

# TM 11-6625-1576-15

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

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**ORGANIZATIONAL, DS, GS, AND DEPOT  
MAINTENANCE MANUAL**

**DISTORTION ANALYZER**

**HEWLETT-PACKARD MODELS  
333A AND 334A**

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**HEADQUARTERS, DEPARTMENT OF THE ARMY  
MAY 1967**

**TM 11-6625-1576-15**

**WARNING**

**DANGEROUS VOLTAGES**

**EXIST IN THIS EQUIPMENT**

Be careful when working on the power supply and  
on the 115-volt ac line connections.

**DO NOT TAKE CHANCES !**

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TECHNICAL MANUAL )  
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HEADQUARTERS  
DEPARTMENT OF THE ARMY  
Washington, D.C., 19 May 1967

Organizational, DS, GS, and Depot Maintenance

DISTORTION ANALYZER, HEWLETT-PACKARD MODELS 333A AND 334A

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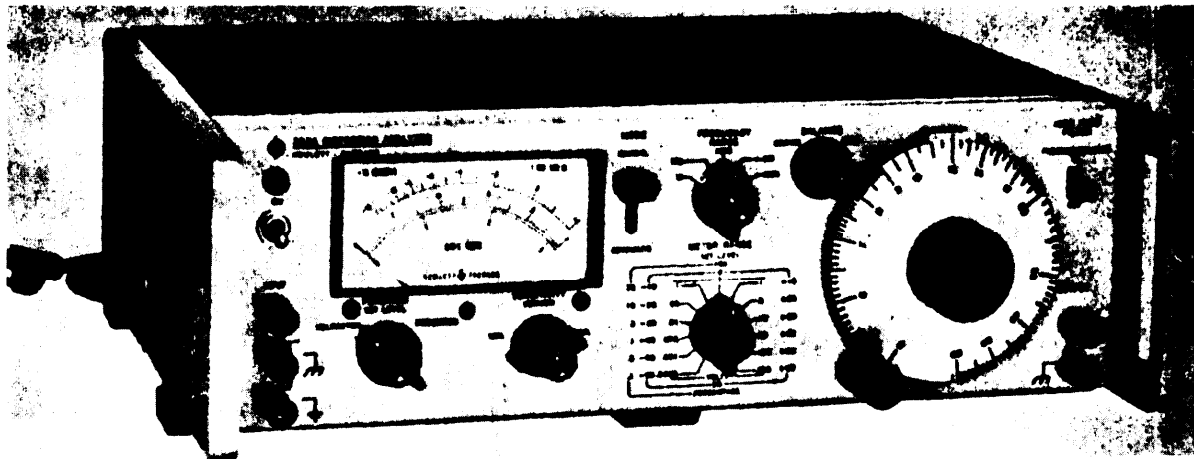


Figure 1-1. Model 333A Distortion Analyzer

Table 1-1. Specifications

MODEL 333A			
<b>DISTORTION MEASUREMENT RANGE:</b> Any fundamental frequency, 5 cps to 600 Kc. Distortion levels of 0.1%-100% are measured full scale in 7 ranges.			
<b>DISTORTION MEASUREMENT ACCURACY:</b> Harmonic frequency measurement accuracy:			
Fundamental Input Less Than 30 v			
<b>RANGE</b>	<b>±3%</b>	<b>±6%</b>	<b>±12%</b>
100%-0.3% F. S.	10 cps- 1 Mc	10 cps- 3 Mc	
0.1% F. S.	30 cps- 300 Kc	20 cps- 500 Kc	10 cps- 1 Mc
Fundamental Input Greater Than 30 v			
<b>RANGE</b>	<b>±3%</b>	<b>±6%</b>	<b>±12%</b>
100%-0.3% F. S.	10 cps- 300 Kc	10 cps- 500 Kc	10 cps- 3 Mc
0.1% F. S.	30 cps- 300 Kc	20 cps- 500 Kc	10 cps- 1 Mc
<b>Elimination Characteristics:</b> Fundamental Rejection >80 db Second Harmonic Accuracy for a fundamental of: 5 to 20 cps: better than +1 db 20 cps to 20 Kc : better than ±0.6 db 20 Kc to 100 Kc : better than -1 db 100 Kc to 300 Kc : better than -2 db 300 Kc to 600 Kc : better than -3 db			
<b>Distortion Introduced by Instrument:</b> <0.03% from 5 cps to 200 Kc <0.06% from 200 Kc to 600 Kc			
Meter indication is proportional to the average value of a waveform.			
<b>FREQUENCY CALIBRATION ACCURACY:</b> Better than ±3% from 5 cps to 200 Kc Better than +8% from 200 Kc to 600 Kc			
<b>INPUT IMPEDANCE:</b> Distortion Mode: 1 megohm shunted by less than 60 pf (10 megohms shunted by 10 pf with -hp-10001A divider probe). Voltmeter Mode: 1 megohm shunted by 30 pf, 1 to 300 v rms; 1 megohm shunted by 60 pf, 300 μv to 0.3 v rms.			
<b>INPUT LEVEL FOR DISTORTION MEASUREMENTS:</b> 0.3 v rms for 100% set level (up to 300 v may be attenuated to set level reference).			
<b>DC ISOLATION:</b> Signal ground may be ±400 vdc from external chassis.			
<b>VOLTMETER RANGE:</b> 300 μv to 300 v rms full scale (13 ranges) 10 db per range.			
<b>VOLTMETER FREQUENCY RANGE:</b> 5 cps to 3 Mc (300 μv range: 20 cps-500 Kc).			
<b>VOLTMETER ACCURACY:</b>			
<b>RANGE</b>	<b>±2%</b>	<b>±5%</b>	
300 μf	30 cps-300 Kc	20 cps-500 Kc	
1 mv-30 v	10 cps-1 Mc	5 cps-3 Mc	
100 v-300 v	10 cps-300 Kc	5 cps-500 Kc	
<b>NOISE MEASUREMENTS:</b> Voltmeter residual noise on the 300 μv range: <25 μv rms terminated in 600 Ω; <30 μv rms terminated with a shielded 100 K resistor.			
<b>OUTPUT:</b> Approximately 0.1 v rms output for full scale meter deflection. Output Impedance: 2 K			

Table 1-1. Specifications (Cont'd)

<p><b>AUTOMATIC NULLING MODE:</b>  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 <math>\pm 0.5\%</math> about true manual null.  X10 through X10 K, manual null tuned to less than 10% of set level; total frequency hold-in <math>\pm 1\%</math> about true manual null.</p> <p><b>AUTOMATIC NULL ACCURACY:</b>  5 cps to 100 cps: Meter reading within 0 to +3 db of manual null.  100 cps to 600 Kc: Meter reading within 0 to +1.5 db of manual null.</p> <p><b>HIGH-PASS FILTER:</b>  3 db point at 400 cps with 18 db per octave roll off. 60 cps rejection &gt;40 db. Normally used only with fundamental frequencies greater than 1 Kc.</p> <p><b>POWER SUPPLY:</b>  115 or 230 <math>\pm 10\%</math>, 50 to 1000 cps, 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 80 ma.</p>	<p><b>WEIGHT:</b>  Net 17-3/4 lbs. (7,98 kg),  Shipping 23 lbs. (10,35 kg).</p> <p style="text-align: center;"><b>MODEL 334A</b></p> <p>Same as Model 333A except as indicated below:</p> <p><b>AM DETECTOR:</b>  High impedance dc restoring peak detector with semi-conductor diode operates from 500 Kc to greater than 65 Mc. Broadband input. Maximum input; 40 vp-pac or 40 v peak transient.</p> <p><b>CARRIER FREQUENCY:</b>  550 Kc to 1.6 Mc: Distortion introduced by detector is &lt;0.3% for 3 to 8 volt carriers modulated 30%.  1.6 Mc to 65 Mc: Distortion introduced by detector is &lt;1% for 3 to 8 volt rms carriers modulated 30%.</p> <p style="text-align: center;"><b>NOTE</b></p> <p>Distortion measurement at carrier levels as low as 1 volt may be made with reduced accuracy.</p> <p><b>OPTION: 01</b>  Indicating meter has VU characteristics conforming to FCC Requirements for AM, FM, and TV broadcasting.</p>
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SECTION I  
GENERAL INFORMATION

## 1-A.1 Scope

This manual includes installation and operation instructions and covers operator's, organizational, direct support (DS), general support (GS), and depot maintenance. It describes Hewlett-Packard (Federal support Code 80537) Distortion Analyzer Models 333A and 334A (fig. 1-1). A basic issue items list for this equipment is not included as part of this manual.

## 1-A.2 Index of Publications

Refer to the latest issue of DA Pam 310-4 to determine whether there are new editions, changes, or additional publications pertaining to the equipment. DA Pam 310-4 is an *index* of current technical manuals, technical bulletins, supply manuals (types 7, 8, and 9), supply bulletins, lubrication orders, and modification work orders that are available through publications supply channels. The index lists the individual parts (-10, -20, -35P, etc) and the latest changes to and revisions of each equipment publication.

## 1-A.3 Forms and Records

a. Reports of Maintenance and Unsatisfactory Equipment. Use equipment forms and records in accordance with instructions in TM 38-750.

b. Report of Damaged or Improper Shipment. Fill out and forward DD Form 6 (Report of Damaged or Improper Shipment) as prescribed in AR 700-58 (Army), NAVSANDA Publication 378 (Navy), and AFR '71-4 (air Force).

c. Reporting of Equipment Manual Improvements. Report of errors, omissions, and recommendations for improving this manual by the individual user is encouraged. Reports should be submitted on DA Form 2028 (Recommended Changes to DA Publications) and forwarded direct to Commanding General, U. S. Army Electronics Command, ATTN: AMSEL-MR-NMP-AD, Fort Monmouth, New Jersey 07703.





**1-1. DESCRIPTION.**

1-2. The Hewlett-Packard Models 333A and 334A Distortion Analyzers are solid state instruments for measuring distortion and 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. A high impedance detector which operates from 500 Kc to greater than 65 Mc 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 cps to 600 Kc. Harmonics are indicated up to 3Mc. The high sensitivity of these instruments requires only 0.3 v 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 cps to 3 Mc (20 cps to 500 Kc for 300 pv range) and a voltage range of 300 pv 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, and lower than 1% distortion 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 Mc 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.

**1-11. Modifications**

1-12. Specification C10-334A is a standard 334A Distortion Analyzer modified by placing the INPUT and OUTPUT terminals on the rear panel of the instrument. The rear terminals are binding post connectors and are in parallel with the front panel terminals. Due to the rear terminal leads, the shunt capacitance of the instrument is increased by 20pF .



## 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.

### 2-5. POWER REQUIREMENTS.

2-6. The Model 333A/334A can be operated from any ac source of 115 or 230 volts (+10%), at 50- 1000 cps. With the instrument disconnected from the ac power source, move the slide (located on the rear panel) until the desired line voltage appears. The instrument can be battery operated by connecting two 28-50 V batteries (rated 80 milliamperes) to the battery terminal on the rear panel. Power dissipation is 10 watts maximum.

### 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. To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green pigtail on the adapter to ground.

### 2-10. INSTALLATION.

2-11 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 (191 F).

### 2-12. BENCH INSTALLATION.

2-13 The Model 333A/334A is shipped with plastic feet and tilt stand in place, ready for use as a bench instrument.

### 2-14. RACK INSTALLATION.

2-15. The Model 333A/334A may be rack mounted by using the 5" RackMount 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.

### 2-16. REPACKAGING FOR SHIPMENT.

2-17. The following paragraphs contain a general guide for repackaging of the instrument for shipment. Refer to Paragraph 2-18 if the original container is to be used; 2-19 if it is not.

2-18. If original container is to be used, proceed as follows:

a. Place instrument in original container if available.

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

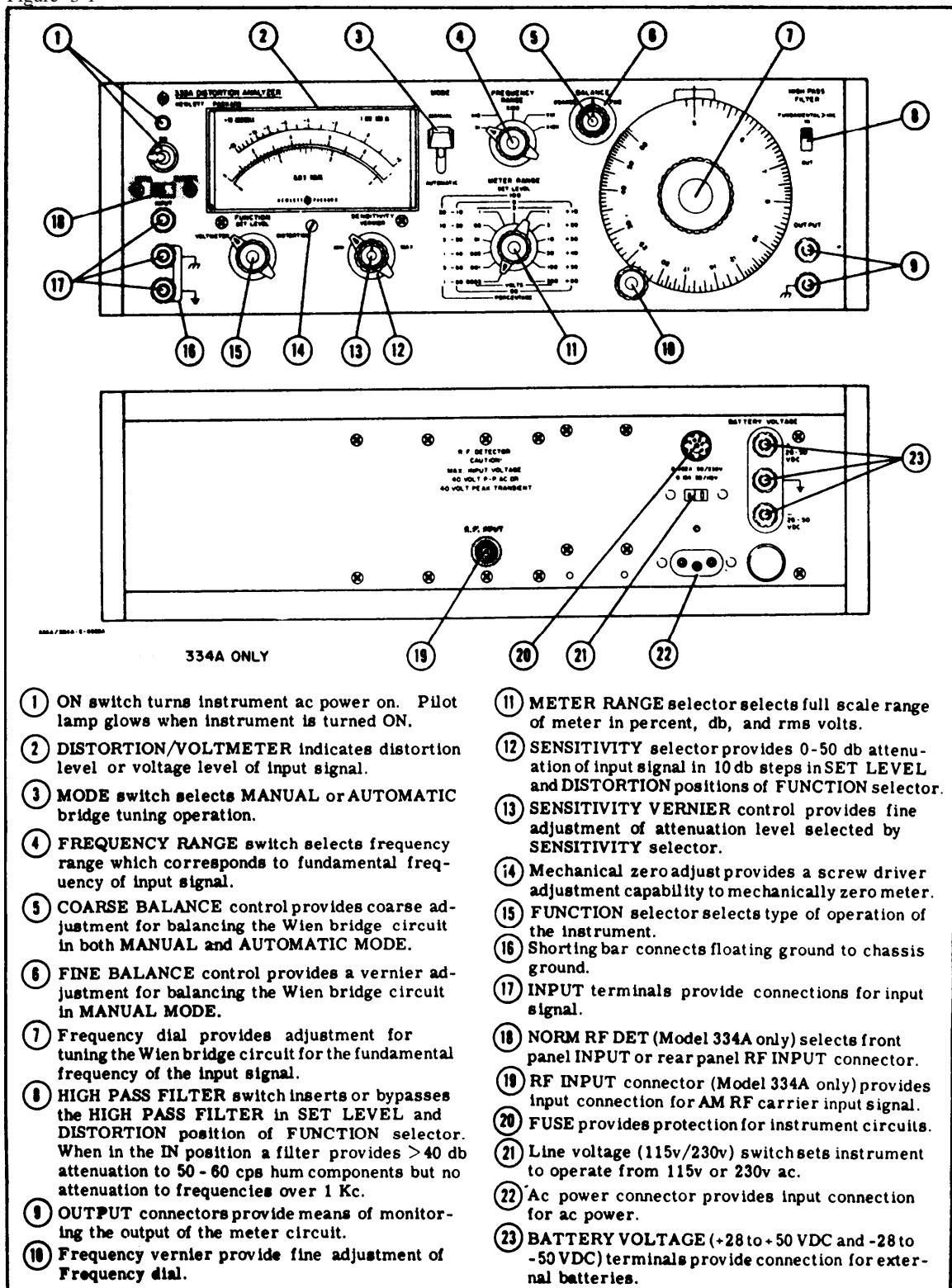
2-19. If original container is not to be used, proceed as follows:

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.



- ① ON switch turns instrument ac power on. Pilot lamp glows when instrument is turned ON.
- ② DISTORTION/VOLTMETER indicates distortion level or voltage level of input signal.
- ③ MODE switch selects MANUAL or AUTOMATIC bridge tuning operation.
- ④ FREQUENCY RANGE switch selects frequency range which corresponds to fundamental frequency of input signal.
- ⑤ COARSE BALANCE control provides coarse adjustment for balancing the Wien bridge circuit in both MANUAL and AUTOMATIC MODE.
- ⑥ FINE BALANCE control provides a vernier adjustment for balancing the Wien bridge circuit in MANUAL MODE.
- ⑦ Frequency dial provides adjustment for tuning the Wien bridge circuit for the fundamental frequency of the input signal.
- ⑧ HIGH PASS FILTER switch inserts or bypasses the HIGH PASS FILTER in SET LEVEL and DISTORTION position of FUNCTION selector. When in the IN position a filter provides > 40 db attenuation to 50 - 60 cps hum components but no attenuation to frequencies over 1 Kc.
- ⑨ OUTPUT connectors provide means of monitoring the output of the meter circuit.
- ⑩ Frequency vernier provide fine adjustment of Frequency dial.
- ⑪ METER RANGE selector selects full scale range of meter in percent, db, and rms volts.
- ⑫ SENSITIVITY selector provides 0-50 db attenuation of input signal in 10 db steps in SET LEVEL and DISTORTION positions of FUNCTION selector.
- ⑬ SENSITIVITY VERNIER control provides fine adjustment of attenuation level selected by SENSITIVITY selector.
- ⑭ Mechanical zero adjust provides a screw driver adjustment capability to mechanically zero meter.
- ⑮ FUNCTION selector selects type of operation of the instrument.
- ⑯ Shorting bar connects floating ground to chassis ground.
- ⑰ INPUT terminals provide connections for input signal.
- ⑱ NORM RF DET (Model 334A only) selects front panel INPUT or rear panel RF INPUT connector.
- ⑲ RF INPUT connector (Model 334A only) provides input connection for AM RF carrier input signal.
- ⑳ FUSE provides protection for instrument circuits.
- ㉑ Line voltage (115v/230v) switch sets instrument to operate from 115v or 230v ac.
- ㉒ Ac power connector provides input connection for ac power.
- ㉓ BATTERY VOLTAGE (+28 to +50 VDC and -28 to -50 VDC) terminals provide connection for external batteries.

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 from 5 cps to 600 Kc. Harmonics up to 3 Mc are included. The sharp elimination characteristics, >80 db, the low level of instrument induced distortion, and the meter accuracy of the 333A and the 334A result in accurate measurement of low level harmonic content in the input signal.

3-3. An RMS voltmeter is inherent in the 333A and 334A. The voltmeter provides a full scale sensitivity of 300 u volts rms (residual noise <25 u volts). The voltmeter frequency range is from 5 cps to 3 Mc except on the 0. 0003 volt range, which is from 20 cps to 500 Kc.

