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DEPARTMENT OF THE ARMY TECHNICAL MANUAL

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

HEWLETT-PACKARD RMS VOLTMETER MODEL 3400A



HEADQUARTERS, DEPARTMENT OF THE ARMY

MAY 1967

WARNING

DANGEROUS VOLTAGES

EXIST IN THIS EQUIPMENT

Be careful when working the power supplies and their circuits, or on the 230- or 115-volt ac line connections.

DO NOT TAKE CHANCES!

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Section I
Figure 1-1 and Table 1-1

Model 3400A

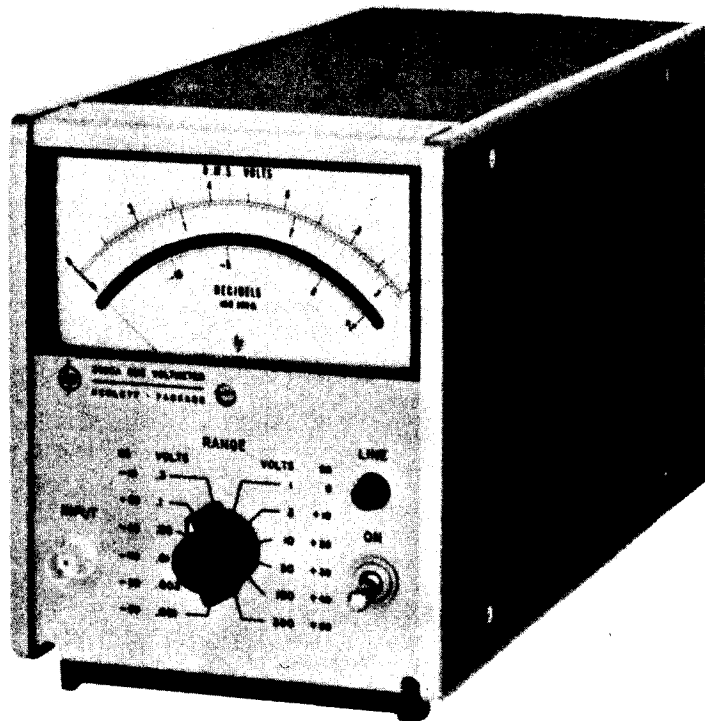


Figure 1-1. Model 3400A RMS Voltmeter

Table 1-1. Model 3400A Specifications

<p>RANGE: 12 full scale ranges from 1 mv to 300 v in a 1, 3, 10 sequence. -72 to +52 dbm. (Usable indications to 100 μv.)</p> <p>METER SCALES: Voltage, 0. 1 to 1 and 0.3 to 3. Decibel, -12 to +2 dbm (0 dbm = 1 mw, 600 ohms). Scales are individually calibrated to the meter movement.</p> <p>FREQUENCY RANGE: 10 cps to 10 Mc.</p> <p>ACCURACY: Within $\pm 1\%$ of full scale, 50 cps to 1 Mc. Within $\pm 2\%$ of full scale from 1 to 2 Mc. Within $\pm 3\%$ of full scale, 2 to 3 Mc. Within $\pm 5\%$ of full scale, from 10 to 50 cps and from 3 to 10 Mc. (Usable readings to 5 cps and 20 Mc.)</p> <p>RESPONSE: Responds to rms value (heating value) of the input signal for all waveforms.</p> <p>CREST FACTOR: (ratio of peak amplitude to rms amplitude): 10 to 1 at full scale (except where limited by maximum input), inversely proportional to pointer deflection, e.g. 20 to 1 at half-scale, 100 to 1 at tenth-scale.</p>	<p>MAXIMUM INPUT: 1000 v peak.</p> <p>INPUT IMPEDANCE: From 0.001 v to 0. 3 v Range: 10 megohms shunted by 40 pf. 1.0 v to 300 v Range: 10 megohms shunted by 15 pf.</p> <p>RESPONSE TIME: Typically <2 sec. to within 1% of final value for a step change.</p> <p>OVERLOAD PROTECTION: 30 db or 1000 v peak, whichever is less, on each range.</p> <p>OUTPUT: Negative 1 vdc at full scale deflection, proportional to pointer deflection (from 10-100% of full scale). 1 ma maximum. Nominal source impedance is 1000 ohms.</p> <p>POWER: 115 or 230 v $\pm 10\%$, 50 to 1000 cps, approximately 7 watts.</p> <p>DIMENSIONS: 5-1/8 in. wide, 6-1/2 in. high, 11 in. deep (1/3 module). (130 x 165 x 279 mm).</p> <p>WEIGHT: Net, 7-1/4 lbs. (3.3 kg) Shipping, 11 lbs. (5 kg).</p>
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Section I

GENERAL INFORMATION

1-A.1. Scope

This manual describes Hewlett-Packard (Federal Supply Code 14493) RMS Voltmeter Model 3400A serial numbers prefixed by 528, 401, and 322. It includes installation and operation instructions and covers operators, organizational, direct support (DS), general support (GS), and depot maintenance. This manual does not include a basic issue items list.

1-A.2. Index of Publications

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

1-A.3. Forms and Records

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

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

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

Model 3400A

Section I
 Paragraphs 1-1 to 1-15
 Tables 1-2 and 1-3

SCOPE

This manual contains the information necessary for operating and servicing the standard Model 3400A RMS Voltmeter and the Model 3400A/Option 01 RMS Voltmeter (DB scale uppermost).

SECTION I

GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. This section contains general information about the Model 3400A RMS Voltmeter (Figure 1-1). Included are discussions of the description and purpose, instrument identification, equipment supplied, and accessory equipment available. Also included is a table of instrument specifications.

1-3. DESCRIPTION AND PURPOSE.

1-4. The Model 3400A RMS Voltmeter measures the actual root-means-square (RMS) value of ac voltages between 100 microvolt and 300 volts. Frequency range is from 10 cps to 10 Mc. Full scale measurements of nonsinusoidal waveforms with crest factors (ratio of peak voltage to rms voltage) of 10 can be made.

1-5. Ac voltages are measured with a specified full-scale accuracy of $\pm 1\%$ from 50 cps to 1 Mc, $\pm 2\%$ from 1 Mc to 2 Mc, $\pm 3\%$ from 2 Mc to 3 Mc, and $\pm 5\%$ from 10 cps to 50 cps and 3 Mc to 10 Mc. A single front panel control selects one of 12 voltage or decibel ranges.

1-6. The Model 3400A crest factor rating is 10:1 which enables full scale readings for pulses which have a 1% duty cycle. At 1/10th of full scale, pulse trains with 0.01% duty cycle (100:1 crest factor) can be accurately measured.

1-7. The Model 3400A provides a dc output which is proportional to the front panel meter reading. By using this voltage to drive auxiliary equipment, the Model 3400A functions as an rms ac-to-dc converter.

1-8. SPECIFICATION.

1-9. Table 1-1 contains the specifications for the Model 3400A.

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 Model 3400A described in this manual.

1-12. EQUIPMENT SUPPLIED.

1-13. The equipment supplied with each Model 3400A is listed and described in Table 1-2.

Table 1-2. Equipment Supplied

IDENTIFICATION NUMBER	QUANTITY	DESCRIPTION
10110A	1	Adapter (BNC to dual banana jack)
8120-0078	1	Power Cord
03400-90003	1	Operating and Service Manual

1-14. ACCESSORY EQUIPMENT AVAILABLE.

1-15. The accessory equipment available is listed in Table 1-3.

Table 1-3. Accessory Equipment Available

IDENTIFICATION NUMBER	DESCRIPTION
10503A	Cable (Male BNC to male BNC, 48 inches)
11001A	Cable (Male BNC to dual banana plug, 45 inches)
11002A	Test Lead (dual banana plug to alligator clip, 60 inches)
11003A	Test Lead (dual banana plug to probe and alligator clip, 60 inches)

SECTION II

INSTALLATION

2-1. INTRODUCTION.

2-2. This section contains information and instructions necessary for installation and shipping of the Model 3400A RMS Voltmeter. Included are initial inspection procedures, power requirements, installation information, and instructions for repackaging for shipment.

2-3. INITIAL INSPECTION.

2-4. The Model 3400A RMS Voltmeter received a careful mechanical and electrical inspection before shipment. As soon as the Model 3400A is received, verify that the contents are intact and as ordered. Although the instrument should be free of marks and scratches and in perfect electrical condition, it should be inspected for any physical damage which may have been incurred in transit. Also test the electrical performance of the instrument using the procedures given in paragraph 5-5.

Should

shipping of the instrument become necessary, refer to paragraph 2-14 for repackaging and shipping instructions.

2-5. POWER REQUIREMENTS.

2-6. The Model 3400A can be operated from any ac source of 115- or 230-volts ($\pm 10\%$), at 50 to 60 cycles. With the instrument disconnected from the ac power source, move the slide switch (located on the rear panel) until the desired line voltage value appears. The ac line fuse is a 0.25 amp, fast blow type for 115- or 230-volt operation. Power dissipation is approximately 7 watts.

2-7. The Model 3400A is equipped with a three-prong power cord. To protect operating personnel, it is necessary to preserve the grounding feature of this plug when using a two contact ac outlet. Use a three-prong to two-prong adapter and connect the green pigtail lead on the adapter to ground.

2-8. INSTALLATION.

2-9. The Model 3400A is a submodular unit suitable for bench top use. However, when used in combination with other submodular units it can be bench and/or rack mounted. The combining case and adapter frame are designed for this purpose.

2-10 COMBINING CASE (Models 1051A or 1052A)

2-11. The combining case is a full-module unit which accepts various combinations of submodular units. Being a full-module unit, it can be bench or rack mounted and is analogous to any full-module instrument.

2-12. ADAPTER FRAME (Part No. 5060-0797).

2-13. The adapter frame is a rack frame that accepts any combination of submodular units. It can be rack mounted only.

2-14. REPACKAGING FOR SHIPMENT.

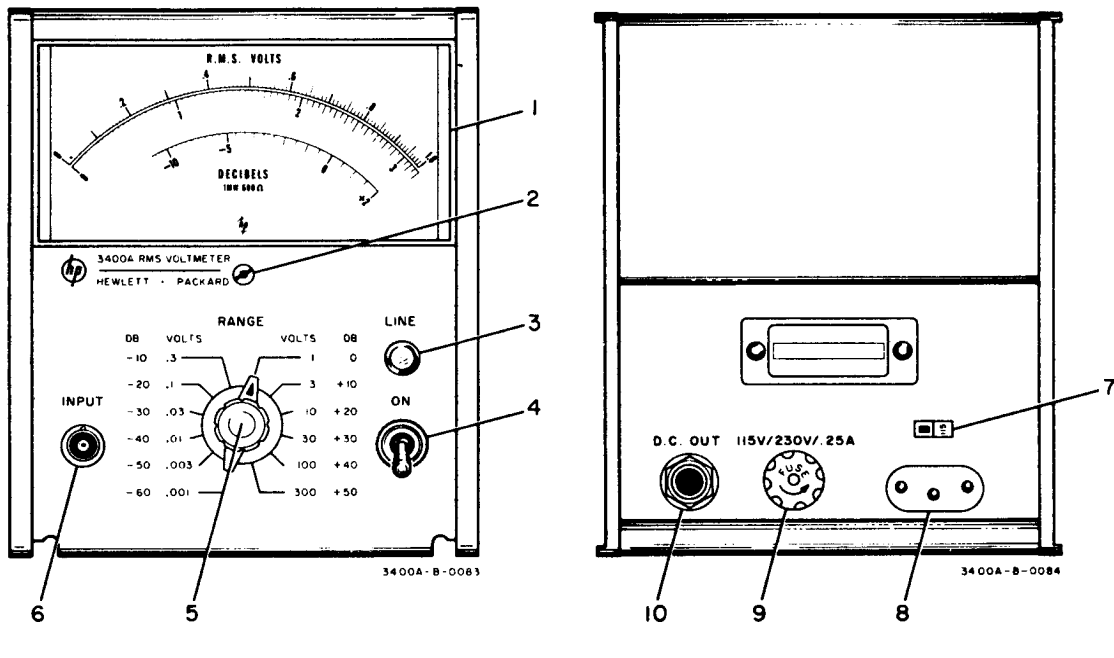
2-15. The following paragraphs contain a general guide for repackaging for shipment. Refer to paragraph 2-16 if the original container is to be used: if it is not.

2-16. If original container is to be used, proceed as follows:

- a. Place instrument in original container if available.
- b. Ensure that the container is well sealed with strong tape or metal bands.

2-17. If original container is not to be used, proceed as follows:

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



1. Direct reading meter: dc meter which indicates rms voltage level of input signal.
2. Mechanical zero adjustment: screwdriver adjustment for zero of direct reading meter.
3. LINE ON pilot lamp: neon lamp which indicates when power is applied to instrument and power switch is ON.
4. Power switch: two-position toggle switch which applies 115- or 230-volts ac to instrument.
5. RANGE switch: 12-position rotary switch which selects various attenuation ranges available within Model 3400A.
6. INPUT connector: BNC jack which enables application of input signal to instruments measuring circuits.
7. 115/230-volt switch: two-position slide switch which sets instrument to operate from either a 115- or 230-volt ac source.
8. Input power jack: three-prong jack which enables application of line voltage to instruments power supply circuits.
9. 115V/230V/.25A FUSE: 0.25 ampere fuse which provides protection against line voltage surges.
10. DC OUT jack: telephone-type jack which provides negative 1-volt dc out at full scale deflection, output is proportional to meter deflection. Output impedance is 1000 ohms.

Figure 3-1. Model 3400A Controls and Indicators

SECTION III
OPERATING INSTRUCTIONS**3-1. INTRODUCTION.**

3-2. This section consists of instructions and information necessary for the operation of the Model 3400A RMS Voltmeter. This section contains identification of controls and indicators, turn-on procedures, and operating instructions. Also included is a discussion of the applications for the Model 3400A.

3-3. CONTROLS AND INDICATORS.

3-4. Each operating control, connector, and indicator located on the Model 3400A is identified and described in Figure 3-1. The description of each component is keyed to an illustration of that component which is included within the figure.

3-5. TURN ON PROCEDURE.

