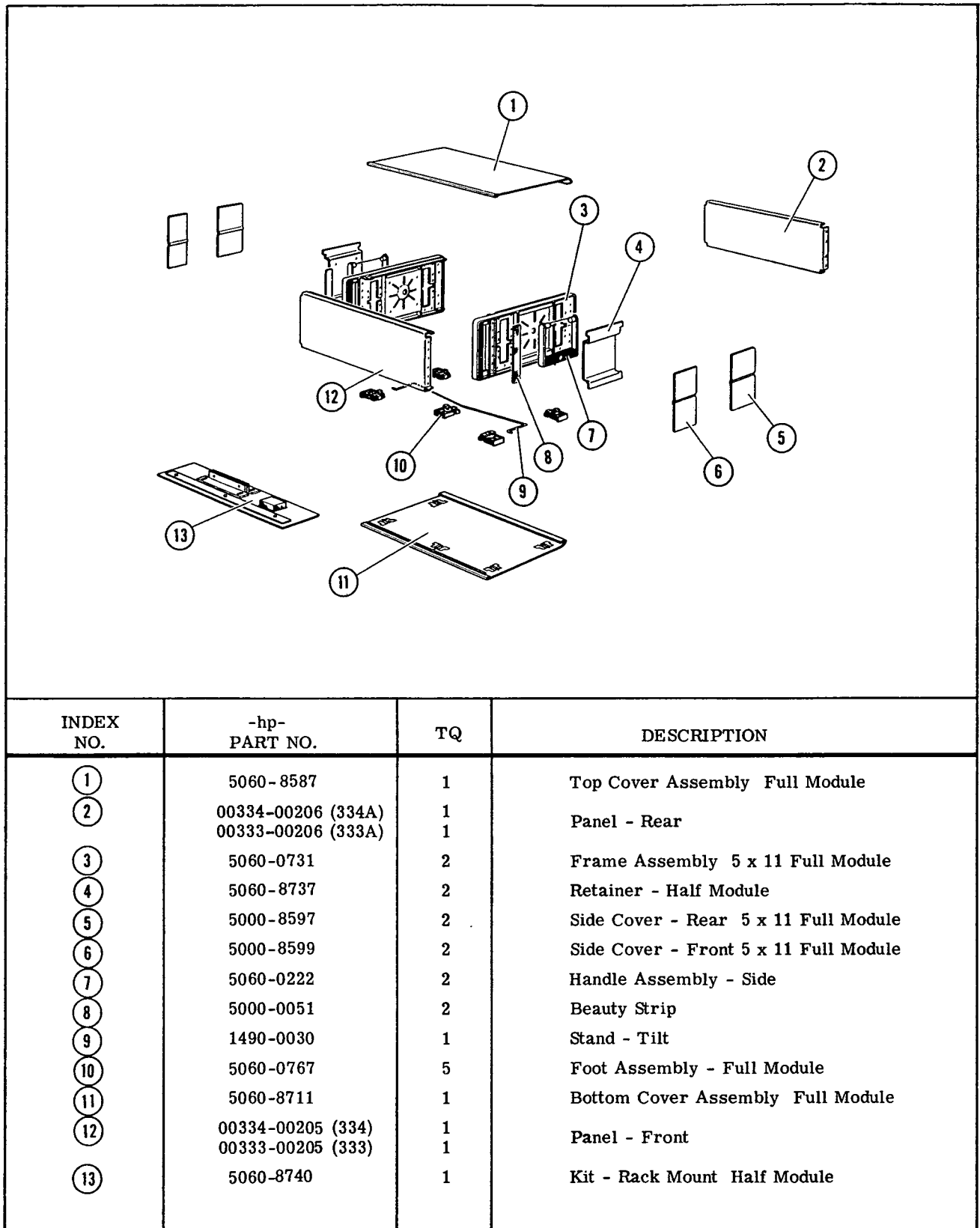


Figure 6-2. Modular Cabinet Parts

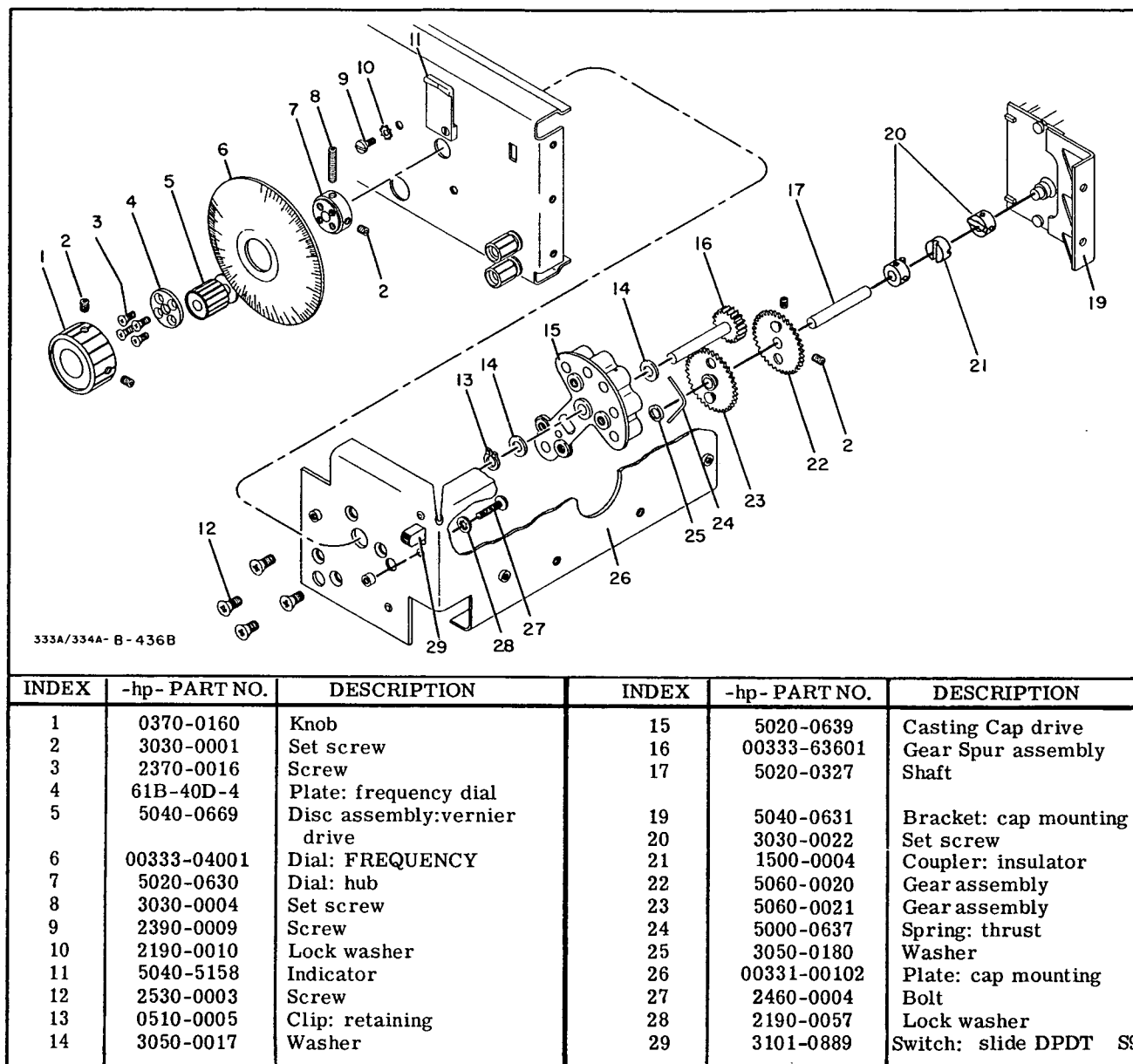


Figure 6-3. Frequency Tuning Assembly
(-hp- Part No. 00333-60701)

NOTE

Items 1 through 11 are not included in assembly, and must be ordered separately.

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
A1	00333-66501	1	Assembly: etched circuit board power supply includes C1 thru C11 Q1 thru Q6 CR1 thru CR7 R1 thru R15	-hp-	
A1C1, A1C2	0180-0308	2	C: fxd Al elect 200 μ F +100% -10% 50 vdcw	56289	34D39720DSB
A1C3	0180-0061	4	C: fxd Al elect 100 μ F +75% -10% 15 vdcw	56289	30D107G015DC2-DSM
A1C4	0150-0085	1	C: fxd cer 2200 pF $\pm$ 20% 500 vdcw	56289	C067B501G222MLO5CDH
A1C5	0180-0058	7	C: fxd Al elect 50 μ F +75% -10% 25 vdcw	56289	30D506G025CC2-DSM
A1C6	0180-0050	2	C: fxd Al elect 40 μ F +75% -10% 50 vdcw	56289	30D406G050D2-DSM
A1C7	0180-0039	3	C: fxd Al elect 100 μ F +75% -10% 12 vdcw	56289	30D107G012CC2-DSM
A1C8			Not assigned		
A1C9	0180-0061		C: fxd Al elect 100 μ F +75% -10% 15 vdcw	56289	30D107G015DC2-DSM
A1C10	0180-0059	2	C: fxd Al elect 10 μ F +75% -10% 25 vdcw	56289	30D106G025BB2-DSM
A1C11	0180-0050		C: fxd Al elect 40 μ F +75% -10% 50 vdcw	56289	30D406G050DD2-DSM
A1CR1 thru A1CR6	1901-0026	6	Diode: Si 200 piv 0.75A	04713	SR1358-8
A1CR7	1902-0045	1	Diode: breakdown 7.2V $\pm$ 2% 400 mW	04713	SZ10939-144
A1Q1	1854-0062	2	TSTR: Si NPN 2N1701	86684	2N701
A1Q2, A1Q3	1854-0039	2	TSTR: Si NPN 2N3053	04713	2N3053
A1Q4, A1Q5	1853-0012	2	TSTR: Si PNP	80131	2N2904A
A1Q6	1854-0062	2	TSTR: Si NPN 2N1701	86684	2N1701
A1R1			Not assigned		
A1R2	0766-0029	2	R: fxd met oxide 10 Ω $\pm$ 2% 3 W	07115	FP-3 obd
A1R3	0686-1025	3	R: fxd comp 1 k Ω $\pm$ 5% 1/2 W	01121	EB1025
A1R4	0686-7525	4	R: fxd comp 7.5 k Ω $\pm$ 5% 1/2 W	01121	EB7525
A1R5	0686-6825	4	R: fxd comp 6.8 k Ω $\pm$ 5% 1/2 W	01121	EB6825
A1R6	0698-4471	1	R: fxd flm 7.15 k Ω $\pm$ 1% 1/8 W	28480	0698-4471
A1R7	0757-0440	1	R: fxd met flm 7.50 k Ω $\pm$ 1% 1/8 W	28480	0757-0440
A1R8	0686-1025		R: fxd comp 1 k Ω $\pm$ 5% 1/2 W	01121	EB1025
A1R9	0766-0029		R: fxd met oxide 10 Ω $\pm$ 2% 3 W	07115	FP-3 obd
A1R10, A1R11	0686-6825		R: fxd comp 6800 Ω $\pm$ 5% 1/2 W	01121	EB6825
A1R12	0686-7525		R: fxd comp 7.5 k Ω $\pm$ 5% 1/2 W	01121	EB7525
#A1R13	2100-2633	1	R: var lin cermet flm 1 k Ω $\pm$ 10% 1/2 W	-hp-	
A1R14	0686-2025	1	R: fxd comp 2 k Ω $\pm$ 5% 1/2 W	01121	EB2025
A1R15	0686-5125	1	R: fxd comp 5.1 k Ω $\pm$ 5% 1/2 W	01121	EB5125
A2	00333-66512	1	Assembly: etched circuit board meter amplifier and impedance converter includes C1 thru C29 Q1 thru Q9 CR1 thru CR8 R1 thru R51	-hp-	
A2	00333-66508	1	Assembly: etched circuit board meter amplifier and impedance converter (Option 01 only) includes C1 thru C25 Q1 thru Q9 C27 thru C29 R1 thru R51 CR1 thru CR8	-hp-	
A2C1	0140-0201	2	C: fxd mica 12 pF $\pm$ 5%	04062	RDM15C120J5C
A2C2, A2C3	0140-0200	4	C: fxd mica 390 pF $\pm$ 5%	04062	RDM15F391J3C

#See Appendix C for backdating information.

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A2C4	0180-0101		1	C: fxd Ta elect 1.8 μ F $\pm 10\%$ 35 vdcw	56289	150D185X9035B2-DYS
A2C5	0180-0033		2	C: fxd Al elect 50 μ F $+100\%$ -10% 6 vdcw	56289	30D506G006CB2-DSM
A2C6	0180-0060		2	C: fxd Al elect 200 μ F $+75\%$ -10% 3 vdcw	56289	30D207F003CC2-DSM
A2C7	0140-0145		1	C: fxd mica 22 pF $\pm 5\%$	04062	RDM15C220J5C
A2C8	0180-0224		6	C: fxd Al elect 10 μ F $+75\%$ -10% 15 vdcw	56289	30D106G015BA2-DSM
A2C9	0140-0193		1	C: fxd mica 82 pF $\pm 5\%$	04062	RDM15E820J3C
A2C10	0180-0104		2	C: fxd Al elect 200 μ F $+75\%$ -10% 15 vdcw	56289	30D207G0150F4-DSM
A2C11	0140-0200			C: fxd mica 390 pF $\pm 5\%$	04062	RDM15F391J3C
A2C12	0160-0170		3	C: fxd elect 0.22 μ F $+80\%$ -20% 25 vdcw	56289	5C9B-CML
A2C13	0160-0161		3	C: fxd my 0.01 μ F $\pm 10\%$ 200 vdcw	56289	192P10392-PTS
A2C14	0180-0307		3	C: fxd Al elect 500 μ F $+75\%$ -10% 15 vdcw	56289	34D507G015FJ4-DSB
A2C15	0180-1736		1	C: fxd Al elect 1300 μ F $+75\%$ -10% 2.5 vdcw	56289	34D138G2R5FJ4-DSB
A2C16	0160-0195		1	C: fxd cer 1000 pF $\pm 20\%$ 250 vdcw	56289	19C251A
A2C17	0140-0218		2	C: fxd mica 160 pF $\pm 20\%$	04062	RDM15F161G3C
A2C18	0180-0061			C: fxd Al elect 100 μ F $+75\%$ -10% 15 vdcw	56289	30D107G015DC2-DSM
A2C19	0140-0200			C: fxd mica 390 pF $\pm 5\%$	04062	RDM15F391J3C
A2C20	0160-0174		1	C: fxd elect 0.47 μ F $+80\%$ -20% 25 vdcw	56289	5C 1137-CML
A2C21	0130-0017		1	C: var cer 8-50 pF	72982	557-610-34E
A2C22*	0140-0190		1	C: fxd mica 39 pF $\pm 5\%$	04062	RDM15E390J3C
A2C23*	0140-0199		1	C: fxd mica 240 pF $\pm 5\%$	04062	RDM15F241J3C
A2C24	0150-0121			C: fxd cer 0.1 μ F $+80\%$ -20% 50 vdcw	56289	5C50B1-CML
A2C25	0180-1941			C: fxd Al elect 130 μ F $+75\%$ -10% 15 vdcw	56289	30D107G015DC2-DSM
A2C26	0180-0033			C: fxd Al elect 50 μ F $+100\%$ -10% 6 vdcw	56289	30D506G006CB2-DSM
A2C26				Delete on Option 01 instrument		
A2C27, A2C28	0180-0058			C: fxd Al elect 50 μ F $+75\%$ -10% 25 vdcw	56289	30D506G025CC2-DSM
A2C29*	0140-0198		1	C: fxd mica 200 pF $\pm 5\%$	-hp-	
A2C30*	0180-0228		1	C: fxd Ta elect 22 μ F $\pm 10\%$ 15 vdcw	56289	150D226X9015B2-DYS
A2CR1 thru A2CR4	1901-0044		4	Diode: Si 20 mA/+1V 10 na at -10V/50 wiv 2 pF 2 ns	07910	obd
A2CR5				Not assigned		
A2CR6, A2CR7	1901-0535		2	Diode: hot carrier	-hp-	
A2CR8	1902-0584		1	Diode: breakdown 14.0V $\pm 5\%$ 75 pF	07263	FZ 1403
A2Q1	1855-0082		1	TSTR: Si P-channel FET	-hp-	
A2Q2	1853-0203		1	TSTR: Si PNP 360 mW 700 MHz	-hp-	
A2Q3	1854-0354		1	TSTR: 0.36 W 350 MHz 15 V	-hp-	
A2Q4	1853-0086		1	TSTR: Si PNP	07263	2N4250
A2Q5	1854-0297		1	TSTR: Si NPN**	04713	MPS6513-5
A2Q6	1853-0010		3	TSTR: Si PNP**	04713	SM4713
A2Q7	1854-0019		1	TSTR: Si NPN	-hp-	
A2Q8, A2Q9	1853-0010			TSTR: Si PNP**	04713	SM4713
A2R1	0683-3015		2	R: fxd comp 300 Ω $\pm 5\%$ 1/4 W	01121	CB3015
A2R2	0683-9135		1	R: fxd comp 91 k Ω $\pm 5\%$ 1/4 W	01121	CB 9135
#A2R3	2100-2031		1	R: var lin trim 50 k Ω $\pm 10\%$ 1/2 W	-hp-	
A2R4	0683-3635		3	R: fxd comp 36 k Ω $\pm 5\%$ 1/4 W	01121	CB3635
A2R5	0683-5145		1	R: fxd comp 510 k Ω $\pm 5\%$ 1/4 W	01121	CB5145

#See Appendix C for backdating information.