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 a drawing included within the figure.

3-6. ADJUSTMENTS OF MECHANICAL ZERO.

3-7. The procedure for adjustment of mechanical zero is given in Section V, Paragraph 5-25.

3-8. GENERAL OPERATING INFORMATION.

3-9. INPUT CONNECTIONS.

3-10. Signal source 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, battery operation is recommended to avoid ground loops. Another method for avoiding ground loops is by connecting only one instrument in a test setup directly to power line ground through a NEMA (three-prong) connector. Connect all other instruments to the power source through a three-prong to two-prong adapter and leave the pigtail disconnected. Both the 333A and 334A have a dc isolation of ±400 vdc from the external chassis with the shorting bar, (item 16 , Figure 3-1), disconnected.

3-11. VOLTMETER CHARACTERISTICS.

9-12. 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 magnitude and phase relation between harmonics and *fundamental* frequency of the signal

applied. Table 3-1 shows the deviation of the meter indication of a sine wave partly distorted by harmonic. As indicated in the table, harmonic content of less than approximately 10% results in very small errors.

Table 3-1  
Effect of Harmonics on Voltage Measurements

Input Voltage Characteristic	True RMS Value	Meter Indication
Fundamental = 100	100	100
Fundamental +10% 2nd harmonic	100. s	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 time errors are inherent in all average-responding type voltage-measuring instruments.

3-13. In 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 residual wave contains many inharmonically related sinusoids, the maximum error in the distortion reading is about 11% low for distortion levels below 10%.

Measured Distortion	Maximum Error In Meter Indication	Total Distortion
2.5%	+0.11 X 0.025 = 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 under most measurement conditions.

3-14. USE OF OUTPUT TERMINALS.

3-15. The OUTPUT terminals provide a 0.1 v rms 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 information

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 the distortion that 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.

3-16. OPERATING PROCEDURES.

3-17. The 333A and 334A Distortion Analyzers can be operated from an ac power source ( 115/230 volt) or a dc power source (+28 to +50 and -28 to -50 volt source). If a dc source is used, check the -25 v output. If necessary, adjust the power supply according to the procedures in Paragraph 5-27.

3-18. DISTORTION MEASUREMENT.

3-19. DISTORTION MEASUREMENT IN PERCENT, AUTOMATIC MODE.

- a. Position FUNCTION selector to SET LEVEL.
- b. Position MODE switch to MANUAL.
- c. If fundamental frequency is 1 Kc or greater, position HIGH PASS FILTER SWITCH to IN.
- d. Rotate SENSITIVITY selector to MIN position.

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).

- e. Position METER RANGE selector to SET LEVEL (100%).

- f. Connect test leads from device under test to INPUT terminals.



REMOVE SHORTING STRAP BETWEEN FLOATING GROUND ~ AND CHASSIS GROUND (+) TERMINALS ON FRONT PANEL INPUT TERMINALS WHEN MEASURING DISTORTION BETWEEN TWO POINTS WHICH ARE BOTH ABOVE GROUND POTENTIAL.

- g. With SENSITIVITY VERNIER control max. CCW, position SENSITIVITY selector for meter indication greater than 1/3 full scale.

NOTE

If unable to adjust for full scale deflection which indicates input signal is below 0.3 volts, use manual mode and position METER RANGE selector down-scale. Use this new position as the 100% SET LEVEL position, thus making the next range 30%, etc.

- h. Adjust SENSITIVITY VERNIER control for full scale deflection.

- j. Position FREQUENCY RANGE selector and frequency dial to fundamental frequency of input signal.

- k. Position FUNCTION selector to DISTORTION,
- m. Adjust METER RANGE selector and frequency dial vernier control for minimum meter indication.

- n. Adjust COARSE and FINE BALANCE controls for further reduction of meter indication. Meter indication must be less than 10% of SET LEVEL indication.

- p. Position MODE switch to AUTOMATIC.

- r. Observe percentage of distortion indicated on meter. Meter indication is in conjunction with METER RANGE selector. For example, if meter indicates .4 and METER RANGE selector is on 1% position, distortion measured is 0.4%.

NOTE

RMS voltage of input signal being analyzed for distortion can be measured by positioning FUNCTION selector to VOLTMETER position.

3-20. DISTORTION MEASUREMENT IN PERCENT, MANUAL MODE.

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.

- a. Perform steps a through n in Paragraph 3-19.
- b. Repeat steps m and n until no further reduction in meter indication can be obtained.
- c. Observe percentage of distortion indicated on meter.

3-21. DISTORTION MEASUREMENT IN DB, AUTOMATIC MODE .

- a. Perform steps a through g of Paragraph 3-19.
- b. Adjust SENSITIVITY VERNIER control for 0 db meter indication.
- c. Perform steps j through 3-19.
- d. Observe meter indication for distortion in db.

NOTE

Distortion in db is obtained by algebraically adding meter indication to db indicated by METER RANGE selector: for example, If meter indicates -2 and METER RANGE selector is on -20 db position, distortion measured is -22 db.

3-22. DISTORTION MEASUREMENT IN DB, MANUAL MODE .

NOTE

Notes in Paragraphs 3-20 and 3-21 apply.

- a. Perform steps a through g of Paragraph 3-19.
- b. Adjust SENSITIVITY VERNIER control for 0 db meter indication.

Model 333A/334A

Section III  
Paragraphs 3-23 to 3-27

- c. Perform steps j through n of Paragraph 3-19.
- d. Repeat steps m and n until no further reduction in meter indication can be obtained.
- e. Observe meter indication for distortion in db.

3-23. DISTORTION MEASUREMENT OF AM RF CARRIERS. (334A Only)

- a. Set NORM - RF SET selector to RF SET.



OBSERVE MAXIMUM INPUT VOLTAGES AS INDICATED ON REAR PANEL.

- b. Connect Input to RF INPUT on rear panel.
- c. Adjust SENSITIVITY VERNIER control for 0 db meter indication.
- d. Perform steps j through n of Paragraph 3-19.
- e. Refer to Paragraph 3-20 for manual measurement in percent.
- f. Refer to Paragraph 3-21 and 3-22 for automatic and manual measurement in db.

-24. VOLTMETER MODE.

NOTE

If DBM measurements are to be made, the DB markings on the METER RANGE switch must each be lowered by 10. That is, the DB marking for the 0.3 v range becomes -10 DBM, 1 v range becomes 0 DBM, 3 v range becomes +10 DBM etc. If the other DB markings are used, the DBM readings will be 10 DBM high.

3-25. The 333A and 334A perform as general purpose AC Voltmeters when the FUNCTION selector is set to VOLTMETER position.

NOTE

With the FUNCTION selector in VOLT-METER position, the SENSITIVITY selector is disabled.

- a. Position METER RANGE selector to a range exceeding the value of the signal to be measured.
- b. Connect signal to INPUT terminals.
- c. Select a METER RANGE to give a reading as close to full scale as possible and observe meter indication.

3-26. OUTPUT TERMINALS.

3-27. In VOLTMETER or SET LEVEL position of the FUNCTION selector, the 333A/334A can be used as a low distortion, high gain, wideband preamplifier. A portion of the meter input (0.1 v RMS output for full scale meter deflection) is provided at the OUTPUT terminal J2. In the DISTORTION position, the distortion is provided for monitoring purposes.



DO NOT EXCEED THE VOLTAGES LISTED BELOW TO PREVENT BLOWING FUSE F2:

- VOLTMETER.= -1 V RANGE AND BELOW, AND DISTORTION ANALYZER, MODE-MAXIMUM SENSITIVITY.
- 1. 300 V ABOVE 100 CPS
  - 2. 50 V ABOVE 1 KC

IF LOW FREQUENCIES ARE NOT TO BE MEASURED, C1 MAY BE REPLACED WITH A SMALLER CAPACITOR, AND THE VOLTAGE LIMITS OF F2 MAY BE RAISED ACCORDINGLY.

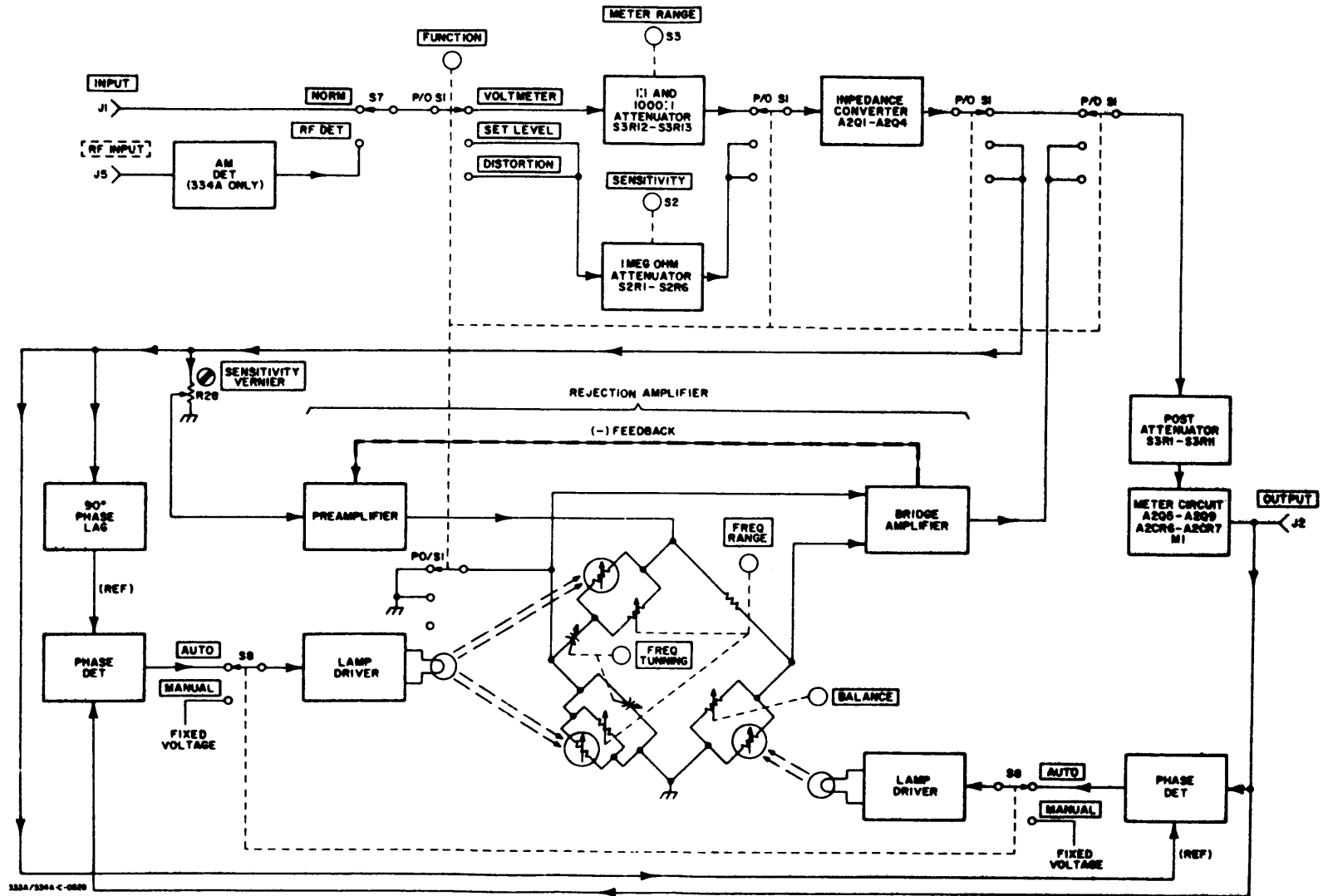


Figure 4-1. Block Diagram



## 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. A block diagram of the instruments is shown in Figure 4-1. 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 an 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, M 1. The AM detector (Model 334A only) detects the modulating signal from the RF carrier and filters any RF components from the modulating signal before it is applied to the impedance converter circuit.

### 4-3. BLOCK DIAGRAM DESCRIPTION.

### 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, a voltage divider network provides 50 db attenuation in 10 db steps. The desired level of attenuation is selected by the SENSITIVITY selector, S2. The impedance converter provides an impedance conversion and unity gain between the instrument INPUT terminals and the input of the rejection amplifier. 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 selector in the SET LEVEL position, a ground is applied in the Wien bridge circuit to allow a signal reference level to be set up on the meter. With the FUNCTION selector in the DISTORTION position, the Wien bridge is used as an interstate coupling network between the preamplifier and bridge amplifier. The Wien bridge is 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. 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. The metering circuit sensitivity is increased to 300 uv for full scale deflection on the 300 pv range. The metering circuit provides a visual indication of the

distortion level of the input signal. In addition to the visual indication provided by the meter, the OUTPUT terminals provide a means of monitoring the distortion components.

### 4-6. DISTORTION MEASUREMENT IN AM CARRIERS.

4-7. 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.

### 4-8. VOLTMETER OPERATION.

4-9. 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 in the .0003 to .3 VOLTS position of the METER RANGE selector S3, and the 1000:1 attenuation ratio is used in the 1 to 300 VOLTS positions. With the FUNCTION selector in the VOLT-METER position, the output of the impedance converter bypasses the rejection amplifier and is applied to the metering circuit through the post-attenuator (METER RANGE selector). Metering circuit sensitivity is increased from 1 mv for full scale deflection to 300 uv on the 300 uv 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.

### 4-10. SCHEMATIC THEORY.

### 4-11. IMPEDANCE CONVERTER CIRCUIT.

4-12. The input signal to the distortion analyzer is applied to the impedance converter circuit (refer to Figure 6-2) through the 1:1 and 1000:1 attenuator S3R12 in the voltmeter mode of operation and through the one megohm attenuator S2R1 through S2R6 in the distortion mode of operation. Capacitive dividers S2C10 through S2C 10 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. 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 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.

4-13. The bias points of the transistors in the impedance converter are selected to minimize instrument induced distortion. A2Q 1, 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.

#### 4-14. REJECTION AMPLIFIER CIRCUIT.

4-15. The rejection amplifier circuit (see Figures 6-3 and 6-6) 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 A5Q 18 with associated lamp and photocell), and the bridge amplifier (A3Q4 thru A3Q6).

#### 4-16. PREAMPLIFIER CIRCUIT.

4-17. 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.

#### 4-18. WIEN BRIDGE CIRCUIT.

4-19. 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.

4-20. When the Wien bridge is not tuned exactly to the frequency to be nulled, a portion of the fundamental 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.

4-2

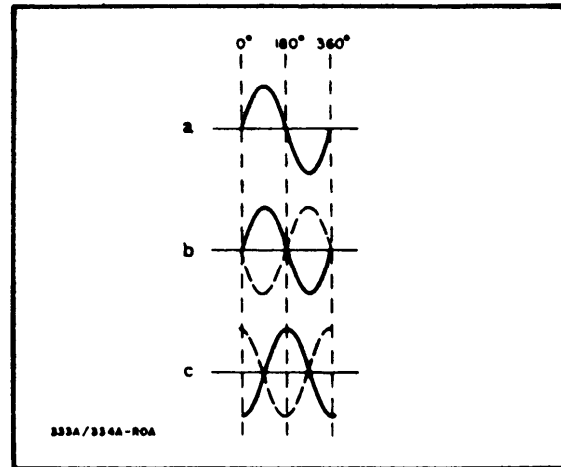


Figure 4-2. Bridge Waveforms

4-21. Figure 4-2a is 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.

4-22. 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 which 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 input differing from the reference by 90°.

4-23. 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.

4-24. 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 causes resistance changes in photocells which form part of the Wien bridge.

4-25. Refer to Figure 4-3 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.

4-26. The operation of the reactive branch control loop is similar to that of the resistive branch. The phase delay circuit (Figure 6-6), A5Q15, A5Q16, S4AF and S4C1 through S4C5, shifts the reference voltage 90°, as shown in Figure 4-3f. 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, Q14, 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 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.

4-27. 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 4-3e and j) will result in outputs from both detectors to tune the bridge and reject the fundamental.

