Errata

Title & Document Type: **493A/495A Microwave Amplifier Operating and Service Manual**

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Agilent Technologies

OPERATING AND SERVICE MANUAL

493A/495A MICROWAVE AMPLIFIER

HEWLETT PACKARD

HP 493A

HEWLETT PACKARD

CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

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All Hewlett-Packard products are warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery, or, in the case of certain major components listed in the operating manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period. No other warranty is expressed or implied. We are not liable for consequential damages.

For any assistance contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

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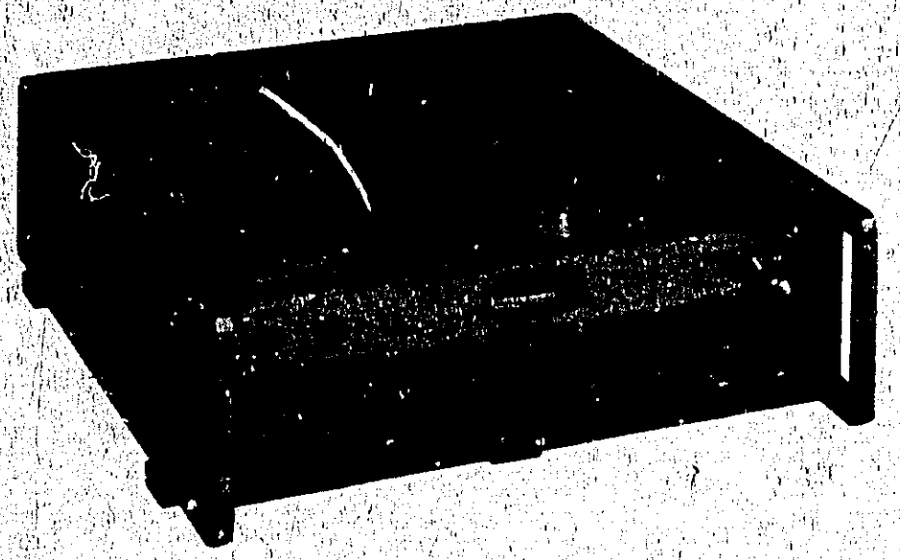


Figure 1-1. The Model 495A Microwave Amplifier
(The Model 493A Microwave Amplifier is exactly the same in its physical construction)

Table 1-1. Specifications

FREQUENCY RANGE:
Model 493A: 4 to 8 Gc
Model 495A: 7 to 12.4 Gc

POWER OUTPUT: 1 watt or greater with 1-mw or less input

GAIN: 30 db or greater with 1-mw or less input

GAIN VARIATION WITH FREQUENCY:
At 1-watt output: 6 db or less across the band.
Small Signal: 5 db or less across any 10% of the band, except the 495A, which is across any 300 MHz of the band. 10 db or less across the band, except the 493A which is 12 db or less across the band

GAIN VARIATION WITH LINE VOLTAGE: 1 db or less for ±10% variation from rated line voltage

MAXIMUM RF INPUT: 100 mw

INPUT/OUTPUT CHARACTERISTICS:
Impedance: 50 ohms
SWR: 2.5 or less (cold)

CONNECTORS: Type N female

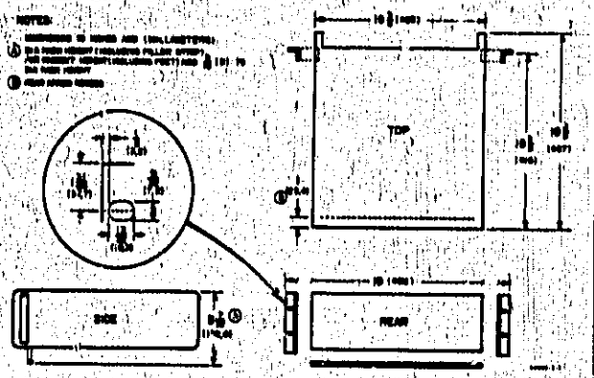
AMPLITUDE MODULATION:
Sensitivity: A modulation input of -20 V peak or greater reduces the RF output by more than 20 db from dc to 50 kc. Above 50 kc modulation decreases approximately 6 db per octave
Residual AM: At least 45 db below modulated output

NOISE:
Noise Figure: 30 db or less
Noise Power Output: 0 dbm or less

FRONT PANEL CONTROL:
Gain; varies grid voltage

METER: Monitors cathode current

DIMENSIONS:



WEIGHT: Net 40 lb (18 kg); shipping 53 lb (23,9 kg)

POWER: 115 or 230 volts ±10%, 50 to 60 cps, approximately 225 watts

ACCESSORIES FURNISHED:
Power Cord, 7-1/2 ft long (2290 mm) NEMA plug.
Hardware for converting cabinet to EIA conforming rack mount.

ACCESSORIES AVAILABLE:
11501A Cable, type N male to type N female, 6 ft long (1830 mm)
11500A Cable, type N male connectors, 6 ft long (1830 mm)

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. This manual provides instructions for installation, operation, circuit description, and maintenance of the Models 493A and 495A Microwave Amplifiers. The manual applies directly to instruments which carry the serial number prefix indicated on the title page. The Model 495A Microwave Amplifier is shown in figure 1-1. Specifications for both instruments are given in table 1-1.

1-3. DESCRIPTION.

1-4. The Models 493A and 495A are broadband linear amplifiers that provide signal amplification to at least 30 db. The Model 493A covers the 4.0 to 8.0 gc range; the Model 495A covers the 7.0 to 12.4 gc range. Both instruments produce at least 1 watt at the output with the application of 1 milliwatt or less at the input.

1-5. The Models 493A and 495A output can be amplitude modulated. Externally supplied modulation signals are applied to the MOD INPUT. Since the modulation circuit is dc coupled, an external leveler circuit can be connected at the MOD INPUT to obtain relatively flat power output across the band.

1-6. The Models 493A and 495A require no tuning and are particularly useful for signal amplification over a broad band of frequencies. The GAIN control is the only variable front panel control. It controls rf signal amplification and average rf power output.

1-7. The Models 493A and 495A traveling-wave amplifier tubes (twt's) utilize periodic permanent magnet focusing, thus they are lightweight, compact and consume less power than solenoid focused twt's.

1-8. An instrument in one frequency range can be converted to an instrument in another frequency range, since both the Models 493A and 495A are identical except for traveling-wave amplifier tube.

1-9. Since the Models 493A and 495A are identical except for the twt, the manual will be discussed in terms of the Model 493A. The Model 495A will be mentioned only when its operation differs from that of the Model 493A.

1-10. The Model 493A uses a modular design which includes a kit that allows conversion to either a cabinet or rack mount configuration.

1-11. INSTRUMINT OPTION.

1-12. The option 01 Model 493A microwave amplifier RF INPUT and OUTPUT connectors are located on the rear panel. In all other respects the option 01 microwave amplifier is the same as a regular microwave amplifier.

1-13. INSTRUMENT IDENTIFICATION.

1-14. Hewlett-Packard uses a two-section eight-digit serial number (00C-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 493A described in this manual.

1-15. COOLING SYSTEM.

1-16. The Model 493A uses the forced air method for obtaining the desired temperature within the instrument. Incoming air is filtered through a specially treated filter at the rear of the instrument. The air filter should be checked periodically and if dirty, cleaned. A dirty air filter will affect instrument performance as well as component life. Refer to paragraph 5-1 for air filter maintenance.

1-17. THREE-CONDUCTOR POWER CABLE.

1-18. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the instrument panel and cabinet be grounded. All Hewlett-Packard instruments are equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument. The offset pin on the power cable's three-prong connector is the green grounding wire.

1-19. To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green pigtail on the adapter to ground.

1-20. INCREASING TUBE LIFE.

1-21. The cathode of the traveling-wave amplifier tube has a shorter cathode life than those used in conventional types of tubes. In addition, the traveling-wave amplifier tube is expensive. TURN THE INSTRUMENT OFF WHEN NOT IN USE.

1-22. TRAVELING-WAVE AMPLIFIER TUBE (TWT).

1-23. The twt supplied with the microwave amplifier and replacement twt's purchased from Hewlett-Packard Company are guaranteed against electrical failure for a specified period (either period of time from date of purchase or number of hours of instrument operation). For information regarding warranty contact your local Hewlett-Packard field office. A sheet for your use is included in the appendix of this manual.

SECTION II
INSTALLATION

2-1. AIR FILTER.

2-2. This instrument is equipped with a renewable type air filter. When first unpacking and placing the instrument into service, the filter must be coated with a dirt gathering adhesive to make it effective. While light machine oil is satisfactory, we recommend a water-soluble adhesive such as "Super Filter Coat" manufactured by Research Products Corporation of Madison 1, Wisconsin.

2-3. MECHANICAL INSPECTION.

2-4. Unpack the instrument upon receipt and inspect it for signs of physical damage such as scratched panel surfaces, broken knobs, etc. The Model 493A should be checked electrically. Section V includes a performance check which is an in-cabinet check to verify proper operation and is a good test as part of incoming inspection. If there is any apparent damage, file a claim with the carrier and refer to the warranty page in this manual.

2-5. INSTALLATION.

2-6. The Model 493A is of modular design. It is shipped as a cabinet instrument. A kit is included with the instrument for conversion from cabinet to rack mount configuration (see paragraph 2-7, Conversion to Rack Mount).

Note

The instrument fan is located on the rear panel. Make provisions to insure that the instrument obtains sufficient air. The ambient temperature within the instrument should not be greater than 35°C.

2-7. CONVERSION TO RACK MOUNT.

2-8. To convert the Model 493A to a rack-mounted instrument, proceed as follows (see Figure 2-1):

a. Remove adhesive-backed trim strip from sides of instrument.

b. Remove tilt stand by pressing the two sides of the stand toward center of instrument.

c. Remove plastic feet by pressing button in center of each foot and sliding the foot toward center of instrument.

d. Attach filler strip to bottom of instrument.

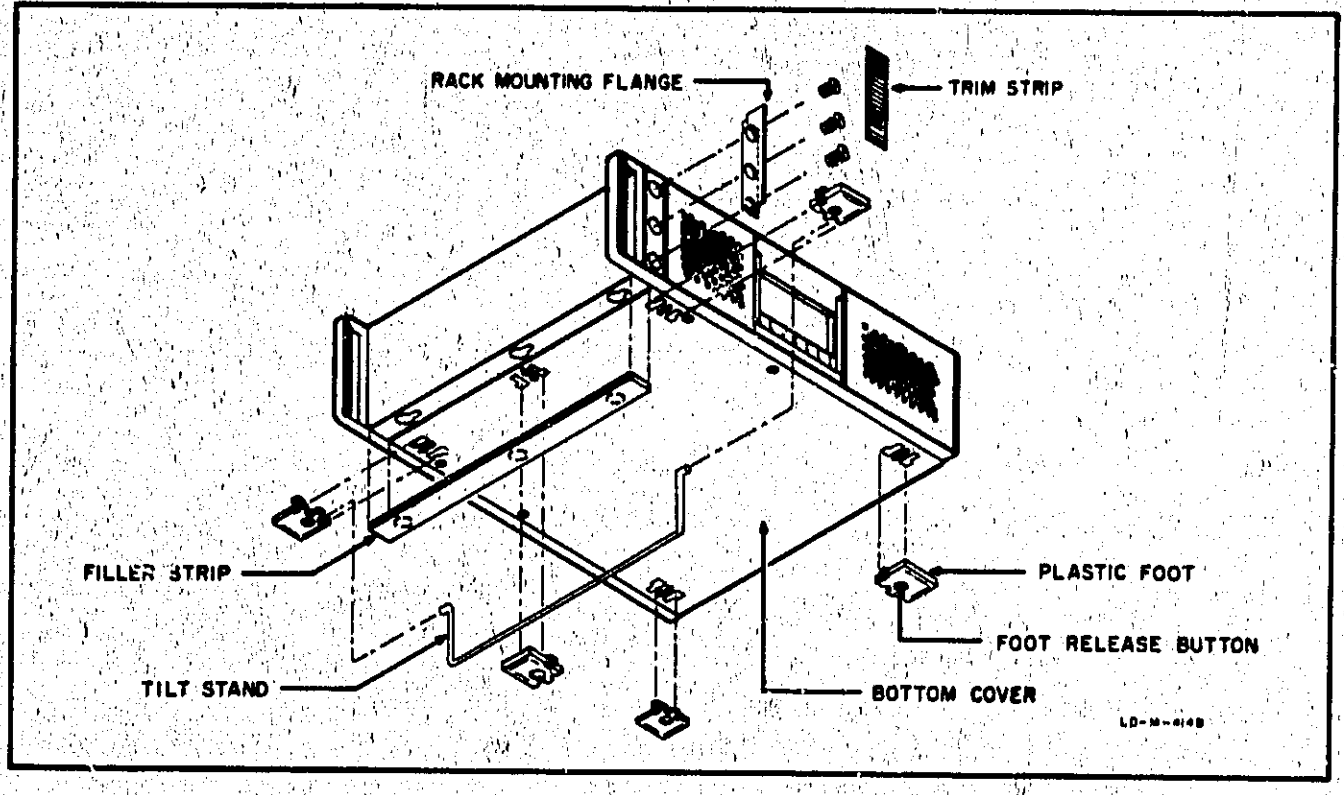


Figure 2-1. Cabinet to Rack Mount Conversion

e. Add filler strip to bottom of instrument.

2-9. POWER REQUIREMENTS.

2-10. The Model 493A is usually shipped connected for 115-volt, 50 to 60 cps operation. To convert to 220-volt, 50 to 60 cps operation:

a. Move slide switch in the rear of the instrument to the 230-volt position (when properly positioned switch will read 230 volts). See figure 2-2.

CAUTION

NEVER SWITCH THE 115-230 VOLT SWITCH S2 FROM ONE POSITION TO THE OTHER WHEN THE INSTRUMENT IS IN OPERATION.

b. Replace the 3-ampere standard fuse with a 1-1/2 ampere standard fuse.

2-11. REPACKAGING FOR SHIPMENT.

2-12. The following list is a general guide for repackaging an instrument for shipment. However, if you have any questions, contact your Hewlett-Packard Engineering Representative.

a. If possible, use the original container designed for the instrument.

b. Wrap the instrument in heavy paper or plastic before placing it in the shipping container.

c. Use plenty of packing material around all sides of the instrument and protect panel faces with cardboard strips.

d. Use a heavy cardboard carton or wooden box to house the instrument and use heavy tape or metal bands to seal the container.

e. Mark the packing box with "Fragile", "Delicate Instrument", etc.

SECTION III
OPERATION

3-1. INTRODUCTION.

3-2. The Model 493A Microwave Amplifier has only one control, the GAIN control; thus it is easy to operate. The GAIN control and input and output connectors are explained under paragraph 3-3.

CAUTION

The instrument should not be allowed to remain in operation for long periods of time without fan duct and panels. Ambient temperature within instrument will increase causing excessive helix current to flow.

3-3. FRONT PANEL CONTROLS.

3-4. GAIN CONTROL. The GAIN control sets the gain of the amplifier. Maximum input-vs-output gain of the instrument is at least 30 db for outputs up to 1 watt. With a signal applied at the microwave amplifier input the only way to insure zero output is to place the instrument on STANDBY.

3-5. CURRENT METER. The current meter monitors cathode current. The instrument has a gain of at least 30 db for outputs up to 1 watt when the GAIN control is adjusted to within the RATED POWER limits indicated on the meter.

3-6. RF INPUT AND OUTPUT. An rf signal, up to 100 milliwatts, in the 4.0 to 8.0 gc range (7.0 to 12.4 gc for the Model 495A) is applied to the RF INPUT. Input and output impedance is 50 ohms at rf frequencies; infinity at dc. SWR is less than 3:1.

CAUTION

DO NOT APPLY AN INPUT SIGNAL BEFORE APPLYING AN EXTERNAL LOAD AT THE RF OUTPUT. THE TWT CAN BE DAMAGED.

3-7. MODULATION INPUT. The MOD INPUT accepts externally applied dc to 500 kc signals up to 10 volts in amplitude, or dc to 100 kc signals up to -20 volts in amplitude. Modulation signal amplitudes of -20 volts will produce a modulation on-off ratio of at least 20 db. Since the modulator is dc coupled, an rf power leveler circuit can be applied between the RF POWER OUTPUT and MOD INPUT (see paragraph 3-16). Under no circumstances should the modulation voltage be allowed to go positive unless GAIN is reduced accordingly. In other words, peak cathode current must not exceed RATED POWER level.

3-8. OPERATING INSTRUCTIONS.

3-9. Turn-on and amplitude modulation procedures are given in figures 3-1 and 3-2.

3-10. MICROWAVE AMPLIFIER APPLICATIONS.

3-11. The Model 493A is used for broadband or narrow-band power amplification and amplitude modulation. An external rf leveler circuit can be employed where relatively constant output power is required.

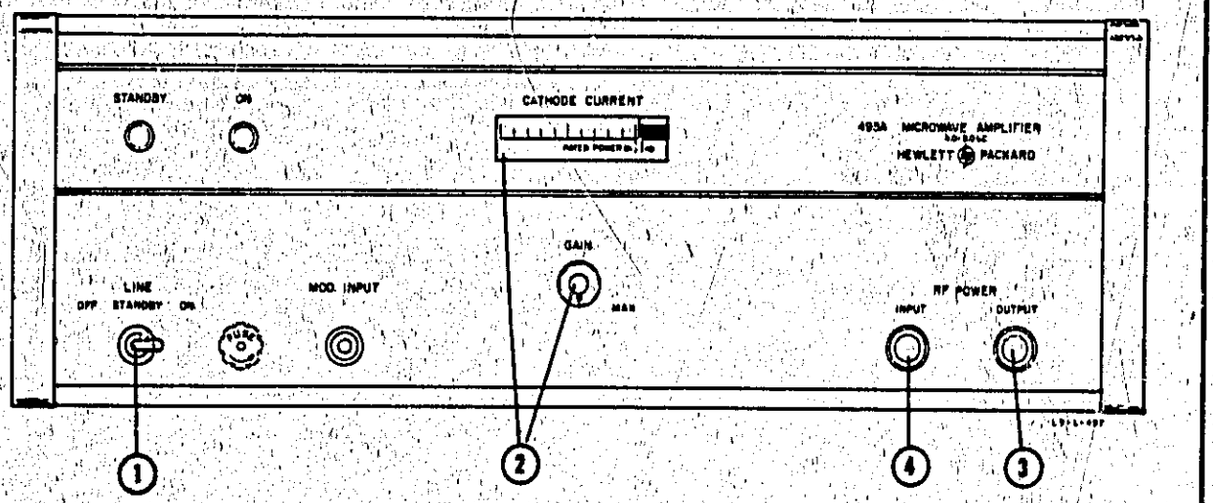
3-12. BROADBAND AMPLIFICATION. The Model 493A will faithfully amplify many broadband signals such as those employed in radar, television relays and microwave carrier systems. In addition to this broadband feature, it has a linear amplification characteristic over the frequency range.

3-13. Of the many broadband applications of the Model 493A, some of the most useful are: 1) investigation of information handling capacity in broadband microwave communications systems, 2) amplification of low-frequency harmonics to produce frequency markers used in microwave-frequency measurements.

3-14. NARROWBAND AMPLIFICATION. The Models 493A and 495A can be used for narrowband amplification at any one point across the 4.0 to 12.4 gc range. Noise can be greatly reduced by employing a narrow bandpass filter in conjunction with the Models 493A and 495A Microwave Amplifiers.

3-15. POWER AMPLIFICATION. The Model 493A can be used as a moderate power, broadband signal source by amplifying the low power output of klystron signal generators in the 4.0 to 12.4 gc range. Thus a microwave source-amplifier combination can be used in many applications where a generous amount of microwave power is required. Typical applications are 1) wide-range antenna measurements to plot patterns to determine efficiency, directivity, etc., 2) portable low-cost means of providing moderate power microwave-signal sources for field-testing a microwave installation.

3-16. CONSTANT OUTPUT AMPLIFICATION. Many amplifier applications require a constant output level characteristic. Although the Model 493A traveling-wave amplifier tube's saturated output characteristic can be used to provide nearly constant power output, the use of feedback circuitry provides a more versatile and effective means of control. One such arrangement for obtaining relatively constant rf output power is shown in figure 3-3. In this circuit a portion of the rf signal is coupled from the traveling-wave amplifier tube output, through a directional coupler to a detector such as a crystal rectifier. The detected rf output is then amplified and applied to the MOD INPUT. With this arrangement any tendency for the output-power level to increase is immediately detected, amplified, and fed back to reduce the gain of the amplifier. Conversely, any reduction in output level increases the



CAUTION

NEVER APPLY POWER TO THE MODEL 493A/495A INPUT UNLESS ITS OUTPUT IS TERMINATED INTO A 50-OHM LOAD. THE TWT CAN BE DAMAGED.

1. Set LINE switch to ON. The STANDBY lamp glows. Approximately 90 seconds later the ON lamp will glow and the instrument is ready for normal operation. If the Model 493A/495A is placed in the STANDBY position, the STANDBY lamp will glow. Approximately 90 seconds later high voltage will be applied to the instrument only when the primary power switch is set from STANDBY to ON. The purpose of the STANDBY position is to instantly turn rf power output "on" or "off" after initial turn-on without waiting for the initial 90-second time delay.

   Note

   The instrument should be turned to ON and allowed to warm up for 30 minutes before proceeding to step 2.

2. Rotate GAIN control clockwise to within RATED POWER indicated on meter (full clockwise). With the CURRENT meter pointer set within normal meter limits, a maximum of 1 mw at the input produces a minimum of 1 watt at the output across the frequency range. Small signal gain is at least 30 db. A constant 1-mw signal at the input of the Model 493A/495A across the band produces an amplified power output variation across the band of 6 db or less.

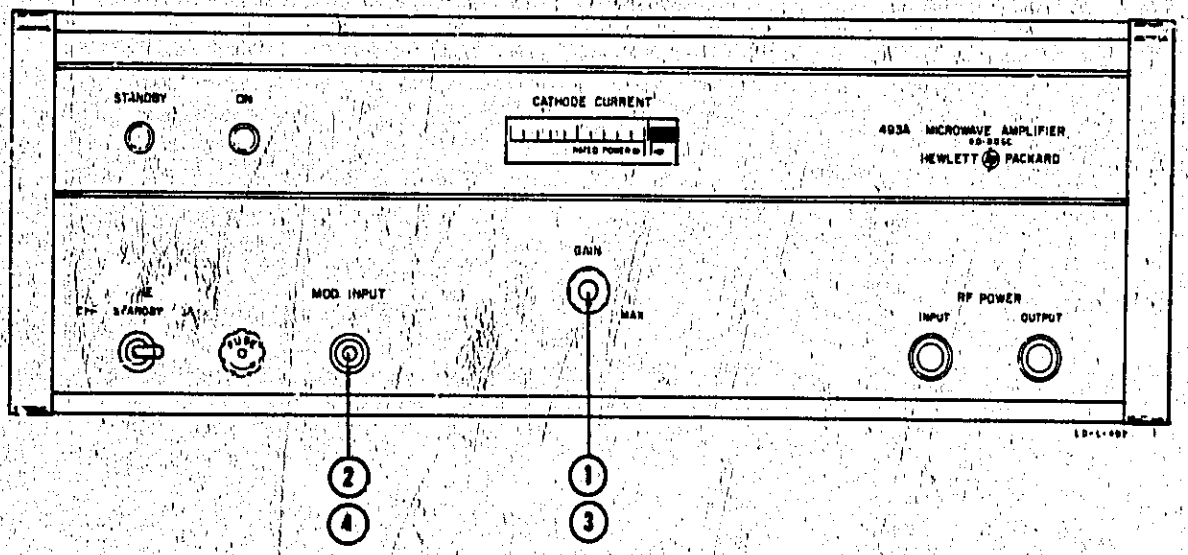
   Note

   If excessive helix current is drawn by the twt, the overload relay K3 will energize, removing high voltage from the circuit. Also if the filament voltage is not correct, the fail-safe relay K304 will energize, removing high voltage and filament voltage from the circuit. In such cases, the primary power switch must be switched off, then on again. If condition persists remove the power from the instrument and troubleshoot.

3. Connect Model 493A/495A OUTPUT to the instrument into which the amplified signal is to be applied.

4. Apply rf power to the Model 493A/495A INPUT. The maximum allowable power than can be applied to the Model 493A/495A INPUT is 100 mw.

Figure 3-1. Turn-On Procedure



1. Rotate the GAIN control full clockwise.

2. Apply a negative-going signal to the MOD INPUT. Specifications: bandpass for small signal inputs dc to 500 kc; bandpass for large signal inputs dc to 100 kc. Small signal inputs are from 0 to -10 volts; large signal inputs -10 to -20 volts. Bandwidths are measured at the grid of the twt.

Note

Peak cathode current must not be allowed to exceed RATED POWER level. If the MOD INPUT voltage is positive during any part of the modulation cycle, GAIN must be reduced accordingly.

Figure 3-2. Amplitude Modulation

gain of the amplifier to hold the output level constant. In practice, output levels can be held within 1 db during input signal variations as great as 20 db.

Note

The limitations to the degree of leveling obtainable is determined by errors introduced by crystal detector and directional coupler.

3-17. BUFFER OR ISOLATION. The Model 493A Microwave Amplifier can also be used as a buffer between a microwave-signal source and an external load. As a buffer it isolates load reflections from the signal source and eliminates the problems which occur when the source is modulated directly.

3-18. AMPLITUDE MODULATION. The Model 493A is particularly suitable for use in power amplifier systems. This feature opens new fields of application since it is not possible to amplitude modulate a reflex klystron directly. Furthermore, the traveling wave amplifier tube's use as a power amplifier means that rf output from a microwave oscillator can be sine wave, pulse, or pulse-train modulated without starting delays and jitter generally present when the oscillator itself is modulated. Thus, in addition to amplification the traveling-wave amplifier tube provides a simple system of amplitude modulation.

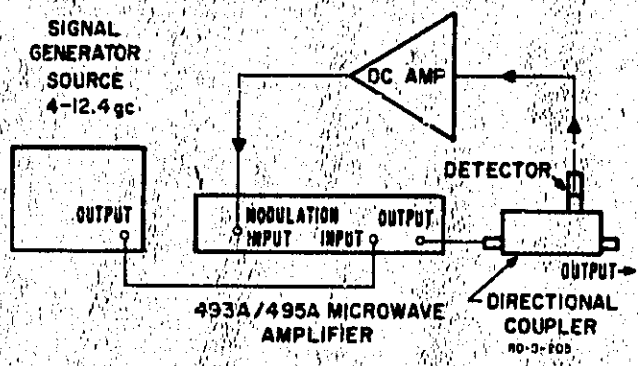


Figure 3-3. RF Leveler Setup

SECTION IV
CIRCUIT DESCRIPTION

4-1. INTRODUCTION.

4-2. The Models 493A and 495A circuitry is the same. Only the traveling-wave amplifier tube (twt) types are different. However, the basic traveling-wave tube explanation given in this section applies for both the Models 493A and 495A twt types.

4-3. OVERALL DESCRIPTION.

4-4. A block diagram of the Model 493A is shown in figure 4-1. The purpose of the Model 493A Microwave Amplifier is to provide a means of amplifying a signal in the 4.0 to 8.0 gc range (7.0 to 12.4 gc range for the Model 495A), to control the amount of amplification produced, and to supply external modulation facilities for the amplified signal.

4-5. The signal is applied to the microwave amplifier input, amplified, and taken at the output of the traveling-wave amplifier tube (twt). All voltages required by the twt are supplied by the regulated high-voltage power supply and the modulator. The regulated high-voltage power supply supplies collector, helix, and anode voltages to the twt. The modulator supplies voltages to the grid of the twt. Power gain of the twt is controlled by the modulator GAIN control. Positive voltage for the modulator is supplied through a +300-volt regulator circuit which maintains +300 at modulator; negative voltage is supplied by the modulator power supply. Cathode current is monitored by the current monitoring meter M201.

4-6. TRAVELING WAVE AMPLIFIER TUBE.

4-7. The traveling-wave amplifier tube used in the Model 493A/495A includes an electron gun which projects a focused beam through a helically-wound coil to a collector electrode (shown in figure 4-2). The focused electrons are held in a pin-like beam through the helix by the periodic permanent magnet focusing which produces a powerful magnetic field along the full length of the tube.

