



OPERATING AND SERVICE MANUAL

(HP PART NO. 00331-90002)

MODEL 331A/332A DISTORTION ANALYZER

SERIALS PREFIXED: 331A - 602-
332A- 604-

Appendix C, Manual Backdating Changes,
adapts this manual to the following instruments:

331A: 602-00820 and below, 536-, 427-

332A: 604-00525 and below, 536-, 504-, 517-

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P. O. Box 301, Loveland Colorado, 80537 U. S. A.

PERFORMANCE CHECK TEST CARD

Hewlett-Packard Model 331A/332A
 Distortion Analyzer
 Serial No. _____

Test performed by _____
 Date _____

| DESCRIPTION | CHECK | |
|--|---|--------------------------|
| Fundamental Rejection Check: | <u>Specification</u> | <u>Indication</u> |
| | > -80 dB | <input type="checkbox"/> |
| Second Harmonic Accuracy Check: | <u>Specification</u> | <u>Indication</u> |
| 20 Hz | < ±0.6 dB | <input type="checkbox"/> |
| 20 kHz | < -1.0 dB | <input type="checkbox"/> |
| 100 kHz | < -2.0 dB | <input type="checkbox"/> |
| 300 kHz | < -3.0 dB | <input type="checkbox"/> |
| Distortion Introduced by Instrument Check: | <u>Specification</u> | <u>Indication</u> |
| 5 Hz | > -70 dB | <input type="checkbox"/> |
| 5 kHz | > -70 dB | <input type="checkbox"/> |
| 50 kHz | > -70 dB | <input type="checkbox"/> |
| 250 kHz | > -64 dB | <input type="checkbox"/> |
| 600 kHz | > -64 dB | <input type="checkbox"/> |
| Frequency Calibration Accuracy Check: | <u>Specification</u> | <u>Indication</u> |
| 5 Hz | 190 to 210 ms | <input type="checkbox"/> |
| 20 Hz | 47.5 to 52.5 ms | <input type="checkbox"/> |
| 200 kHz | 190K to 210K | <input type="checkbox"/> |
| 600 kHz | 540K to 660K | <input type="checkbox"/> |
| Input Resistance Check: | <u>Specification</u> | <u>Indication</u> |
| | 1 MΩ ±5% | <input type="checkbox"/> |
| Input Shunt Capacitance Check: | <u>Specification</u> | <u>Indication</u> |
| Voltmeter: | | |
| 1 V | < 30 pF | <input type="checkbox"/> |
| .3 V | < 70 pF | <input type="checkbox"/> |
| Distortion: | | |
| .3 V | < 70 pF (At any SENSITIVITY setting) | <input type="checkbox"/> |

PERFORMANCE CHECK TEST CARD (Cont'd)

| DESCRIPTION | CHECK | |
|--------------------------------------|-------------------------|--------------------------|
| Minimum Input Level Check: | <u>Specification</u> | <u>Indication</u> |
| Sensitivity Controls | 100% set level | <input type="checkbox"/> |
| DC Isolation Check: | <u>Specification</u> | <u>Indication</u> |
| Distortion Analyzer meter | No change in indication | <input type="checkbox"/> |
| Power Supply ammeter | No indication | <input type="checkbox"/> |
| Voltmeter Accuracy Check: | <u>Specification</u> | <u>Indication</u> |
| .0003 V | ± 2% | <input type="checkbox"/> |
| .001 V | ± 2% | <input type="checkbox"/> |
| .003 V | ± 2% | <input type="checkbox"/> |
| .01 V | ± 2% | <input type="checkbox"/> |
| .03 V | ± 2% | <input type="checkbox"/> |
| .1 V | ± 2% | <input type="checkbox"/> |
| .3 V 105 Vac to | ± 2% | <input type="checkbox"/> |
| 1 V 125 Vac | ± 2% | <input type="checkbox"/> |
| 3 V | ± 2% | <input type="checkbox"/> |
| 10 V | ± 2% | <input type="checkbox"/> |
| 30 V | ± 2% | <input type="checkbox"/> |
| 100 V | ± 2% | <input type="checkbox"/> |
| 300 V | ± 2% | <input type="checkbox"/> |
| Voltmeter tracking | ± 1% | <input type="checkbox"/> |
| Voltmeter Frequency Response Check: | <u>Specification</u> | <u>Indication</u> |
| 5 Hz | ± 5% | <input type="checkbox"/> |
| 20 Hz | ± 2% | <input type="checkbox"/> |
| 10 kHz 105 Vac to | ± 2% | <input type="checkbox"/> |
| 500 kHz 125 Vac | ± 2% | <input type="checkbox"/> |
| 1 MHz | ± 2% | <input type="checkbox"/> |
| 3 MHz | ± 5% | <input type="checkbox"/> |
| Residual Noise Check: | <u>Specification</u> | <u>Indication</u> |
| 600Ω | < 25 μV | <input type="checkbox"/> |
| 100kΩ | < 30 μV | <input type="checkbox"/> |
| AM Detector Check (Model 332A only): | <u>Specification</u> | <u>Indication</u> |
| | > -40 dB | <input type="checkbox"/> |

3

hp MANUAL CHANGES

MODEL 331A/332A DISTORTION ANALYZER

Manual Serial Prefixed: 331A-602, 332A-604
-hp- Part No. 00331-90002

► New or revised item

| Instrument Serial Number | Make Manual Changes | Instrument Serial Number | Make Manual Changes |
|--------------------------|--------------------------|--------------------------|--------------------------|
| ALL | ERRATA | ALL | ERRATA |
| 602-01401 and above | #1 | 604-00711 and above | #1 |
| 716-02101 and above | #1, 2 | 717-01061 and above | #1, 2, 3 |
| 724-02301 and above | #1, 2, 3 | ALL | RECOMMENDED REPLACEMENTS |
| ALL | RECOMMENDED REPLACEMENTS | | |

ERRATA

Specifications:

- Change FREQUENCY CALIBRATION ACCURACY to - -
Better than $\pm 5\%$ from 5 cps to 300 Kc.
Better than $+10\%$ from 300 Kc to 600 Kc.
- Change INPUT IMPEDANCE shunt capacitance to less than
70 pF in Distortion Mode and less than 70 pF in Voltmeter
Mode, 300 μ V to 0.3 V ranges.

Page 3-1:

Add to Page 3-1

————— WARNING —————

When instrument is operated in a floating condition, set screws in control knobs will be at floated potential. To protect operating personnel, ensure that set screw holes are filled with an insulating material such as G. E. silicon rubber, RTV-108 (-hp- Part No. 0470-0304).

- Paragraph 5-12:
Step a, delete NOTE.
Step j, change to - - The Electronic Counter shall indicate the period of 5 cps $\pm 5\%$, i. e. 190 to 210 m sec.
- Table 5-4:
In first line of table, change READING of 5532A to 190 to 210 m sec; change second line to 47.5 to 52.5 m sec; change third line to 190 K to 210K; change fourth line to 540 K to 660 K.
- Paragraph 5-14:
Step f, change L-C meter indication to less than 70 pF.
Step h, change L-C meter indication to less than 70 pF.

Figure 5-9:

Interchange designators "R3" and "R2".

Paragraph 5-30 g: Delete . . "and FREQUENCY RANGE to X10K."

CHANGE #1

Figure 6-3:

Change value of S3C5 to 62 pF. Change value of A2R34 to 50Ω.

Table 7-1:

Change -hp- Part No. of A2R33 to 0757-0346.

Delete -hp- Part No. 2100-0227 from A2R34.

Use -hp- Part No. and description of A2R34 Opt. 01 for standard instrument also.

Change -hp- Part No. for S3C5 to 0140-0064, C: fxd mica 62 pF ±5% 500 vdcw.

CHANGE #2

Table 7-1:

Change A2 Board Assembly to 00333-66502, and A2 Opt. 01 to 00333-66508.

Change A2C12 to 0180-1735, fxd, 0.22 μF ±10%, 35 vdcw.

Change A2C15 to 0180-1736, fxd, 1300 μF, +100% -10%, 2.5 vdcw.

Change A2C20 to 0180-0376, fxd, 0.47 μF ±10% 35 vdcw.

Change A2C23 to 0140-0226, fxd, 320 pF, ±5% 500 vdcw.

Add A2C30*, 0180-0228, fxd, 22 μF ±10%, 15 vdcw.

Add A2CR8, 1902-0584.

Change A2Q8 to 1853-0010.

Change A2R16 to 0683-4705, fxd, 47Ω ±5% 1/4 W.

Change A2R28 to 0683-2405, fxd, 24Ω ±5% 1/4 W.

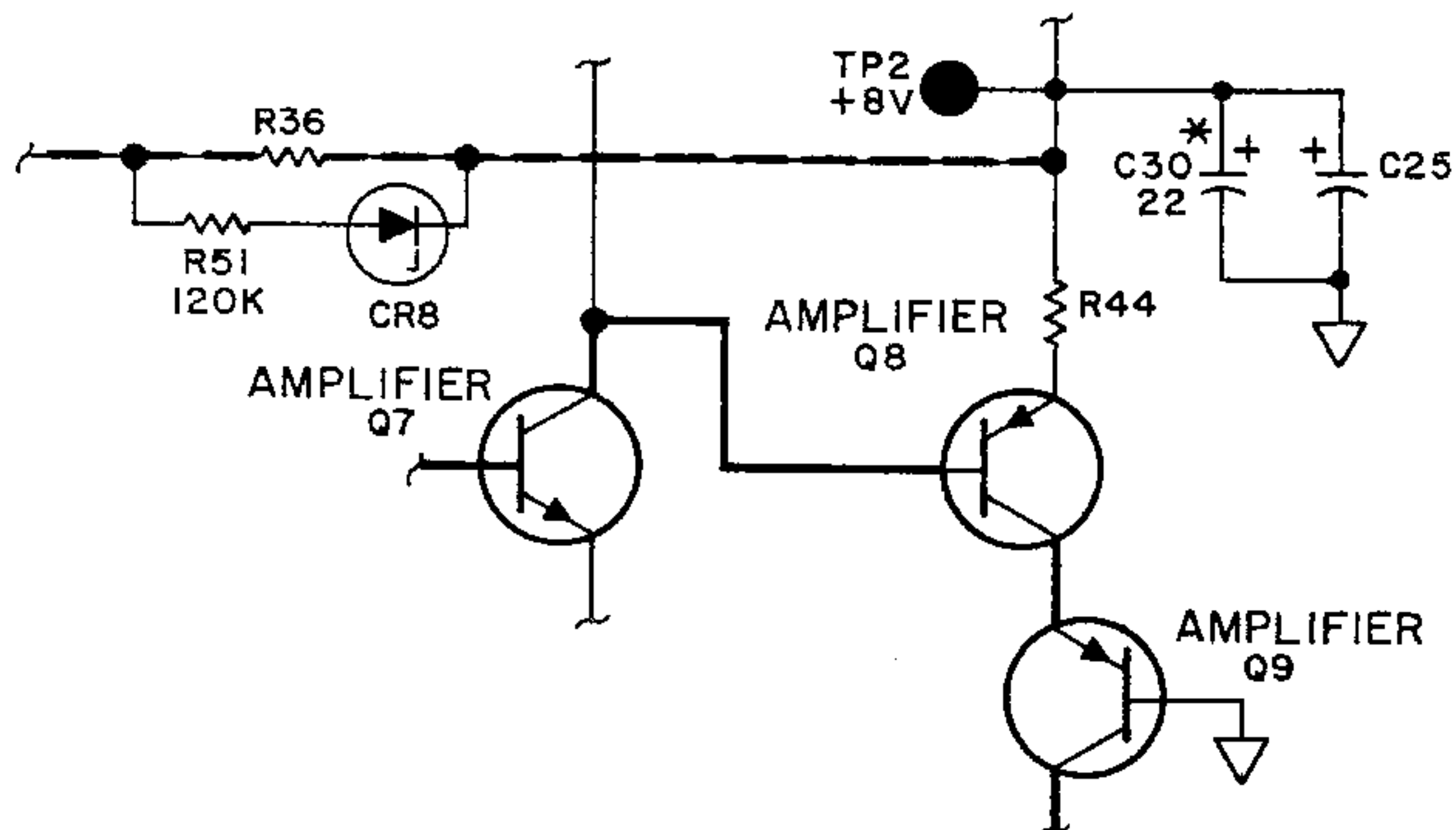
Add A2R51, 0683-1245, 120K, ±5% 1/4 W.

Figure 6-1:

Change value of A2C12 to 0.22 μF. Change value of A2R16 to 47Ω.

Figure 6-3:

Add A2C30, A2CR8, and A2R51 as shown below:



Change A2C15 to 1300 μF; change A2C20 to 0.47 μF; change A2C23 to 320 pF; change A2R28 to 24Ω.

Manual Changes Model 331A/332A Page 3

- CHANGE #3 Figure 6-1:
Delete A2CR5. Replace with Resistor A2R18, 24Ω.
- Figure 6-3:
Add Resistor A2R19, 200Ω, in series with base lead of A2Q5.
- Table 7-1:
Delete A2CR5.
Change A2Q1 to 1855-0052, 2N4360.
Change A2Q6, A2Q9 to 1853-0010, Si PNP.
Add A2R18, 0683-2405, 24Ω ±5% 1/4 W.
Add A2R19, 0683-2015, 200Ω ±5% 1/4 W.

RECOMMENDED (If components below fail, change to value and part number
REPLACEMENTS listed. Most instruments have had these components changed
at factory.)

- Figure 6-3:
Change A2C23 to 240 pF, and change A2C29* to 390 pF.
- Table 7-1:
Change A2C23 to 0140-0199, 240 pF.
Change A2C29* to 0140-0200, 390 pF.
Change A2Q2 to 1853-0086, TSTR: Si PNP 2N5087.
Change A2Q3 to 1854-0203, TSTR: JEDEC 2N3694.
Change A2Q5 to 1854-0297, TSTR: Si NPN
Change A2Q7, A3Q1, A3Q5 to 1854-0215, TSTR: Si NPN 2N3904
Change A3Q4 to 1855-0068, TSTR: Field Effect
Change A3Q6 to 1855-0036, TSTR: Dual

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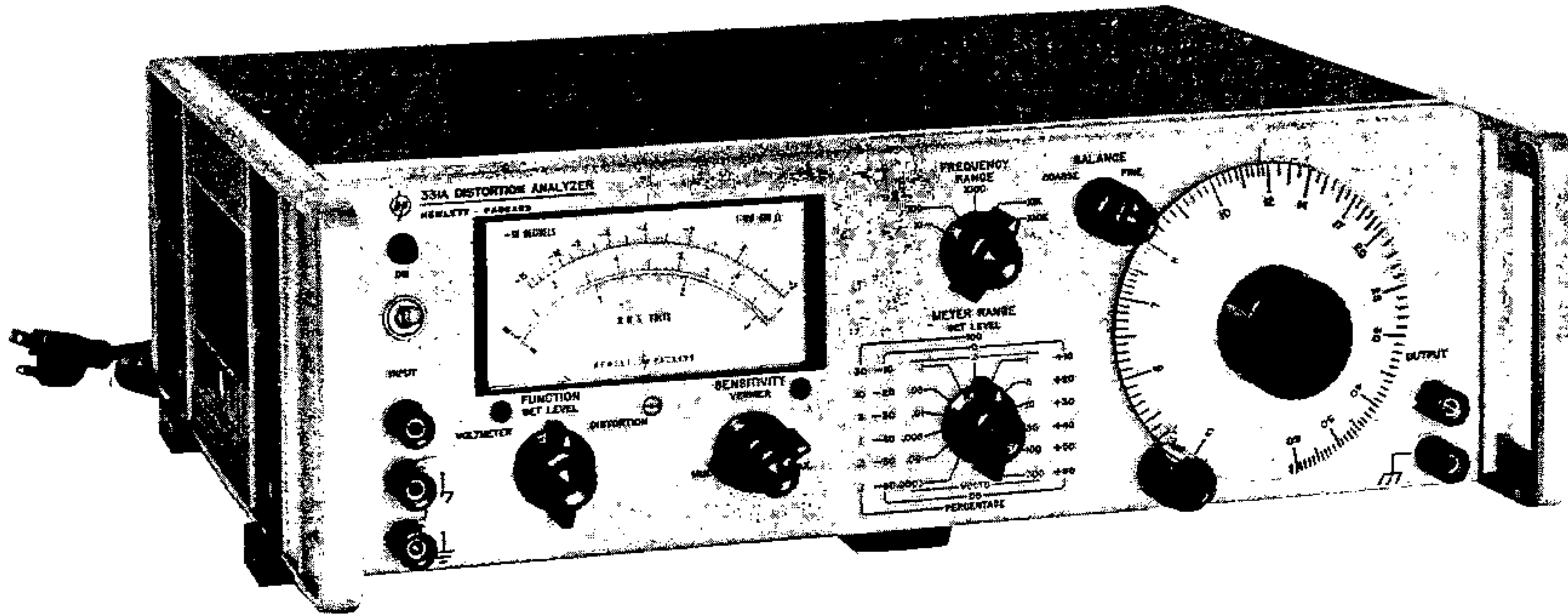


Figure 1-1. Model 331A Distortion Analyzer

Table 1-1. Specifications

| MODEL 331A | | | |
|--|---------------|---------------|-------------|
| <p>DISTORTION MEASUREMENT RANGE: Any fundamental frequency, 5 cps to 600 Kc. Distortion levels of 0.1%-100% are measured full scale in 7 ranges.</p> | | | |
| <p>DISTORTION MEASUREMENT ACCURACY: Harmonic frequency measurement accuracy:</p> | | | |
| <p>Fundamental Input Less Than 30 v</p> | | | |
| RANGE | ±3% | ±6% | ±12% |
| 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 |
| <p>Fundamental Input Greater than 30 v</p> | | | |
| RANGE | ±3% | ±6% | ±12% |
| 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 |
| <p>Elimination Characteristics:</p> <p>Fundamental Rejection > 80 db</p> <p>Second Harmonic Accuracy for a fundamental of:</p> <p>5 to 20 cps: better than +1 db</p> <p>20 cps to 20 Kc : better than ±0.6 db</p> <p>20 Kc to 100 Kc : better than -1 db</p> <p>100 Kc to 300 Kc : better than -2 db</p> <p>300 Kc to 600 Kc : better than -3 db</p> | | | |
| <p>Distortion Introduced by Instrument:</p> <p><0.03% from 5 cps to 200 Kc</p> <p><0.06% from 200 Kc to 600 Kc</p> | | | |
| <p>Meter indication is proportional to the average value of a wave form.</p> | | | |
| <p>FREQUENCY CALIBRATION ACCURACY:</p> <p>Better than ±2% from 10 cps to 200 Kc</p> <p>Better than -3% from 5 to 10 cps</p> <p>Better than +8% from 200 to 600 Kc</p> | | | |
| <p>INPUT IMPEDANCE:</p> <p>Distortion Mode: 1 megohm shunted by less than 60 pf (10 megohms shunted by 10 pf with 10001A divider probe).</p> <p>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.</p> | | | |
| <p>INPUT LEVEL FOR DISTORTION MEASUREMENTS:</p> <p>0.3 v rms for 100% set level (up to 300 v may be attenuated to set level reference).</p> | | | |
| <p>DC ISOLATION: Signal ground may be ±400 vdc from external chassis.</p> | | | |
| <p>VOLTMETER RANGE: 300 μv to 300 v rms full scale (13 ranges) 10 db per range.</p> | | | |
| <p>VOLTMETER FREQUENCY RANGE: 5 cps to 3 Mc (300 μv range: 20 cps-500 Kc).</p> | | | |
| <p>VOLTMETER ACCURACY:</p> | | | |
| RANGE | ±2% | ±5% | |
| 300 μv | 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 | |
| <p>NOISE MEASUREMENTS: 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.</p> | | | |
| <p>OUTPUT: Approximately 0.1 v rms output for full scale meter deflection.</p> <p>Output Impedance: 2 K</p> | | | |

Table 1-1. Specifications (Cont'd)

| | |
|--|--|
| <p>POWER SUPPLY: 115 or 230 $\pm 10\%$, 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 40 ma.</p> <p>WEIGHT: Net 17-3/4 lbs. (7, 98 kg), Shipping 23 lbs. (10, 35 kg.)</p> <p style="text-align: center;">MODEL 332A</p> <p>Same as Model 331A except as indicated below:</p> <p>AM DETECTOR: High impedance dc restoring peak detector with semi-conductor diode operates from 500 Kc to greater than 65 Mc. Broadband input. Maximum input; 40 v p-p ac or 40 v peak transient.</p> | <p>CARRIER FREQUENCY: 550 Kc to 1.6 Mc: Distortion introduced by detector is $< 0.3\%$ for 3 to 8 volt carriers modulated 30%.</p> <p>CARRIER FREQUENCY: 1.6 Mc to 65 Mc: Distortion introduced by detector is $< 1\%$ for 3 to 8 volt rms carriers modulated 30%.</p> <p style="text-align: center;">NOTE</p> <p>Distortion measurement at carrier levels as low as 1 volt may be made with reduced accuracy.</p> <p>OPTION: 01 Indicating meter has VU characteristics conforming to FCC Requirements for AM, FM, and TV broadcasting.</p> |
|--|--|

SECTION I

GENERAL INFORMATION

1-1 DESCRIPTION.

1-2. The Hewlett-Packard Models 331A and 332A Distortion Analyzers are solid state instruments for measuring distortion and ac voltages. The Model 332A includes a high impedance AM detector which operates from 500 Kc to greater than 65 Mc.

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 3 Mc. The high sensitivity of these instruments requires only 0.3 v rms for the 100% set level reference. A low distortion output is provided at the OUTPUT connectors for monitoring 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 transistorized voltmeter contained in the Model 331A and 332A can be used separately for general purpose voltage and gain measurements. The voltmeter has a frequency range of 5 cps to 3 Mc (20 cps to 500 Kc for 300 μ v range) and a voltage range of 300 μ v to 300 v rms full scale.

1-5. The AM detector included in the Model 332A 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 331A and 332A Distortion Analyzers is a voltage divider probe, -hp-Model No. 10001A. The features of the probe are:

- a. 10 megohm shunted by 10 pf.
- b. 10:1 attenuation dc to 30 Mc bandwidth.
- c. 2% division accuracy.
- d. 600 V peak input.
- e. 5 nsec rise-time.

1-8. OPTION.

1-9. Option 01 is a standard @Model 331A or 332A with a special meter and meter amplifier, compensated to permit response to VU (volume units) characteristics.

1-10. INSTRUMENT IDENTIFICATION.

1-11. Hewlett-Packard uses a two-section eight-digit serial number (000-00000). If the first three digits of the serial number on your instrument do not agree with those on the title page of this manual, change sheets supplied with the manual will define differences between your instrument and the 331A and 332A described in this manual.