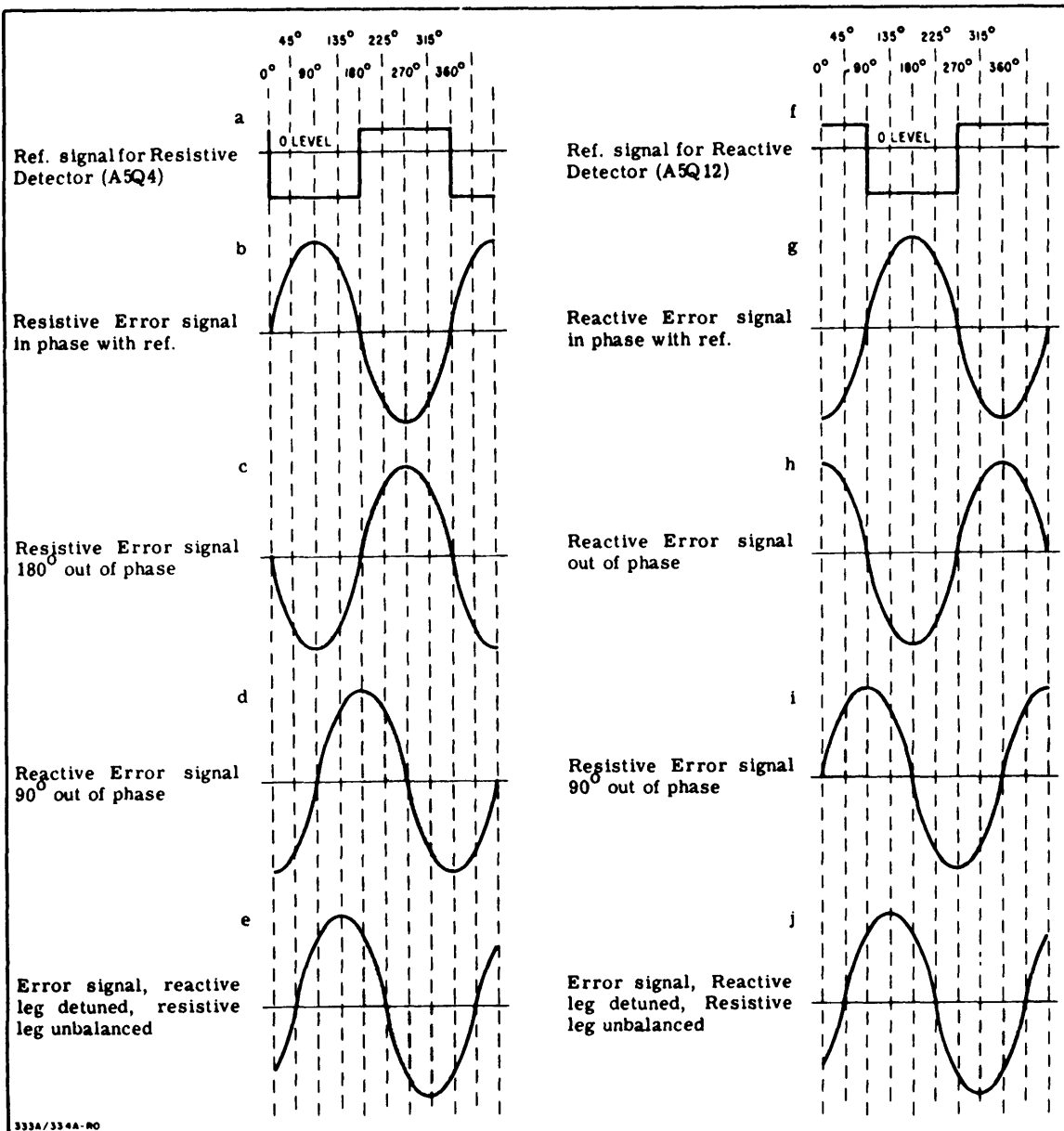


Figure 4-3. Reference and Error Phase Relationship

Section IV  
 Paragraphs 4-28 to 4-35 and Figures 4-4 to 4-5

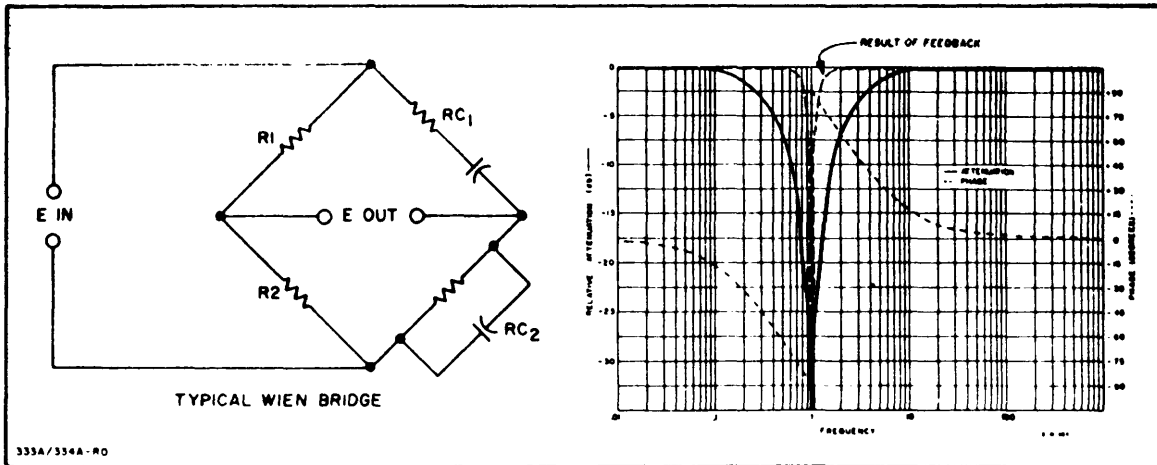


Figure 4-4. Wien Bridge Circuit and Rejection Characteristics

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 4-4 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 course 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 4-5 simplified 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 TP3 is between 0 and -1 volt. The dc output of the filter network causes the voltage at TP3 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.

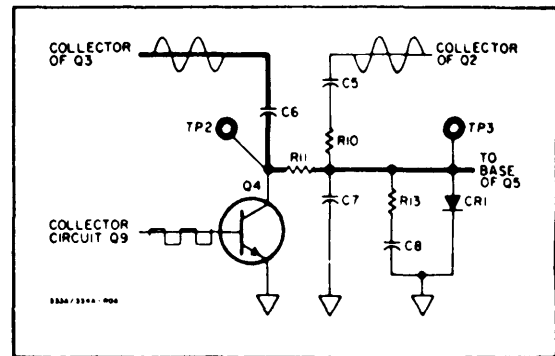


Figure 4-5. Auto Control Loop Detector

4-33. When the FUNCTION selector is set to the VOLT-METER or SET LEVEL position, the junction of the series and shunt reactive branches of the Wien bridge is connected to circuit ground through R19 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.

4-34. BRIDGE AMPLIFIER CIRCUIT.

4-35. The bridge amplifier circuit consists of three stages of amplification, A3Q4 through A3Q6. The

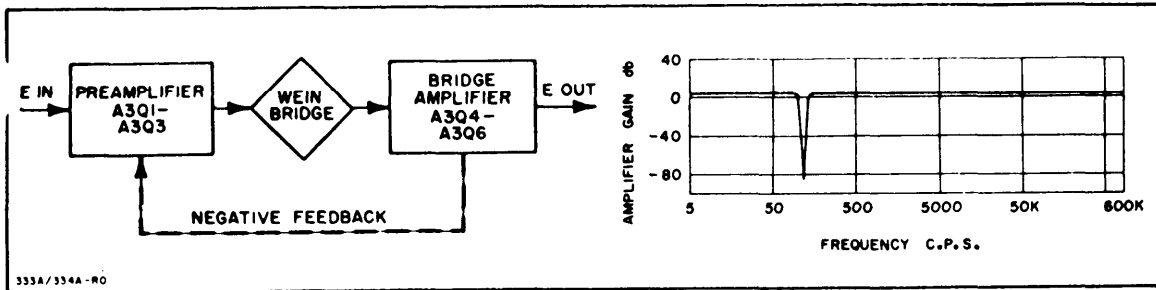


Figure 4-6. Rejection Amplifier Block Diagram and Typical Frequency Rejection Characteristic

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 maximum 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 4-4) 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 4-4. 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.

#### 4-36. HIGH PASS FILTER.

4-37. The HIGH PASS FILTER (see Figure 6-3) is normally used when the fundamental of the input signal is greater than 1 Kc. In the voltmeter mode of operation, the filter is not used. In the SET LEVEL and DISTORTION position of the FUNCTION switch the filter presents >50 db attenuation to 50 or 60 cycle hum components, but offers no attenuation to frequencies over 1 Kc. The filter assembly, A7, consists of A7C1, A7C2, and A7L1. The filter can be inserted or bypassed by the HIGH PASS FILTER switch, S9.

#### 4-38. METER CIRCUIT.

4-39. The meter circuit (refer to Figure 6-4) consists of the post attenuator, the meter amplifier circuit, and the meter rectifier circuit.

#### 4-40. POST ATTENUATOR.

4-41. The post attenuator, S3R1 through S3R11, is a series of resistive networks which attenuate 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 uv for full scale deflection on the 300 uv 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 300 pv range to extend the passband of the amplifier.

#### 4-42. METER AMPLIFIER CIRCUIT.

4-43. 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 A3CR8 are electrically in the circuit only when the meter circuit is overloaded. When the voltage on the emitter of A2Q9 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 circuit. 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.

#### 4-44. METER RECTIFIER CIRCUIT.

4-45. The meter rectifier is connected in a bridge type of 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 circuit 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.

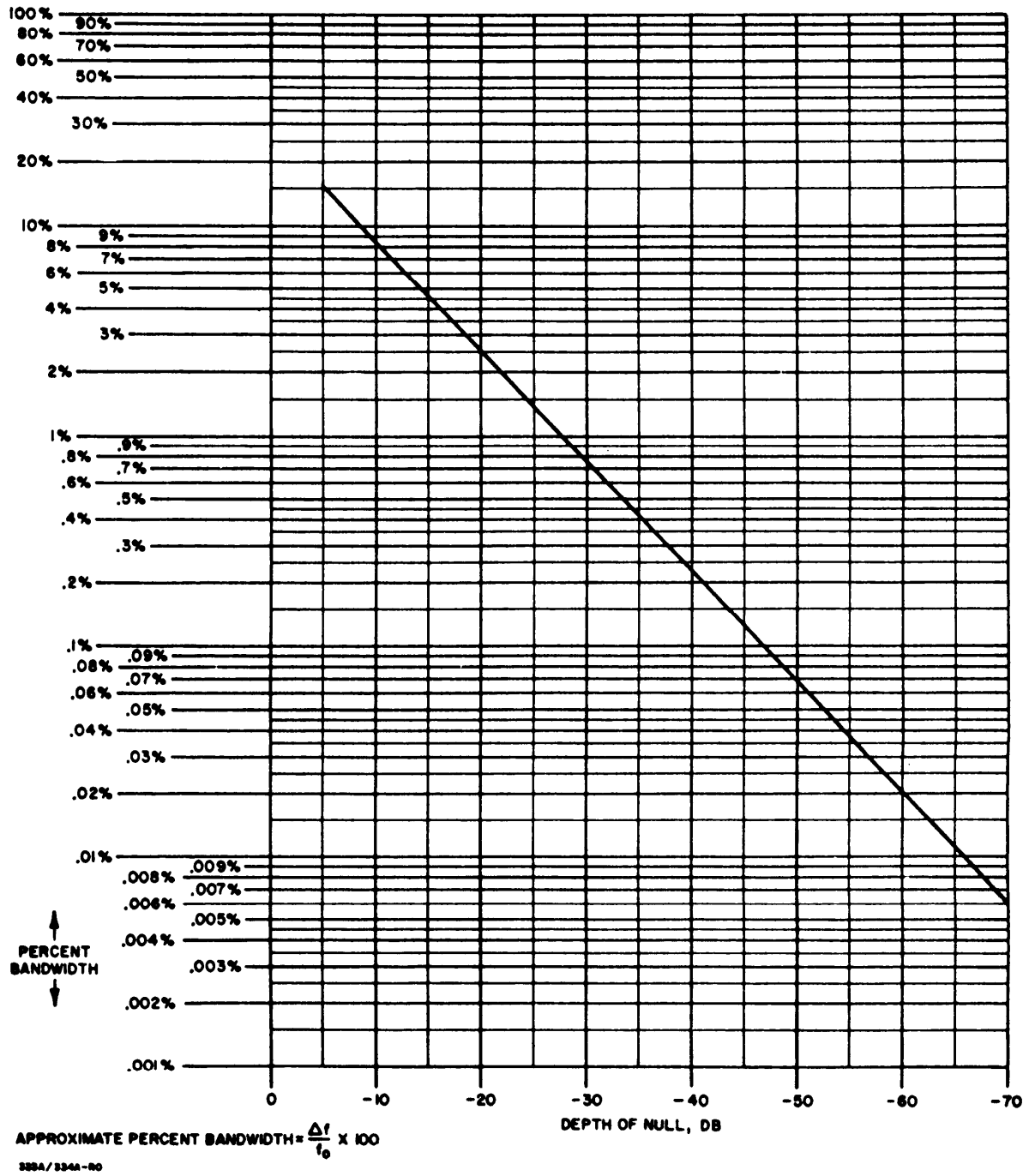


Figure 4-7. Bandwidth Versus Null Depth

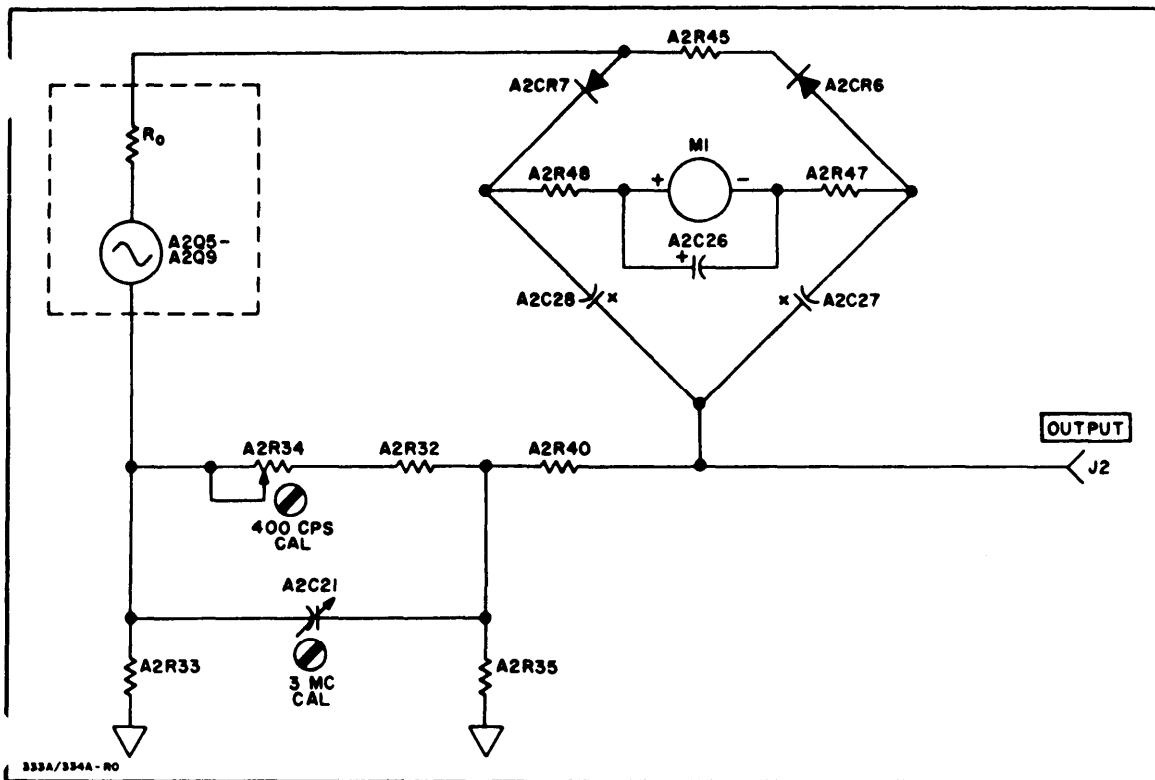


Figure 4-8. Simplified Metering Circuit

4-46. POWER SUPPLY CIRCUIT.

4-47. The power supply circuit (refer to Figure 6-5) 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.

4-48. 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.

4-49. The +25 volt regulated supply is of the conventional series regulator type and operates the same as the -25 volt regulated supply.

4-50. 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.

4-51. RF DETECTOR CIRCUIT. (334A only)

4-52. The RF detector circuit consists of a rectifier A4CR1 and filter circuit shown on the schematic diagram of Figure 6-2. 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.

Table 5-1. Test Equipment Required

INSTRUMENT TYPE	REQUIRED CHARACTERISTICS	USE	RECOMMENDED MODEL
Voltmeter Calibrator	AC Voltage Range: 300 $\mu$ v to 300 v rms	Performance Checks	-hp- Model 738BR Voltmeter Calibrator
Frequency Response Test Set	Frequency Range: 5 cps to 5 Mc	Performance Checks Adjustment and Calibration Procedure	-hp- Model 739AR Frequency Response Test Set with -hp- Model 200SR Oscillator
Test Oscillator	Frequency Range: 10 cps to 3 Mc	Performance Checks Adjustment and Calibration Procedure	-hp- Model 651A Test Oscillator
Wave Analyzer	Frequency: 1 Kc Range: 80 db	Performance Checks	-hp- Model 302A Wave Analyzer
Electronic Counter	Functions: period, 1 sec. gate Accuracy: 0.2%	Performance Checks	-hp- Model 5532A Electronic Counter
DC Voltmeter	Voltage Range: $\pm$ 25 vdc Accuracy: $\pm$ 1.0% F. S.	Adjustment and Calibration Procedure	-hp- Model 412A DC Vacuum Tube Voltmeter
Function Generator	Frequency Range: 5 cps to 5 Kc Distortion: < 64 db Output System: floating ground	Performance Checks	-hp- Model 203A Variable Phase Function Generator
Filter Box	Filtered Outputs: 5 cps, 5 Kc, 250 Kc, 600 Kc Output Distortion: < 80 db	Performance Checks	White Model 2640 Filter Set
Power Supply	Output Voltage: $\pm$ 400 vdc	Performance Checks	-hp- Model 711A Power Supply
Signal Generator	Carrier Frequency: 1 Mc Int. Mod. Frequency: 400 cps	Performance Checks (Model 334A only)	-hp- Model 606A Signal Generator
Capacitance Meter	Range: 0 - 60 pf	Performance Checks	Tektronix Type 130, L - C Meter
Variable Line Transformer	Voltage Range: 103 - 128 vac Power Capability: 4 watts	Performance Checks	Superior Type UC1M
Shielded Load	Resistance: 600 ohms	Performance Checks	See Figure 5-6
Shielded Load	Resistance: 100 K ohms	Performance Checks	See Figure 5-6
Resistor	Resistance: 100 K ohms $\pm$ 1.0%, fixed carbon film Wattage: 1/2 watt	Performance Checks	-hp- Part No. 0727-0208
Resistor	Resistance: 300 ohms $\pm$ 1.0%, fixed carbon film Wattage: 1/2 watt	Performance Checks	-hp- Part No. 0727-0065
Resistor	Resistance: 600 ohms $\pm$ 1.0%, fixed carbon film Wattage: 1/2 watt	Performance Checks	-hp- Part No. 0727-0081



## 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. TEST EQUIPMENT REQUIRED.

5-4. Test equipment used in the calibration of the 333A and 334A is given in Table 5-1, Test Equipment Required. This table lists the type of equipment to be used, required characteristics, and recommended commercially available test equipment.

### 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.

5-7. Performance Checks for both the 333A and 334A are provided. The performance checks are applicable to both instruments except where noted in paragraph heading.

5-8. The Performance Checks are performed with the ac power cord connected to nominal line voltage (115 v/230 V) 50 to 1000 cps, MODE SWITCH to MANUAL, HIGH PASS FILTER to OUT, and NORM RF DET switch to NORM, unless otherwise specified. Selector positions for the SENSITIVITY Selector will be referred to as follows: MIN=Position 1, next step-Position 2, etc, to Max= Position 6.