4-8. The rf signal coupled into the gun end of the helix travels around the turns of the helix and thus has its linear velocity reduced by an amount equal to the ratio of the length of wire in the helix to the length of the helix itself. The electron beam velocity, determined by the potential difference between the cathode and the helix, is adjusted so that the electron beam travels a little faster than the rf signal. The electric field of the rf signal on the helix interacts with the

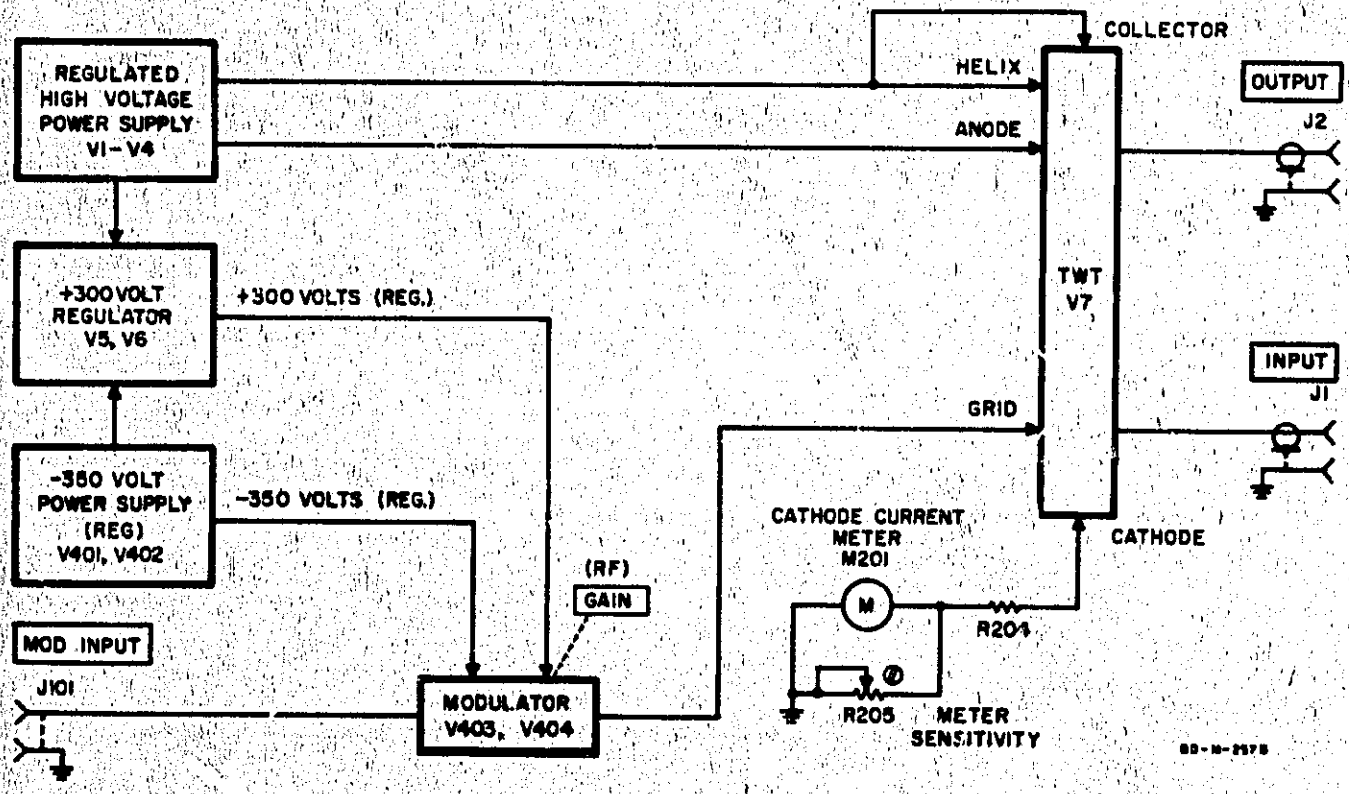
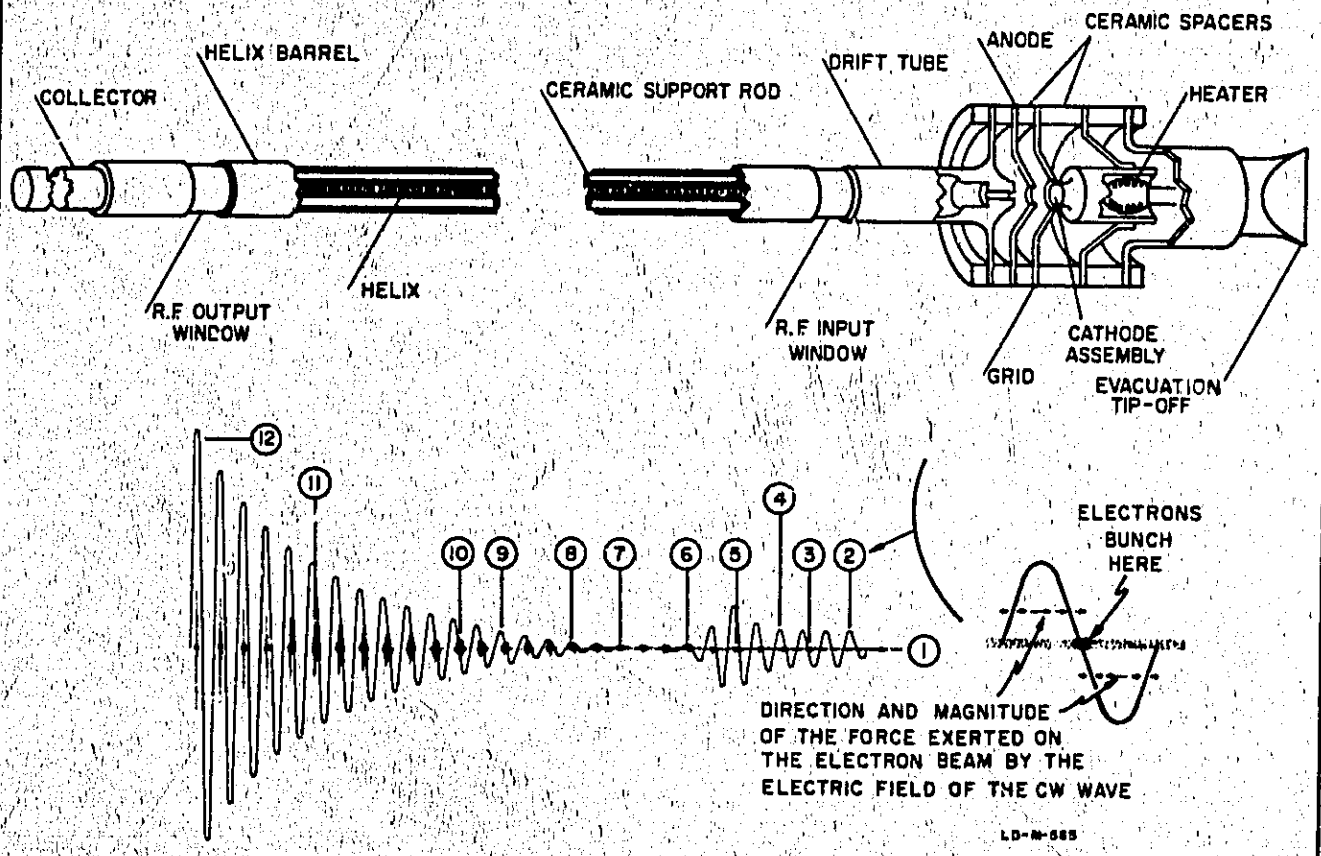


Figure 4-1. Model 493A/495A Block Diagram



1. Electron beam directed through center of helix.
2. RF signal coupled into helix. The arrows show direction and magnitude of force exerted on the electron beam by the rf signal.
3. Electron bunching caused by the electric field of the rf signal.
4. Amplification of signal of helix begins as the field formed by the electron bunches interacts with the electric field of the rf signal. The newly formed electron bunch adds a small amount of voltage to the rf signal on the helix. The slightly amplified rf signal then produces a denser electron bunch which in turn adds a still greater voltage to the rf signal, and so on.
5. Amplification increases as the greater velocity of the electron beam pulls the electron bunches more nearly in phase with the electric field of the rf signal. The additive effect of the two fields exactly in phase produces a greatest resultant amplification.
6. Attenuators placed near the center of the helix reduce all the waves traveling along the helix to nearly zero. This prevents undesired waves, such as waves reflected from mismatched loads, from returning to the tube input and causing oscillation.
7. Electron bunches travel through attenuator unaffected.
8. Electron bunches emerging from attenuator induce a new rf signal on helix. New rf signal is the same frequency as the original rf signal applied.
9. Field of newly induced rf signal interacts with bunched electrons to begin the amplification process over again.
10. For a short distance the velocity of the electron bunches is reduced slightly due to the large amount of energy absorbed by the formation of the new rf signal.
11. Amplification increases as the greater velocity of the electron beam pulls the electron bunches more nearly in phase with the electric field of the rf signal.
12. At point of desired amplification the amplified rf signal is coupled out of the helix. NOTE THAT THE "AMPLIFIED" RF SIGNAL IS A NEW SIGNAL WHOSE ENERGY IS WHOLLY SUPPLIED BY THE BUNCHED ELECTRON BEAM.

Figure 4-2. TWT and How it Works

electron field created by the electron beam and increases the amplitude of the signal on the helix, thus producing the desired amplification.

Note

The ceramic magnets used in twt, 493A will defocus the electron beam if ambient temperature of the instrument exceeds 35 °C. Thus with twt operating above this temperature poor power amplification performance can be expected.

4-9. REGULATED HIGH VOLTAGE POWER SUPPLY.

4-10. A block diagram of Regulated High Voltage Power Supply is shown in figure 4-3. The regulated high-voltage power supply is a series regulated power supply that includes series regulator V1/V2, reference tubes V3, V4, and differential amplifier V5.

4-11. The series regulator V1/V2 is connected in series with the main load. A regulated output voltage is obtained by varying the internal resistance of the series regulator to compensate for variations in load current and source voltage.

4-12. Initially the voltage at the grid of V5B sets the conduction of the series regulator which in turn sets the output voltage level. When the output voltage varies from the level set by the high voltage level adjust R57, these variations are sensed at the grid of V5A/B. The resultant signal is amplified and sent to the series regulator. The series regulator resistance varies to maintain the output voltage constant.

4-13. C12 and C13 (see figure 5-12) are part of the bypass and filter circuits at the output of the regulator tubes V3, V4. C15 couples ac ripple directly to the grid of V5, thus decreasing ripple voltage by lowering dynamic impedance.

4-14. A voltage doubler which includes CR7 through CR20 and C11A/B produces approximately 2.9 to 3.4 kv at normal line voltage. The actual high voltage output is dependent on how the transformer T1 has been connected (see table, figure 5-12).

4-15. CATHODE CURRENT ADJ. The cathode current adj R53, is connected in a resistive string from the high-voltage power supply regulated output to ground. When an anode type tube is used, adjustment of R53 sets the voltage on the anode thus setting beam current. The anode voltage is set to the value that will produce at least 1 watt at the RF OUTPUT with the application of 1 milliwatt or less at RF INPUT. R53 is inoperative for those tubes that do not have an anode.

4-16. +300 VOLT REGULATION CIRCUIT.

4-17. This regulated power supply includes the +300 volt regulator V6, and +300 volt control tube V8. The circuit is a series regulated supply similar in operation to that of the high voltage power supply. The supply derives its voltage from the regulated high voltage power supply and thus produces a nearly ripple free highly regulated voltage to the modulator. There is no control for adjustment of the +300 volt modulator power supply. All components are fixed to provide the +300 volt output to the modulator regardless of the high voltage power supply output. The -350 volt supply is the reference for the +300 volt regulated power supply.

4-18. MODULATOR.

4-19. A block diagram of the modulator is shown in figure 4-4. The modulator includes an amplifier circuit and a regulated power supply. The amplifier circuit is a dc coupled circuit that sets the gain characteristics of the traveling-wave amplifier tube and accepts externally applied amplitude modulation signals from dc to 500 kc (dc to 100 kc for large signals). The regulated power supply provides -350 volts to the amplifier circuit and high voltage power supply.

4-20. AMPLIFIER CIRCUIT. The amplifier circuit includes Differential Amplifier V403; Output Amplifier V404, and Hold-off Transistor Q401. External modulation signals are applied through the A section of the Differential Amplifier V403, to the output amplifier V404. The V404 output is applied to the grid of the traveling-wave tube. Degenerative feedback is supplied from the output of V404 to V403 to increase stability and frequency response.

4-21. Gain of the TWT (average rf output level) is set by adjusting the GAIN control in the B section of the Differential Amplifier V403. The voltage at the grid of the TWT is set at some negative potential. The Gain Limit Adj control R418 sets the highest positive voltage on the grid of the TWT. Hold-off transistor Q401 protects the TWT from a transient when the instrument is switched from STANDBY to ON. Normally, the application of a step-function positive voltage when turning on the +300 volt supply to the modulator would result in a positive transient spike to the TWT grid. This transient spike would cause excess helix current to be drawn and the helix overload relay to operate. To protect the instrument the Hold-off Transistor Q401 applies a positive voltage to V403B during the stand-by period. This positive voltage saturates V403B holding V404 in a condition such that the voltage applied to the grid of the TWT is negative. This action takes place whenever the voltage on the base of Q401 (a npn transistor) drops. This drop in voltage causes Q401 to cut-off. When Q401 is cut off the only voltage applied to CR403 is the voltage developed through R414, R415, and R431. This positive voltage is applied through CR403, since CR403 will now be forward-biased, to the grid of V403B. When the instrument is switched from STANDBY to ON the positive voltage from the +300 volt supply is applied to the base of Q401 through R416 and R417. This positive voltage turns Q401 on, causing current to flow from the -350 volt supply through R417, Q401, and R415 to CR403. This negative voltage will back-bias CR403 causing it to open and disconnect the hold-off circuitry. The instrument is now back to its normal operating condition.

4-22. -350 VOLT REGULATED POWER SUPPLY. The regulated power supply is a conventional series regulated power supply that provides -350 volts for the amplifier circuit. The circuit includes the series regulator V401A, control tube V401B, and reference tube V402. The -350 V Adj control R405 is used to set the regulated voltage output of the supply.

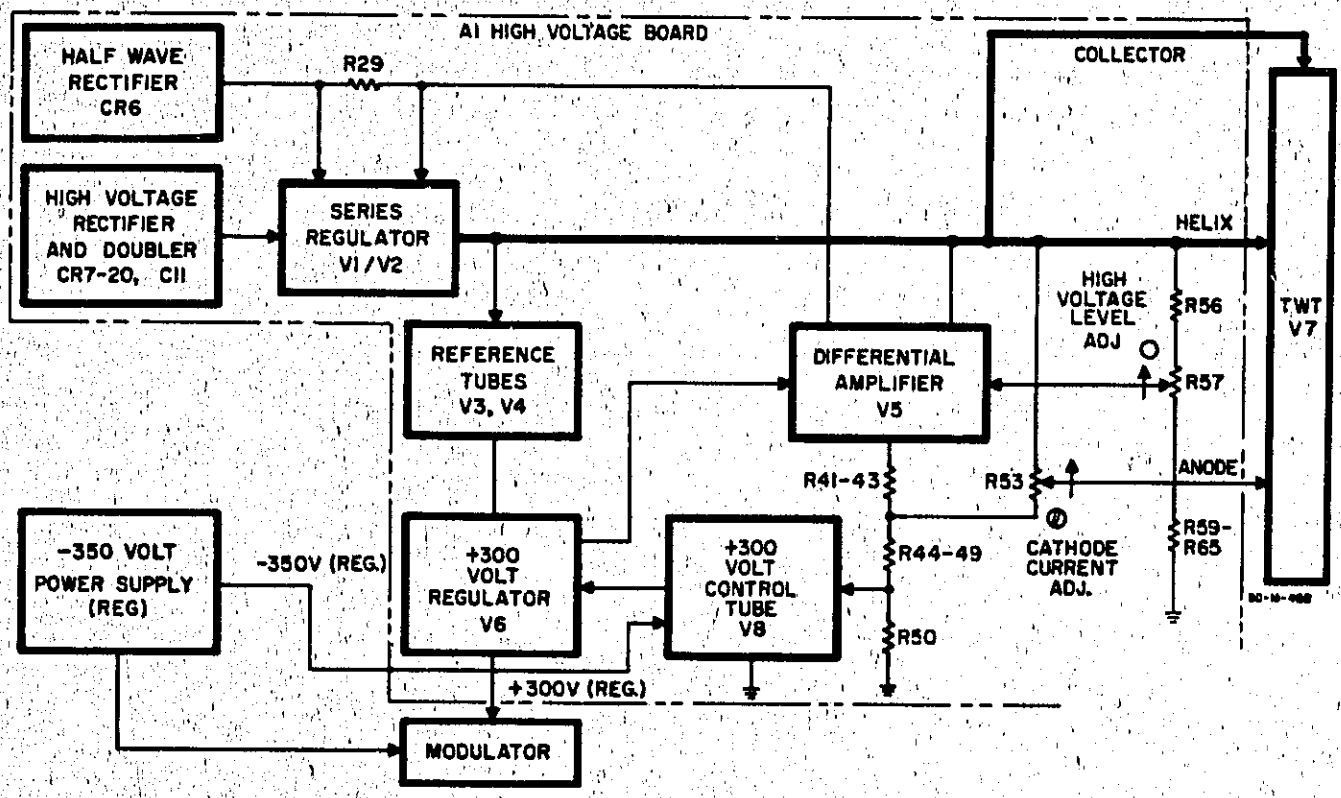


Figure 4-3. Block Diagram of Regulated High Voltage Power Supply

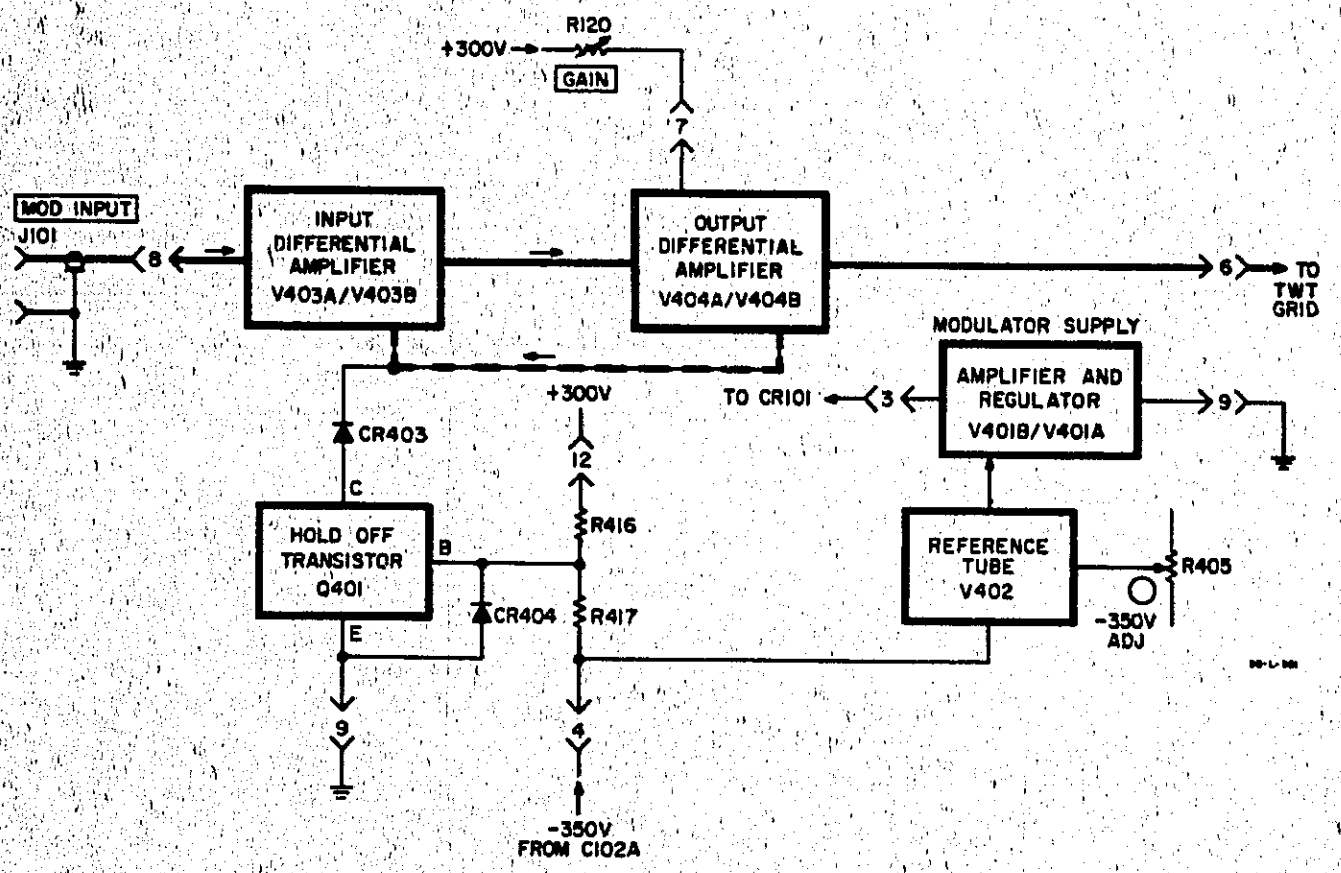


Figure 4-4. Block Diagram of Modulator

4-23. RELAY SEQUENCE.

4-24. A simplified illustration of the relay sequence is shown in figure 4-5. When the Model 493A is first turned to ON, power is applied to the transformer T2. Filament voltage is applied to all tubes in the instrument as well as to the 90-second time delay relay K1. After 90 seconds have elapsed, relay K1 will close, completing current flow path for delay slave relay K2. The relay K2 will energize: 1) completing the current path to the high voltage transformer T1, and 2) it will act as a holding relay for itself by bypassing the contacts at the time delay relay K1. The instrument is now operating normally. V1, V2, and V5 filaments and relays K1, K2, and K3 are held 200 volts above the helix.

4-25. When the instrument is placed on STANDBY the sequence will be the same as described in paragraph 4-24, but high voltage will be applied to the instrument after 90 seconds, only if the Model 493A primary power switch is placed in the ON position. The STANDBY position permits the turning of RF power "on" or "off" instantly by switching from STANDBY to ON (or from ON to STANDBY), once the initial 90-second time delay has elapsed.

4-26. In the event excessive helix current is drawn by the traveling-wave amplifier tube, a protective device, the overload relay K3, will energize. Energizing K3 interrupts the current path for delay slave relay K2, which in turn removes power from the high voltage transformer T1. CR22 acts as a half-wave rectifier for the 5.3 vac signal, when the overload relay K3 is energized. This rectified output supplies approximately 2.5 ma to the overload relay K3 holding it energized, once high voltage has been removed.

4-27. REGULATED FILAMENT SUPPLY.

4-28. The filament supply is a conventional series regulated power supply that supplies approximately 6.3 volts dc to the filament of the differential amplifier V103, and TWT, V7. Successive regulation is provided by CR304 and CR305 to hold the base of Q301 constant. The filament adj. R306 sets the regulated output voltage.

4-29. Protection in the event that the filament voltage exceeds the limits set by the filament adj. R306 is provided by the relay K304 and CR308. K304 and CR308 are placed in parallel with the filaments. If the voltage limit set by filament adjust R306, is exceeded, CR308 will break down and K304, will energize, opening the filament circuit and removing ac power to high voltage power supply.

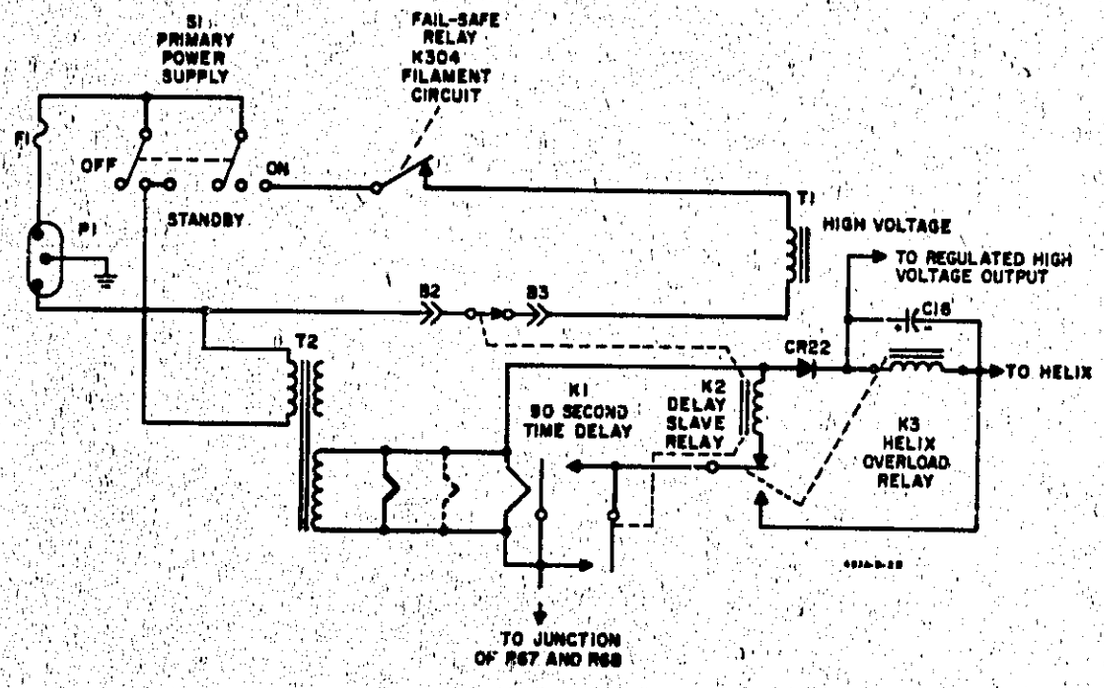


Figure 4-5. Relay Sequence

4-23. RELAY SEQUENCE.

4-24. A simplified illustration of the relay sequence is shown in figure 4-5. When the Model 493A is first turned to ON, power is applied to the transformer T2. Filament voltage is applied to all tubes in the instrument as well as to the 90-second time delay relay K1. After 90 seconds have elapsed, relay K1 will close, completing current flow path for delay slave relay K2. The relay K2 will energize: 1) completing the current path to the high voltage transformer T1, and 2) it will act as a holding relay for itself by bypassing the contacts at the time delay relay K1. The instrument is now operating normally. V1, V2, and V5 filaments and relays K1, K2, and K3 are held 200 volts above the helix.

4-25. When the instrument is placed on STANDBY the sequence will be the same as described in paragraph 4-24, but high voltage will be applied to the instrument after 90 seconds, only if the Model 493A primary power switch is placed in the ON position. The STANDBY position permits the turning of RF power "on" or "off" instantly by switching from STANDBY to ON (or from ON to STANDBY), once the initial 90-second time delay has elapsed.

4-26. In the event excessive helix current is drawn (5 to 7 ma) by the traveling-wave amplifier tube, a protective device, the overload relay K3, will energize. Energizing K3 interrupts the current path for delay slave relay K2, which in turn removes power from the high voltage transformer T1. CR9 acts as a half-wave rectifier for the 6.3 vac signal, when the overload relay K3 is energized. This rectified output supplies approximately 2.5 ma to the overload relay K3 holding it energized, once high voltage has been removed.

4-27. REGULATED FILAMENT SUPPLY.

4-28. The filament supply is a conventional series regulated power supply that supplies approximately 6.3 volts dc to the filament of the differential amplifier V103, and TWT, V7. Successive regulation is provided by CR304 and CR305 to hold the base of Q301 constant. The filament adj. R306 sets the regulated output voltage.

4-29. Protection in the event that the filament voltage exceeds the limits set by the filament adj. R306 is provided by the relay K304 and CR308. K304 and CR308 are placed in parallel with the filaments. If the voltage limit set by filament adjust R306, is exceeded, CR308 will break down and K304, will energize, opening the filament circuit and removing ac power to high voltage power supply.

SECTION V
MAINTENANCE

5-1. AIR FILTER MAINTENANCE.

