HEWLETT-PACKARD COMPANY / OPERATING AND SERVICE MANUAL

492A/494A

TRAVELING-WAVE AMPLIFIER

OPERATING AND SERVICE MANUAL

MODEL 492A

AND

MODEL 494A

SERIALS PREFIXED: 010-

TRAVELING-WAVE AMPLIFIERS

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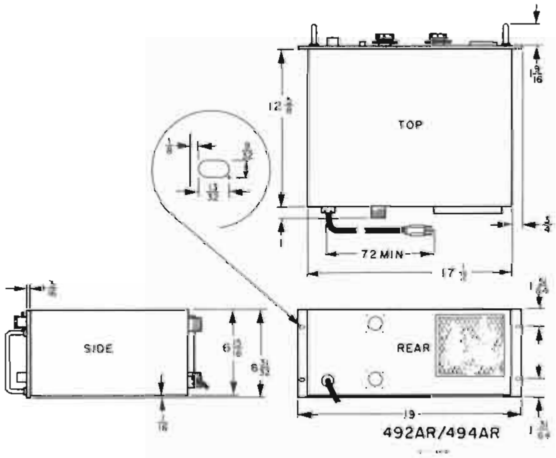
TABLE OF CONTENTS

LIST OF ILLUSTRATIONS AND TABLES

Table 1-1, Specifications

	Model 492A	Model 494A
Frequency Range:	4 gc to 8 gc	7 gc to 12.4 gc
Maximum Output Power:	20 mw minimum into 50 ohm load	20 mw minimum into 50 ohm load
Modulated Pulse Delay:	Approximately 20 ns	Approximately 15 ns
Helix Modulating Voltage:	Approximately 40 volts peak-to-peak. Provides 360° phase shift. Input impedance 100K	Approximately 50 volts peak-to-peak. Provides 360° phase shift. Input impedance 100K
Hum and Spurious Modulation:	At least 45 db below signal level	At least 45 db below signal level
Weight:	66 lb net, 85 lb shipping	63 lb net, 84 lb shipping
Power Supply:	115 volts ±10%, 50 to 60 cps, approximately 200 watts	115 volts ±10%, 50 to 60 cps, approximately 225 watts
Accessories Furnished:	AC-16Q cable assembly	AC-16Q cable assembly

	For Both Models
Small Signal Gain:	30 db minimum
Meter Monitors:	Cathode current, anode current, helix current, collector current.
Input Impedance:	50 ohms, swr less than 2
Output Internal Impedance:	50 ohms, swr less than 3
Dimensions:	Cabinet Mount: 7-3/8 in.wide, 11-1/2 in.high, 20 in.deep. Rack Mount: 
Connectors, RF Input and Output:	Type N
Noise Figure:	Less than 30 db
Pulse Rise and Decay Time:	Approximately 15 ns
Amplitude Modulating Voltage:	Approximately 50 volts peak positive pulse will produce a 40 db change in rf power output. Sensitivity approximately 1 db/volt

SECTION I

GENERAL INFORMATION

1-1. DESCRIPTION.

1-2. The hp Models 492A and 494A Traveling Wave Amplifiers are broadband, linear amplifiers providing adjustable amplification up to at least 30 db, between 4 and 12.4 gc, and have a maximum power output of at least 20 milliwatts to an external load of 50 ohms. The frequency range of the hp Model 492A is 4 to 8 gc; the frequency range of the Model 494A is 7 to 12.4 gc. These traveling wave tube (twt) amplifiers are designed to be used also as buffer amplifiers or modulators for any signal within their frequency range. As buffers, their input impedances remain constant with any reasonable load change at the output terminal; the attenuation between input and output signals is at least 60 db, minus the gain of the amplifier. As modulators, they can be used to amplitude, frequency, pulse, or phase modulate the signal being amplified with no interaction on the signal source. The gain and power output of the amplifiers are continuously adjustable by the front panel GRID BIAS control. Hum and spurious modulation generated within the amplifiers are at least 45 db below the output signal level and the noise figure is less than 30 db.