1-12. If an E or G prefixes the serial number, the instrument was manufactured in Europe (E for England, G for Germany).

SECTION II INSTALLATION

2-1. INSPECTION.

2-2. 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 Section V. If there is damage or deficiency, see the warranty on the inside front cover of this manual.

2-3. POWER REQUIREMENTS.

2-4. The Model 331A and 332A will operate from either 115 or 230 vac, 50 - 1000 cps. The instruments can be easily converted from 115 to 230 volt operation by changing the position of the slide switch, located on rear panel, so that the designation appearing on the switch matches the nominal voltage of the power source. A 1/16 ampere, slow-blow fuse is used for 115-volt operation; a 1/32 ampere slow-blow fuse is used for 230-volt operation. The instruments can be battery operated by connecting two 28 - 50 v batteries (rated at 40 milliamperes) to the battery terminals on the rear panel.

2-5. THREE-CONDUCTOR POWER CABLE.

2-6. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the instrument panel and cabinet be grounded. This instrument is 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.

2-7. To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong adapter and connect the green pigtail on the adapter to ground.

2-8. INSTALLATION.

2-9. The 331A and 332A are fully transistorized; therefore, no special cooling is required. However, the instruments should not be operated where the ambient temperature exceeds 55°C (131°F).

2-10. RACK/BENCH INSTALLATION.

2-11. The 331A and 332A are initially shipped as bench-type instruments (unless ordered specifically as a rack-type) with plastic feet and a tilt stand in place. Conversion to a rack-mounted instrument can be accomplished by using the rack mounting kit and instructions furnished with your instrument.

2-12. REPACKAGING FOR SHIPMENT.

2-13. The following is a general guide for repackaging for shipment. If you have any questions, contact your local \odot Sales and Service Office.

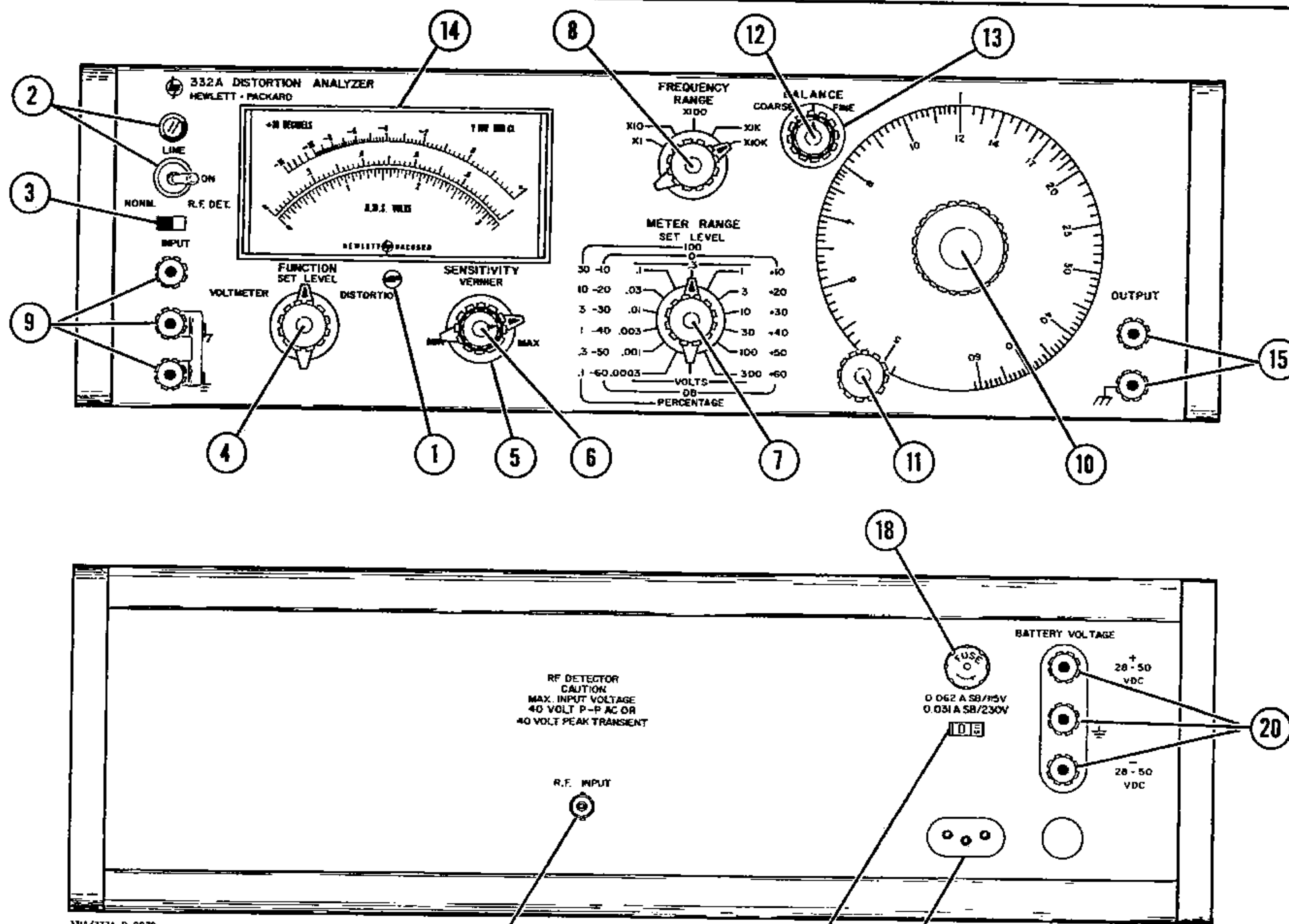
NOTE

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

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

If original container is not used,

- b. Wrap instrument in heavy paper or plastic before placing in an inner container.
- c. Use plenty of packing material around all sides of instrument and protect panel faces with cardboard strips.
- d. Place instrument and inner container in a heavy carton or wooden box and seal with strong tape or metal bands.
- e. Mark shipping container with "Delicate Instrument", "Fragile" etc.



- ① MECHANICAL ZERO ADJUST mechanically zero-sets meter prior to turning instrument on.
- ② ON switch turns instrument ac power on. Pilot lamp glows when instrument is turned ON.
- ③ NORM-RF DET switch (Model 332A only) selects front panel INPUT connectors or rear panel RF INPUT connector.
- ④ FUNCTION selector selects mode of operation of the instrument.
- ⑤ SENSITIVITY selector provides 0 to 50 db attenuation of input signal in 10 db steps in SET LEVEL and DISTORTION positions of FUNCTION selector.
- ⑥ SENSITIVITY VERNIER control provides fine adjustment of attenuation level selected by SENSITIVITY selector.
- ⑦ METER RANGE selector selects full scale range of meter in percentage, db, and rms volts.
- ⑧ FREQUENCY RANGE selector selects frequency range to correspond to fundamental frequency of input signal.
- ⑨ INPUT terminals provide connections for input signals.
- ⑩ FREQUENCY dial selects fundamental frequency of input signal.
- ⑪ Frequency vernier control provides fine adjustment of FREQUENCY dial.
- ⑫ COARSE BALANCE control provides coarse adjustment for balancing the Wien bridge circuit.
- ⑬ FINE BALANCE control provides a vernier adjustment for balancing the Wien bridge circuit.
- ⑭ DISTORTION/VOLTMETER indicates distortion level and voltage levels of input signals.
- ⑮ OUTPUT connectors provide means of monitoring the output of the meter circuit with an oscilloscope, a true rms voltmeter, or a wave analyzer.
- ⑯ RF INPUT connector (Model 332A only) provides input connection for AM RF carrier input signal.
- ⑰ LINE VOLTAGE (115V/230V) switch sets instrument to operate from 115V or 230V ac.
- ⑱ FUSE provides protection for instrument circuits.
- ⑲ AC power connector provides input connections for ac power.
- ⑳ BATTERY VOLTAGE (+28 to +50 VDC and -28 to -50 VDC) terminals provide connections for external batteries.

Figure 3-1. Front and Rear Panel Description

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 combinations 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 331A and 332A 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).

NOTE

If 28 volt dc sources are used, the -25 volt power supply may require adjustment. Refer to Section V Power Supply Adjustment.

3-18. DISTORTION MODE.

NOTE

Accuracy of distortion measurements is affected by frequency stability of the input signal. An inaccuracy in distortion indications occurs where the frequency drift of the input signal exceeds the bandwidth of the rejection curve.

3-19. DISTORTION MEASUREMENTS IN PERCENT.

- a. Position FUNCTION selector to SET LEVEL.
- b. 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).

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

NOTE

When the input signal level is below 0.3 v, position METER RANGE selector downscale (below 0.3 v position as the 100% set level position, thus making the next range 30% etc.

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

CAUTION

REMOVE SHORTING STRAP BETWEEN POWER-LINE GROUND (\perp) AND CHASSIS GROUND (///) TERMINALS ON FRONT PANEL INPUT TERMINALS WHEN MEASURING DISTORTION BETWEEN TWO POINTS WHICH ARE BOTH ABOVE GROUND POTENTIAL.

- e. Position SENSITIVITY selector for meter indication greater than 1/3 full scale.

NOTE

Position SENSITIVITY selector with the SENSITIVITY VERNIER control turned CCW, taking as much attenuation as possible with the SENSITIVITY selector. This procedure will normally insure minimum SENSITIVITY selector setting. However, for certain input voltages, the Set Level for DB or % readings can be achieved in two positions of the SENSITIVITY selector. In this case, the minimum position of the SENSITIVITY selector will be achieved by having the VERNIER control in the most CW position.

- f. Adjust SENSITIVITY VERNIER control for full scale deflection.
- g. Position FREQUENCY RANGE selector and frequency dial to fundamental frequency of input signal.

NOTE

Select a frequency range by the FREQUENCY RANGE selector such that the frequency dial can be used on the low end of the dial. This procedure insures maximum accuracy in distortion measurements.

- h. Position FUNCTION selector to DISTORTION.
- j. Adjust METER RANGE selector and frequency dial vernier control for minimum meter indication.
- k. Adjust COARSE and FINE BALANCE controls for further reduction of meter indication.
- m. Repeat steps j and k until no further reduction in meter indication can be obtained.

SECTION III OPERATING INSTRUCTIONS

3-1. INTRODUCTION.

3-2. The Models 331A and 332A Distortion Analyzers have two modes of operation, the distortion mode and the voltmeter mode. Total harmonic distortion measurements from 5 cps to 600 Kc are possible and harmonics are indicated up to 3 Mc when the instruments are used in the distortion mode. Distortion measurement accuracy is determined by the overall effect of harmonic frequency measurement accuracy, elimination characteristics, distortion introduced by the instrument, and meter accuracy (refer to Table 1-1, Specifications). In the voltmeter mode, the transistorized voltmeter provides a full scale sensitivity of 300 μ v rms (residual noise < 25 μ v). The voltmeter frequency range is 5 cps to 3 Mc (20 cps to 500 Kc on the 300 μ v range).

3-3. The distortion measurement accuracy of the 331A and 332A is a result of the sharp elimination characteristic of the rejection amplifier circuit and the low level of distortion introduced by the instrument. The fundamental rejection is at least 80 db, which is small compared to the distortion introduced by the instrument; thus, low level harmonic content in the input signal can be measured accurately. The 331A and 332A can be used in conjunction with a wave analyzer for extremely sensitive (> 80 db down in the audio frequency range) measurements of odd harmonics.

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. ADJUSTMENT OF MECHANICAL ZERO.

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

3-8. GENERAL OPERATING INFORMATION.

3-9. INPUT CONNECTIONS.

3-10. A signal source can be connected to the 331A and 332A 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, avoid ground loop currents 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 331A and 332A have a dc isolation of ± 400 vdc from the external chassis.

3-11. VOLTMETER CHARACTERISTICS.

3-12. 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 harmonics. 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 Characteristics | True RMS Value | Meter Indication |
|----------------------------------|----------------|------------------|
| Fundamental = 100 | 100 | 100 |
| Fundamental +10% 2nd harmonic | 100.5 | 100 |
| Fundamental +20% 2nd harmonic | 102 | 100 - 102 |
| Fundamental +50% 2nd harmonic | 112 | 100 - 110 |
| Fundamental +10% 3rd harmonic | 100.5 | 96 - 104 |
| Fundamental +20% 3rd harmonic | 102 | 94 - 108 |
| Fundamental +50% 3rd harmonic | 112 | 90 - 116 |

NOTE

This chart is universal in application since these errors are inherent in all average-responding 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% | $+0.11 \times 0.025 =$ 0.00027 | $0.025 + 0.0027 =$ 0.0277 or 2.8% |

NOTE

Because of the high sensitivity and narrow rejection notch, pressure applied to the top cover may cause the null to shift. This shift is caused by small capacitive changes between the bridge and case. However, accuracy of reading is not degraded if pressure is constant and the bridge is rebalanced.

- n. 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 MEASUREMENTS IN DB.

- Perform steps a through e of the preceding paragraph (Distortion Measurements in Percent).
- Adjust SENSITIVITY VERNIER control for 0 db meter indication.
- Perform steps g through m in preceding paragraph.
- 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.

3-21. DISTORTION MEASUREMENTS OF AM RF CARRIERS. (Model 332A Only)

- Set NORM-RF DET selector to RF DET.
- Connect AM RF carrier signal to RF INPUT connector on rear panel of instrument.
- Perform steps a through c and e through n of Distortion Measurements in Percent paragraph.
- Refer to preceding paragraph for distortion in db.

3-22. 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 .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 for DBM measurements, the readings will be 10 DBM high.

3-23. The 331A and 332A become general purpose voltmeters when the FUNCTION selector is set to VOLTMETER position.

NOTE

The SENSITIVITY selector is disabled when the FUNCTION selector is placed in VOLTMETER position.

Perform the following steps when making voltage measurements:

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

3-24. OUTPUT TERMINALS.

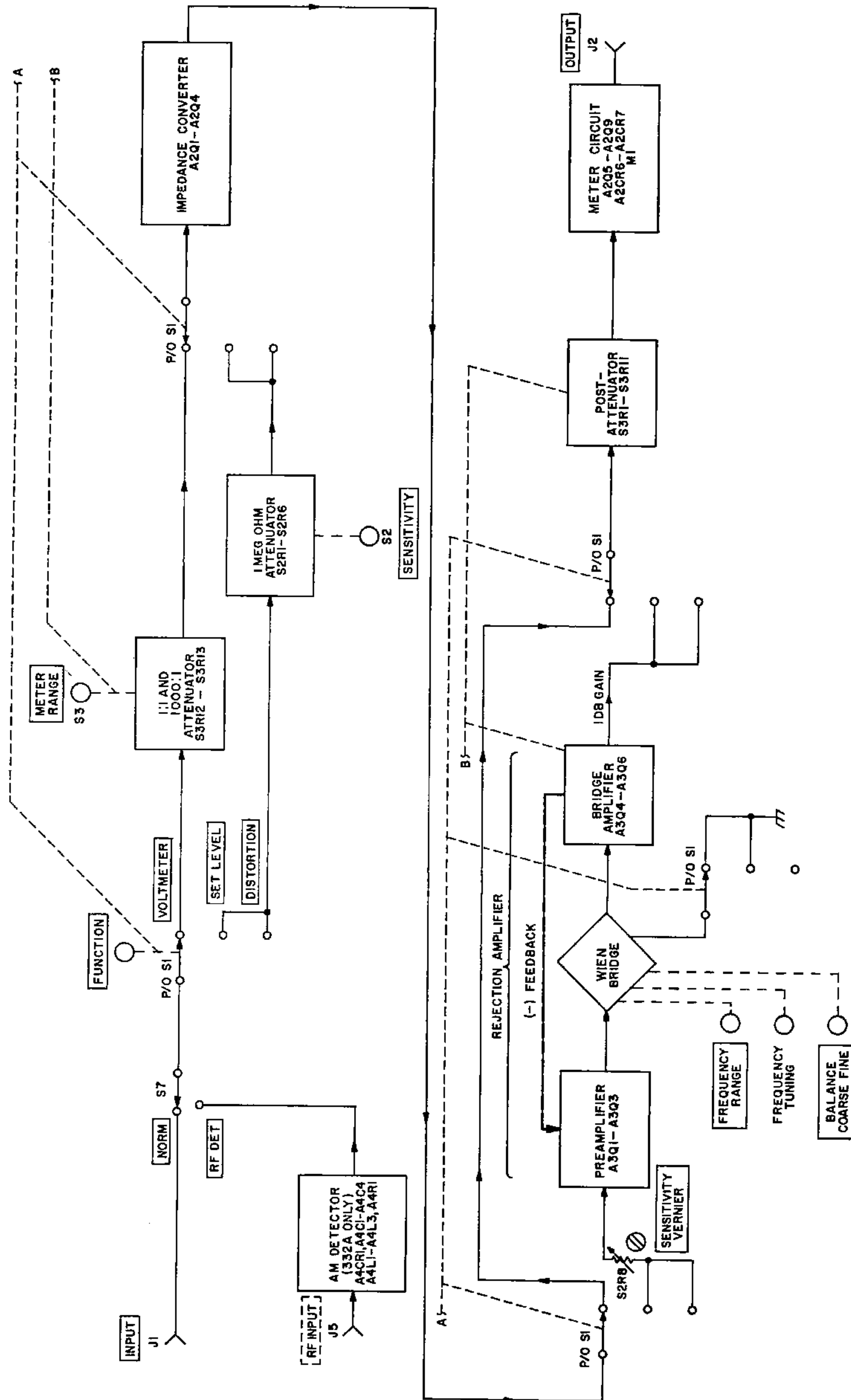
3-25. In VOLTMETER or SET LEVEL position of the FUNCTION selector, the 333A/334A can be used as a low distortion, high gain, wideband preamplifier. A portion of the meter input (0.1 V RMS output for full scale meter deflection) is provided at the OUTPUT terminal J2. In the DISTORTION position, the distortion is provided for monitoring purposes.

CAUTION

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

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



331A-C-0043

Figure 4-1. Model 331A and 332A Block Diagram

SECTION IV

THEORY OF OPERATION

4-1. OVERALL DESCRIPTION.

4-2. Models 331A and 332A Distortion Analyzer include an impedance converter circuit, a rejection amplifier, a metering circuit, and a power supply circuit. In addition to these four circuits, the Model 332A contains an AM detector circuit. A block diagram of the instrument is shown in Figure 4-1. The impedance converter provides a low noise input circuit with a high source impedance independent of signal 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 M1. The AM detector circuit (Model 332A 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 MODE.

4-5. In the distortion measuring mode of operation, the input signal is applied to the impedance converter circuit, Assembly A2, through the FUNCTION selector S1 and a one megohm attenuator. The attenuator is a voltage divider network which provides 50 db attenuation in 10 db steps. The desired level of attenuation is selected by the SENSITIVITY selector S2. The impedance converter circuit provides an impedance conversion and unity gain between the instrument input terminals and the input of the rejection amplifier circuit, Assembly A3. The rejection amplifier consists of a preamplifier, a Wien bridge, and a bridge amplifier circuit. The SENSITIVITY VERNIER control, at the input of the preamplifier circuit, provides a set level signal to obtain full scale readings on meter M1 for any voltage level at input of the instrument. With the FUNCTION selector in the SET LEVEL position, a ground is applied to the Wien bridge circuit to allow a signal reference level to be set up on the meter M1 in the metering circuit. With the FUNCTION selector in the DISTORTION position, the Wien bridge is used as an interstage coupling network between the preamplifier and bridge amplifier circuits. The Wien bridge is tuned and balanced to reject the fundamental frequency of the applied input signal. The remaining frequency components are passed on to the bridge amplifier circuit 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 circuit. The output of the rejection amplifier (1 db gain) 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 μ v for full scale deflection on the 300 μ v range. The metering circuit provides a visual indication of the distortion level in the input signal. In addition to the visual indication provided by the meter M1, the OUTPUT terminals provide a means of monitoring the distortion with an oscilloscope, a true rms voltmeter, or a wave analyzer.

4-6. DISTORTION MEASUREMENT IN AM CARRIERS.

4-7. The Model 332A 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. The signal then goes through the same circuits previously described in the Distortion Measuring Mode.

4-8. VOLTMETER MODE.

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 and METER RANGE selector. In the voltmeter mode, metering circuit sensitivity is increased from 1 mv for full scale deflection to 300 μ v on the 300 μ v range, the same as it was in the distortion mode of operation. The function of the post-attenuator and metering circuit is the same for the voltmeter mode as for the distortion mode.

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 6-1) 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 act in conjunction with the attenuators to 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. Distortion of the signal being measured is prevented by keeping the input impedance and the gain of the impedance converter linear. The input impedance is made linear by "boot strapping" the protection diodes A2CR2 and A2CR3 and the gate

to drain capacitance of A2Q1 with local positive feedback. By keeping the input impedance linear, signals having a high source impedance can be measured accurately and the SENSITIVITY selector S2 can be used in the high impedance positions without distorting the input signal. In addition to having a high input impedance, the impedance converter serves as a linear amplifier. The open loop gain of the circuit is increased by "boot strapping" the collector load impedances of A2Q2 and A2Q3 with local positive feedback. Overall negative feedback from the emitter circuit of A2Q4 to the source of A2Q1 results in unity gain from the impedance converter circuit and keeps the distortion generated by the circuit well within the specifications listed in Table 1-1.

4-13. The bias points of the transistors in the impedance converter circuit have been selected for optimum distortion performance. The voltage at test point TP1 is set for optimum distortion performance for each individual instrument and should not be changed from the set value unless the field effect transistor A2Q1 is replaced. The field effect transistor, used in the impedance converter circuit, provides an extremely low noise performance circuit independent of the signal source impedance and aids in producing the high impedance input to the impedance converter circuit.

4-14. REJECTION AMPLIFIER CIRCUIT.