5-2. The air filter is located at the rear of the instrument. Inspect air filter frequently and clean whenever an appreciable amount of dirt has collected on it. Proper maintenance of the filter will produce longer cwt tube and component life.

5-3. The filter should be washed in hot water and detergent to throughly remove all dirt deposits. After filter is clean, allow it to dry. Compressed air speeds the process.

5-4. To be most effective, the filter must be coated with a dirt gathering adhesive. While light machine oil is satisfactory, we recommend using a water-soluble adhesive such as "Super Filter Coat" manufactored by Research Products Corporation of Madison 1, Wisconsin.

5-5. This product is available in 1.5 fl. ounce cans equipped with a handy spray applicator at most heating supply stores. You can also obtain it from your ⓗ Engineering Representative. The ⓗ Stock Number is 3150-0002.

5-6. COVER REMOVAL.

5-7. ⓗ modular instrument enclosures have removable top, bottom, and side covers for easy access to the instrument interior (see Figure 5-1). Instructions for cover removal and replacement are given below.

5-8. TOP AND BOTTOM COVERS.

a. Remove four flat-head screws from covers.

b. Slide cover back and off instrument.

c. To replace cover reverse procedure.

5-9. SIDE COVERS.

a. Remove four round-head screws holding each side cover.

b. Remove side cover.

c. Reverse procedure to replace the side-cover sections.

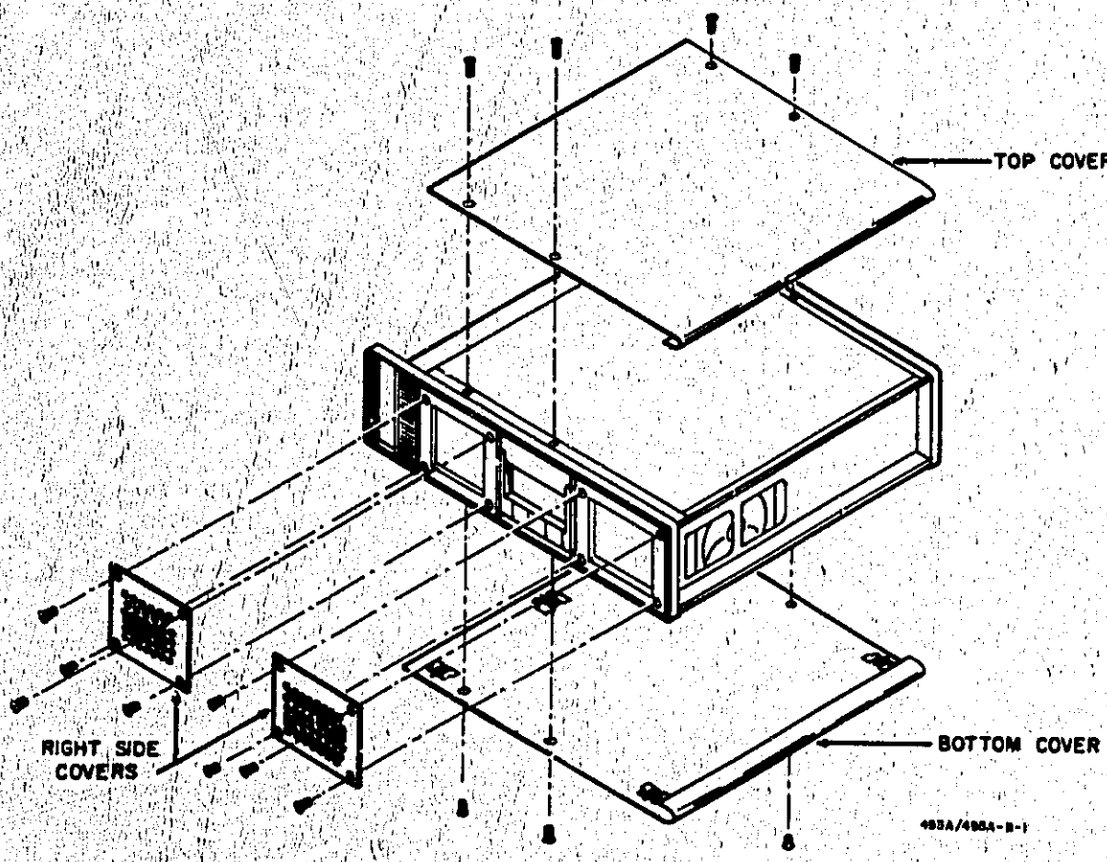


Figure 5-1. Cover Removal

Table 5-1. Test Equipment Required

Instrument Type	Critical Specifications	Use	Instrument Recommended
VOM	Range: 5 to 3000 volts Accuracy: ±3% Impedance: 10 megohms (floating input)	Check DC Voltages	Triplett Model 620A
AC Voltmeter	Range: 5 to 25 millivolts Accuracy: 2% Frequency Range: 10 to 1000 cps Impedance: 10 megohms	Check AC Ripple	Ⓜ Model 400D AC VTVM A 0.02 μfd Capacitor (5000 volt rating) connected in series with AC VTVM
DC Clip-On Milliammeter	Range: 3 ma to 10 ma Accuracy: ±3%	Check □ Helix Current Figure 5-5	Ⓜ Model 428A Milliammeter
Signal Generator	Frequency Range: 4.0 to 8.0 gc, 8.0 to 12.4 gc* Power Output: 1 mw	Figure 5-5 through 5-9	Ⓜ Model 618B Ⓜ Model 620A Ⓜ Model 626A*
Power Meter	Range: 0.1 mw to 3 w Frequency Range: 4.0 to 8.0 gc, 8.0 to 12.4 gc* Accuracy: Within ±5% of full scale	Figures 5-5 and 5-8	Ⓜ Model 434A
Power Supply	Regulated Output: 0 to 20 volts	Figure 5-8	Ⓜ Model 721A
Wide Range Oscillator	Frequency Range: 1 kc - 500 kc ±2% Output to 600 ohms: 10 volts	Figure 5-7	Ⓜ Model 200CD Wide Range Oscillator
Oscilloscope	Band Pass: dc to 1 mc Sensitivity: 0.5 v/cm	Figures 5-6 and 5-7	Ⓜ Model 175A with Ⓜ Model 1750A, 1751A Vertical Amplifier
Square Wave Generator	Frequency Range: 1 to 10 kc Rise Time: 0.01 μsec Signal Amplitude: 10 volts	Figures 5-6 and 5-9	Ⓜ Model 211A
Crystal Detector	Frequency Response: 4.0 to 8.0 gc, 8.2 to 12.4 gc* Square Law Characteristic: ±1 db (matched pair ±2 db) Sensitivity: 0.1 v/mw	Figures 5-7 and 5-9	Ⓜ Model 423A Crystal Detector

* for Model 495A only

NO marking used for both Models 493A and 495A

□ A VOM used in conjunction with the current monitoring resistors R201, R202 R203 can also be used to measure current

5-10. TEST EQUIPMENT REQUIRED.

5-11. Test equipment used in the calibration of the Model 493A is given in table 5-1, Test Equipment Required. The table includes the type of equipment to be used, the critical specifications required for testing, where test equipment is used, and recommended commerically available test equipment used in the calibration of the instrument.

5-12. TROUBLESHOOTING PROCEDURE.

5-13. The troubleshooting procedure localizes troubles to a section (twt, high voltage power supply, or modulator). Troubles that usually arise affect power amplification or modulation. The following procedure lists checks to be made, voltage limits, and references to adjustment procedures. Voltage limits for collector/helix, anode and grid refer to values stamped on the twt capsule. If a voltage cannot be adjusted within the limits given, use the troubleshooting chart (figure 5-2) as a guide to isolate the cause of trouble.

CAUTION

Do not operate instrument without fan duct and covers for long periods of time. Cover is needed to maintain ambient temperature of the instrument below 35°C.

a. TWT filament voltage 6.2 ±0.1 volts (para 5-24).

b. Collector/helix voltage ±10% (para 5-25).

c. Anode voltage ±10% (para 5-26).

d. Grid voltage ±1 volt (para 5-28) check:

(1) -350 volts ±2 volts applied to modulator.

(2) 300 volts ±10 volts applied to modulator.

(3) R418, gain limit adj.

(4) Current sink, Q401.

e. Frequency response and bandwidth of modulator (paragraphs 5-32 and 5-33).

f. V403 and V404.

Note

Any change in collector/helix voltage causes a proportional change in anode voltage. Following repair or adjustment of collector/helix voltage, adjust anode voltage and check for proper grid voltage.

5-14. REPAIR.

5-15. The Model 493A uses etched circuit boards. A special procedure is required to repair or replace components on the boards. The procedure for repairing the circuit boards is given below.

5-16. ⊕ uses three types of etched circuit boards: the single sided, double sided, and plated through circuit board. Soldering techniques vary for each. Regardless of which board is used, these general rules should be followed.

a. Take care not to apply excessive heat to the conductor or component being soldered.

b. Use a toothpick to clean holes before inserting new component.

c. To remove damaged component, clip component leads near component. Then apply heat and remove each component lead with a straight upward motion.

d. After replacing a component, the printed circuit board should be sprayed with a clear plastic such as Krylon.

5-17. SINGLE SIDED BOARD: The single sided etched circuit board consists of a base board, funneled eyelets, and conductor. TO INSURE GOOD CONNECTION BETWEEN THE EYELET AND CONDUCTOR, SOLDER FROM CONDUCTOR SIDE.

5-18. DOUBLE SIDED BOARD: The double sided etched circuit board consists of a base board, funneled eyelets and conductors located on both sides of the board. TO INSURE GOOD CONNECTION BETWEEN THE EYELETS AND CONDUCTOR, APPLY SOLDER FROM BOTH SIDES OF THE BOARD.

5-19. PLATED THROUGH BOARD: The plated through etched circuit board consists of a base board and conductor. The board does not include funneled eyelets. The conductor material is plated to the walls of the hole and effectively the conductor is extended into the hole. THIS TYPE OF BOARD CAN BE SOLDERED FROM EITHER THE CONDUCTOR OR COMPONENT SIDE WITH EQUALLY GOOD RESULTS.

5-20. TWT REMOVAL.

a. Remove ac power cable from instrument.

b. Remove instrument's top and bottom covers(see paragraph 5-8, Panel Removal).

c. Remove fan air duct.

d. Disconnect twt leads from terminal board E1.

e. Return cables and type N Panel Connectors with tube. If input and output cables are detachable, disconnect them at the tube without disassembling type-N panel connectors. If the cables are not detachable, disassemble type-N connectors, remove from panel, re-assemble them, and return them with the tube.

f. Remove modulator plug-in A400.

g. Remove E1 mounting screw nearest ground terminal (E1A, Figure 5-3), and swing E1 assembly aside.

h. Place instrument on its side and remove four screws holding twt to main deck (see Figure 5-4).

i. Remove twt and refer to twt warranty claim sheet for packing instructions. Note: Fill out warranty claim completely and include reason for returning twt (e.g., low power, no power, etc.).

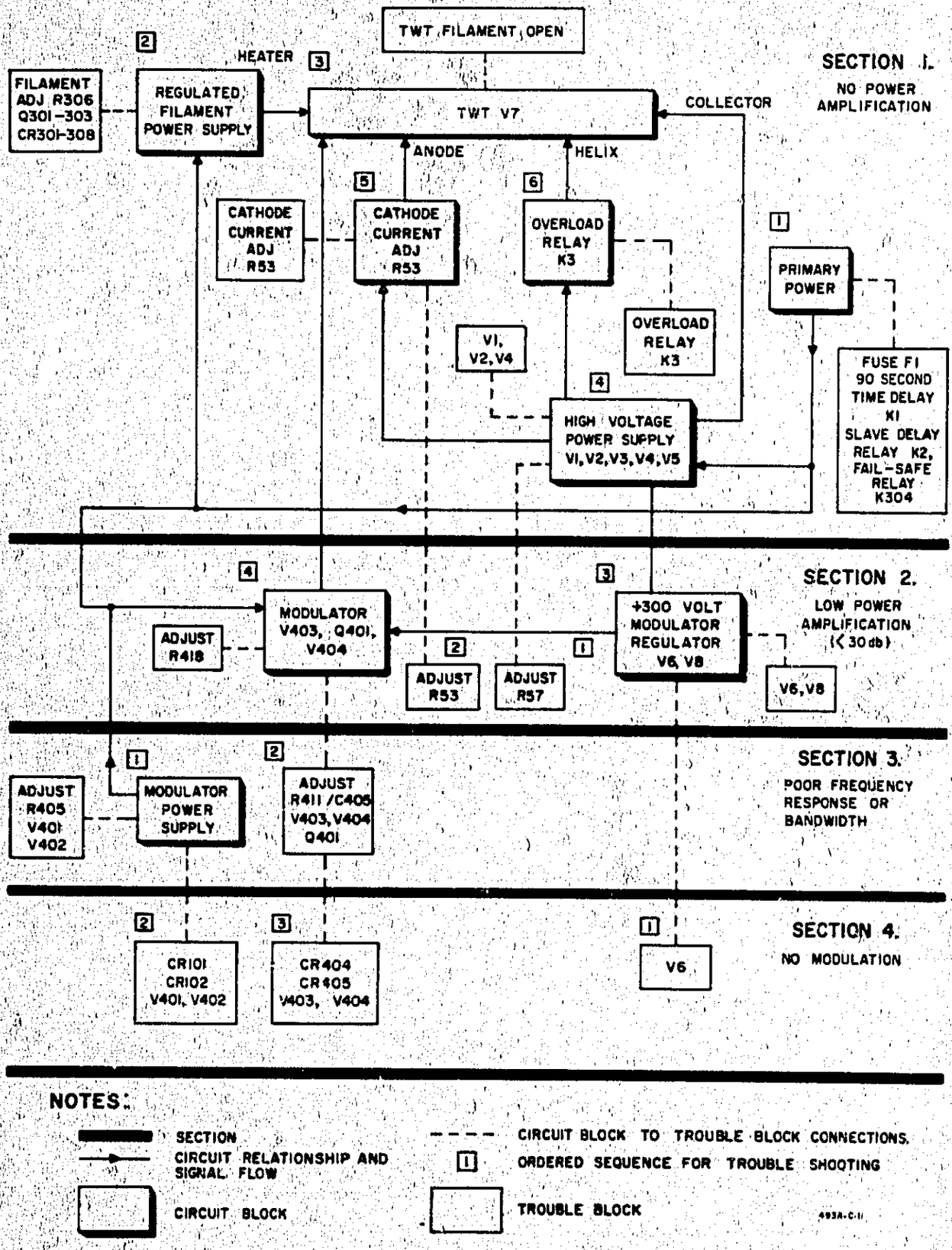


Figure 5-2. Troubleshooting Chart

5-21. TWT INSTALLATION.

a. Replace modulator board.

b. Before installing new TWT, adjust filament voltage to value stamped on TWT capsule with a 5-ohm, 5-watt load across filament circuit (see paragraph 5-24 FILAMENT ADJUSTMENT). Rough set -350 volt supply (measured between C401 and R431 and ground), collector/helix voltage, anode and grid voltage as instructed in paragraph 5-24 through 5-27.

c. Remove modulator board.

d. Install TWT.

e. Re-attach the E1 board to the instrument wall. Connect the TWT leads to terminal board E1.

f. Connect jumper wire between E1C (grey filament lead) and E1E (white cathode lead) on the E1 board. All replacement tubes require the jumper between E1C and E1E. Connect the TWT lead to terminal board E1 as shown in table 5-2 and figure 5-3.

g. If the replacement tube is supplied with detachable input and output cables, remove the cables from the tube to avoid disassembling the type-N panel connectors. If the cables are not detachable, disassemble the type-N connectors to mount them in the panel.

h. Repeat step f with the TWT input cable connector.

i. Replace modulator board.

j. Refer to paragraph 5-29 for optimizing TWT element voltages to obtain proper power amplification.

Note

The new modulator board, ◎ Stock No. 495A-65D, can be used with the old type TWT, ◎ Stock No. 1952-0016, if diode CR405, ◎ Stock No. 1901-0029, is installed between pin 1 of V404A and pin 6 of V404B.

k. Replace top and bottom cover.

Table 5-2. TWT Lead Identification

TWT Element	E1 Board Terminal	Color Lead
Collector	E1H	Refer to tube data sheet for proper identification of leads.
Helix	E1G	
Anode	E1F	
Cathode	E1E	
Grid	E1D	
Heater/Cathode	E1C	
Heater	E1B	
Ground	E1A	

5-22. TWT VOLTAGE ADJUSTMENTS.

5-23. Use this procedure when resetting TWT voltages or after installing a TWT. Note that adjustment of the collector/helix voltage affects anode voltage. When collector/helix adjustments are made, the anode voltage adjustment must also be made, if applicable.

CAUTION: The instrument should not be operated for long periods of time without fan duct and covers. Ambient temperature within the instrument will increase causing excessive helix current to flow. This will result in low power amplification and/or damage to TWT.

5-24. FILAMENT ADJUSTMENT.

a. Remove the instrument top cover (see para 5-8).

b. Rotate filament adjust R306, (figure 5-3) full counterclockwise.

c. Connect dc voltmeter between E1B and E1C (see figure 5-3). DC voltmeter to 10-volt range.

d. Set Model 493A power switch to STANDBY.

e. Adjust filament adjust R306, for 6.2 vdc.

f. Vary power line voltage from 103 to 127 vac. The dc voltmeter reading should not vary more than 6.2 ±0.1 volt.

Note

The filament voltage is factory adjusted to 6.2 volts dc. This will extend the filament life of the TWT considerably.

5-25. COLLECTOR/HELIX ADJUSTMENT.

a. Parallel an ac and dc voltmeter; connect between helix terminal (E1G) and ground (figure 5-3).

CAUTION: AC and dc voltmeter should be isolated to withstand 3000 volts.

b. Set Model 493A power switch to ON.

c. With the high voltage adj. R57, (figure 5-3) set the collector/helix voltage to the value stamped on the TWT capsule.

WARNING: High voltage is present on the high-voltage board A1 and the terminal board E1.

d. Vary power-line voltage from 103 to 127 vac; collector/helix voltage should not vary more than 5 volts; ripple voltage should not exceed 10 millivolts.

5-26. ANODE ADJUSTMENTS (If Applicable).

a. Parallel and ac and dc voltmeter; connect between anode terminal (E1F) and ground (figure 5-3).

b. With the cathode current adjust R53 (figure 5-3), set anode voltage to value listed in TWT data sheet.

Note

If the anode voltage range is not great enough to obtain anode voltage needed, R54 and R55 (see figure 5-12) can be interchanged to provide proper voltage range. This is assuming collector/helix voltage is set to the proper value.

c. Vary power-line voltage from 103 to 127 vac. Anode voltage should not vary more than 10 volts; ripple should not exceed 25 millivolts (measured on the TWT side of R203).

5-27. -350 VOLT ADJUSTMENT.

a. Parallel an ac and dc voltmeter; connect between junction of C401 and R431 (see figures 5-13 and 5-14) and ground.

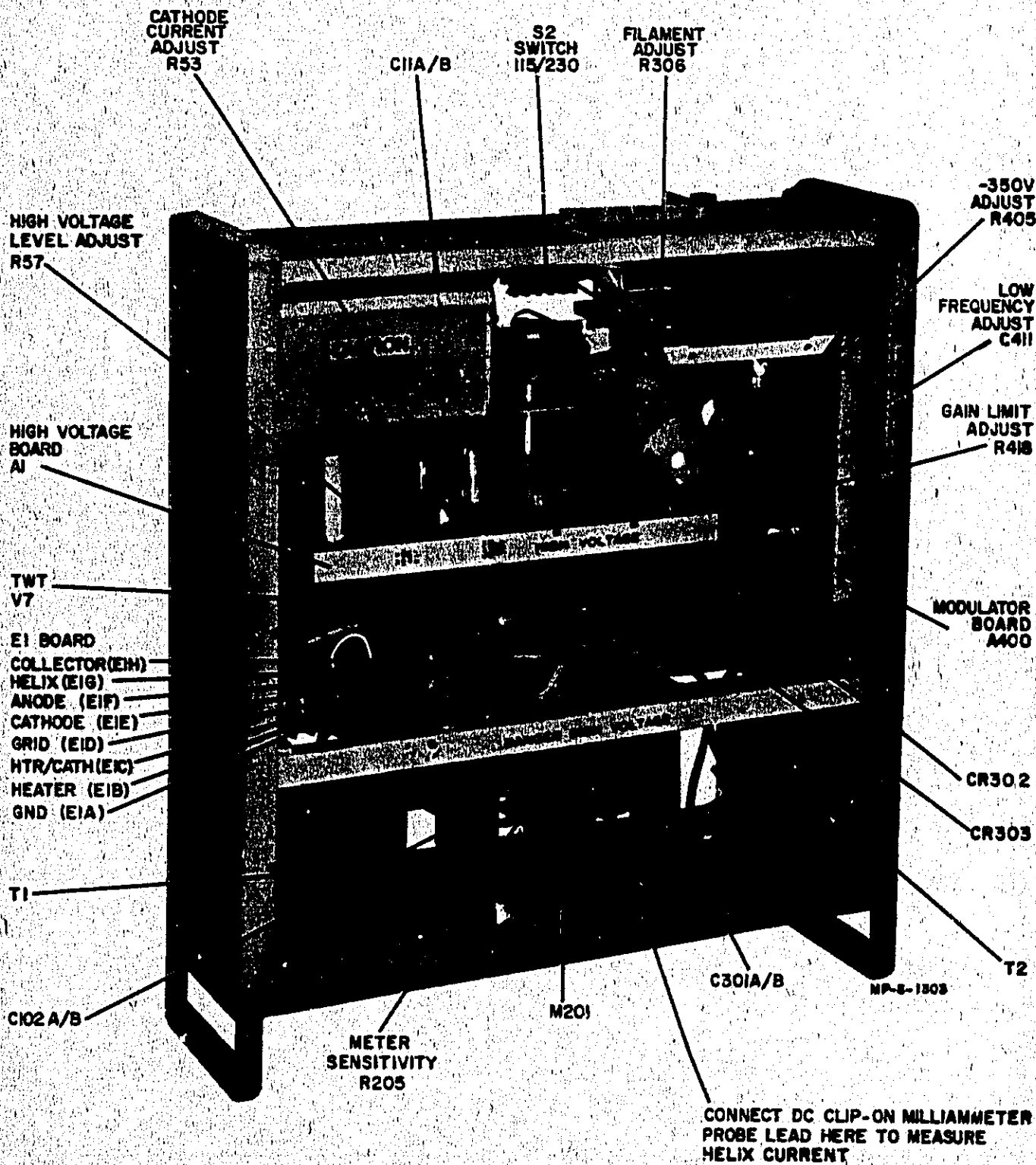


Figure 5-3. Model 493A Top View

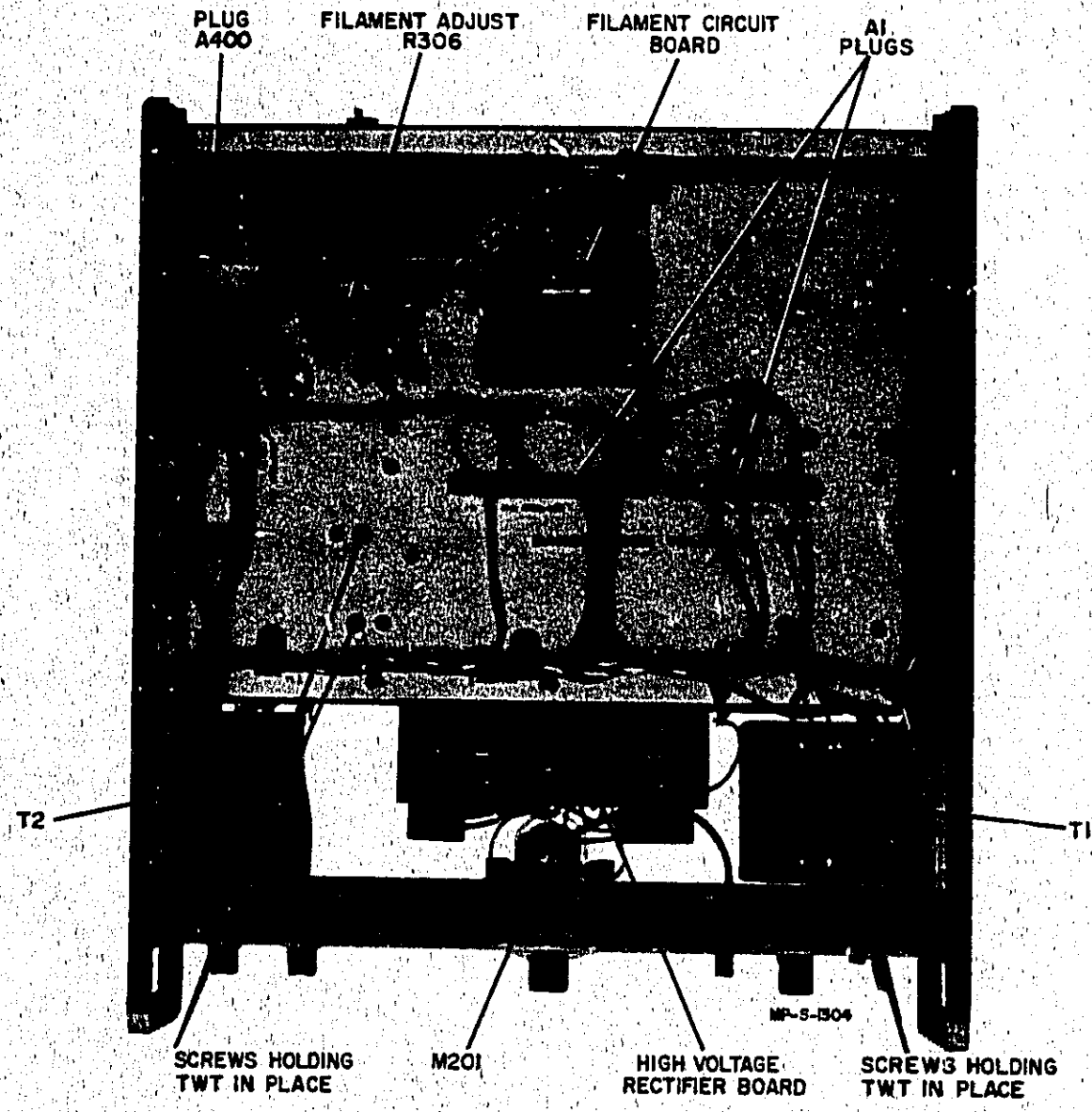


Figure 5-4. Model 493A Bottom View

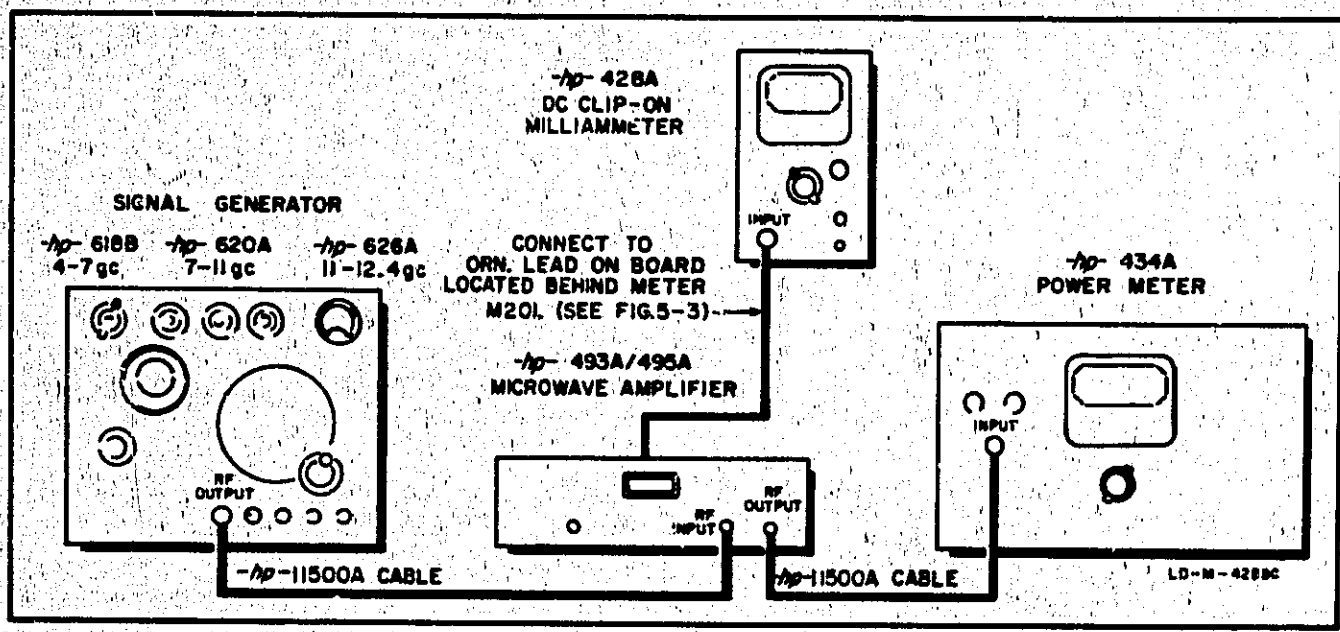


Figure 5-5. Power Amplification Setup

b. With the -350 volt adj. R405 (figure 5-3), set -350 volt regulated power supply to -350 volts.

c. Vary line voltage from 103 to 127 vac. The -350 volts should not vary more than ±3 volts; -350 volt-supply ripple voltage should be less than 10 millivolts.

d. Connect dc voltmeter between pin 12 of A400 and ground. Place the dc voltmeter on the +300 volt range and check +300 volts. Meter should read +300 volts ±10 volts. If not within the tolerance specified check V6 and V8. Then, if still out of specification replace R38 and R39.

e. Refer to para. 5-28, Gain Limit Adjustment.