3-6. To turn on the Model 3400A, proceed as follows:

- Set 115/230 switch (7, Figure 3-1) to correct position for input line voltage.
- Apply ac voltage to Model 3400A by plugging power cord into input power jack (8) ac receptacle.
- Operate power switch (4) to ON ensure that LINE indicator (3) lights.

NOTE

Allow five minutes for the Model 3400A to warm up and stabilise before making a reading.

3-7. OPERATING INSTRUCTIONS.

DO NOT MEASURE SIGNAL ABOVE 100 VOLTS WITH 10 TO 1 CREST FACTOR. OTHERWISE, THE MAXIMUM INPUT RATING (1000 VOLTS PEAK) WILL BE EXCEEDED. WHEN MEASURING SIGNALS UP TO 100 VOLTS RMS WITH A 10 TO 1 CREST FACTOR, USE THE BNC TO DUAL BANANA JACK, ACCESSORY 10110A, SUPPLIED WITH THE INSTRUMENT, OR OTHER INPUT TEST LEADS AND CONNECTIONS THAT WILL WITH STAND THE MAXIMUM INPUT OF 1000 VOLTS PEAK.

3-8. To operate the Model 3400A as an rms voltmeter proceed as follows:

- Attach test lead to INPUT connector (6, Figure 3-1). (See Table 1-3 for a list of test leads available.)
- Set RANGE switch (5) to 300 VOLTS position.



WHEN MEASURING AN AC SIGNAL SUPERIMPOSED ON A DC LEVEL, ALWAYS SET THE RANGE SWITCH TO THE 300 VOLT POSITION BEFORE MAKING THE INITIAL CONNECTION TO A CIRCUIT SINCE A HIGH VOLTAGE TRANSIENT DUE TO THE APPLICATION OF A DC VOLTAGE WILL DAMAGE THE INPUT CIRCUITRY.

- Connect test lead to point to be measured.
- Rotate RANGE switch in a counterclockwise direction (decreased attenuation) until direct reading meter (1) indicates on upper two thirds of scale.

3-9. APPLICATIONS.

3-10. The Model 3400A can be used in conjunction with other test instruments to measure the rms value of ac signal with a dc component, measure rms current and act as an rms ac-to-dc converter.

3-11. RMS VALUE OF AC SIGNALS WITH DC COMPONENT.

3-12. Since the 3400A is an ac device it will measure only the rms value of the ac component of a wave. If it is necessary to include the rms value of the dc component when measuring a signal use a Model 412A DC Voltmeter to measure the dc component. Substitute the reading from the Model 412A and Model 3400A in the following formula:

$$e_{\text{rms}} = \sqrt{e_{\text{ac}}^2 + e_{\text{dc}}^2}$$

3-13. RMS CURRENT.

3-14. To measure rms current, use an Model 456A AC Current Probe. This probe clips around the current conductor and provides an output voltage that is proportional to the current being measured. Using this method, rms currents of one milliamper to one ampere can be measured.

3-15. RMS AC-TO-DC CONVERTER.

3-16. Since the Model 3400A is provided with a dc output (10, Figure 3-1) which is proportional to the meter deflection, it can be used as a linear rms ac to dc converter. The dc output can be used to drive a Model 3440A Digital Voltmeter for high resolution measurements and/or a Mosely Model 680 Strip Chart Recorder where an analog record is desired. External loading does not affect the meter accuracy so that both the meter and dc output can be used simultaneously.

SECTION IV

THEORY OF OPERATION

4-1. INTRODUCTION.

4-2. This section contains the theory of operation of the Model 3400A RMS Voltmeter. Included is a general and detailed description of the theory of operation.

4-3. GENERAL DESCRIPTION.

4-4. The Model 3400A comprises two attenuators, an impedance converter, a video amplifier, a modulator/demodulator, a chopper amplifier, an emitter follower, a thermocouple pair, and a direct reading meter. (See Figure 4-1.)

4-5. A signal being measured with the Model 3400A is applied to input attenuator A1 through the INPUT jack, located on the Model 3400A front panel. The input attenuator has an input impedance of over 10 megohms and provides two ranges of attenuation. The output of the input attenuator is applied to impedance converter A2. The impedance converter is a non-inverting unity voltage gain amplifier. It presents a high impedance to the input signal and provides a low impedance output to drive the second attenuator A3. The second attenuator provides 6 ranges in a 1, 3, 10 sequence. The two attenuators are switched to provide 12 ranges of attenuation.

4-6. The output of the second attenuator is amplified by video amplifier A4. The video amplifier is a wide-band, five stage amplifier. The overall gain of the video amplifier is controlled by an ac feedback loop. The ac output of the amplifier is applied to TC401; one of the thermocouples of the thermocouple pair.

4-7. The dc output of TC401 is modulated by modulator A5. The modulator comprises two photocells which are alternately illuminated by two neon lamps which in turn are controlled by the oscillator located on power supply assembly, A7. Also applied to one of the photocells is the TC401 dc output. The resultant output of the modulator is a square wave whose amplitude is proportional to the dc input level.

4-8. The square wave output of the modulator is amplified by chopper amplifier A6. The chopper amplifier is a three-stage, high gain ac amplifier. Its output is applied to demodulator A5. The demodulator output is a dc level whose magnitude is proportional to the amplitude of the ac input. The demodulator output is applied to a two-stage, direct coupled emitter follower. The emitter follower is used to make the impedance transformation from the high impedance output of the demodulator to the low impedance of the direct reading meter M1 and TC402; the second thermocouple of the thermocouple pair.

4-9. The thermocouple pair acts as a summing point for the ac output of the video amplifier A4 and the dc output of the emitter follower. The difference in the heating effect of these voltages is felt as a dc input to modulator A5. This difference input is amplified and is fed to TC402 and to meter M1. This amplified dc voltage represents the rms value of the ac signal applied at the INPUT jack.

4-10. The dc voltage driving meter M1 is also available at the DC OUT jack, located at the rear of the Model 3400A.

4-11. DETAILED DESCRIPTION.

4-12. INPUT ATTENUATOR ASSEMBLY A1.

4-13. The input attenuator assembly is a capacitive-compensated attenuator which provides two ranges of attenuation for the 12 positions of the RANGE switch. See input attenuator schematic diagram illustrated on Figure 6-1.

4-14. When the RANGE switch is positioned to one of the six most sensitive ranges (.001 to .3 VOLTS), the attenuator output voltage is equal to the input voltage. When the RANGE switch is positioned to one of six highest ranges (1 to 300 VOLTS), the input signal is attenuated 60 db (1000:1 voltage division) by the resistive voltage divider consisting of R101, R103, and R104. Trimmer C102 is adjusted at 100 kc, and R104 is adjusted at 400 cps to provide constant attenuation over the input frequency range.

4-15. IMPEDANCE CONVERTER ASSEMBLY A2.

4-16. The impedance converter assembly utilizes a nuvistor tube cathode follower circuit to match the high output impedance of the input attenuator to the low input impedance of the second attenuator. The cathode follower circuit preserves the phase relationship of the input and output signals while maintaining a gain of unity. See impedance converter assembly schematic diagram illustrated on Figure 6-1.

4-17. The ac signal input to the impedance converter is RC coupled to the grid of cathode follower V201 through C201 and R203. The output signal is developed by Q201 which acts as a variable resistance in the cathode circuit of V201. The bootstrap feedback from the cathode of V201 to R203 increases the effective resistance of R203 to the input signal. This prevents R203 from loading the input signal and preserves the high input impedance of the Model 3400A. The gain compensating feedback from the plate of V201 to the base of Q201 compensates for a decrease in gain of V201 caused by tube aging.

4-18. Breakdown diode CR201 controls the grid bias voltage on V201 thereby establishing the operating point of this stage. CR202 across the base-emitter junction of Q201 protects Q201 in the event of a failure in the +75 volt power supply. Regulated dc is supplied to V201 filaments to avoid inducing ac hum in the signal path.

4-19. SECOND ATTENUATOR ASSEMBLY A3.

4-20. The second attenuator is a resistive divider which attenuates the ac input signal while maintaining a low impedance output for the following amplification stages. See second attenuator assembly schematic diagram illustrated in Figure 6-1.

4-21. The ac input signal is applied to a precision resistance voltage divider consisting of R302 through R312. These resistors are arranged to give six attenuation ranges from 0.001 to 0.3 volts. Trimmer capacitor C303 (.3V ADJ) provides an adjustment for frequency response at the higher frequencies.

4-22. VIDEO AMPLIFIER ASSEMBLY A4.

4-23. The video amplifier functions to provide constant gain to the ac signal being measured over the Model 3400A operating ranges. See video amplifier assembly schematic diagram illustrated on Figure 6-2.

4-24. The ac input signal from the second attenuator is coupled through C402 to the base of input amplifier Q401. Q401, a class A amplifier, amplifies and inverts the signal which is then direct coupled to the base of bootstrap amplifier Q402. The output, taken from Q402 emitter is applied to the base of Q403 and fed back to the top of R406 as a bootstrap feedback. This positive ac feedback increases the effective ac resistance of R406 allowing a greater portion of the signal to be felt at the base of Q402. In this manner, the effective ac gain of Q401 is increased for the mid-band frequencies without disturbing the static operating voltages of Q401.

4-25. Driver amplifier Q403 further amplifies the ac signal and the output at Q403 collector is fed to the base circuit of emitter follower Q404. The feedback path from the collector of Q403 to the base of Q402 through C 405 (10 MC ADJ) prevents spurious oscillations at high input frequencies. A dc feedback loop exists from R433, in the emitter circuit of Q403, to the base of Q401. This feedback stabilizes the Q401 bias voltage. Emitter follower Q404 acts as a driver for the output amplifier consisting of Q405 and Q406; a complimentary pair operating as a push-pull amplifier. The video amplifier output is taken from the collectors of the output amplifiers and applied to thermocouples TC401. A gain stabilizing feedback is developed in the emitter circuits of the output amplifiers. This negative feedback is applied to the emitter of input amplifier Q401 and establishes the overall gain of the video amplifier.

4-26. Trimmer capacitor C405 is adjusted at 10 mc for frequency response of the video amplifier. Diodes CR402 and CR406 are protection diodes which prevent voltage surges from damaging transistors in the video amplifier. CR401, CR407, and CR408 are temperature compensating diodes to maintain the zero signal balance condition in the output amplifier over the operating temperature range. CR403, a breakdown diode, establishes the operating potentials for the output amplifier.

4-27. MODULATOR/DEMOMUMTOR ASSEMBLY A5, CHOPPER AMPLIFIER ASSEMBLY, AND THERMOCOUPLE PAIR ASSEMBLY (PART OF A4).

4-28. The modulator/demodulator, chopper amplifier, and thermocouple pair form a servo loop which functions to position the direct reading meter M1 to the rms value of the ac input signal. See modulator/demodulator, chopper amplifier, and thermocouple pair schematic diagram illustrated in Figure 6-3.

4-29. The video amplifier output signal is applied to the heater of thermocouple TC401. This ac voltage causes a dc voltage to be generated in the resistive portion of TC401 which is proportional to the heating effect (rms value) of the ac input. The dc voltage is applied to photocell V501.

4-30. Photocells V501 and V502 in conjunction with neon lamps DS501 and DS502 form a modulator circuit. The neon lamps are lighted alternately between 90 and 100 cps. Each lamp illuminates one of the photocells. DS501 illuminates V501; DS502 illuminates V502. When a photocell is illuminated it has a low resistance (approximately 6K ohms) compared to its resistance when dark (approximately 500K ohms). Therefore, when V501 is illuminated, the output of thermocouple TC401 is applied to the input of the chopper amplifier through V501. When V502 is illuminated, the ground signal felt through R634 is applied to the chopper amplifier. The alternate illumination of V501 and V502 modulates the dc input at a frequency between 90 and 100 cps. The modulator output is a square wave whose amplitude is proportional to the input dc level

4-31. The chopper amplifier, consisting of Q601 through Q603 is a high gain amplifier which amplifies the square wave developed by the modulator. Noise and power supply voltage variations are reduced by breakdown diode CR601 and CR603. Diodes CR602 and CR603 are biasing diodes for Q602 and Q603 respectively. The amplified output is taken from the collector of Q603 and applied to the demodulator through C605.

4-32. The demodulator comprises two photocells, V503 and V504, which operate in conjunction with DS501 and DS502; the same neon lamps used to illuminate the photocells in the modulator. Photocells V503 and V504 are illuminated by DS501 and DS502, respectively.

4-33. The demodulation process is the reverse of the modulation process discussed in paragraph 4-30. The output of the demodulator is a dc level which is proportional to the demodulator input. The magnitude and phase of the input square wave determines the magnitude and polarity of the dc output level. This dc output level is applied to the emitter follower consisting of Q604 and Q605.

4-34. The emitter follower is needed to match the high output impedance of the demodulator to the low impedance input of the meter and thermocouple circuits. The voltage drop across CR604 in the collector circuit of Q604 is the operating bias for Q604. This fixed bias prevents Q604 failure when the base voltage is zero with respect to ground.

4-35. The dc level output, taken from the emitter of Q605, is applied to meter M1 and to the heating element of thermocouple TC402. The voltage developed in the resistive portion of TC402 is effectively subtracted from the voltage in TC401. The input signal to the modulator then becomes the difference in the dc outputs of the two thermocouples.

4-36. A frequency stabilizing feedback path exists through C610 and C611 during one half cycle of the modulated square wave and through C607 and C608 during the other half cycle. AC components in the modulated square wave which are not synchronized with the modulated square wave receive heavy attenuation due to this negative feedback. In this manner, the chopper amplifier is effectively tuned to the modulator frequency.

4-37. POWER SUPPLY ASSEMBLY A7.

4-38. The power supply assembly provides the operating voltages for the tube and transistors used in the Model 3400A. See power supply assembly schematic diagram illustrated on Figure 6-4.

4-39. Either 115 or 230 volts ac is connected to the primary of power transformer T1 through fuse F1 and the POWER switch S1. Switch S2 (slide switch on rear panel) connects T1 primary windings in series for 230-volt operation or in parallel for 115-volt operation. Neon lamp DSI lights to indicate power ON when ac power is applied and S1 is closed.

4-40. REGULATOR OPERATION.