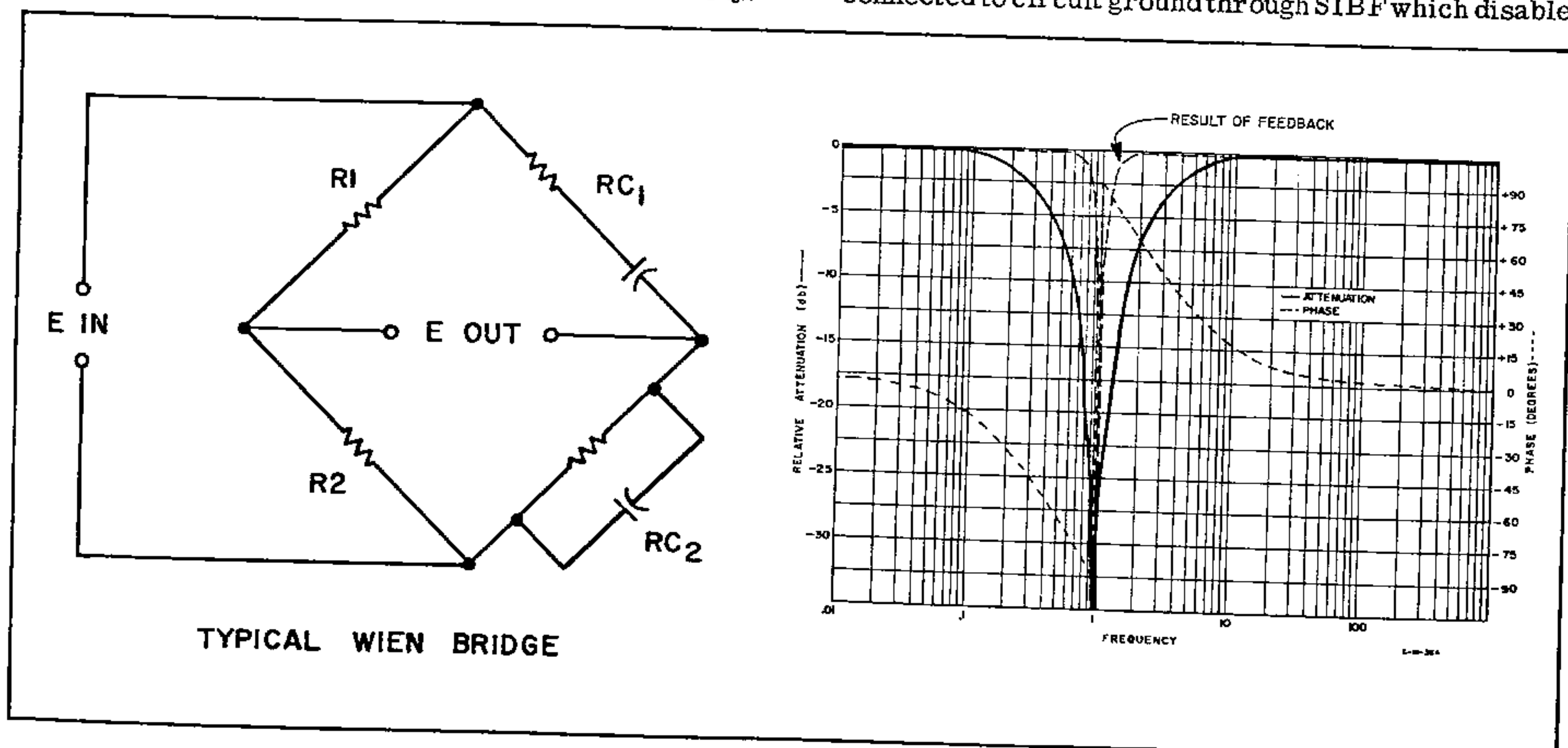
4-15. The rejection amplifier circuit (refer to Figure 6-2) consists of the preamplifier A3Q1 through A3Q3, the Wien bridge circuit, and the bridge amplifier A3Q4 through A3Q6.

4-16. PREAMPLIFIER CIRCUIT. The signal coupled from the impedance converter circuit is applied to the preamplifier circuit which is operational in the SET LEVEL and DISTORTION modes of operation. 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 whole preamplifier circuit. The preamplifier circuit, like the impedance converter circuit, is designed for high open loop gain to insure maximum distortion performance.

4-17. WIEN BRIDGE CIRCUIT. The Wien bridge circuit is used, in the distortion mode of operation, 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 varying the frequency tuning capacitors C4A through C4D after the FREQUENCY RANGE selector S4 is set for the applicable frequency range. The bridge circuit is brought into balance by adjusting the COARSE BALANCE control R4 and the FINE BALANCE control R5. When the bridge circuit is tuned and balanced, the voltage and phase of fundamental, which appears at junction of the series reactive arm (S4R1-S4R10 and C4A/B) and the shunt reactive arm (S4R11-S4R20 and C4C/D), is the same as at the midpoint of the resistive branch (A3R12 and A3R14). When these two voltages are equal and are in phase, no output signal will appear at the drain of the field effect transistor A3Q4. For frequencies other than the fundamental, the reactive branch of the Wien bridge offers various degrees of attenuation and phase shift. The difference voltage between the reactive branch and resistive branch is amplified by A3Q4. Figure 4-2 illustrates a typical Wien bridge circuit and the rejection characteristic for this circuit. The Wien bridge circuit is designed to cover a continuous frequency range of 12 to 1 to insure an overlap of the coarse tuning range. Coarse tuning ranges are selected by the FREQUENCY RANGE selector S4 which changes the bridge circuit constants in five decade steps.

4-18. When the FUNCTION selector is set to the VOLT-METER or SET LEVEL position, the junction of the series and shunt reactive arm of the Wien bridge is connected to circuit ground through 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, the harmonics, and for the residuals to establish the set level reference in the SET LEVEL mode of operation.

4-19. BRIDGE AMPLIFIER CIRCUIT. The bridge amplifier circuit consists of three stages of amplification, A3Q4 through A3Q6. The first stage of amplification A3Q4 is a field effect transistor which amplifies the difference signal between the gate and the source. The field effect transistor is selected for 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 bias potential at test point TP2 is set for maximum distortion performance for each individual instrument and should not be changed from the set value unless the field effect transistor A3Q4 is replaced. The output of A3Q6 is coupled to the meter circuit through 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 4-2) 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 amplitude and phase characteristic of Figure 4-2. Refer to Figure 4-3, Bandwidth versus Null Depth for further detail on the rejection characteristic. Figure 4-4 shows a simplified block diagram of the rejection amplifier with the typical frequency-rejection characteristic.

4-20. METER CIRCUIT.

4-21. The meter circuit (refer to Figure 6-3) consists of the post attenuator, the meter amplifier circuit, and the meter rectifier circuit.

4-22. POST ATTENUATOR. The post attenuator, S3R1 through S3R11, is a series of resistor networks which provide attenuation of input signals 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 μ V for full scale deflection on the 300 μ V 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 μ v range to extend the passband of the amplifier.

4-23. METER AMPLIFIER CIRCUIT. 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. Negative ac feedback is applied from the collector circuit of A2Q9 to the emitter circuit of A2Q5. This feedback is used to insure a flat frequency response, to im-

prove 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.

4-24. METER RECTIFIER CIRCUIT. The meter rectifier is connected in a bridge type of configuration with a diode in each upper arm and a dc milliammeter connected across the midpoints of the bridge. The simplified meter rectifier is illustrated in Figure 4-5. The generator represented by A2Q5-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 and the output signal to the OUTPUT connector. The mechanical inertia of the meter prevents the meter from responding to individual current pulses, therefore the meter pointer reading corresponds to the average value of the current pulses rather than the peak value. The meter calibration is to the rms value of a sine wave. Resistor A2R45 impresses a fixed bias across diodes A2CR6 and A2CR7 (biasing them close to the contact potential) to make the meter circuit response linear to large variations in signal amplitude. The linearity of this type of circuit is also increased by enclosing the meter circuit in the overall feedback loop.

4-25. POWER SUPPLY CIRCUIT.

4-26. The power supply circuit (refer to Figure 6-4) 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.

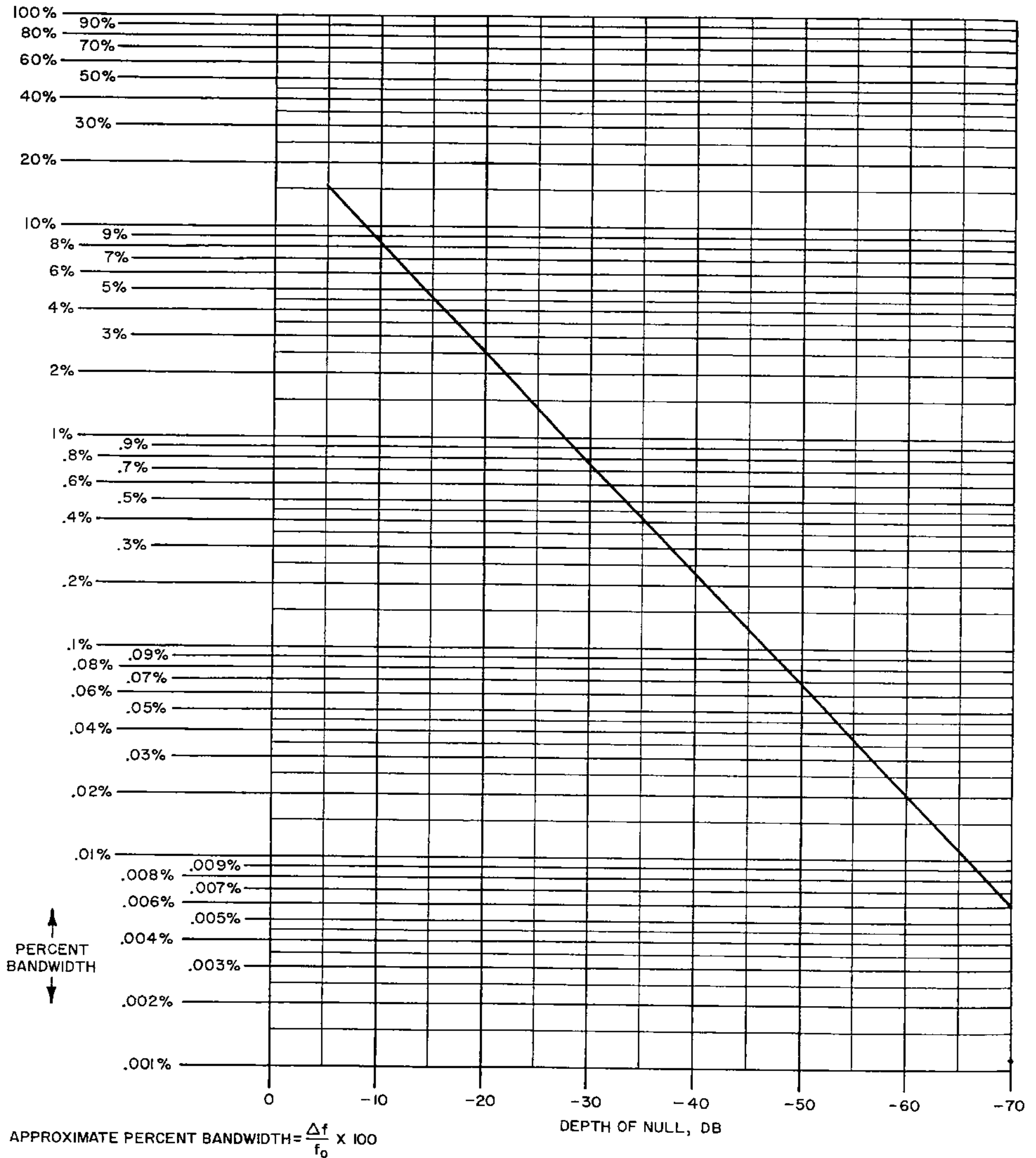
4-27. The -25 volt regulated supply is of the conventional series regulator type. The amplifier A1Q5 is used to increase the loop gain of the circuit, thus improving voltage regulation. The positive feedback applied to the junction of A1R11 and A1R12 is used to further improve the line frequency suppression of the circuit.

4-28. The +25 volt regulated supply is of the conventional series regulator type and operates the same as the -25 volt regulated supply.

4-29. 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 in the wrong direction when the ac power is being used with batteries connected to the battery terminals.

**4-30. RF DETECTOR CIRCUIT
(332A ONLY).**

4-31. The RF detector circuit consists of a rectifier A4CR1 and filter circuit shown on the schematic diagram of Figure 6-1. 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.



331A/332A-RO

Figure 4-3. Bandwidth versus Null Depth

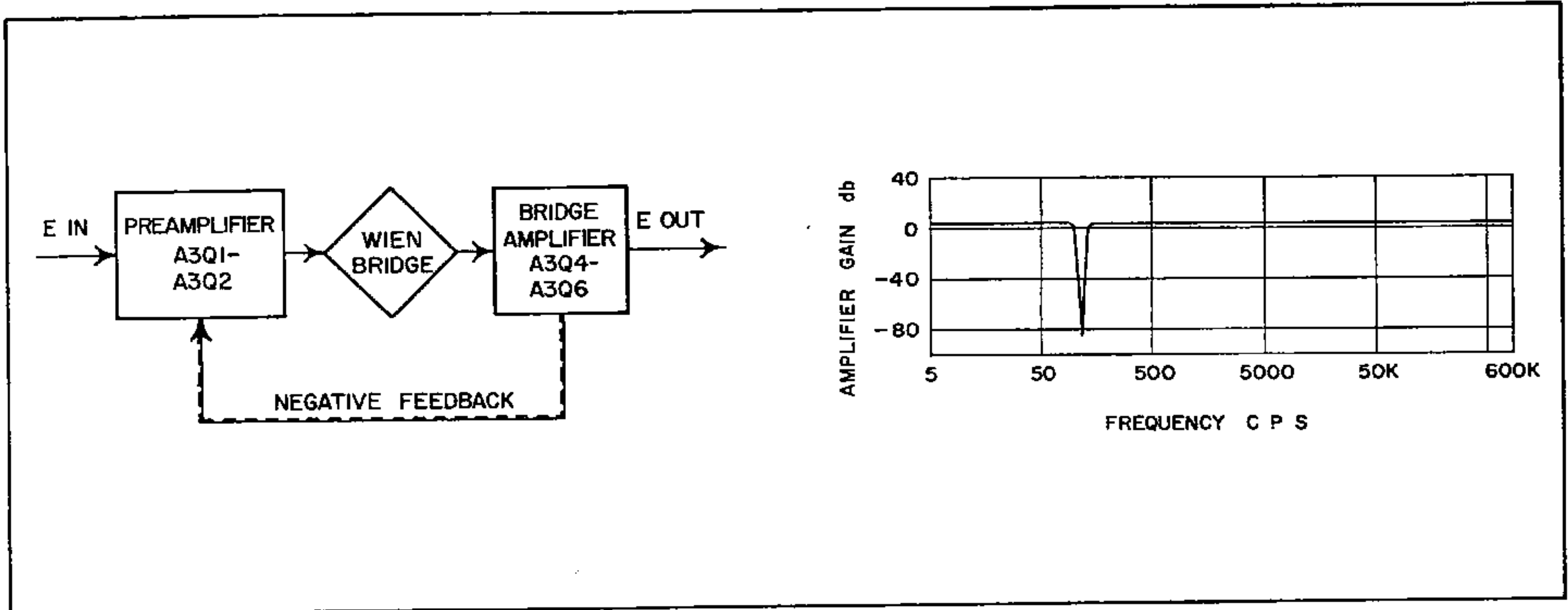


Figure 4-4. Rejection Amplifier Block Diagram and Typical Frequency Rejection Characteristic

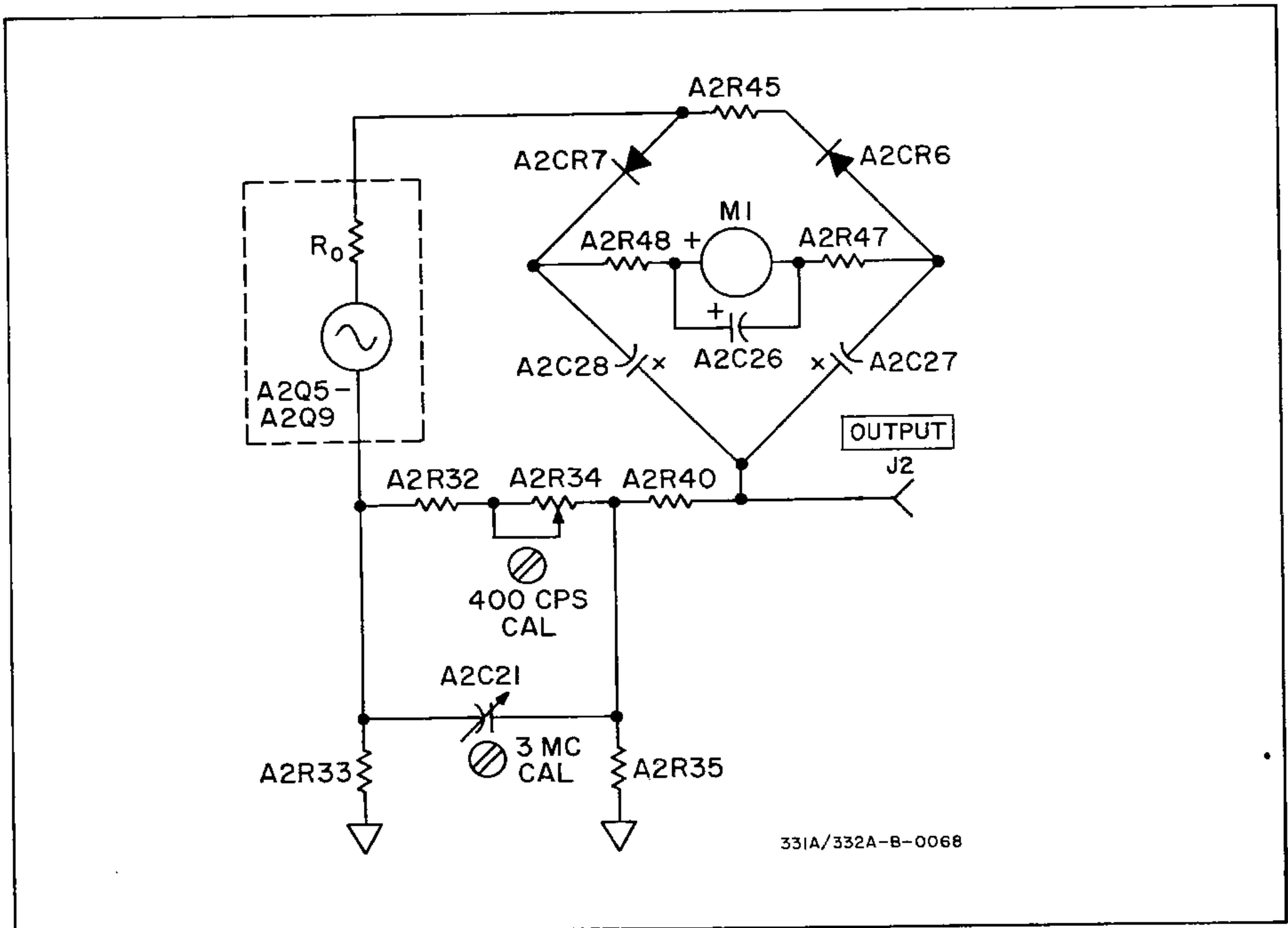


Figure 4-5. Simplified Metering Circuit

Table 5-1. Test Equipment Required

| INSTRUMENT TYPE | REQUIRED CHARACTERISTICS | USE | RECOMMENDED MODEL |
|-----------------------------|---|---|---|
| Voltmeter Calibrator | AC Voltage Range: 300 μ v to 300 v rms | Performance Checks | Ⓜ Model 738BR Voltmeter Calibrator |
| Frequency Response Test Set | Frequency Range: 5 cps to 5 Mc | Performance Checks Adjustment and Calibration Procedure | Ⓜ Model 739AR Frequency Response Test Set with Ⓜ Model 200SR Oscillator |
| Test Oscillator | Frequency Range: 10 cps to 3 Mc | Performance Checks Adjustment and Calibration Procedure | Ⓜ Model 651A Test Oscillator |
| Wave Analyzer | Frequency: 1 Kc Range: 80 db | Performance Checks | Ⓜ Model 302A Wave Analyzer |
| Electronic Counter | Functions: period, 1 sec. gate Accuracy: 0.2% | Performance Checks | Ⓜ Model 5532A Electronic Counter |
| DC Voltmeter | Voltage Range: \pm 25 vdc Accuracy: \pm 1.0% F.S. | Adjustment and Calibration Procedure | Ⓜ Model 412A DC Vacuum Tube Voltmeter |
| Function Generator | Frequency Range: 5 cps to 5 Kc Distortion: < 64 db Output System: floating ground | Performance Checks | Ⓜ Model 203A Variable Phase Function Generator |
| Filter | Filtered Outputs: 5 cps, 5 Kc, 250 Kc, 600 Kc Output Distortion: < 80 db | Performance Checks | White Instrument Lab Model 2640 Filter |
| Power Supply | Output Voltage: \pm 400 vdc | Performance Checks | Ⓜ Model 711A Power Supply |
| Signal Generator | Carrier Frequency: 1 Mc w/external modulation capability | Performance Checks (Model 332A only) | Ⓜ 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 VC1M |
| Shielded Load | Resistance: 600 ohms | Performance Checks | See Figure 5-7 |
| Shielded Load | Resistance: 100 K ohms | Performance Checks | See Figure 5-7 |
| Resistor | Resistance: 100 K ohms \pm 1.0%, fixed carbon film Wattage: 1/2 watt | Performance Checks | Ⓜ Part No. 0727-0208 |
| Resistor | Resistance: 300 ohms \pm 1.0%, fixed carbon film Wattage: 1/2 watt | Performance Checks | Ⓜ Part No. 0727-0065 |
| Resistor | Resistance: 600 ohms \pm 1.0%, fixed carbon film Wattage: 1/2 watt | Performance Checks | Ⓜ Part No. 0727-0081 |

SECTION V MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains maintenance and service information for the 331A and 332A 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 331A and 332A 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 331A and 332A are provided, and the heading of each paragraph indicates whether the procedure is applicable to one or to both instruments.

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, unless otherwise specified.

5-9. FUNDAMENTAL REJECTION CHECK (331A/332A).

- 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
- c. Set Filter (White Instrument Lab Model 2640) to 5 Kc.

- d. Set Test Oscillator (Model 651A) frequency to 5 Kc and adjust amplitude for indication of 1.0 volt on Distortion Analyzer meter.
- e. Switch Distortion Analyzer FUNCTION to SET LEVEL. Switch METER RANGE to 0.3 VOLTS. Adjust SENSITIVITY controls for full scale meter indication.
- f. Set Wave Analyzer controls (Model 302A) as follows:
 SCALE VALUE RELATIVE
 MAX INPUT VOLTAGE 1
 RANGE 0 DECIBELS
 MODE SELECTOR NORMAL
- g. Adjust Wave Analyzer FREQUENCY controls for maximum meter reading (approximately 5 Kc).
- h. Adjust Wave Analyzer REF ADJUST for 0 db meter indication. Note Range setting.

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.