1-3. The hp Models 492A and 494A Traveling Wave Amplifiers, amplify any type of rf signal: cw, swept, sine-modulated, pulsed, multiple signals on different frequencies, etc. A twt amplifier used as a modulator, in conjunction with a signal generator, can be used to amplitude modulate an rf carrier to approximately 30% with less than 2.5% harmonic distortion and up to 50% with less than 5% distortion. Amplitude modulation sensitivity is approximately 1 db/volt. Pulse modulation is excellent; the rise time is less than 15 ns. Phase modulation up to 360° with less than 1 db amplitude modulation is also possible. Wide-band frequency modulation is simulated by a step-wise phase modulation described in section III.

1-4. The front panel meter is provided for checking and adjusting electrode currents in the traveling-wave tube. The meter helps to obtain desired operating characteristics during normal operation of the amplifier and also assists with preventive maintenance and troubleshooting. An anode voltage adjustment on the instrument chassis provided to adjust the cathode current of the twt back to normal due to tube ageing.

Figure 1-1. Model 492A Traveling Wave Amplifier

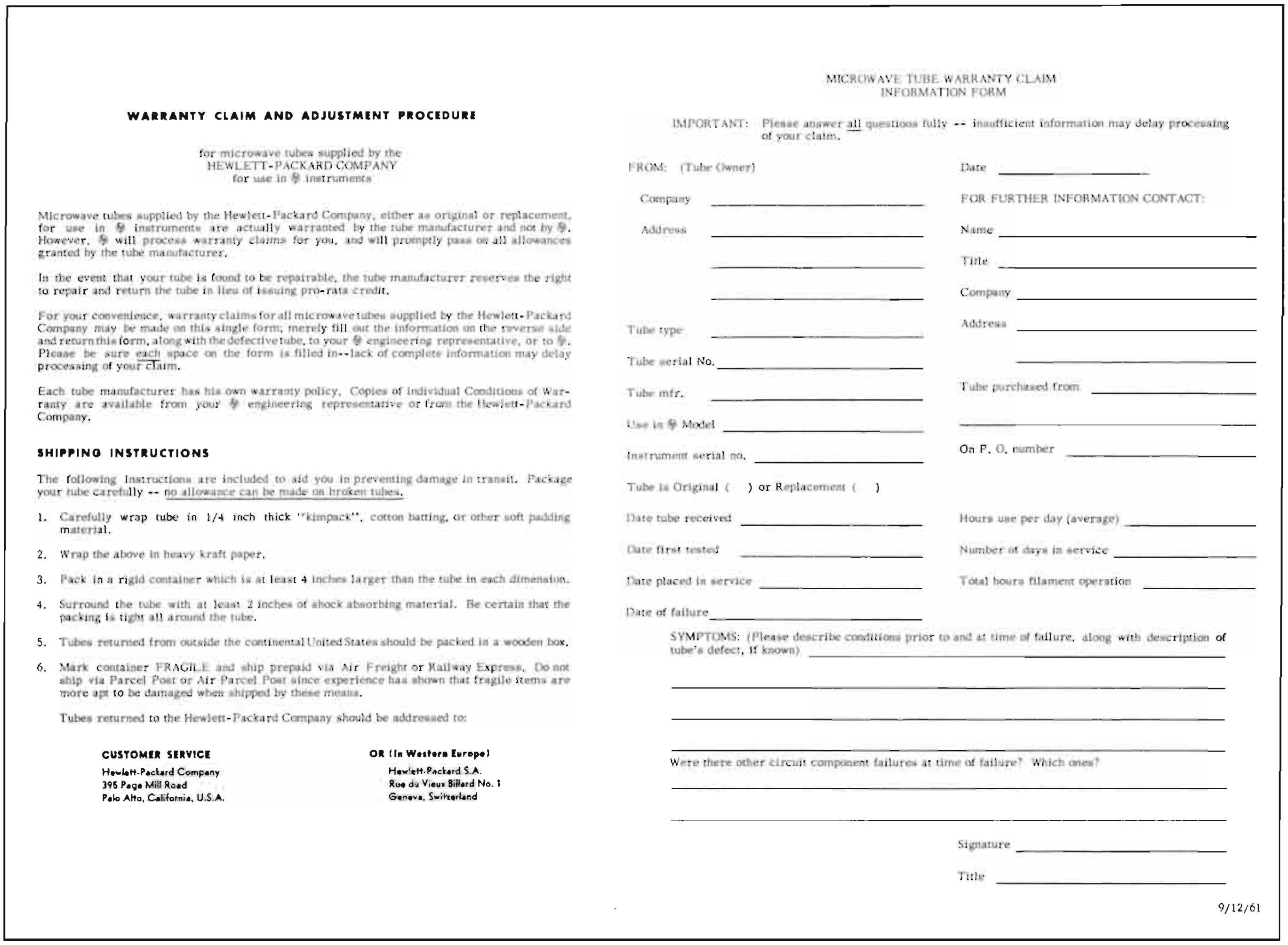
1-5. The hp Model 492A and 494A are similar in that one model may be changed to the other, by replacing the twt, as covered in paragraph 5-17.