4-41. The series regulator acts as a dynamic variable resistor in series with the power supply output. A control amplifier senses changes in the output voltage by comparing the output with a fixed reference voltage. The control amplifier then supplies any output voltage changes to the driver transistor, which in

turn changes the resistance of the series regulator to oppose the change in output voltage. Diodes across the base emitter junction of the series regulator provide over current protection.

4-42. +75-VOLT SUPPLY.

4-43. The +75-volt supply consists of a full-wave rectifier (CR701 and CR702) whose output is filtered by CIA and CIB and regulated by series regulator Q1. The +75-volt supply provides regulated +75 volts which is used as the plate supply voltage for V201. Voltage variation from the output is felt at Q702 base circuit through C704, R715, and R? 16. The C703 and R709 network provides phase correction for power supply stability. The regulation circuitry is in the negative leg of the +75-volt supply, and uses the -17.5-volt supply as a reference.

4-44. -17.5-VOLT SUPPLY.

4-45. The regulated -17.5-volt supply consists of a full-wave rectifier (CR711, and CR712) whose output is filtered by C706 and C708 and regulated by Q2. Breakdown diode CR715 provides reference voltage at the base of Q704. Regulation operation is the same described in paragraph 4-40.

4-46. -6-VOLT SUPPLY.

4-47. The regulated -6.3-volt supply consists of a full-wave rectifier (CR716 and CR717) whose output is filtered by C2 and regulated by Q3. Emitter follower Q705 is connected to the -17.5-volt supply which provides a reference for the -6.3 volt supply. Series regulator Q3 acts as a dynamic variable resistor in series with the output to oppose changes in output voltage.

4-48. NEON LAMP DRIVE OSCILLATOR.

4-49. The neon lamp drive oscillator consists of transistor Q706, diode CR718, resistors R701, R702, R712, R713, and capacitor C711. Transistor Q706 is held on (conducting) by the base bias developed at the junction of R712 and CR718. The collector current of Q706 charges up capacitor C711 through R701 or R702 depending upon the illuminated neon lamp on the Chopper Amplifier Assembly, A6. When the capacitor reaches a sufficient charge to fire the dark neon lamp, the illumination of the neon lamps alternate and the capacitor discharges through the previously dark neon lamp. With the previously dark neon lamp illuminated, the capacitor charges up in the opposite direction until firing the previously illuminated neon lamp. The cycle described above repeats at a frequency of 90 to 100 cps as determined by the RC time constant of R701, C711, and R702, and C711.

Table 5-1. Required Test Equipment

INSTRUMENT TYPE	REQUIRED CHARACTERISTICS	USE	RECOMMENDED MODEL
DC Voltmeter/ Ohmmeter	Voltmeter Accuracy: \pm . 1% full scale Voltage Range: 10 mv to 100 v Ohmmeter Accuracy: \pm 3% Ohms Range: 2 Ω to 100 M Ω	Performance Checks Power Supply Checks Alignment and Adjust- ment Troubleshooting	Ⓢ Model 3440A/3444A Digital Voltmeter
Voltmeter Cali- brator	Voltage Range: 1 mv to 300 v rms Frequency: 400 cps Accuracy: \pm 0.2%	Performance Checks Alignment and Adjust- ment	Ⓢ Model 738B Voltmeter Calibrator
Oscillator	Frequency Stability: .001%/minute Frequency Range: 10 cps to 10 Mc	Performance Checks Alignment and Adjust- ment Troubleshooting	Ⓢ Model 651A Test Os- cillator
Frequency Re- sponse	Frequency Range (with external os- cillator): 15 cps to 10 Mc Frequency Response: \pm 0.5%, 15 cps to 10 Mc	Performance Checks Alignment and Adjust- ment	Ⓢ Model 739AR Frequen- cy Response Test Set
Oscilloscope	Sensitivity: 0.1 v/cm Bandwidth: 2 cps to 50 Mc	Performance Checks Power Supply Checks Troubleshooting	Ⓢ Model 175A/1752B 50 Mc Oscilloscope
Pulse Generator	Pulse Width: variable to 10 μ sec Pulse Amp: \pm 2 volts peak, variable Pulse Rate: 250 to 1000 pps	Performance Checks	Ⓢ Model 212A Pulse Generator
Pulse Counter	Range: 250 to 1000 pps Accuracy: \pm 1 count	Performance Checks	Ⓢ Model 5512A Elec- tronic Counter
AC Voltmeter	Voltage Range: 1 to 150 v Accuracy: \pm 3%	Power Supply Checks Troubleshooting	Ⓢ Model 403A/B AC Voltmeter
Power Supply 200 K Ω Resis- tor	Output: 0 - 1 vdc, variable Metal film, 1/4 w, 1%	Troubleshooting Performance Checks	Ⓢ Model 721A Ⓢ Part No. 0757-0782
50 Ω Feed-Thru Termination	Resistor: fixed, composition, 50 ohms \pm 5%, 1/4 w	Performance Checks Alignment and Adjust- ment	Ⓢ Model 11048B 50 Ohm Feed-Thru Termination
BNC-T-Adapter	UG-274B/U	Performance Checks Alignment and Adjust- ment	Ⓢ Part No. 1250-0072
Adapter-Con- nector	UG-201A/U	Performance Checks Alignment and Adjust- ment	Ⓢ Part No. 1250-0067

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains the information necessary for maintenance of the Model 3400A RMS Voltmeter. Included are performance checks, repair procedures, adjustment and calibration procedures, and troubleshooting techniques.

5-3. TEST EQUIPMENT.

5-4. The test equipment required for the maintenance of the Model 3400A is listed in Table 5-1. Equipment having similar characteristics may be substituted for the equipment listed.

5-5. PERFORMANCE CHECKS.

5-6. The performance checks presented in this section are front-panel procedures designed to compare the Model 3400A with its published specifications. These checks can be incorporated in periodic maintenance, post-repair, and incoming quality control inspection. These checks should be conducted before any attempt is made at instrument calibration. During all performance checks, periodically vary the Model 3400A line voltage $\pm 10\%$.

NOTE

Allows 30-minute warm-up period before making performance checks.

5-7. ACCURACY, LINEARITY, AND DC OUTPUT PERFORMANCE CHECK.

5-8. The accuracy, linearity, and dc output test setup is illustrated in Figure 5-1. A Voltmeter Calibrator (Model 738B) and a DC Voltmeter (Model 3440A 3444A) are required for this test.

- a. Connect test setup illustrated in Figure 5-1.
- b. Set Model 3400A RANGE switch to .001 position.
- c. Adjust Voltmeter Calibrator for 0.001 volt, 400 cps output: set dc voltmeter to measure 1 volt.
- d. If Model 3400A does not indicate within values listed under METER READING in Table 5-2, perform low frequency calibration procedure, Paragraph 5-31.
- e. Dc output as indicated on dc voltmeter should be within values listed under DC OUTPUT in Table 5-2.
- f. Repeat steps c thru e for remaining voltage values listed under VOLTMETER CALIBRATOR OUTPUT in Table 5-2.

Table 5-2. Accuracy, Linearity, and DC Output Performance Check, Supplemental Data

VOLTMETER CALIBRATOR OUTPUT	METER READING	DC OUTPUT
0.001 v	0.00099 to 0.00101	0.990 to 1.01
0.003 v	0.00297 to 0.00303	0.940 to 0.960
0.1 v	0.099 to 0.101	0.990 to 1.01
0.3 v	0.297 to 0.303	0.940 to 0.960
1.0 v	0.99 to 1.01	0.990 to 1.01
3.0 v	2.97 to 3.03	0.940 to 0.960
30.0 v	29.7 to 30.3	0.940 to 0.960
100.0 v	99.0 to 101.0	0.990 to 1.01
300.0 v	297.0 to 303.0	0.940 to 0.960

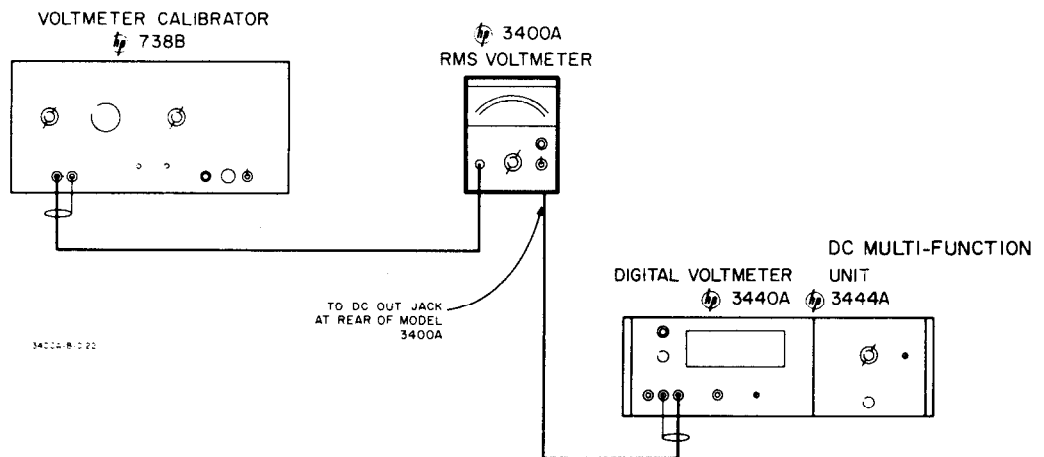


Figure 5-1. Accuracy, Linearity, and DC Output Test Setup

5-9. **FREQUENCY RESPONSE PERFORMANCE CHECK.**

5-10. The frequency response test setup is illustrated in Figure 5-2. A Frequency Response Test Set (Model 739AR) and an Oscillator (Model 651A) are required for this test.

NOTE

The Frequency Response Test Set used to check the 3400A accuracy should be calibrated at the end of its output cable. At 10 Mc there is typically a 2% loss in the 739A output cable.

- a. Connect test setup illustrated in Figure 5-2.
- b. Set Model 3400A RANGE switch and frequency response test set output attenuator to 1 volt position.
- c. Set frequency response test set to use external input.
- d. Adjust oscillator output frequency for 400 cps; adjust oscillator output amplitude for full-scale deflection on the Model 3400A
- e. Adjust frequency response test set meter to convenient reference.
- f. Adjust oscillator output frequency to values listed under FREQUENCY in Table 5-3; adjust oscillator output voltage to maintain reference set in step e. If Model 3400A does not indicate within values under METER READING in Table 5-3, perform high frequency calibration procedures, Paragraph 5-36.

5-11. **INPUT IMPEDANCE PERFORMANCE CHECK.**

5-12. An Oscillator (Model 651A) and a 200K Ω resistor (Part No. 0757-0782) are required for the input impedance performance check.

- a. Set Model 3400A RANGE switch to 1 volt position.
- b. Adjust oscillator output frequency to 50 cps; output voltage for full-scale deflection as indicated on Model 3400A.
- c. Insert 200 K Ω resistor in series with Model 3400A input; meter reading should change less than 0.02 volts. This corresponds to an input impedance of 10 megohms where:
$$E_{\text{change}} = \frac{E_{\text{app}} R_{\text{series}}}{R_{\text{total}}}$$
- d. Adjust oscillator frequency to 50 Kc; Model 3400A reading should be greater than 0.7 volts. This correspond to input shunt capacity of less than 15 pf.
- e. Set Model 3400A RANGE switch to .001 position.
- f. Repeat steps b and c.
- g. Adjust oscillator frequency to 16 Kc; Model 3400A reading should be greater than 0.7 volts. This corresponds to an input shunt capacity of less than 40 pf.

Table 5-3. Frequency Response Performance Check. Supplemental Data

FREQUENCY	METER READING
15 cps	0.95 to 1.05
45 cps	0.95 to 1.05
100 cps	0.99 to 1.01
900 Kc	0.99 to 1.01
1.2 Mc	0.98 to 1.02
1.8 Mc	0.98 to 1.02
2.2 Mc	0.97 to 1.03
2.8 Mc	0.97 to 1.03
3.2 Mc	0.95 to 1.05
9.8 Mc	0.95 to 1.05

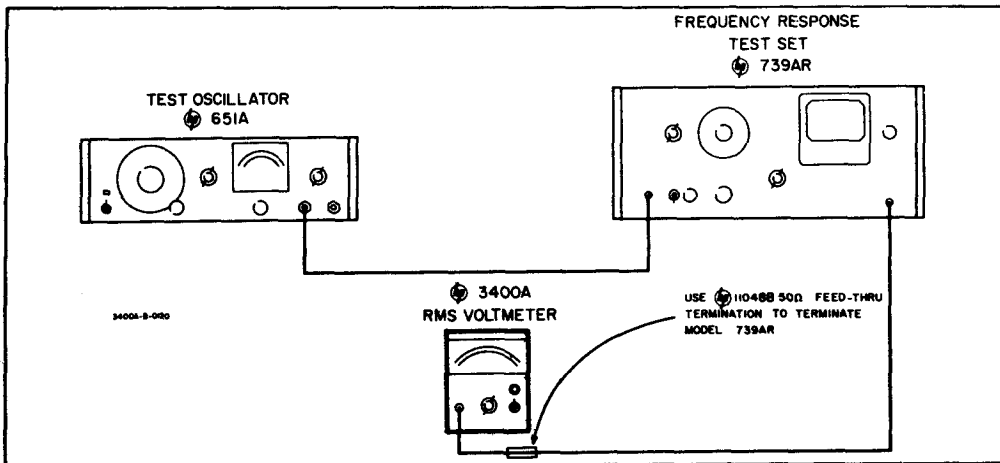


Figure 5-2. Frequency Response Test Setup

5-13. CREST FACTOR PERFORMANCE CHECK

5-14. The crest factor performance check test setup is illustrated in Figure 5-3. A Pulse Generator (Model 212A), a High Frequency Oscilloscope (Model 175A/1750B), and an Electronic Counter (Model 5512A) are required for this test.

- a. Connect test setup illustrated in Figure 5-3.
- b. Set Model 3400A RANGE switch to 0.1 volt position.
- c. Adjust pulse generator for pulse output with following characteristics:
 E peak 1.00 v as indicated on oscilloscope
 Pulse Rate 990 pps as indicated on electronic counter
 Pulse Width 10 μsec

This corresponds to a crest factor of 10 where:

$$E_{rms} = E\sqrt{D(1-D)} \text{ where } D = T_o/T$$

$$CF = \frac{E_{peak}}{E_{rms}}$$

$$= \frac{E(1-D)}{E\sqrt{D(1-D)}}$$

$$= \sqrt{\frac{1-D}{D}}$$

- d. Model 3400A should indicate 0.1 volt (±5%).
- e. Adjust pulse generator pulse rate to 250 pps as indicated on electronic counter; this corresponds to a crest factor of 20.
- f. Model 3400A should indicate 0.05 volts (±5%).