- j. 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.
- k. 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

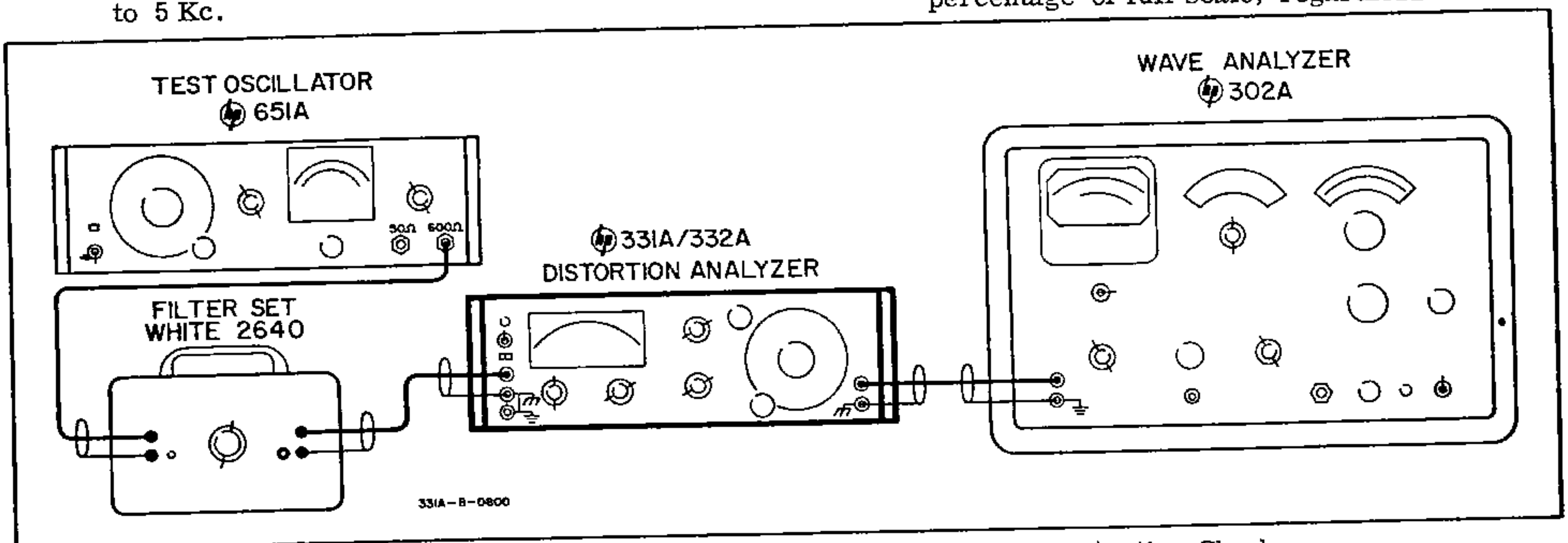


Figure 5-1. Test Setup for Fundamental Rejection Check.

- 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.
- h. Repeat steps a through g with controls set as indicated in Table 5-3. Distortion shall be down from the reference level as indicated.

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

Table 5-3. Distortion Introduced by Instrument Check

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

5-12. FREQUENCY CALIBRATION ACCURACY CHECK (331A/332A).

- a. Connect 331A/332A as shown in Figure 5-3.

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.

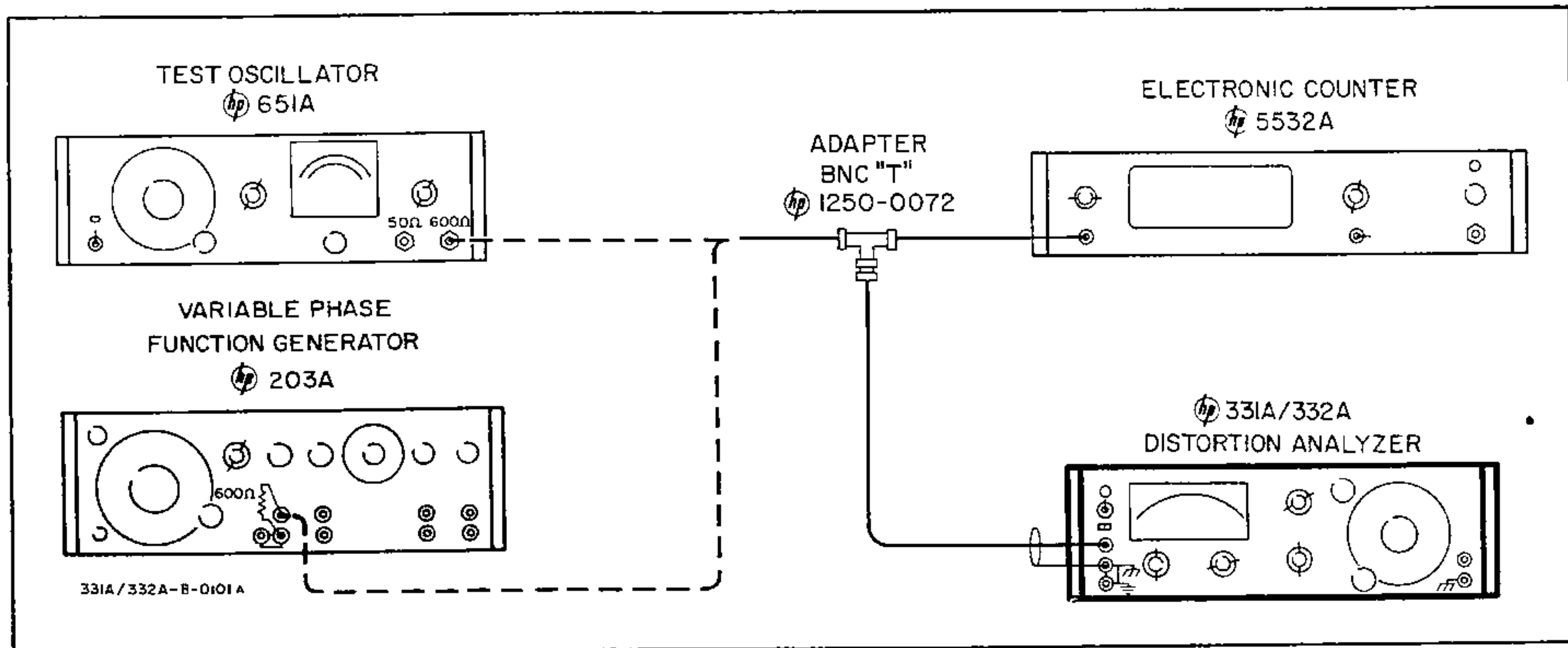


Figure 5-3. Test Setup for Frequency Calibration Accuracy Check

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 51 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 |

5-13. INPUT RESISTANCE CHECK (331A/332A).

- a. Connect Test Oscillator (Ⓢ 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 VOLTS
- c. Set Test Oscillator controls as follows:
 FREQUENCY RANGE X10
 FREQUENCY Dial 10
 OUTPUT ATTENUATOR 1.0 VOLTS
- d. Adjust Test Oscillator AMPLITUDE control for an indication of 1.0 volts (E_{in}) rms on the Distortion Analyzer meter.
- e. Connect a 100 K Ω (R_a) ±1.0%, 1/2 watt, fixed carbon film resistor in series with the Distortion Analyzer INPUT. Note the Distortion Analyzer meter reading (E_o).
- f. Calculate the Distortion Analyzer input resistance using the following formula:

$$R_{input} = \left(\frac{E_o}{E_{in} - E_o} \right) (R_a)$$

- 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 (331A/332A).

- a. Set Distortion Analyzer controls as follows:
 FUNCTION Selector VOLTMETER
 METER RANGE Selector 1 VOLTS
- b. Set L - C Meter controls (Tektronix Type 130) as follows:
 RANGE SELECTOR 30 μμF
- c. Adjust L - C Meter COARSE ZERO and FINE ZERO controls for zero meter indication.
- d. Connect 331A/332A as shown in Figure 5-4. Test leads should not be over six inches long. If longer, the leads will add capacitance, and the test will be incorrect.
- e. The L - C Meter shall indicate less than 30 μμF.
- f. Switch L - C Meter RANGE SELECTOR to 100 μμF. Repeat steps c and d with the Distortion Analyzer on the .3 VOLTS range. The L - C Meter shall indicate less than 60 μμF.
- g. Set Distortion Analyzer controls as follows:
 FUNCTION Selector DISTORTION
 SENSITIVITY Selector MIN.
 METER RANGE Selector3 VOLTS
- h. Repeat steps c and d at each SENSITIVITY selector setting. The L - C Meter shall indicate less than 60 μμF on each of these settings.

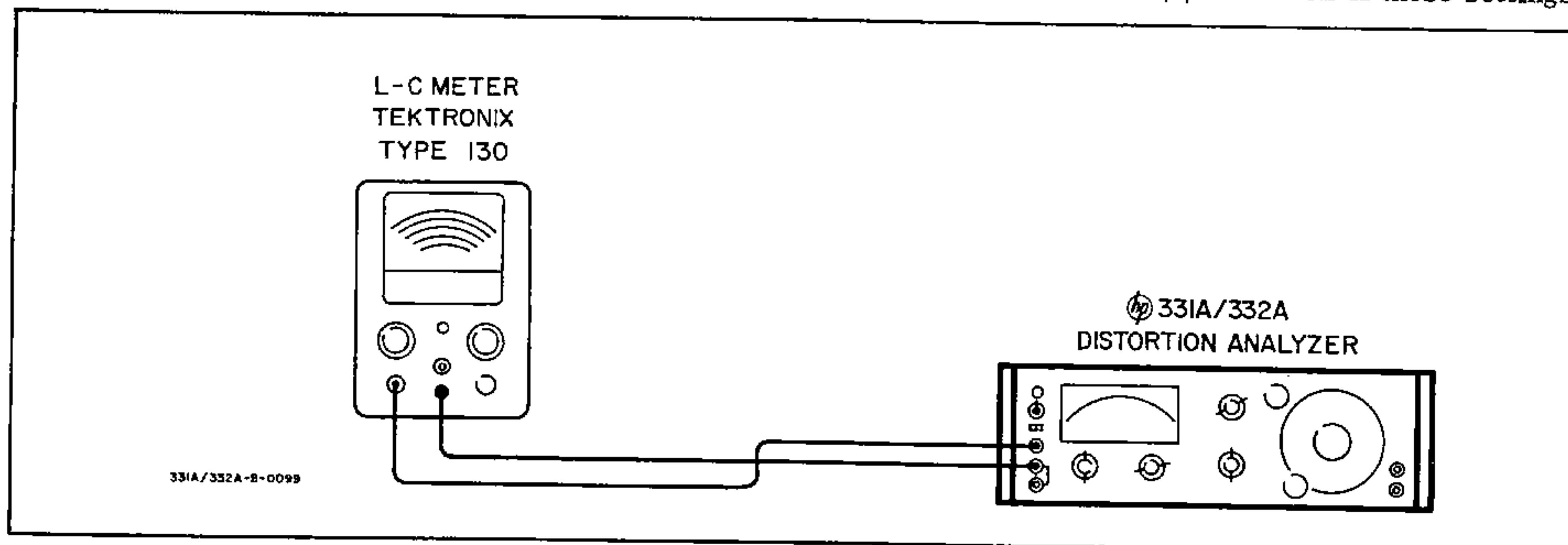


Figure 5-4. Test Setup for Input Shunt Capacitance Check

5-15. MINIMUM INPUT LEVEL CHECK (331A/332A).

- a. Connect Test Oscillator (hp Model 651A) 600 Ω output to Distortion Analyzer INPUT terminals. Terminate Test Oscillator with 600 Ω ±1.0%, 1/2 watt resistor.
- b. Set Distortion Analyzer controls as follows:
FUNCTION Selector VOLTMETER
METER RANGE Selector 0.3 VOLTS
SENSITIVITY Selector MIN.
- c. Set Test Oscillator controls as follows:
FREQUENCY RANGE X10
FREQUENCY DIAL 2
OUTPUT ATTENUATOR 1.0 VOLTS
- d. Adjust Test Oscillator AMPLITUDE control for a Distortion Analyzer meter indication of 0.3 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 (100% set level).

FUNCTION GENERATOR OUTPUT TERMINALS.

- b. Set Distortion Analyzer controls as follows:
FUNCTION Selector VOLTMETER
METER RANGE Selector 0.1 VOLTS
- c. Set Power Supply controls (hp Model 711A) as follows:
AC VOLTAGE ON
DC VOLTAGE OFF
DC VOLTS ADJ 400 VOLTS
- d. Set Function Generator controls (hp Model 203A) as follows:
FREQUENCY MULTIPLIER 100
FREQUENCY DIAL 10
- e. Adjust Function Generator REFERENCE PHASE ~AMPLITUDE control for an indication of 0.9 on the Distortion Analyzer meter.
- f. Switch the Power Supply DC VOLTAGE switch to ON. There shall be no change in the indication on the Distortion Analyzer meter.
- g. Depress the Power Supply 10 MA FULL SCALE button. There shall be no indication on the Power Supply Ammeter.

5-16. DC ISOLATION CHECK (331A/332A).

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

5-17. VOLTMETER ACCURACY CHECK (331A/332A).

- a. Connect Voltmeter Calibrator (hp Model 738B) and Variable Line Transformer (Superior Type VC1M) to Distortion Analyzer as shown in Figure 5-6. Remove shorting bar between power line ground and circuit ground terminals.

CAUTION

REMOVE SHORTING BARS BETWEEN POWER LINE GROUND AND CIRCUIT GROUND TERMINALS ON DISTORTION ANALYZER INPUT TERMINALS AND

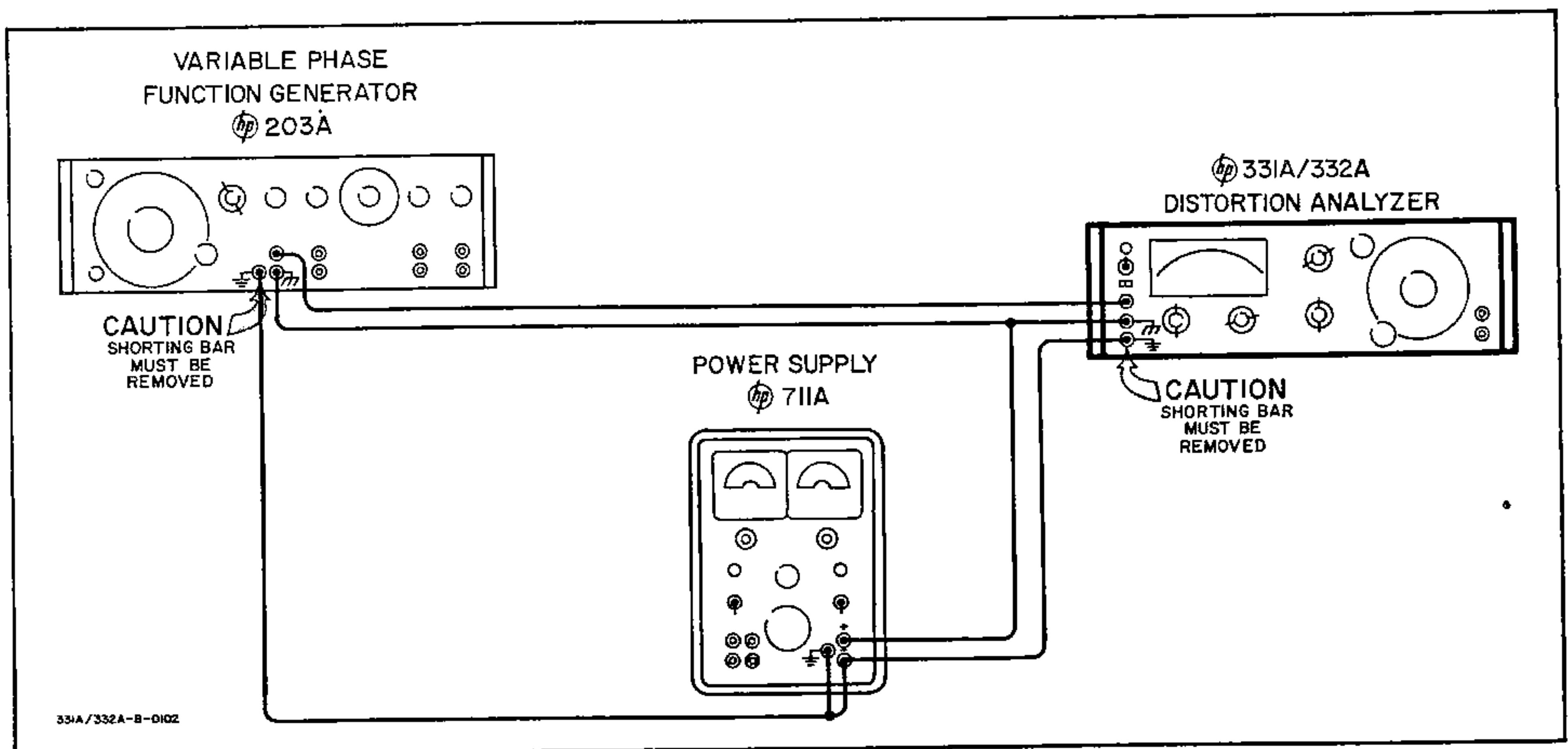


Figure 5-5. Test Setup for DC Isolation Check

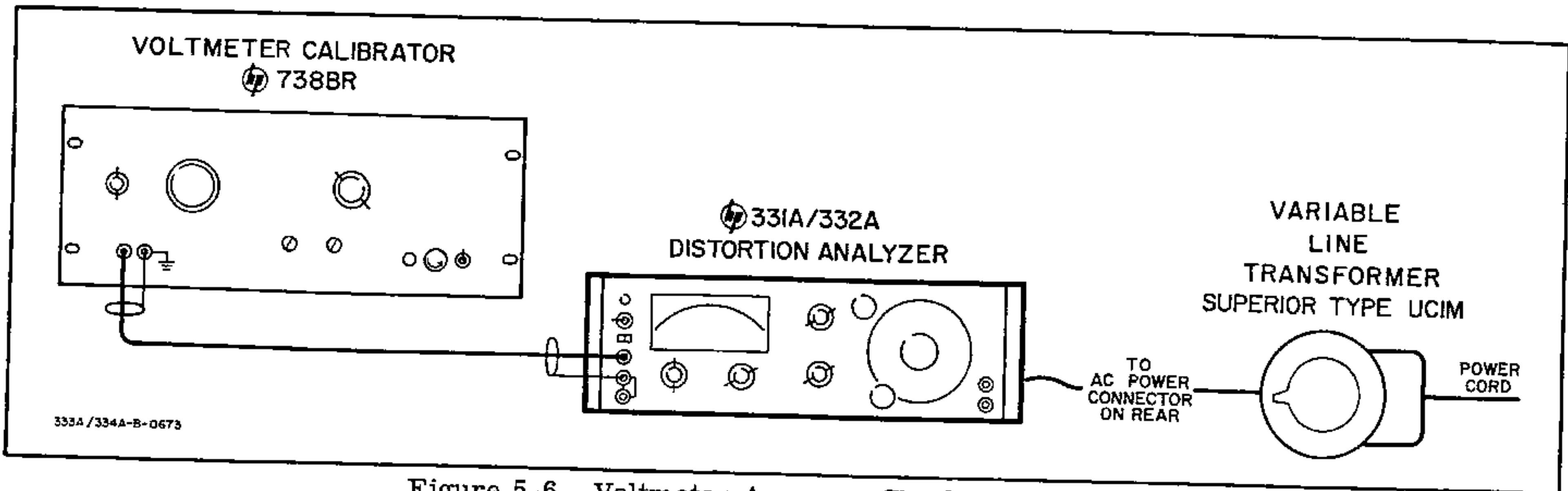


Figure 5-6. Voltmeter Accuracy Check Test Setup

- b. Set Variable Line Transformer for 115 v output.
- c. Set Distortion Analyzer controls as follows:
FUNCTION Selector. VOLTMETER
- d. Set Voltmeter Calibrator controls as follows:
OUTPUT SELECTOR. 400 ~RMS
- e. Check the Distortion Analyzer voltmeter full scale readings on all ranges against the appropriate 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 a through f while operating the Distortion Analyzer at line voltages of 105 VAC and 125 VAC.
- f. Adjust the Frequency Response Test Set METER SET control to SET LEVEL indication on the meter.
- g. Switch the Oscillator RANGE switch to X1 and set the Frequency Dial to 5.
- h. Readjust the Oscillator AMPLITUDE control until the Frequency Response Test Set meter indicates SET LEVEL.
- j. The Distortion Analyzer meter shall indicate between 0.855 and 0.945 ($\pm 5\%$).
- k. Set the Oscillator to the frequencies listed in Table 5-5. Repeat step h after each setting. The Distortion Analyzer meter shall indicate $0.9 \pm$ the tolerances indicated.

5-18. VOLTMETER FREQUENCY RESPONSE CHECK
(331A/332A).

- a. Connect 331A/332A as shown in Figure 5-7.
- b. Set Distortion Analyzer controls as follows:
FUNCTION Selector. VOLTMETER
METER RANGE Selector 0.01 VOLTS
- c. Set Frequency Response Test Set control (Model 739AR) as follows:
RANGE SELECTOR. EXTERNAL
OUTPUT ATTENUATOR 0.01
- d. Set Oscillator controls (Model 200SR) as follows:
RANGE. X10
Frequency Dial 40
- e. Adjust the Oscillator AMPLITUDE control for an indication of 0.9 on the Distortion Analyzer meter.

Table 5-5. Voltmeter Frequency Response Check

| OSCILLATOR FREQUENCY | TOLERANCE | READING |
|----------------------|-----------|-------------|
| 20 cps | $\pm 2\%$ | .88 to .92 |
| 10 Kc | $\pm 2\%$ | .88 to .92 |
| 500 Kc | $\pm 2\%$ | .88 to .92 |
| TEST SET FREQUENCY | | |
| 1 Mc | $\pm 2\%$ | .88 to .92 |
| 3 Mc | $\pm 5\%$ | .855 to .92 |

- m. 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 a through m while operating the Distortion Analyzer on line voltages of 105 VAC and 125 VAC.