> Option 01 only

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
A2R6	0683-1025	2	R: fxd comp 1000Ω ±5% 1/4 W	01121	CB1025
A2R7	0683-3025	4	R: fxd comp 3000Ω ±5% 1/4 W	01121	CB3025
A2R8	0683-1025		R: fxd comp 1000Ω ±5% 1/4 W	01121	CB1025
A2R9	0683-7515	1	R: fxd comp 750Ω ±5% 1/4 W	01121	CB7515
A2R10	0683-1535	1	R: fxd comp 15 kΩ ±5% 1/4 W	01121	CB1535
A2R11	0683-4335	1	R: fxd comp 43 kΩ ±5% 1/4 W	01121	CB4335
A2R12	0683-6215	2	R: fxd comp 620Ω ±5% 1/4 W	01121	CB6215
A2R13	0683-6815	1	R: fxd comp 680Ω ±5% 1/4 W	01121	CB6815
A2R14	0683-1515	1	R: fxd comp 150Ω ±5% 1/4 W	01121	CB1515
A2R15	0683-4715	1	R: fxd comp 470Ω ±5% 1/4 W	01121	CB4715
A2R16	0683-4705	1	R: fxd comp 47Ω ±5% 1/4 W	01121	CB4705
A2R17	0683-6215		R: fxd comp 620Ω ±5% 1/4 W	01121	CB6215
A2R18	0683-2405	2	R: fxd comp 24Ω ±5% 1/4 W	01121	CB2405
A2R19	0683-2015	4	R: fxd comp 200Ω ±5% 1/4 W	01121	CB2015
#A2R20	2100-1738	1	R: var lin trim 10 kΩ ±10% 1/2 W	-hp-	
A2R21	0683-3025		R: fxd comp 3000Ω ±5% 1/4 W	01121	CB3025
A2R22	0683-5115	3	R: fxd comp 510Ω ±5% 1/4 W	01121	CB5115
A2R23	0683-5105	1	R: fxd comp 51Ω ±5% 1/4 W	01121	CB5105
A2R24	0683-6825	1	R: fxd comp 6800Ω ±5% 1/4 W	01121	CB6825
A2R25	0683-2015		R: fxd comp 200Ω ±5% 1/4 W	01121	CB2015
A2R26	0683-2025	5	R: fxd comp 2000Ω ±5% 1/4 W	01121	CB2025
A2R27	0683-1235	7	R: fxd comp 12 kΩ ±5% 1/4 W	01121	CB1235
A2R28	0683-2405		R: fxd comp 24Ω ±5% 1/4 W	01121	CB2405
A2R29	0698-3174	1	R: fxd carbon flm 4.42Ω ±1% 1/2 W	91637	DCS 1/2
A2R30	0683-3015		R: fxd comp 300Ω ±5% 1/4 W	01121	CB 3015
A2R31			Not assigned		
A2R32	0698-3147	1	R: fxd met flm 191Ω ±1% 1/8 W	91637	MFF 1/8 T-1
A2R32	0757-1102	1	R: fxd met flm 180Ω ±1% 1/8 W (Opt. 01 only)	75042	CEA T-O obd
A2R33	0757-0346	2	R: fxd met flm 10.0Ω ±1% 1/8 W	75042	CEA T-O obd
A2R34	2100-0206	1	R: var ww lin trim 50Ω ±10% 1.5 W	71450	110 obd
A2R35	0757-0346		R: fxd met flm 10.0Ω ±1% 1/8 W	75042	CEA T-O obd
A2R36	0683-3945	1	R: fxd comp 390 kΩ ±5% 1/4 W	01121	CB 3945
A2R37	0683-3025		R: fxd comp 3000Ω ±5% 1/4 W	01121	CB3025
A2R38	0683-1015	7	R: fxd comp 100Ω ±5% 1/4 W	01121	CB1015
#A2R39	2100-1788	1	R: var cermet flm lin trim 500Ω ±10% 1/2 W	-hp-	
A2R40	0757-0390	1	R: fxd met flm 36.5Ω ±1% 1/8 W	75042	CEA T-O obd
A2R41	0683-1815	1	R: fxd comp 180Ω ±5% 1/4 W	01121	CB1815
A2R42	0683-1005	5	R: fxd comp 10Ω ±5% 1/4 W	01121	CB1005
A2R43	0683-2425	1	R: fxd comp 2400Ω ±5% 1/4 W	01121	CB2425
A2R44	0683-1015		R: fxd comp 100Ω ±5% 1/4 W	01121	CB1015
A2R45	0683-2405	1	R: fxd comp 24Ω ±5% 1/4 W	01121	CB2405
A2R46	0683-3025		R: fxd comp 3000Ω ±5% 1/4 W	01121	CB3025
A2R47, A2R48	0683-5115	2	R: fxd comp 510Ω ±5% 1/4 W	01121	CB5115
A2R47, A2R48	0683-5105	2	R: fxd comp 51Ω ±5% 1/4 W (Option 01 only)	01121	CB5105
A2R49, A2R50	0683-2025		R: fxd comp 2000Ω ±5% 1/4 W	01121	CB2025
A2R51	0683-1245	1	R: fxd comp 120 kΩ ±5% 1/4 W	01121	CB1245
A3	00333-66503	1	Assembly: etched circuit board rejection amplifier includes C1 thru C15 Q1 thru Q6 CR1 R1 thru R33	-hp-	
A3C1	0180-0039		C: fxd Al elect 100 μF +75% -10% 12 vdcw	56289	30D107G012CC2-DSM
A3C2	0180-0060		C: fxd Al elect 200 μF +75% -10% 3 vdcw	56289	30D207G003CC2-DSM
A3C3	0180-0022	2	C: fxd Ta elect 3.9 μF ±10% 35 vdcw	56289	150D395X9035B2
A3C4	0140-0190	1	C: fxd mica 39 pF ±5%	14655	obd

#See Appendix C for backdating information.

> Option 01 only

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		T Q	DESCRIPTION	MFR.	MFR. PART NO.
A3C5	0140-0199		1	C: fxd mica 240 pF $\pm 5\%$	-hp-	
A3C6	0180-0022			C: fxd Ta elect 3.9 μ F $\pm 10\%$ 35 vdcw	56289	150D395X9035B2
A3C7	0170-0040		1	C: fxd my 0.047 μ F $\pm 10\%$ 200 vdcw	56289	192P47392-PTS
A3C8	0180-0039			C: fxd Al elect 100 μ F $+75\%$ -10% 12 vdcw	56289	30D107G012CC2-DSM
A3C9	0180-0062		1	C: fxd Al elect 300 μ F $+100\%$ -10% 6 vdcw	56289	30D307G006DF2-DSM
A3C10	0140-0196		1	C: fxd mica 150 pF $\pm 5\%$	00853	RDM15F151J3C
A3C11*	0140-0110		1	C: fxd mica 127 pF $\pm 2\%$	00853	RDM15E(127) G
A3C12	0180-0104			C: fxd Al elect 200 μ F $+75\%$ -10% 15 vdcw	56289	30D207G015DF4-DSM
A3C13	0180-0307			C: fxd Al elect 500 μ F $+75\%$ -10% 15 vdcw	56289	34D507G015FJ4-DSB
A3C14	0140-0191		1	C: fxd mica 56 pF $\pm 5\%$ 300 vdcw	19701	RCM15E560J 300 V
A3C15	0180-0307			C: fxd Al elect 500 μ F $+75\%$ -10% 15 vdcw	56289	34D507G015FJ4-DSB
A3CR1	1901-0053		1	Diode: Si 30V working low leakage	07263	FD3444
A3Q1	1854-0215		2	TSTR: Si NPN 2N3904	04713	Sps 3611
A3Q2	1854-0297		2	TSTR: Si NPN 310 mW	04713	MPS 6513-5
A3Q3	1854-0354		1	TSTR: Si NPN	07263	S24817
A3Q4	1855-0209		1	TSTR: Si	-hp-	
A3Q5	1854-0354			TSTR: Si NPN	07263	S24817
A3Q6	1853-0036			TSTR: Si PNP 2N3906	04713	2N3906-5
A3R1	0683-2415		1	R: fxd comp 240 Ω $\pm 5\%$ 1/4 W	01121	CB2415
A3R2	0683-1245		1	R: fxd comp 120 k Ω $\pm 5\%$ 1/4 W	01121	CB1245
A3R3	0683-1035		2	R: fxd comp 10 k Ω $\pm 5\%$ 1/2 W	01121	EB1035
A3R4	2100-2522		1	R: var lin trim 10 k Ω $\pm 10\%$ 1/2 W	73138	62-227-1
A3R5	0686-2015		2	R: fxd comp 200 Ω $\pm 5\%$ 1/2 W	01121	EB2015
A3R6	0686-3625		4	R: fxd comp 3.6 k Ω $\pm 5\%$ 1/2 W	01121	EB3625
A3R7	0683-1025			R: fxd comp 10 k Ω $\pm 5\%$ 1/4 W	01121	CB1035
A3R8	0683-6825			R: fxd comp 6800 Ω $\pm 5\%$ 1/4 W	01121	CB6825
A3R9	0757-0281		1	R: fxd met flm 2.74 k Ω $\pm 1\%$ 1/8 W	75042	CEA T-O obd
A3R10	0683-1515		1	R: fxd comp 150 Ω $\pm 5\%$ 1/4 W	01121	CB1515
A3R11	0683-2035		1	R: fxd comp 20 k Ω $\pm 5\%$ 1/4 W	01121	CB2035
A3R12	0757-0435		1	R: fxd flm 3920 Ω $\pm 1\%$ 1/8 W	-hp-	
A3R13	0698-4471		1	R: fxd flm 7.15 k Ω $\pm 1\%$ 1/8 W	-hp-	
A3R14	0757-0281		1	R: fxd met flm 2.74 k Ω $\pm 1\%$ 1/8 W	-hp-	
A3R15	0683-1265		1	R: fxd comp 12M Ω $\pm 5\%$ 1/4 W	01121	CB1265
A3R16	2100-2489		1	R: var lin trim 5 k Ω $\pm 10\%$ 1/2 W	73138	62-226-1
A3R17*	0683-3025			R: fxd comp 3000 Ω $\pm 5\%$ 1/4 W	01121	CB3025
A3R18	0683-7525			R: fxd comp 7500 Ω $\pm 5\%$ 1/4 W	01121	CB7525
A3R19	0683-1015			R: fxd comp 100 Ω $\pm 5\%$ 1/4 W	01121	CB1015
A3R20	0683-3625			R: fxd comp 3600 Ω $\pm 5\%$ 1/4 W	01121	CB3625
A3R21	0683-5615		1	R: fxd comp 560 Ω $\pm 5\%$ 1/4 W	01121	CB5615
A3R22	0683-3015		1	R: fxd comp 300 Ω $\pm 5\%$ 1/4 W	01121	CB3015
A3R23	0683-3315		1	R: fxd comp 330 Ω $\pm 5\%$ 1/4 W	01121	CB3315
A3R24, A3R25	0683-2025		2	R: fxd comp 2000 Ω $\pm 5\%$ 1/4 W	01121	CB2025
A3R26	0683-4705		1	R: fxd comp 47 Ω $\pm 5\%$ 1/4 W	01121	CB4705
A3R27	0683-2015			R: fxd comp 200 Ω $\pm 5\%$ 1/4 W	01121	CB2015
A3R28	0683-1035			R: fxd comp 10 k Ω $\pm 5\%$ 1/4 W	01121	CB1035
A3R29	0683-7525			R: fxd comp 7500 Ω $\pm 5\%$ 1/4 W	01121	CB7525
A3R30				Not assigned		
A3R31	0683-3335		2	R: fxd comp 33 k Ω $\pm 5\%$ 1/4 W	01121	CB3335
A3R32	0757-0445		1	R: fxd flm 13 k Ω $\pm 1\%$ 1/8 W	-hp-	
A3R33	0683-3335			R: fxd comp 33 k Ω $\pm 5\%$ 1/4 W	01121	CB3335
A3R34	0683-1035		1	R: fxd 10 k Ω $\pm 5\%$ 1/4 W	01121	CB 1035
A3R35, A3R36	0683-4705		1	R: fxd 47 Ω $\pm 5\%$ 1/4 W	01121	CB 4705
A3R37	0683-3315		1	R: fxd 330 Ω $\pm 5\%$ 1/4 W	01121	CB 3315

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A4	00332-66502		1	Assembly: etched circuit board RF detector (334A only) includes C1 thru C3 L1 and L2 CR1	-hp-	
A4C1, A4C2	0140-0180		4	C: fxd mica 2000 pF $\pm 2\%$	00853	RDM19F202G3C
A4C3	0140-0156		1	C: fxd mica 1500 pF $\pm 2\%$	00853	RDM19F152G3C
A4CR1	1910-0016		3	Diode: Ge 60 wiv 1 ms	93332	D2361
A4L1, A4L2	9140-0052		2	Coil: RF 3.3 mH	82042	WC-611
A5	00333-66505		1	Assembly: auto control board includes C1 thru C31 Q1 thru Q18 CR1 thru CR6 R1 thru R71	-hp-	
A5C1	0180-0064		4	C: fxd Al elect 35 μ F +75% -10% 6 vdcw	56289	30D356G006BB2- DSM
A5C2	0180-0063		1	C: fxd Al elect 500 μ F +75% -10% 3 vdcw	56289	30D507G003DF2- DSM
A5C3	0150-0093		5	C: fxd cer 0.01 μ F +80% -20% 100 vdcw	91418	TA obd
A5C4	0180-0224			C: fxd Al elect 10 μ F +75% -10% 15 vdcw	56289	30D106G015A2- DSM
A5C5, A5C6	0180-0058			C: fxd Al elect 50 μ F +75% -10% 25 vdcw	56289	30D506G025CC2- DSM
A5C7	0150-0093			C: fxd cer 0.01 μ F +80% -20% 100 vdcw	91418	TA obd
A5C8	0180-1737		2	C: fxd Al elect 2600 μ F +75% -10% 2.5 vdcw	56289	34D268G2R5FP4- DSB
A5C9	0140-0195		1	C: fxd mica 130 pF $\pm 5\%$	00853	RDM15F131J3C
A5C10	0180-1735		2	C: fxd Ta elect 0.22 μ F $\pm 10\%$ 35 vdcw	56289	150D224X9035A2- DYS
A5C11	0150-0093			C: fxd cer 0.01 μ F +80% -20% 100 vdcw	91418	TA obd
A5C12, A5C13	0180-0064			C: fxd Al elect 35 μ F +75% -10% 6 vdcw	56289	30D356G006BB2- DSM
A5C14	0160-0179		2	C: fxd mica 33 pF $\pm 5\%$	00853	RDM15E330J3S
A5C15	0180-0161		2	C: fxd Ta elect 3.3 μ F $\pm 20\%$ 35 vdcw	56289	150E335X0035B2- DYS
A5C16	0180-1735			C: fxd Ta elect 0.22 μ F $\pm 10\%$ 35 vdcw	56289	150D224X9035A2- DYS
A5C17, A5C18	0180-0224			C: fxd Al elect 10 μ F +75% -10% 15 vdcw	56289	30D106G015BA2- DSM
A5C19, A5C20	0180-0058			C: fxd Al elect 50 μ F +75% -10% 25 vdcw	56289	30D506G025CC2- DSM
A5C21	0150-0093			C: fxd cer 0.01 μ F +80% -20% 100 vdcw	91418	TA obd
A5C22	0180-1737			C: fxd Al elect 2600 μ F +75% -10% 2.5 vdcw	56289	34D268G2R5FP4- DSB
A5C23	0180-0197			C: fxd Ta elect 2.2 μ F $\pm 10\%$ 20 vdcw	56289	150D225X9020A2- DYS
A5C24	0180-0064			C: fxd Al elect 35 μ F +75% -10% 6 vdcw	56289	30D356G006BB2- DSM
A5C25	0180-0224			C: fxd Al elect 10 μ F +75% -10% 15 vdcw	56289	30D106G015A2- DSM
A5C26	0180-0045		1	C: fxd Al elect 20 μ F +75% -10% 25 vdcw	56289	30D206G025CB2- DSM
A5C27	0160-0157		1	C: fxd my 0.0047 μ F $\pm 10\%$ 200 vdcw	56289	192P47292 PTS
A5C28	0180-0224			C: fxd Al elect 10 μ F +75% -10% 15 vdcw	56289	30D106G015A2- DSM
A5C29	0160-0179			C: fxd mica 33 pF $\pm 5\%$	00853	RDM15E330J3S
A5C30	0150-0093			C: fxd cer 0.01 μ F +80% -20% 100 vdcw	91418	TA obd