5-15. RESIDUAL NOISE PERFORMANCE CHECK.

5-16. A 100 KΩ shielded load is required for the residual noise performance check.

- a. Connect 100 KΩ shielded load to the Model 3400A INPUT.
- b. Rotate RANGE switch to 0.001. Zero offset should be less than 5% of full scale.

5-17. REPAIR PROCEDURES.

5-18. COVER REMOVAL.

5-19. When it is necessary to repair or adjust the Model 3400A, one or more covers will have to be removed. Refer to Figure 5-4 and the following steps for cover removal procedure.

- a. TOP COVER. Remove top cover screw; slide cover to rear and lift to remove.
- b. SIDE COVERS. Remove four screws in side cover; lift to remove.
- c. BOTTOM COVER. Remove bottom cover screw at rear of cover. Slide cover to rear and remove.

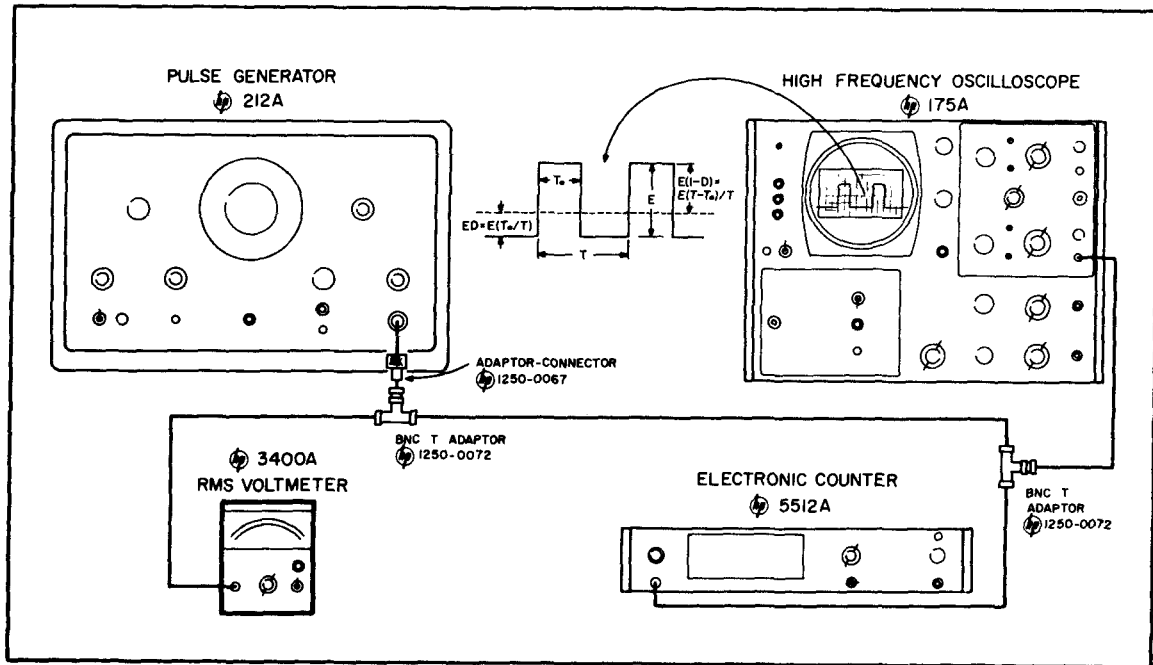


Figure 5-3. Crest Factor Test Setup

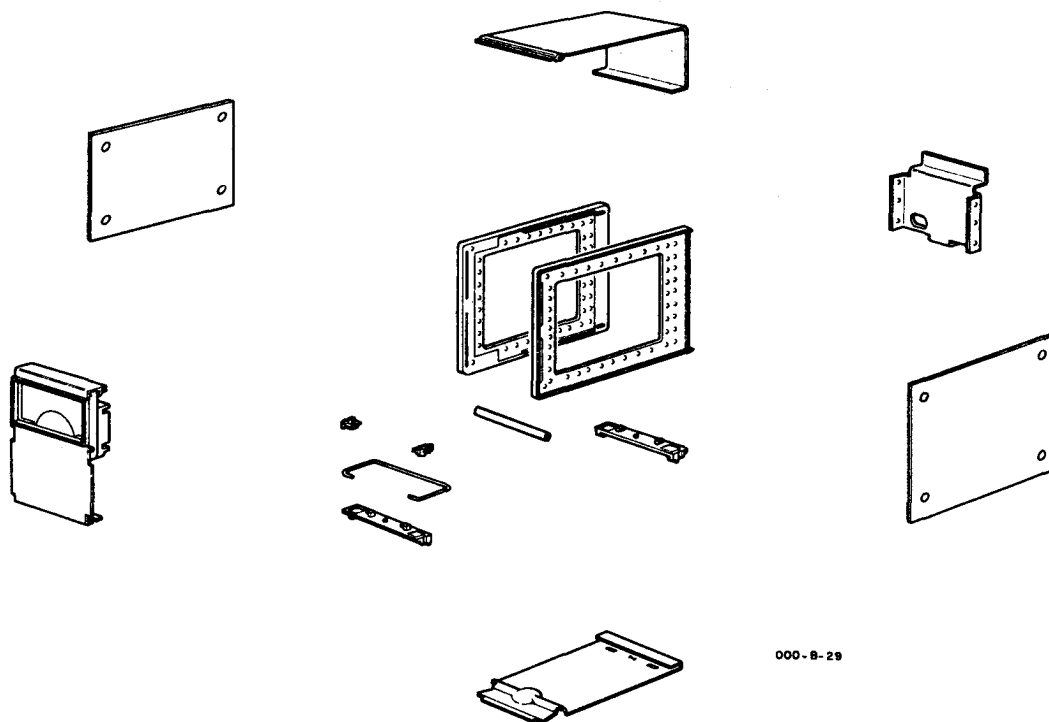


Figure 5-4. Model 3400A Modular Cabinet

5-20. SERVICING ETCHED CIRCUIT BOARDS.

5-21. The Model 3400A has five etched circuit boards. Use caution when removing them to avoid damaging mounted components. The assembly and Part No. are silk screened on the interior of the circuit board to identify it. Refer to Section VII for parts replacement and Part Number information.

5-22. The etched circuit boards are a plated-through type. The electrical connection between sides of the board is made by a layer of metal plated through the component holes. When working on these boards, observe the following general rules.

- a. Use a low-heat (25 to 50 watts) small-tip soldering iron and a small diameter rosin core solder.
- b. Circuit components can be removed by placing the soldering iron on the component lead on either side of the board and pulling up on lead. If a component is obviously damaged, clip leads as close to component as possible and then remove. Excess heat can cause the circuit and board to separate or cause damage to the component.
- c. Component lead hole should be cleaned before inserting new lead.

- d. To replace components, shape new leads and insert them in holes. Reheat with iron and add solder as required to insure a good electrical connection.
- e. Clean excess flux from the connection and adjoining area.
- f. To avoid surface contamination of the printed circuit, clean with weak solution of warm water and mild detergent after repair. Rinse thoroughly with clean water. When completely dry, spray lightly with Krylon (#1302 or equivalent).

5-23. THERMOCOUPLE REPLACEMENT.

CAUTION

Exercise extreme care when removing or replacing the amplifier printed circuit board assembly and when shaping the thermocouple leads.

5-24. Should a thermocouple be defective, it is necessary to replace both as a matched pair (see Section VII, Table of Replaceable Parts) to ensure for proper operation. To replace thermocouples, proceed as follows:

- a. Turn instrument power off and remove left side and top covers.
- b. Remove two screws in left side of amplifier board and one screw through ground lug connecting board to chassis.
- c. Lift board slightly to clear lanced guide on chasms. Gently pull bottom of board to outside until board will drop down and top will clear main frame. Adjust amplifier input and output cables to ensure free passage through grommets and carefully fold board down to expose the four nuts holding the thermocouple shield.
- d. Remove four shield nuts; lift shield off. Remove thermocouples, noting orientation.
- e. Leads must be shaped before inserting new thermocouples. Ensure that red dot on thermocouples face board. During the shaping process, hold leads between bending point and glass with long-nose pliers.
- f. Carefully install new thermocouples and solder. Refer to Paragraph 5-22.
- g. Clean the board as discussed in Paragraph 5-22. Carefully mask thermocouple shield during spraying.
- h. Apply silicon grease (Dow Corning 5 Compound or equivalent) to shield contact edges.
- j. Reverse steps d, c, b, and a for reassembly.
- k. Refer to Paragraph 5-25 and calibrate the amplifier.

5-25. ADJUSTMENT AND CALIBRATION PROCEDURES.

5-26. The following is a complete adjustment and calibration procedure for the Model 3400A. These operations should be conducted only if it has previously been established by Performance Checks, Paragraphs 5-5 to 5-16, that the Model 3400A is out of adjustment. Indiscriminate adjustment of the internal controls to refine settings may actually cause more difficulty. If the procedures outlined do not rectify any maladjustments that may exist, and you have carefully rechecked your connections and settings, refer to Paragraph 5-41, Troubleshooting, for possible cause and recommended corrective action.

5-27. MECHANICAL METER ZERO.

5-28. The mechanical meter zero screw is located on the instrument front panel. If the meter pointer does not indicate zero when the instrument power has been off for at least one minute, mechanically zero the meter following the procedure outlined below.

- a. Turn instrument power off; disconnect input signal; remove cable from J2 (DC OUT) at rear of instrument; and allow one minute for meter pointer to stabilize.
- b. Rotate zero adjust CW until pointer is to left of zero, moving up scale. Continue until pointer is at zero. If pointer overshoots zero, repeat operation.
- c. When the pointer is exactly at zero, rotate the adjusting screw slightly counterclockwise to free it. If the meter pointer moves to the left during this adjustment, repeat steps b through c.

Table 5-4. Power Supply Checks

POWER SUPPLY	TEST EQUIPMENT AND CHECK POINT	DC VOLTAGE SPECIFICATIONS	REGULATION (Vary line voltage between 103.5 and 126.5 vac)	RIPPLE SPECIFICATIONS
-17.5 vdc	Connect DC Voltmeter, AC Voltmeter, or Oscilloscope to pin 1 (violet lead) on chopper amplifier (A6) and chassis ground.	-17 to -18 vdc	±0.5 volt from nominal reading at 115 vac line.	400 μv rms or 1.1 mv p-p
+75 vdc	Connect DC Voltmeter, AC Voltmeter, or Oscilloscope to pin 15 (red/wht/blue) of chopper amplifier (A6) and chassis ground.	70.0 to 78.0 vdc	±1 volt from nominal reading at 115 vac line.	400 μv rms or 1.1 mv p-p
-6.3 vdc	Connect DC Voltmeter, AC Voltmeter, or Oscilloscope to Q3 emitter (grey lead) and chassis ground.	-5.9 to -6.5 vdc	±0.1 volt from nominal reading at 115 vac line.	2 mv rms or 5.7 mv p-p

5-29. POWER SUPPLY CHECKS.

5-30. Power supply voltage and ac ripple specifications are listed in Table 5-4. Test points are also indicated in this table. When making ripple voltage measurements, it may be desirable to isolate the ac testing instrument from power line ground to avoid any undesirable ground loop currents. Use a three-prong to two-prong adapter in the power line receptacle.

5-31. LOW FREQUENCY CALIBRATION.

5-32. The low frequency calibration comprises the amplifier gain adjustment, the 1/10 scale adjustment, and the 1 volt adjustment. A Voltmeter Calibrator (Model 738B) and a DC Voltmeter (Model 3440A/3444A) are required.

5-33. AMPLIFIER GAIN ADJUSTMENT.

- a. Connect test setup illustrated in Figure 5-1.
- b. Set Model 3400A RANGE switch to .01 volt position.
- c. Adjust voltmeter calibrator for 0.01 volt, 400 cps output; set dc voltmeter to measure 1 volt.
- d. Remove Model 3400A top cover; adjust R4 (CAL) for 1.0 volt as indicated on dc voltmeter. If R4 (CAL) does not have enough range to calibrate the dc output, the value of R3 should be changed. Typical range of R3 is from 1.0 K to 2.6 K ohms.
- e. Adjust R6 (FULL SCALE ADJUST) for Model 3400A full-scale meter reading.

5-34. 1/10 SCALE ADJUSTMENT.

- a. Connect test setup illustrated in Figure 5-1; omit dc voltmeter.
- b. Set Model 3400A RANGE switch to .1 volt position.
- c. Adjust voltmeter calibrator for 0.01 volt, 400 cps output.

NOTE

The 1/10 SCALE ADJUST should be set slightly low (needle's width) to reduce meter (needle) offset with shorted input.

- d. Remove Model 3400A top cover; adjust R7 (1/10 SCALE ADJUST) for Model 3400A 1/10 scale meter reading.

5-35.1 VOLT ADJUSTMENT.

- a. Connect test setup illustrated in Figure 5-1.
- b. Set Model 3400A RANGE switch to 1 volt position.
- c. Adjust voltmeter calibrator for 1.0 volt, 400 cps output.
- d. Adjust R104 (1 V ADJUST) for Model 3400A for full-scale reading.

5-36. HIGH FREQUENCY CALIBRATION.

5-37. The high frequency calibration comprises the amplifier gain adjustment, the input attenuator adjustment, and the second attenuator adjustment. A

Frequency Response Test Set (Model 739AR) and an Oscillator (Model 651A) are required.

5-38. AMPLIFIER GAIN ADJUSTMENT.

NOTE

The frequency response test set used to calibrate the 3400A should be calibrated at the end of its output cable. At 10 Mc there is typically a 2% loss in the output cable.