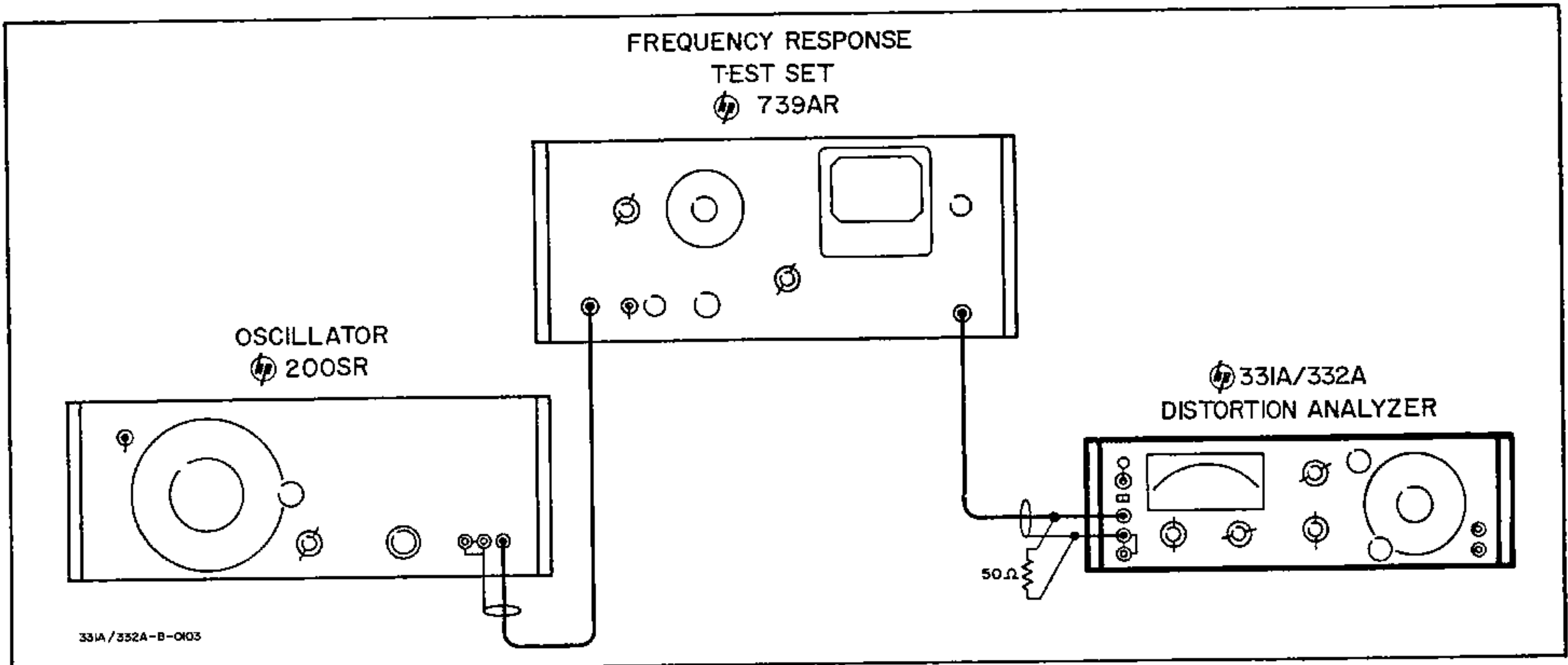


Figure 5-7. Test Setup for Voltmeter Frequency Response Check and Adjustment and Sensitivity Switch Calibration

5-19. RESIDUAL NOISE CHECK (331A/332A).

- a. Connect a shielded 600 Ω resistor across the Distortion Analyzer INPUT terminals. (See Figure 5-8 for details on constructing shielded load.) Secure the shorting bar between the power line ground and circuit ground terminals.
- b. Set Distortion Analyzer controls as follows:
FUNCTION Selector VOLTMETER
METER RANGE Selector 0003 VOLTS
- c. The meter shall indicate less than 25 μ volts.
- d. Remove the 600 Ω 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 μ volts.

- 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

- 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 Selector and VERNIER control for 0DB 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.

5-20. AM DETECTOR CHECK (Model 332A only).

- a. Connect Signal Generator (Model 606A) 50 Ω RF OUTPUT to Distortion Analyzer RF INPUT.

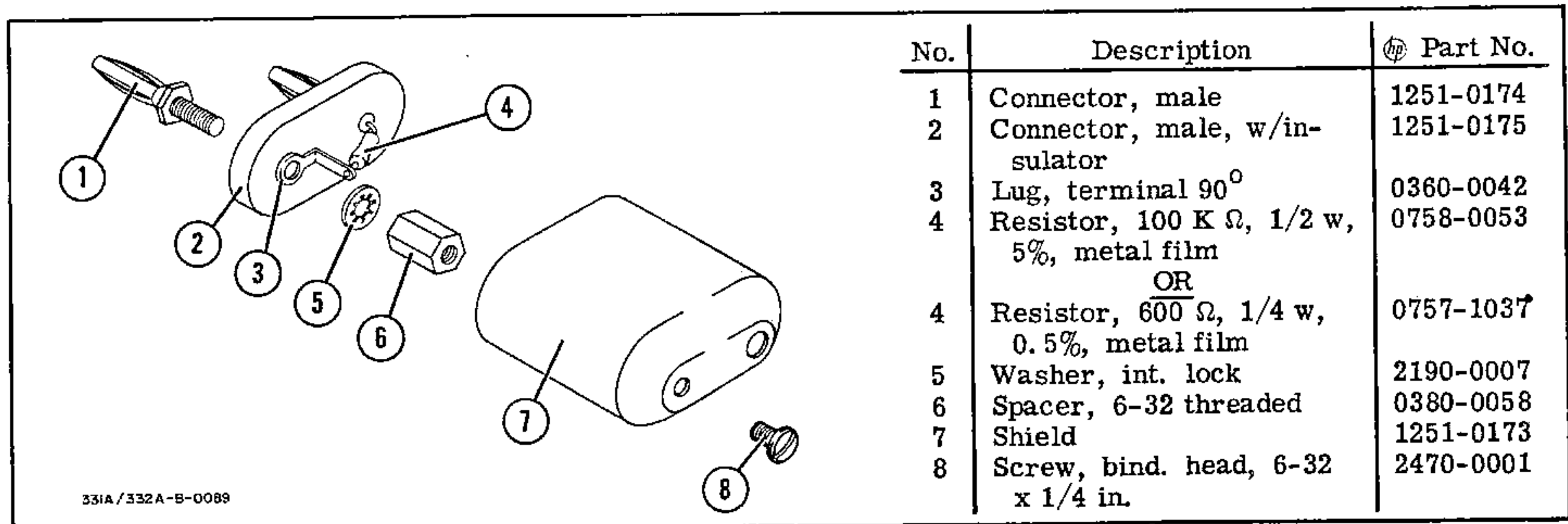


Figure 5-8. Shielded Load

5-21. ADJUSTMENT AND CALIBRATION PROCEDURE.

5-22. The following is a complete adjustment and calibration procedure for the 331A and 332A. 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 for possible cause and corrective action.

5-23. 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, unless otherwise specified.

5-24. METER MECHANICAL ZERO SET.

5-25. 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 counter-clockwise. This is enough to free the zero adjustment screw from the meter suspension. If pointer moves during this step, repeat steps a through c.

5-26. POWER SUPPLY ADJUSTMENTS.

- a. Remove top and bottom covers.
- b. Secure the shorting bar between the power line ground and circuit ground INPUT terminals.
- c. Connect common lead of VTVM ($\text{\textcircled{C}}$ Model 412A) to either INPUT ground terminals.
- d. The measurement points, adjustments, voltage limits and line regulation specifications are given in Table 5-6.

5-27. VOLTMETER GAIN ADJUSTMENTS.

- a. Connect Voltmeter Calibrator ($\text{\textcircled{C}}$ Model 738BR) to Distortion Analyzer INPUT terminals. Remove shorting bar between earth ground and floating ground terminals.
- b. Set Distortion Analyzer controls as follows:
FUNCTION Selector VOLTMETER
METER RANGE Selector 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 .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.

5-28. VOLTMETER FREQUENCY RESPONSE ADJUSTMENT.

- a. Connect instruments as shown in Figure 5-7.

NOTE

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

- b. Set Distortion Analyzer controls as follows:
FUNCTION Selector VOLTMETER
METER RANGE Selector 0003 VOLTS
- c. Set Frequency Response Test Set controls ($\text{\textcircled{C}}$ Model 739AR) as follows:
RANGE SELECTOR EXTERNAL
- d. Set Oscillator ($\text{\textcircled{C}}$ Model 200SR) frequency to 400 cps. Adjust the Oscillator AMPLITUDE control for an indication of 0.9 on the 1.0 scale.
- e. Adjust the Frequency Response Test Set METER SET control to SET LEVEL indication on the meter.
- f. Change Oscillator frequency to 20 cps.
- g. Readjust the Oscillator AMPLITUDE control until the Frequency Response Test Set meter indicates SET LEVEL.
- h. The Distortion Analyzer meter shall indicate 0.9, $\pm 5\%$.

NOTE

If reading exceeds these limits, change A2C25. Typical values for this capacitor are between 50 and 200 μf . Increasing capacitance increases the meter reading, and vice versa.

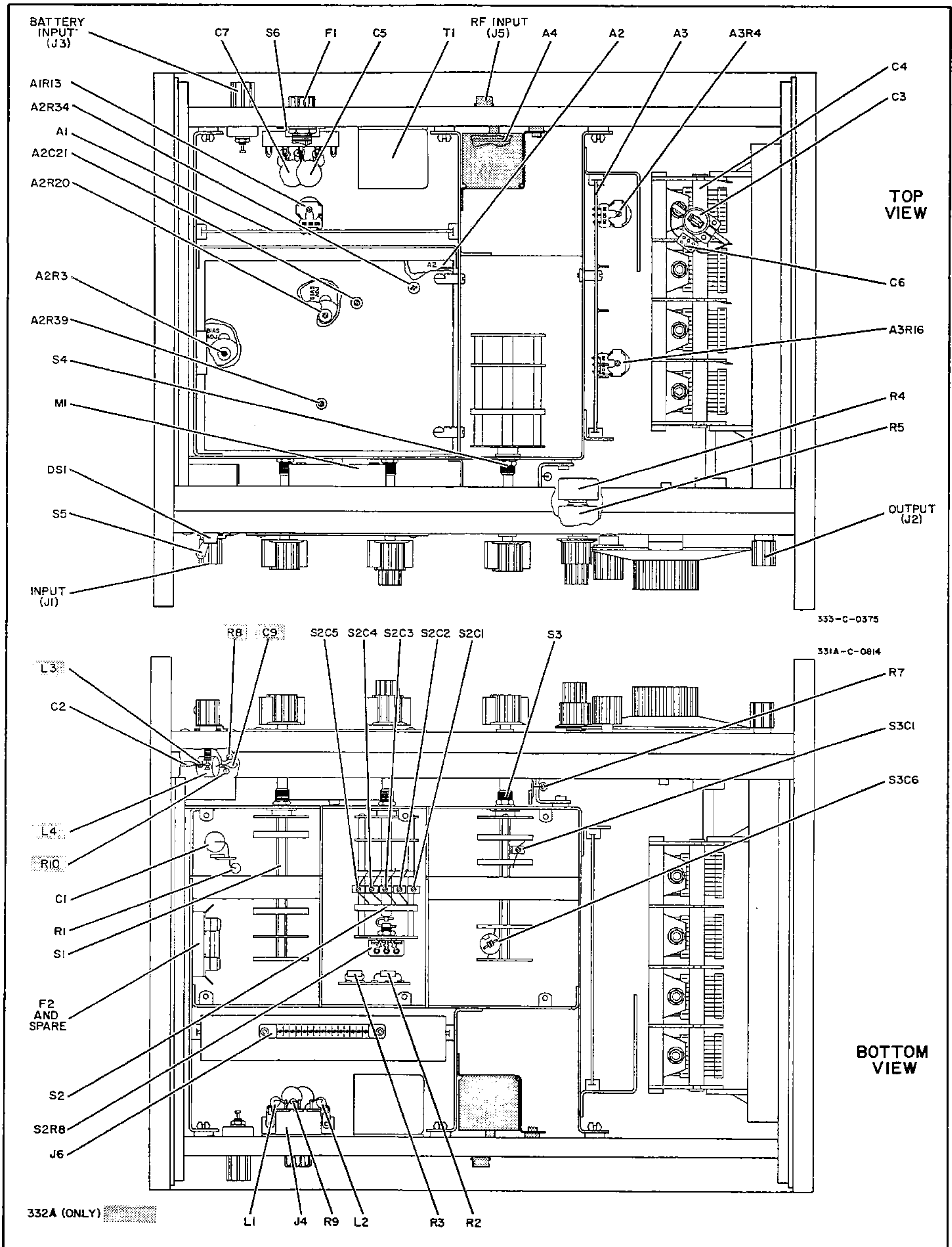


Figure 5-9. Adjustment and Chassis Component Location

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 +25 volts -11.3 volts bias +8.0 volts bias +2.8 volts bias -20.2 volts bias | Any violet wire Any red wire A2, Test Point 1 A2, Test Point 2 A3, Test Point 1 A3, Test Point 2 | A1R13 None* A2R3** A2R20 A3R4 A3R16† | -25 volts ± 0.5 volts +25 volts ± 1.0 volt -11.3 volts +8.0 volts ± 0.5 volts +2.8 volts ± 0.2 volts -20.2 volts ± 0.2 volts | -25 volts ± 0.5 volts +25 volts ± 1.0 volt ± 0.1 volt of optimum setting +8.0 volts ± 0.5 volts +2.8 volts ± 0.2 volt -20.3 volts ± 0.2 volt |
| <p>* 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.</p> | | | | |

- j. Switch Distortion Analyzer METER RANGE Selector to .001 VOLTS. Repeat steps d and e.
- k. Change Oscillator frequency to 5 cps. Repeat step g.
- m. The Distortion Analyzer meter shall indicate $0.9 \pm 5\%$.
- n. Switch Distortion Analyzer METER RANGE Selector to .01 VOLTS. Repeat steps d and e.
- p. Switch Frequency Response Test Set RANGE SELECTOR to 1 - 3 Mc range. Adjust FREQ. TUNING dial for 2 Mc output. Adjust AMPLITUDE control until meter indicates SET LEVEL.
- q. Adjust A2R39 (GAIN ADJUST) for a Distortion Analyzer meter indication of 0.9 on the 1.0 scale.
- r. Change the Frequency Response Test Set frequency to 3 Mc. Readjust the AMPLITUDE control until meter indicates SET LEVEL.
- s. 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 through s until all adjustments are within specifications.

- t. Switch Distortion Analyzer METER RANGE to .3 VOLTS. Repeat steps c through e.
- u. Repeat step p. Adjust S3C6 (VOLTAGE CAL. at 3 MC .3 V RANGE trimmer) for a Distortion Analyzer meter indication of 0.9 on the 1.0 scale.
- v. Switch Distortion Analyzer METER RANGE Selector to 3 VOLTS. Repeat steps c through e.
- w. Change Oscillator frequency to 200 Kc. Repeat step g.

- x. Adjust S3C1 (200 KC CAL) for a Distortion Analyzer indication of 0.9 on the 1.0 scale.

5-29. SENSITIVITY SWITCH CALIBRATION.

- a. Connect instruments as shown in Figure 5-7.

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 Selector01 VOLTS
- c. Set Frequency Response Test Set controls ($\text{\textcircled{p}}$ Model 739AR) as follows:
 RANGE SELECTOR. EXTERNAL
 OUTPUT ATTENUATOR03
- d. Set Oscillator ($\text{\textcircled{p}}$ 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 S2C5 for a meter indication of 0.9 on the 1.0 scale.
- h. With METER RANGE Selector on .01 volts, 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 | .03 | S2C5 |
| Position 4 | 0.1 | S2C4 |
| Position 3 | 0.3 | S2C3 |
| Position 2 | 1.0 | S2C2 |
| Position 1 | 3.0 | S2C1 |

5-30. C3 BRIDGE BALANCE ADJUST.

- a. Test equipment required for C3, Bridge Balance Adjust: Test Oscillator (Ⓢ Model 200SR).
- b. Set Distortion Analyzer controls as follows:
 FUNCTION Selector SET LEVEL
 METER RANGE Switch . SET LEVEL RANGE
 FREQUENCY RANGE Selector X1K
 SENSITIVITY Selector Position 5
- c. Connect the test oscillator to the Distortion Analyzer and set frequency to 5 Kc. Adjust the oscillator output amplitude and SENSITIVITY VERNIER to give a reading of +2 db on the Distortion Analyzer.
- d. Set the Distortion Analyzer FUNCTION Selector to DISTORTION. Adjust the frequency dial and BALANCE controls for best null. (Minimum of 40 db down from the +2 db reference.) COARSE BALANCE control should be near center of its extremes.
- e. Position METER RANGE Switch to SET LEVEL, FUNCTION Selector to SET LEVEL.
- f. Change test oscillator frequency to 60 Kc and adjust its output amplitude to give a +2 db reading on the Distortion Analyzer meter.
- g. Set the Distortion Analyzer FUNCTION Selector to DISTORTION and FREQUENCY RANGE to X10K.
- h. Without disturbing the BALANCE controls, adjust frequency dial and C3 for best null. (Minimum of 40 db down from the +2 db reference.)

5-31. TROUBLESHOOTING PROCEDURE.

5-32. 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 cannot be eliminated by the Adjustment and Calibration Procedures. An investigation should also be made to insure that the trouble is not a result of conditions external to the 331A/332A.



THE 331A/332A CONTAINS VERY HIGH IMPEDANCE, HIGH FREQUENCY CIR-

CUITS. 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 FINGERS, 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 AN 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.

5-33. Conduct a visual check of the 331A/332A for possible burned or loose components, loose connections, or any other obvious condition which might suggest a source of trouble.

5-34. 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.

5-35. 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.

5-36. 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.

5-37. BOTTOM SHIELD REMOVAL.

5-38. 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.

5-39. SERVICING ETCHED CIRCUIT BOARDS.

5-40. The Model 331A has three etched circuit boards and the Model 332A, four. Use caution when removing them to avoid damaging mounted components. The -hp- Part Number for the assembly is marked on the circuit board to identify it. Refer to Section VII for parts replacement and -hp- Part Number information.

5-41. 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.

5-42. SERVICING ROTARY SWITCHES.

5-43. The 331A/332A 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.

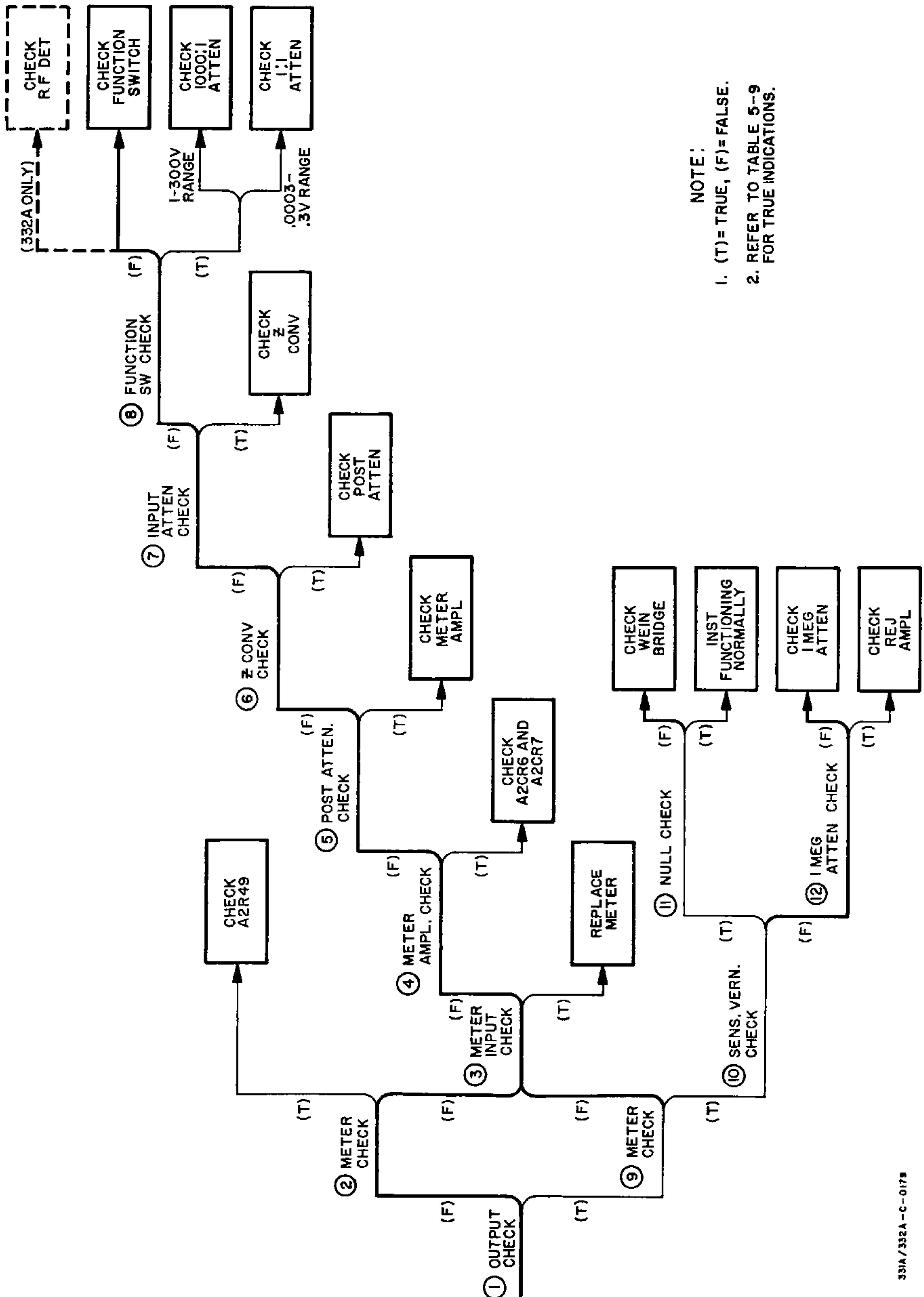
d. After cleaning the switch, apply a light coat of lubriplate to the switch detent balls. DO NOT apply lubricant to the switch contacts or allow lubricant to contaminate components.