1-6. INSTRUMENT IDENTIFICATION.

1-7. Hewlett-Packard uses a two-section eight-digit serial number (000-00000). If the first three digits of the serial number on your instrument do not agree with those on the title page of this manual, change sheets supplied with the manual will define differences between your instrument and the Model 492A or 494A described in this manual.

1-8. TRAVELING WAVE TUBE WARRANTY.

1-9. The Traveling Wave Tube Warranty is illustrated in figure 1-2. A sheet for your use is included in the appendix of this manual.



WARRANTY CLAIM AND ADJUSTMENT PROCEDURE

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

Microwave tubes supplied by the Hewlett-Packard Company, either as original or replacement, for use in hp instruments are actually warranted by the tube manufacturer and not by hp. However, hp will process warranty claims for you, and will promptly pass on all allowances granted by the tube manufacturer.

In the event that your tube is found to be repairable, the tube manufacturer reserves the right to repair and return the tube in lieu of issuing pro-rata credit.

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 hp engineering representative, or to hp. 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 hp engineering representative 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 "kimpack", cotton batting, or other soft padding material.
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.

Tubes returned to the Hewlett-Packard Company should be addressed to:

CUSTOMER SERVICE
Hewlett-Packard Company
395 Page Mill Road
Palo Alto, California, U.S.A.

OR (In Western Europe)
Hewlett-Packard S.A.
Rue du Vieux Billard No. 1
Geneva, Switzerland

MICROWAVE TUBE WARRANTY CLAIM
INFORMATION FORM

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

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 first tested ______________________

Date placed in service ______________________

Date of failure ______________________

Date ______________________

FOR FURTHER INFORMATION CONTACT:

Name ______________________

Title ______________________

Company ______________________

Address ______________________

____

Tube purchased from ______________________

____

On P. O. number ______________________

Hours use per day (average) ______________________

Number of days in service ______________________

Total hours filament operation ______________________

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

____

____

____

Were there other circuit component failures at time of failure? Which ones?

____

____

Signature ______________________

Title ______________________

9/12/61

Figure 1-2. Traveling Wave Tube Warranty

SECTION II

INSTALLATION

2-1. MECHANICAL INSPECTION.

2-2. Unpack the instrument upon receipt and inspect it for signs of physical damage such as scratched panel surfaces, broken knobs, etc. If there is any apparent damage, file a claim with the carrier and refer to the warranty page in this manual.

2-3. POWER REQUIREMENTS.

2-4. The Model 492A and Model 494A require a power source of 115 volts ±10%, single phase, 50 to 60 cps, which can deliver approximately 225 watts.

2-5. POWER CABLE.

2-6. For the protection of operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the instrument panel and cabinet be grounded. This instrument is equipped with a three-prong conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument. The offset pin on the power cable three-prong connector is the ground pin.

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

2-8. INSTALLATION.

2-9. The only special precaution necessary for installing the twt amplifiers is that they should not be operated close to very large magnetic fields, such as 60-cycle fields, unless externally shielded. While the twt amplifiers are shielded within the cabinet, complete protection against large low-frequency fields would require more shielding than is practical to include in the design.

2-10. To operate, connect the instrument to a 115-volt ac power source, check and adjust tube operating currents as described in preliminary operating procedure, section III, and connect to the external equipment with coaxial cables terminated in standard UG-21D/U, type N connectors.

2-11. In section V, beginning with paragraph 5-32, is a list of performance checks for this instrument. These procedures make a good test as part of incoming quality-control inspection following initial turn-on.