### 5-9. FUNDAMENTAL REJECTION CHECK

a. Connect 331A/332A as shown in Figure 5-1.

b. Set Distortion Analyzer controls as follows:

FUNCTION Selector . . . . . VOLTMETER  
METER RANGE Selector . . . . . 1 VOLT  
FREQUENCY RANGE Selector . . . . . X100  
Frequency Dial . . . . . 50

Set filter (White Instr Lab Model 2640) . . . . . 5Kc

c. Set Test Oscillator (-hp - Model 651A) frequency to 5 Kc and adjust amplitude for indication of 1.0 volt on Distortion Analyzer meter.

d. Switch Distortion Analyzer FUNCTION to SET LEVEL. Switch METER RANGE to 0.3 VOLTS. Adjust SENSITIVITY controls for full scale meter indication.

e. Set Wave Analyzer controls (-hp - Model 302A) as follows:

SCALE VALUE . . . . . RELATIVE  
MAX INPUT VOLTAGE . . . . . 1  
RANGE . . . . . 0 DECIBELS  
MODE SELECTOR . . . . . NORMAL

f. Adjust Wave Analyzer FREQUENCY controls for maximum meter reading (approximately 1 Kc).

g. Adjust Wave Analyzer REF ADJUST for 0 db meter indication.

#### NOTE

If the range of the REF ADJUST control is insufficient to set meter to 0 db reference, adjust the Distortion Analyzer SENSITIVITY VERNIER control slightly to set reference.

h. Switch Distortion Analyzer FUNCTION to DISTORTION. Adjust BALANCE controls and FREQUENCY dial for null indication on Distortion Analyzer meter. Reduce Distortion Analyzer METER RANGE selector setting as necessary to maintain deflection on meter scale.

j. After achieving null indication on Distortion Analyzer meter, observe Wave Analyzer meter and continue to adjust for a null indication. Reduce Wave Analyzer RANGE setting as necessary to maintain deflection on meter scale.

#### NOTE

The Distortion Analyzer OUTPUT is a 0 to 0.1 volt signal representing a percentage of full scale, regardless of RANGE

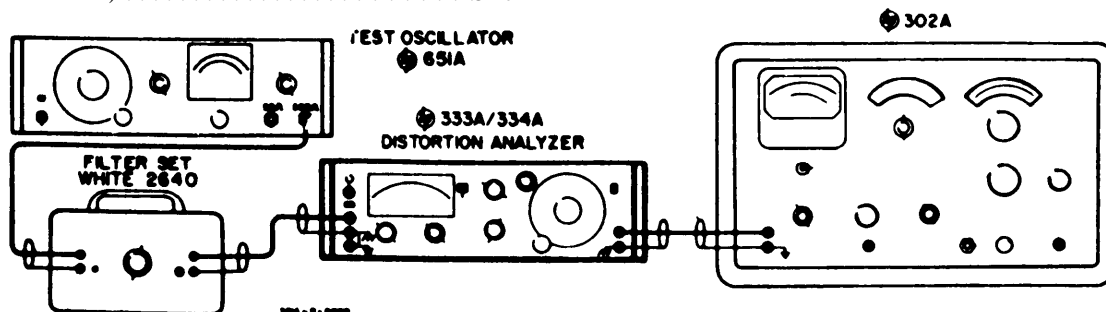


Figure 5-1. Test Setup for Fundamental Rejection Check

setting. Each decrease of the RANGE switch represents 10 db fundamental rejection. Therefore, the total fundamental rejection is the sum of the Wave Analyzer reading and the 333A/334A indication.

k. The Distortion Analyzer METER RANGE setting plus the Wave Analyzer RANGE setting plus the two meter indications shall total more than -80 db.

5-10. SECOND HARMONIC ACCURACY CHECK.

a. Connect Test Oscillator (-hp-Model 651A) 600Ω output to Distortion Analyzer \*

b. Set Distortion Analyzer controls as follows:

FUNCTION Selector . . . . . SET LEVEL  
FREQUENCY RANGE . . . . . X1  
Frequency Dial . . . . . .20  
METER RANGE Selector . . . . . 0 DB

c. Set Test Oscillator controls (-hp- Model 651A) as follows:

FREQUENCY RANGE . . . . . X10  
FREQUENCY Dial. . . . . . 2  
OUTPUT ATTENUATOR . . . . . 1.0 VOLTS  
AMPLITUDE . . . . . 1 Volt

d. Adjust Distortion Analyzer SENSITIVITY controls for a meter reading of 0 db.

e. Switch Distortion Analyzer FUNCTION selector to DISTORTION. Adjust Frequency dial and BALANCE controls for a null indication on meter.

f. Switch Distortion Analyzer FUNCTION selector to SET LEVEL.

g. Adjust Test Oscillator frequency to 40 cps. Adjust AMPLITUDE control for a 0 db indication on the Distortion Analyzer meter.

h. Switch Distortion Analyzer FUNCTION selector to DISTORTION. The meter reading shall not change more than ±0.6 db.

j. Repeat steps a through h at the frequency settings indicated in Table 5-2. The meter readings shall change within the limits specified.

Table 5-2. Second Harmonic Accuracy Check

TEST OSCILLATOR FREQUENCY	DISTORTION ANALYZER FREQUENCY SETTING	LIMITS
40 cps	20 cps	< ±0.6 db
40 Kc	20 Kc	< -1.0 db
200 Kc	100 Kc	< -2.0 db
600 Kc	300 Kc	< -3.0 db

5-11. DISTORTION INTRODUCED BY INSTRUMENT CHECK AND AUTOMATIC CONTROL LOOP OPERATION.

a. Connect 333A/334A as shown in Figure 5-2.

b. Set Distortion Analyzer controls as follows:

FUNCTION Selector . . . . . SET LEVEL  
SENSITIVITY Selector . . . . . Position 1 step CCW  
from Full CW position  
SENSITIVITY VERNIER Control . . . . . full CCW  
METER RANGE Selector . . . . . 0 db  
FREQUENCY RANGE Selector . . . . . X1  
Frequency Dial . . . . . .5

c. Set oscillator for approximately 1 volt output at 5 cycles.

d. Set filter box for 5 cycles.

e. Adjust oscillator amplitude for an indication of +2 db on the Distortion Analyzer meter.

f. Switch Distortion Analyzer FUNCTION selector to DISTORTION. Adjust frequency dial and BALANCE controls for a null meter indication. (If reading is in lower 1/3 of meter scale, decrease METER RANGE selector setting.)

g. The meter indication at "null" shall be at least -8 db on the -60 db METER RANGE which is equivalent to -70 db. Note reading.

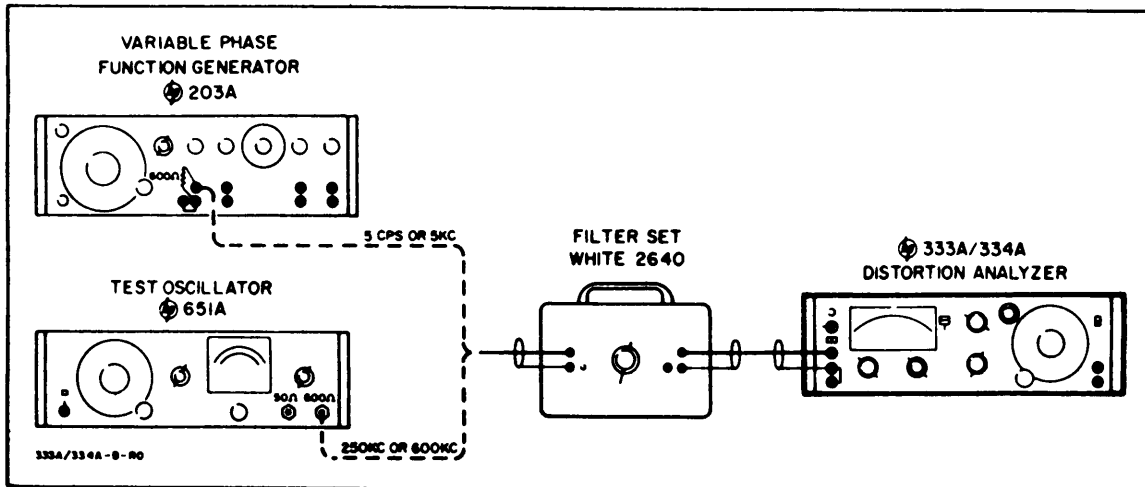


Figure 5-2. Instrument Induced Distortion and Automatic Control Loop Test Setup

h. Set METER RANGE to O. 01 volt RANGE and off-set frequency dial to a lower reading so that meter reads full scale. Set MODE switch to AUTOMATIC and note distortion level. Distortion level should be within +3 -0 db of manually nulled reading.

j. Set MODE switch to MANUAL (and meter range to o. 01). Offset frequency dial past null to a higher dial reading so that meter reads full scale. Return MODE switch to automatic. Distortion reading should be within +3 -0 db of manually nulled reading obtained in step g of this paragraph.

k. Set MODE switch to MANUAL and adjust frequency dial for null. Adjust COURSE BALANCE Control CW with METER RANGE set at 0. 01 so that meter reads full scale. Return MODE Switch to AUTOMATIC. Distortion reading should be within +3 -0 db of manually nulled reading obtained in step g of this paragraph.

m. Set MODE switch to MANUAL and METER RANGE to O. 01. Adjust COARSE BALANCE Control CCW so that meter reads +2 db. Set Mode switch to Automatic. Distortion reading should be within +3 -0 of manually nulled reading obtained in step g of this paragraph.

n. Repeat steps b through m with controls set as indicated in Table 5-3. Except in steps j thru m use METER RANGE setting of O. 03 to obtain +2 db reading when detuning Frequency Dial and COARSE BALANCE Control to verify automatic control loop operation.

Table 5-3. Distortion Introduced By Instrument Check

SOURCE	FILTER BOX	FREQ. RANGE	FREQ. DIAL	DISTORTION
5 cps (203A)	5 cps	X1	5	> -70 db
500 cps (203A)	500 cps	X10	50	> -70 db
5 Kc (203A)	5 Kc	X100	50	> -70 db
50 Kc (203A)	50 Kc	X1K	50	> -70 db
250 Kc (651A)	250 Kc	X10K	25	> -70 db
600 Kc (651A)	600 Kc	X10K	60	> -64 db

5-12. FREQUENCY CALIBRATION ACCURACY CHECK.

a. Connect 333A/334A as shown in Figure 5-3.

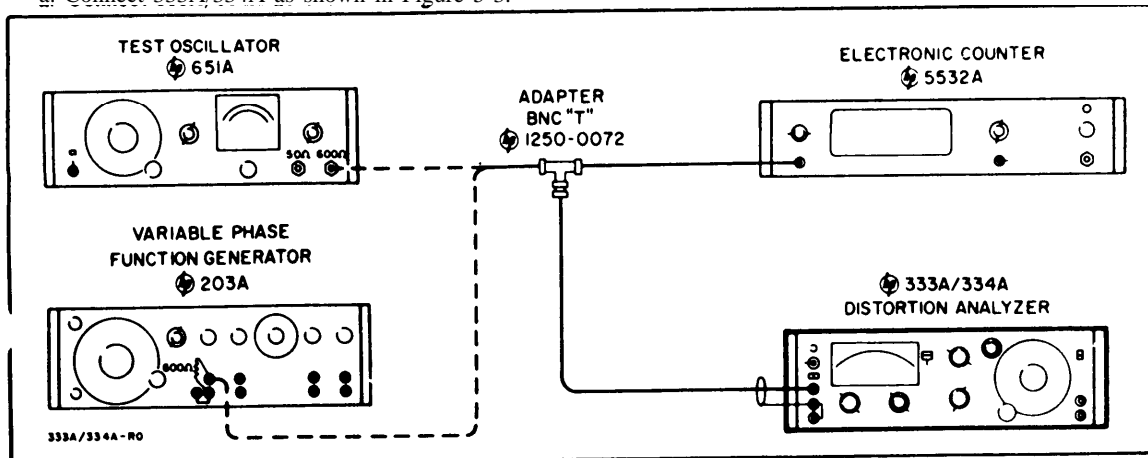


Figure 5-3. Test Setup for Frequency Calibration Accuracy Check

NOTE

From 5 cps to 10 cps the FREQUENCY dial may be as much as 3% low. In this test the dial is held constant, and the input frequency is varied and monitored. If the dial is low, the input frequency at null will be high. If the period of the input frequency is measured, it will be low when the dial is low. From 200 Kc to 600 Kc the dial may be as much as 8% high. Consequently, a low frequency reading at null would indicate that the dial is reading high.

b. Set Distortion Analyzer controls as follows:

- FUNCTION Selector . . . . . SET LEVEL
- METER RANGE Selector . . . . . 0 DB
- SENSITIVITY Selector . . . . . MIN.
- FREQUENCY RANGE Selector . . . . . X1
- Frequency Dial . . . . . .5

c. Set Test Oscillator controls (-hp- Model 203A) as follows:

- FREQUENCY RANGE . . . . . X1
- FREQUENCY DIAL . . . . . 5
- OUTPUT ATTENUATOR . . . . . 1.0 VOLT

d. Set Electronic Counter controls (-hp - Model 5532A) as follows:

- SENSITIVITY . . . . . 3 VOLTS RMS
- Function Switch. . . . . 1 PERIOD AVERAGED
- DISPLAY . . . . . Full CCW

e. Adjust Test Oscillator AMPLITUDE control for a full scale indication on the Distortion Analyzer meter.

f. Switch Distortion Analyzer FUNCTION selector to DISTORTION.

g. Adjust Test Oscillator FREQUENCY DIAL for a null indication on the Distortion Analyzer meter. (If reading is in lower 1/3 of meter scale, decrease METER RANGE selector setting, )

h. Adjust Distortion Analyzer BALANCE controls for a null indication on the meter. Repeat steps g and h until a null is reached.

Table 5-4. Frequency Calibration Accuracy Check

331A/332A		203A or 651A		5532A	
FREQ. RANGE	FREQ. DIAL	FREQ. RANGE	FREQ. DIAL	FUNCTION SWITCH	READING
X1	5	X1 (203A)	5	1 per avg.	194 to 200 ms
X1	20	X1 (203A)	20	1 per avg.	49 to 50 ms
X10 K	20	X100 K (651A)	2	1 SEC.	196 K to 204 K
X10 K	60	X100 K (651A)	6	1 SEC.	552 K to 600 K

j. The Electronic Counter shall indicate the period of 5 cps -3%, i. e. 194 to 200 msec.

k. Repeat steps b through h with controls set as indicated in Table 5-4. The Electronic Counter shall indicate the Test Oscillator output frequencies within the limits indicated.

5-13. INPUT RESISTANCE CHECK

a. Connect Test Oscillator (-hp- Model 651A) 600 Ω output to Distortion Analyzer INPUT terminals.

b. Set Distortion Analyzer controls as follows:  
 FUNCTION Selector . . . . . VOLTMETER  
 SENSITIVITY Selector . . . . . MAX.  
 SENSITIVITY VERNIER Control . . . . . MIN.  
 METER RANGE Selector. . . . . 1 VOLT

c. Set Test Oscillator controls as follows:  
 FREQUENCY RANGE . . . . . X10  
 FREQUENCY Dial . . . . . 10  
 OUTPUT ATTENUATOR . . . . . 1.0 VOLT

d. Adjust Test Oscillator AMPLITUDE control for an indication of 1.0 volt (E<sub>m</sub>) rms on the Distortion Analyzer meter.

e. Connect a 100 K Ω (R<sub>i</sub>) ±1. 0%, 1/2 watt, fixed carbon film resistor in series with the Distortion Analyzer INPUT. Note the Distortion Analyzer meter reading (E<sub>i</sub>).

f. Calculate the Distortion Analyzer input resistance using the following formula:

$$R_{input} = \frac{E_o}{E_{in} - E_o} R_a$$

g. The input resistance shall be 1 M Ω ±5%.

h. Switch FUNCTION selector to Distortion and calculate the input resistance in this position. It shall be 1 M Ω ±5%.

5-14. INPUT SHUNT CAPACITANCE CHECK.

a. Set Distortion Analyzer controls as follows:  
 FUNCTION Selector . . . . . VOLTMETER  
 METER RANGE Selector . . . . . 1 VOLT

b. Connect an L - C meter to the 333A/334A and measure the input capacitance.

c. The L - C meter shall indicate less than 30 pf.

d. Switch the Distortion Analyzer on the 0. 3 range and measure capacitance. Meter shall indicate less than 60 pf.

e. Set Distortion Analyzer controls as follows:

FUNCTION Selector . . . . .DISTORTION  
 SENSITIVITY Selector . . . . . MIN.  
 METER RANGE Selector . . . . . VOLTS

f. Measure Capacitance at each SENSITIVITY selector setting of the Distortion Analyzer. The L - C meter shall indicate less than 60 pf on each of these settings.

5-15. MINIMUM INPUT LEVEL CHECK.

a. Connect Test Oscillator (-hp- Model 651A) 600 Ω output to Distortion Analyzer INPUT terminals 1 Terminate test oscillator with 600 Ω ±1% 1/2 w resistor.

b. Set Distortion Analyzer controls as follows:

FUNCTION Selector . . . . . VOLTMETER  
 METER RANGE Selector . . . . . 3 VOLT  
 SENSITIVITY Selector . . . . . MIN.  
 SENSITIVITY VERNIER . . . . . , CCW

c. Set Test Oscillator for 20 cps.

d. Adjust Test Oscillator amplitude for a Distortion Analyzer meter indication O. 3 volts.

e. Switch Distortion Analyzer FUNCTION selector to SET LEVEL.

f. Switch SENSITIVITY selector to MAX and VERNIER to full CW. The SENSITIVITY controls shall have sufficient range to give a full scale meter reading.

5-16. DC ISOLATION CHECK.

a. Connect 333A/334A as shown in Figure 5-4.



REMOVE SHORTING BARS BETWEEN POWER LINE GROUND TERMINALS ON DISTORTION ANALYZER INPUT TERMINALS AND FUNCTION GENERATOR OUTPUT TERMINALS.

b. Set Distortion Analyzer controls as follows:

FUNCTION Selector . . . . .VOLTMETER  
 METER RANGE Selector . . . . . 1 VOLT

c. Apply ac power to dc power supply and set for 400 v. Set Power Supply controls but do not apply dc to the Distortion Analyzer.

d. Set Function Generator for 1 Kc and adjust the amplitude control for an indication of 0. 9 on the Distortion Analyzer meter.