Table 5-8. Troubleshooting Aid

| SYMPTOM | PROBABLE CAUSE |
|--|---|
| 1. FRONT PANEL SYMPTOMS | |
| A. No meter deflection with signal at input; ON lamp not illuminated. (All FUNCTION Modes.) | Check Fuse (F1). |
| B. No meter deflection with signal at input (.3 VOLT range); No output; ON lamp illuminated. (All FUNCTION Modes.) | Check Fuse (F2). |
| C. No meter deflection with signal at input; Output normal. (All FUNCTION Modes.) | Check A2CR6, A2CR7 and M1. |
| D. Meter pegs up-scale with or without input on all ranges. (All FUNCTION Modes.) | Check A2C27 and A2C28. |
| E. Will not null; VOLTMETER and SET LEVEL modes normal. (DISTORTION Mode Only.) | Check S4AF, C4A-D, C3, R4, R5. |
| F. No SENSITIVITY VERNIER control in SET LEVEL mode. VOLTMETER mode normal. (SET LEVEL Mode Only.) | Check R2, R3, S2R8 and A3Q1 through A3Q6. |
| G. BALANCE controls erratic. (DISTORTION Mode Only.) | Check R4 and R5. |
| 2. INTERNAL ADJUSTMENT SYMPTOMS | |
| A. Insufficient -25 volts adjustment with A1R13, measured at any violet wire. (Refer to Paragraph 5-26.) | Check A1C1, A1C11, A1CR3, A1CR4, A1CR7 and A1Q4 through A1Q6. |
| B. +25 volts supply out of specs, measured at any red wire. (Refer to Paragraph 5-26.) | 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. (Refer to Paragraph 5-26.) | Check -25 volts (see Symptom 2-A above), A2C4, A2C14 and A2Q1 through A2Q4. |
| D. Insufficient bias adjustment with A2R20, measured at A2TP2. (Refer to Paragraph 5-27.) | 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. (Refer to Paragraph 5-27.) | Check +8 volts bias (see Symptom 2-D above), check for -4 vdc at + Meter terminal, change A2R30 (see Paragraph 5-27), and check M1. |
| F. Insufficient gain adjustment with A2R39. (Refer to Paragraph 5-28.) | Check A2Q5 through A2Q9. |
| G. Insufficient 3 Mc calibration adjustment with A2C21. (Refer to Paragraph 5-28.) | Change A2C22. (Increasing value of C will decrease meter reading.) |
| H. Insufficient bias adjustment with A3R4, measured at A3TP1. (Refer to Paragraph 5-26.) | 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. (Refer to Paragraph 5-26.) | 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.) |

Table 5-9. Normal Troubleshooting Indications

| CHECK NUMBER | FUNCTION SELECTOR | METER RANGE | INPUT SIGNAL | NORMAL INDICATION |
|--------------|-------------------|-------------|------------------|---|
| ① | VOLTMETER | .3 VOLTS | 0.3 vrms, 1 Kc | 0.1 vrms $\pm 10\%$ at OUTPUT terminals. |
| ② | VOLTMETER | .3 VOLTS | 0.3 vrms, 1 Kc | Meter should read 0.3 vrms. |
| ③ | VOLTMETER | .3 VOLTS | No Input | Approx. -4 vdc at + Meter terminal. |
| ④ | VOLTMETER | .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 .0003 Volt. Approx. 0.3 mvrms for F. S. on .0003 Volt range. |
| ⑥ | VOLTMETER | .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 .0003 to .3 Volt ranges; approx. 1/1000 of input signal on 1 to 300 volt ranges; measured at A2R1 |
| ⑧ | Vary | .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 | .3 VOLTS | 0.3 vrms, 1 Kc | Meter should read 0.3 vrms. |
| ⑩ | SET LEVEL | .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 and BALANCE controls should give "null" indication as outlined in Paragraph 3-18. |
| ⑫ | SET LEVEL | .3 VOLTS | 0.3 vrms, 1 Kc | SENSITIVITY switch should attenuate input in > 10 db steps, measured at A2R1. |



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

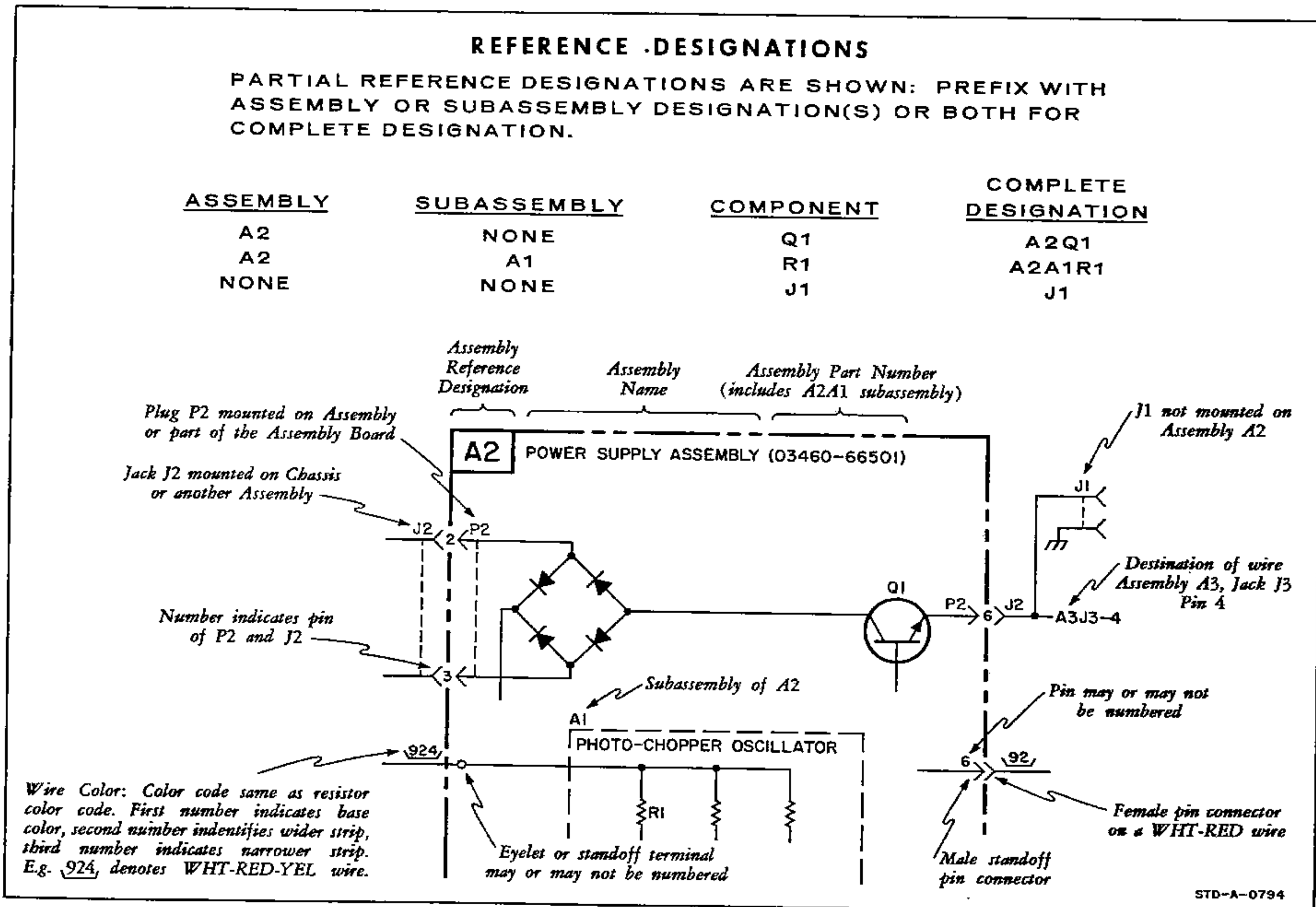
Figure 5-10. Troubleshooting Logic

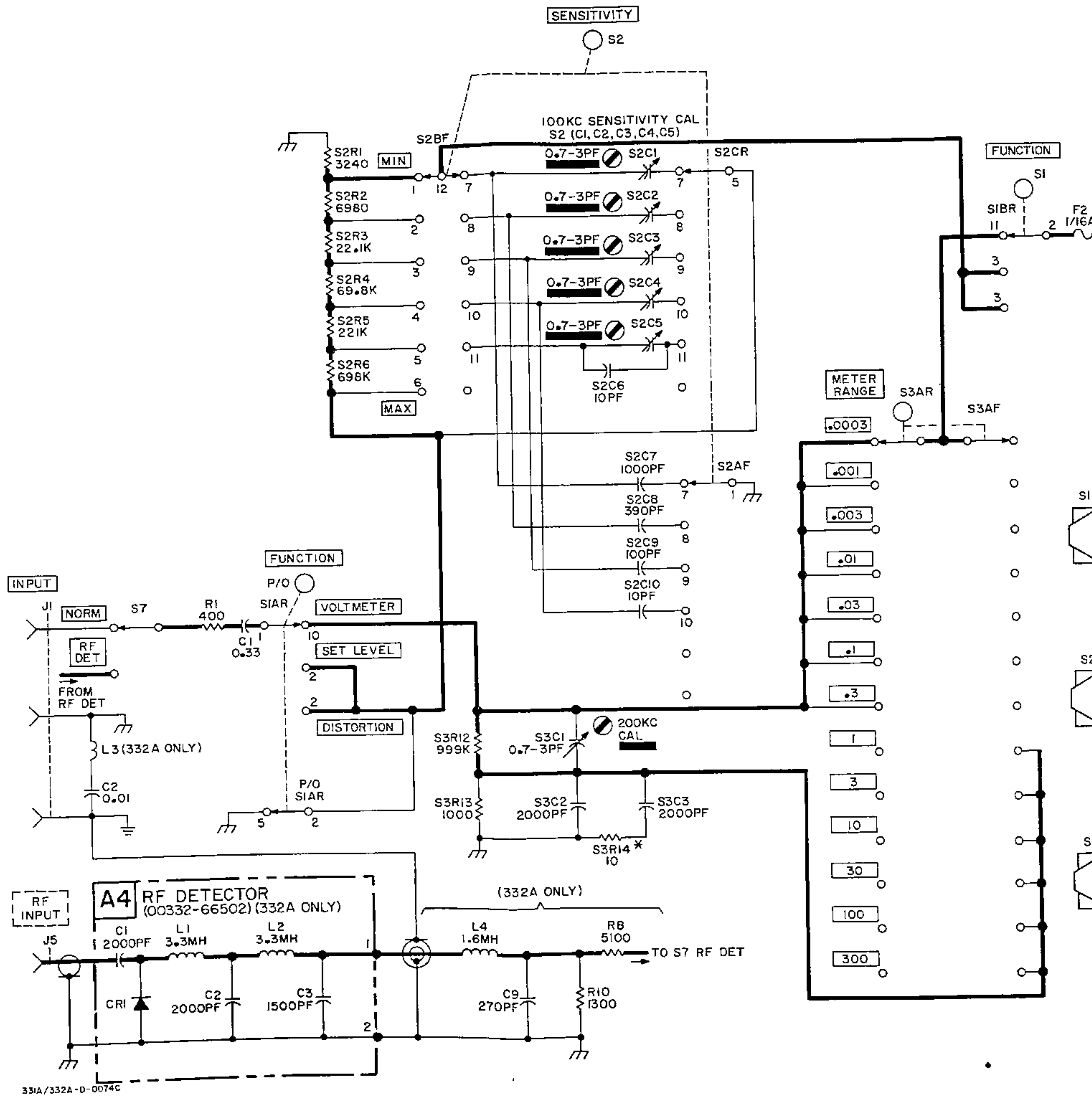
SECTION VI SCHEMATIC DIAGRAMS

6-1. SCHEMATIC DIAGRAMS.

This section contains the schematic diagrams necessary for operation and maintenance of the 331A and 332A Distortion Analyzers. The schematic

diagrams 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).

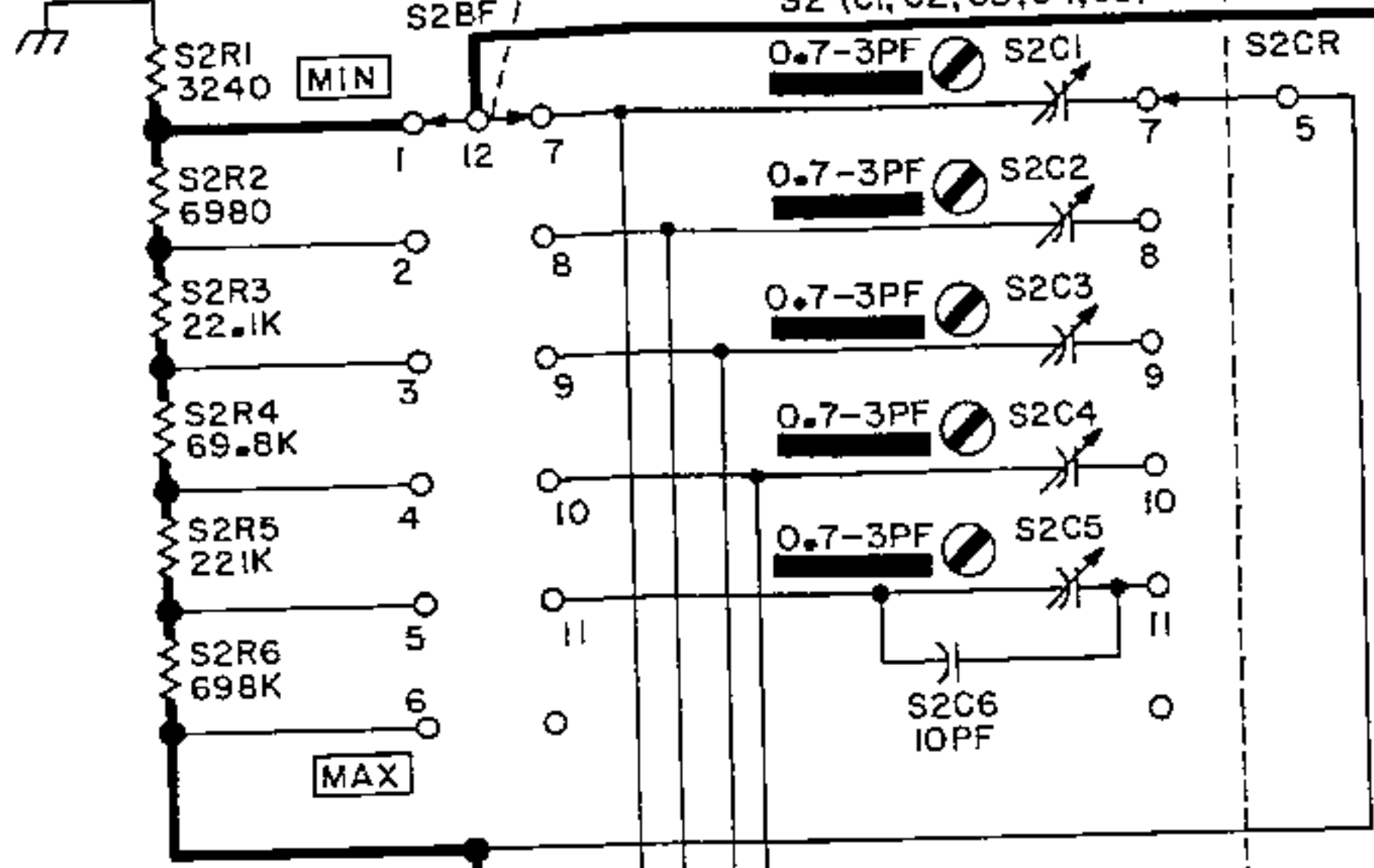




SENSITIVITY

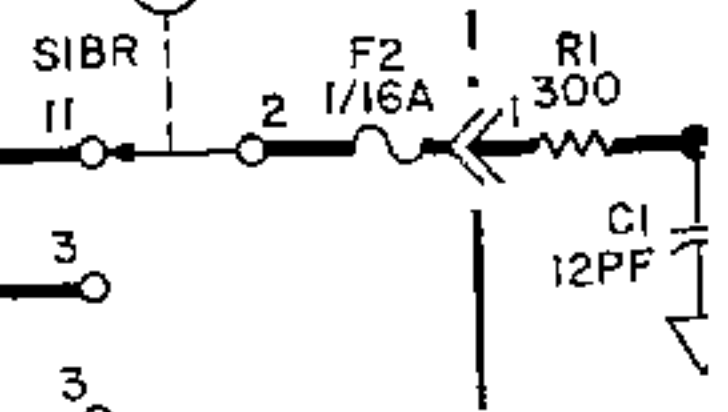
S2

100KC SENSITIVITY CAL
S2 (C1, C2, C3, C4, C5)



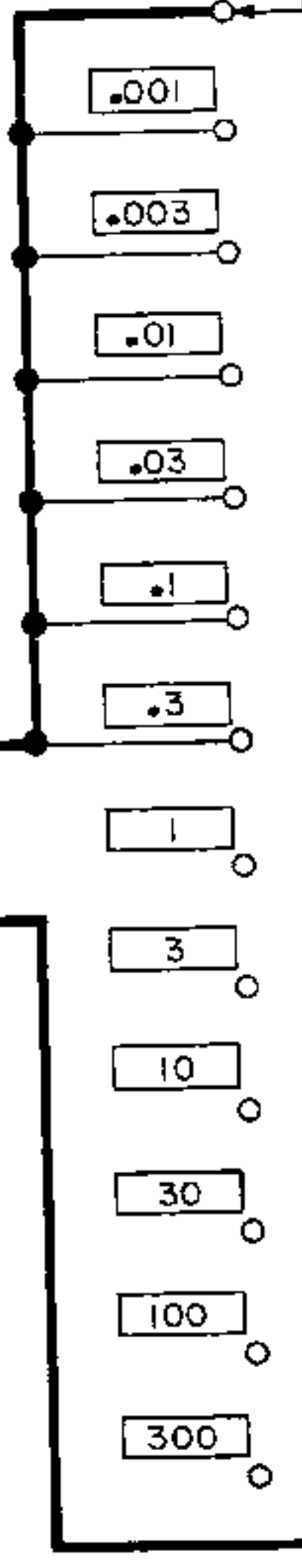
FUNCTION

S1



METER RANGE

.0003



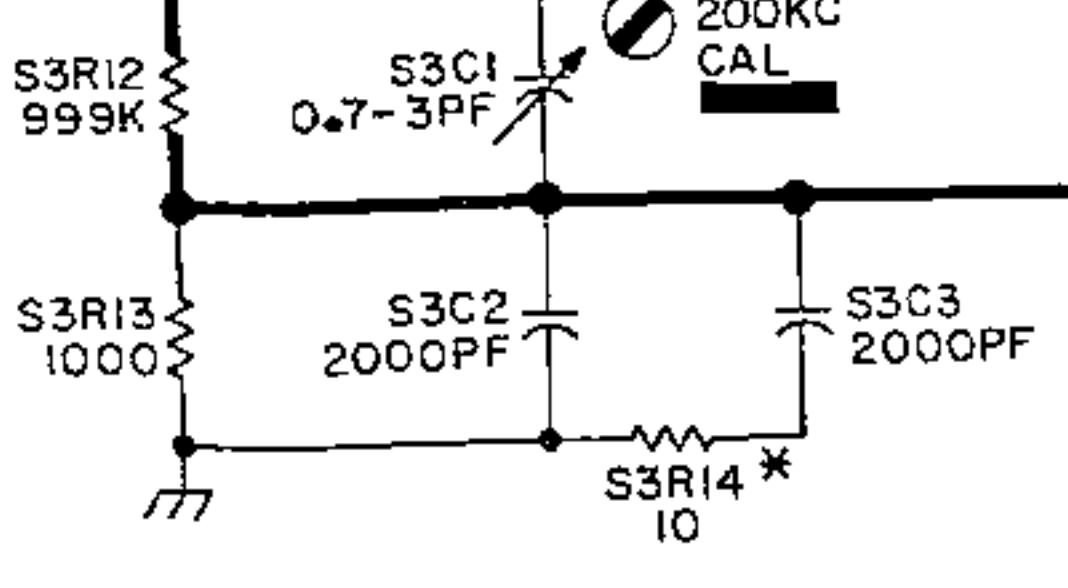
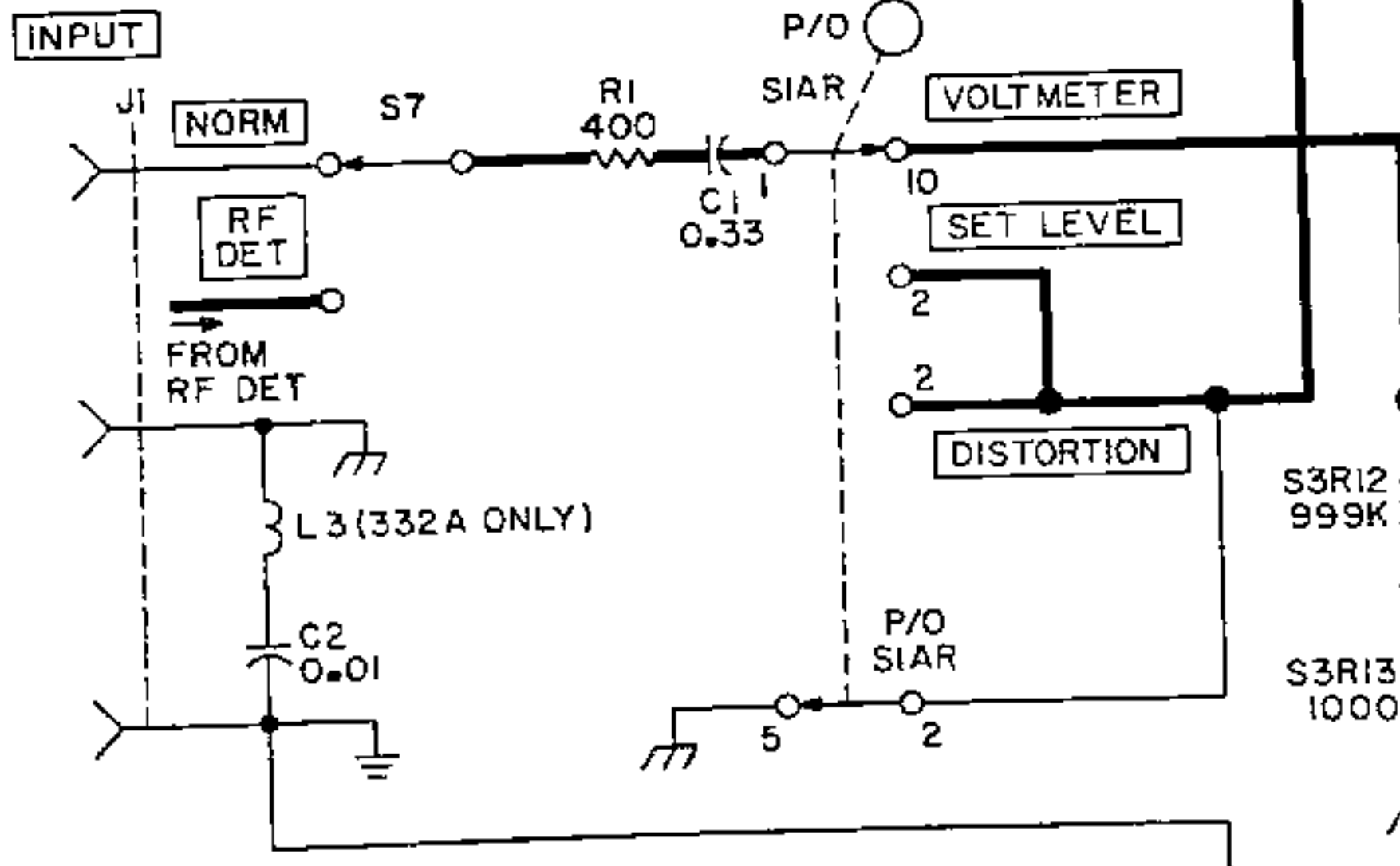
FUNCTION