5-28. GAIN LIMIT ADJUSTMENT.

a. Parallel an ac and a dc voltmeter; connect between grid terminal E1D and E1E (figure 5-3).

b. Rotate GAIN control full clockwise.

c. Adjust gain limit control R418, to voltage value stamped on twt capsule.

d. Vary power-line voltage from 103 to 127 vac. Grid voltage should not vary more than ±1.5 volts; ripple voltage should be less than 10 millivolts.

5-29. OPTIMIZING TWT ELEMENT VOLTAGES TO OBTAIN PROPER POWER AMPLIFICATION.

5-30. When all twt element voltages have been set, it may be necessary to go back and optimize the collector/helix anode and grid voltages to obtain the desired power amplification.

a. Set up the Model 493A as shown in figure 5-5.

b. Set up the signal generator for a 1 milliwatt output at twt low power point (8.0 gc for 493A, 12.4 gc for 495A).

Note

Make sure that the 1 milliwatt signal generator output includes the attenuation produced by the coaxial cable and that the losses in the cable running to the output power meter have been accounted for.

c. Microwave output power should be 1 watt or more. If it is not, optimize the collector/helix voltage (high voltage level adj. R57) for maximum power reading on the power meter.

d. Optimize grid voltage. If power at minimum power point is still less than 1 watt, increase anode voltage to produce an rf output of at least 1 watt.

e. Connect a dc clip-on milliammeter to the orange or yellow lead located on the board directly behind the current meter (see figure 5-3).

Note

Another method of measuring helix current is to place a VOM across R202. Since R202 is 1K, volts equal milliamperes.

f. Set signal generator frequency to low end of the band; optimize the GAIN control for maximum helix current. The helix current should be less than 4 ma.

g. If the helix current is greater than 4 ma or rf output power is still below 1 watt, re-optimize the collector/helix and grid voltage.

h. Adj. meter sensitivity control R205 for correct meter indication within meter Rated Power limit.

5-31. MODULATOR ADJUSTMENT.

5-32. FREQUENCY RESPONSE.

a. Connect the Model 493A/495A as shown in figure 5-6.

b. Rotate GAIN control full clockwise.

c. Set square-wave generator frequency to 10 kc and adjust square-wave generator amplitude for modulator output of 10 volts peak-to-peak.

d. Adjust high frequency adj. R411 (see figure 5-3), for optimum square-wave output. Rise time should be less than 0.8 μsec, overshoot less than 5%.

e. Set square-wave generator frequency to 1 kc; increase signal amplitude to produce a 100-volt peak-to-peak signal at the grid of the twt. Rise time should be less than 10 μsec, overshoot less than 5%.

5-33. BANDWIDTH.

a. Connect the Model 493A as shown in figure 5-7.

b. Set the sine-wave oscillator at 1 kc and adjust its output amplitude for a 10-volt peak-to-peak sine-wave output at the grid of the twt.

c. Increase the frequency of the sine-wave oscillator until the amplitude of the sine-wave voltage on the grid of the twt decreases to 7 volts peak-to-peak. Bandwidth specifications: 3 db variation from dc to 500 kc.

5-34. PERFORMANCE CHECK.

5-35. This performance check is an in-cabinet check that is used to check instrument specifications. All checks are made from the front panel. This procedure can also be used as an incoming or outgoing quality control check.

5-36. POWER AMPLIFICATION CHECK.

a. Refer to turn-on procedure, figure 3-1, and set up the Model 493A; set primary power switch to ON and allow the Model 493A to warm up for approximately 30 minutes.

b. Connect the Model 493A as shown in figure 5-5. Milliammeter not necessary for this check. Refer to table 5-1, Test Equipment Required.

c. Set up the signal generator for 1 mw cw output at 4.0 gc for 493A, 12.4 gc for 495A.

d. Set power meter to 3-watt range; zero-set the power meter.

e. Switch Model 493A primary power switch from STANDBY to ON.

f. Reading on power meter should be at least 1 watt. Specification: At least 1 watt at the output with application of 1 mw at the input. Remember to compensate for the losses in cable between the twt amplifier and the power meter.

5-37. GAIN CONTROL POWER ON-OFF RATIO.

a. Set up the Model 493A as shown in figure 5-8 (power supply power off). Signal generator set up for a 1 mw output at microwave amplifier low power point.

b. Rotate Model 493A GAIN control full counterclockwise; record power meter reading.

c. Rotate Model 493A GAIN control full clockwise; record power meter reading. Difference between the two readings should be at least 20 db. Specifications: "Modulation On-Off Ratio". Power OUTPUT change should be at least 20 db with the GAIN control.

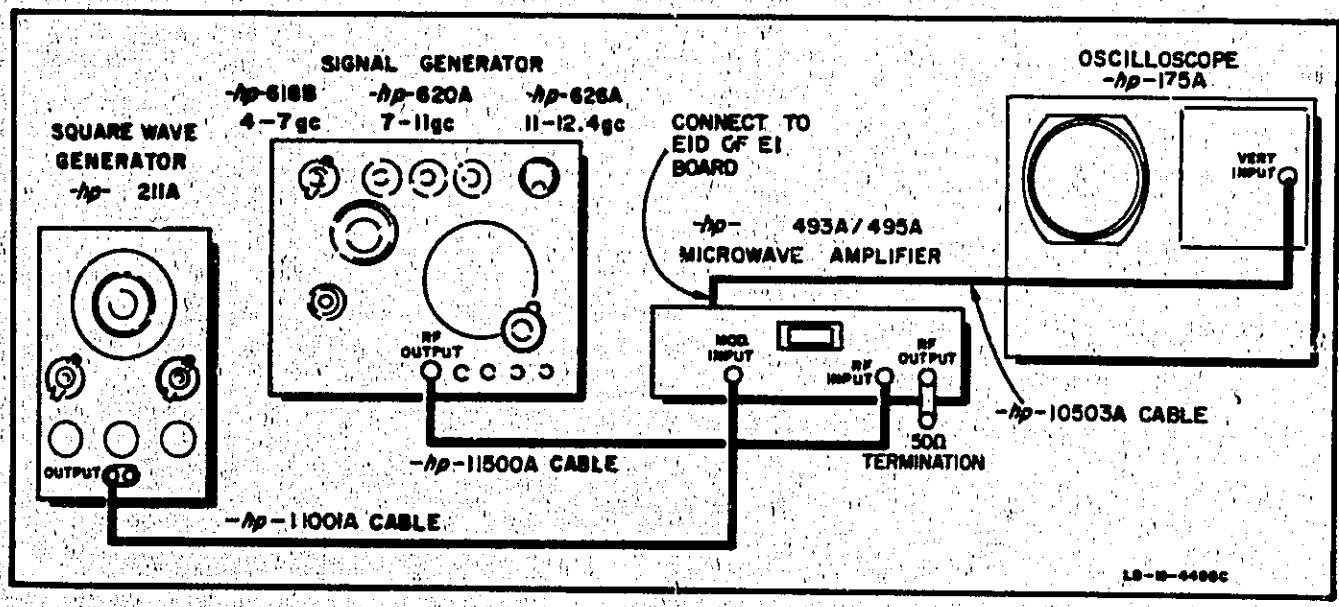


Figure 5-6. Frequency Response Setup

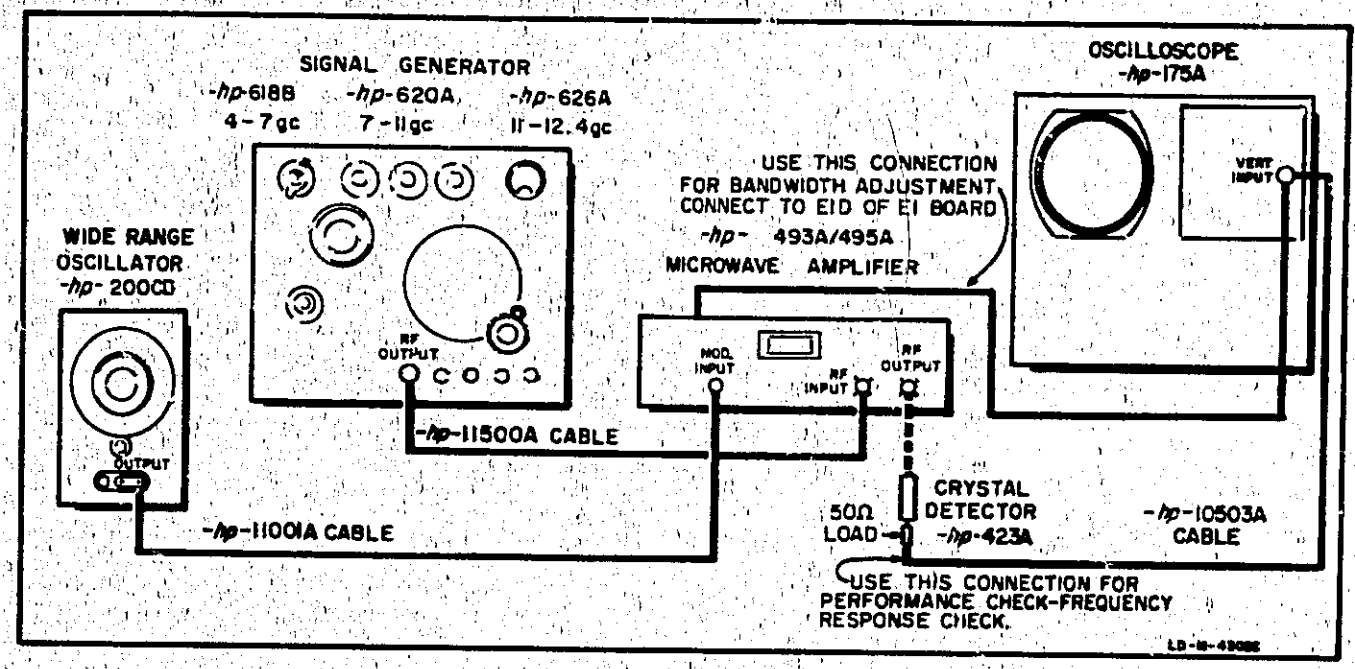


Figure 5-7. Bandwidth Setup

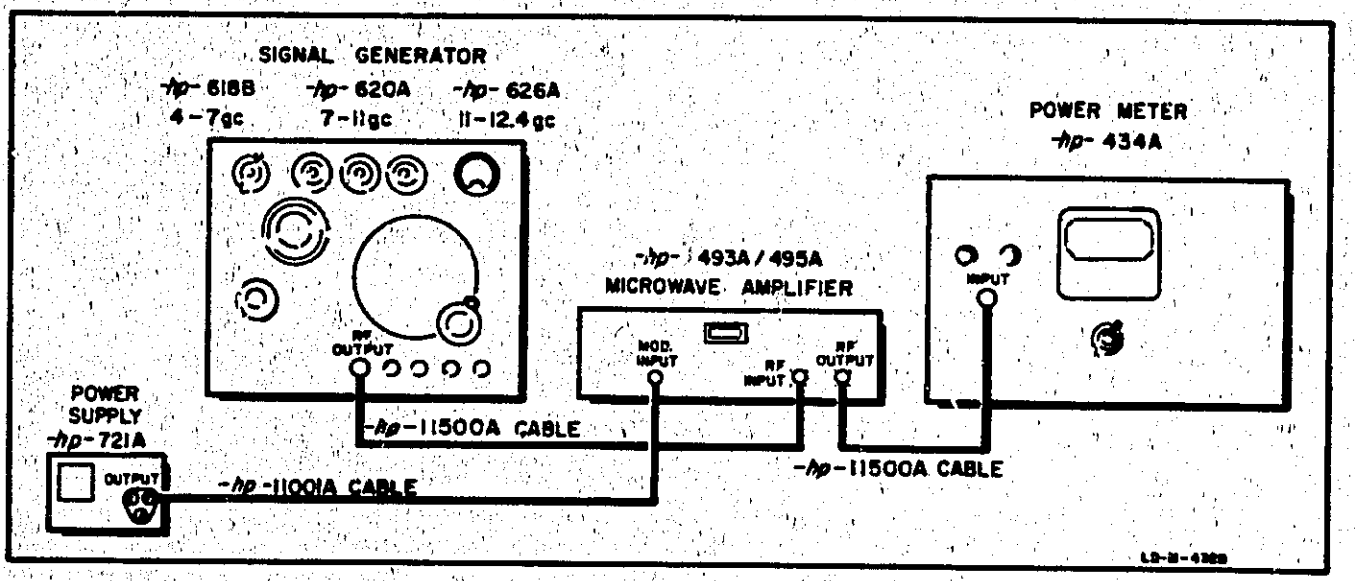


Figure 5-8. Modulator On-Off Ratio

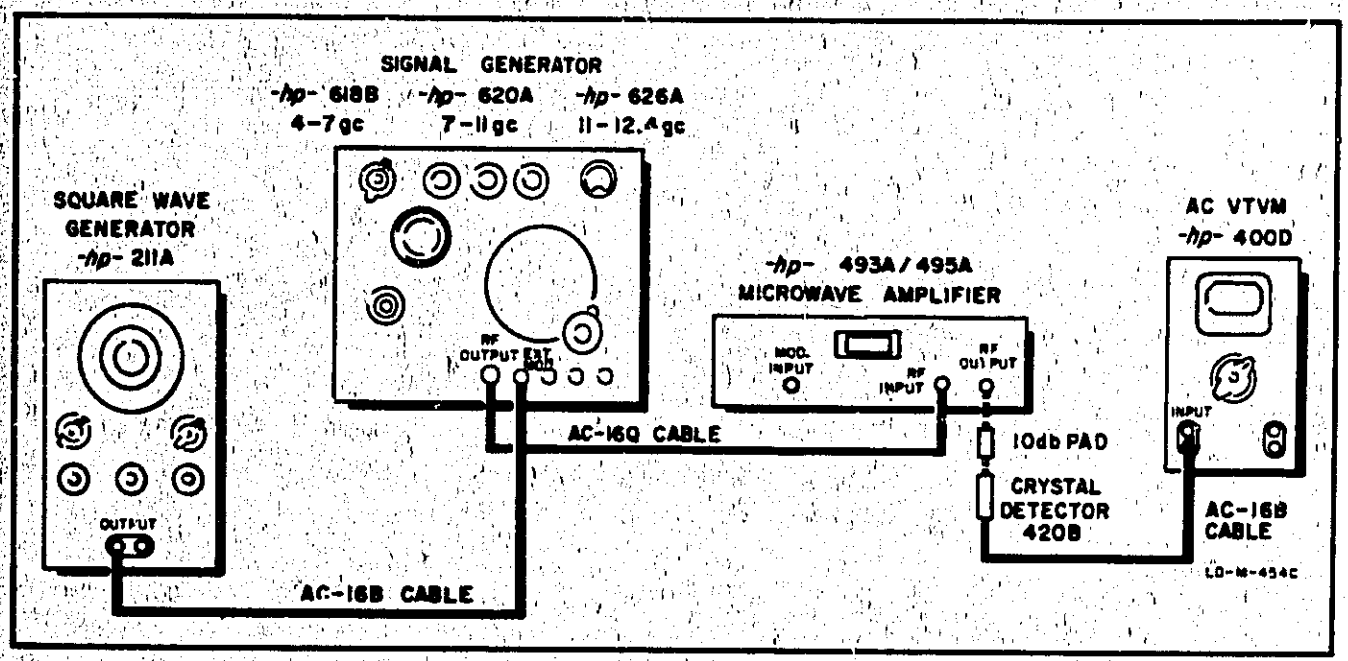


Figure 5-9. Residual AM Check

5-38. MODULATOR ON-OFF RATIO.

a. Connect the Model 493A as shown in figure 5-8, with the signal generator and the power meter at the same setting as those in paragraph 5-36 steps c and d.

b. Rotate the Model 493A GAIN control full clockwise.

c. Power supply output voltage to the Model 493A MOD INPUT, ZERO volts; record power meter reading.

d. Turn on power supply. Adjust for negative output. Increase power-supply output until power-meter reading is 20 db less than that recorded in step c. Power-supply voltage should be between 0 and -20 volts.

5-39. RESIDUAL AM CHECK.

a. Connect the Model 493A as shown in figure 5-9.

Note

Make sure the residual AM of the signal generator used to test the Model 493A is at least 45 db below signal level.

b. Set up the square-wave generator for 1 kc.

c. Signal generator output frequency 8 gc (12.4 gc for the Model 495A). Set generator MOD SELECTOR for EXT + modulation.

d. Adjust INPUT power to Model 493A for 100 millivolts (-18 db) reading at the ac vtvm.

e. Set Signal Generator for CW output and record ac VTVM reading which should be less than -55 db.

Note

Readings taken on an average-reading voltmeter, such as Model 400D, require a +8 db correction factor to obtain the actual value of the residual AM. This +8 db factor accounts for a) the crystal square-law characteristic and b) the difference between average and peak values of square and sine waves. Thus, a -55 db ac vtvm reading includes the following: -10 db (-18 from step d plus 8 as explained above) produced by ac vtvm and crystal detector, and -45 db caused by residual AM.

5-40. MODULATOR FREQUENCY RESPONSE.

a. Connect the Model 493A as shown in figure 5-7.

b. Set Model 493A GAIN control full clockwise.

c. Set up the signal generator for -15 dbm output at 8 gc (12.4 gc for Model 495A).

d. Set up the wide range oscillator for a 1 volt peak-to-peak output at 1 kc.

e. Adjust the signal generator power output so that the detected 1 kc modulated signal on the oscilloscope is set to a reference level.

f. Set up the wide range oscillator for a 1 volt peak-to-peak output at 500 kc. The amplitude of the detected signal should not have dropped more than 3 db.

Specification: Less than 3 db small signal output variation dc to 500 kc.

5-41. SWR CHECK.

5-42. SWR of the rf input and output circuit is 3:1 or better, and normally need not be checked if the instrument meets gain and power output specifications.

5-43. If it is desired to check the swr, normal swr measuring techniques (i.e., slotted line or swept frequency reflectometer) can be employed. Ⓗ Application Note 54 (available from your Ⓗ Engineering Representative) describes new, improved swept frequency techniques for measurement of swr, etc.

Note

The dc resistance of the input and output circuits, when measured at the panel jacks from center conductor to ground, will read ∞. The 50 Ω impedance is achieved through transmission line coupling.

5-44. FREQUENCY RANGE CONVERSION.

a. Remove the twt from the instrument (see twt removal, paragraph 5-20).

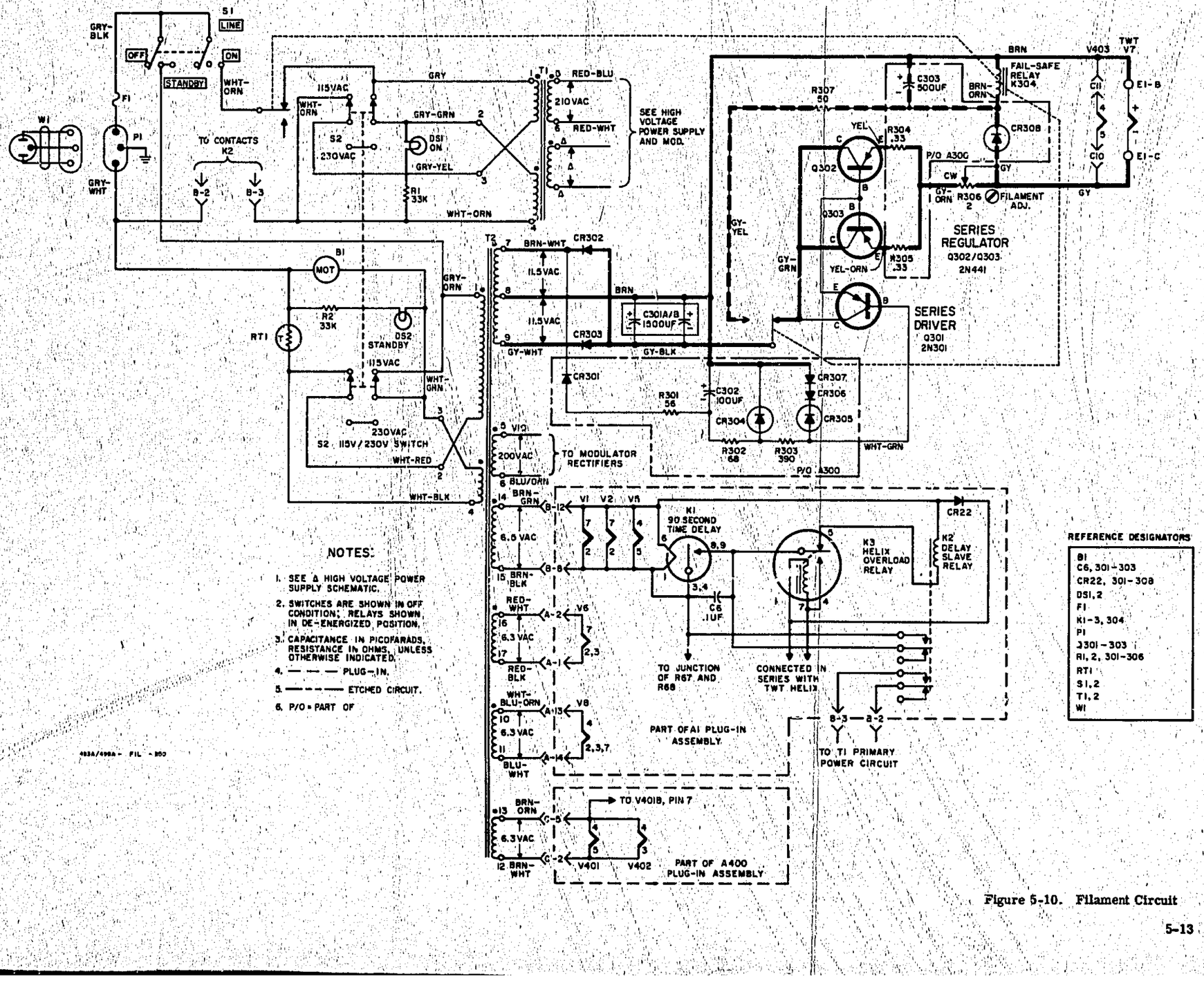
b. Replace twt in the instrument with twt in the range desired (4 - 8 gc or 7 - 12.4 gc). See twt installation, paragraph 5-21.

Note

Conversion from one frequency range to another may require switching of high voltage transformer leads. Refer to "note" on regulated high voltage power supply schematic.

c. Refer to performance check procedure, paragraph 5-34 and check instrument for specifications.

d. Replace the identification plate on the instrument with one indicating the frequency range and model number of the new twt installed.