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A5C31	0160-0161			C: fxd my 0.01 μ F $\pm 10\%$ 200 vdcw	56289	192P10392-PTS
A5CR1	1910-0016			Diode: Ge 60 wiv 1 ms	93332	D2361
A5CR2, A5CR3	1901-0025		5	Diode: Si 100 wiv 12 pF 100 mA	93332	D3072
A5CR4	1910-0016			Diode: Ge 60 wiv 1 ms	93332	D2361
A5CR5, A5CR6	1901-0025			Diode: Si 100 wiv 12 pF 100 mA	93332	D3072
A5Q1 thru A5Q3	1854-0033		12	TSTR: Si NPN 2N3391	24446	2N3391
A5Q4	1851-0017		2	TSTR: Ge NPN 2N1304	01295	2N1304
A5Q5 thru A5Q7	1854-0033			TSTR: Si NPN 2N3391	24446	2N3391
A5Q8, A5Q9	1854-0005		4	TSTR: Si NPN 2N708	07263	obd
A5Q10, A5Q11	1854-0033			TSTR: Si NPN 2N3391	24446	2N3391
A5Q12	1851-0017			TSTR: Ge NPN 2N1304	01295	2N1304
A5Q13 thru A5Q16	1854-0033			TSTR: Si NPN 2N3391	24446	2N3391
A5Q17, A5Q18	1854-0005			TSTR: Si NPN 2N708	07263	obd
A5R1	0683-2235			R: fxd comp 22 k Ω $\pm 5\%$ 1/4 W	01121	CB 2235
A5R2	0683-1035			R: fxd comp 10 k Ω $\pm 5\%$ 1/4 W	01121	CB 1035
A5R3	0683-2735			R: fxd comp 27 k Ω $\pm 5\%$ 1/4 W	01121	CB 2735
A5R4	0683-1035			R: fxd comp 10 k Ω $\pm 5\%$ 1/4 W	01121	CB 1035
A5R5, A5R6	0683-1235			R: fxd comp 12 k Ω $\pm 5\%$ 1/4 W	01121	CB 1235
A5R7, A5R8	0683-1015			R: fxd comp 100 Ω $\pm 5\%$ 1/4 W	01121	CB 1015
A5R9	0683-1235			R: fxd comp 12 k Ω $\pm 5\%$ 1/4 W	01121	CB 1235
A5R10, A5R11	0683-1035			R: fxd comp 10 k Ω $\pm 5\%$ 1/4 W	01121	CB 1035
A5R12	0683-7545			R: fxd comp 750 k Ω $\pm 5\%$ 1/4 W	01121	CB 7545
A5R13	0683-0515			R: fxd comp 5.1 Ω $\pm 5\%$ 1/4 W	01121	51G5
A5R14	0683-2015			R: fxd comp 200 Ω $\pm 5\%$ 1/4 W	01121	CB 2015
A5R15	0683-1035			R: fxd comp 10 k Ω $\pm 5\%$ 1/4 W	01121	CB 1035
A5R16	0683-2235			R: fxd comp 22 k Ω $\pm 5\%$ 1/4 W	01121	CB 2235
A5R17	0683-1035			R: fxd comp 10 k Ω $\pm 5\%$ 1/4 W	01121	CB 1035
A5R18	0683-2025			R: fxd comp 2000 Ω $\pm 5\%$ 1/4 W	01121	CB 2025
A5R19	0683-3635			R: fxd comp 36 k Ω $\pm 5\%$ 1/4 W	01121	CB3635
A5R20	0683-1615		2	R: fxd comp 160 Ω $\pm 5\%$ 1/4 W	01121	CB 1615
A5R21	0683-3615		2	R: fxd comp 360 Ω $\pm 5\%$ 1/4 W	01121	CB 3615
A5R22 *	0757-0437		1	R: fxd met flm 4.75 k Ω $\pm 1\%$ 1/8 W	75042	CEC T-O obd
A5R23	0683-1045		1	R: fxd comp 100 k Ω $\pm 5\%$ 1/4 W	01121	CB 1045
A5R24	0683-1035			R: fxd comp 10 k Ω $\pm 5\%$ 1/4 W	01121	CB 1035
A5R25	0683-5125		2	R: fxd comp 5100 Ω $\pm 5\%$ 1/4 W	01121	CB 5125
A5R26 thru A5R30	0683-1035			R: fxd comp 10 k Ω $\pm 5\%$ 1/4 W	01121	CB 1035
A5R31	0683-1845		1	R: fxd comp 180 k Ω $\pm 5\%$ 1/4 W	01121	CB 1845
A5R32	0683-3035			R: fxd comp 30 k Ω $\pm 5\%$ 1/4 W	01121	CB 3035
A5R33	0683-6835		2	R: fxd comp 68 k Ω $\pm 5\%$ 1/4 W	01121	CB 6835
A5R34, A5R35	0683-1005			R: fxd comp 10 Ω $\pm 5\%$ 1/4 W	01121	CB 1005
A5R36, A5R37	0683-1035			R: fxd comp 10 k Ω $\pm 5\%$ 1/4 W	01121	CB 1035
A5R38, A5R39	0683-1015			R: fxd comp 100 Ω $\pm 5\%$ 1/4 W	01121	CB 1015
A5R40 thru A5R42	0683-1235			R: fxd comp 12 k Ω $\pm 5\%$ 1/4 W	01121	CB 1235
A5R43, A5R44	0683-1035			R: fxd comp 10 k Ω $\pm 5\%$ 1/4 W	01121	CB 1035
A5R45	0683-7545			R: fxd comp 750 k Ω $\pm 5\%$ 1/4 W	01121	CB 7545
A5R46	0683-1005			R: fxd comp 10 Ω $\pm 5\%$ 1/4 W	01121	CB 1005
A5R47	0683-2015			R: fxd comp 200 Ω $\pm 5\%$ 1/4 W	01121	CB 2015
A5R48	0683-1035			R: fxd comp 10 k Ω $\pm 5\%$ 1/4 W	01121	CB 1035
A5R49	0683-2235			R: fxd comp 22 k Ω $\pm 5\%$ 1/4 W	01121	CB 2235
A5R50	0683-1035			R: fxd comp 10 k Ω $\pm 5\%$ 1/4 W	01121	CB 1035
A5R51	0683-2025			R: fxd comp 2000 Ω $\pm 5\%$ 1/4 W	01121	CB 2025

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	T Q	DESCRIPTION	MFR.	MFR. PART NO.
A5R52	0683-3635		R: fxd comp 36 k Ω $\pm 5\%$ 1/4 W	01121	CB 3635
A5R53	0683-1615		R: fxd comp 160 Ω $\pm 5\%$ 1/4 W	01121	CB 1615
A5R54	0683-3615		R: fxd comp 360 Ω $\pm 5\%$ 1/4 W	01121	CB 3615
A5R55*	0698-4470		R: fxd met flm 6.98 k Ω $\pm 1\%$ 1/8 W	75042	CEA T-O obd
A5R56*	0757-0446		R: fxd comp 15 k Ω $\pm 1\%$ 1/8 W	75042	CEA T-O obd
A5R57	0683-2225		R: fxd comp 2200 Ω $\pm 5\%$ 1/4 W	01121	CB 2225
A5R58	0683-1035		R: fxd comp 10 k Ω $\pm 5\%$ 1/4 W	01121	CB 1035
A5R59	0683-1215	1	R: fxd comp 120 Ω $\pm 5\%$ 1/4 W	01121	CB 1215
A5R60	0683-1035		R: fxd comp 10 k Ω $\pm 5\%$ 1/4 W	01121	CB 1035
A5R61 thru A5R64	0683-3325	4	R: fxd comp 3300 Ω $\pm 5\%$ 1/4 W	01121	CB 3325
A5R65 thru A5R69	0683-1035		R: fxd comp 10 k Ω $\pm 5\%$ 1/4 W	01121	CB 1035
A5R70	0683-3035		R: fxd comp 30 k Ω $\pm 5\%$ 1/4 W	01121	CB 3035
A5R71	0683-6835		R: fxd comp 68 k Ω $\pm 5\%$ 1/4 W	01121	CB 6835
A6	00333-66506	1	Assembly: bridge balance board includes DS1 and DS2 V1 thru V5	-hp-	
A6DS1, A6DS2	2140-0053	2	Lamp: incd 10 V 14 mA	24446	1869 D obd
A6V1 thru A6V3	1990-0043		Cell: photoconductive CdS	03911	CL905HL
A6V4, A6V5	1990-0044		Cell: photoconductive CdS	03911	CL905HN
A7	00333-66507	1	Assembly: filter board includes C1 and C2 L1	-hp-	
A7C1	0160-2115	1	C: fxd my 1.3 μ F $\pm 10\%$ 50 vdcw	56289	148P Yellow jacket
A7C2	0170-0064	1	C: fxd my 0.47 μ F $\pm 10\%$ 100 vdcw	56289	148P47491
A7L1	9100-1317	1	Inductor: 180 mH $\pm 2\%$ 7 pin miniature socket base	-hp-	
C1	0160-0953	1	C: fxd my 0.33 μ F $\pm 10\%$ 400 vdcw	84411	663UW obd
C2	0160-3327	2	C: fxd my 1 μ F $\pm 10\%$ 400 vdcw	84411	663F obd
C3	0130-0006	1	C: var cer 5-20 pF	72982	503000B2PO28R
C4	0121-0004	1	C: var air 12.5 to 535.1 pF 4 sect	-hp-	
C5	0160-3333	2	C: fxd cer .005 μ F $\pm 20\%$ 250 vac	08988	THD-8-502M 1.4KV
C6	0140-0021	1	C: fxd mica 39 pF $\pm 10\%$	72136	RCM15E390K
C7	0160-3333	1	C: fxd cer .005 μ F $\pm 20\%$ 250 vac	08988	THD-8-502M 1.4KV
C8	0140-0206	1	C: fxd mica 270 pF $\pm 5\%$ 500 vdcw	04062	3DM15F271J5C
C9*	0150-0015	1	C: fxd TiO ₂ 2.2 pF $\pm 10\%$ 500 vdcw	78488	Type GA obd
CR1	1901-0025		Diode: Si 100 mA 100 wiv 12 pF (Option 01 only)	07263	FD 2387
DS1	1450-0049	1	Light: indicator	72765	599-125 (clear)
F1	2110-0320	1	Fuse: 0.15 amp 250 V slow-blow (115V Op.)	71400	MDL-15/100
F1	2110-0311	1	Fuse: 0.062 amp 250 V slow-blow (230V Op.)	71400	MDL-1/16
F2	2110-0318	2	Fuse: 1/8 amp 250V slow-blow	71400	MDL-1/8
J1, J2			See Figure 6-1		
J4	1251-2357	1	Connector: ac power cord receptacle	82389	EAC-301 obd
L1, L2	9140-0041	2	Inductor: fxd 2.5 mH $\pm 10\%$ 30 Ω	95265	SA-2500-I
L3	9170-0016	1	Bead: shielding	02114	56-590-652A1/38
L4	9170-0805	1	Coil: fixed configuration	-hp-	
L5	9100-3447		Coil: fixed choke	-hp-	
M1	1120-0352	1	Meter: 334A	-hp-	
M1	1120-0398	1	Meter: VU (Option 01 only)	-hp-	

> Option 01 only

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	T Q	DESCRIPTION	MFR.	MFR. PART NO.
R1	0767-0001	1	R: fxd met oxide $400\Omega \pm 5\%$ 3 W	75042	PMF-3 obd
R2	0687-4701	1	R: fxd comp $47\Omega \pm 10\%$ 1/2 W	01121	EB 4701
R3*	0686-3915	1	R: fxd comp $390\Omega \pm 5\%$ 1/2 W	01121	EB 3915
R4, R5	2100-1736	1	R: var conc rear sect. $3\text{ k}\Omega$ panel sect. $100\Omega \pm 10\%$ 2 W	01121	obd
R6	0686-1035	1	R: fxd comp $10\text{ k}\Omega \pm 5\%$ 1/2 W	01121	EB 1035
R7	0813-0029	2	R: fxd $1.0\Omega \pm 3\%$ 3 W	91637	RS2B-95
R8	0683-5125	1	R: fxd comp $5100\Omega \pm 5\%$ 1/4 W	01121	CB 5125
R10	0683-1325	1	R: fxd comp $1300\Omega \pm 5\%$ 1/4 W	01121	CB 1325
R11			Not assigned		
R12	0683-3335	1	R: fxd comp $33\text{ k}\Omega \pm 5\%$ 1/4 W	-hp-	
R14	0686-1055	1	R: fxd comp $1\text{ M} \pm 5\%$ 1/2 W	01121	EB 1055
S1	3100-0878	1	Switch: function	76854	1332 obd
S2	00331-61902	1	Switch Assembly: sensitivity	-hp-	
S2C1 thru S2C5	0132-0004	5	C: var trim 0.7 to 3.0 pF	72982	535-009-4R
S2C6	0160-0205	2	C: fxd mica $10\text{ pF} \pm 5\%$ 500 vdcw	04062	RDM15C100J5S
S2C7	0140-0152	1	C: fxd mica $1000\text{ pF} \pm 5\%$ 300 vdcw	04062	DM16F102J
S2C8	0160-0958	1	C: fxd mica $390\text{ pF} \pm 5\%$ 300 vdcw	04062	RDM15F391J3S
S2C9	0160-0990	1	C: fxd mica $100\text{ pF} \pm 2\%$ 300 vdcw	04062	RDM15F101G3S
S2C10	0160-0205		C: fxd mica $10\text{ pF} \pm 5\%$ 500 vdcw	04062	RDM15C100J5S
S2R1	0698-3118	1	R: fxd met flm $3240\Omega \pm 1\%$ 1/2 W	19701	MF7C T-O obd
S2R2	0698-3119	1	R: fxd met flm $6980\Omega \pm 1\%$ 1/2 W	19701	MF7C T-O obd
S2R3	0757-0846	1	R: fxd met flm $22.1\text{ k}\Omega \pm 1\%$ 1/2 W	19701	MF7C T-O obd
S2R4	0698-3120	1	R: fxd met flm $69.8\text{ k}\Omega \pm 1\%$ 1/2 W	19701	MF7C T-O obd
S2R5	0757-0862	1	R: fxd met flm $221\text{ k}\Omega \pm 1\%$ 1/2 W	19701	MF7C T-O obd
S2R6	0698-3121	1	R: fxd met flm $698\text{ k}\Omega \pm 1\%$ 1/2 W	19701	MF7C T-O obd
S2R7			Not assigned		
S2R8	2100-1438	1	R: var pot lin $1000\Omega \pm 10\%$ 1/2 W	11237	Series 45 obd
S3	00333-61903	1	Switch Assembly: meter range includes C1 thru C6 R1 thru R14	-hp-	
S3C1	0132-0004	1	C: var trim 0.7-3.0 pF	72982	535-009-4R
S3C2, S3C3	0140-0180	2	C: fxd mica $2000\text{ pF} \pm 2\%$	72136	RDM19F202G3C
S3C4	0160-0182	1	C: fxd mica $47\text{ pF} \pm 2\%$	-hp-	
S3C5	0140-0064	1	C: fxd mica $62\text{ pF} \pm 5\%$	72136	RCM 15E 620 J
S3C6	0121-0039	1	C: var cer trim 8-50 pF	72982	557-062-U2PO34R
S3R1	0686-2215	1	R: fxd comp $220\Omega \pm 5\%$ 1/2 W	01121	CB 2215
S3R2	0698-3138	4	R: fxd met flm $277.5\Omega \pm 1/4\%$ 1/4 W	19701	MF6C T-O obd
S3R3	0698-3139	5	R: fxd met flm $410.26\Omega \pm 1/4\%$ 1/4 W	19701	MF6C T-O obd
S3R4	0698-3138		R: fxd met flm $277.5\Omega \pm 1/4\%$ 1/4 W	19701	MF6C T-O obd
S3R5	0698-3139		R: fxd met flm $410.26\Omega \pm 1/4\%$ 1/4 W	19701	MF6C T-O obd
S3R6	0698-3138		R: fxd met flm $277.5\Omega \pm 1/4\%$ 1/4 W	19701	MF6C T-O obd
S3R7	0698-3139		R: fxd met flm $410.26\Omega \pm 1/4\%$ 1/4 W	19701	MF6C T-O obd
S3R8	0698-3138		R: fxd met flm $277.5\Omega \pm 1/4\%$ 1/4 W	19701	MF6C T-O obd
S3R9, S3R10	0698-3139		R: fxd met flm $410.26\Omega \pm 1/4\%$ 1/4 W	19701	MF6C T-O obd
S3R11	0698-3137	1	R: fxd met flm $189.7\Omega \pm 1/4\%$ 1/4 W	19701	MF6C T-O obd
S3R12	0698-3146	1	R: fxd met flm $999\text{ k}\Omega \pm 1/4\%$ 1/4 W	19701	MF6C T-O obd
S3R13	0698-3145	1	R: fxd met flm $1\text{ k}\Omega \pm 1/4\%$ 1/4 W	19701	MF6C T-O obd
S3R14	0683-0755	1	R: fxd comp $7.5\Omega \pm 5\%$ 1/4 W	01121	CB-75G5
S4	00333-61901	1	Switch Assembly: frequency range includes C1 thru C5 R1 thru R21	-hp-	
S4C1	0180-0197	1	C: fxd $2.2\text{ }\mu\text{F} \pm 10\%$ 200 vdcw	56289	150D225X9020A2-DYS