- a. Connect test setup illustrated in Figure 5-2.
- b. Set Model 3400A RANGE switch and frequency response test set output attenuator to 1 mv position.
- c. Set frequency response test set to use external input.
- d. Adjust oscillator output frequency for 400 cps; output voltage for 90% full scale as indicated on Model 3400A meter.
- e. Adjust frequency response test set meter to convenient reference.
- f. Adjust oscillator output frequency for 10 Mc; output voltage to maintain reference set in step e.
- g. Remove Model 3400A left-side cover; adjust C405 (10 MC ADJUST) for 90% full scale as indicated on Model 3400A meter. Replace cover; readjust C405 if meter reading varies from 90% full scale.
- h. Vary oscillator between 3 and 10 Mc; maintain oscillator output voltage to reference set in step e. If Model 3400A meter reading varies below 85% or above 95% of full scale, repeat step g until optimum response is obtained between 3 and 10 Mc.

5-39. INPUT ATTENUATOR ADJUSTMENT.

NOTE

The frequency response test set used to calibrate the 3400A should be calibrated at the end of its output cable. At 10 Mc there is typically a 2% loss in the output cable.

- a. Connect test setup illustrated in Figure 5-2.
- b. Set Model 3400A RANGE switch and frequency response test set output attenuator to 1 volt position.
- c. Set frequency response test set to use external input.
- d. Adjust oscillator output frequency for 400 cps; output voltage for 90% full scale as indicated on Model 3400A meter.
- e. Adjust frequency response test set meter to convenient reference.
- f. Adjust oscillator output frequency for 100 Kc; output voltage to maintain reference in step e.

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Paragraphs 5-40 to 5-49 and Table 5-5

- g. Remove Model 3400A bottom cover; adjust C102 (1 V, 100 KC ADJUST) for 90% full scale as indicated on Model 3400A meter. Replace cover; readjust C405 if meter reading varies from 90% full scale.
- h. Vary oscillator between 100 Kc and 10 Mc; maintain oscillator output voltage to reference set in step e. If Model 3400A meter reading varies more than $\pm 1\%$ to 1 Mc, $\pm 2\%$ from 1 Mc to 2 Mc, $\pm 3\%$ from 2 Mc to 3 Mc, or $\pm 5\%$ from 3 Mc to 10 Mc, repeat step g until optimum response is obtained.

5-40. SECOND ATTENUATOR ADJUSTMENT.

NOTE

The frequency response test set used to calibrate the 3400A should be calibrated at the end of its output cable. At 10 Mc there is typically a 2% loss in the output cable.

- a. Connect test setup illustrated in Figure 5-2.
- b. Set Model 3400A RANGE switch and frequency response test set output attenuator to .3 volt position.
- c. Set frequency response test set to use external input.
- d. Adjust oscillator output frequency for 400 cps; output voltage for 90% full scale as indicated on Model 3400A meter.
- e. Adjust frequency response test set meter to convenient reference.
- f. Adjust oscillator output frequency for 3 Mc; output voltage to maintain reference in step e.
- g. Remove Model 3400A bottom cover; adjust C303 (.3 V ADJ) for 90% full scale as indicated on Model 3400A meter.
- h. Vary oscillator between 3 Mc and 10 Mc; maintain oscillator output voltage to reference set

in step e. If Model 3400A meter reading varies below 85% or above 95% of full scale, repeat step g until optimum response is obtained between 3 and 10 Mc.

5-41. TROUBLESHOOTING PROCEDURE.

5-42. This section contains procedures designed to assist in the isolation of malfunctions. These operations should be undertaken only after it has been established that the difficulty cannot be eliminated by the Adjustment and Calibration Procedures, Paragraph 5-25. An investigation should also be made to ensure that the trouble is not a result of conditions external to the Model 3400A.

5-43. Conduct a visual check of the Model 3400A for possible burned or loose components, loose connections, or any other condition which might suggest a source of trouble.

5-44. Table 5-5 contains a summary of the front-panel symptoms that can be used in initial efforts to select a starting point for troubleshooting operations.

5-45. Table 5-6, in conjunction with Figure 5-5, contains procedures which may be used as a guide in isolating malfunctions. The steps in Table 5-6 describe the normal conditions which should be encountered during the checks (circled numbers **(N)**) in Figure 5-5.

5-46. The checks outlined in Table 5-6 are not designed to measure all circuit parameters, rather, only to localize the malfunction. Therefore, it is quite possible that additional measurements will be required to completely isolate the problem. Amplifier gain may also vary slightly between instruments; therefore, it should not be necessary to precisely duplicate waveforms or values described.

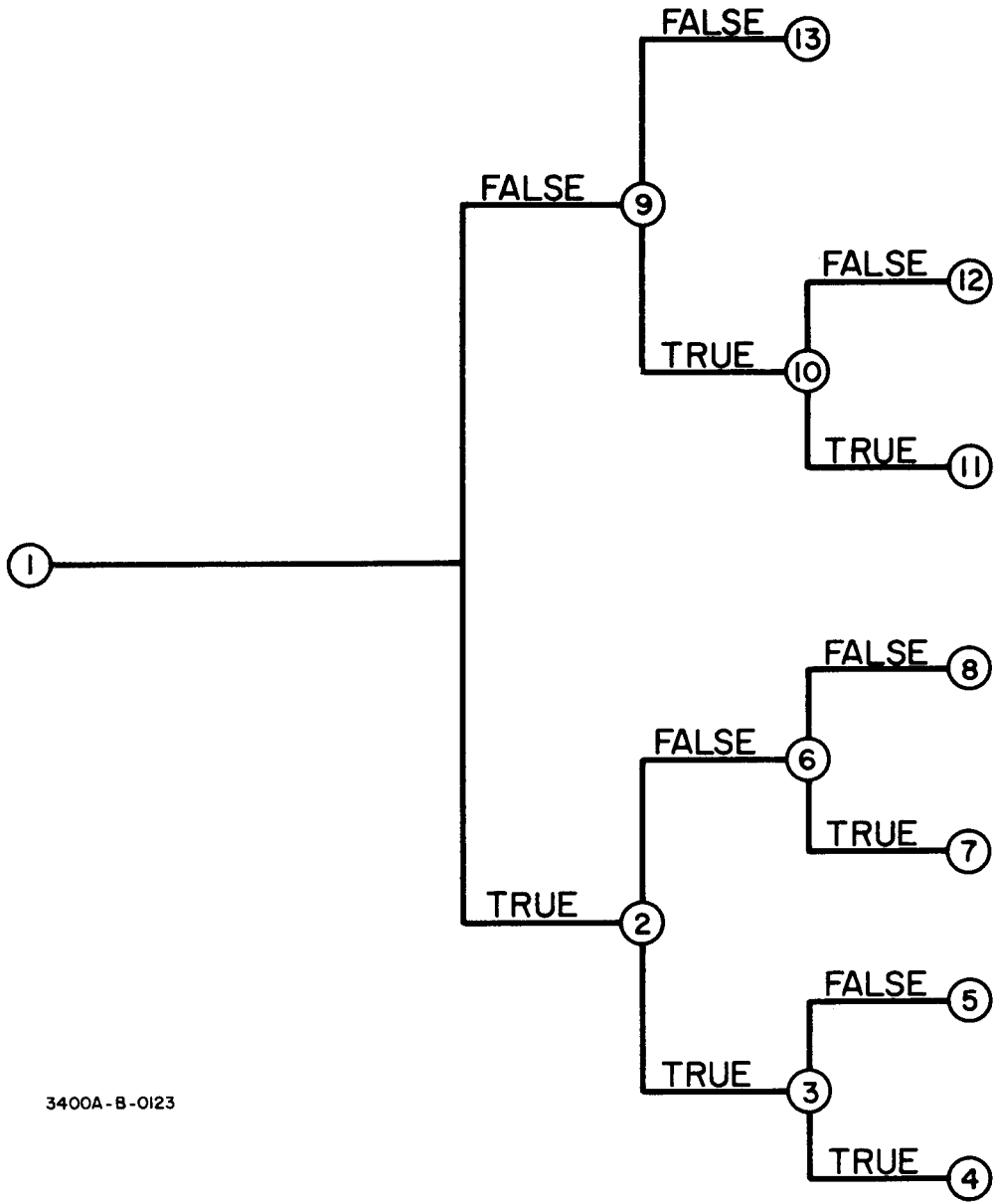
5-47. Voltage values indicated are based on 0.1 v rms input at 400 cps unless otherwise specified.

5-48. When required, check power supply voltages as outlined in Paragraph 5-29.

5-49. Figures 5-6 through 5-17 are typical waveforms in Model 3400A.

Table 5-5. Front Panel Symptoms

SYMPTOM	POSSIBLE CAUSE
1/2 scale readings on all RANGE switch settings and input voltages.	Chopper Amplifier (A6), C612.
3 to 5% meter offset on all ranges with shorted input.	R7 misadjusted. C405 misadjusted. Check Q605.
400 cps calibration low and frequency response falls off above 50 Kc.	Q401 or Q402 shorted.
Switching transients exceed 5% of full scale with shorted input.	Check collector voltage of Q201 (should not exceed 9.0v).
Instrument has been overloaded.	Check Q201, Q401, and Q402.
Meter jitter or flutter exceeds 0.5% of full scale.	Check Q601, Chopper Assembly (neons).
Full-scale difference from range to range.	Check resistors in second attenuator.

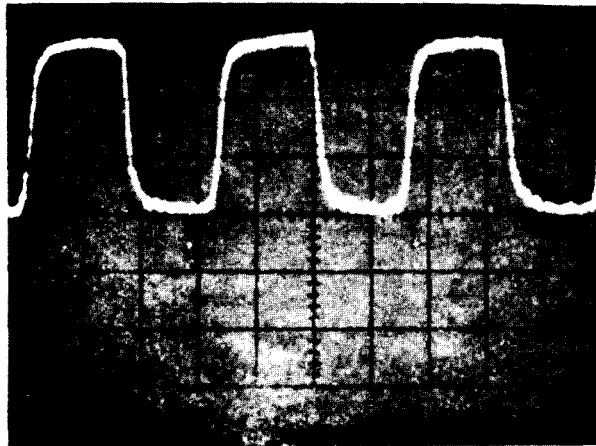


3400A-B-0123

Figure 5-5. Troubleshooting Tree

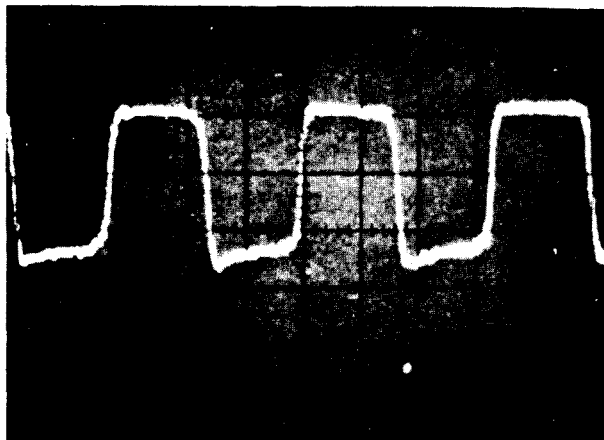
Table 5-6. Troubleshooting Procedure

CHECK	PROCEDURE	ACTION
①	Measure ac signal at junction of C413 and C415. Reading should be between 240 mv and 260 mv.	TRUE: Proceed to check ②. FALSE: Proceed to check ⑨.
②	Measure ac signal to Demodulator at positive end of C605. Refer to Figures 5-6 through 5-8.	TRUE: Proceed to check ③. FALSE: Proceed to check ⑥.
<p>NOTE</p> <p>Waveforms shown in Section V are typical and may vary in amplitude and/or width from instrument to instrument, depending on frequency of modulator.</p>		



(Junction of C605 and V503)
3400A on 1 volt range with 1 volt input.
Scope (175A)
Sweep = 5 ms/cm
Vert = 0.2 volts/cm
Dc coupled (Center graticule = 0)

Figure 5-6. Input to Demodulator



(Junction of C605 and V503)
3400A on 1 volt range with 0.1 volt input.
Scope (175A)
Sweep = 5 ms/cm
Vert = 0.2 volts/cm
Dc coupled (Center graticule = 0)

Figure 5-7. Input to Demodulator

Table 5-6. Troubleshooting Procedure (Cont'd)

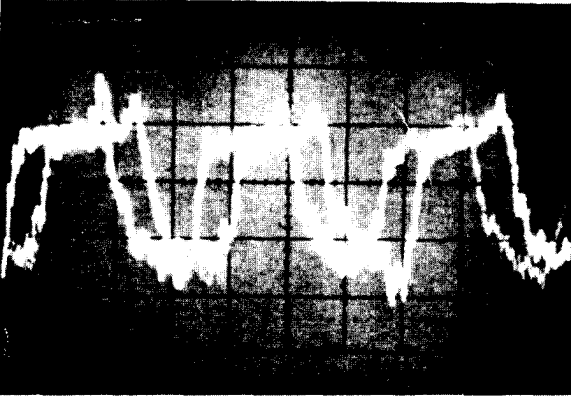
CHECK	PROCEDURE	ACTION
<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;">  </div> <div style="width: 50%;"> <p>(Junction of C605 and V503) No input; 3400A on 1.0 v range. Scope (175A) Sweep = 5 ms/cm Vert = 0.1 v/cm Dc coupled (Noise - caused by faulty chopper or Q605)</p> </div> </div> <p style="text-align: center;">Figure 5-8. Input to Demodulator</p>		
<p>③</p> <p>④</p> <p>⑤</p> <p>⑥</p>	<p>Measure dc level at the base of Q604. Reading should be -0.6 v for full-scale deflection.</p> <p>Investigate Emitter Follower.</p> <p>Investigate Demodulator.</p> <p>Measure the ac voltage at the positive side of C605 during slight overdrive conditions (1.0 v input on 0.3 v range). See Figure 5-9.</p>	<p>TRUE: Proceed to check ④. FALSE: Proceed to check ⑤.</p> <p>a. Check dc values and component values listed in Figure 6-3. b. Check Q604 and Q605. c. Check C612. If this capacitor were slightly open, amplifier gain would be reduced and Q604 base voltage approaches zero. Voltage across C612 should be less than 300 μv peak-to-peak. d. If Q604 bias voltage is abnormal, check CR604.</p> <p>a. Observe Demodulator input on oscilloscope using LINE SYNC. At full-scale deflection, waveform should be negative. As deflection decreases to zero, waveform inverts, passing through zero at approximately one-half scale. Noise in Figure 5-8 caused by either faulty neons in chopper or Q605. Figure 5-13 is indicative of faulty chopper neon. b. Demodulator output should be proportional to ac input.</p> <p>TRUE: Proceed to check ⑦. FALSE: Proceed to check ⑧.</p>