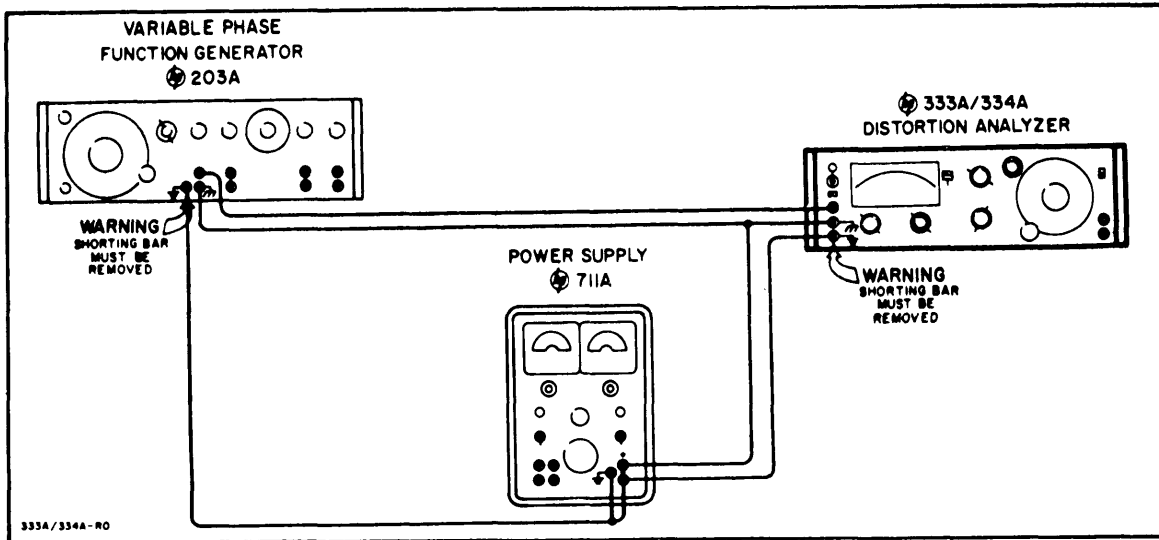


Figure 5-4. DC Isolation Check Test Setup

e. Apply the 400 v dc to the Distortion Analyzer. There shall be no change in the indication on the Distortion Analyzer meter, or any indication on the ammeter of the *power* supply.

5-17. VOLTMETER ACCURACY CHECK

a. Connect Voltmeter Calibrator (-hp- Model 738B) and Variable Line Transformer (Superior Type UC1M) to Distortion Analyzer as shown in Figure 5-5. Remove shorting bar between power line ground and circuit ground terminals.

b. Set Variable Line Transformer for 115 v output.

c. Set Distortion Analyzer FUNCTION Selector to VOLTMETER.

d. Set voltmeter calibrator for 400 cps output.

e. Check the Distortion Analyzer voltmeter full scale readings on all ranges against the appropriate rms input voltages from the voltmeter calibrator. The voltmeter accuracy shall be within  $\pm 2\%$ .

f. Set the Distortion Analyzer METER RANGE selector to 1 VOLT range.

g. Check the Distortion Analyzer voltmeter tracking at 0.1 volt increments from 0.1 volt to 1 volt. The voltmeter tracking accuracy shall be within  $\pm 1\%$ .

h. Repeat steps d through g with the variable Line Transformer set to 105 v & 125 v.

5-18. HIGH PASS FILTER CHECK

a. Connect the 333A/334A as shown in Figure 5-6.

b. Set Distortion Analyzer controls as follows:

FUNCTION Selector . . . . . SET LEVEL  
METER RANGE Selector . . . . . SET LEVEL  
HIGH PASS FILTER switch . . . . . In  
SENSITIVITY Selector . . . . . Position 5  
SENSITIVITY VERNIER . . . . . CCW

c. Adjust frequency response test set to 5Kc and set output amplitude to obtain a zero db indication on Distortion Analyzer.

d. Adjust frequency response test set meter to set level reference.

e. Set frequency response test set to 1 Kc and adjust output amplitude so that test set meter reads set level.

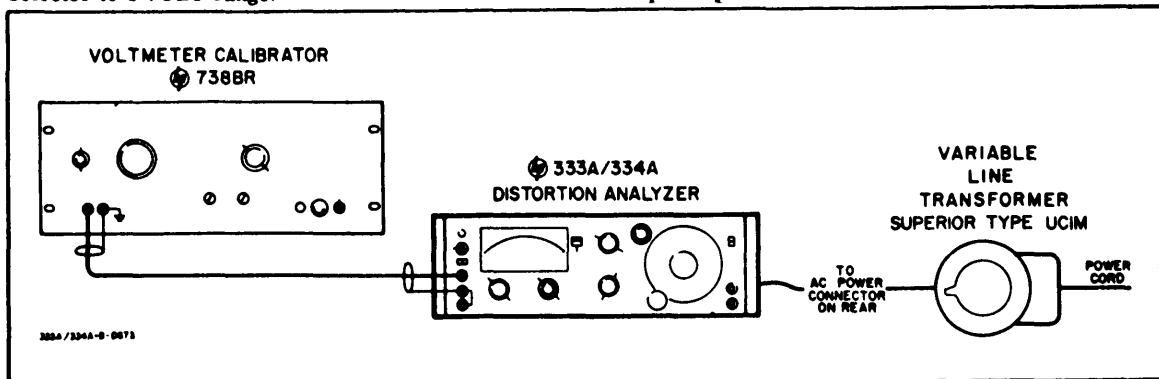


Figure 5-5. Voltmeter Accuracy check Test Setup

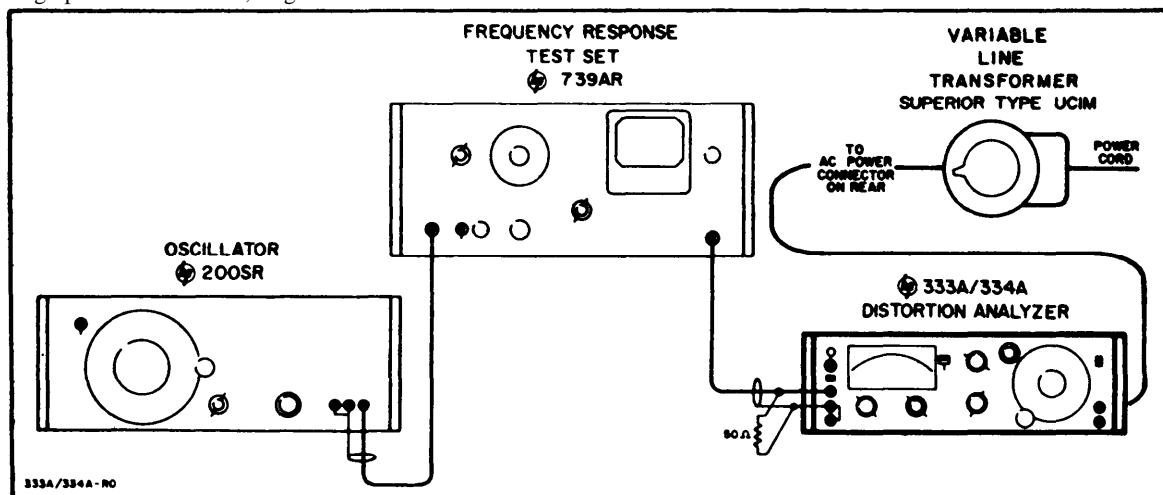


Figure 5-6. Voltmeter Frequency Response Check Test Setup

- f. Reading on Distortion Analyzer shall be within 0.5 db of zero db setting.
- g. Set frequency response test set to 60 cps and adjust the output amplitude so that test set meter reads set level.
- h. Switch Distortion Analyzer Meter Range to 0.003 volt range,
- j. Reading should be > -40 db.

5-19, VOLTMETER FREQUENCY RESPONSE CHECK.

- a. Connect Distortion Analyzer to test equipment as shown in Figure 5-6.
- b. Set Distortion Analyzer controls as follows:  
 FUNCTION Selector . . . . . VOLTMETER  
 METER RANGE Selector. . . . . 0.01 VOLTS
- c. Set the Variable Line Transformer output to 115 v.
- d. Adjust the Oscillator for an indication of 0.9 at 400 cps on the Distortion Analyzer meter.
- e. Adjust the Frequency Response Test Set METER SET control to SET LEVEL indication on the meter.
- f. Switch the Oscillator RANGE switch to X 1 and set the Frequency Dial to 5.
- g. Readjust the Oscillator AMPLITUDE control until the Frequency Response Test Set meter indicates SET LEVEL.
- h. The Distortion Analyzer meter shall indicate between 0.855 and 0.945 ( $\pm 5\%$ ).
- j. Set the Oscillator to the frequencies listed in Table 5-5. Repeat step g after each setting. The Distortion Analyzer meter shall indicate  $0.9 \pm$  the tolerances indicated.
- k. Switch the Frequency Response Test Set RANGE SELECTOR to the 1-3 Mc position. Set the FREQ. TUNING dial to the frequencies listed in Table 5-5. Adjust the Frequency Response Test Set AMPLITUDE control until the meter indicates SET LEVEL after each frequency setting. The Distortion Analyzer meter shall indicate  $0.9 \pm$  the tolerances indicated.

- n. Repeat steps b through k with the Variable Line Transformer set to 105 v and 125 v.

Table 5-5. Voltmeter Frequency Response Check

OSCILLATOR FREQUENCY	TOLERANCE	READING
20 cps	$\pm 2\%$	0.88 to 0.92
10 Kc	$\pm 2\%$	0.88 to 0.92
500 Kc	$\pm 2\%$	0.88 to 0.92
TEST SET FREQUENCY		
1 Mc	$\pm 2\%$	0.88 to 0.92
3 Mc	$\pm 5\%$	0.855 to 0.945

5-20. RESIDUAL NOISE CHECK

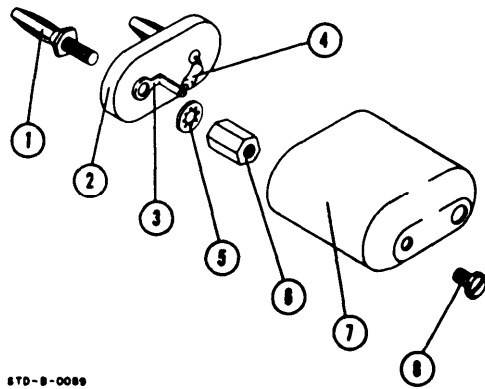
- a. Connect a shielded 600  $\Omega$  resistor across the Distortion Analyzer INPUT terminals. (See Figure 5-7 for details on constructing shielded load.) Secure the shorting bar between the power line ground and circuit ground terminals.
- b. Set Distortion controls  $\chi\omicron\nu\tau\rho\lambda\sigma$  as follows:  
 FUNCTION Selector . . . . . VOLTMETER  
 METER RANGE Selector . . . . . 0.0003 VOLTS
- c. The meter shall indicate less than 25  $\mu$  volts.
- d. Remove the 600  $\Omega$  resistor. Connect a shielded 100 K ohm resistor across the INPUT terminals. (See Figure 5-7 for details on constructing shielded load.)
- e. The meter shall indicate less than 30  $\mu$  volts.

5-21. AM DETECTOR CHECK (Model 334A only).

- a. Connect Signal Generator (hp- Model 606A) 50 RF OUTPUT to Distortion Analyzer RF INPUT.
- b. Set Distortion Analyzer controls as follows:  
 FUNCTION Selector . . . . . SET LEVEL  
 NORM-RF DET Switch . . . . . RF DET  
 METER RANGE Selector . . . . . 0 DB  
 FREQUENCY RANGE Selector . . . . . X100  
 FREQUENCY Dial . . . . . 10

Model 333A/334A

Section V  
Paragraphs 5-23 to 5-27, Figure 5-7 and Table 5-6



No.	Description	-hp- Part No.
1	Connector, male	1251-0174
2	Connector, male w/insulator	1251-0175
3	Lug, terminal 90°	0360-0042
4	Resistor, 100 K Ω, 1/2 w, 5% metal film	0758-0053
4	Resistor, 600 K Ω, 1/4 w, 0.5% metal film	0757-1037
5	Washer, int. lock	2190-0007
6	Spacer, 6-32 threaded	0380-0058
7	Shield	1251-1073
8	Screw, bind. head, 6-32 x 1/4 in	2470-0001

Figure 5-7. Shielded Load Assembly

c. Set Signal Generator controls as follows:

FREQUENCY . . . . . 1 Mc  
 MODULATION SELECTOR . . . . . EXT  
 ATTENUATOR/VERNIER . . . . . 3.0 VOLTS  
 Modulate Signal Generator output 30% with a 1000 cps signal using a 203A Function Generator or comparable oscillator.

d. Adjust Distortion Analyzer SENSITIVITY Select- and VERNIER control for 0 DB reference.

e. Switch FUNCTION selector to DISTORTION. Adjust BALANCE controls and Frequency Dial for null indication.

f. Distortion shall be more than -40 db down.

switch to MANUAL, HIGH PASS FILTER to OUT, and NORM RF DET switch to NORM, unless otherwise specified.

5-25. METER MECHANICAL ZERO SET.

5-26. The meter is properly zero-set when the pointer rests over the zero calibration mark on the meter scale and the meter is in its normal operating environment and turned off, Adjust the zero-set, if necessary, as follows:

a. Rotate mechanical zero-adjustment screw clockwise until meter pointer is to the left of zero and moving upscale toward zero.

b. Continue to rotate adjustment screw clockwise; stop when pointer is exactly at zero. If the pointer overshoots zero, repeat step a.

c. When pointer is exactly on zero, rotate adjustment screw approximately 2 degrees counterclockwise. This is enough to free the zero adjustment screw from the meter suspension. If pointer moves during this step, repeat steps a through c.

5-22. ADJUSTMENT AND CALIBRATION PROCEDURE.

5-23. 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 5-33. Adjustment locations are shown in Figure 5-8.

5-24. The Adjustment and Calibration Procedure is performed with the ac power cord connected to nominal line voltage ( 115 v/230 v) 50 to 1000 cps, MODE

5-27. POWER SUPPLY AND BIAS ADJUSTMENTS

a. Refer to Table 5-6 for the power supply and bias measurement points, adjustments, voltage limits and line regulation specifications.

Table 5-6. Power Supply Adjustments

POWER SUPPLY	MEASUREMENT POINT	ADJUSTMENT	VOLTAGE LIMITS	REGULATION (vary line voltage between 103.5 and 127.5 VAC)
-25 volts	Any violet wire	A1R13	-25 volts ±0.5 volts	-25 volts ±0.25 volts
+25 volts	Any red wire	None*	+25 volts ±1.0 volt	+25 volts ±1.0 volt
-11.3 volts bias	A2, Test Point 1	A2R3**	-11.3 volts	±0.1 volt of optimum setting
+8.0 volts bias	A2, Test Point 2	A2R20	+8.0 volts ±0.5 volts	+8.0 volts ±0.5 volts
+2.8 volts bias	A3, Test Point 1	A3R4	+2.8 volts ±0.2 volts	+2.8 volts ±0.2 volts
-20.2 volts bias	A3, Test Point 2	A3R16†	-20.2 volts ±0.2 volts	-20.3 volts ±0.2 volts

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

\*\* This voltage has been adjusted for optimum distortion performance. Do not readjust unless A2Q1 is changed.

† This voltage has been adjusted for optimum distortion performance. Do not readjust unless A3Q4 is changed.

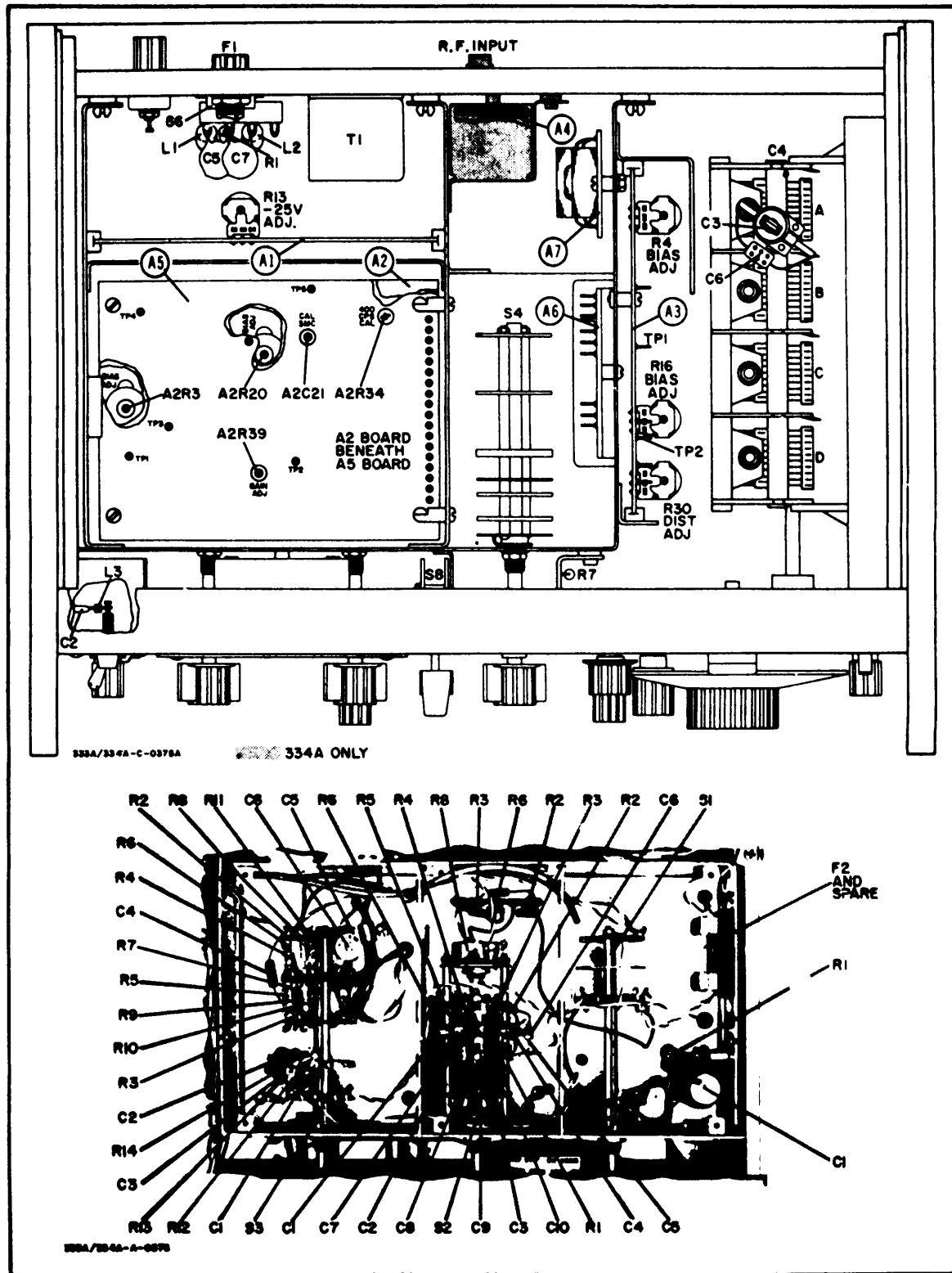


Figure 5-8 Component and Adjustment Location



Model 333A/334A

Section V  
Paragraphs 5-28 to 5-29 and Figure 5-9

- b. Remove top and bottom covers.
- c. Secure the shorting bar between the power line ground and circuit ground INPUT terminals.
- d. Connect common lead of VTVM (-hp- Model 412A) to either INPUT ground terminals.
- e. Perform the measurements and adjustments listed in Table 5-6.