NOTES:

1. SEE Δ HIGH VOLTAGE POWER SUPPLY SCHEMATIC.
2. SWITCHES ARE SHOWN IN OFF CONDITION; RELAYS SHOWN IN DE-ENERGIZED POSITION.
3. CAPACITANCE IN PICOFARADS, RESISTANCE IN OHMS, UNLESS OTHERWISE INDICATED.
4. — — — PLUG-IN.
5. ——— ETCHED CIRCUIT.
6. P/O = PART OF

REFERENCE DESIGNATORS

B1
C6, 301-303
CR22, 301-308
DS1, 2
F1
K1-3, 304
P1
J301-303
R1, 2, 301-306
RT1
S1, 2
T1, 2
W1

Figure 5-10. Filament Circuit

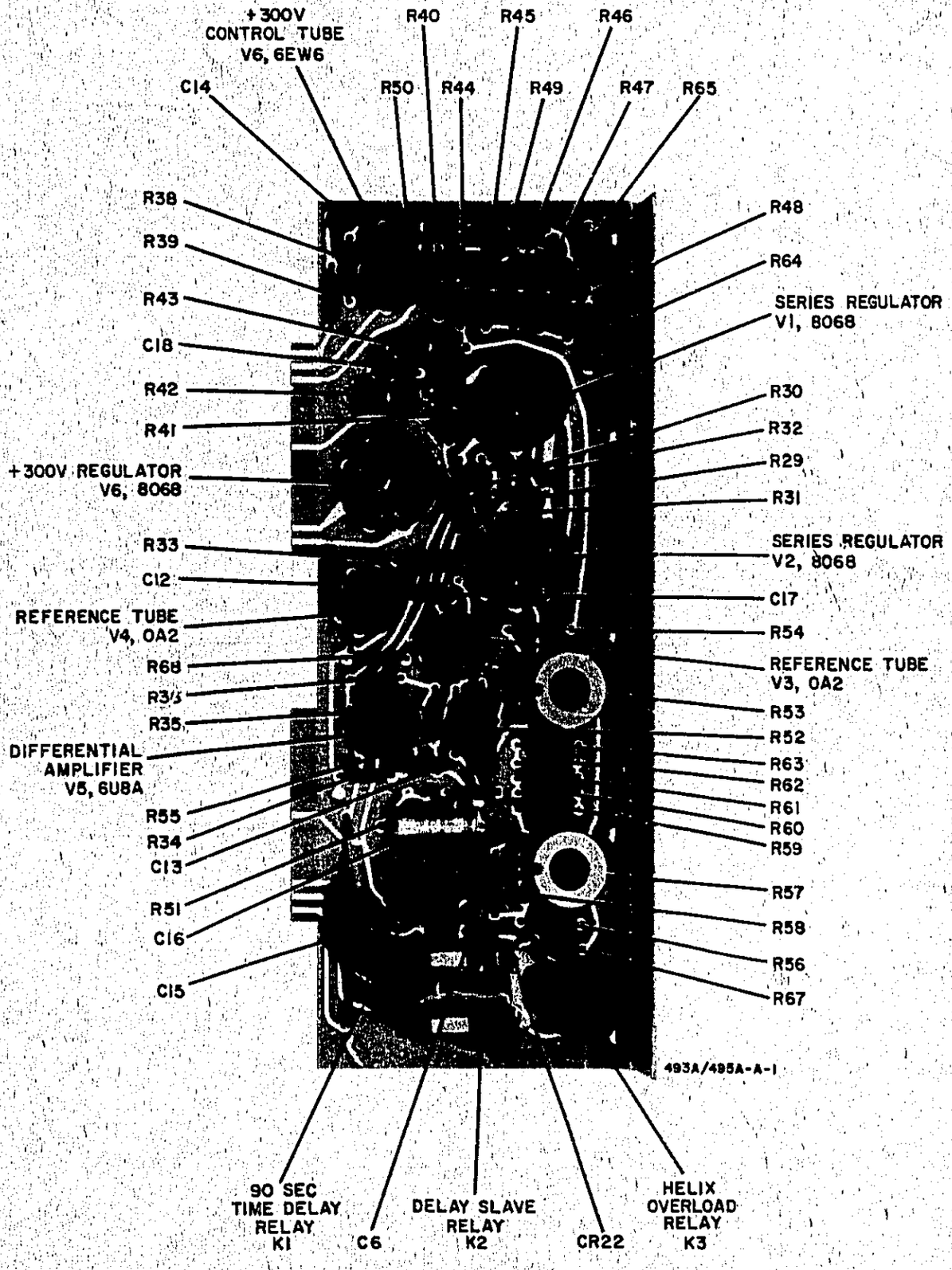
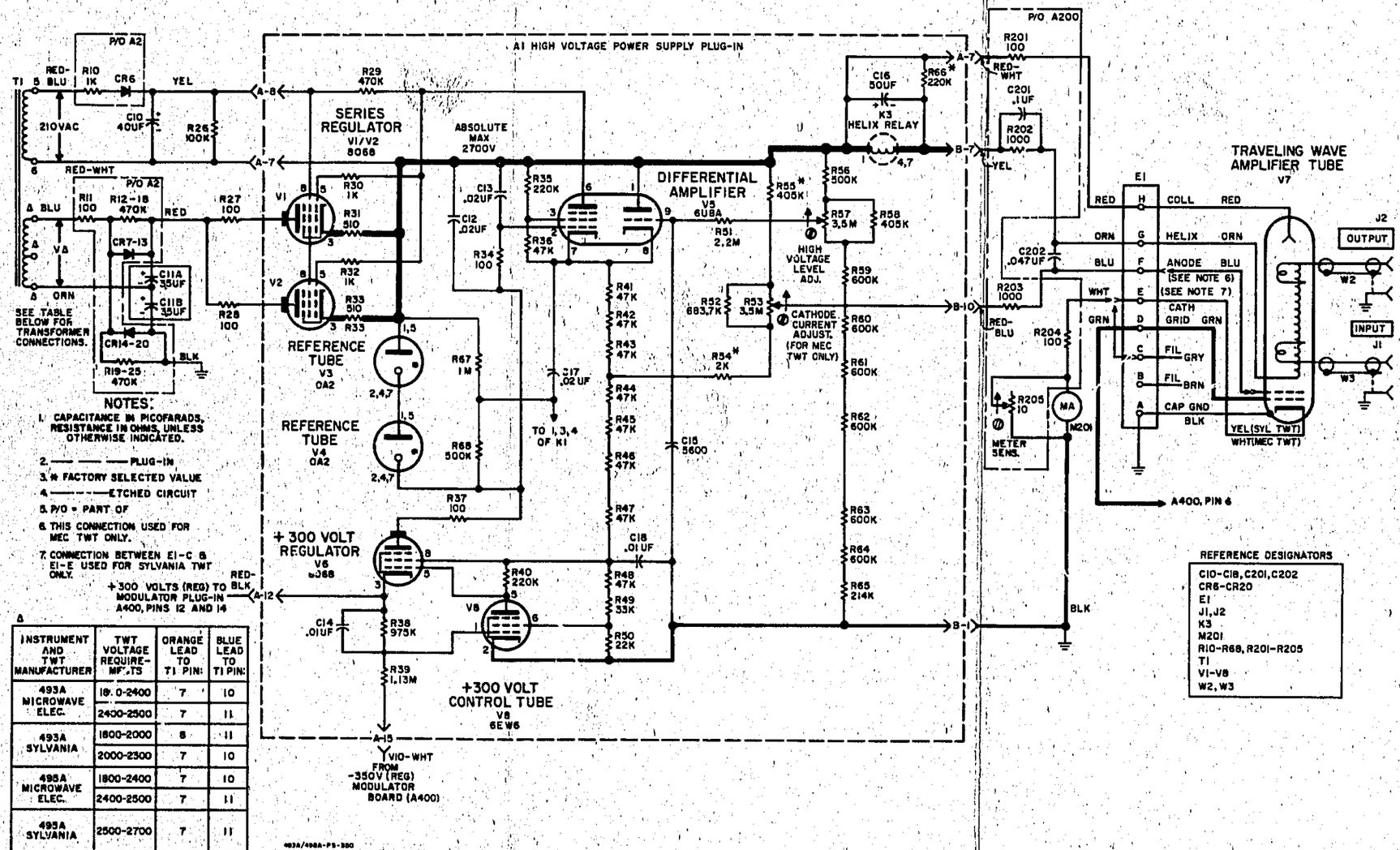


Figure 5-11. High Voltage Board (A1)



Δ

INSTRUMENT AND TWT MANUFACTURER	TWT VOLTAGE REQUIREMENTS	ORANGE LEAD TO T1 PIN:	BLUE LEAD TO T1 PIN:
493A MICROWAVE ELEC.	1800-2400	7	10
	2400-2500	7	11
493A SYLVANIA	1800-2000	8	11
	2000-2300	7	10
495A MICROWAVE ELEC.	1800-2400	7	10
	2400-2500	7	11
495A SYLVANIA	2500-2700	7	11

Figure 5-12. High Voltage Power Supply

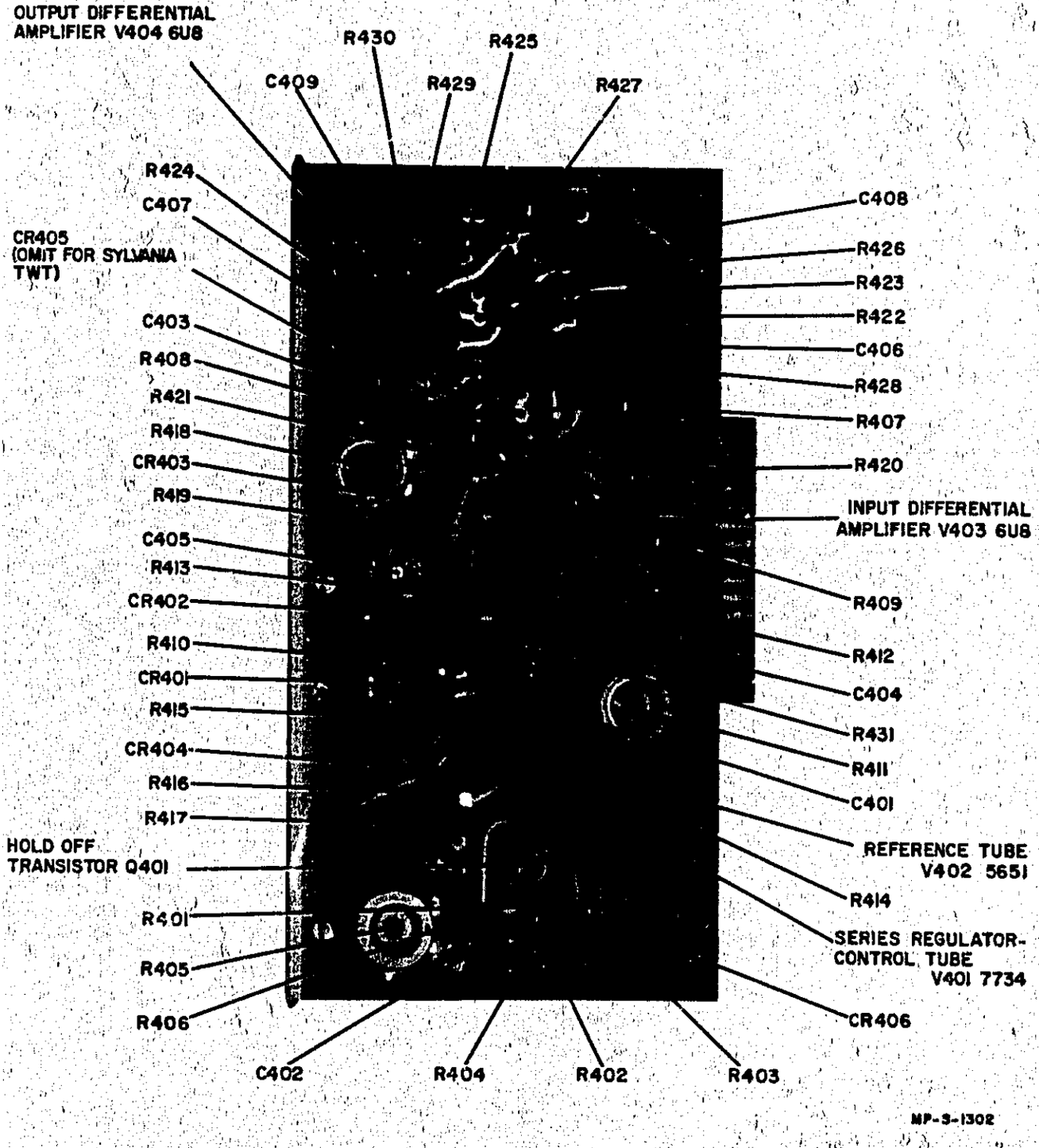
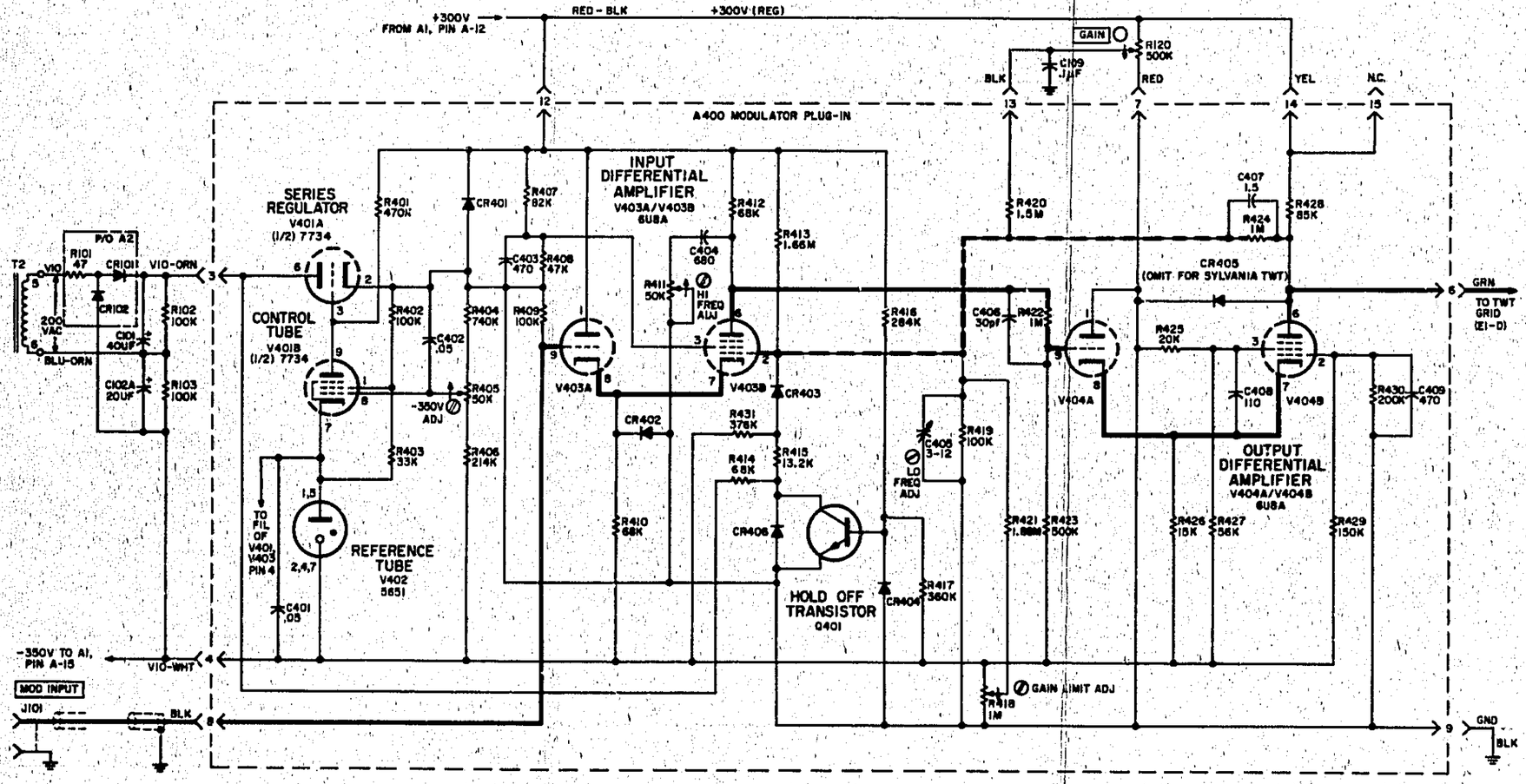


Figure 5-13. Modulator Board (A400)



REFERENCE DESIGNATORS

C101
C102A
C109
C401-409
CR101,102
CR401-406
J101
Q401
R101-103
R120
R401-431
T2
V401-404

NOTES:

1. ——— PLUG-IN
2. CAPACITANCE IN PICOFARADS, RESISTANCE IN OHMS, UNLESS OTHERWISE INDICATED.
3. ———ETCHED CIRCUIT
4. P/O = PART OF

Figure 5-14. Modulator

Additional Warranty Claim Shipping Instructions

Sylvania TWT

Include RF input and output cables when returning this TWT for warranty adjustment.

Microwave Electronics (MEC) TWT

Do NOT include RF input and output cables when returning this TWT for warranty adjustment.

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts for instruments serial prefixed 350. For those with other prefixes, see Appendix II. Table 6-1 lists parts in alpha-numerical order of their reference designators and indicates the description and ⓗ stock number of each part, together with any applicable notes. Table 6-2 lists parts in numerical order of their ⓗ stock numbers and provides the following information on each part:

a. Description of the part (see list of abbreviations below).

b. Typical manufacturer of the part in a five-digit code; see list of manufacturers in Appendix I.

c. Manufacturer's stock number.

d. Total quantity used in the instrument (TQ col.).

6-3. Miscellaneous parts not indexed in Table 6-1 are listed at the end of the table.

6-4. ORDERING INFORMATION.

6-5. To order a replacement part, address order or inquiry to your nearest Hewlett-Packard field office (see maps at the rear of this manual).

6-6. Specify the following information for each part:

a. Model and complete serial number of instrument.

b. Hewlett-Packard stock number.

c. Circuit reference designator.

d. Description.

6-7. To order a part not listed in tables 6-1 and 6-2, give a complete description of the part and include its function and location.

REFERENCE DESIGNATORS

A	= assembly	F	= fuse	P	= plug	V	= vacuum tube, neon bulb, photocell, etc.
B	= motor	FL	= filter	Q	= transistor	W	= cable
C	= capacitor	J	= jack	R	= resistor	X	= socket
CR	= diode	K	= relay	RT	= thermistor	Y	= crystal
DL	= delay line	L	= inductor	S	= switch	Z	= network
DS	= device signaling (lamp)	M	= meter	T	= transformer		
E	= misc. electronic part	MP	= mechanical part				

ABBREVIATIONS

A	= amperes	ELECT	= electrolytic	MOM	= momentary	RH	= round head
A.F.C	= automatic frequency control	ENCAP	= encapsulated	MTG	= mounting	RMO	= rack mount only
AMP	= amplifier			MY	= mylar	RMS	= root-mean-square
		F	= farads			ROT	= rotary
B.F.O.	= beat frequency oscillator	FH	= flat head	NC	= normally closed		
BE CU	= beryllium copper	FIL H	= fillister head	NE	= neon	S-B	= slow-blow
BH	= binder head	FXD	= fixed	NI PL	= nickel plate	SE	= selenium
BP	= bandpass			NO	= normally open	SECT	= section(s)
BRS	= brass	GE	= germanium	NPO	= negative positive zero (zero temperature coefficient)	SEMICON	= semiconductor
BWO	= backward wave oscillator	GL	= glass			SI	= silicon
		GRD	= ground(ed)			SIL	= silver
CER	= ceramic			NSR	= not separately replaceable	SL	= slide
CMO	= cabinet mount only	H	= henries			SPL	= special
COEF	= coefficient	HEX	= hexagonal			SST	= stainless steel
COM	= common	HG	= mercury	OBD	= order by description		
COMP	= composition	HR	= hour(s)	OH	= oval head		
CONN	= connector			OX	= oxide	TA	= tantalum
CP	= cadmium plate	IMPG	= impregnated			TD	= time delay
CRT	= cathode-ray tube	INCD	= incandescent	P	= peak	TI	= titanium
		INS	= insulation(ed)	PC	= printed circuit board	TOG	= toggle
DEPC	= deposited carbon			PF	= picofarads = 10^{-12} farads	TOL	= tolerance
EIA	= Tubes or transistors meeting Electronic Industries' Association standards will normally result in instrument operating within specifications; tubes and transistors selected for best performance will be supplied if ordered by ⓗ stock numbers.	K	= kilo = 1000	PH BRZ	= phosphor bronze	TRIM	= trimmer
				PIV	= peak inverse voltage	TWT	= traveling wave tube
		LIN	= linear taper	POLY	= polystyrene	U	= micro = 10^{-6}
		LK	= lock	POR	= porcelain		
		LOG	= logarithmic taper	POS	= position(s)	VAC	= vacuum
		LPF	= low pass filter	POT	= potentiometer	VAR	= variable
		M	= milli = 10^{-3}	PP	= peak-to-peak		
		MEG	= meg = 10^{6}	PT	= point	W	= watts
		METFLM	= metal film			W/	= with
		MFR	= manufacturer	RECT	= rectifier	W/O	= without
		MINAT	= miniature	RF	= radio frequency	WW	= wirewound

Table 6-1. Reference Designation Index

Circuit Reference	Stock No.	Description	Note
A1	495A-65B	ASSY:HV REGULATOR BOARD	
A2	495A-65A	ASSY:HV RECTIFIER	
A3 THRU A199		NOT ASSIGNED	
A200	495A-65E	ASSY:TWT TEST	
A201 THRU A299		NOT ASSIGNED	
A300	489A-65D	ASSY:FILAMENT REGULATOR	
A301 THRU A399		NOT ASSIGNED	
A400	495A-65D	ASSY:MODULATOR BOARD	
B1	3160-0026	FAN:MUFFIN	
C6	0150-0084	C:FXD CER 0.1 UF +80-20% 50VDCW	
C7 THRU C9		NOT ASSIGNED	
C10	0180-0024	C:FXD ELECT 40 UF 450VDCW	
C11	0160-0121	C:FXD PAPER 3.5 X 3.5 UF 10% 2000VDCW	
C12	0150-0024	C:FXD CER 0.02 UF +80-20% 600VDCW	
C13	0150-0024	C:FXD CER 0.02 UF +80-20% 600VDCW	
C14	0150-0012	C:FXD CER 0.01 UF 20% 1000VDCW	
C15	0160-0384	C:FXD PAPER 5600 PF +80-20% 3000VDCW	
C16	0180-0058	C:FXD ELECT 50 UF +100-10% 25VDCW	
C17	0150-0024	C:FXD CER 0.02 UF +80-20% 600VDCW	
C18	0150-0012	C:FXD CER 0.01 UF 20% 1000VDCW	
C19 THRU C100		NOT ASSIGNED	
C101	0180-0024	C:FXD ELECT 40 UF 450VDCW	
C102	0180-0012	C:FXD ELECT 2 X 20UF 450VDCW	
C103 THRU C108		NOT ASSIGNED	
C109	0160-0013	C:FXD MY 0.1 UF 10% 400VDCW	
C110 THRU C200		NOT ASSIGNED	
C201	0150-0084	C:FXD CER 0.1 UF +80-20% 50VDCW	
C202	0160-0056	C:FXD PAPER 0.047 UF 10% 1000VDCW	
C203 THRU C300		NOT ASSIGNED	
C301	0180-0028	C:FXD ELECT 2 X 1500 UF 15VDCW	
C302	0180-0061	C:FXD ELECT 100 UF +100-10% 25VDCW	
C303	0180-0063	C:FXD ELECT 500 UF +100-10% 3VDCW	
C304 THRU C400		NOT ASSIGNED	
C401	0150-0052	C:FXD CER 0.05 UF 20% 400VDCW	
C402	0150-0052	C:FXD CER 0.05 UF 20% 400VDCW	
C403	0140-0149	C:FXD MICA 470 PF 5% 300VDCW	
C404	0140-0208	C:FXD MICA 680 PF 5% 300VDCW	
C405	0130-0013	C:VAR CER 3-12 PF NPO	
C406	0140-0203	C:FXD MICA 30 PF 5% 500VDCW	
C407	0150-0011	C:FXD TI 1.5 PF 20% 500VDCW	
C408	0140-0194	C:FXD MICA 110 PF 5% 300VDCW	
C409	0140-0149	C:FXD MICA 470 PF 5% 300VDCW	
CR6 THRU CR20	1901-0030	SEMICON DEVICE:DIODE JUNCTION	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	# Stock No.	Description	Note
CR21		NOT ASSIGNED	
CR22	1901-0029	SEMICON DEVICE:DIODE SILICON	
CR23 THRU CR100		NOT ASSIGNED	
CR101	1901-0030	SEMICON DEVICE:DIODE JUNCTION	
CR102	1901-0030	SEMICON DEVICE:DIODE JUNCTION	
CR103 THRU CR300		NOT ASSIGNED	
CR301	1901-0025	SEMICON DEVICE:DIODE SILICON	
CR302	1901-0032	SEMICON DEVICE:DIODE 1N3209	
CR303	1901-0032	SEMICON DEVICE:DIODE 1N3209	
CR304	1902-0142	SEMICON DEVICE:DIODE SILICON,BREAKDOWN	
CR305	1902-0163	SEMICON DEVICE:DIODE SILICON,BREAKDOWN	
CR306	1901-0025	SEMICON DEVICE:DIODE SILICON	
CR307	1902-0025	SEMICON DEVICE:DIODE SILICON	
CR308	1902-0163	SEMICON DEVICE:DIODE SILICON,BREAKDOWN	
CR309 THRU CR400		NOT ASSIGNED	
CR401	1901-0029	SEMICON DEVICE:DIODE SILICON	
CR402	1901-0025	SEMICON DEVICE:DIODE JUNCTION	
CR403	1901-0025	SEMICON DEVICE:DIODE JUNCTION	
CR404	1901-0025	SEMICON DEVICE:DIODE JUNCTION	
CR405	1901-0029	SEMICON DEVICE:DIODE SILICON	
CR406	1902-0056	SEMICON DEVICE:DIODE SILICON	
DS1	1450-0048	LAMP:PILOT NE2H	
DS2	1450-0048	LAMP:PILOT NE2H	
E1	0360-0017	BOARD:TERMINAL	
F1	2110-0003	FUSE:CARTRIDGE 3A (115V OPERATION ONLY)	
	2110-0005	FUSE:CARTRIDGE 1.5A (230V OPERATION ONLY)	
J1	1250-0083	CONNECTOR:BNC	
J2	1250-0083	CONNECTOR:BNC	
K1	0490-0135	RELAY:THERMAL SPDT	
K2	0490-0039	RELAY:DPDT	
K3	0490-0010	RELAY:SPDT 115AC	
K4 THRU K303		NOT ASSIGNED	
K304	0490-0038	RELAY:DPDT 5A RESISTIVE	
M201	1120-0131	METER:1MA	
P1	1251-0148	CONNECTOR:POWER,MALE 3 PIN	
Q301	1850-0038	TRANSISTOR:GERMANIUM PNP 2N301	
Q302	1850-0021	TRANSISTOR:GERMANIUM PNP 2N441	
Q303	1850-0021	TRANSISTOR:GERMANIUM PNP 2N441	
Q304 THRU Q400		NOT ASSIGNED	
Q401	1854-0003	TRANSISTOR:SILICON NPN	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Stock No.	Description	Note
R1	0687-3331	R:FXD COMP 33K OHM 10% 1/2W	
R2	0687-3331	R:FXD COMP 33K OHM 10% 1/2W	
R3 THRU R9		NOT ASSIGNED	
R10	0693-1021	R:FXD COMP 1000 OHM 10% 2W	
R11	0813-0020	R:FXD WW 100 OHM 10% 5W	
R12 THRU R25			
R26	0692-4745	R:FXD COMP 470K OHM 5% 2W	
R27	0690-1041	R:FXD COMP 100K OHM 10% 1W	
R28	0690-1011	R:FXD COMP 100 OHM 10% 1W	
R29	0690-1011	R:FXD COMP 100 OHM 10% 1W	
R30	0687-4741	R:FXD COMP 470K OHM 10% 1/2W	
R31	0687-1021	R:FXD COMP 1000 OHM 10% 1/2W	
R32	0689-5115	R:FXD COMP 510 OHM 5% 1W	
R33	0687-1021	R:FXD COMP 1000 OHM 10% 1/2W	
R34	0689-5115	R:FXD COMP 510 OHM 5% 1W	
R35	0687-1011	R:FXD COMP 100 OHM 10% 1/2W	
R36	0690-2241	R:FXD COMP 220K OHM 10% 1W	
R37	0687-4731	R:FXD COMP 47K OHM 10% 1/2W	
R38	0690-1011	R:FXD COMP 100 OHM 10% 1W	
R39	0727-0266	R:FXD DEPC 975K OHM 1% 1/2W	
R40	0727-0278	R:FXD DEPC 1.13 MEGOHM 1% 1/2W	
R41 THRU R48	0690-2241	R:FXD COMP 220K OHM 10% 1W	
R49	0693-4731	R:FXD COMP 47K OHM 10% 2W	
R50	0693-3331	R:FXD COMP 33K OHM 10% 2W	
R51	0693-2231	R:FXD COMP 22K OHM 10% 2W	
R52	0687-2251	R:FXD COMP 2.2 MEGOHM 10% 1/2W	
R53	0730-0096	R:FXD DEPC 683.7K OHM 1% 1W	
R54	2100-0100	R:VAR COMP 3.5 MEGOHM 30% LIN 1/4W	
R55	0727-0115	R:FXD DEPC 2000 OHM 1% 1/2W FACTORY SELECTED COMP;TYPICAL VALUE GIVEN	
R56	0727-0240	R:FXD DEPC 405K OHM 1% 1/2W FACTORY SELECTED COMP;TYPICAL VALUE GIVEN	
R57	0727-0245	R:FXD DEPC 500K OHM 1% 1/2W	
R58	2100-0100	R:VAR COMP 3.5 MEGOHM 30% LIN 1/4W	
R59	0727-0240	R:FXD DEPC 405K OHM 1% 1/2W	
R60	0727-0246	R:FXD DEPC 600K OHM 1% 1/2W	
R61	0727-0246	R:FXD DEPC 600K OHM 1% 1/2W	
R62	0727-0246	R:FXD DEPC 600K OHM 1% 1/2W	
R63	0727-0246	R:FXD DEPC 600K OHM 1% 1/2W	
R64	0727-0246	R:FXD DEPC 600K OHM 1% 1/2W	
R65	0727-0222	R:FXD DEPC 214K OHM 1% 1/2W	
R66	0690-2241	R:FXD COMP 220K OHM 10% 1W FACTORY SELECTED COMP;TYPICAL VALUE GIVEN	
R67	0727-0276	R:FXD DEPC 1MEGOHM 1% 1/2W	
R68	0727-0245	R:FXD DEPC 500K OHM 1% 1/2W	
R69 THRU R100		NOT ASSIGNED	
R101	0690-4701	R:FXD COMP 47 OHM 10% 1W	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Stock No.	Description	Note
R102	0690-1041	R:FXD COMP 100K OHM 10% 1W	
R103	0690-1041	R:FXD COMP 100K OHM 10% 1W	
R104 THRU R119		NOT ASSIGNED	
R120	2100-0043	R:VAR COMP 500K OHM 10% LIN 2W	
R121 THRU R200		NOT ASSIGNED	
R201	0727-0043	R:FXD DEPC 100 OHM 1% 1/2W	
R202	0727-0100	R:FXD DEPC 1000 OHM 1% 1/2W	
R203	0727-0100	R:FXD DEPC 1000 OHM 1% 1/2W	
R204	0727-0043	R:FXD DEPC 100 OHM 1% 1/2W	
R205	2100-0335	R:VAR WW 10 OHM 20% 2W	
R206 THRU R300		NOT ASSIGNED	
R301	0687-5601	R:FXD COMP 56 OHM 10% 1/2W	
R302	0687-6801	R:FXD COMP 68 OHM 10% 1/2W	
R303	0687-3911	R:FXD COMP 390 OHM 10% 1/2W	
R304	0812-0019	R:FXD WW 0.33 OHM 5% 3W	
R305	0812-0019	R:FXD WW 0.33 OHM 5% 3W	
R306	2100-0308	R:VAR WW 2 OHM 10% LIN 5W	
R307 THRU R400	0816-0015	R:FXD WW 50 OHM 10% 10W	
R401		NOT ASSIGNED	
R402	0687-4741	R:FXD COMP 470K OHM 10% 1/2W	
	0687-1041	R:FXD COMP 100K OHM 10% 1/2W	
R403	0687-3331	R:FXD COMP 33K OHM 10% 1/2W	
R404	0727-0252	R:FXD DEPC 740K OHM 1% 1/2W	
R405	2100-0094	R:VAR COMP 50K OHM 30% LIN 1/5W	
R406	0727-0222	R:FXD DEPC 214K OHM 1% 1/2W	
R407	0690-8231	R:FXD COMP 82K OHM 10% 1W	
R408	0690-4731	R:FXD COMP 47K OHM 10% 1W	
R409	0690-1041	R:FXD COMP 100K OHM 10% 1W	
R410	0765-0008	R:FXD MET FLM 68K OHM 10% 2W	
R411	2100-0094	R:VAR COMP 50K OHM 30% LIN 1/5W	
R412	0765-0008	R:FXD MET FLM 68K OHM 10% 2W	
R413	0727-0283	R:FXD DEPC 1.66 MEGOHM 1% 1/2W	
R414	0758-0076	R:FXD MET FLM 68K OHM 5% 1/2W	
R415	0727-0165	R:FXD DEPC 13.2K OHM 1% 1/2W	
R416	0727-0230	R:FXD DEPC 284K OHM 1% 1/2W	
R417	0727-0235	R:FXD DEPC 360K OHM 1% 1/2W	
R418	2100-0096	R:VAR COMP 1 MEGOHM 30% LIN 1/5W	
R419	0727-0208	R:FXD DEPC 100K OHM 1% 1/2W	
R420	0727-0282	R:FXD DEPC 1.5 MEGOHM 1% 1/2W	
R421	0727-0286	R:FXD DEPC 1.88 MEGOHM 1% 1/2W	
R422	0727-0276	R:FXD DEPC 1 MEGOHM 1% 1/2W	
R423	0727-0245	R:FXD DEPC 500K OHM 1% 1/2W	
R424	0727-0276	R:FXD DEPC 1 MEGOHM 1% 1/2W	
R425	0689-2055	R:FXD COMP 20K OHM 5% 1W	
R426	0767-0010	R:FXD MET FLM 15K OHM 5% 3W	
R427	0693-5631	R:FXD COMP 56K OHM 10% 2W	
R428	0773-0010	R:FXD MET FLM 85K OHM 5% 5W	
R429	0727-0332	R:FXD DEPC 150K OHM 1% 1/2W	
R430	0727-0221	R:FXD DEPC 200K OHM 1% 1/2W	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	# Stock No.	Description	Note
R131	C/27-0237	R:FXD DEPC 376K OHM 1% 1/2W	
RT1	0839-0017	THERMISTOR:250 OHM 10%	
S1	3101-0041	SWITCH:TOGGLE DPDT 3 POSITION	
S2	3101-0034	SWITCH:SLIDE 4PDT	
T1	9100-0153	TRANSFORMER:POWER	
T2	9100-0152	TRANSFORMER:POWER	
V1	1923-0048	ELECTRON TUBE:PENTODE 8068	
V2	1923-0048	ELECTRON TUBE:PENTODE 8068	
V3	1940-0004	ELECTRON TUBE:0A2 VOLTAGE REGULATOR	
V4	1940-0004	ELECTRON TUBE:0A2 VOLTAGE REGULATOR	
V5	1933-0004	ELECTRON TUBE:PENTODE 6U8	
V6	1923-0048	ELECTRON TUBE:PENTODE 8068	
V7	1952-0016	ELECTRON TUBE:TWT,4-8GC,MEC(493A ONLY)	
V7	1952-0019	ELECTRON TUBE:TWT,7-12.4GC,SYLVANIA(495A ONLY)	
OR			
V7	1952-0010	ELECTRON TUBE:TWT 7-12.4GC,MEC(495A ONLY)	
V7	1952-0017	ELECTRON TUBE:TWT 4-8GC,SYLVANIA(493A ONLY)	
V8	1923-0043	ELECTRON TUBE:PENTODE 6EW6	
V9 THRU V400		NOT ASSIGNED	
V401	1933-0005	ELECTRON TUBE:PENTODE 7734	
V402	1940-0001	ELECTRON TUBE:5651	
V403	1933-0004	ELECTRON TUBE:PENTODE 6U8	
V404	1933-0004	ELECTRON TUBE:PENTODE 6U8	
W1	8120-0078	ASSY:POWER CABLE	
W2	495A-16D	ASSY:RF POWER OUTPUT CABLE(MEC TWT C-,X-BAND ONLY)	
W3	495A-16D	ASSY:RF POWER OUTPUT CABLE(MEC TWT C-,X-BAND ONLY)	
XK1	1200-0062	SOCKET:TUBE 9 PIN	
XK2		NOT ASSIGNED	
XK3	1200-0049	SOCKET:TUBE 7 PIN	
XV1	1200-0084	SOCKET:TUBE	
XV2	1200-0084	SOCKET:TUBE	
XV3	1200-0053	SOCKET:TUBE 7 PIN	
XV4	1200-0053	SOCKET:TUBE 7 PIN	
XV5	1200-0062	SOCKET:TUBE 9 PIN	
XV6	1200-0084	SOCKET:TUBE	
XV7		NOT ASSIGNED	
XV8	2100-0053	SOCKET:TUBE 7 PIN	
XV9 THRU XV400		NOT ASSIGNED	
XV401	1200-0062	SOCKET:TUBE 9 PIN	
XV402	1200-0053	SOCKET:TUBE 7 PIN	
XV403	1200-0062	SOCKET:TUBE 9 PIN	
XV404	1200-0062	SOCKET:TUBE 9 PIN	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	# Stock No.	Description	Note
		MISCELLANEOUS	
	3150-0019	AIR FILTER:3 5/8 X 7 11/16 X 1/2	
	5060-0752	BOTTOM COVER ASSEMBLY:16L FM	
	1401-0006	CLIP:TUBE	
	1251-0160	CONNECTOR:P.C. 15 CONTACTS(FOR A1 & A101)	
	5000-0738	COVER:SIDE	
	5000-0739	COVER:SIDE	
	5000-0732	FRAME	
	5060-0767	FOOT ASSEMBLY:FM	
	1400-0084	FUSEHOLDER:EXTRACTOR POST TYPE	
	1200-0081	INSULATOR:BUSHING,NYLON(Q301 MTG.)	
	1200-0088	INSULATOR:DIODE(SMALL WASHER FOR CR302,CR303 AND Q302,Q303 MTG.)	
	1200-0079	INSULATOR:TRANSISTOR(4 HOLE,Q303 MTG.)	
	1200-0043	INSULATOR:TRANSISTOR MTG.(Q301)	
	0370-0026	KNOB:GAIN ADJUST	
	489A-12Q	RETAINER,AIR FILTER	
	1220-0008	SHIELD:TUBE,FOR K3	
	489A-57A	SHOULDER SCREW:AIR FILTER RETAINER	
	5060-0222	SIDE HANDLE ASSEMBLY	
	1490-0030	STAND:TILT	
	5060-0740	TOP COVER ASSEMBLY:16L FM	
	1200-0080	WASHER:INSULATOR(CR302,CR303 MTG)	