Table 5-6. Troubleshooting Procedure (Cont'd)

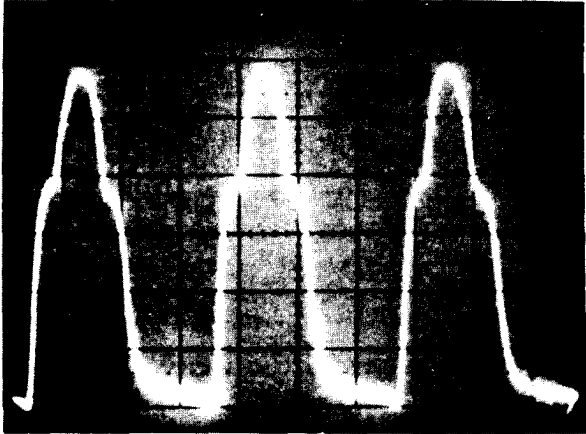
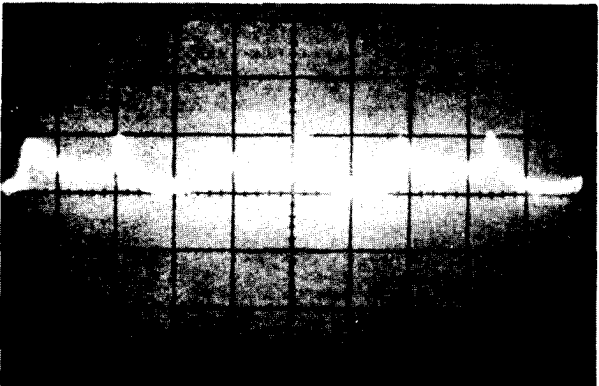
CHECK	PROCEDURE	ACTION
	 <p data-bbox="672 919 1127 948">Figure 5-9. Demodulator Input (Overdriven)</p>	<p data-bbox="1052 542 1308 571">(Junction C605 and V503)</p> <p data-bbox="1052 578 1382 607">3400A on .3 v range with 1 v input.</p> <p data-bbox="1052 613 1182 642">Scope (175A)</p> <p data-bbox="1052 648 1230 677">Sweep = 5 ms/cm</p> <p data-bbox="1052 683 1198 712">Vert = 2 v/cm</p> <p data-bbox="1052 718 1166 747">Dc coupled</p>
<p data-bbox="396 1023 423 1052">⑦</p>	<p data-bbox="483 1023 922 1094">Investigate Demodulator output during normal and overdrive conditions. See Figures 5-10 and 5-11.</p>	<p data-bbox="980 1023 1464 1073">TRUE: Perform check ④; investigate feedback loops.</p> <p data-bbox="980 1073 1263 1102">FALSE: Perform check ⑤.</p>
	 <p data-bbox="678 1665 1127 1694">Figure 5-10. Demodulator Output (Normal)</p>	<p data-bbox="1039 1321 1169 1350">(BASE Q604)</p> <p data-bbox="1039 1357 1354 1386">3400A on 1 v range with 1 v input.</p> <p data-bbox="1039 1392 1169 1421">Scope (175A)</p> <p data-bbox="1039 1427 1218 1456">Sweep = 5 ms/cm</p> <p data-bbox="1039 1462 1201 1491">Vert = 0.1 v/cm</p> <p data-bbox="1039 1498 1153 1527">Dc coupled</p>

Table 5-6. Troubleshooting Procedure (Cont'd)

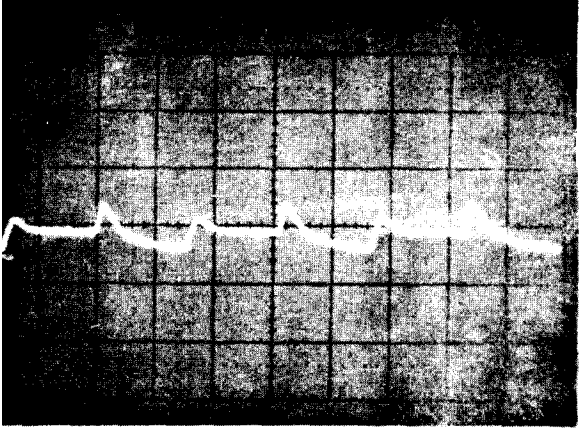
CHECK	PROCEDURE	ACTION
		<p>(BASE Q604) 3400A on .3 v range with 1 v input. Scope (175A) Sweep = 5 ms/cm Vert = 0.5 v/cm Dc coupled</p> <p>Figure 5-11. Demodulator Output (Overdriven)</p>
<p>⑧</p>	<p>Investigate Modulator, Chopper Amplifier, and Thermocouples. See Figures 5-12 through 5-17.</p>	<ol style="list-style-type: none"> a. Disconnect the base of Q604 from the chopper assembly (V503). Insert a dc signal, through a small resistor (1 K Ω), between the base of Q604 and chassis ground, to provide -1.0v(+.15 v for 1/10 scale deflection). The meter should indicate full-scale deflection. Trace the signal from the base of Q604, through the thermocouples, back to the modulator and through the chopper amplifier. b. Should a defective modulator be suspected, break the line between pin 13 (A6) and V501. Apply a 10 mv dc signal through a 500 K resistor to V501. Check for a "chopped" waveform at the junction of V501 and V502. The modulated output should be proportional to input dc level at pin 13. c. Figure 5-12 describes a proper neon voltage waveform. Figure 5-13 describes an improperly firing neon. Note negative voltage dip during conduction. Current variation through neon, following voltage waveform, causes noise as shown in Figure 5-8. For proper chopper action, neon firing potential (most negative point on waveform) is typically between 110 v and 120 v (never greater than 130 v). Jitter occurring on front panel meter may be seen at firing point or extinguishing point. d. Check thermocouples and dc feedback from C608. Check thermocouples for open circuit or ground.

Table 5-6. Troubleshooting Procedure (Cont'd)

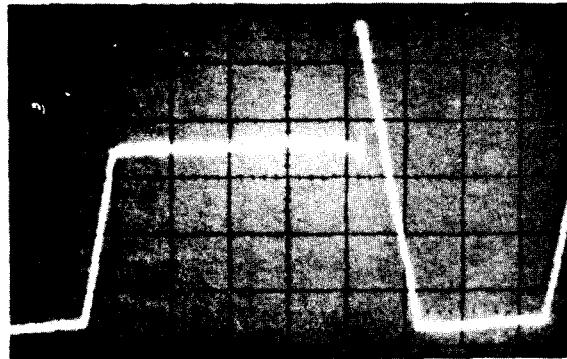


Figure 5-12
CHOPPER NEON VOLTAGE
(Pins 3 and 5, A6)
No input voltage to 3400A.
Scope (175A)
Sweep = 5 ms/cm
Vert = 20 v/cm
Dc coupled

Figure 5-12. Chopper Neon Voltage, Serials Prefixed 322, 401

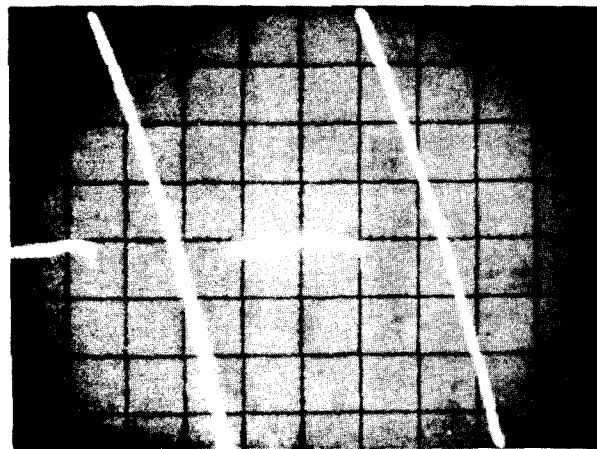


Figure 5-13
CHOPPER NEON VOLTAGE
(Pins 3 and 5, A6)
No input voltage to 3400A.
Scope (175A)
Sweep = 5 ms/cm
Vert = 10 v/cm
Dc coupled

Figure 5-13. Chopper Neon Voltage, Serial Prefixed 528

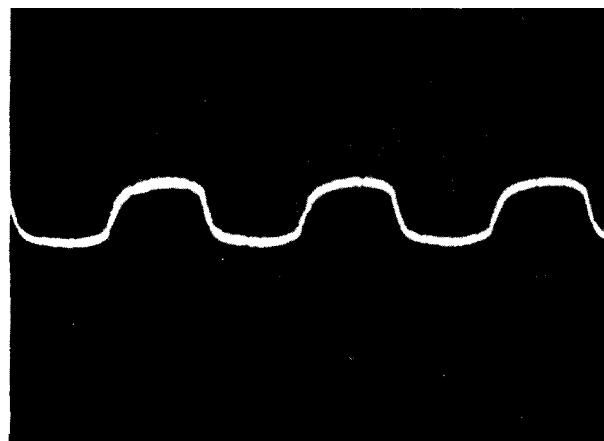


Figure 5-14
OUTPUT OF MODULATOR (OVER-DRIVEN)
Waveform taken at the junction of V501 and C601
3400A on 0.3 volt range with 1 v input.
Scope:
Sweep = 5 ms/cm
Vert = 5 mv/cm

Figure 5-14. Output of Modulator (Overdriven)

Table 5-6. Troubleshooting Procedure (Cont'd)

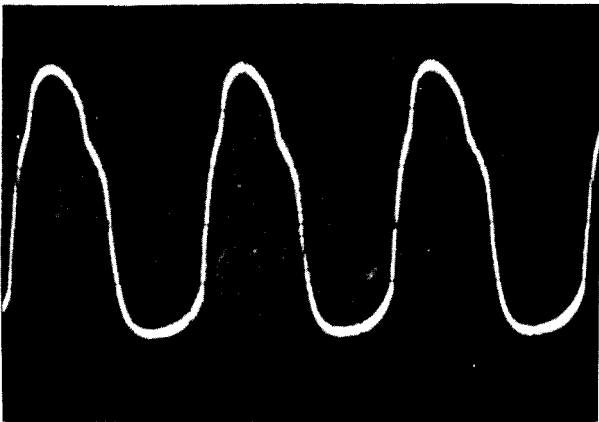


Figure 5-15
COLLECTOR OF Q601
3400A on 0.3 volt range with 1 v input.
Scope:
Sweep = 5 ms/cm
Vert = 5 mv/cm

Figure 5-15. Collector of Q601

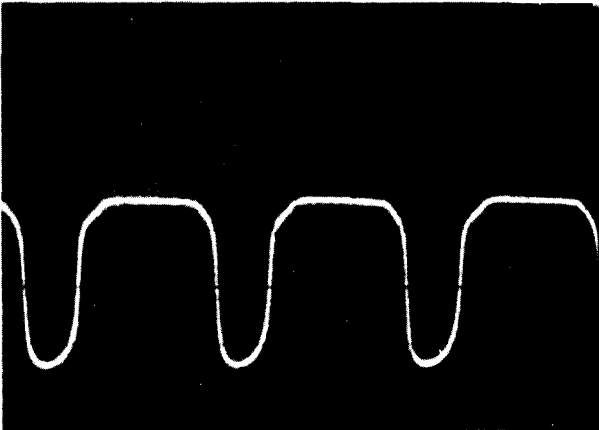


Figure 5-16
COLLECTOR OF Q602
3400A on 0.3 volt range with 1 v input.
Scope:
Sweep = 5 ms/cm
Vert = 0.2 v/cm

Figure 5-16. Collector of Q602

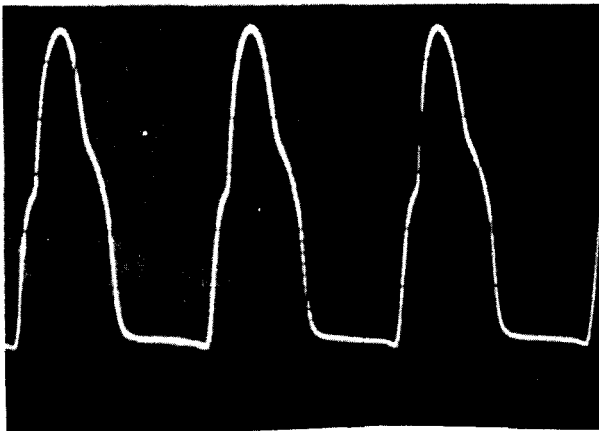


Figure 5-17
COLLECTOR OF Q603
3400A on 0.3 volt range with 1 v input.
Scope:
Sweep = 5 ms/cm
Vert = 2 v/cm

Figure 5-17. Collector of Q603

Table 5-6. Troubleshooting Procedure (Cont'd)

CHECK	PROCEDURE	ACTION
⑨	Measure ac signal to second Attenuator at negative end of C205. Reading should be between 0.90 mv and 1.0 mv.	TRUE: Proceed to check ⑩. FALSE: Proceed to check ⑬.
⑩	Measure ac signal to Amplifier (A4) at the positive side of C402. Reading should be 0.95 mv.	TRUE: Proceed to check ⑪. FALSE: Proceed to check ⑫.
⑪	Investigate Amplifier (A4).	a. Check ac voltage at the junction of C402 and Q401 (0.95 mv). b. Check C405. Although it is a high frequency adjustment, it can affect 400 cps calibration. This could affect 1 v tracking or cause excessive noise or oscillation. c. Amplifier gain can be checked using circled ac values in Figure 6-2. d. Check Q401 and Q402. If Q401 gain is low, check feedback loop through C411. e. If bias at Q405 or Q406 is abnormal, check CR401, 407, 408, and R419. Dc voltage at collector of Q406 should be -2 v ±0.5 v. R419 can be adjusted (0 to 350 ohms) in an effort to accomplish this. If the dc voltage is exceedingly high, check for shorted transistors or diodes.
⑫	Investigate Second Attenuator.	a. Check voltage at junction of C205 and R302. b. In six lower ranges, this voltage should equal the input signal (±5%). c. When replacing attenuator resistors, matched set must be utilized.
⑬	Investigate Input Attenuator and Impedance Converter.	a. Check R101 (10 M ±1/4%). b. On the higher six ranges, the input attenuator should appear as a 1000:1 divider. c. Check C102. d. Dc collector voltage at Q201 should not exceed 9.0 v, or switching transients will be introduced.