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
S4C2	0180-1735	1	C: fxd Ta elect 0.22 μ F $\pm 10\%$ 35 vdcw	56289	150D224X9035A2-DYS
S4C3	0160-0162	1	C: fxd my 0.022 μ F $\pm 10\%$ 200 vdcw	56289	192P22392-PTS
S4C4	0160-0154	1	C: fxd my 0.0022 μ F $\pm 10\%$ 200 vdcw	56289	192P22292-PTS
S4C5	0140-0083	1	C: fxd mica 220 pF $\pm 5\%$	00853	RCM15E221J
S4C6	0150-0015	1	C: fxd TI 2.2 MMF $\pm 10\%$ 500 vdcw	78488	Type GA
S4R1	0698-8686	2	R: fxd carbon flm 28.8 M Ω $\pm 1\%$ 2 W	-hp-	
S4R2	0757-0872	2	R: fxd met flm 1.3 M Ω $\pm 1\%$ 1/2 W	19701	MF7C 1/2-To-1304-F
S4R3	0727-0853	2	R: fxd carbon flm 2.61 M Ω $\pm 1\%$ 1/2 W	91637	DCS 1/2 obd
S4R4, S4R5	0698-3544	4	R: fxd met flm 255 k Ω $\pm 1\%$ 1/2 W	75042	CEC T-O obd
S4R6*			Part of Frequency Range switch assembly (not separately replaceable)		
S4R7	0698-3418	2	R: fxd met flm 26.1 k Ω $\pm 1\%$ 1/2 W	75042	CEC T-O obd
S4R8*			Part of Frequency Range switch assembly (not separately replaceable)		
S4R9	0698-3535	2	R: fxd met flm 1.65 k Ω $\pm 1\%$ 1/2 W	75042	CEC T-O obd
S4R10	0698-4424	2	R: fxd flm 1.40 k Ω $\pm 1\%$ 1/8 W	75042	CEC T-O obd
S4R11	0698-8686	2	R: fxd carbon flm 28.8 M Ω $\pm 1\%$ 2 W	-hp-	
S4R12	0757-0872	2	R: fxd met flm 1.3 M Ω $\pm 1\%$ 1/2 W	19701	MF7C1/2-To-1304-F
S4R13	0727-0853		R: fxd carbon flm 2.61 M Ω $\pm 1\%$ 1/2 W	91637	DCS 1/2 obd
S4R14, S4R15	0698-3544		R: fxd met flm 255 k Ω $\pm 1\%$ 1/2 W	75042	CEC T-O obd
S4R16*			Part of Frequency Range switch assembly (not separately replaceable)		
S4R17	0698-3418		R: fxd met flm 26.1 k Ω $\pm 1\%$ 1/2 W	75042	CEC T-O obd
S4R18*			Part of Frequency Range switch assembly (not separately replaceable)		
S4R19	0698-3535		R: fxd met flm 1.65 k Ω $\pm 1\%$ 1/2 W	75042	CEC T-O obd
S4R20	0698-4424		R: fxd flm 1.40 k Ω $\pm 1\%$ 1/8 W	75042	CEC T-O obd
S4R21 thru S4R26*			Part of Frequency Range switch assembly (not separately replaceable)		
S5	3101-0036	1	Switch: toggle AC power spst	88140	8928K61
S6	3101-1609	1	Switch: slide 2-DPDT 1.5A 250 VAC	82389	11E - 1036
S7	3101-0110	2	Switch: slide DPDT (334A only)	82389	11A-1039A
S8	3100-1716	1	Switch: position lever	76854	Type 187 obd
S9	3101-0889		Switch: slide DPDT	-hp-	
T1	9100-1316	1	Transformer: power	-hp-	
W1	8120-1348	1	Assembly: cable power cord set	70903	KH-4147 obd
<u>MISCELLANEOUS</u>					
	0400-0111	1	Bushing: nylon black plastic	28520	SB-437-5
	00331-61603	1	Cable "A"	-hp-	
	00331-61604	1	Cable "B"	-hp-	
	00331-61605	1	Cable "C"	-hp-	
	00333-61603	1	Cable: control	-hp-	
	00333-61602	1	Cable: filter	-hp-	
	00333-61601	1	Cable: main	-hp-	
	1400-0043	1	Clip: Fahnstock brass	79963	#146
	1400-0084	1	Holder: Fuse F1 extractor post type	75915	342014
	00333-90006	1	Manual: operating and service	-hp-	
	00332-00601	1	Shield: Power A	-hp-	
	5040-0702	2	Washer: shoulder	-hp-	
	0340-0089	1	Insulator: binding post	-hp-	
	0403-0150	4	Guides: P.C. board grey	-hp-	
	00332-61603	1	Cable Assembly Consisting of:	-hp-	
	1250-1414	1	Connector: RF TRAXL FEM SGL HOLE RR	24931	30JS119-1
	8120-0789	1	Coaxial-Cable: 50 Ω , 3-in., 11-OD, 28 AWG	-hp-	

SECTION VII

CIRCUIT DIAGRAMS

7-1. INTRODUCTION.

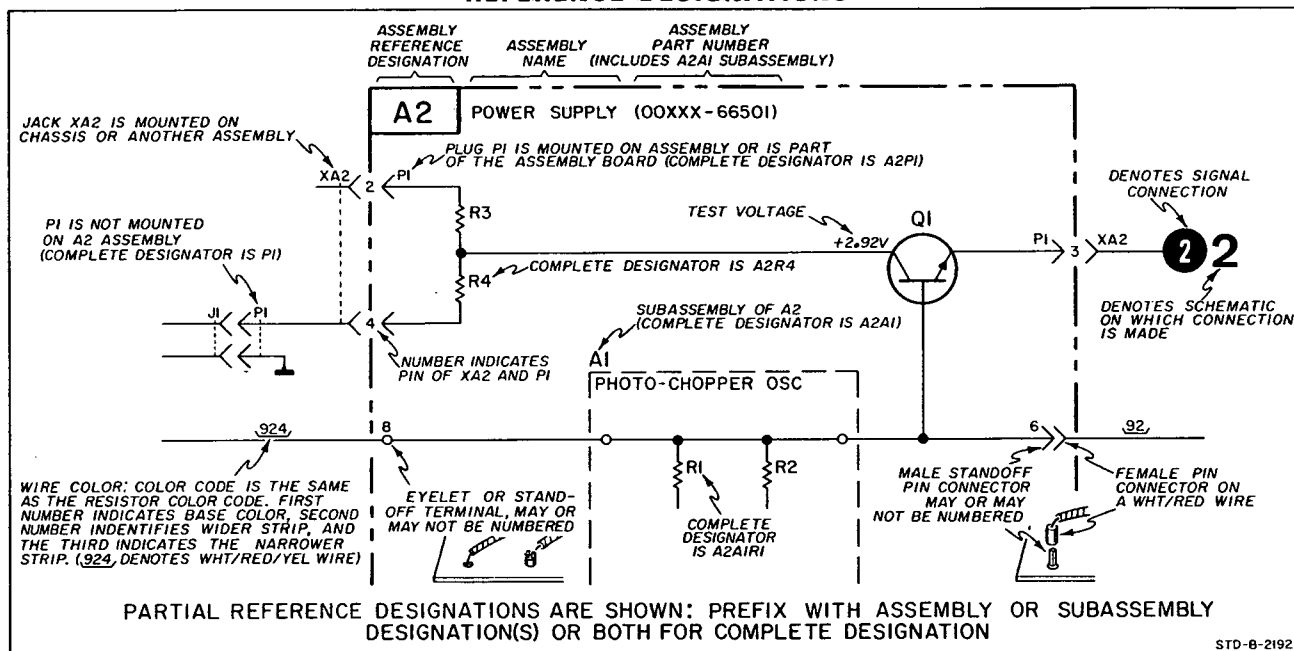
7-2. This section contains circuit diagrams to aid in the operation and maintenance of the Models 333A and 334A. Figure 7-1 is an internal wiring diagram that shows the colors of the circuit board wires. Figures 7-2 through 7-6 contain detailed schematic

diagrams as well as component location drawings of each printed circuit board.

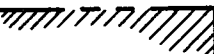
7-3. General schematic notes, which apply to all the schematic diagrams, are listed on page 7-2.

7-4. An explanation of terms and symbols used on the schematic diagrams is given below.

REFERENCE DESIGNATIONS



GENERAL SCHEMATIC NOTES

1. PARTIAL REFERENCE DESIGNATIONS ARE SHOWN. PREFIX WITH ASSEMBLY OR SUBASSEMBLY DESIGNATION(S) OR BOTH FOR COMPLETE DESIGNATION.
2. COMPONENT VALUES ARE SHOWN AS FOLLOWS UNLESS OTHERWISE NOTED:
 RESISTANCE IN OHMS
 CAPACITANCE IN MICROFARADS
3.  DENOTES FRAME GROUND.
4.  DENOTES EARTH GROUND.
5.  DENOTES CHASSIS GROUND. (FLOATABLE)
6.  DENOTES CIRCUIT GROUND. (ON BOARD)
7.  DENOTES ASSEMBLY.
8.  DENOTES MAIN SIGNAL PATH.
9.  DENOTES FEEDBACK PATH.
10.  DENOTES FRONT PANEL MARKING.
11.  DENOTES REAR PANEL MARKING.
12.  DENOTES SCREWDRIVER ADJUST.
13.  DENOTES FRONT PANEL CONTROL.
14. * AVERAGE VALUE SHOWN, OPTIMUM VALUE SELECTED AT FACTORY.
15.  DENOTES COMPONENTS NOT MOUNTED ON ASSEMBLY.
16. ☆ DENOTES TROUBLESHOOTING INFORMATION LOCATED ON APRON PAGE OF RESPECTIVE SCHEMATIC.
17. † DENOTES DC VOLTAGE THAT MUST BE MEASURED WITH 10 MΩ/10 pF IMPEDANCE PROBE TO PREVENT OSCILLATIONS.
18.  DENOTES SIGNAL CONNECTION.
19.  DENOTES SCHEMATIC ON WHICH SIGNAL CONNECTION IS MADE.

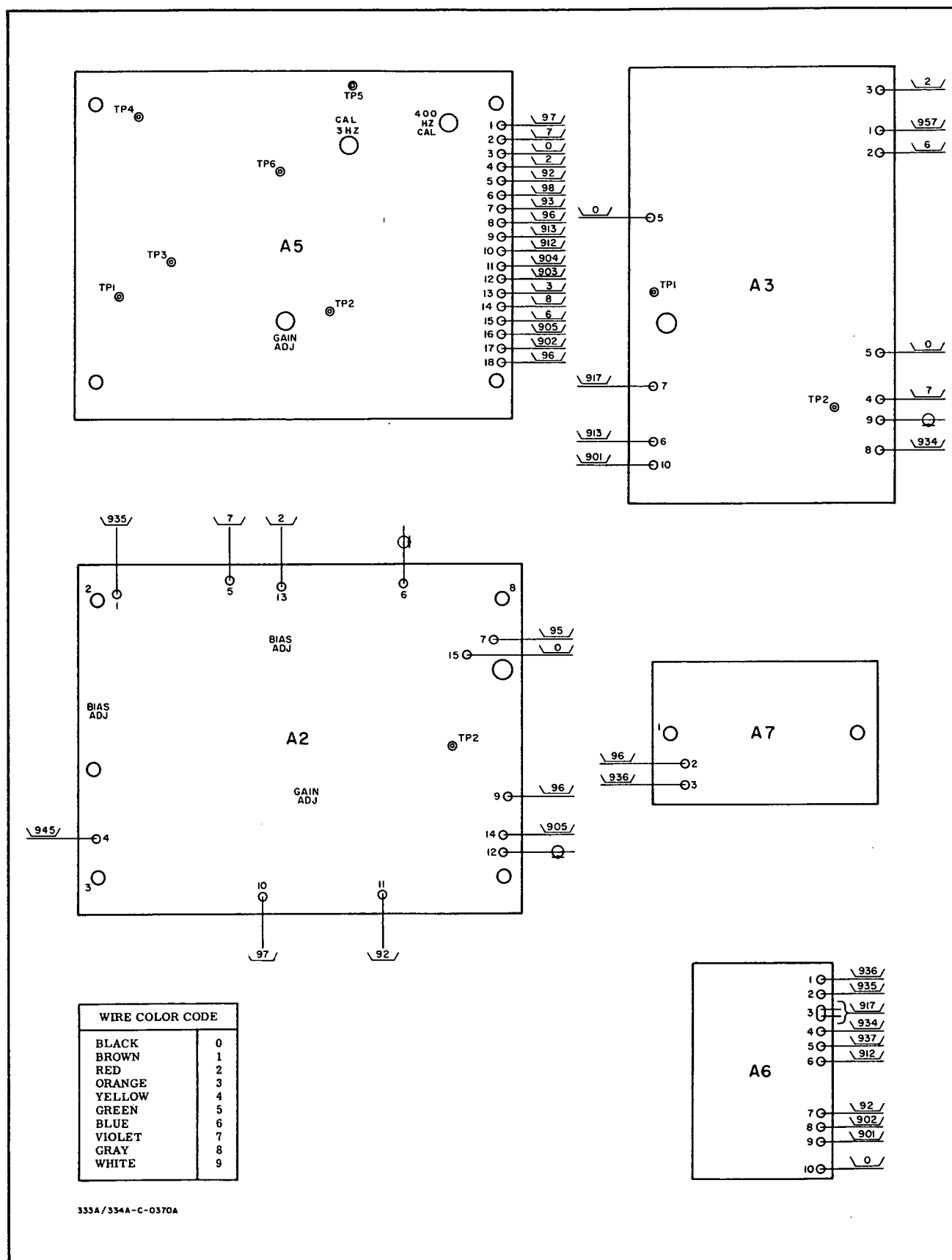


Figure 7-1. Internal Wiring Data

BACKDATING INFORMATION

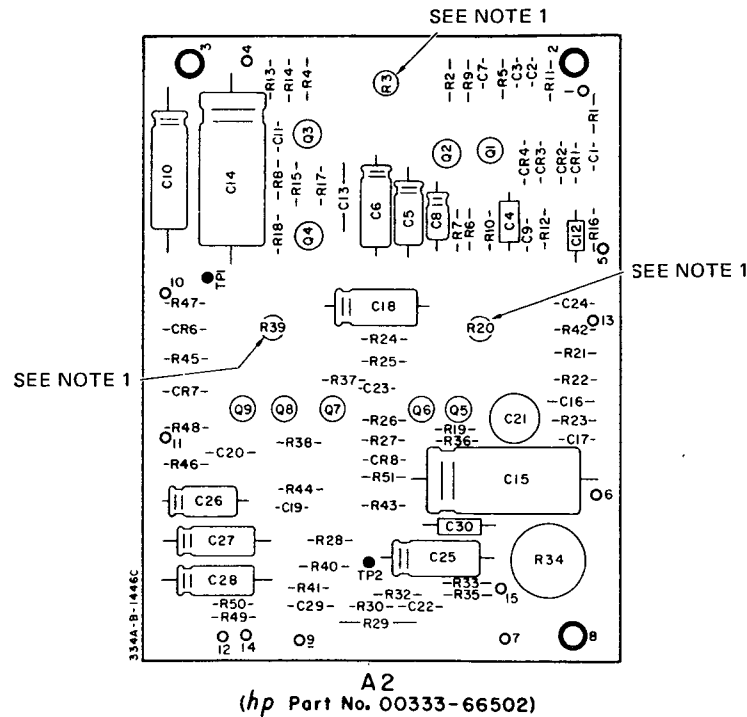
NOTE 1 - A2R3/R20/R39 are different in some earlier instruments and are not directly interchangeable with the ones listed in Table 6-1. See Appendix C, Change 11 for applicable numbers.