See introduction to this section

Table 6-2. Replaceable Parts

Stock No.	Description #	Mfr.	Mfr. Part No.	TQ
0130-0013	C:VAR CER 3-12 PF NPO	28480	0130-0013	1
0140-0149	C:FXD MICA 470 PF 5% 300VDCW	04062	DM15F471J	2
0140-0194	C:FXD MICA 110 PF 5% 300VDCW	04062	DM15F111J 300V	1
0140-0203	C:FXD MICA 30 PF 5% 500VDCW	04062	DM15E300J 500V	1
0140-0208	C:FXD MICA 680 PF 5% 300VDCW	04062	DM15F681J	1
0150-0011	C:FXD TI 1.5 PF 20% 500VDCW	78488	TYPE GA	1
0150-0012	C:FXD CER 0.01 UF 20% 1000VDCW	28480	0150-0012	2
0150-0024	C:FXD CER 0.02 UF +80-20% 600VDCW	71590	DD203	3
0150-0052	C:FXD CER 0.05 UF 20% 400VDCW	56289	33C17A/50000PF	2
0150-0084	C:FXD CER 0.1 UF +80-20% 50VDCW	56289	33C41	2
0160-0013	C:FXD MY 0.1 UF 10% 400VDCW	56289	160P10494	1
0160-0056	C:FXD PAPER 0.047 UF 10% 1000VDCW	56289	160P473910	1
0160-0121	C:FXD PAPER 3.5 X 3.5 UF 10% 2000VDCW	56289	P49900	1
0160-0384	C:FXD CER 5600 PF +80-20% 3000VDCW	71590	DA172-098CB	1
0180-0012	C:FXD ELECT 2 X 20 UF 450VDCW	28480	0180-0012	1
0180-0024	C:FXD ELECT 40 UF +50-10% 450VDCW	56289	D32441	2
0180-0028	C:FXD ELECT 2 X 1500 UF 15VDCW	56289	D32442	1
0180-0058	C:FXD ELECT 50 UF +100-10% 25VDCW	56289	D28110	1
0180-0061	C:FXD ELECT 100 UF +100-10% 15VDCW	56289	30D107G015DD4	1
0180-0063	C:FXD ELECT 500 UF +100-10% 3VDCW	56289	D32530	1
0360-0017	BOARD:TERMINAL	75382	601-Y-8	1
0370-0026	KNOB:GAIN ADJUST	28480	0370-0026	1
489A-65D	FILAMENT REGULATOR BOARD	28480	489A-65D	1
489A-65D-1	BLANK PRINTED CIRCUIT BOARD	28480	489A-65D-1	1
0490-0010	RELAY:SPDT 115 AC	77342	SM-4107	1
0490-0038	RELAY:DPDT 5A RESISTIVE	04298	GHA/2C/6VAC	1
0490-0039	RELAY:DPDT	77342	KA11AY-6.3	1
0490-0135	RELAY:SPDT THERMAL	70563	6NO-180T	1
495A-16D	ASSY:RF POWER INPUT,OUTPUT CABLE	28480	495A-16D	2
495A-65A	ASSY:RECTIFIER BOARD	28480	495A-65A	1
495A-65A-1	BLANK PRINTED CIRCUIT BCARD	28480	495A-65A-1	1
495A-65B	ASSY:HV REGULATOR BOARD	28480	495A-65B	1
495A-65B-1	BLANK PRINTED CIRCUIT BOARD	28480	495A-65B-1	1
495A-65D	ASSY:MODULATOR BOARD	28480	495A-65D	1
495A-65D-1	BLANK PRINTED CIRCUIT BOARD	28480	495A-65D-1	1
495A-65E	ASSY:TWT TEST	28480	495A-65E	1
495A-65E-1	BLANK PRINTED CIRCUIT BOARD	28480	495A-65E-1	1
0687-1011	R:FXD COMP 100 OHM 10% 1/2W	01121	EB 1011	1
0687-1021	R:FXD COMP 1000 OHM 10% 1/2W	01121	EB 1021	2
0687-1041	R:FXD COMP 100K OHM 10% 1/2W	01121	EB 1041	1
0687-2251	R:FXD COMP 2.2 MEGOHM 10% 1/2W	01121	EB 2251	1
0687-3331	R:FXD COMP 33K OHM 10% 1/2W	01121	EB 3331	3
0687-3911	R:FXD COMP 390 OHM 10% 1/2W	01121	EB 3911	1
0687-4731	R:FXD COMP 47K OHM 10% 1/2W	01121	EB 4731	1
0687-4741	R:FXD COMP 470K OHM 10% 1/2W	01121	EB 4741	2
0687-5601	R:FXD COMP 56 OHM 10% 1/2W	01121	EB 5601	1

See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	
0687-6801	R:FXD COMP 68 OHM 10% 1/2W	01121	EB 6801	1	
0689-2035	R:FXD COMP 20K OHM 5% 1W	01121	GB 2035	1	
0689-5115	R:FXD COMP 510 OHM 5% 1W	01121	GB 5115	2	
0690-1011	R:FXD COMP 100 OHM 10% 1W	01121	GB 1011	3	
0690-1041	R:FXD COMP 100K OHM 10% 1W	01121	GB 1041	4	
0690-2241	R:FXD COMP 220K OHM 10% 1W	01121	GB 2241	2	
0690-4701	R:FXD COMP 47 OHM 10% 1W	01121	GB 4701	1	
0690-4731	R:FXD COMP 47K OHM 10% 1W	01121	GB 4731	1	
0690-8231	R:FXD COMP 82K OHM 10% 1W	01121	GB 8231	1	
0692-4745	R:FXD COMP 470K OHM 5% 2W	01121	HB 4745	1A	
0693-1021	R:FXD COMP 1000 OHM 10% 2W	01121	HB 1021	1	
0693-2231	R:FXD COMP 22K OHM 10% 2W	01121	HB 2231	1	
0693-3331	R:FXD COMP 33K OHM 10% 2W	01121	HB 3331	1	
0693-4731	R:FXD COMP 47K OHM 10% 2W	01121	HB 4731	8	
0693-5631	R:FXD COMP 56K OHM 10% 2W	01121	HB 5631	1	
0727-0043	R:FXD DEPC 100 OHM 1% 1/2W	28480	0727-0043	2	
0727-0100	R:FXD DEPC 1000 OHM 1% 1/2W	19701	CD 1/2C	2	
0727-0115	R:FXD DEPC 2000 OHM 1% 1/2W	19701	DC 1/2C	1	
0727-0165	R:FXD DEPC 13.2K OHM 1% 1/2W	19701	DC 1/2C	1	
0727-0208	R:FXD DEPC 100K OHM 1% 1/2W	19701	DC 1/2C	1	
0727-0221	R:FXD DEPC 200K OHM 1% 1/2W	19701	DC 1/2A	1	
0727-0222	R:FXD DEPC 214K OHM 1% 1/2W	19701	DC 1/2C	2	
0727-0230	R:FXD DEPC 284K OHM 1% 1/2W	19701	DC 1/2C	1	
0727-0235	R:FXD DEPC 360K OHM 1% 1/2W	19701	DC 1/2B	1	
0727-0237	R:FXD DEPC 376K OHM 1% 1/2W	19701	DC 1/2C	1	
0727-0240	R:FXD DEPC 405K OHM 1% 1/2W	19701	DC 1/2	2	
0727-0245	R:FXD DEPC 500K OHM 1% 1/2W	19701	DC 1/2C	3	
0727-0246	R:FXD DEPC 600K OHM 1% 1/2W	19701	DC 1/2C	6	
0727-0252	R:FXD DEPC 740K OHM 1% 1/2W	19701	DC 1/2A	1	
0727-0266	R:FXD DEPC 975K OHM 1% 1/2W	19701	DC 1/2C	1	
0727-0276	R:FXD DEPC 1 MEGOHM 1% 1/2W	19701	DC 1/2C	3	
0727-0278	R:FXD DEPC 1.13 MEGOHM 1% 1/2W	19701	DC 1/2C	1	
0727-0282	R:FXD DEPC 1.5 MEGOHM 1% 1/2W	19701	DC 1/2-1.5M-1%	1	
0727-0283	R:FXD DEPC 1.66 MEGOHM 1% 1/2W	19701	DC 1/2A	1	
0727-0286	R:FXD DEPC 1.88 MEGOHM 1% 1/2W	19701	DC 1/2C	1	
0727-0332	R:FXD DEPC 150K OHM 1% 1/2W	19701	CF 1/2	1	
0730-0096	R:FXD DEPC 683.7K OHM 1% 1W	19701	DC1	1	
0758-0076	R:FXD MET FLM 68K OHM 5% 1/2W	07115	C20	1	
0765-0008	R:FXD MET FLM 68K OHM 10% 2W	07115	C42S	2	
0767-0010	R:FXD MET FLM 15K OHM 5% 3W	07115	LP1-3	1	
0773-0010	R:FXD MET FLM 85K OHM 5% 5W	07115	LP1-5	1	
0812-0019	R:FXD WW 0.33 OHM 5% 3W	35434	VTA-3	2	
0813-0020	R:FXD WW 100 OHM 10% 5W	94310	FRL-5	1	
0816-0015	R:FXD WW 50 OHM 10% 10W	35434	GC10 50	1	
0839-0017	THERMISTOR:250 OHM 10%	24446	ID 751	1	
1120-0131	METER:1 MA	06555	MODEL E-25	1	
1200-0049	SOCKET:TUBE 7 PIN	71785	111-51-11-096	1	
1200-0053	SOCKET:TUBE 7 PIN	71785	111-51-11	4	
1200-0062	SOCKET:TUBE 9 PIN	71785	121-51-11-060	5	
1200-0084	SOCKET:TUBE	71785	101-04-11-100	3	

See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	
1250-0083	CONNECTOR:BNC	91737	UG-1094/U	2	
1251-0148	CONNECTOR:POWER MALE 3 PIN	60427	H-1060-1G-3L	1	
1251-0160	CONNECTOR:PC 15 CONTACTS	07233	250-15-30-210	3	
1400-0084	FUSEHOLDER:EXTRACTOR POST TYPE	75915	342014	1	
1401-0006	CLIP:TUBE(PLATE CONNECTOR V1,V2,V6.)	91418	SPP-3	1	
1450-0048	LAMP:PILOT NE2H	08717	858R	2	
1490-0030	STAND:TILT	28480	1490-0030	1	
1850-0021	TRANSISTOR:GERMANIUM PNP 2N441	16758	2N441	2	
1850-0038	TRANSISTOR:GERMANIUM PNP	86684	34879	1	
1854-0003	TRANSISTOR:SILICON NPN	28480	1854-0003	1	
1901-0025	SEMICON DEVICE:DIODE JUNCTION	28480	1901-0025	6	
1901-0029	SEMICON DEVICE:DIODE SILICON	28480	1901-0029	3	
1901-0030	SEMICON DEVICE:DIODE JUNCTION	28480	1901-0030	17	
1901-0032	SEMICON DEVICE:DIODE JUNCTION 1N3209	04713	1N3209	2	
1902-0025	SEMICON DEVICE:DIODE SILICON	28480	1902-0025		
1902-0056	SEMICON DEVICE:DIODE SILICON	28480	1902-0056	1	
1902-0215	SEMICON DEVICE:DIODE SILICON,BREAKDOWN	28480	1902-0215	1	
1902-0218	SEMICON DEVICE:DIODE SILICON,BREAKDOWN	28480	1902-0218	2	
1923-0043	ELECTRON TUBE:PENTODE 6EW6	33173	6EW6	1	
1923-0048	ELECTRON TUBE:PENTODE 8068	33173	8068	3	
1933-0004	ELECTRON TUBE:PENTODE 6U8	33173	6U8	3	
1933-0007	ELECTRON TUBE:PENTODE 6AU8	33173	6AU8	1	
1940-0001	ELECTRON TUBE:5651	86684	5651	1	
1940-0004	ELECTRON TUBE:0A2 VOLTAGE REGULATOR	86684	0A2	2	
1952-0010	ELECTRON TUBE:TWT 7-12.4GC (495A ONLY)	08040	M2403-LB	1	
1952-0016	ELECTRON TUBE:TWT 4-8GC(493A ONLY)	08040	M2407-DB	1	
1952-0017	ELECTRON TUBE:TWT 4-8GC(493A ONLY)	04651	SYT 4278C	1	
1952-0019	ELECTRON TUBE:TWT 7-12.4GC (495A ONLY)	04651	SYT 4273C	1	
2100-0043	R:VAR COMP 500K OHM 10% LIN 2W	28480	2100-0043	1	
2100-0094	R:VAR COMP 50K OHM 30% LIN 1/5W	28480	2100-0094	2	
2100-0096	R:VAR COMP 1 MEGOHM 30% LIN 1/5W	28480	2100-0096	1	
2100-0100	R:VAR COMP 3.5 MEGOHM 30% LIN 1/4W	28480	2100-0100	2	
2100-0308	R:VAR WW 2 OHM 10% LIN 5W	28480	2100-0308	1	
2100-0335	R:VAR WW 10 OHM 20% 2W	28480	2100-0335	1	
2110-0003	FUSE:CARTRIDGE 3A	75915	312003	1	
2110-0043	FUSE:CARTRIDGE 1.5A 250V	75915	31201.5	1	
3101-0034	SWITCH:SLIDE 4PDT	82190	6633	1	
3101-0041	SWITCH:TOGGLE DPDT 3 POSITION	80131	8906K370	1	
3150-0019	AIR FILTER:3 5/8 X 7 11/16 X 1/2	92866	10337	1	
3160-0026	FAN:MUFFIN	28480	3160-0026	1	
5000-0732	FRAME	28480	5000-0732	1	
5000-0738	COVER:SIDE	28480	5000-0738	1	
5000-0739	COVER:SIDE	28480	5000-0739	1	
5060-0740	TOP COVER ASSY.16L FM	28480	5060-0740	1	
5060-0752	BOTTOM COVER ASSY.16L FM	28480	5060-0752	1	
5060-0222	SIDE HANDLE ASSY	28480	5060-0222	2	
5060-0767	FOOT ASSY. FM	28480	5060-0767	1	
8120-0078	POWER CABLE	28480	8120-0078	1	
9100-0152	TRANSFORMER:POWER	28480	9100-0152	1	
9100-0153	TRANSFORMER:POWER	28480	9100-0153	1	

See introduction to this section

TABLE 6-3.
CODE LIST OF MANUFACTURERS

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 Handbooks.

Code No.	Manufacturer	Address
00000	U.S.A. Common	Any supplier of U.S.
00136	McCoy Electronics	Mount Holly Springs, Pa.
00213	Sage Electronics Corp.	Rochester, N.Y.
00282	Cenco Inc.	Danielson, Conn.
00334	Hamidial	Colton, Calif.
00340	Microtron Co., Inc.	Valley Stream, N.Y.
00373	Garlock Inc., Electronics Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00818	Northern Engineering Laboratories, Inc.	Burlington, Wis.
00853	Sangamo Electric Co., Pickens Div.	Pickens, S.C.
00865	Gen Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
00929	Microlab Inc.	Livingston, N.J.
01009	Alden Products Co.	Brockton, Mass.
01121	Allen Bradley Co.	Milwaukee, Wis.
01295	Litton Industries, Inc.	Beverly Hills, Calif.
01281	TRW Semiconductors, Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc., Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01930	Amerock Corp.	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02706	Cole Rubber and Plastics Inc.	Sunnyvale, Calif.
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America, Semiconductor and Materials Div.	Somerville, N.J.
02771	Vacaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Prod. Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	Compton, Calif.
03877	Transitron Electric Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co., Inc.	Cedar Knolls, N.J.
03954	Singer Co., Diehl Div. Finderne Plant	Somerville, N.J.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04013	Taurus Corp.	Lambertville, N.J.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04354	Precision Paper Tube Co.	Chicago, Ill.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Products, Microwave Device Div.	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc. Western Div.	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04796	Sequoia Wire Co.	Redwood City, Calif.
04811	Precision Coil Spring Co.	El Monte, Calif.
04870	P.R. Mallory Company	Westchester, Ill.
05088	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp. Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Calif.
05363	Illuminonic Engineering Co.	Sunnyvale, Calif.
05618	Cosmo Plastic (c/o Electrical Spec. Co.)	Cleveland, Ohio
05624	Barber Colman Co.	Rockford, Ill.
05729	Tiffen Optical Co.	Roslyn Heights, Long Island, N.Y.
05729	Metro-Tel Corp.	Westbury, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
05820	Wakefield Engineering Inc.	Wakefield, Mass.
06004	Bassick Co., The	Bridgeport, Conn.
06090	Raychem Corp.	Redwood City, Calif.
06175	Bausch and Lomb Optical Co.	Rochester, N.Y.
06402	E.T.A. Products Co. of America	Chicago, Ill.
06540	Amatom Electronic Hardware Co., Inc.	New Rochelle, N.Y.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06666	General Devices Co., Inc.	Indianapolis, Ind.
06751	Semcor Div. Components Inc.	Phoenix, Ariz.
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
06980	Varian Assoc. Eimac Div.	San Carlos, Calif.
07088	Kelvin Electric Co.	Van Nuys, Calif.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07145	Filmohm Corp.	New York, N.Y.
07233	Cinch-Graphik Co.	City of Industry, Calif.
07261	Avnet Corp.	Culver City, Calif.
07263	Fairchild Camera & Inst. Corp. Semiconductor Div.	Mountain View, Calif.
07322	Minnesota Rubber Co.	Minneapolis, Minn.
07387	Bircher Corp., The	Monterey Park, Calif.
07700	Technical Wire Products Inc.	Cranford, N.J.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Raytheon Mfg. Co., Semiconductor Div.	Mountain View, Calif.
07965	Shockley Semi-Conductor Laboratories	Palo Alto, Calif.
07980	Hewlett-Packard Co., Boonton Radio Div.	Rockaway, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08289	Blinn, Delbert Co.	Pomona, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada
08664	Bristol Co., The	Waterbury, Conn.
08717	Sloan Company	Sun Valley, Calif.
08718	ITT Cannon Electric Inc.,	Phoenix Div. Phoenix, Arizona
08792	CBS Electronics Semiconductor Operations, Div of C.B.S. Inc.	Lowell, Mass.
08984	Mal-Rain	Indianapolis, Ind.
09026	Babcock Relays Div.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09145	Aloha Electronics	Sun Valley, Calif.
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
10214	General Transistor Western Corp.	Los Angeles, Calif.
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11242	Bay State Electronics Corp.	Waltham, Mass.
11312	Teledyne Inc., Microwave Div.	Palo Alto, Calif.
11534	Duncan Electronics Inc.	Costa Mesa, Calif.
11711	General Instrument Corp., Semiconductor Div., Products Group	Newark, N.J.
11717	Imperial Electronic, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12136	Philadelphia Handle Co.	Camden, N.J.
12697	Clarostat Mfg. Co.	Dover, N.H.
12859	Nippon Electric Co., Ltd.	Tokyo, Japan
12881	Molex Electronics Corp.	Clark, N.J.
12930	Delta Semiconductor Inc.	Newport Beach, Calif.
12954	Dickson Electronics Corp.	Scottsdale, Arizona
13103	Thermalloy	Dallas, Texas
13396	Telefunken (GmbH)	Hanover, Germany
13835	Midland-Wright Div. of Pacific Industries, Inc.	Kansas City, Kansas
14099	Sem-Tech	Newbury Park, Calif.
14193	Calif. Resistor Corp.	Santa Monica, Calif.
14298	American Components, Inc.	Conshohocken, Pa.
14433	ITT Semiconductor, A Div. of Int. Telephone & Telegraph Corp.	West Palm Beach, Fla.
14493	Hewlett-Packard Company	Loveland, Colo.
14655	Cornell Dubilier Electric Corp.	Newark, N.J.
14674	Corning Glass Works	Corning, N.Y.
14752	Electro Cube Inc.	So. Pasadena, Calif.
14940	Williams Mfg. Co.	San Jose, Calif.
15203	Webster Electronics Co.	New York, N.Y.
15291	Adjustable Bushing Co.	N. Hollywood, Calif.
15558	Micron Electronics	Garden City, Long Island, N.Y.
15566	Amprobe Inst. Corp.	Lynbrook, N.Y.
15772	Twentieth Century Coil Spring Co.	Santa Clara, Calif.
15818	Amelco Inc.	Mt. View, Calif.
15909	Daven Div. Thomas A. Edison Ind. McGraw-Edison Co.	Long Island City, N.Y.
16037	Spruce Pine Mica Co.	Spruce Pine, N.C.
16179	Omni-Spectra Inc.	Detroit, Ill.
16352	Computer Diode Corp.	Lodi, N.J.
16688	Ideal Prec. Meter Co., Inc. De Jur Meter Div.	Brooklyn, N.Y.
16758	Delco Radio Div. of G.M. Corp.	Kokomo, Inc.
17109	Thermonetics Inc.	Canoga Park, Calif.
17474	Transa Company	Mountain View, Calif.
17675	Hamlin Metal Products Corp.	Akron, Ohio
17745	Angstrohm Prec. Inc.	No. Hollywood, Calif.
18042	Power Design Pacific Inc.	Palo Alto, Calif.
18476	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
18486	TRW Elect. Comp. Div.	Des Plaines, Ill.
18583	Curtis Instrument, Inc.	Mt. Kisco, N.Y.
18873	E.I. DuPont and Co., Inc.	Wilmington, Del.
18911	Durant Mfg. Co.	Milwaukee, Wis.
19315	Bendix Corp., The Eclipse-Pioneer Div.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19644	LRC Electronics	Horseheads, N.Y.
19701	Electra Mfg. Co.	Independence, Kansas
20183	General Atronics Corp.	Philadelphia, Pa.
21226	Executone, Inc.	Long Island City, N.Y.
21335	Fahnir Bearing Co., The	New Britain, Conn.
21520	Fenateel Metallurgical Corp.	N. Chicago, Ill.
23783	British Radio Electronics Ltd.	Washington, D.C.
24455	G.E. Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26365	Gries Reproducer Corp.	New Rochelle, N.Y.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
36196	Stanwyck Coil Products Ltd.	Hawkesbury, Ontario, Canada
37942	P.R. Mallory & Co. Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C.A. Norgren Co.	Englewood, Colo.