5-50. NEON SUBASSEMBLY, ④ PART NO. 1990-0206, REPLACEMENT IN PHOTOCOPPER ASSEMBLY ④ PART NO. 1990-0017.

5-51. To replace neon subassembly, proceed as follows:

- a. Remove chopper amplifier assembly (A6).
- b. Disconnect all components and leads attached to photochopper assembly at the A6 board. Note location of connections for remounting of chopper assembly.
- c. Remove the two screws on back of board and remove the chopper assembly from the A6 board. When removing the neon subassembly, note that

the three wire cable grommet is off centered toward the end of the chopper block that has the green wire connected to it.

- d. Remove and discard the defective neon subassembly.
- e. Install replacement neon subassembly (-hp-Part No. 1990-0206). Insure replacement is orientated correctly. See note in step 3 above.
- f. Remount the chopper assembly. Reconnect all components and leads disconnected in step 2.
- g. Recalibrate the Model 3400A as outlined in the Maintenance Section.

SECTION VI
CIRCUIT DIAGRAMS

6-1. INTRODUCTION.

6-2. This section contains the circuit diagrams necessary for the operation and maintenance of the Model 3400A RMS Voltmeter. Included are schematic and parts location diagrams.

6-3. SCHEMATIC DIAGRAMS.

6-4. The schematic diagrams depict the circuits contained within each assembly of the 3400A as well as assembly interconnection. Main signal paths and significant feedback paths are identified.

6-5. The schematic diagrams are arranged in ascending order of assembly reference designation.

6-6. PARTS LOCATION DIAGRAMS.

6-7. The parts location diagrams show the physical location of parts within an assembly. Parts are identified-by reference designation. A parts location diagram is included for each assembly which does not have adequate silk screening of reference designations

6-8. The parts location diagrams are located on the same figure as the schematic of the assembly.

Model 3400A

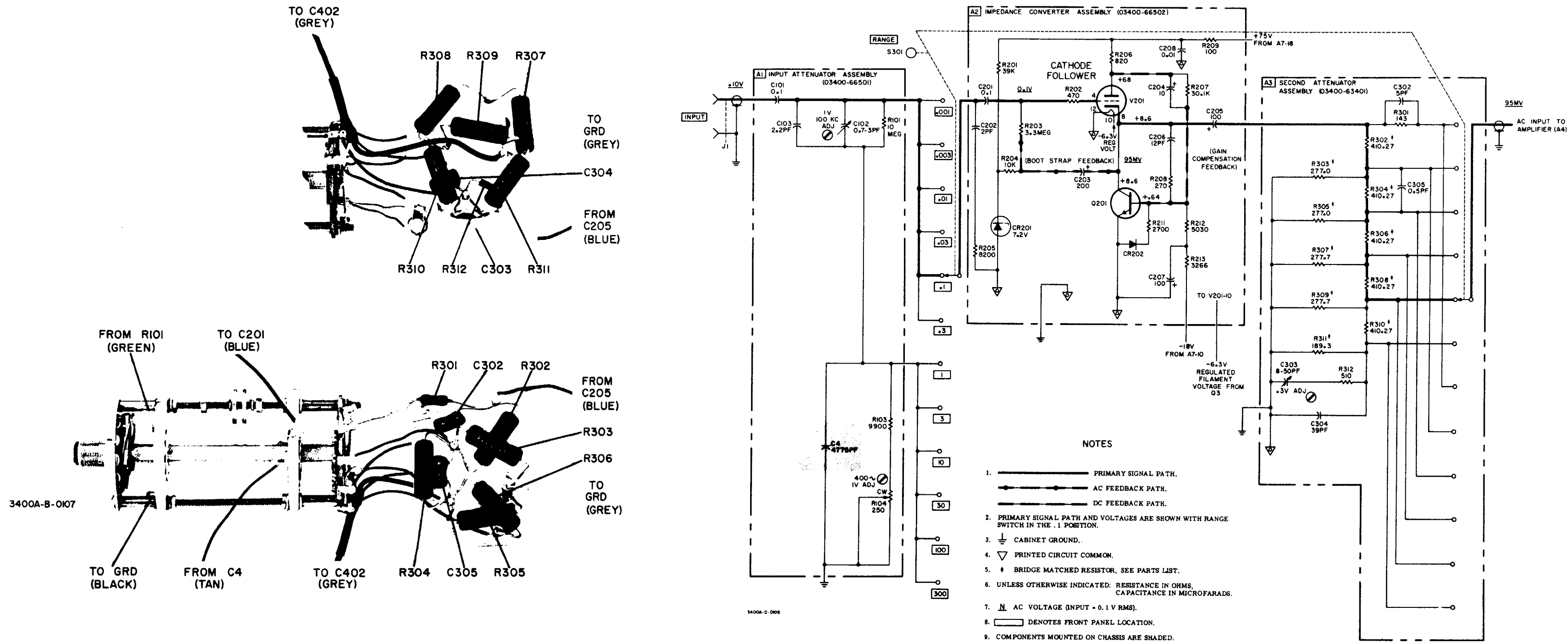
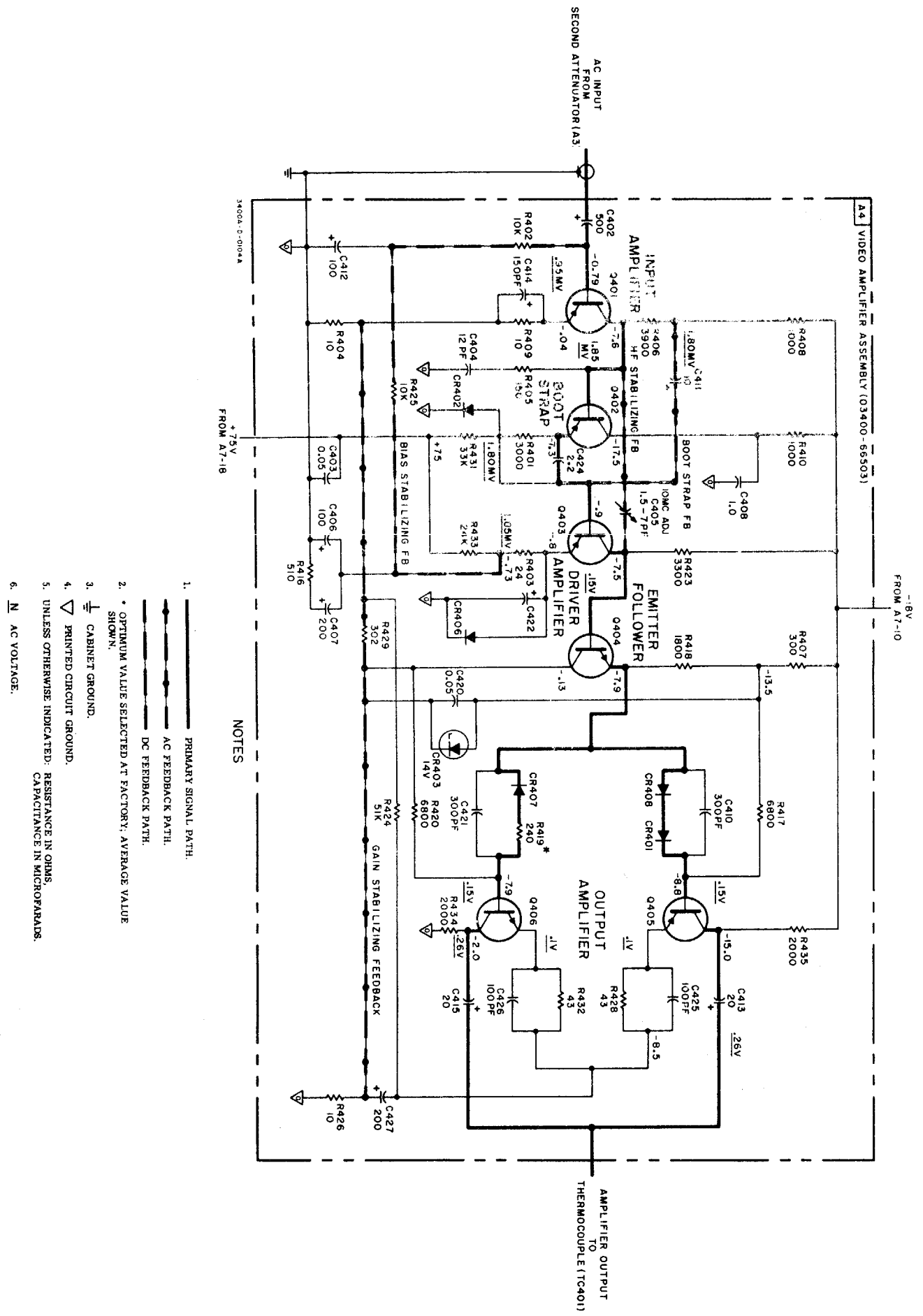


Figure 6-1. Input Attenuator A1, Impedance Converter A2, and Second Attenuator A3 Schematic and Parts Location Diagram



A4 AMPLIFIER ASSEMBLY (03400-66503)

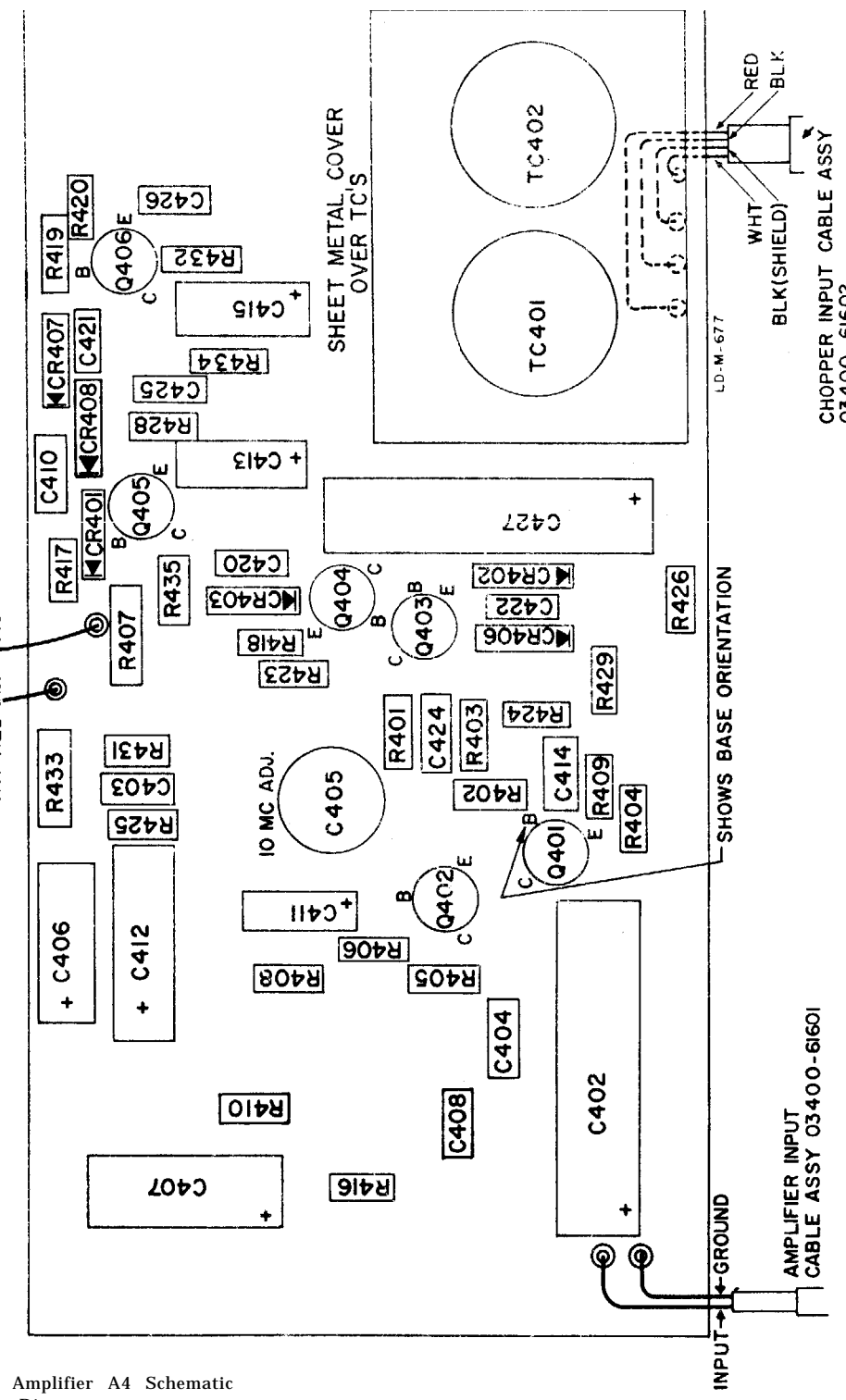
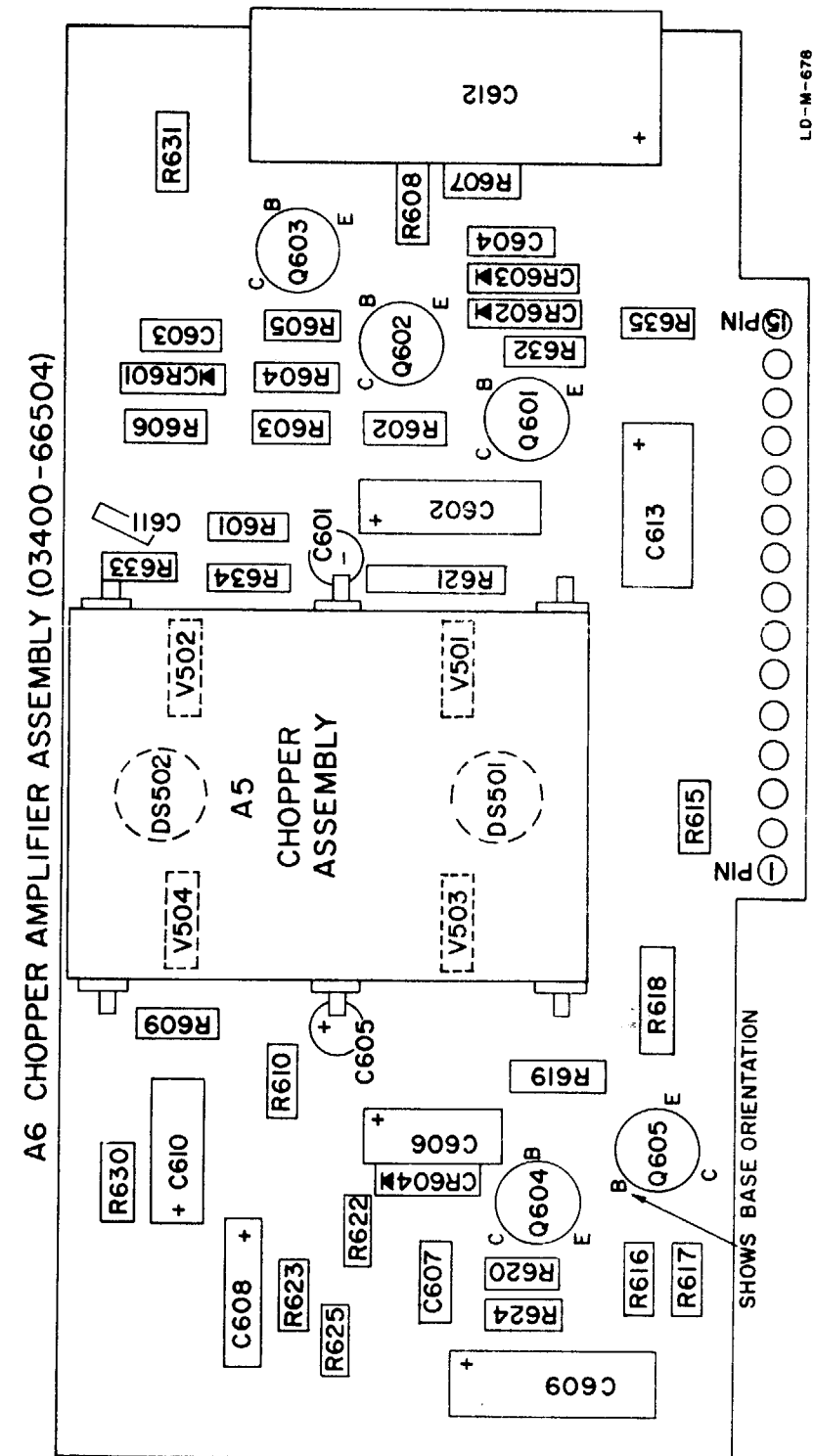