**CAUTION**

DO NOT ALLOW PROBE TO SHORT TP1 TO GROUND. IF THIS HAPPENS, A2Q4 MAY BE DESTROYED.

5-28. A3R16 AND A3R30 DISTORTION ADJUST.

- a. Connect test equipment to the 333A/334A as shown in Figure 5-9.

- b. Set Distortion Analyzer controls as follows:
 

	A3R16 ADJ	A3R90 ADJ
FUNCTION Selector . .	SET LEVEL	SET LEVEL
METER RANGE Switch .	SET LEVEL	SET LEVEL
	Range	Range
FREQUENCY RANGE . . . . .	X1K . . . . .	X100
Selector		
FREQUENCY Dial. . . . .	5 . . . . .	50
SENSITIVITY Selector . . . . .	Position 5 . . . . .	Position 5
SENSITIVITY VERNIER . . . . .	CCW . . . . .	CCW

- c. Adjust Filter Set to 5 Kc.
- d. Set Function Generator for 5 Kc and adjust the output amplitude for +2 db reading on the Distortion Analyzer.
- e. Switch Distortion Analyzer to DISTORTION and obtain best null (minimum of 40 db down from +2 db reference). Decrease METER RANGE switch as necessary.
- f. Set MODE switch to Automatic and METER RANGE switch to 0.0003 range and adjust A3R16 for minimum distortion reading (minimum of 70 db down from +2 db reading on the Distortion Analyzer).

NOTE

When adjusting A3R16, the voltage at A3TP2 must remain within the limits of +19.9 to +20.5 volts.

- g. Repeat steps b through f, adjusting A3R30 instead of A3R16.

5-29. BRIDGE BALANCE ADJUSTMENT (C3).

**CAUTION**

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

- a. Connect the Test Oscillator to the Distortion Analyzer.
- b. Set the Distortion Analyzer controls as follows:
 

FUNCTION Selector . . . . .	SET LEVEL
METER RANGE Switch . . . . .	SET LEVEL
FREQUENCY RANGE Selector . . . . .	X1K
SENSITIVITY Selector . . . . .	Position 5
- c. Turn the slot on trimmer capacitor C3 parallel with the side casting of the Distortion Analyzer.
- d. Set the Test Oscillator to 5 Kc and Adjust the amplitude to give an indication of +2.0 db on the Distortion Analyzer.
- e. Set the Distortion Analyzer FUNCTION selector to DISTORTION. Adjust the Frequency dial and BALANCE controls for the best null. (Null must be at least 90 db down from +2.0 db reference.) After the Distortion Analyzer is nulled, the COARSE BALANCE control should be near the center of its extremes. if it is near either end, there will not be enough range on the BALANCE control at other frequencies.
- f. Position the METER RANGE switch and FUNCTION selector to SET LEVEL
- g. Set the Test Oscillator to 60 Kc and adjust the amplitude to give an indication of +2.0 db on the Distortion Analyzer.
- h. Set the Distortion Analyzer FUNCTION selector to DISTORTION and set the FREQUENCY RANGE switch to X10K.
- j. Without disturbing the BALANCE controls, adjust the Frequency dial and C3 for best null. (Null must be at least 40 db down from +2.0 db reference.)

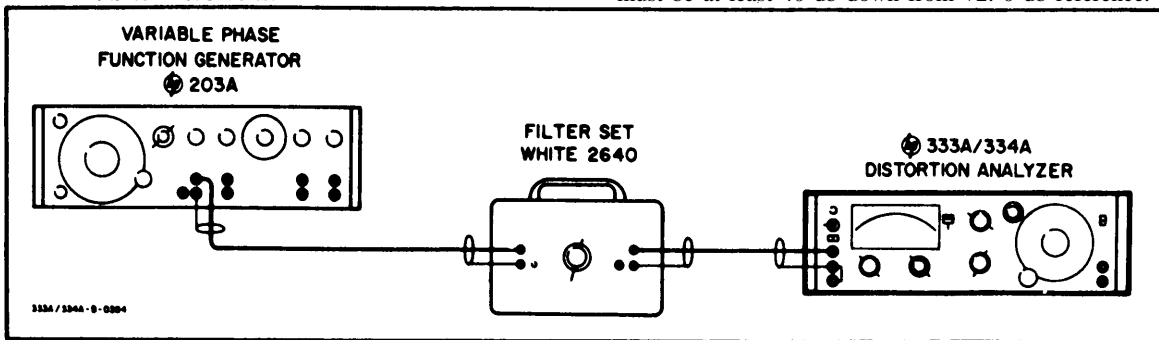


Figure 5-9. A3R16 and A3R30 Distortion Adjust Test Setup

NOTE

If the 60 on the Frequency dial is not under the cursor after step j is completed, refer to Figure 7-1 and perform the following steps:

- 1) Remove set screws (#2) from knob on Frequency dial, and then remove knob (#31). Do not change C4 setting.
- 2) Loosen retaining screws on Frequency dial (#3), and slip dial until 60 is under cursor, being careful not to disturb C4 setting.
- 3) Tighten retaining screws and replace knob and set screws.

5-30. VOLTMETER GAIN ADJUSTMENTS.

a. Connect Voltmeter Calibrator (-hp- Model 738BR) to Distortion Analyzer as shown in Figure 5-5. Remove shorting bar between earth ground and floating ground terminals.

b. Set Distortion Analyzer controls as follows:  
FUNCTION Selector . . . . . VOLTMETER  
METER RANGE Selector . . . . .0.001 VOLTS

c. Set Voltmeter Calibrator to 400 ~ RMS, 1.0 millivolt output.

d. Adjust A2R34 (400 cps CAL. 2) for a meter indication of 1.0.

e. Set Voltmeter Calibrator to 400 ~ RMS, 0. 3 millivolt output. Set Distortion Analyzer METER RANGE selector to 0.0003 VOLTS.

f. The meter shall indicate  $3.0 \pm 1/3$  of a minor division ( $\pm 0. 55\%$ ). If necessary, change A2R30 to set reading within these limits,

NOTE

If transistors are replaced in the meter amplifier, it may be necessary to change A2R30. Typical values for this resistor are between 140-260 ohms. Increasing resistance decreases the meter reading and vice versa.

g. Perform the Voltmeter Accuracy Check of Paragraph 5-17. The meter shall indicate within the limits specified.

5-31. VOLTMETER FREQUENCY RESPONSE ADJUSTMENT.

a. Connect the test equipment to the 333A/334A as shown in Figure 5-6.

NOTE

Range switch cover must be in place before performing these adjustments.

b. Set the Distortion Analyzer controls as follows:  
FUNCTION Selector . . . . . VOLTMETER  
METER RANGE Selector . . . . .0.0003 VOLTS

c. Set the frequency response test set for 400 cps and adjust the output amplitude for a Distortion Analyzer meter indication of 0.9 on the 1.0 scale.

5-10

d. Adjust the frequency response test set meter control for a set level indication

e. Change frequency response test set frequency to 20 cps.

f. Readjust the amplitude until the frequency response test set meter indicates set level.

g. The Distortion Analyzer meter shall indicate  $0.9 \pm 5\%$ .

NOTE

If reading exceeds these limits, change A2C25. Typical value for this capacitor is between 50 and 200  $\mu$ f. Increasing capacitance reduces the meter reading, and vice versa.

h. Switch Distortion Analyzer METER RANGE selector to 0. 001 VOLTS, Repeat steps c and d.

j. Change frequency response test set to 5 cps. Repeat step f.

k. The Distortion Analyzer meter shall indicate  $0.9 \pm 5\%$ .

m. Switch the Distortion Analyzer METER RANGE selector to 0. 01 VOLTS. Repeat steps c and d.

n. Adjust frequency response test set frequency for 2Mc and adjust the output amplitude until the frequency response test set indicates set level.

p. Adjust A2R39 (GAIN ADJUST) for a Distortion Analyzer meter indication of 0. 9 on the 1.0 scale.

q. Change the frequency response test set frequency to 3 Mc. Readjust the output amplitude until the frequency response test set indicates set level.

r. Adjust A2C21 (3 Mc CAL trimmer) for a Distortion Analyzer meter Indication of 0. 9 on the 1.0 scale.

NOTE

The frequency response adjustments made thus far interact. It will be necessary to repeat steps n thru r until all adjustments are within specifications.

s. Switch Distortion Analyzer METER RANGE to 0. 3 VOLTS. Repeat steps c and d.

t. Change the frequency response test set frequency to 2.5 Mc. Readjust the output amplitude until the meter indicates set level. Adjust S3C6 (VOLTAGE CAL at 2.5 Mc 0. 3 v RANGE trimmer) for a Distortion Analyzer meter indication of 0. 9 on the 1.0 scale.

v. Switch the Distortion Analyzer METER RANGE selector to 3 VOLTS. Repeat steps c and d.

w. Change the frequency response test set frequency to 200 Kc. Repeat step f.

x. Adjust S3C1 (200 Kc CAL) for a Distortion Analyzer indication of 0. 9 on the 1.0 scale.

5-32. SENSITIVITY SWITCH CALIBRATION.

a. Connect instruments as shown in Figure 5-6.

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 Selector . . . . . SET LEVEL  
 SENSITIVITY Selector . . . . . Position 5  
 SENSITIVITY VERNIER Control . . . . . MAX  
 METER RANGE Selector . . . . . 0.01 VOLTS
- c. Set Frequency Response Test Set controls (-hp- Model 739AR) as follows:  
 RANGE SELECTOR . . . . . EXTERNAL  
 OUTPUT ATTENUATOR . . . . . 0.03
- d. Set Oscillator (-hp- Model 200SR) frequency to 400 cps. Adjust AMPLITUDE control for an indication on Distortion Analyzer meter of 0.9 on the 1.0 scale.
- e. Adjust Frequency Response Test Set METER SET for SET LEVEL indication.
- f. Change Oscillator frequency to 100 Kc. Readjust Oscillator AMPLITUDE control for SET LEVEL indication on Frequency Response Test Set meter.
- g. Adjust S2C 5 for a meter indication of 0.9 on the 1.0 scale.
- h. Repeat steps d through f, calibrating sensitivity at the settings indicated in Table 5-7.

NOTE

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

Table 5-7. Sensitivity Switch Calibration

SENSITIVITY Switch	Test Set ATTENUATOR	Adjust for 0.9
Position 5	0.03	S2C 5
Position 4	0.1	S2C 4
Position 3	0.3	S2C 3
Position 2	1.0	S2C 2
Position 1	3.0	S2C 1

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 problem. These operations should be undertaken only after it has been established that the difficulty can not 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.



THE 333A/334A CONTAINS VERY HIGH IMPEDANCE, HIGH FREQUENCY CIRCUITS. CONTAMINATION OF THE SWITCHES, CIRCUIT BOARDS OR TUNING CAPACITORS WILL CAUSE HIGH

IMPEDANCE LEAKAGE PATHS AND SUBSEQUENT DETERIORATION OF THE PERFORMANCE OF THE INSTRUMENT. AVOID TOUCHING ANY OF THESE CIRCUITS WITH THE BARE FINGER, AS SKIN OILS ARE EXTREMELY CONTAMINATING. IF HANDLING IS NECESSARY, WEAR CLEAN COTTON OR RUBBER GLOVES. DO NOT USE A PENCIL TO TRACE CIRCUITS IN THE INSTRUMENT. GRAPHITE PENCIL LEAD IS AN EXTREMELY GOOD CONDUCTOR AND MAY ACCIDENTLY INTRODUCED PATH OF THIS TYPE IS SOMETIMES DIFFICULT TO LOCATE. TO AVOID SURFACE CONTAMINATION OF A PRINTED CIRCUIT OR SWITCH, CLEAN WITH A WEAK SOLUTION OF WARM WATER AND MILD DETERGENT AFTER REPAIR. RINSE THOROUGHLY WITH CLEAN WATER AND ALLOW IT TO DRY COMPLETELY BEFORE OPERATING. DO NOT USE ALCOHOL OR ANY OTHER CLEANING SOLUTION EXCEPT DETERGENT AND WATER. DO NOT APPLY ANY COMMERCIAL MOISTURE SEALING SPRAY TO THE BOARDS. APPLICATION OF THESE AGENTS WILL CAUSE LEAKAGE PATHS AND SUBSEQUENT DETERIORATION TO THE OPERATION OF THE INSTRUMENT.

- 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.
- 5-36. Table 5-8 contains a summary of the front panel symptoms and internal adjustment symptoms that might be encountered. It should be used in initial efforts to select a starting point for troubleshooting procedures.
- 5-37. Table 5-9, in conjunction with Figure 5-10, contains procedures which may be used as a guide in isolating malfunctions. The steps in Table 5-9 describe the normal conditions which should be encountered during the checks (circled numbers N ) in Figure 5-10.
- 5-38. The checks outlined in Table 5-9 are not designed to measure all the circuit parameters, rather to localize a malfunction. Therefore, it is quite possible that additional measurements will be required to completely isolate a problem. Circuit parameters may vary slightly between instruments; therefore, it should not be necessary to precisely duplicate the values given.
- 5-39. BOTTOM SHIELD REMOVAL.
- 5-40. The bottom shield is attached by seven screws. Access to six is obtained by removing the bottom cover. Access to the other is obtained by removing the left (as viewed from the front of instrument) rear side cover.
- 5-41. SERVICING ETCHED CIRCUIT BOARDS.
- 5-42. The Model 333A has six-etched circuit boards and the Model 334A, seven. Use caution when removing them to avoid damaging mounted components.

Table 5-8. Troubleshooting Aid

SYMPTOM	PROBABLE CAUSE
<b>1. FRONT PANEL SYMPTOMS</b>	
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 (.3 VOLT range); No output; ON lamp illuminated. (All FUNCTIONS)	Check Fuse (F2).
C. No meter deflection with signal at input; Output normal. (All FUNCTIONS).	Check A2CR6, A2CR7, and M1.
D. Meter pegs up-scale with or without input on all ranges. (All FUNCTIONS).	Check A2C27 and A2C28.
E. Will not null manually; VOLTMETER and SET LEVEL FUNCTIONS normal.	Check A4AF, C4A-D, C3, R4, R5, A6DS1, and A6V1.
F. No SENSITIVITY VERNIER control in SET LEVEL mode. VOLTMETER mode normal. (SET LEVEL FUNCTION only.)	Check R2, R3, S2R8 and A3Q1 through A3Q6.
G. BALANCE controls erratic. (DISTORTION FUNCTION only.)	Check R4 and R5.
<b>2. INTERNAL ADJUSTMENT SYMPTOMS</b>	
A. Insufficient -25 volts adjustment with A1R13, measured at any violet wire.	Check A1C1, A1C11, A1CR3, A1CR4, A1CR7 and A1Q4 through A1Q8.
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 A2Q8.
E. Insufficient 400 cps adjustment with A2R34.	Check +8 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.
G. Insufficient 3 Mc calibration adjustment with A2C21.	Check A2C22. (Increasing value of C 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, A3C13 and A3Q4 through A3Q6. Change A3R17. (Increasing value of R will increase voltage at A3TP2.)
<b>3. AUTOMATIC MODE INOPERATIVE</b>	
A. No indication of square wave reference voltage (frequency of fundamental of the input signal) at A5TP1 or A5TP4.	Check A5R6, A5Q7, and A5C10.
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 A5TP2. A5TP5 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 and A5Q13.

The -hp- Part Number for the assembly is marked on the circuit board to identify it.

5-43. 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 with 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.