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TABLE 6-3.

CODE LIST OF MANUFACTURERS (Continued)

Code No.	Manufacturer	Address
44655	Ohmite Mfg. Co.	Skokie, Ill.
46384	Penn Eng. & Mfg. Corp.	Doylestown, Pa.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer & Inst. Co.	Southampton, Pa.
49956	Microwave & Power Tube Div.	Waltham, Mass.
52090	Rowan Controller Co.	Westminster, Md.
52983	Sanborn Company	Waltham, Mass.
54294	Shallcross Mfg. Co.	Selma, N. C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N. Y.
55938	Raytheon Co., Commercial Apparatus & Systems Div.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N. Y.
56289	Sprague Electric Co.	North Adams, Mass.
56446	Talon, Inc.	St. Paul, Minn.
56730	Thomas & Betts Co.	Elizabeth, N. J.
58741	Triplett Electrical Inst. Co.	Bluffton, Ohio
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Pittsburgh, Pa.
62119	Universal Electric Co.	Owosso, Mich.
63743	Ward-Leonard Electric Co.	Mt. Vernon, N. Y.
64959	Western Electric Co., Inc.	New York, N. Y.
65092	Weston Inst. Inc. Weston-Newark	Newark, N. J.
66295	Witnik Mfg. Co.	Chicago, Ill.
66346	Revere Wallensak Div. Minn. Mining & Mfg. Co.	St. Paul, Minn.
70276	Allen Mfg. Co.	Hartford, Conn.
70318	Allmetal Screw Product Co., Inc.	Garden City, N. Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	Union City, N. J.
70843	Boldon Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N. Y.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio, Inc.	Willoughby, Ohio
71286	Camloc Fastener Corp.	Paramus, N. J.
71311	Cardwell Condenser Corp.	Lindenhurst L. I., N. Y.
71400	Bussmann Mfg. Div. of McGraw-Edison Co.	St. Louis, Mo.
71436	Chicago Condenser Corp.	Chicago, Ill.
71447	Calif. Spring Co., Inc.	Pico-Rivera, Calif.
71450	CTS Corp.	Elkhart, Ind.
71468	ITT Cannon Electric Inc.	Los Angeles, Calif.
71471	Cinema Plant, Hi-Q Div. Aerovox Corp.	Burbank, Calif.
71482	C. P. Clare & Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71616	Commercial Plastics Co.	Chicago, Ill.
71700	Cornish Wire Co., The	New York, N. Y.
71707	Coto Coil Co., Inc.	Providence, R. I.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A. O. Smith Corp., Crowley Div.	West Orange, N. J.
71785	Cinch Mfg. Co., Howard B. Jones Div.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72354	John E. Fast Co., Div. Victoreen Inst. Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N. Y.
72656	Indiana General Corp., Electronics Div.	Keasby, N. J.
72699	General Instrument Corp., Cap. Div.	Newark, N. J.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72962	Robert M. Hadley Co.	Los Angeles, Calif.
72982	Erie Technological Products, Inc.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73076	H. H. Harper Co.	Chicago, Ill.
73138	Helipot Div. of Beckman Inst., Inc.	Fullerton, Calif.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Philips Co., Inc.	Hicksville, N. Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Div. MSL Industries Inc.	Philadelphia, Pa.
73734	Federal Screw Products Inc.	Chicago, Ill.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	General Industries Co., The	Elyria, Ohio
73846	Gosben Stamping & Tool Co.	Goshen, Ind.
73899	JFD Electronics Corp.	Brooklyn, N. Y.
73905	Jennings Radio Mfg. Corp.	San Jose, Calif.
74276	Signalite Inc.	Neptune, N. J.
74455	J. H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R. F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E. F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75378	CTS Knights Inc.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N. Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littelfuse, Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76218	C. W. Marwedel	San Francisco, Calif.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J. W. Miller Co.	Los Angeles, Calif.
76530	Cinch-Monadnock, Div. of United Carr Fastener Corp.	San Leandro, Calif.
76545	Moulded Electric Co.	Cleveland, Ohio
76783	National Union	Newark, N. J.
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	Bendix Corp., The Bendix Pacific Div.	N. Hollywood, Calif.
77075	Pacific Metals Co.	San Francisco, Calif.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	American Machine & Foundry Co., Potter & Brumfield Div.	Princeton, Ind.
77638	RCA Electronic Components Div.	Camden, N. J.
77638	General Instrument Corp., Rectifier Div.	Brooklyn, N. Y.
77764	Resistance Products Co.	Harrisburg, Pa.
77969	Rubbercraft Corp. of Calif.	Torrance, Calif.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78283	Signal Indicator Corp.	New York, N. Y.
78290	Struthers-Dunn Inc.	Pitman, N. J.
78452	Thompson-Bremer & Co.	Chicago, Ill.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78493	Standard Thomson Corp.	Waltham, Mass.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	San Gabriel, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79136	Waldes Kohinoor Inc.	Long Island City, N. Y.
79142	Weeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N. Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N. J.
80128	Scholtzer Alloy Products Co.	Elizabeth, N. J.
80130	Times Telephone Equipment	New York, N. Y.
80131	Electronic Industries Association. Any brand Tube meeting EIA Standards-Washington, DC.	
80227	Unimax Switch, Div. Maxon Electronics Corp.	Wallingford, Conn.
80223	United Transformer Corp.	New York, N. Y.
80748	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Inc.	Riverside, Calif.
80411	Acro Div. of Robertshaw Controls Co.	Columbus, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80509	Avery Adhesive Label Corp.	Monrovia, Calif.
80583	Wanmatund Co., Inc.	New York, N. Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments Inc.	Orange, Conn.
81073	Grayhill Co.	LaGrange, Ill.
81095	Triad Transformer Corp.	Venice, Calif.
81312	Winchester Elec. Div. Litton Ind., Inc.	Oakville, Conn.
81349	Military Specification	
81483	International Rectifier Corp.	El Segundo, Calif.
81541	Airpax Electronics, Inc.	Cambridge, Mass.
81860	Barry Controls, Div. Barry Wright Corp.	Watertown, Mass.
82042	Carter Precision Electric Co.	Skokie, Ill.
82047	Sperti Faraday Inc., Copper Hewitt Electric Div.	Hoboken, N. J.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Fairchild Camera & Inst. Corp. Defense Prod. Division	Clifton, N. J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc. Electronic Tube Division	Emporium, Pa.
82376	Astron Corp.	East Newark, Harrison, N. J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals & Controls Inc. Spencer Products	Attleboro, Mass.
82768	Philips-Advance Control Co.	Joliet, Ill.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Mfg. Co., Inc.	Woodstock, N. Y.
82893	Vector Electronic Co.	Glendale, Calif.
83053	Western Washer Mfg. Co.	Los Angeles, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N. H.
83125	General Instrument Corp., Capacitor Div.	Darlington, S. C.
83148	ITT Wire and Cable Div.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Springfield, N. J.
83298	Bendix Corp., P. C. Bank Div.	Red Bank, N. J.
83315	Hubbell Corp.	Bridgeport, Ill.
83330	Smith, Herman H., Inc.	Brooklyn, N. Y.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Co. Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp. Electronic Tube Div.	Plainfield, N. J.
83748	Union Carbide Corp. Consumer Prod. Div.	New York, N. Y.
83777	Nodal Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
83942	Aeronautical Inst. & Radio Co.	Lodi, N. J.
84171	Arco Electronics Inc.	Great Neck, N. Y.
84396	A. J. Glesener Co., Inc.	San Francisco, Calif.
84411	TRW Capacitor Div.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N. J.

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TABLE 6-3.

CODE LIST OF MANUFACTURERS (Continued)

Code No.	Manufacturer	Address
05471	A. B. Boyd Co.	San Francisco, Calif.
05474	R. M. Bracamonte & Co.	San Francisco, Calif.
05660	Kulled Hards, Inc.	Hamden, Conn.
05911	Seamless Rubber Co.	Chicago, Ill.
06197	Clifton Precision Products Co., Inc.	Clifton Heights, Pa.
06579	Precision Rubber Products Corp.	Dayton, Ohio
06484	Radio Corp. of America, Electronic Comp. & Devices Div.	Harrison, N. J.
07034	Merca Industries	Anaheim, Calif.
07716	Philco Corporation (Lansdale Division)	Lansdale, Pa.
07473	Western Fibrous Glass Products Co.	San Francisco, Calif.
07660	Van Waters & Rogers Inc.	San Francisco, Calif.
07930	Tower Mfg. Corp.	Providence, R. I.
0814C	Cutler-Hammer, Inc.	Lincoln, Ill.
08220	Gould-National Batteries, Inc.	St. Paul, Minn.
08421	Federal Telephone & Radio Corp.	Clifton, N. J.
08630	General Mills, Inc.	Buffalo, N. Y.
09231	Graybar Electric Co.	Oakland, Calif.
09645	United Transformer Co.	Chicago, Ill.
90179	US Rubber Co., Consumer Ind. & Plastics Prod. Div.	Passaic, N. J.
90478	Boeing Engineering Co.	San Francisco, Calif.
91260	Conner Spring Mfg. Co.	San Francisco, Calif.
91345	Miller Dial & Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Willow Grove, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91929	Honeywell Inc., Micro Switch Div.	Freeport, Ill.
91961	Hahn-Bros. Spring Co.	Oakland, Calif.
92190	Tru-Connector Corp.	Peabody, Mass.
92367	Elgeet Optical Co. Inc.	Rochester, N. Y.
92755	Universal Industries, Inc.	City of Industry, Calif.
92902	Tensolite Insulated Wire Co., Inc.	Tarrytown, N. Y.
93332	Sylvania Electric Prod. Inc. Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N. Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93929	G. V. Controls	Livingston, N. J.
94137	General Cable Corp.	Bayonne, N. J.
94144	Raytheon Co., Comp. Div., Ind. Comp. Operations	Quincy, Mass.
94148	Scientific Electronics Products, Inc.	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N. J.
94197	Curtiss-Wright Corp. Electronics Div.	East Paterson, N. J.
94222	South Chester Corp.	Chester, Pa.
94310	Tru-Ohm Products Newcor Components Div.	Huntington, Ind.
94330	Wire Cloth Products, Inc.	Bellwood, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
94696	Magnecraft Electric Co.	Chicago, Ill.
95023	George A. Philbrick Researchers, Inc.	Boston, Mass.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N. Y.
95263	Leecraft Mfg. Co., Inc.	Long Island, N. Y.
95264	Lenco Electronics, Inc.	Burbank, Calif.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95348	Gardas Corp.	Bloomfield, N. J.
95354	Methode Mfg. Co.	Chicago, Ill.
95712	Dage Electric Co., Inc.	Franklin, Ind.
95984	Simon Mfg. Co.	Wayne, Ill.
95987	Rochesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96295	Hi-Q Div. of Aerovox Corp.	Olean, N. Y.
96256	Thordarson-Meissner Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97464	Industrial Retaining Ring Co.	Irvington, N. J.
97539	Automatic & Precision Mfg.	Englewood, N. J.
97979	Resn Resistor Corp.	Yonkers, N. Y.
97983	Litton System Inc., Adler-Westrex Commun. Div.	New Rochelle, N. Y.
98141	R-Tronics, Inc.	Jamaica, N. Y.
98159	Rubber Tech, Inc.	Gardena, Calif.
98220	Hewlett-Packard Co., Moseley Div.	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N. Y.
98376	Zero Mfg. Co.	Burbank, Calif.
98731	General Mills Inc., Electronics Div.	Minneapolis, Minn.
98734	Sanca Div. of Hewlett-Packard Co.	Palo Alto, Calif.
98821	North Hills Electronics, Inc.	Glen Cove, N. Y.
98978	International Electronic Research Corp.	Burbank, Calif
99109	Columbia Technical Corp.	New York, N. Y.
99313	Varian Associates	Palo Alto, Calif.
99378	Allen Corp.	Winchester, Mass.
99515	Marshall Ind. Elect. Products Div.	San Mateo, Calif.
99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
99800	Delevan Electronics Corp.	East Aurora, N. Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Rembrandt, Inc.	Boston, Mass.
99942	Hoffman Electronics Corp. Semiconductor Div.	El Monte, Calif.
99957	Technology Instrument Corp. of Calif.	Newbury Park, Calif.

THE FOLLOWING HP VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

0000F	Malco Tool and Die	Los Angeles, Calif.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000Z	Willow Leather Products Corp.	Newark, N. J.
00AAA	British Radio Electronics Ltd.	Washington, D. C.
00AAB	ETA	England
00BB8	Precision Instrument Components Co.	Van Nuys, Calif.
00BMB	Rubber Eng. & Development	Hayward, Calif.
00BNN	A "N" D Mfg. Co.	San Jose, Calif.
00BQQ	Coaltron	Oakland, Calif.
00BWW	California Eastern Lab.	Burlington, Calif.
00BYY	S. N. Smith Co.	Los Angeles, Calif.

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MANUAL CHANGES

This manual describes Model 493A and 495A instruments with serial numbers prefixed 350-. Change the manual as indicated below for serials indicated. For other serials, either a different manual or a change sheet is required. If the prefix on your instrument is not specifically mentioned either here or on a change sheet, the correct information can be obtained from your Hewlett-Packard Field Office.

Instrument Serial Prefix	Make Manual Changes	Instrument Serial Prefix	Make Manual Changes
330-	1		
304-	1, 2		
229-, 207-, 151-	1, 2, 3		

CHANGE 1

The turn-on time-delay is 3 minutes rather than 90 seconds. Change reference to this delay in Figure 3-1, 4-5, 5-2, 5-10, and 5-11. and in paragraphs 4-24 and 4-25.

Tables 6-1 and 6-2: K1: Change ℗ Stock Number to 0490-0037 and Mfr. Part No. to 6N0180T.
R414: Change to R: fxd mtl flm 100K ohms 5% 1/2W; ℗ Stock No. 0758-0053; Mfr 07115; Mfr. Part No. C20; TQ 1.
Delete: ℗ Stock No. 0758-0076

CHANGE 2

Figure 5-12:
C15: Change value to 0.015 μf
R51: Change value to 1 M

Tables 6-1 and 6-2:

Change to:	C15	0160-0062	C: fxd, paper, 0.015 μf ±10% 3000 vdcw	56289	184P153	1
	R51	0687-1051	R: fxd, comp, 1 M ±10%, 1/2W	01121	EB1051	1

Delete 0160-0384 and 0687-2151

CHANGE 3

Figure 5-13. Modulator Board (A101): Change as illustrated.
Figure 5-14. Modulator: Change as illustrated.

Table 6-1:
Delete all items with 400-series designations.
Insert:

A101	495A-65C	Assembly: Mod Board
C103, C104	0150-0052	C: fxd, cer, dual, 0.05 μf ±20%, 400 vdcw
C105	0150-0012	C: fxd, cer, 0.01 μf ±20%, 1000 vdcw
C106	0140-0216	C: fxd, mica, 120 pf ±2%, 300 vdcw
C107	0140-0146	C: fxd, mica, 82 pf ±5%, 300 vdcw
C108	0130-0013	C: var, cer, 2-12 pf
C110	0150-0015	C: fxd, TiO_2, 2.2 pf ±10%, 500 vdcw
C111	0130-0017	C: var, cer, 8-50 μf, 500 vdcw
C112	0140-0225	C: fxd, mica, 300 pf ±1%, 300 vdcw
CR103	1901-0030	Diode, Si: 800 PIV
CR104, CR105	1901-0025	Diode, Si
CR106	1902-0163	Diode
CR107, CR108	1901-0030	Diode, Si: 300 PIV
Q101	1854-0003	Transistor Si: NPN
R104	0693-4741	R: fxd, comp, 470K ohms ±10%, 2W
R105, R106	0693-1531	R: fxd, comp, 15K ohms ±10%, 2W
R107	0727-0246	R: fxd, dep c, 600K ohms ±1%, 1/2W
R108	2100-0094	R: var, comp, lin, 50K ohms ±30%, 1/4W
R109	0727-0226	R: fxd, dep c, 250K ohms ±1%, 1/2W

MANUAL CHANGES (Cont'd)

Table 6-1 (cont'd)

R110	0693-8231	R: fxd, comp, 82K ohms ±10%, 2W
R111	0687-4731	R: fxd, comp, 47K ohms ±10%, 1/2W
R112	0687-1231	R: fxd, comp, 12K ohms ±10%, 1/2W
R113	0693-6831	R: fxd, comp, 68K ohms ±10%, 2W
R114	0690-1041	R: fxd, comp, 100K ohms ±10%, 1W
R115, R116	0693-2731	R: fxd, comp, 27K ohms ±10%, 2W
R117	0693-1531	R: fxd, comp, 15K ohms ±10%, 2W
R118	0727-0292	R: fxd, dep c, 3M ±1%, 1/2W
R119	0727-0255	R: fxd, dep c, 800K ohms ±1%, 1/2W
R121	2100-0144	R: var, comp, 250K ohms
R122	0727-0208	R: fxd, dep c, 100K ohms ±1%, 1/2W
R123	0730-0093	R: fxd, dep c, 516K ohms ±1%, 1W
R124	0727-0149	R: fxd. dep c, 7.96K ohms ±1%, 1/2W
R125	0727-0245	R: fxd, dep c, 500K ohms ±1%, 1/2W
R126, R127	0773-0010	R: fxd, mfgl, 85K ohms ±5%, 5W
R128	0687-1521	R: fxd, comp, 1.5K ohms ±10%, 1/2W
R129	0687-4741	R: fxd, comp, 470K ohms ±10%, 1/2W
R130	0686-6845	R: fxd, comp, 680K ohms ±5%, 1/2W
V101	1933-0005	Tube, delectron: 7734
V102	1940-0007	Tube, electron: OB2
V103	1933-0004	Tube, electron: 6U8A
V104	1923-0043	Tube, electron: 6EW6
XV101	1200-0048	Socket tube: 9 pin, minat
XV102	1200-0047	Socket tube: 7 pin, minat w/ears (for pc)
XV103	1200-0048	Socket tube: 9 pin, minat
XV104	1200-0047	Socket tube: 7 pin, minat w/ears (for pc)

Table 6-2:

Delete:

0140-0149	0727-0237	0765-0008	0727-0282
0140-0208	1902-0026	0727-0283	0727-0286
0130-0016	0687-1041	0727-0165	0690-2231
0140-0203	0727-0252	0727-0230	0767-0010
0150-0011	0690-8231	0727-0235	0693-5631
0140-0194	0690-4731	2100-0096	0727-0332
			0727-0221

0687-3331: Increase TQ to 2
0727-0276: Decrease TQ to 1
0773-0010: Increase TQ to 2
1901-0030: Increase TQ to 20
0150-0012: Increase TQ to 3
0130-0013: Decrease TQ to 1
0727-0246: Increase TQ to 7
2100-0094: Decrease TQ to 1
0687-4731: Increase TQ to 2

Add:

0130-0017	C: var, cer, 8-50 μf, 500 vdcw	72982	557-019-U2PO-34R	1	1
0140-0146	C: fxd, mica, 82 pf ±5%, 300 vdcw	72136	DM15F820J	1	1
0140-0216	C: fxd, mica, 120 pf ±2%, 300 vdcw	72136	DM15F121G-300V	1	1
0140-0225	C: fxd, mica, 300 pf ±1%, 300 vdcw	72136	DM15F301F-300V	1	1
0150-0015	C: fxd, TiO_2, 2.2 pf ±10%, 500 vdcw	82142	Type JM	1	1
0686-6845	R: fxd, comp, 680K ohms ±5%, 1/2W	01121	EB6854	1	1
0687-1231	R: fxd, comp, 12K ohms ±10%, 1/2W	01121	EB1231	1	1
0687-1421	R: fxd, comp, 1.5K ohms ±10%, 1/2W	01121	EB1521	1	1
0693-1531	R: fxd, comp, 15K ohms ±10%, 2W	01121	HB1531	3	1
0693-2731	R: fxd, comp, 27K ohms ±10%, 2W	01121	HB2731	2	1
0693-4741	R: fxd, comp, 470K ohms ±10%, 2W	01121	HB4741	1	1
0693-6831	R: fxd, comp, 68K ohms ±10%, 2W	01121	HB6831	1	1
0693-8231	R: fxd, comp, 82K ohms ±10%, 2W	01121	HB8231	1	1
0727-0149	R: fxd, dep c, 7.96K ohms ±1%, 1/2W	19701	DC1/2CR5 obd#	1	1
0727-0226	R: fxd, dep c, 250K ohms ±1%, 1/2W	19701	DC1/2CR5 obd#	1	1
0727-0255	R: fxd, dep c, 800K ohms ±1%, 1/2W	19701	DC1/2AR5 obd#	1	1
0727-0292	R: fxd, dep c, 3M ±1%, 1/2W	19701	DC1/2CR5 obd#	1	1
0730-0093	R: fxd, dep c, 516K ohms ±1%, 1W	19701	CD1R5 obd#	1	1
1902-0163	Diode	28480	1902-0163		
1933-0005	Tube, electron: 7734	07138	7734	1	1
1940-0007	Tube, electron: OB2	86684	obd#	1	1
2100-0144	R: var, comp, 250K ohms	11237	Type UPE-70 obd#	1	1

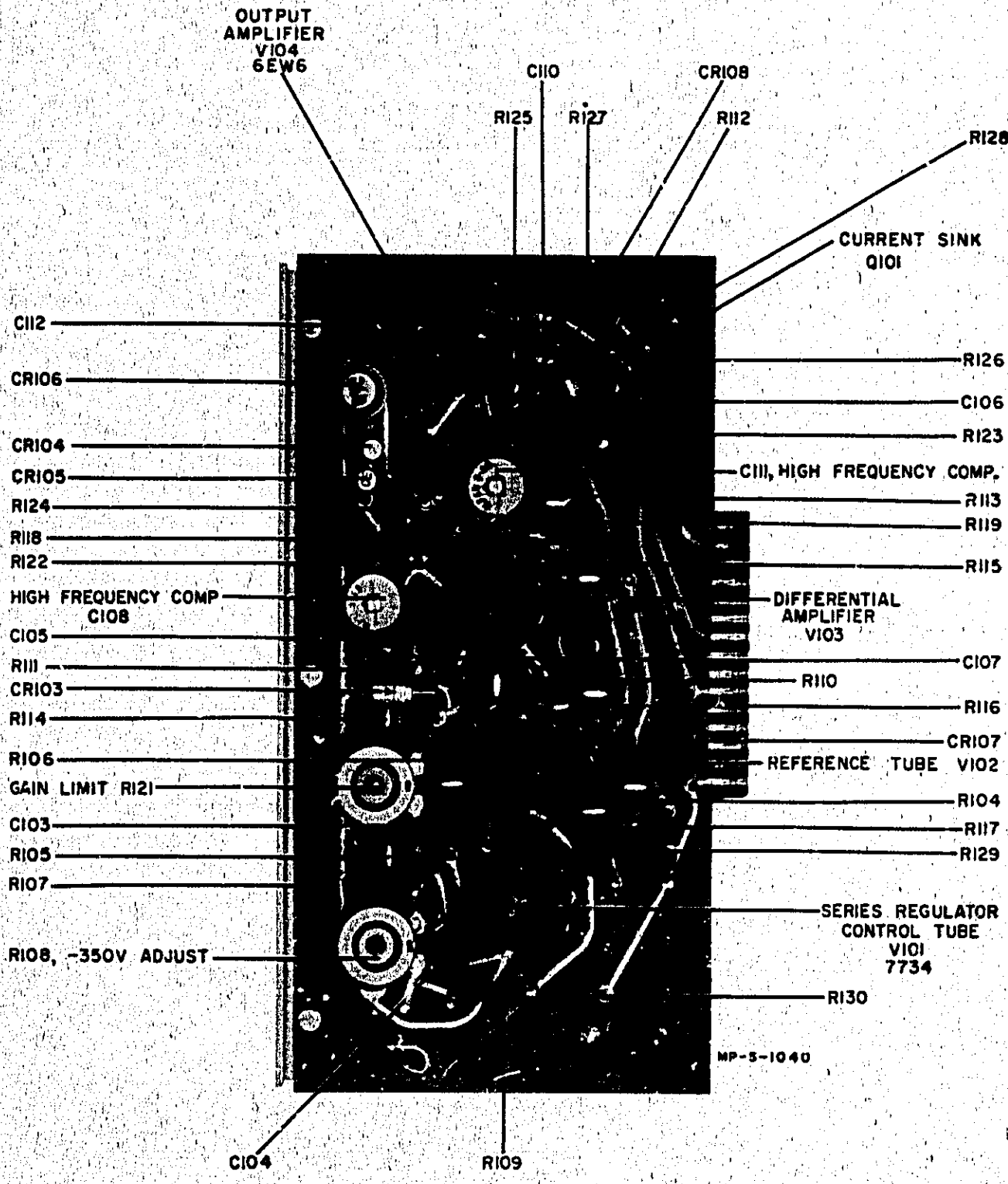


Figure 5-13. Modulator Board (For Change 3)

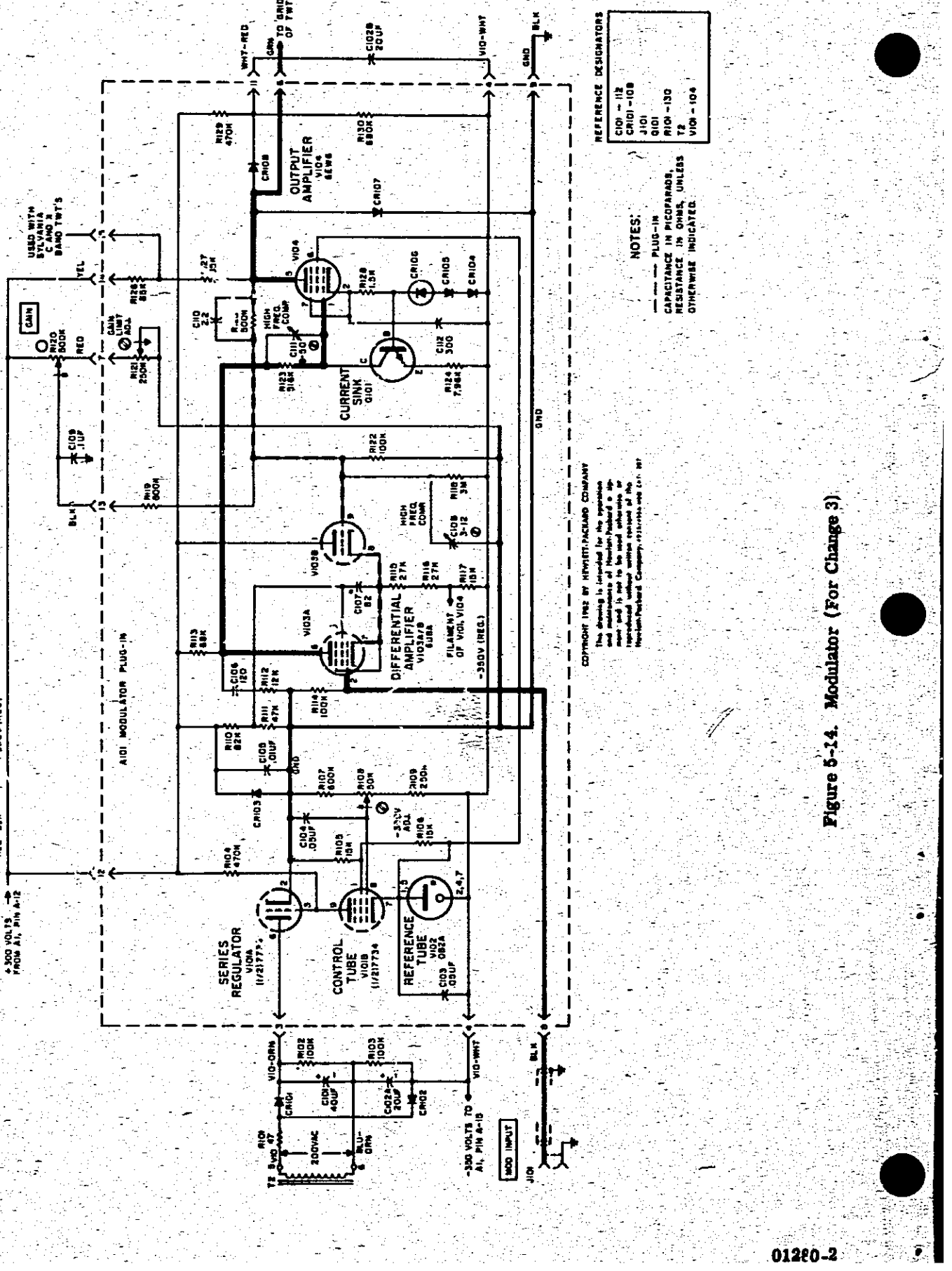


Figure 5-14. Modulator (For Change 3)

MANUAL CHANGES
MICROWAVE AMPLIFIER
MODEL 493A/495A

Make all corrections in this manual according to errata below, then check the following table for your instrument serial prefix (3 digits) or serial number (8 digits) and make any listed change(s) in the manual.