NOTE 2 - The A2 Component locator for earlier instruments is shown below. It applies to the following instruments and serial numbers:

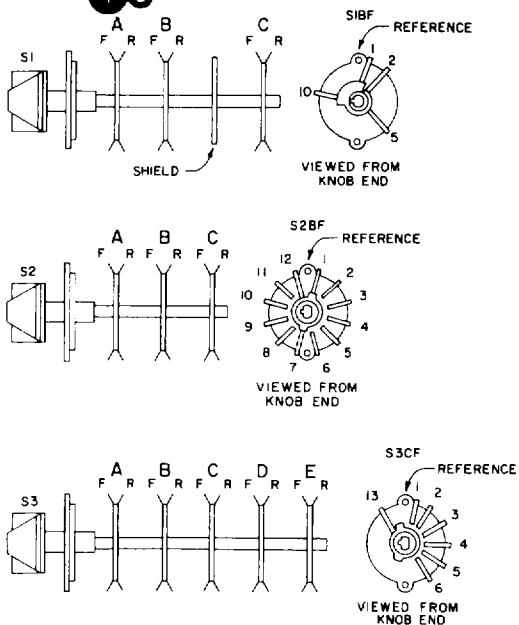
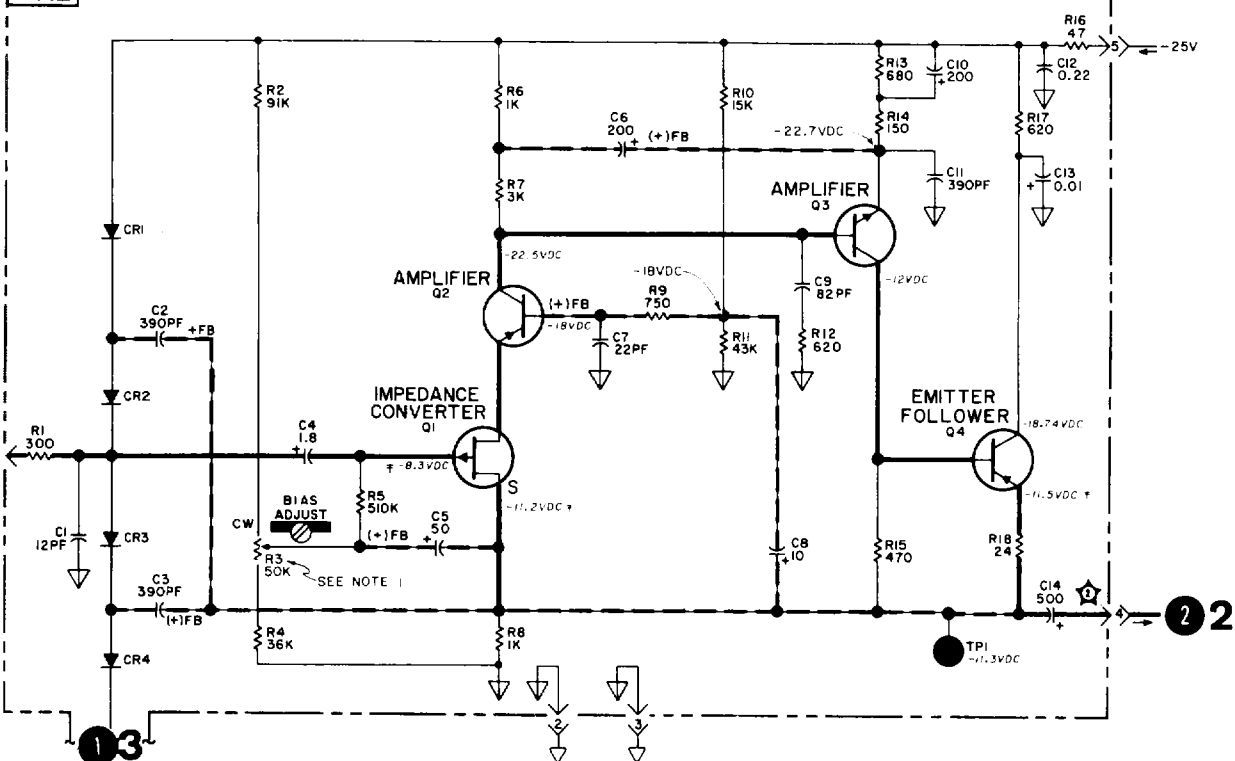
333A - 1101A02085 and below

334A - 1106A03240 and below

(Also applies to Option 01)



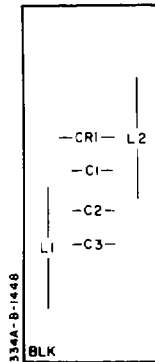
P/O A2 IMPEDANCE CONVERTER (00333-66512)



1

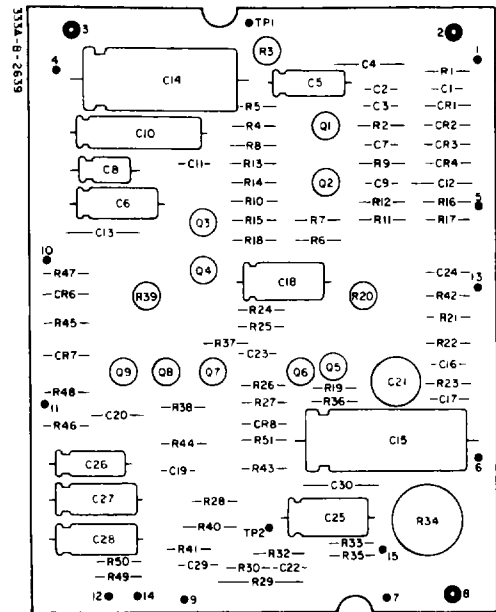
Figure 7-2. Impedance Converter (P/O A2) and RF Detector (A4)





A4

(hp Part No. 00332-66502)



A2

hp Part No. 00333-66512

TROUBLESHOOTING INFORMATION



1 mV rms between pin 1 and ground side of A2R12, for full scale meter deflection in VOLTMETER function on 1 V range.



1 mV rms at pin 4 for full scale meter deflection in VOLTMETER function on 1 V range. Use a 10 MΩ/10 pF impedance probe for this measurement.

BACKDATING INFORMATION

NOTE 1 - A2R3/R20/R39 are different in some earlier instruments and are not directly interchangeable with the ones listed in Table 6-1. See Appendix C, Change 11 for applicable numbers.

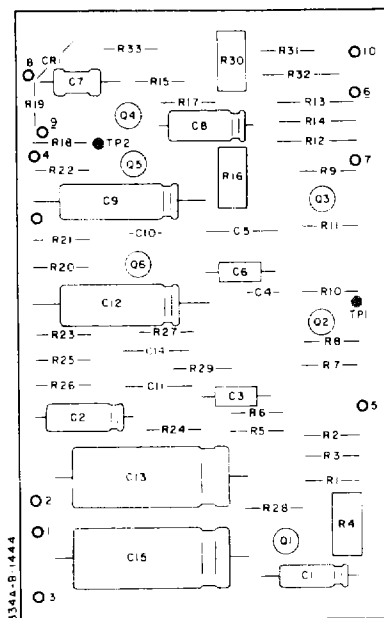
NOTE 2 - The A2 Component locator for earlier instruments is shown below. It applies to the following instruments and serial numbers:

333A - 1101A02085 and below

334A - 1106A03240 and below

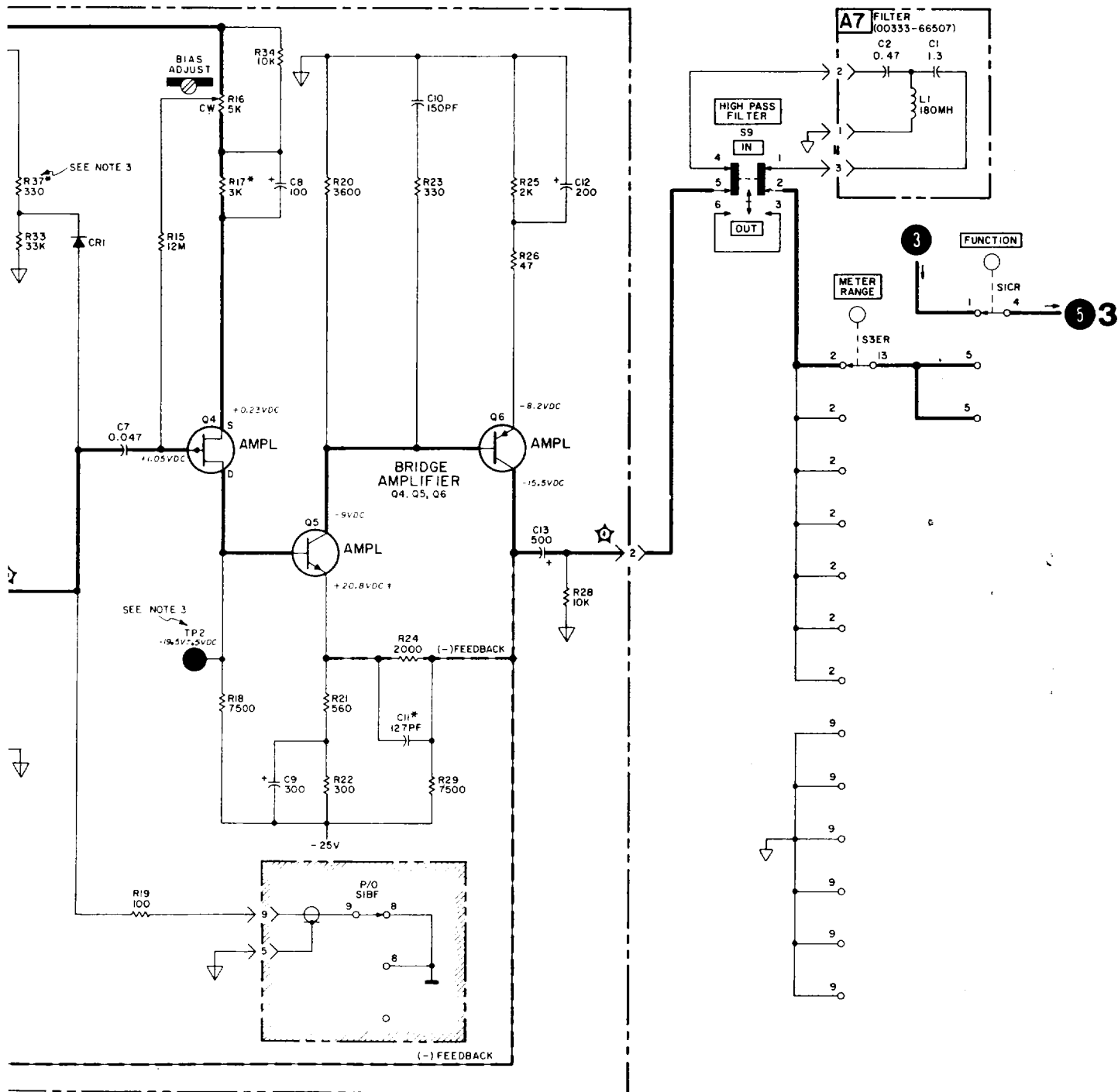
(Also applies to Option 01)

Note 3 - The value of A3R37 is 47 K Ω in earlier instruments. The voltage at A3RP2 will also be increased to -20.2 V dc. See change No. 14 in Appendix C.



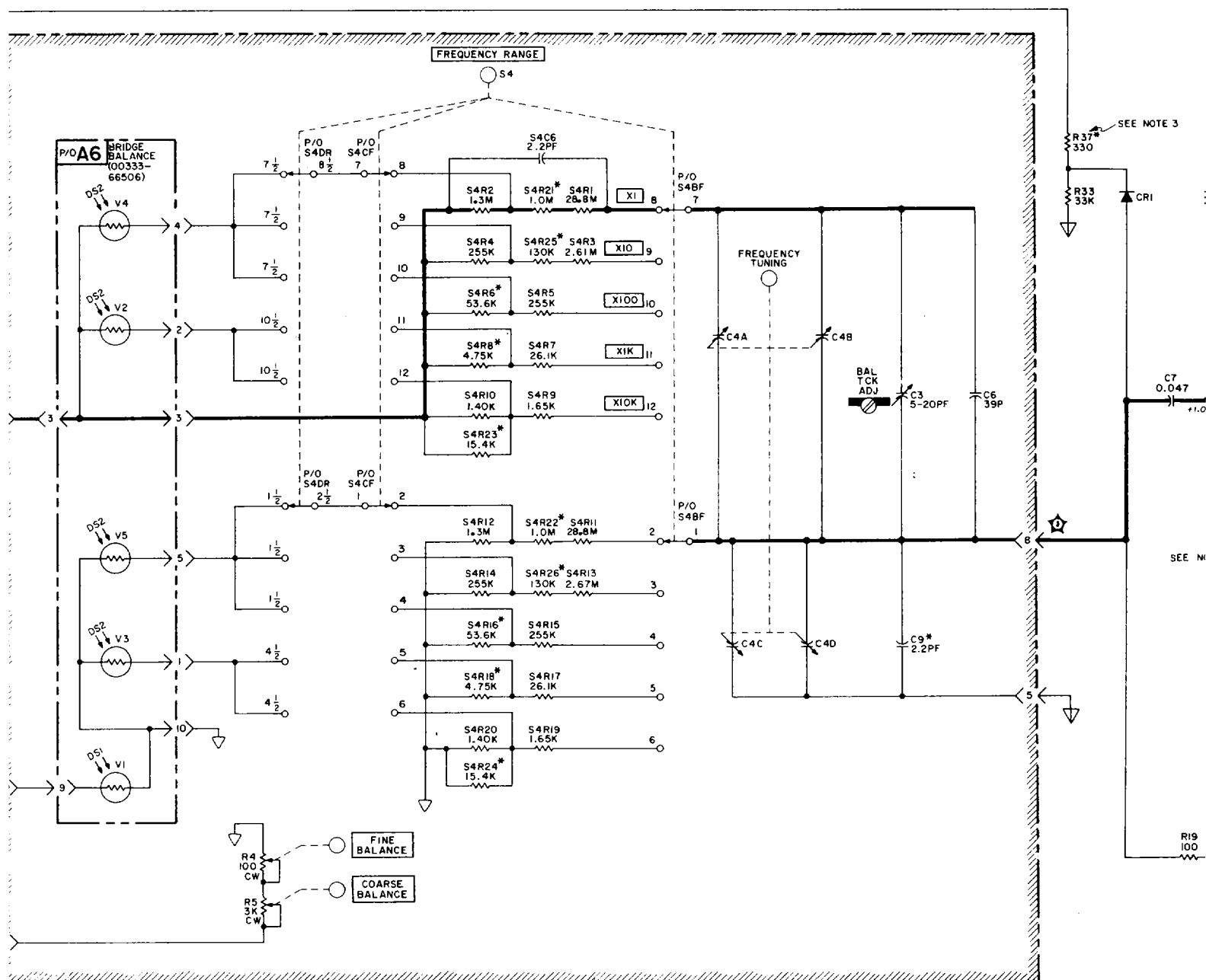
A 3

hp Part No. 00333-66503



2

Figure 7-3. Rejection Amplifier (A3), Bridge Balance (P/O A6) and High Pass Filter (A7).





TROUBLESHOOTING INFORMATION

When checking the voltages and waveforms for this circuit, set the 333A/334A controls as follows, unless otherwise noted:

FUNCTION SET LEVEL
METER RANGE 0.3 VOLTS
MODE MANUAL
SENSITIVITY MAX.
SENSITIVITY VERNIER MAX.
FREQUENCY RANGE X100
Frequency Dial 10
Input Signal 0.3 V rms at 1 kHz



0.29 V rms at pin 1.



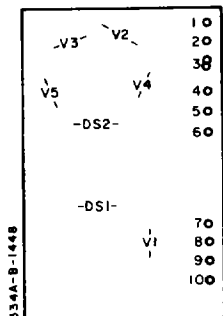
0.185 V rms at pin 7. In DISTORTION function, with input nulled, signal at pin 7 should change to 2.4 V rms. Use a 10 M Ω /10 pF impedance probe for this measurement.