**5-44. SERVICING ROTARY SWITCHES.**

5-45. 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:

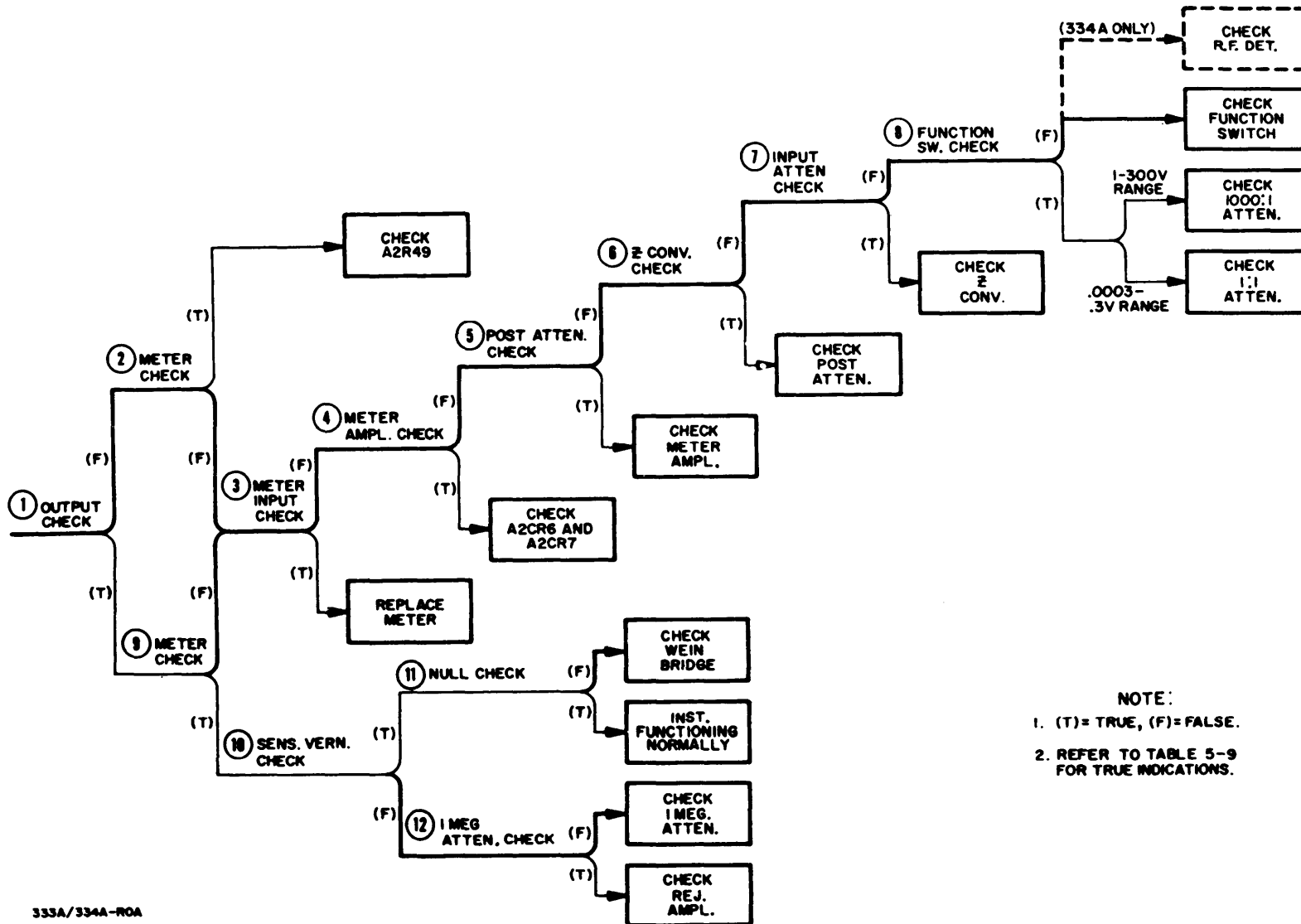
- a. Use a low-heat (25 to 50 watts) small-tip soldering iron and a small diameter rosin core solder.
- b. When replacing components, attempt to dress them as nearly to their original alignment as possible.
- c. Clean excessive flux from the connection and adjoining area.
- d. After cleaning the switch, 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.

Table 5-9. Normal Troubleshooting Indications

CHECK NUMBER	FUNCTION SELECTOR	METER RANGE	INPUT SIGNAL	NORMAL INDICATION
①	VOLTMETER	0.3 VOLTS	0.3 vrms, 1 Kc	0.1 vrms $\pm 10\%$ at OUTPUT terminals.
②	VOLTMETER	0.3 VOLTS	0.3 vrms, 1 Kc	Meter should read 0.3 vrms.
③	VOLTMETER	0.3 VOLTS	No Input	Approx. -4 vdc at +Meter terminal.
④	VOLTMETER	0.3 VOLTS	0.3 vrms, 1 Kc	Approx. 0.1 vrms at junction A2C26, A2C27.
⑤	VOLTMETER	Vary	Full Scale, 1 Kc	Approx. 1 mvrms at A2C15 for F. S. input on all ranges except 0.0003 Volt. Approx. 0.3 mvrms for F. S. on 0.0003 volt range.
⑥	VOLTMETER	0.3 VOLTS	0.3 vrms, 1 Kc	Approx. 0.3 vrms at A2C14.
⑦	VOLTMETER	Vary	Full Scale, 1 Kc	Approx. same as input signal on 0.0003 to 0.3 Volt ranges; approx. 1/1000 of input signal on 1 to 300 volt ranges; measured at A2R1
⑧	Vary	0.3 VOLTS	0.3 vrms, 1 Kc	Approx. same as input voltage; measured at S1AR (10) on VOLT-METER mode; measured at S1AR (2) on SET LEVEL and DISTORTION modes.
⑨	VOLTMETER	0.3 VOLTS	0.3 vrms, 1 Kc	Meter should read 0.3 vrms.
⑩	SET LEVEL	0.3 VOLTS	0.3 vrms, 1 Kc	SENSITIVITY VERNIER should have > 10 db range, as read on meter.
⑪	DISTORTION	Vary	0.3 vrms, 1 Kc	Adjustment of FREQUENCY, BALANCE, and AUTOMATIC controls should give both MANUAL and AUTOMATIC "null" indication as outlined in Section III.
⑫	SET LEVEL	0.3 VOLTS	0.3 vrms, 1 Kc	SENSITIVITY switch should attenuate input in > 10 db steps, measured at A2R1.

Section V

Figure 5-10



NOTE:  
 1. (T)= TRUE, (F)= FALSE.  
 2. REFER TO TABLE 5-9 FOR TRUE INDICATIONS.

333A/334A-ROA

Figure 5-10. Troubleshooting Logic

Section V  
Table 5-10

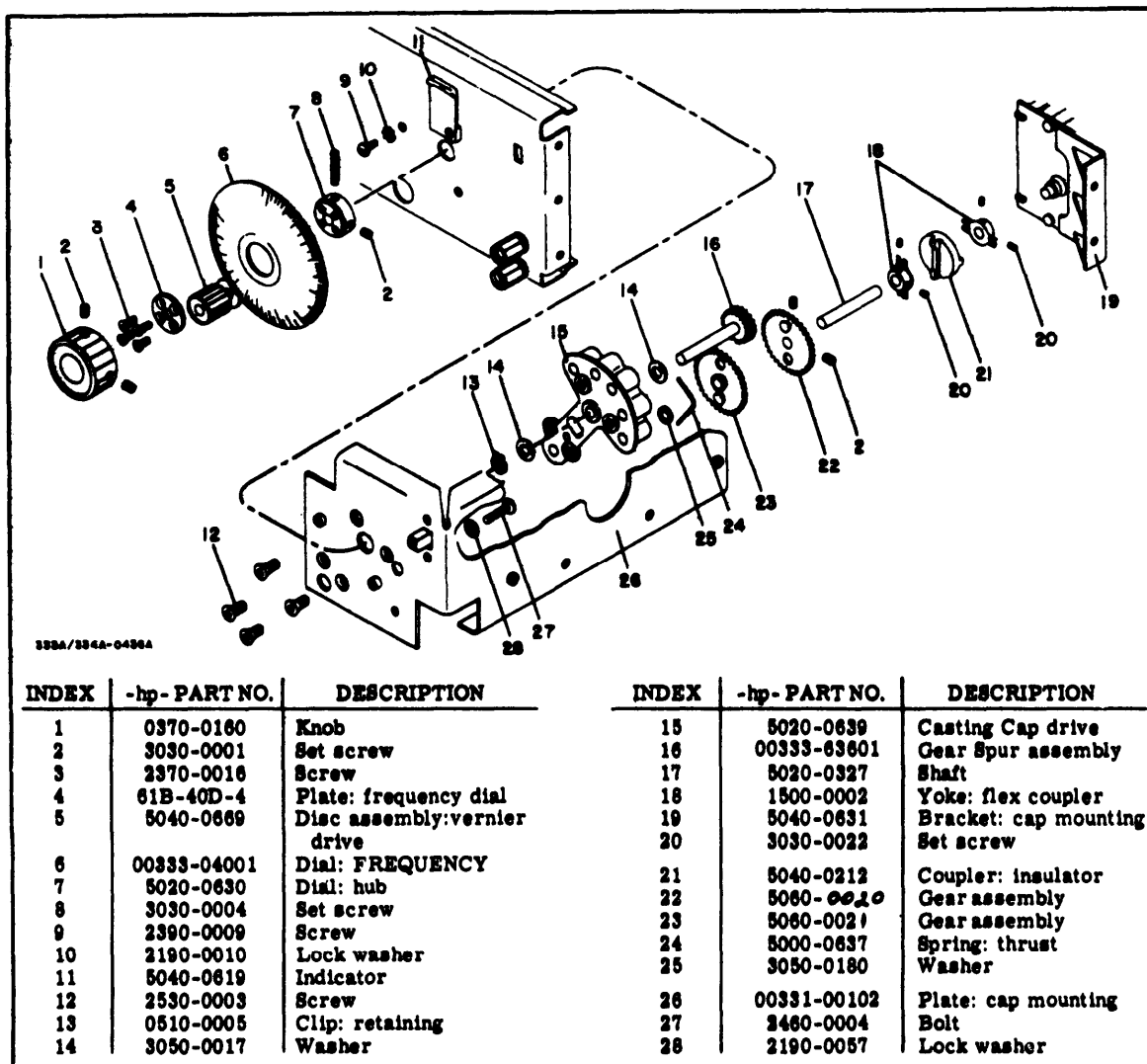


Figure 5-11 Frequency Tuning Assembly



## SECTION VI

### SCHEMATICS

#### 6-1. SCHEMATIC DIAGRAMS.

6-2. This section contains the schematic diagram, wiring data, and A5 board component location diagram for the 33A and 334A Distortion Analyzers. The schematic diagram illustrate the circuits contained within each assembly as well as the assembly interconnections.

Main signal paths and significant feedback paths are identified (refer to notes on the schematic diagrams). An A5 board component location diagram is included, because the A5 components are not identified on the printed circuit boards. A partial interconnecting diagram is also included to assist in reconnecting pc boards.

Section VI  
Figure 6-1

Model 333A/334A

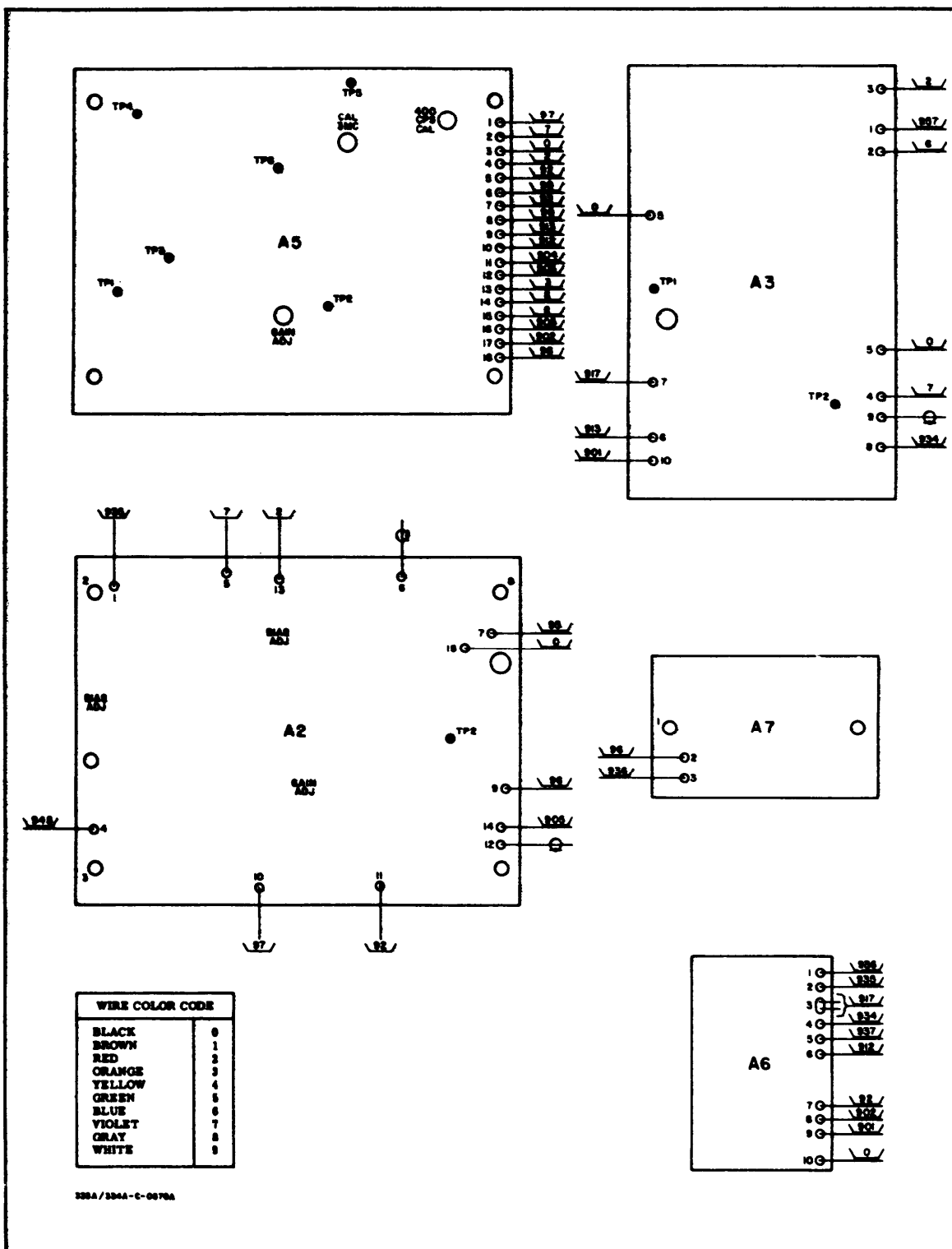


Figure 6-1. P/O Internal Wiring Data

**By Order of the Secretary of the Army:**

**HAROLD K. JOHNSON,**  
*General, United States Army,*  
*Chief of Staff.*

**Official:**

**KENNETH G. WICKHAM**  
*Major General, United States Army,*  
*The Adjutant General.*

**Distribution:**

*Active Army :*

**USAMB (1)**  
**USACDCEC (1)**  
**USACDCCEA (1)**  
**USACDCCEA :**  
**Ft Huachuca (1)**

**Eighth USA (5)**  
**SAAD (5)**  
**TOAD (6)**  
**LEAD (8)**

**NG : None.**

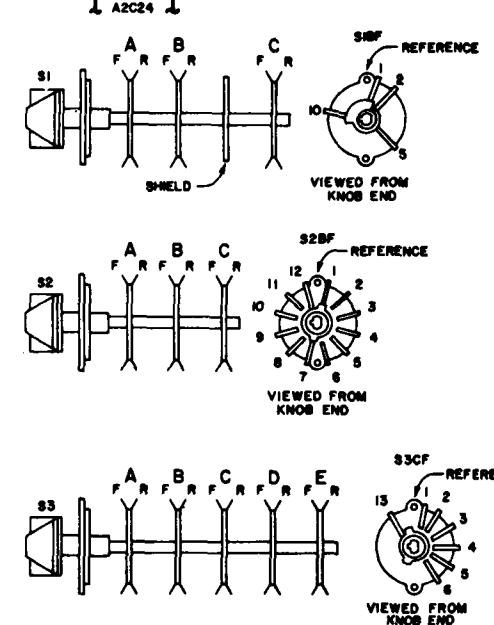
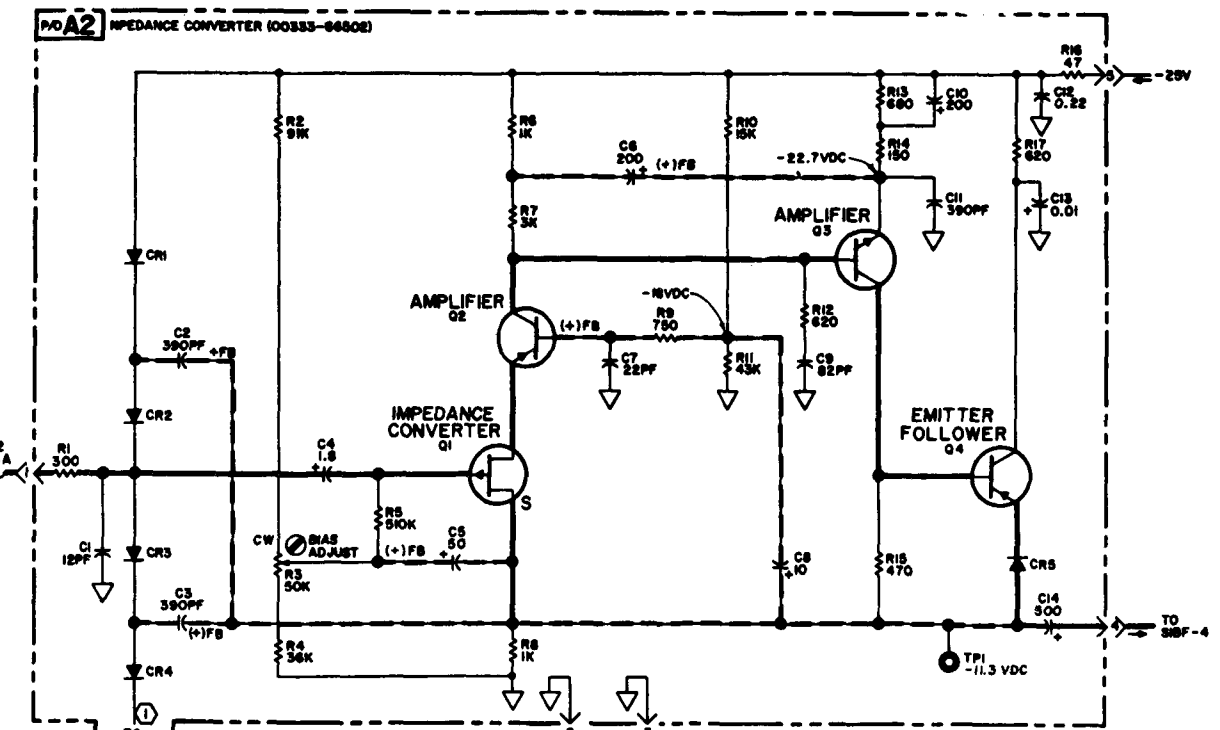
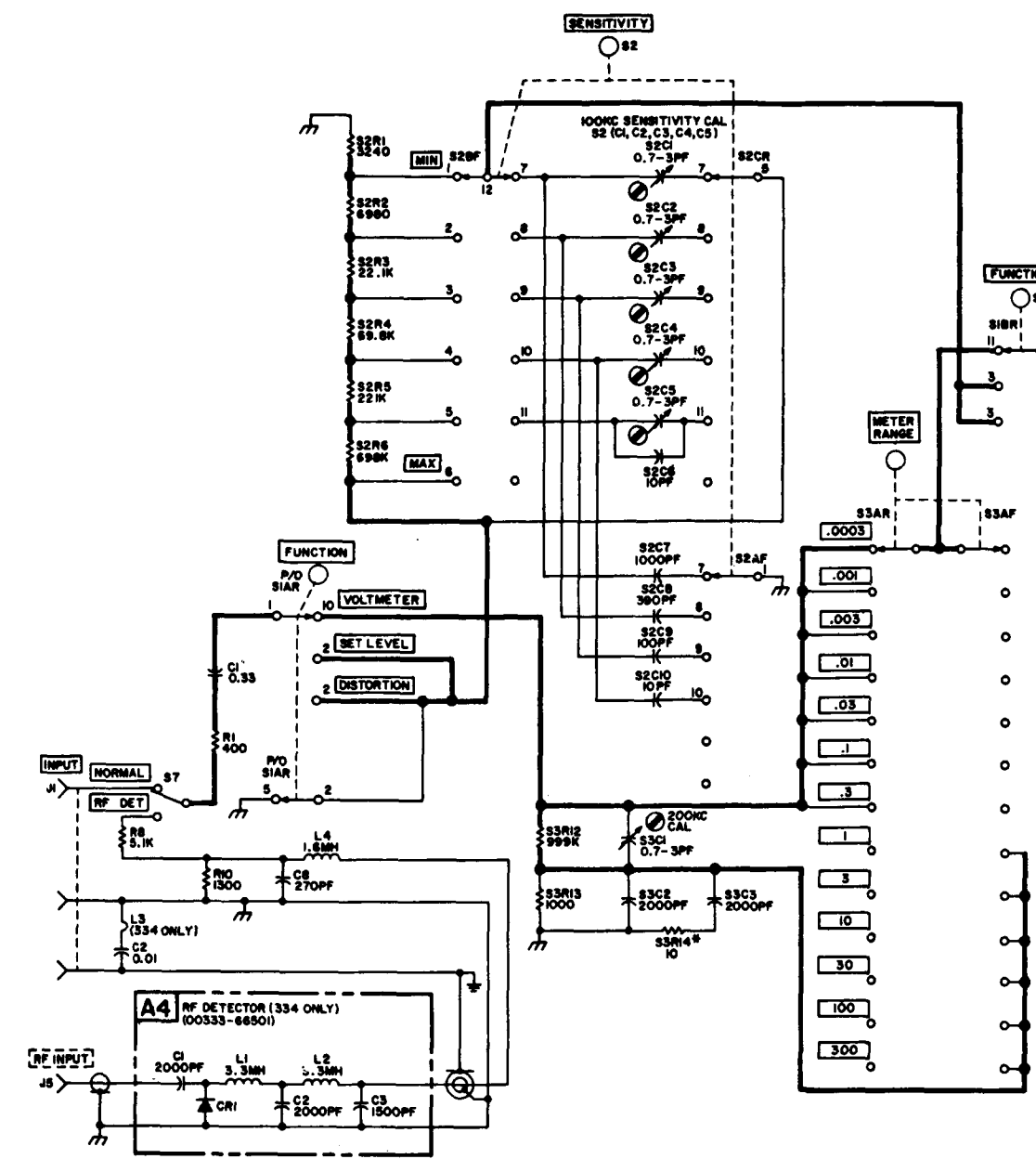
**USAR: None.**