▲NEW ITEM

SERIAL		MAKE CHANGES
Prefix	Number	
424		1
449		1, 2
746		1, 2, 3
811		1, 2, 3, 4
811	1296 – up	1 through 5
826		1 through 6
843		1 through 7
963		1 through 8
963	1536–1555	1 through 9
963	1556–1645	1 through 10
963	1646–1231A –1835	1 through 11
1231A	1836–Up	1 through 12

ERRATA

Page 1-0, Table 1-1, under AMPLITUDE MODULATION.
Change Sensitivity specification to read, "A modulation input of –20V peak or greater reduces the RF output by more than 20 dB from dc to 50kHz. Above 50kHz, modulation decreases approximately 6 dB per octave."
Under GAIN VARIATION WITH FREQUENCY:
Change Small Signal specification to read, "5 dB or less across any 10% of the band, except the 495A, which is across any 300 MHz of the band, 10 dB or less across the band, except the 493A, which is 12 dB or less across the band."

Page 4-6:
Delete all entries, (reprint of previous page.)

Page 5-14, Figure 5-11:
Indicate location provided for R69 (beside R34), and indicate location provided for R66 (beside C16).

Page 5-15, Figure 5-12:
Indicate on schematic that R66 and R69 are selected for correct Helix overload trip current. R69 is connected between pin 4 of helix relay K3 and the junction of resistors R37 and R68. Complete the connection between terminals E1C and E1E.
Delete Notes 6 and 7.

Add pin 7 beside the ORN lead of T1 and change the voltage table below to show the BLU lead to pin 10 for 1800-2400 volts, pin 11 for 2400-2700 volts (the ORN lead remains connected to pin 7).
R53: Change "MEC" to read "anode type".
TWT V7: Delete wire colors and references to SYL TWT and MEC TWT.

Page 5-16, 5-17, Figures 5-13 and 5-14:
Change note for CR405 to read "install for tubes having negative grid voltage".

Page 6-6, Table 6-1:
Change V403 and V404 to Electron Tube: Triode-Pentode 6U8, HP Part No. 1933-0014.

Page 6-7, Table 6-1:
Change Frame in MISCELLANEOUS to HP Part No. 5060-0732.
Add Conditions of Warranty page attached.

CHANGE 1:

Page 6-5, Table 6-1: Change R417 to HP Part No. 0727-0236.
Page 6-6, Table 6-1: Change T2 to HP Part No. 9100-0299.

CHANGE 2:

Page 6-6, Table 6-1: Delete the existing reference to V7 and replace with the following:
V7 1952-0017 Electron Tube: TWT 4 – 8 GHz, MEC (493A only)
V7 1952-0022 Electron Tube: TWT 4 – 8 GHz, MA (493A only)
V7 1952-0019 Electron Tube: TWT 7 – 12.4 GHz, MEC (495A only)
V7 1952-0023 Electron Tube: TWT 7 – 12.4 GHz, MA (495A only)
Page 6-10, Table 6-2: Delete entries for 1952-0010, 1952-0016, 1952-0017 and 1952-0019 and replace with the following:
1952-0017 Electron Tube: TWT 4 – 8 GHz (493A only) 11312 MEC M4278C
1952-0019 Electron Tube: TWT 7 – 12.4 GHz (495A only) 11312 MEC M4273C
1952-0022 Electron Tube: TWT 4 – 8 GHz (493A only) 96341 MA 2344
1952-0023 Electron Tube: TWT 7 – 12.4 GHz (495A only) 96341 MA 2345G

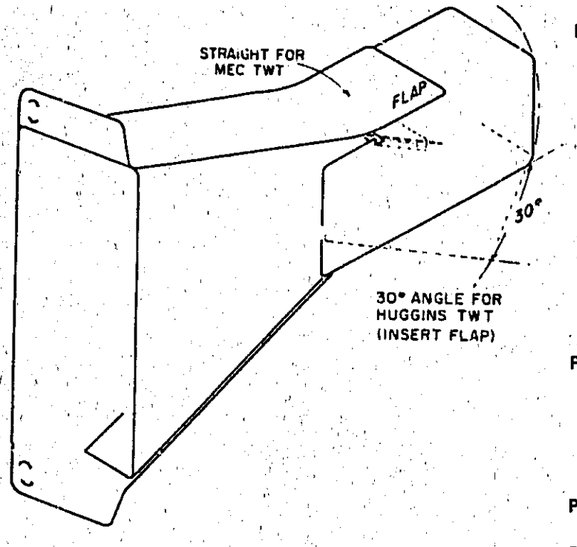


Figure 1. Model 495A Air Duct Assy, 00495-6001

CHANGE 3:

Figure 5-3 and Parts List (Model 495A only): An Air Duct Assembly, HP Part No. 00495-6001 is mounted between the fan housing (above FILAMENT adjust R306) and the TWT, V7. This air duct assembly is shown in Figure 1. Note the duct is straight for the MEC TWT, and bent to an angle with the flap inserted for the MA TWT. In each case, the air flow is forced directly onto the TWT collector. Included in the 00495-6001 assembly is a finger guard which is to be used in place of the air filter and should be mounted onto the fan behind the rear panel. This finger guard is available separately as HP Part No. 3160-0099.

Page 5-12, paragraph 5-44 (both Models 493A and 495A): Add introductory paragraphs to read:

"To change a Model 493A (4 – 8 GHz) to the 7 – 12.4 GHz frequency range, the 00495-6001 Air Duct Assembly must be installed, and is included as part of the Replacement Kit, TWT, HP Part No. 495A-95A.

To change a Model 495A (7 – 12.4 GHz) to the 4 – 8 GHz frequency range, the following two parts must be ordered: Bracket, Fan Mounting, HP Part No. 489A-85B (includes 493A-type air duct). The 00495-6001 Air Duct Assembly included in the 495A is not used with the 4 – 8 GHz frequency range TWT."

Page 6-7, Table 6-1: Parts List, under MISCELLANEOUS: Delete HP Part No. 3150-0019 Air Filter (495A only).

CHANGE 4:

Page 6-2, Table 6-1: Change A200 Assembly to HP Part No. 489A-65E.

Page 6-5, Table 6-1: Change R205 to HP Part No. 2100-1767.

CHANGE 5:

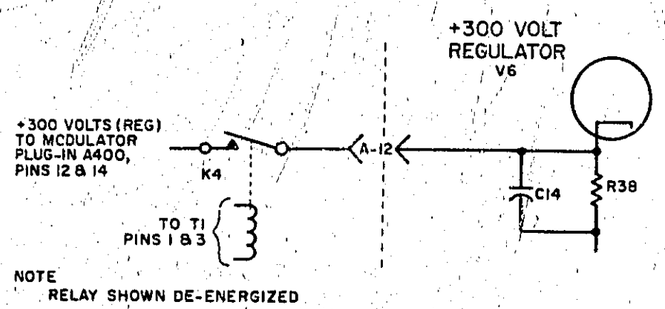
Page 6-3, Table 6-1: Change K2 to HP Part No. 0490-0746. Under K2 listing, add:
Relay Socket, HP Part No. 0490-0751.
Relay Retainer, HP Part No. 0490-0750.

CHANGE 6:

Page 5-6, Figure 5-3: Replace existing Figure 5-3 with attached copy.

Page 5-15, Figure 5-12: Add chassis part K4. Connect as shown in partial schematic below:

Page 6-3, Table 6-1: Add K4, HP Part No. 0490-0026.



Page 5-17, Figure 5-14 and Page 6-3, Table 6-1: Add chassis part CR103, Diode:Silicon, HP Part No. 1901-0033. On schematic, connect CR103 anode to A400 pin 8 and cathod to ground.

Page 5-17, Figure 5-14 and Page 6-5, Table 6-1:
Change R38 to R:FXD, MET FILM, 988K ohm, 1%, ½W, HP Part No. 0698-3545.
Change R39 to R:FXD, MET FILM, 1.1 Megohm, 1%, ½W, HP Part No. 0757-0139.
Change R54 to R:FXD, MET FILM, 2000 ohm, 1%, ½W, HP Part No. 0757-0824.
Change R55* to R:FXD, MET FILM, 402K ohm, 1%, ½W, HP Part No. 0698-4022.
Retain the asterisk (*) to indicate FACTORY SELECTED PART, TYPICAL VALUE GIVEN.
Change R56 to R:FXD, MET FILM, 500K ohm, 1%, ½W, HP Part No. 0757-0052.
Change R58 to R:FXD, MET FLM, 402K ohm, 1%, ½W, HP Part No. 0698-4022.
Change R59, R60, R61, R62, R63, and R64 to R:FXD, MET FILM, 604K ohm, 1%, ½W, HP Part No. 0757-0155.
Change R65 to R:FXD, MET FILM, 215K ohm, 1%, ½W, HP Part No. 0757-0127.
Change R67 to R:FXD, MET FILM, 1 Megohm, 1%, ½W, HP Part No. 0757-0059.
Change R68 to R:FXD, MET FILM, 500K ohm, 1%, ½W, HP Part No. 0757-0052.

Page 5-15, Figure 5-12 and Page 6-5, Table 6-1:
Change R202 and R203 to R:FXD, MET FILM, 1000 ohm, 1%, ½W, HP Part No. 0757-0159.

Page 5-17, Figure 5-14 and Page 6-5, Table 6-1:
Change R404 to R:FXD, MET FILM, 750K ohm, 1%, ½W, HP Part No. 0757-0137.
Change R406 to R:FXD, MET FILM, 215K ohm, 1%, ½W, HP Part No. 0757-0127.
Change R413 to R:FXD, MET FILM, 1.5 Megohm, 1%, ½W, HP Part No. 0757-0156.
Change R415 to R:FXD, MET FILM, 12.1K ohm, 1%, ½W, HP Part No. 0757-0841.
Change R416 to R:FXD, MET FILM, 287K ohm, 1%, ½W, HP Part No. 0757-0154.
Change R419 to R:FXD, MET FILM, 100K ohm, 1%, ½W, HP Part No. 0757-0367.
Change R420 to R:FXD, MET FILM, 1.5 Megohm, 1%, ½W, HP Part No. 0757-0156.
Change R422 and R424 to R:FXD, MET FILM, 1 Megohm, 1%, ½W, HP Part No. 0757-0059.
Change R423 to R:FXD, MET FILM, 500K ohm, 1%, ½W, HP Part No. 0757-0052.
Change R430 to R:FXD, MET FILM, 200K ohm, 1%, ½W, HP Part No. 0757-0128.

Page 5-17, Figure 5-14 and Page 6-6, Table 6-1: Change R431 to R:FXD, MET FILM, 365K ohm, 1%, ½W, HP HP Part No. 0757-0865.

CHANGE 8:

Page 5-13, Figure 5-10:
Replace existing Figure 5-10 with the attached copy.

Page 6-3, Table 6-1:
Change F1 (115V) to 4 amp, HP Part No. 2110-0055.
Change F1 (230V) to 2 amp, HP Part No. 2110-0002.
Change J3 to HP Part No. 1251-2357.
Add K5, Relay: 3PDT, HP Part No. 0490-0124.

Page 6-6, Table 6-1:
Change S2 to HP Part No. 3101-1272.
Change W1 to HP Part No. 8120-1348.

CHANGE 9:

Page 6-3, Table 6-1:
Change DS1 and DS2 from HP Part No. 1450-0048 to HP Part No. 1450-0419. This changes the front panel lamps from red to white to conform to IEC recommendations.

CHANGE 10:

Page 3-2, Table 3-1, Step 1:
Change all time delay references from 90 seconds to 120 seconds (three places).

Page 4-5:
Change all time delay references from 90 seconds to 120 seconds (four places).

Page 5-13, Figure 5-10:
Change K1 to 120 SECOND TIME DELAY.

Page 6-3, Parts List:
Change K1 to HP Part No. 0490-0933 RELAY:TIME DELAY, 120 second. (HP Part No. 0490-0933 is the recommended replacement for HP Part No. 0490-0135 in all models 493/495 Microwave Amplifiers regard regardless of serial prefix).

CHANGE 11:

Page 6-6, Table 6-1: Add V7 1952-0031 Electron Tube: TWT 4-8 GHz (WJ) (493A only)

Page 6-10, Table 6-2: Add 1952-0031 Electron Tube: TWT 4-8 GHz (WJ)

▲CHANGE 12:

On page 6-2, change C11 to HP Part No. 0160-4050, 2 X 3.5μF, 2KV.

On page 6-6, change V7 to HP Part No. 1952-0035 (Model 493A only) or HP Part No. 1952-0036 (Model 495A only).

In Parts list, delete air duct assembly with new TWT, forced air on the collector end of the tube is not required.

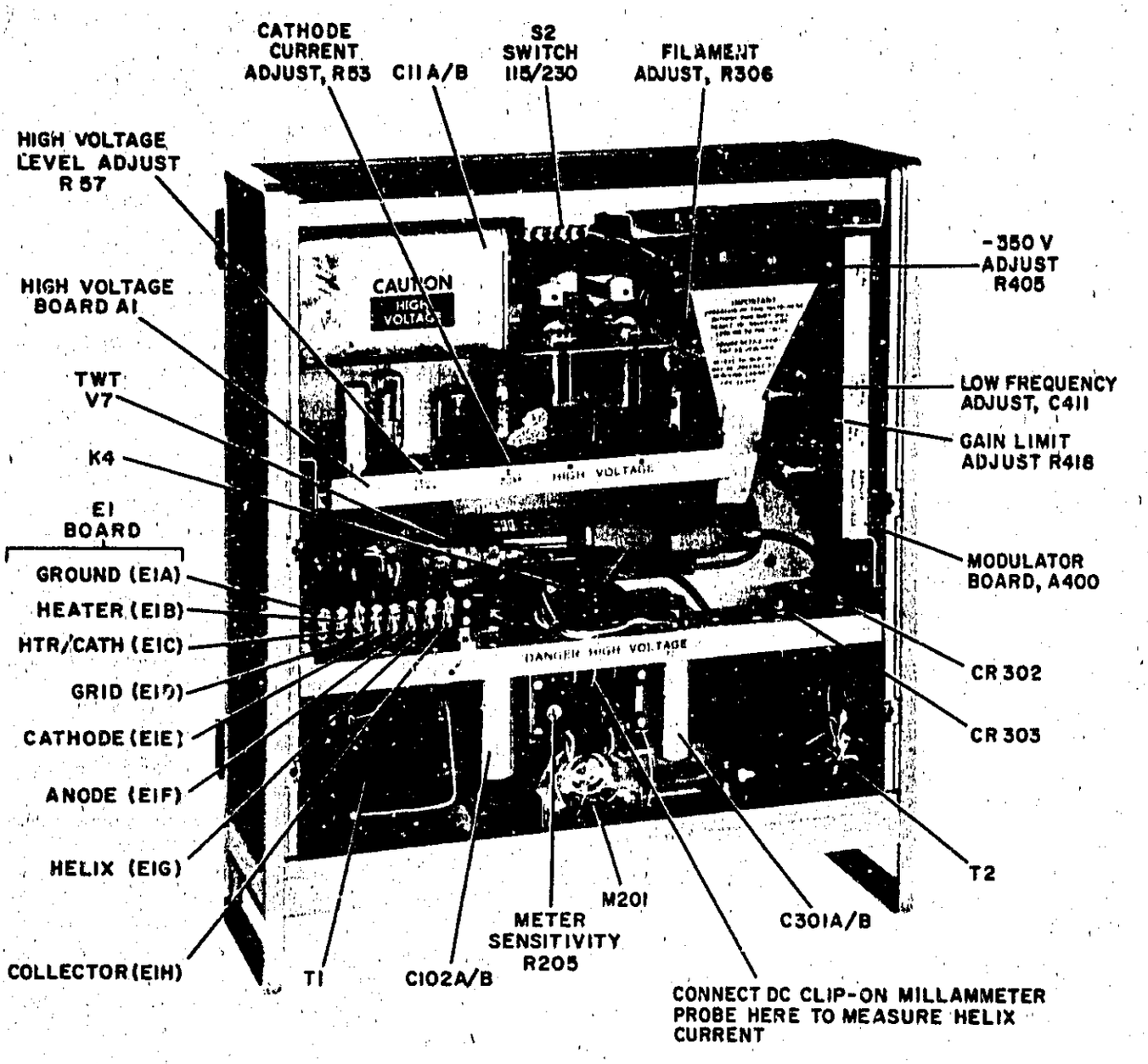
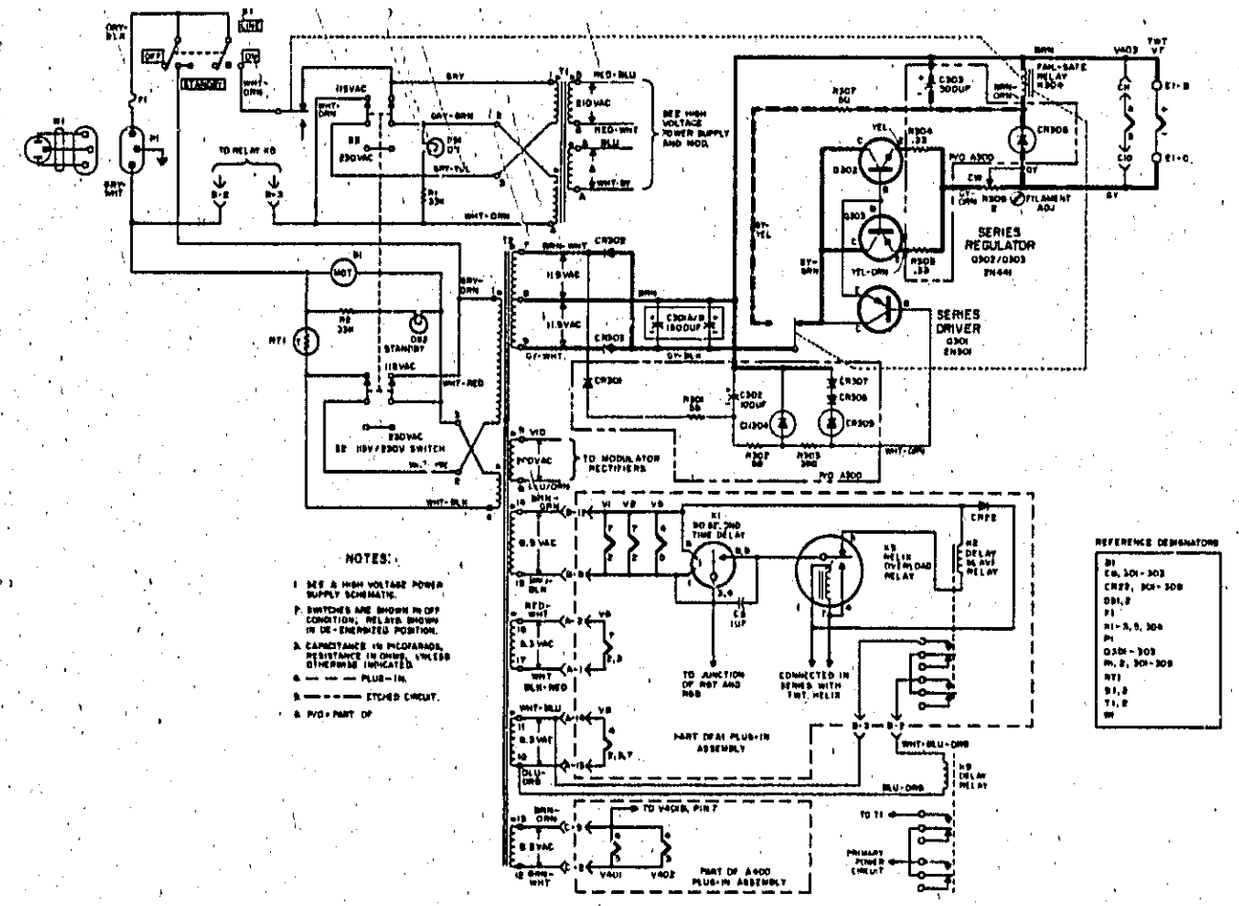


Figure 5-3. Model 493A, Top View


SERIES REGULATOR
Q302/Q303
2N441
SERIES DRIVER
Q301
2N301
SEE HIGH VOLTAGE POWER SUPPLY AND MOD.
TO MODULATOR RECTIFIERS
TO JUNCTION OF R87 AND R88
CONNECTED IN SERIES WITH TWT HELIX
PART OF PLUG-IN ASSEMBLY
PART OF A400 PLUG-IN ASSEMBLY
TO V403, PIN 7
TO T1
PRIMARY POWER CIRCUIT
NOTES:
1. SEE A HIGH VOLTAGE POWER SUPPLY SCHEMATIC.
2. SWITCHES ARE SHOWN IN OFF CONDITION; RELAYS SHOWN IN DE-ENERGIZED POSITION.
3. CAPACITANCE IN MICROFARADS, RESISTANCE IN OHMS, UNLESS OTHERWISE INDICATED.
4. — — — PLUG-IN.
5. — · — · — ETCHED CIRCUIT.
6. P/O = PART OF
REFERENCE DESIGNATORS
B1
C6, 301 - 303
CR29, 304 - 309
DS1, 2
F1
H1 - 3, 5, 304
P1
Q301 - 303
R1, 2, 301 - 309
RT1
S1, 2
T1, 2
W1

CONDITIONS OF WARRANTY

FOR

BACKWARD WAVE OSCILLATOR TUBES

AND

TRAVELING WAVE TUBES

Microwave (BWO, TWT) tubes are warranted to be free from manufacturing defects for a period of one year from date of purchase from Hewlett-Packard. The Hewlett-Packard Company will process warranty claims for customers on tubes which were supplied by Hewlett-Packard for use in Hewlett-Packard instruments.

"In Warranty" tubes purchased from Hewlett-Packard must be returned immediately (not to exceed 30 days from date of failure) with a completed warranty Claim Form, to your local Hewlett-Packard Sales and Service Office. Addresses are listed in the instrument Manual. Be sure to pack the tube in accordance with the Packing Instructions listed on the Warranty Claim Form; warranty allowance cannot be made on tubes received broken due to improper packaging or showing evidence of tampering.

Instructions for filing a warranty claim are listed on the "Microwave Tube Warranty Claim" form which is included with the Operating and Service Manual for your instrument. This form is also included with replacement Microwave tubes supplied by Hewlett-Packard. Additional copies may be obtained from your local Hewlett-Packard Sales and Service Office. (Please ref: HP Stock No. 9320-1865.)

After expiration of this warranty, Hewlett-Packard specified replacement tubes can be obtained from your local Hewlett-Packard Sales and Service Office.

WARRANTY CLAIM AND ADJUSTMENT PROCEDURE

for microwave tubes supplied by the
HEWLETT-PACKARD COMPANY
for use in Hewlett-Packard instruments

The procedure described below is for use within the United States. For warranty claims arising outside the U.S.A., before returning the tube, fill out the form on the reverse side and send it with a request for shipping instructions to your nearest Hewlett-Packard Sales and Service Office or to:

(in Western Europe)

Hewlett-Packard S.A.
54 Route des Acacias
Geneva, Switzerland
Telephone: (022) 42.81.50
Telex: 2.24.86
Cable: HEWPACKSA

(Rest of World)

Hewlett-Packard Co.
International Marketing Dept.
1501 Page Mill Road
Palo Alto, California, 94304, U.S.A.
Telephone: (415) 326-7000
Telex: 033811
Cable: HEWPACK

Microwave tubes supplied by the Hewlett-Packard Company, either as original or replacement, for use in Hewlett-Packard instruments are actually warranted by the tube manufacturer and not by Hewlett-Packard. However, all warranty claims on tubes obtained from us either as original or replacement will be processed by Hewlett-Packard.

In the event of failure you should purchase a new tube and return your old tube immediately to Hewlett-Packard. Credit allowances will be passed on to you upon receipt of the defective tube.

For your convenience, warranty claims for all microwave tubes supplied by the Hewlett-Packard Company may be made on this single form; merely fill out the information on the reverse side and return this form, along with the defective tube, to your Hewlett-Packard Sales and Service Office or to Hewlett-Packard. Please be sure each space on the form is filled in--lack of complete information may delay processing of your claim.

Each tube manufacturer has his own warranty policy. Copies of individual Conditions of Warranty are available from your Hewlett-Packard Sales and Service Office or from the Hewlett-Packard Company.

SHIPPING INSTRUCTIONS

The following instructions are included to aid you in preventing damage in transit. Package your tube carefully--no allowance can be made on broken tubes.

1. Carefully wrap tube in 1/4-inch thick cellulosic cushioning, cotton batting, or other soft padding material. Cable assemblies and other accessories not rigidly mounted to the tube should be padded and wrapped separately to prevent damage to the tube during shipment.
2. Wrap the above in heavy kraft paper.
3. Pack in a rigid container which is at least 4 inches larger than the tube in each dimension.
4. Surround the tube with at least 2 inches of shock absorbing material. Be certain that the packing is tight all around the tube.
5. Tubes returned from outside the continental United States should be packed in a wooden box.
6. Mark container FRAGILE and ship prepaid via Air freight or Railway Express. Do not ship via Parcel Post or Air Parcel Post since experience has shown that fragile items are more apt to be damaged when shipped by these means.

Note

Tubes with permanent magnets can interfere with magnetic compasses.
For air shipment plainly mark container: "MAGNETIZED MATERIAL"

In warranty tubes purchased from Hewlett-Packard may be returned, with a completed warranty Claim Form, to your local Hewlett-Packard Sales and Service Office, or to:

Hewlett-Packard Company
Customer Service Center
333 Logue Avenue
Mountain View, California 94040
USA

MICROWAVE TUBE WARRANTY CLAIM
INFORMATION FORM

IMPORTANT: Please answer all questions fully -- insufficient information may delay processing of your claim.

DATE: _____

FROM: (Tube Owner)

Company _____

Address _____

_____

_____

Tube type _____

Tube serial No. _____

Tube mfr. _____

Use in HP Model _____

Instrument serial No. _____

Tube is Original ( ) or Replacement ( )

Date tube received _____

Date of failure _____

Total hours filament operation _____

SYMPTOMS: (Please describe conditions prior to and at time of failure, along with description of tube's defect, if known) _____

_____

_____

_____

IMPORTANT:
Replacement (new) tube serial No. _____

Signature _____

Title _____

For HP use only
Repair order # _____

5/1/68
01153-4