P/O SIAR

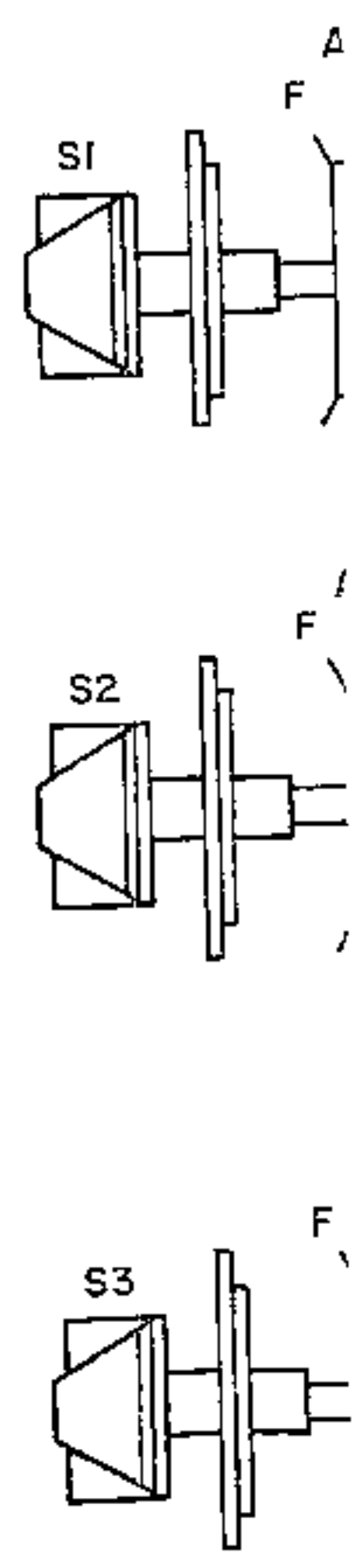
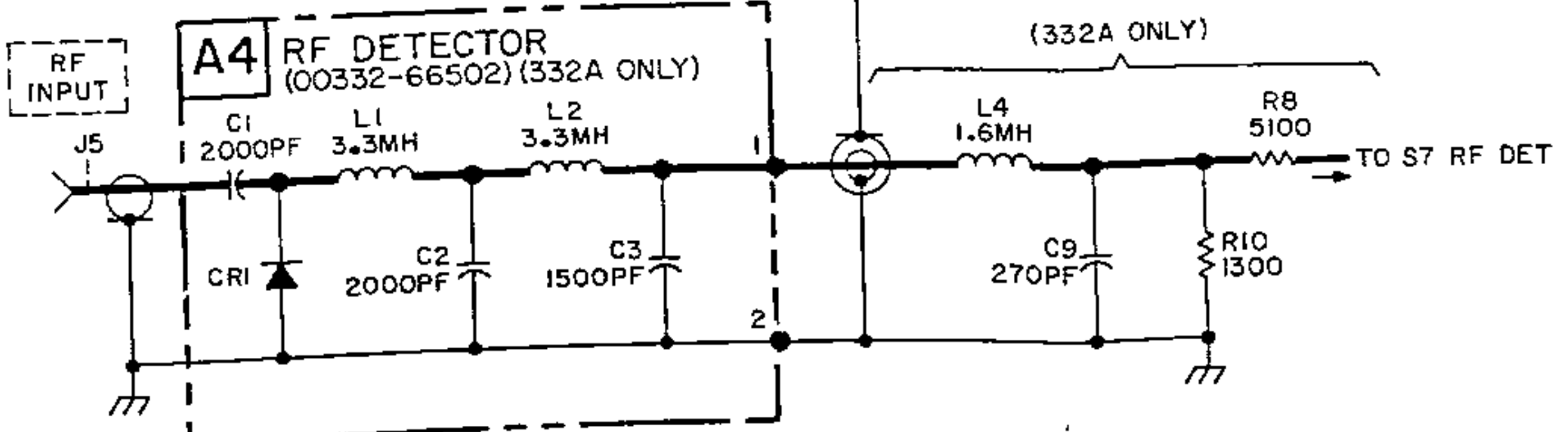
VOLTMETER

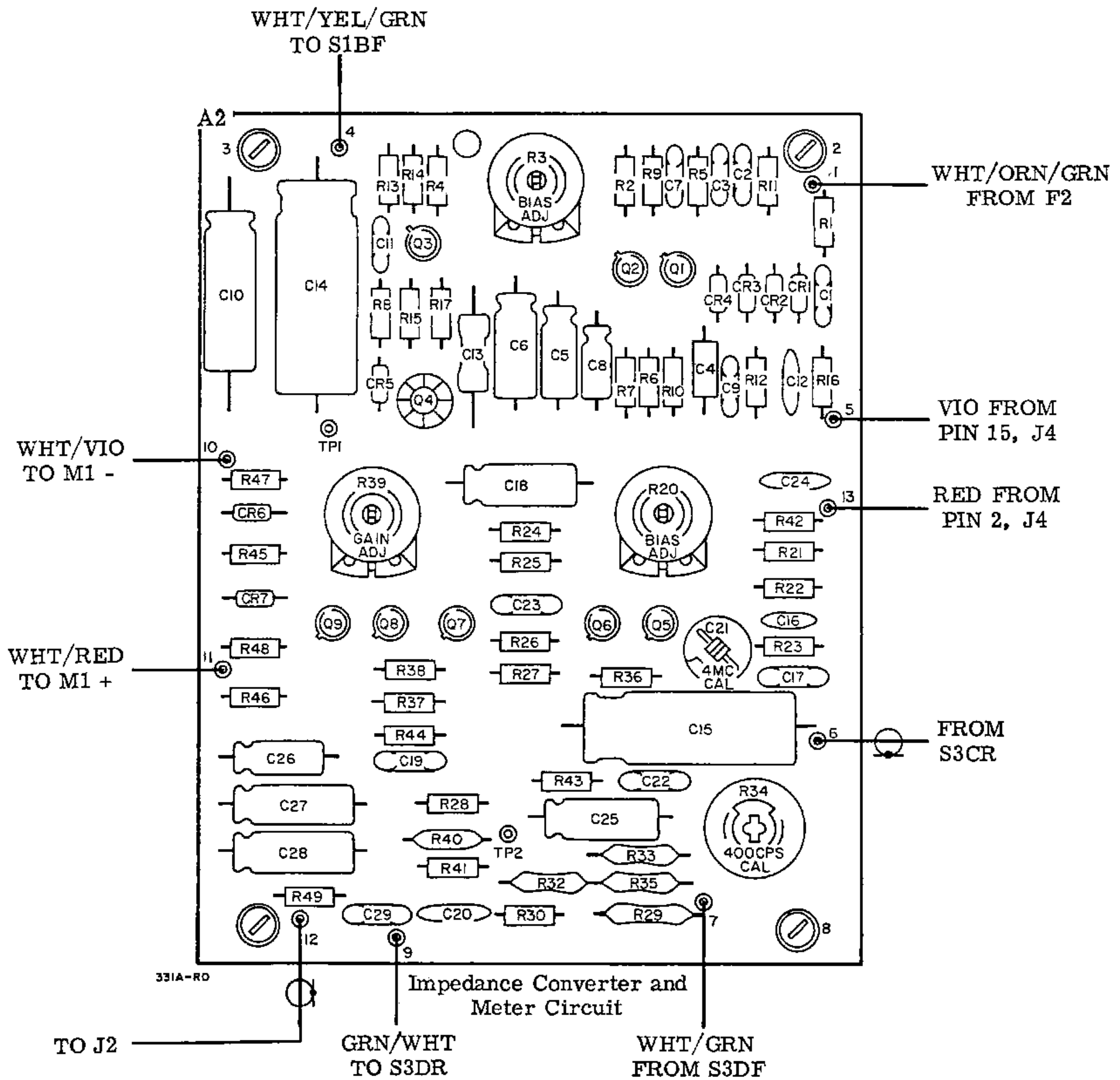
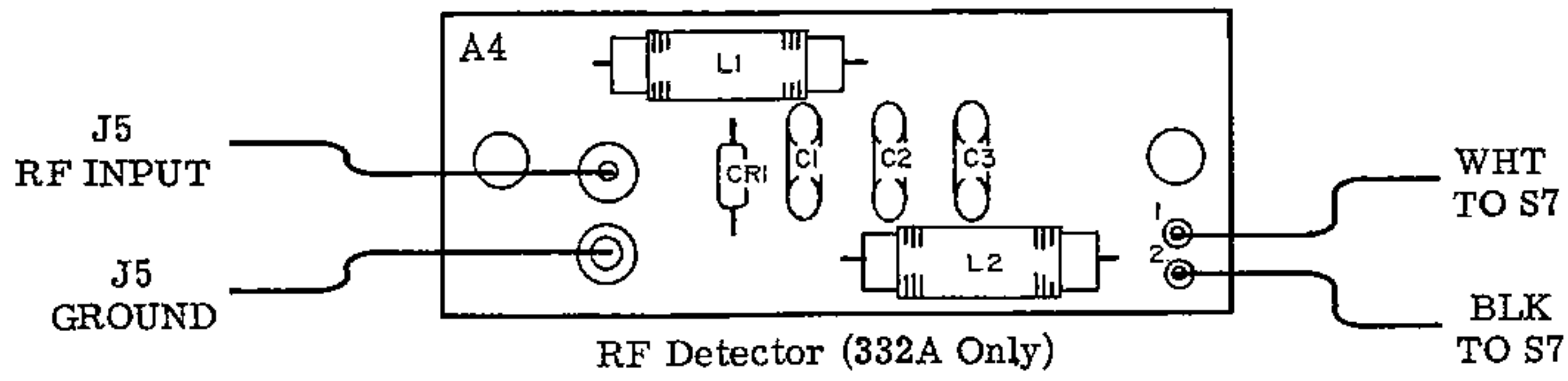
SET LEVEL

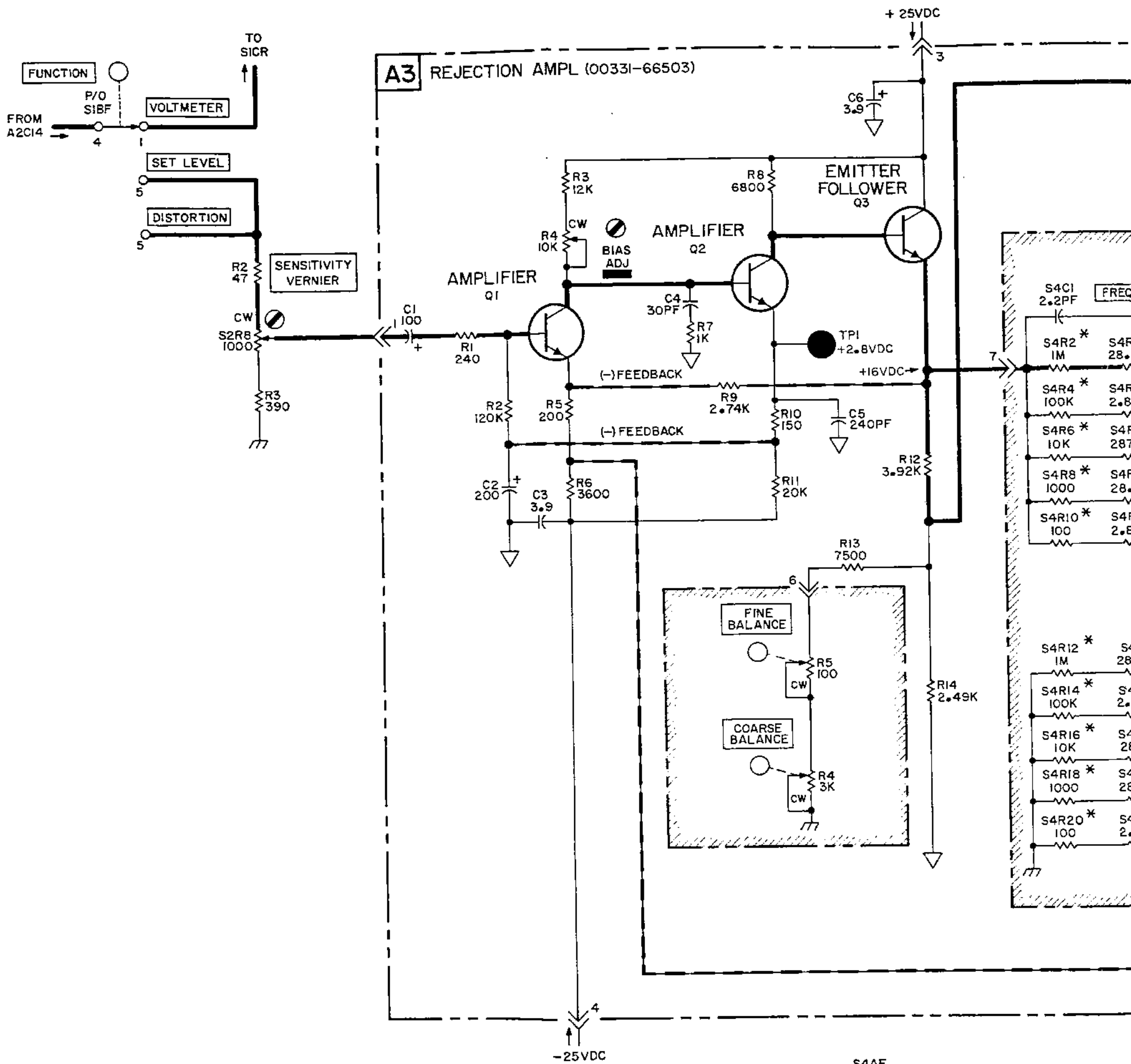
DISTORTION



A4 RF DETECTOR
(00332-66502) (332A ONLY)



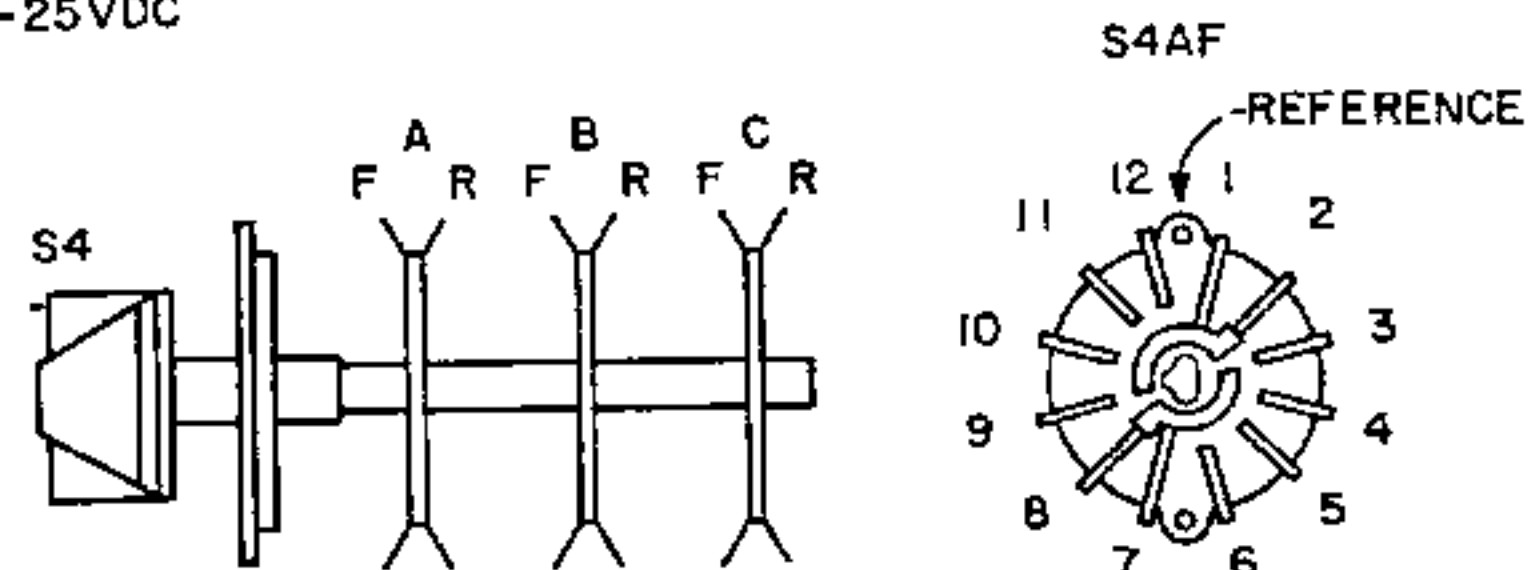


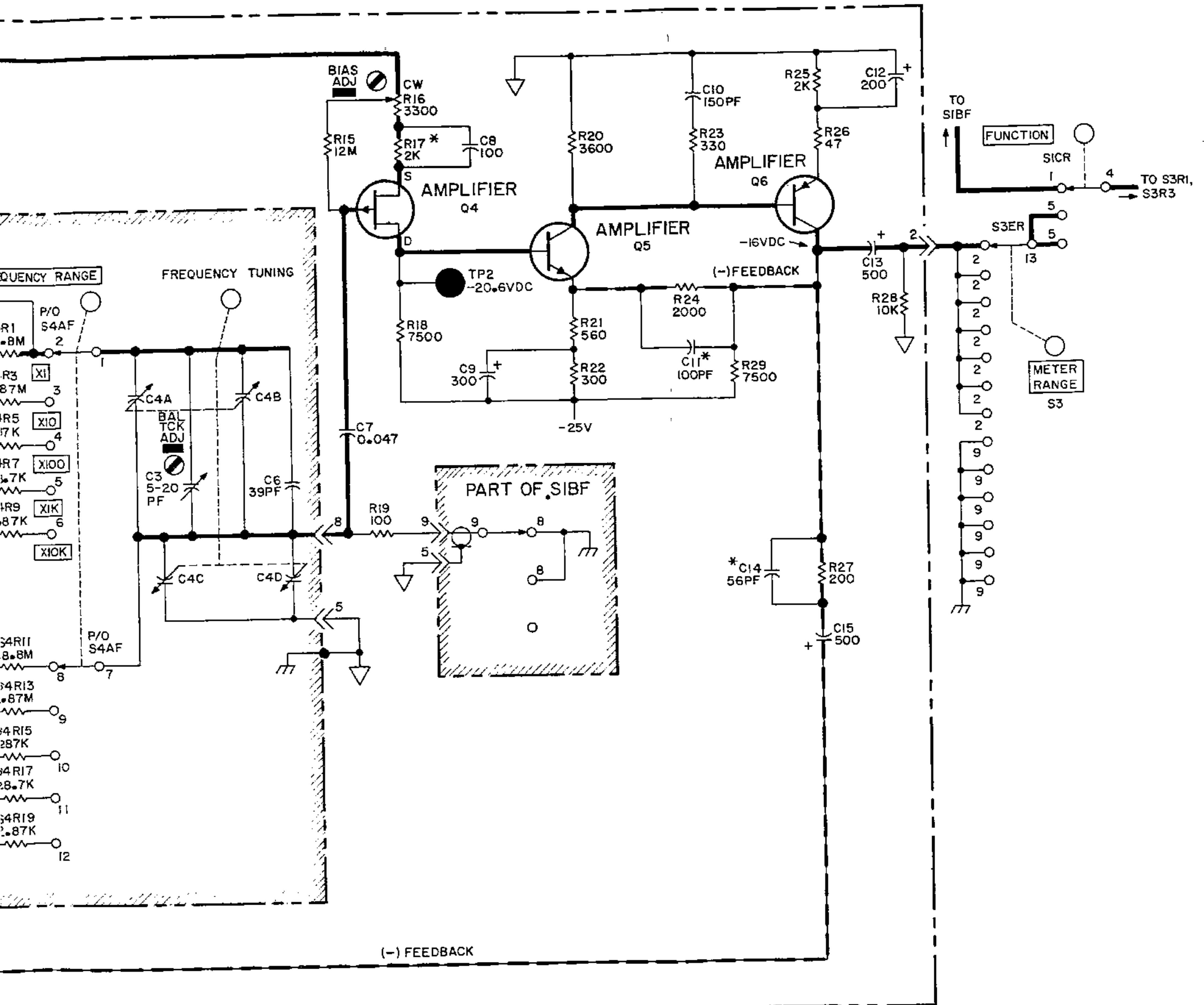


NOTES

1. SEE NOTES ON IMPEDANCE CONVERTER SCHEMATIC.
2. S4 SHOWN IN XI POSITION.
3. DENOTES COMPONENTS NOT MOUNTED ON ASSEMBLY.