**For explanation of abbreviations used, see AR 320-50.**









CHASSIS	A2	A4	S2	S3
C1-C2, C5	C1-C14	C1-C4	C1-C10	C1-C3
F2	CR1-CR5	Q1-Q4	RI-R8	RI2-RI4
R1, R8	Q1-Q4	L1-L3	RI-R8	RI2-RI4
J1, J5	RI-RI7	RI		
S1A, S1B				
S2A-S2C				
S3A				
S7				

- NOTES**
- PARTIAL REFERENCE DESIGNATIONS ARE SHOWN. PREFIX WITH ASSEMBLY OR SUBASSEMBLY DESIGNATION(S) OR BOTH FOR COMPLETE DESIGNATION.
  - COMPONENT VALUES ARE SHOWN AS FOLLOWS UNLESS OTHERWISE NOTED:  
RESISTANCE IN OHMS.  
CAPACITANCE IN MICROFARADS.
  - DENOTES FRONT PANEL MARKING.
  - DENOTES REAR PANEL MARKING.
  - ⊕ DENOTES SCREWDRIVER ADJUST.
  - DENOTES ASSEMBLY.
  - DENOTES FEEDBACK PATH.
  - ⊕ CHASSIS GROUND. ⚡ FLOATING GROUND. ⚡ SIGNAL GROUND.
  - S1 SHOWN IN VOLTMETER POSITION. S2 SHOWN IN MIN SENSITIVITY POSITION.
  - S3 SHOWN IN .005 POSITION.
  - ⊕ AVERAGE VALUE SHOWN. OPTIMUM VALUE SELECTED AT FACTORY.

Figure 6-2. Impedance Converter

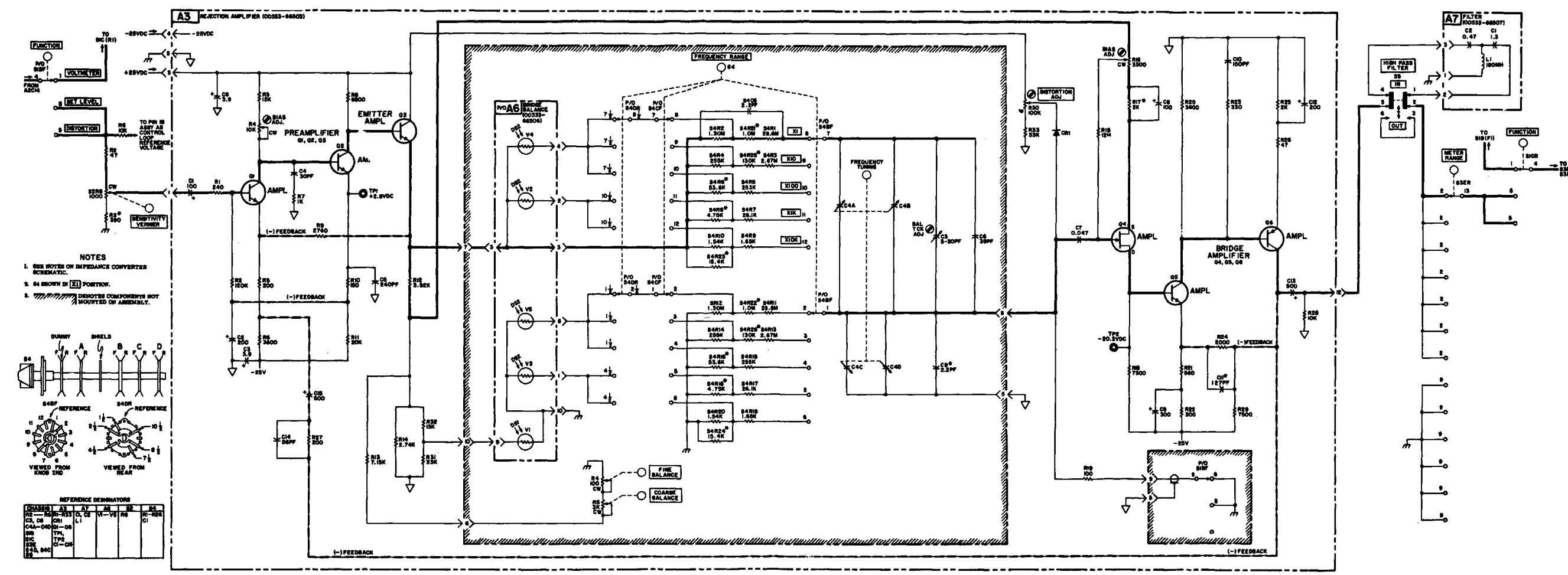


Figure 6-3. Rejection Amplifier 6-5



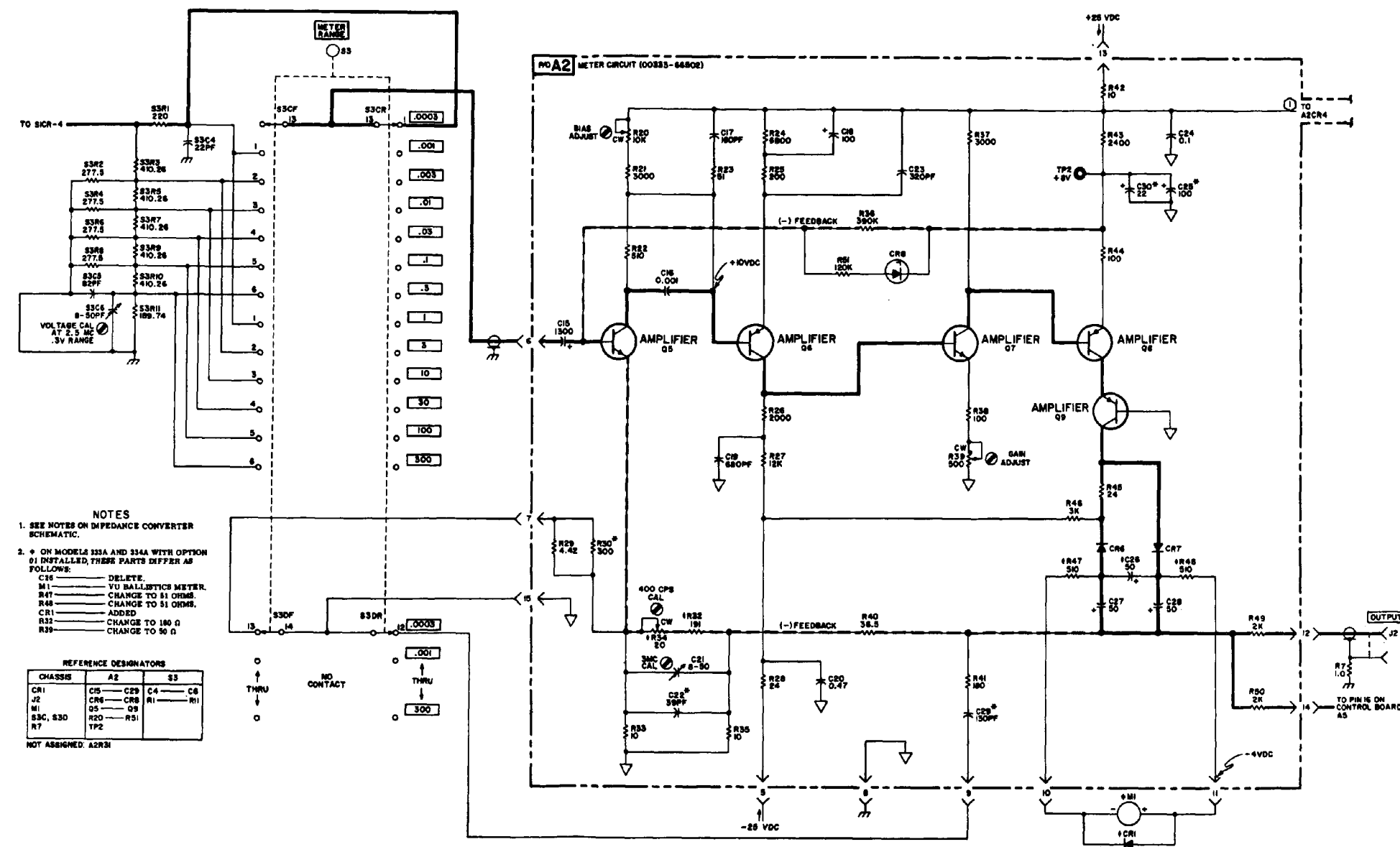


Figure 6-4. Metering Circuit

Model 333A/334A

Section VI  
Figure 6-5

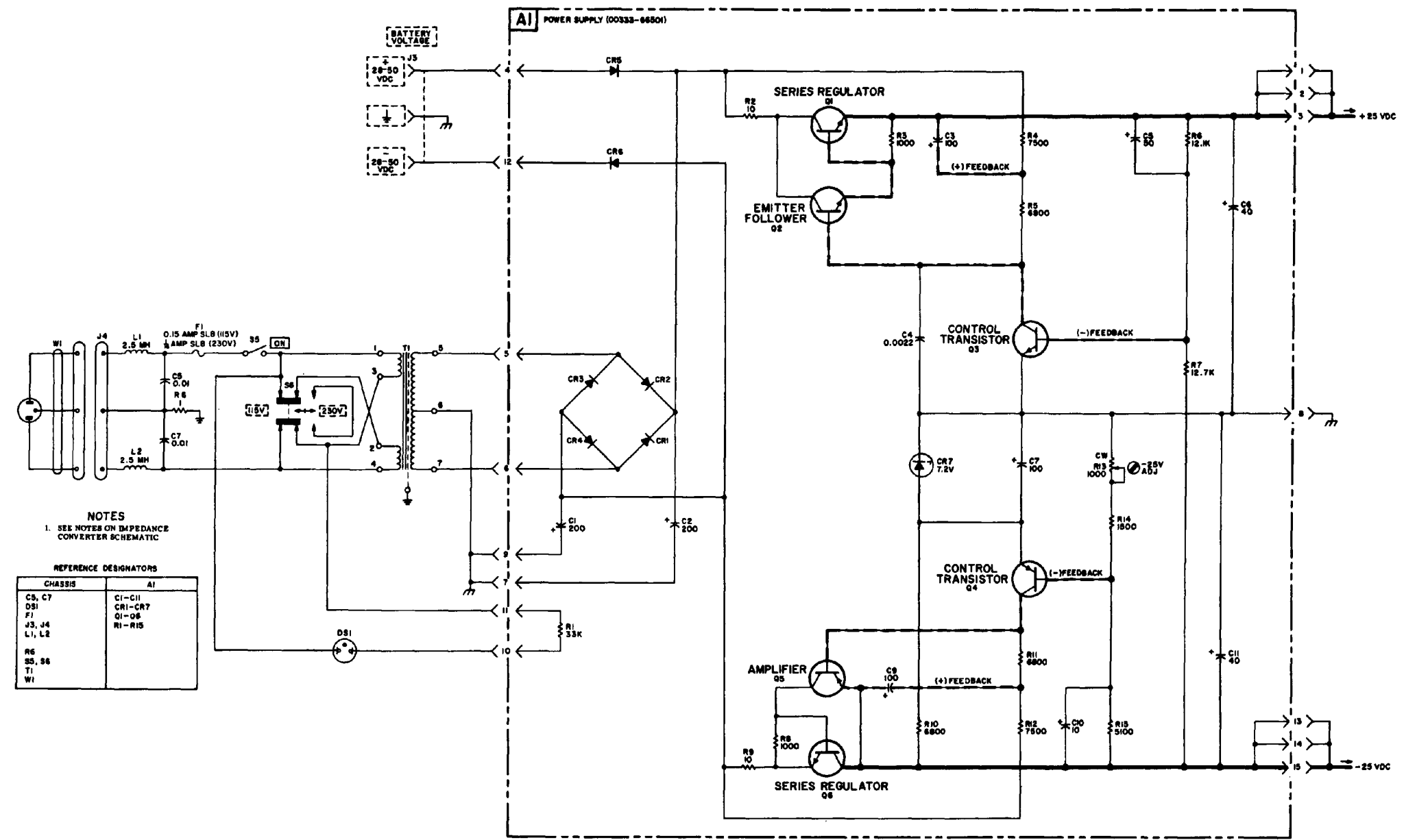


Figure 6-5. Power Supply

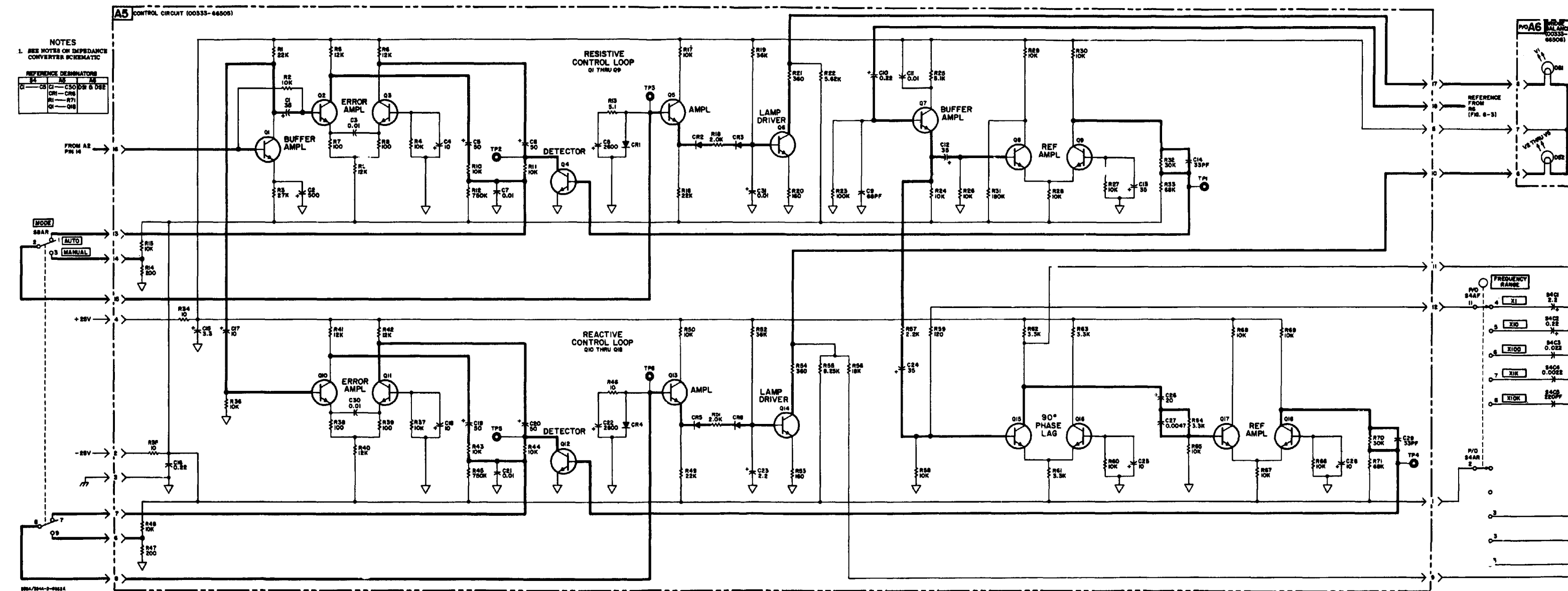


Figure 8-6. A5 Auto Control Circuit and Component Location