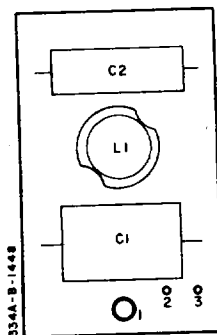
0 V rms at pin 8. In DISTORTION function but not nulled (frequency dial set to 50), signal at pin 8 changes to 0.315 V rms. Use a 10 M Ω /10 pF impedance probe for this measurement.



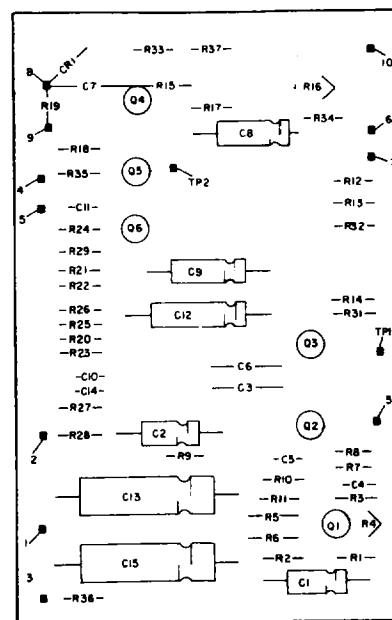
0.32 V rms at pin 2.



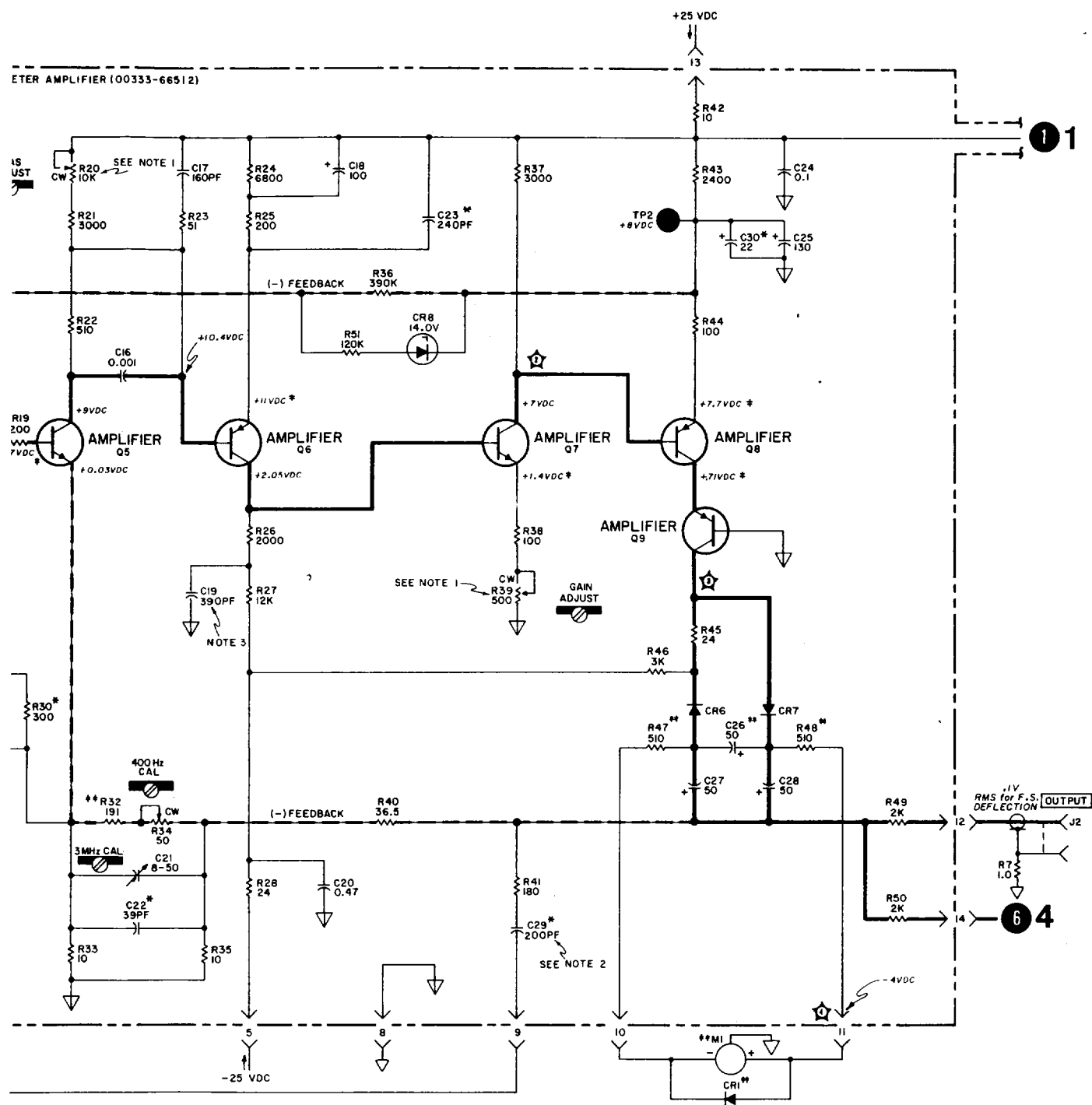
A6
(hp Part No. 00333-66506)



A7
(hp Part No. 00333-66507)

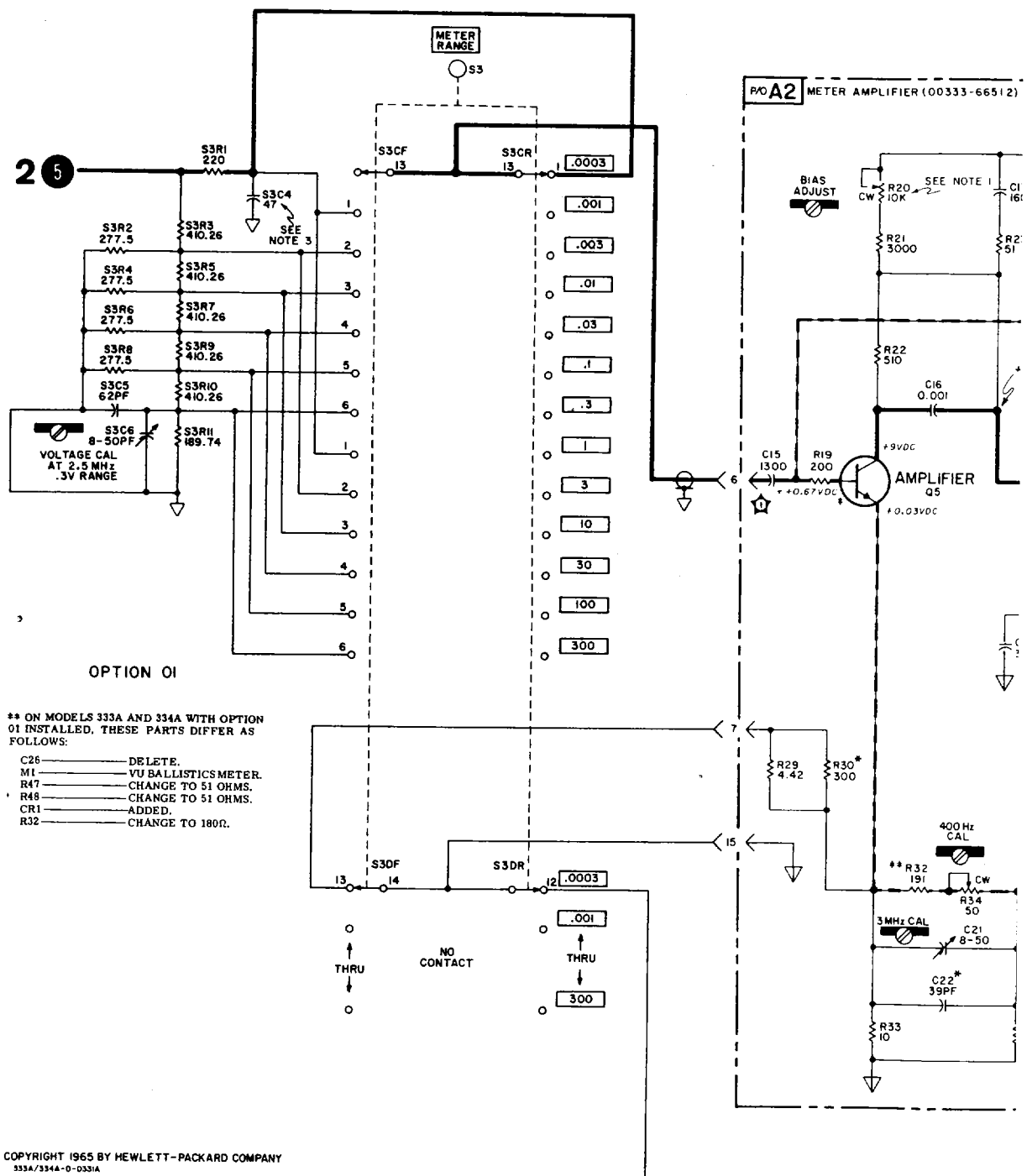


A3
(hp PART NO. 00333-66503 REV.D)



3

Figure 7-4. Meter Amplifier (P/O A2)



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333A/334A-0-0331A

BACKDATING INFORMATION

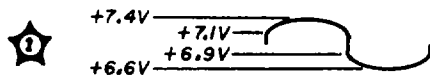
NOTE 1 - A2R3/R20/R39 are different in some earlier instruments and are not directly interchangeable with the ones listed in Table 6-1. See Appendix C (Change No. 11) for applicable serial numbers.

NOTE 2 - A2C29 was 390 pF in some earlier instruments. Do not change A2C29 to the value shown in Table 6-1 unless a frequency response problem is encountered on the 300 μ V range. See Appendix C for applicable serial numbers (Change No. 7).

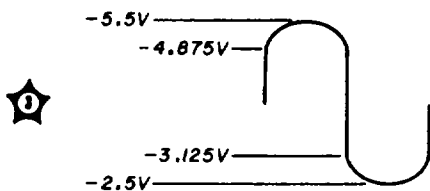
NOTE 3 - S3C4 was 22 pF and A2C19 was 680 pF on some earlier instruments. These capacitors should not be changed unless frequency response becomes a problem at 3 MHz and 1 MHz respectively. Refer to Appendix C, Change No. 5 for applicable serial numbers.

TROUBLESHOOTING INFORMATION

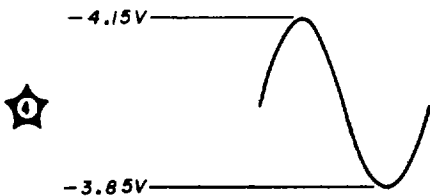
- 1 mV rms between pins 6 and 15 for full scale deflection on the 0 to 1 scale on the 0.001 V to 300 V ranges. 300 μ V rms between pins 6 and 15 for 300 μ V indication on 300 μ V range.



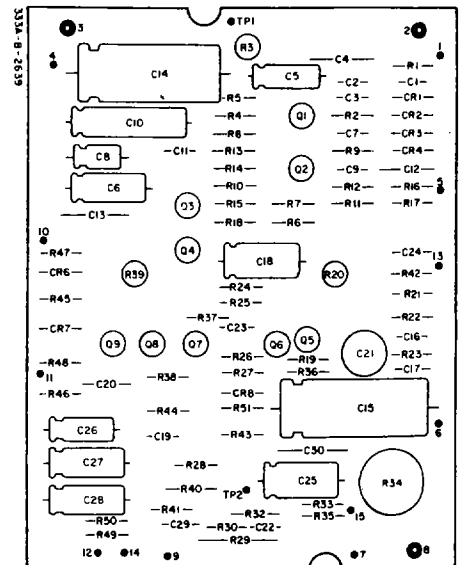
Voltage between collector of A2Q7 and pin 15 for full scale deflection on the 0 to 1 scale.



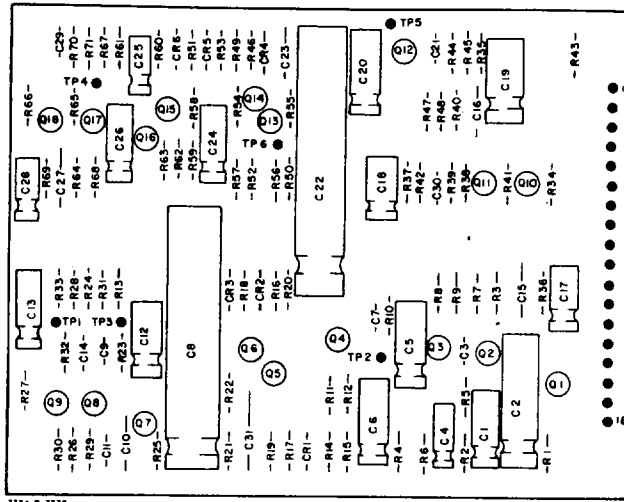
Voltage between collector of A2Q9 and pin 15 for full scale deflection on the 0 to 1 scale on 0.01 V range and above. (Cannot be measured on 0.01 V range and below because the meter amplifier will oscillate.)