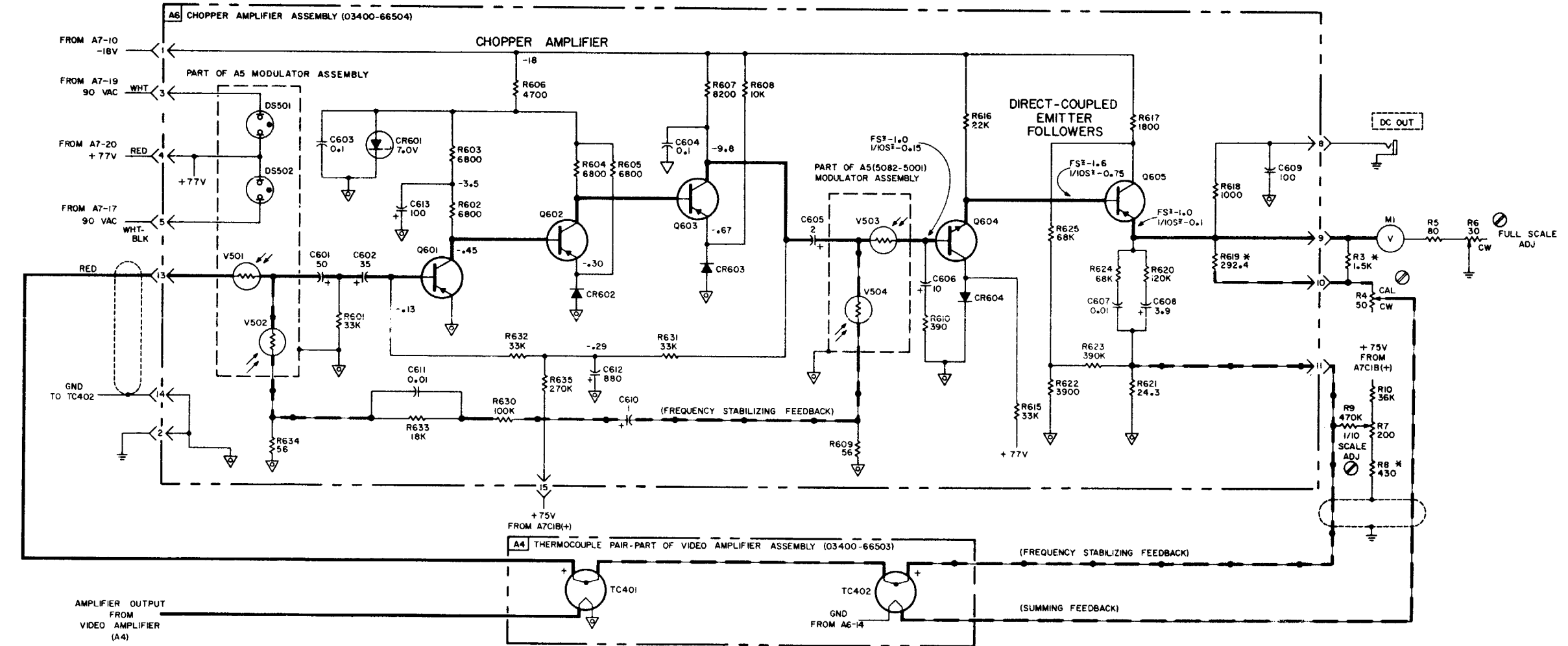
Figure 6-2. Video Amplifier A4 Schematic and Parts Location Diagram

- NOTES
1. PRIMARY SIGNAL PATH.
 2. AC FEEDBACK PATH.
 3. DC FEEDBACK PATH.
 4. OPTIMUM VALUE SELECTED AT FACTORY; AVERAGE VALUE SHOWN.
 5. PRINTED CIRCUIT GROUND.
 6. UNLESS OTHERWISE INDICATED: RESISTANCE IN OHMS; CAPACITANCE IN MICROFARADS.
 7. AC VOLTAGE.

Model 3400A



LD-M-678

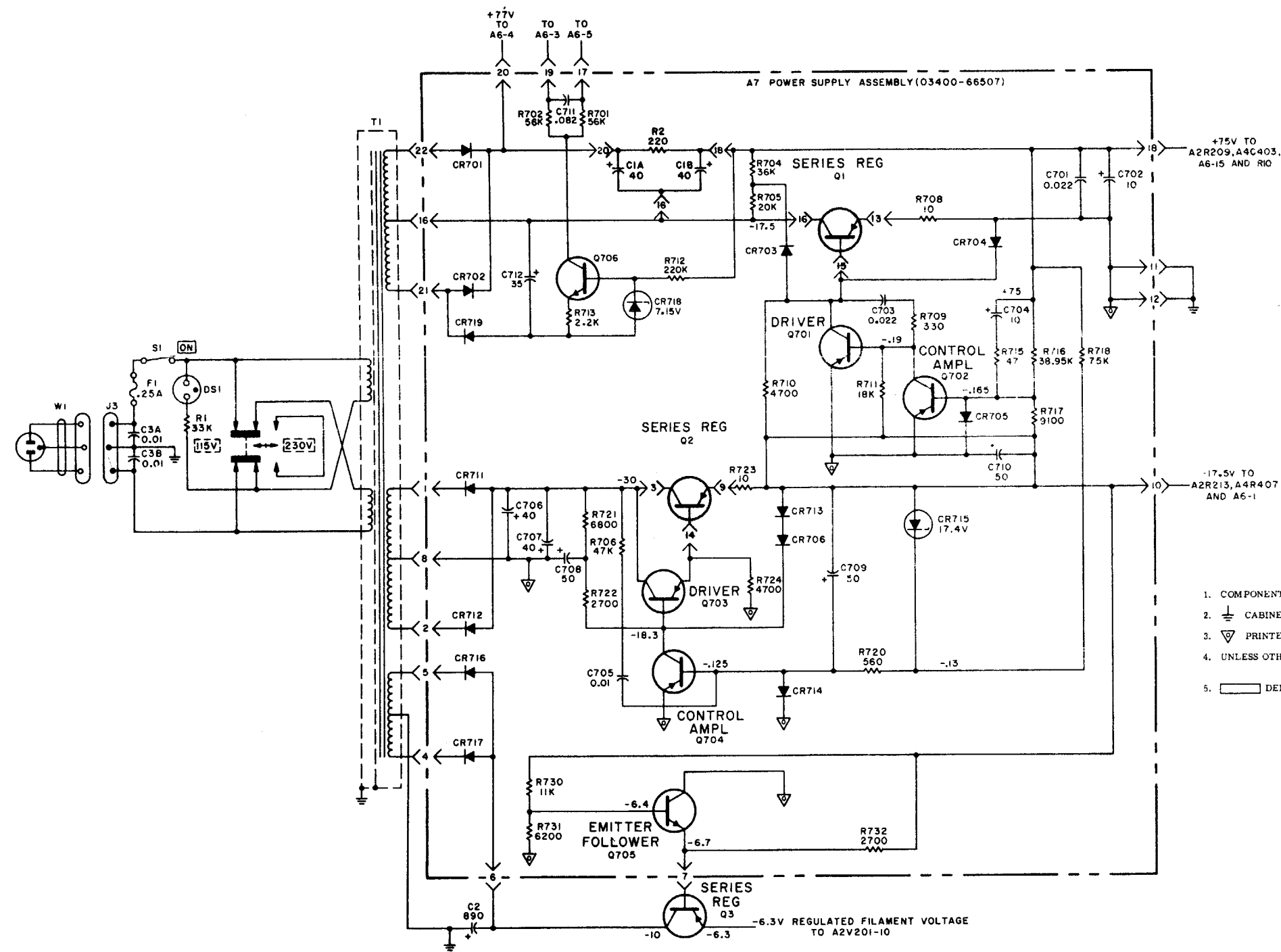


3400A-D-0088A

NOTES

1. — PRIMARY SIGNAL PATH.
- - - AC FEEDBACK PATH.
- - - DC FEEDBACK PATH.
2. * OPTIMUM VALUE SELECTED AT FACTORY; AVERAGE VALUE SHOWN.
3. ⊥ CABINET GROUND.
4. ▽ PRINTED CIRCUIT GROUND.
5. UNLESS OTHERWISE INDICATED, RESISTANCE IN OHMS, CAPACITANCE IN MICROFARADS.
6. [] DENOTES REAR PANEL LOCATION.

Figure 6-3. Modulator/Demodulator A5, Chopper Amplifier A6, and Thermocouple Pair (Part of A4) Schematic and Parts Location Diagram



NOTES

1. COMPONENTS MOUNTED ON CHASSIS ARE SHADED.
2. \perp CABINET GROUND.
3. ∇ PRINTED CIRCUIT COMMON.
4. UNLESS OTHERWISE INDICATED, CAPACITANCE IN MICROFARADS, RESISTANCE IN OHMS.
5. DENOTES FRONT PANEL LOCATION.

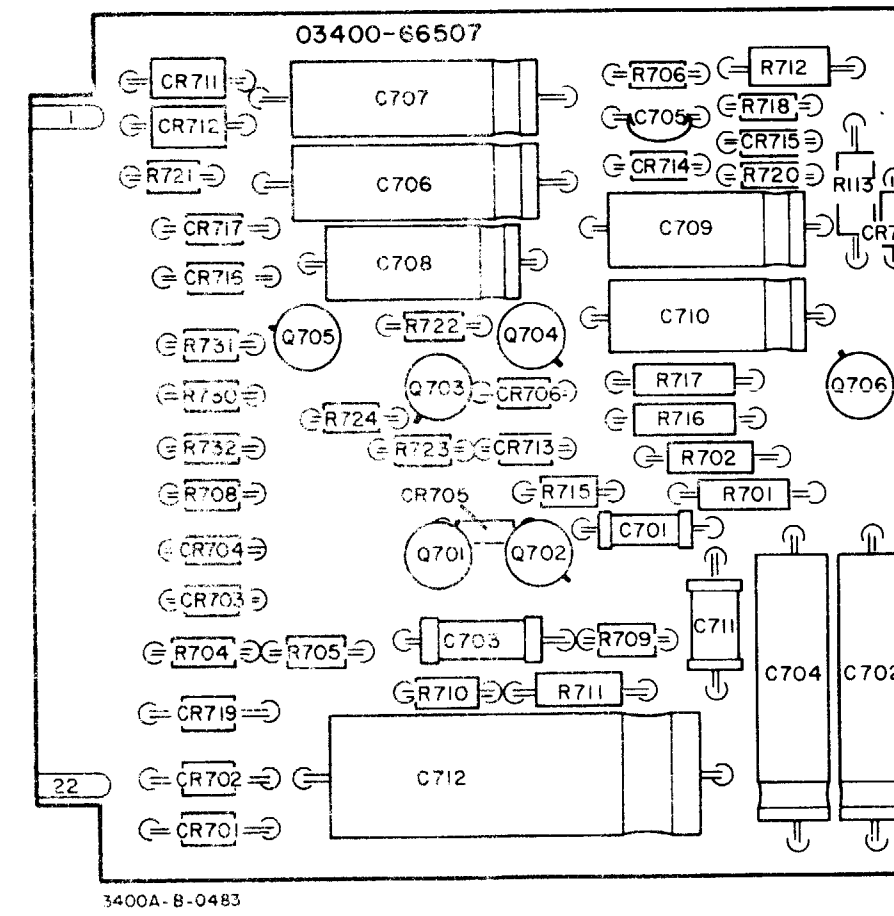


Figure 6-4. Power Supply A7
Schematic Diagram
6-6

Figure 6-4. Power Supply A7 Schematic
and Parts Location Diagram

TM 11-6625-1541-15

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D. C., 11 May 1967

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NG: None.

USAR: None.

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