331A / 332A-D-0073C



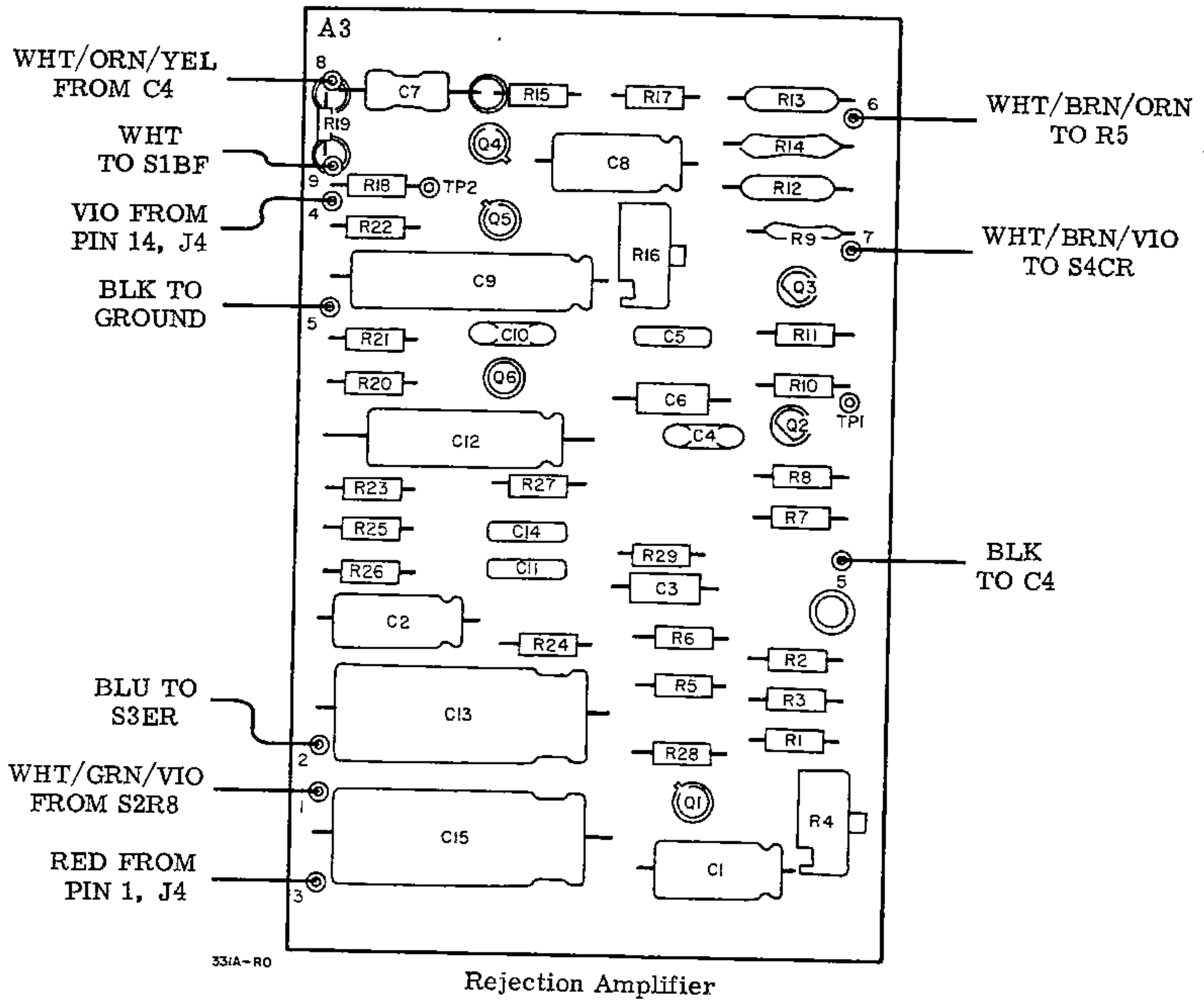


REFERENCE DESIGNATORS

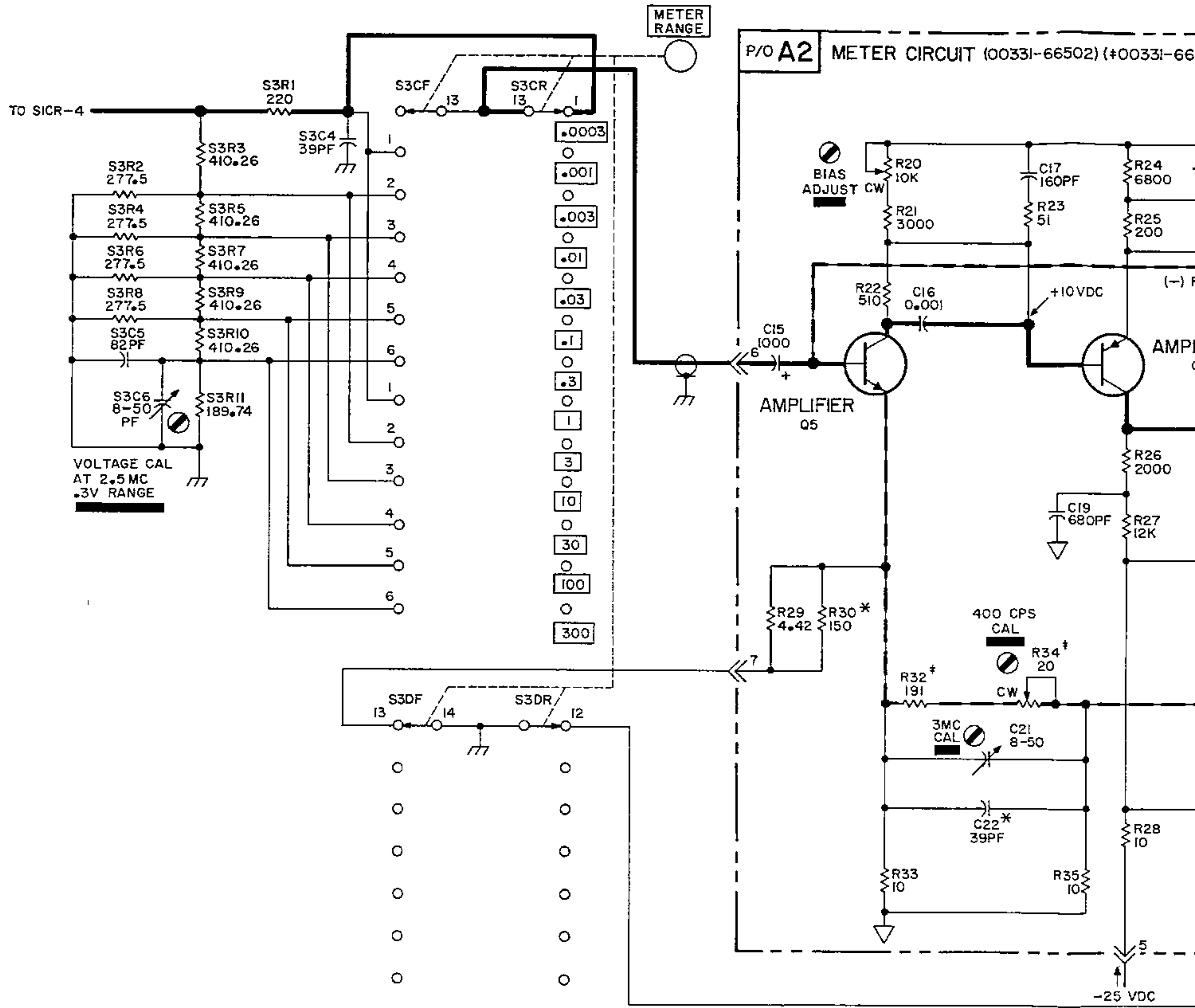
| CHASSIS | A3 | S2 | S4 |
|-------------|----------|----|--------|
| R2-R5 | C1-C15 | RB | R1-R20 |
| C3, C4A-C4D | Q1-Q6 | | C1 |
| S3E | R1-R28 | | |
| S4A | TP1, TP2 | | |

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Figure 6-2. Rejection Amplifier Schematic

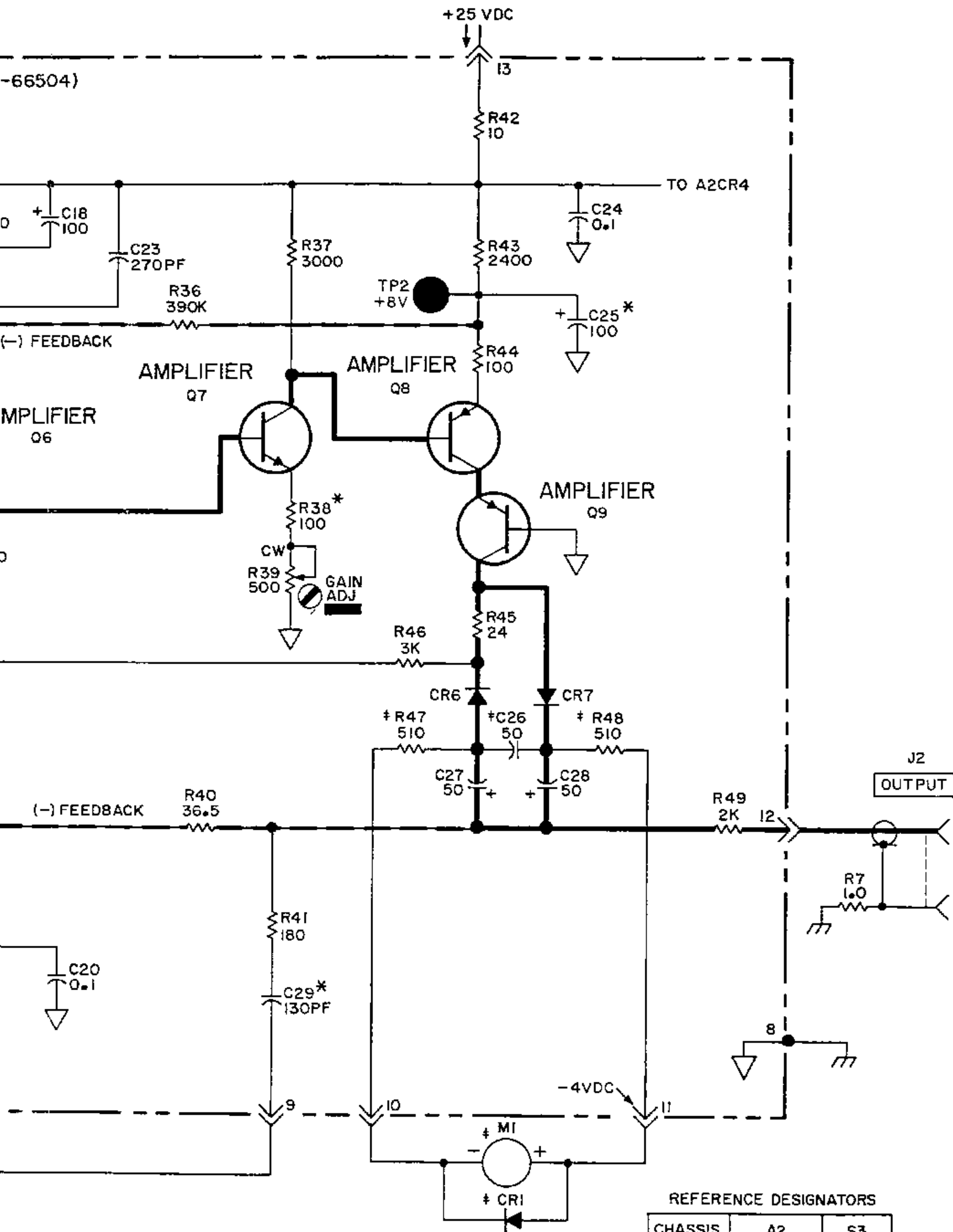


A3 Component Location



331A/332A-D-0071C

- 1. SEE NOTES C
- 2. * ON MODEL 5
- THESE PARTS
- C26 _____
- MI _____
- R47 _____
- R48 _____
- CRI _____
- R32 _____
- R34 _____



NOTES

- RES ON IMPEDANCE CONVERTER SCHEMATIC.
- MODELS 331A AND 332A WITH OPTION 01 INSTALLED,
- PARTS DIFFER AS FOLLOWS.
- DELETE.
- VU BALLISTICS METER.
- CHANGE TO 51 OHMS.
- CHANGE TO 51 OHMS.
- ADDED.
- CHANGE TO 180 OHMS.
- CHANGE TO 50 OHMS.

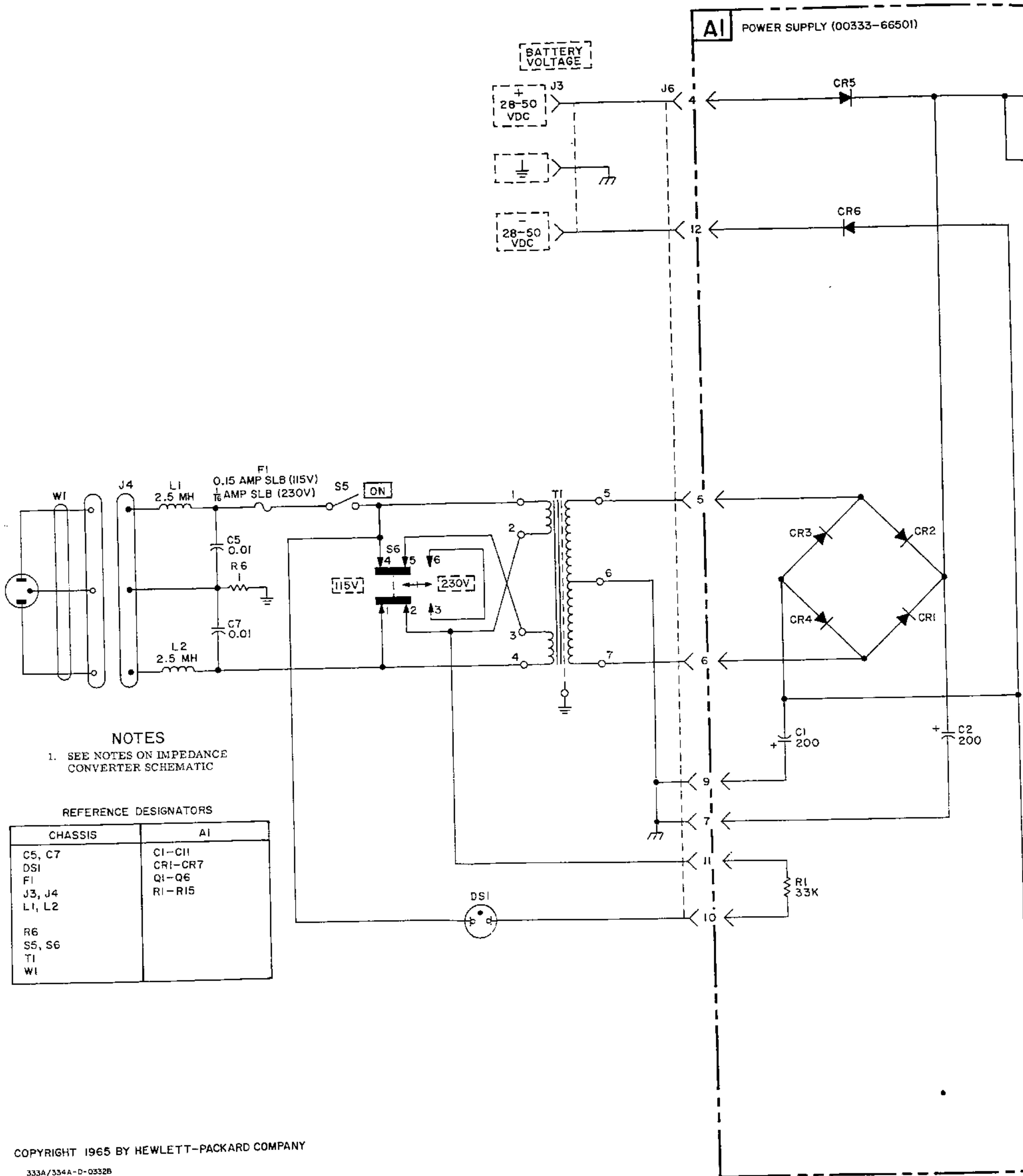
REFERENCE DESIGNATORS

| CHASSIS | A2 | S3 |
|----------|----------|--------|
| J2 | C15-C29 | C4-C6 |
| M1 | CR6, CR7 | R1-R11 |
| S3C, S3D | Q5-Q9 | |
| R7 | R20-R49 | |
| CR1 | TP2 | |

NOT ASSIGNED: A2R31

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Figure 6-3. Metering Circuit Diagram



NOTES

1. SEE NOTES ON IMPEDANCE CONVERTER SCHEMATIC

REFERENCE DESIGNATORS

| CHASSIS | AI |
|---------|---------|
| C5, C7 | CI-CII |
| DS1 | CR1-CR7 |
| F1 | Q1-Q6 |
| J3, J4 | RI-R15 |
| L1, L2 | |
| R6 | |
| S5, S6 | |
| T1 | |
| W1 | |

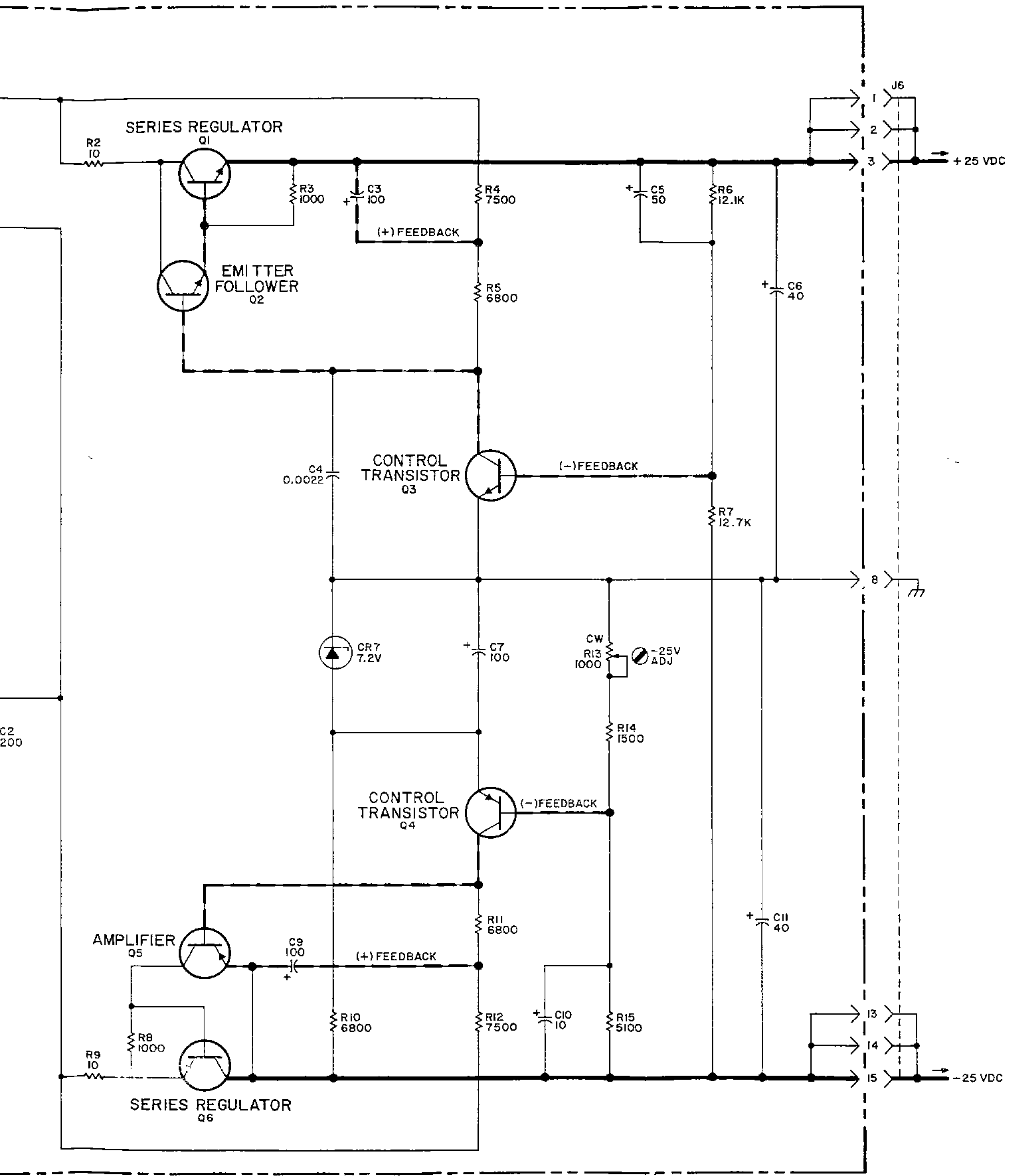
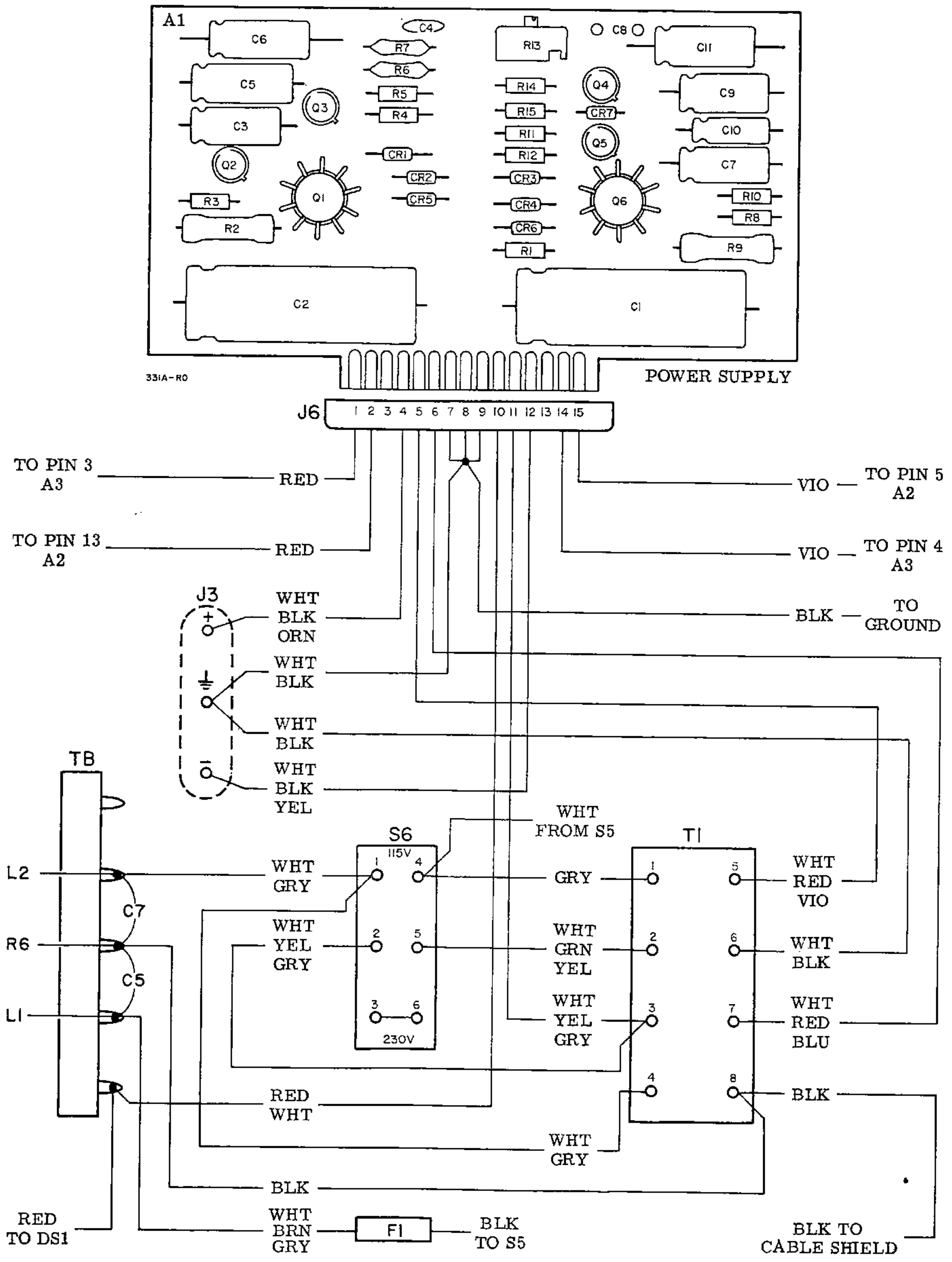


Figure 6-4. Power Supply Schematic
6-9/6-1



A1 Component Location and Wiring Diagram