0.3 V p-p from either pin 10 or 11 to ground for full scale deflection on 0 to 1 scale.



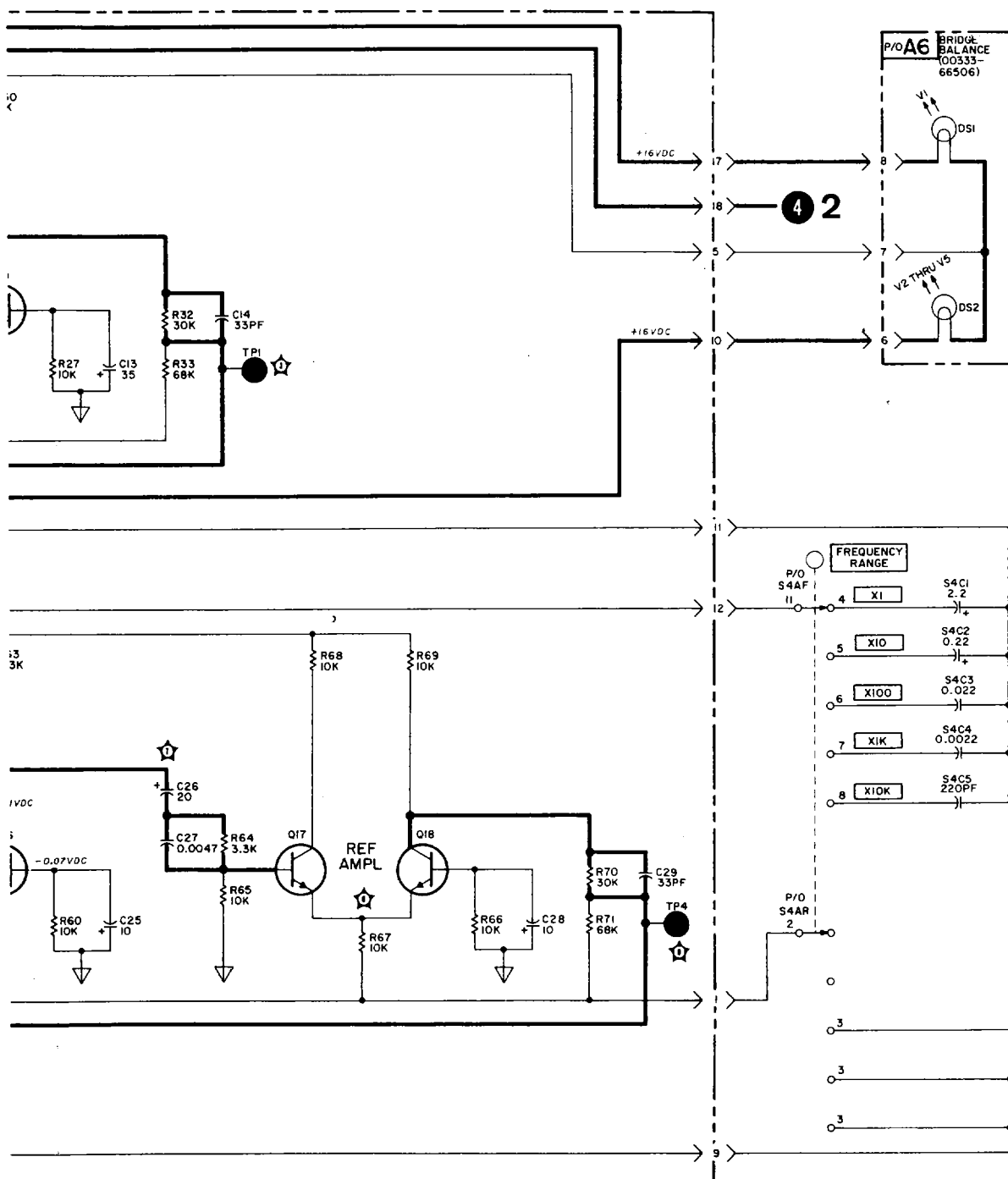
A2
hp Part No. 00333-66512



A5

hp Part No. 00333-26505

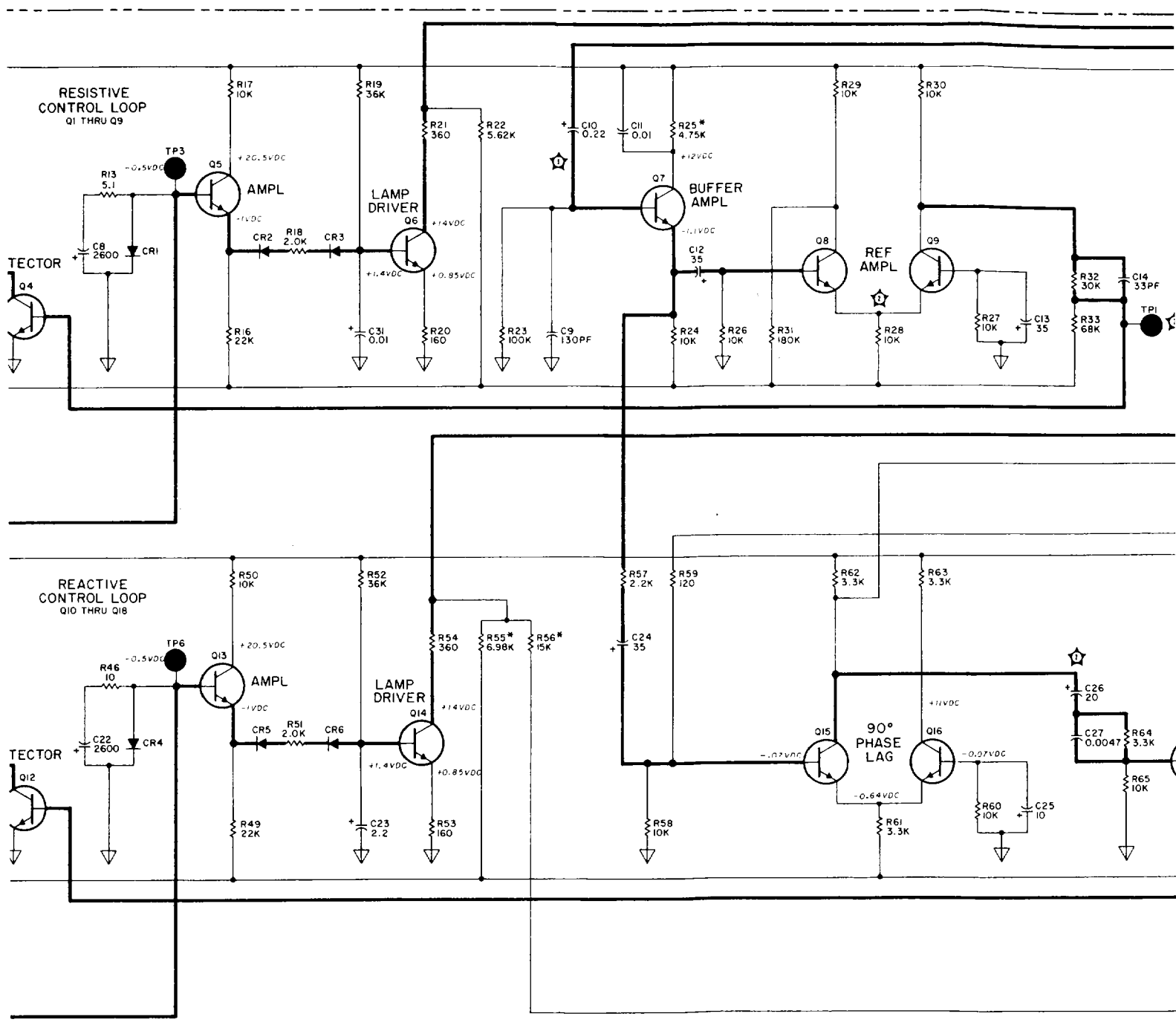
Rev. C



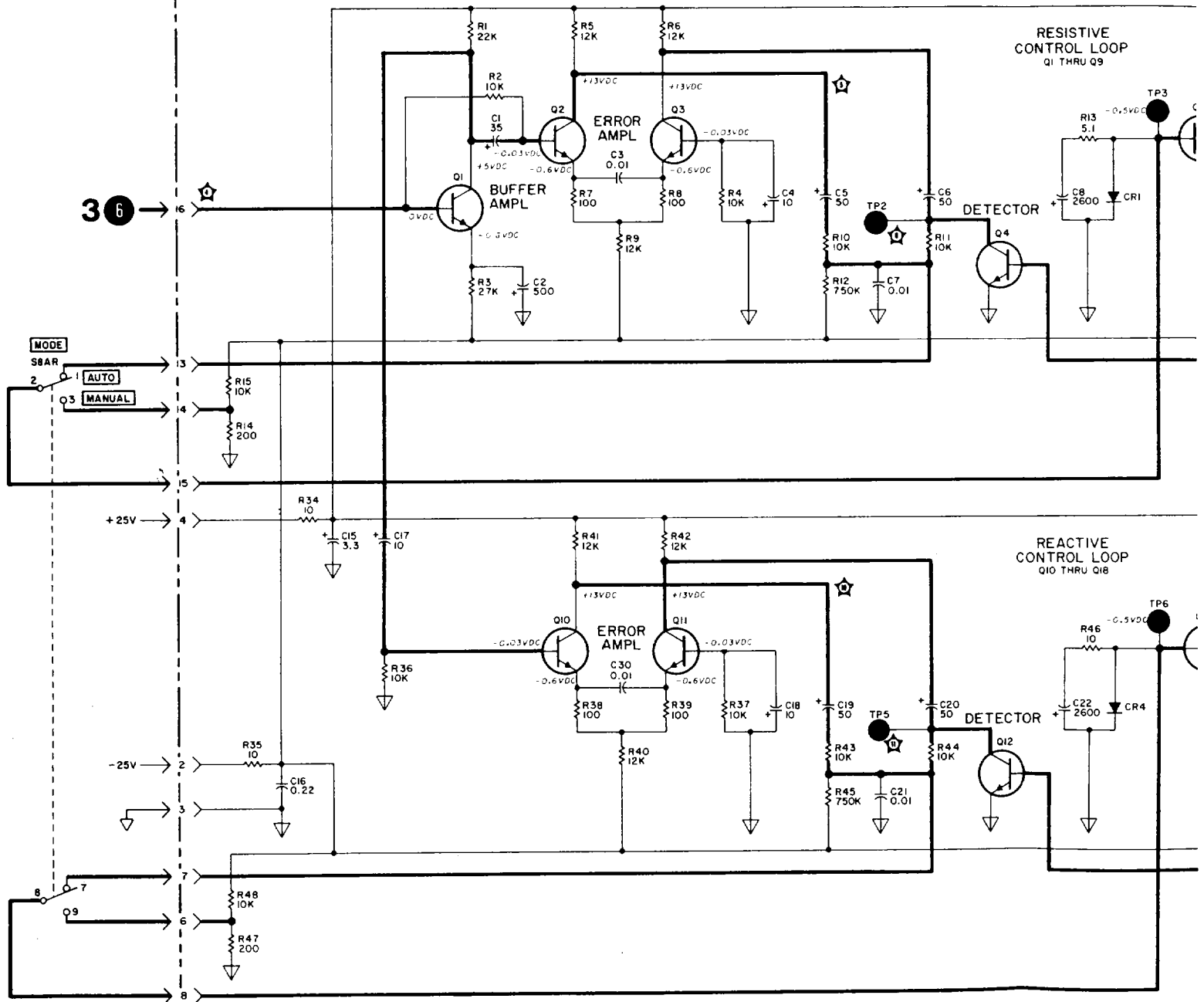
4

Figure 7-5. Control Circuit (A5) and Bridge Balance (P/O A6)

7-11/7-12



A5 CONTROL CIRCUIT (00333-66505)

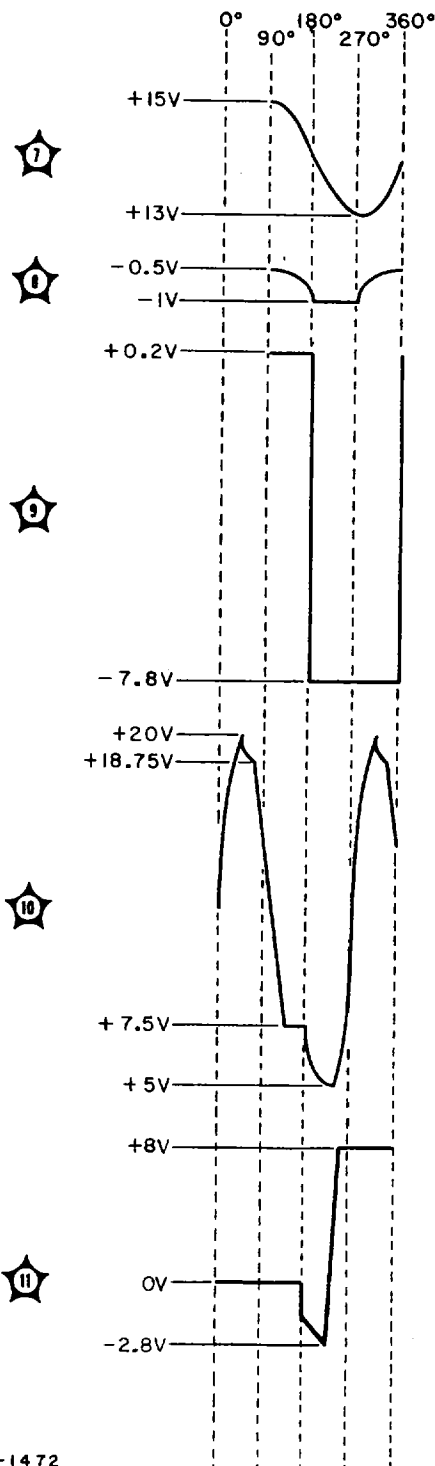
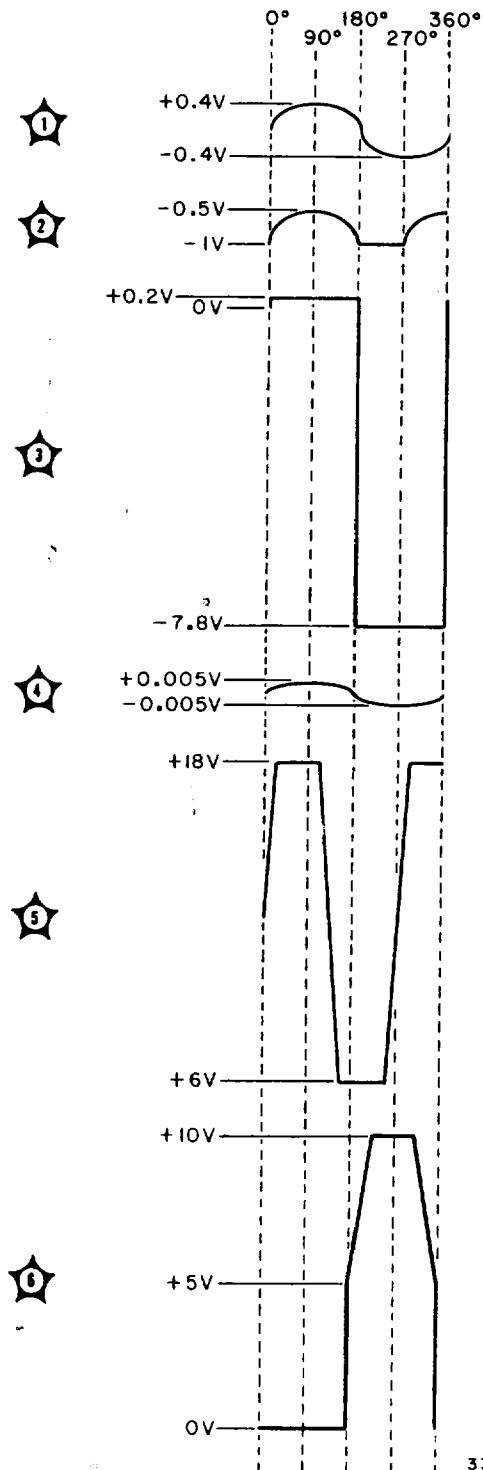


333A/334A-E-0333A
COPYRIGHT 1965 BY HEWLETT-PACKARD COMPANY

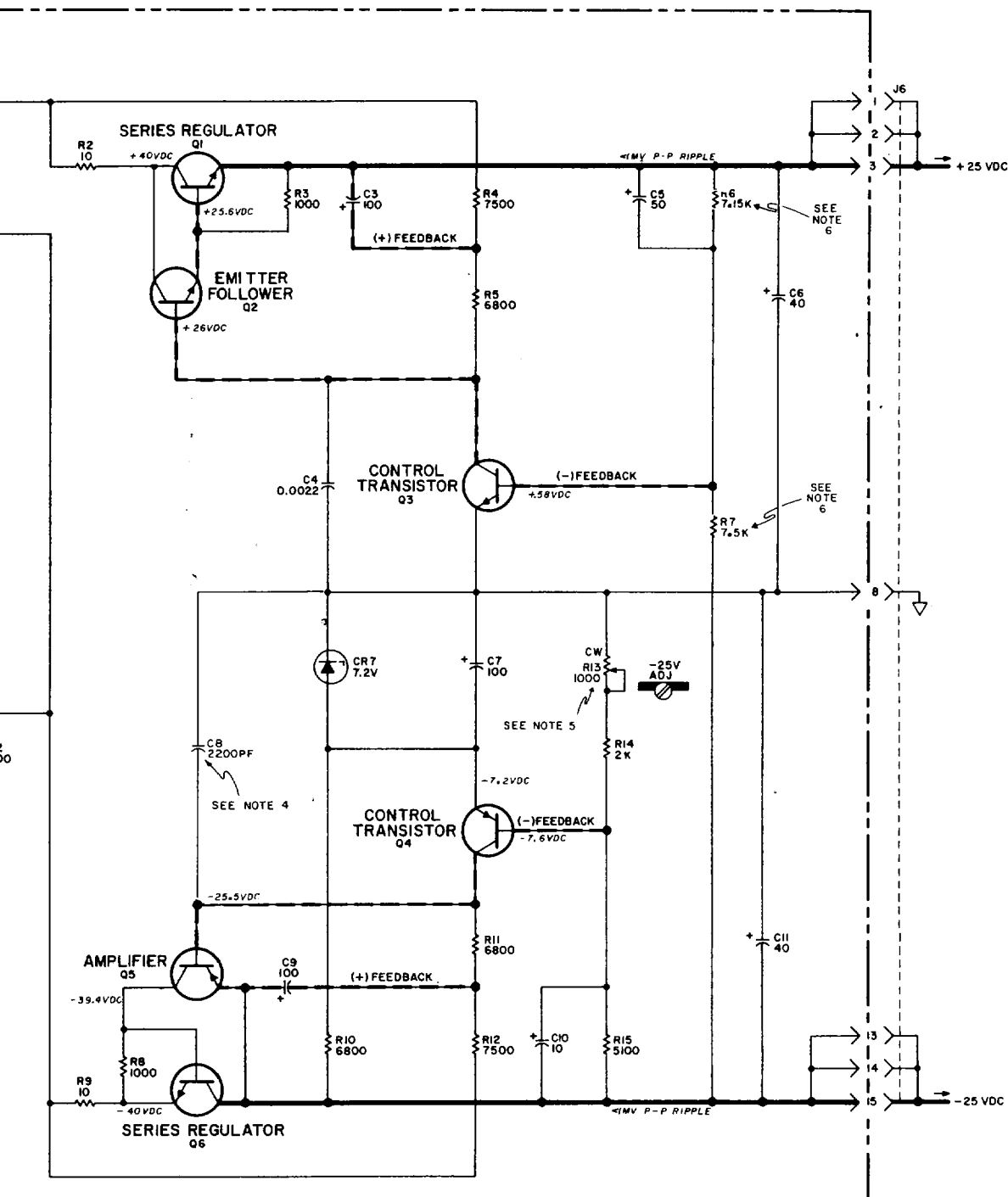
TROUBLESHOOTING INFORMATION

When checking the voltages and waveforms for this circuit, set the 333A/334A controls as follows, unless otherwise noted:

FUNCTION	SET LEVEL
METER RANGE	SET LEVEL
MODE	MANUAL
FREQUENCY RANGE	X100
Frequency Dial	10
Input Signal	1 kHz for full scale indication on 333A/334A meter



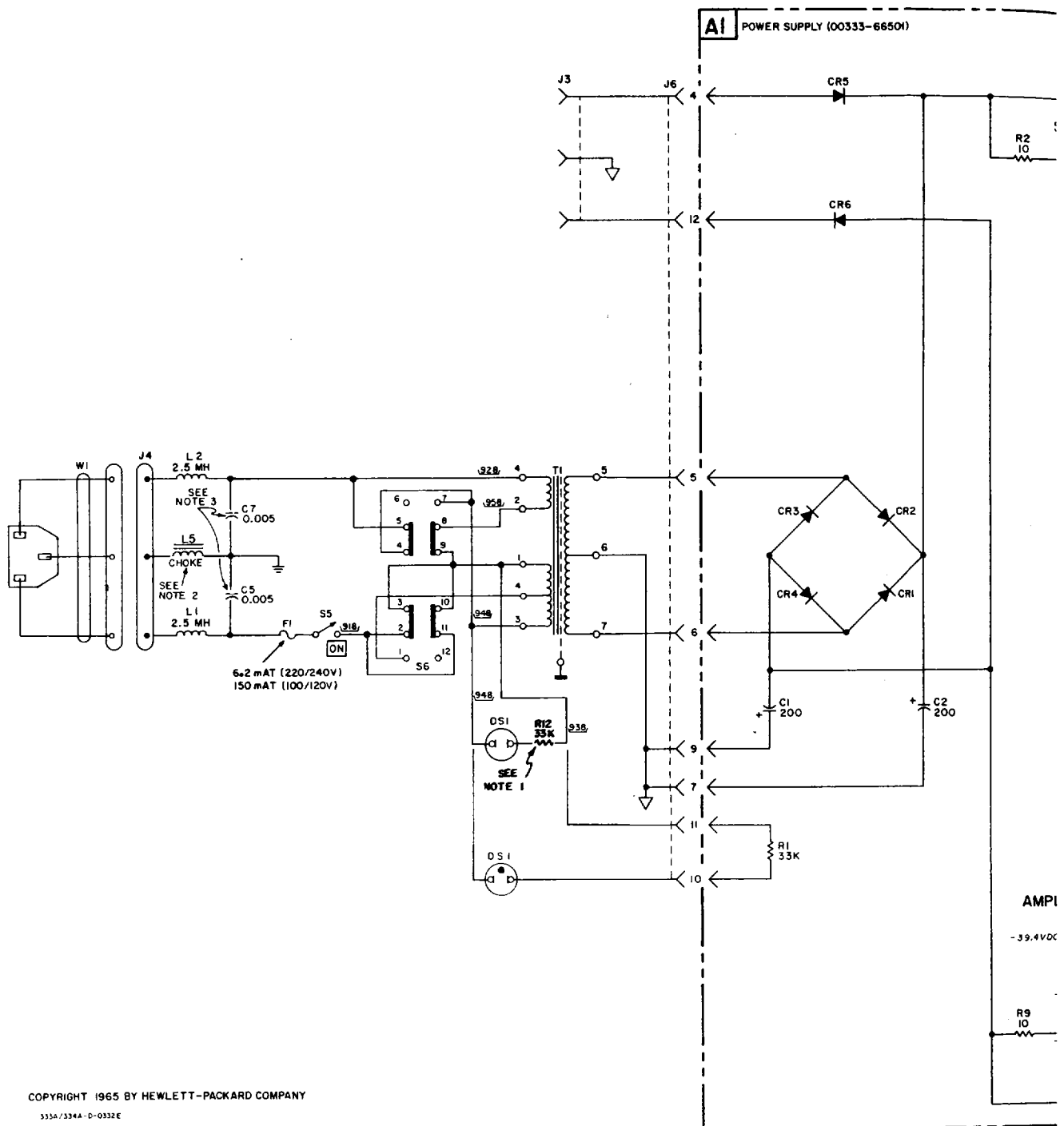
333A-B-1472



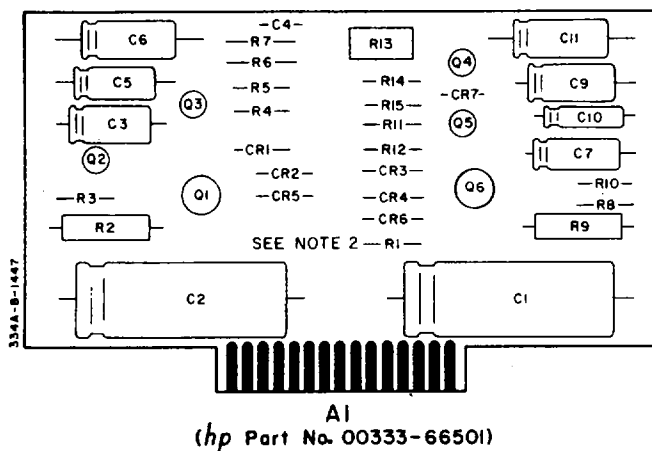
5

Figure 7-6. Power Supply (A1)

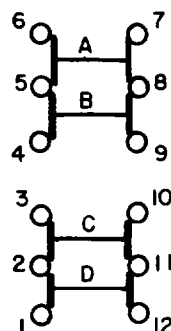
7-13/7-14



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333A/334A-D-0332E



SWITCH ASSEMBLY CONFIGURATION



VOLTAGE
240V
220V
120V
100V

SLIDE
POSITION
A & C
A & D
B & C
B & D

BACKDATING INFORMATION

NOTE 1 – R12 was located on the A1 Assembly and designated as A1R1. The resistor was connected between pins 10 and 11 on A1. See Appendix C, for applicable serial numbers.

NOTE 2 – R9 is added here on instruments prefixed 820- (822- for 334A) and below.

NOTE 3 – Value was .01 μ F on serials 820-01245 (822-01565 for 334A) and below.

NOTE 4 – C8 is added to instruments whose serial number is 533-00200 (538-00200 for 334A) and below.

NOTE 5 – A1R13 was different in some earlier instruments and is not directly interchangeable with the one listed in Table 6-1. See Appendix C for applicable serial numbers.

NOTE 6 – In some earlier instruments A1R6 was 12.1 k Ω and A1R7 was 12.7 k Ω . To improve power supply regulation these resistors should be changed to the values shown in Figure 7-6. See Appendix C for applicable serial numbers.

**MODEL 333A/334A**

DISTORTION ANALYZER

333A

[illegible]

334A

[illegible]

Manual Backdating Changes Model 333A/334A Page 2

CHANGE #1

Table 6-1:

Add A1C8, 0150-0085 C: fxd cer 0.0022 μ F 500 vdcw.
Change A2R51 to 0683-7535 R: fxd comp 75 k Ω 1/4 W $\pm$ 5%.

Figure 7-4:

Change value of A2R51 to 75 k Ω .

Figure 7-6:

Add Capacitor, A1C8, 0.0022 μ F, between cathode of A1CR7 and base of A1Q5.

CHANGE #2

Table 6-1:

Change A2C12 to 0150-0084 C: fxd cer 0.1 μ F +80% -20% 50 vdcw.
Change A2C20 to 0180-1735 C: fxd 0.47 μ F $\pm$ 10% 35 vdcw.
Change A2R16 and A2R28 to 0683-1005 R: fxd comp 10 ohms $\pm$ 5% 1/4 W.

NOTE 1 Excluding: 822-01787, -01791, -01792, -01794, -01796, -01799 thru -01802, -01806 thru -01808, -01811, -01813, -01817, -01823, -01824, -01825, -01827, -01829, -01830, -01832, -01834, -01835, -01837, -01839, -01842, -01844, -01845, -01848, -01851, -01852, -01853, -01855, -01858, -01861, and -01863.

NOTE 2 Excluding: 910-01493, -01494, -01495, -01497, -01500, -01501, -01503, -01504, -01507, -01508, -01509, -01510, -01512, -01514, -01515, -01516, -01518, -01520, -01521, and -01524.

Figure 7-2:

Change value of A2R16 to 10 ohms.
Change value of A2C12 to 0.1 μ F.

Figure 7-4:

Delete A2C30 from circuit.
Change value of A2R28 to 10 ohms.
Change value of A2C20 to 0.22 μ F.

CHANGE #3

Figure 7-5:

Delete A5C31 from circuit.

Table 6-1:

Delete A5C31.

CHANGE #4

Figure 7-2:

Delete A2R18 from circuit. Replace with Diode A2CR5.

Figure 7-4:

Delete A2R19 from circuit.

Table 6-1:

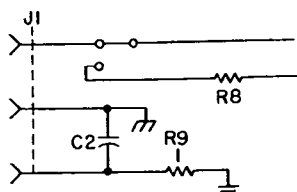
Delete A2R18 and A2R19.
Add A2CR5, 1901-0025, Diode: Si 50 mA, $\pm$ 1 V 100 piv 12 pF.
Change A2Q1 to 1855-0082.

CHANGE #5

Change A2C19 to 680 pF, Part # 0140-0208. This capacitor should not be replaced with the value listed in Table 6-1 unless a frequency response problem is encountered at 1 MHz. S3C4 was 22 pF and should not be replaced unless a frequency response problem is encountered at 3 MHz on the 1 V and 1 mV ranges.

CHANGE #6

Change the location of R9 as indicated in the following illustration.



Manual Backdating Changes Model 333A/334A Page 3

- CHANGE #7** A2C29 was 390 pF in some earlier instruments. Do not change A2C29 to the value shown in Table 6-1 unless a frequency response problem is encountered on the 300 μ V range.
- CHANGE #8** Change A3R3 to 12 k Ω . If A3Q1 is changed it may be necessary to change the value of A3R3 to compensate for transistor gain.
- CHANGE #9** Delete R12 and add A1R1, connected between pins 10 and 11 on A1. A1R1 is 33 k Ω , part # 0687-3331.
- CHANGE #10** Table 6-1:
Change the part # of Cable W1 to 8120-0078.
Change the part # of J4 to 1251-1009.
Page 6-4:
Change the part # of the 333A rear panel to 00333-00202 and change the part # of the 334A rear panel to 00334-00202.
The parts in this change are not directly interchangeable unless all parts are changed.
- CHANGE #11** Change A1R13 part # to 2100-1434.
Change A2R3 to part # 2100-0094.
Change A3R20 to part # 2100-1738.
Change A3R39 to part # 2100-0151.
The resistors in this change are not directly interchangeable with the ones listed in Table 6-1.
- CHANGE #12** Figure 7-3:
Delete the 47 ohm resistors A3R35 and A3R36 in series with the ± 25 volt lines.
Replace the resistors with a direct connection.
Change the value of A3R16 to 3300 ohms and delete A3R34.
Change the circuit in the vicinity of A3R37 as shown below:

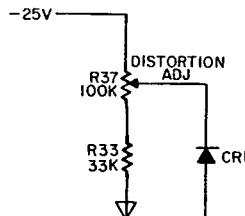


Table 6-1:

Change A3R16 to R: var 3.3 k Ω $\pm$ 10 % 1/8 W, -hp- part no. 2100-1435.
Change A3R37 to R: var 100 k Ω $\pm$ 30 % 1/8 W, -hp- part no. 2100-0362.
Delete A3R34, A3R35, and A3R36.

CHANGE #13

Page 6-3:

Change ⑨ to 5040-0642.

Page 6-4:

Change ① to 5060-0739.

Change ④ to 5060-0766.

Change ⑤ to 5000-0732.

Change ⑥ to 5000-0733.

Change ⑪ to 5060-0751.

Change ⑫ to 00334-00201 and 00333-00201.

Change ⑬ to 5060-0775.

CHANGE #14

Page 5-8, Table 5-5:

The voltage limits and regulation values for A3TP2 are changed to - 20.2 V $\pm$ 0.3 V.

Page 6-9:

Change A3Q4 to Part No. 1855-0006.

Change A3R37 to Part No. 0683-4735, 47 k Ω .

CHANGE #15

Page 6-12 :
Delete L59100-3447.

Page 6-13 :
Add R9, Part No. 0813-0029, R: fxd $1.0 \Omega \pm 3\%$ 3 W.

CHANGE #16

Page 5-6:
Under DC ISOLATION check Paragraph d, Change "approximately .27 mA" to "No Current", and "1 mA range" to "10 mA range".

Page 6-13:
Delete R14, Part No. 0686-1055, R: fxd comp. $1 M\Omega$.

Figure 7-2, Page 7-5/7-6:
Delete R14; $1 M\Omega$ in parallel with C2, C3 input circuit.

CHANGE #17

Page 6-14:
Change S4R2 and S4R12 to Part No. 0698-4074, $1.02 M\Omega$.
Change S4R1 and S4R11 to Part No. 0698-4075, $30.0 M\Omega$.

Figure 7-3, Page 7-7/7-8:
Change S4R2, S4R12 to $1.02 M\Omega$ and S4R1, S4R11 to $30.0 M\Omega$.

CHANGE #18

Page 1-2, Table 1-1:
Delete 100 V/120 V/ 220 V/ 240 V + 5% - 10%, 48 to 66 Hz, approximately 4 watts.
Add 115 V or 230 V $\pm 10\%$, 48% to 440 Hz, approximately 4 watts. Terminals are provided for external battery supply. Positive and negative voltages between 28 V and 50 V are required. Current drain from each voltage is 40 mA.

Page 2-1, Paragraph 2-6:
Delete 100 V/ 120 V/ 220 V/ 240 V + 5% - 10%, 48 to 66 Hz.
Add 115 or 230 volts ($\pm 10\%$), at 48 - 440 Hz.
Add at the end of the paragraph: The instrument can be battery operated by connecting two 28 - 50 V batteries (rated at 40 milliamperes) to the battery terminal on the rear panel.

Figure 3-1, Page 3-0:
Change the rear panel illustration as shown below.

Change Index No. 21 to read: Line Voltage (115/230 V) switch sets instrument to operate from 115 V or 230 V ac.
Add Index No. 23; Battery voltage (+ 28 to + 50 V dc and - 28 to - 50 V dc) terminals provide connection for external batteries.

Page 3-2:
Delete text under Paragraph 3-15.
Add steps a and b indicated below.

- a. If line voltage is to be used, set 115-230 V ac switch to coincide with voltage. Turn LINE switch to ON position. Pilot lamp will glow, indicating application of primary power.
- b. If batteries are to be used, connect both a + 28 to + 50 V and - 28 to - 50 V battery (or other dc source) to + and - battery terminals, respectively. (The LINE switch and pilot lamp are not in the circuit when batteries are used, therefore, an external switch may be used to provide a convenient means for disconnecting the batteries). When a dc power source is used, check the - 25 V power supply output (any violet lead). If the output is not $- 25 V \pm 0.5 V$, adjust the power supply according to the procedure in Paragraph 5-26.

Page 4-7:
Add the following text to the discussion on the Power Supply Circuit.

4-53. Diodes A1CR5 and A1CR6 are coupling and protection diodes for external battery supplies. The diodes protect the series regulator circuits from application of incorrect polarity at the battery input terminals. The diodes also protect external batteries from being charged when the ac power is being used with batteries connected to the battery terminals.

Page 5-1, Paragraph 5-7:

Change the first sentence to read: The performance checks are made with the ac power cord connected to nominal line voltage (115 V/ 220 V, 48 to 440 Hz),...

Page 5-8, Paragraph 5-25:

Change 440 Hz to 66 Hz.

Figure 6-1, Page 6-2:

Add battery terminal inputs, Index No. 's 34, 35, and 36 to the top and bottom view of the cabinet.

Figure 6-1, Page 6-3:

Add the Index No. 's and associated data as indicated below.

INDEX NO.	PART NO.	TQ	DESCRIPTION
34	0340-0087	1	Insulator-Binding Post, Triple
35	0340-0091	1	Insulator-Binding Post, Triple
36	1510-0011	3	Binding Post Assembly, Black

Change Index No. 15 to Part No. 1510-0091 and Index No. 22 to Part No. 1510-0534.

Page 6-12, Table 6-1:

Delete J1, J2.
Add J1 thru J3.

Figure 7-6, Page 7-13/7-14:

Add J3 to the schematic as shown below.