2-12. REPACKAGING FOR SHIPMENT.

2-13. The following list is a general guide for repackaging an instrument for shipment. If you have any questions, contact your authorized Hewlett-Packard sales 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.

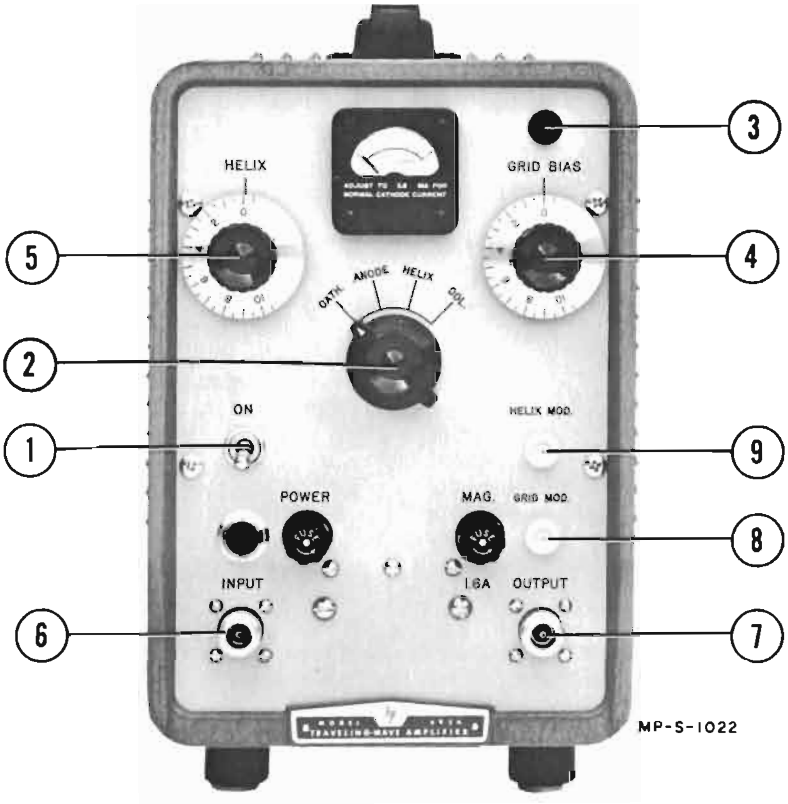
c. Use plenty of packing material around all sides of the instrument and protect the panel with cardboard strips.

d. Use 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.

Note

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



1. Turns on all circuits of the amplifier (allow 15 minutes warmup).
2. Meter selector switch is used for selection of circuit to be checked on the front-panel meter.
3. Pin jack is for measuring grid bias (measures E_k; grid grounded).
4. GRID BIAS control is used to adjust for desired tube current. Normal cathode current is indicated on the meter plate. Do not exceed maximum operating currents, refer to table 3-1.
5. HELIX control is used to adjust for best broadband response, position 5, or for maximum gain at any one frequency.
6. INPUT rf connector is where the rf signal to be amplified is coupled into the instrument.
7. OUTPUT rf connector is where the amplified rf signal is coupled from the instrument.
8. GRID MOD. connector is the input for amplitude modulation signals.
9. HELIX MOD. connector is the input for phase and frequency modulation signals.

Figure 3-1. Operating Controls

SECTION III

OPERATING INSTRUCTIONS

3-1. INTRODUCTION.

3-2. This section contains operating instructions for the Models 492A and 494A Traveling Wave Tube Amplifiers. Figure 3-1 gives basic operating instructions. The remainder of this section supplements these instructions.

3-3. PRELIMINARY OPERATING PROCEDURE.

3-4. The front panel controls, indicator, and connectors for the 492A and 494A are shown in figure 3-1. This figure also shows the uses for the controls, indicator, and connectors. Whenever the twt is turned on, use the front panel meter to measure the current to each electrode in the traveling-wave tube with the GRID BIAS control set for zero bias. The safe maximum current for each electrode is shown in table 3-1. Normal cathode current for your instrument is indicated on the plate attached to the meter face. Currents are usually a little high when the instrument is first turned on, but decrease to normal during warmup. Allow 15 minutes warmup before making final reading. The GRID BIAS control may be used to reduce the tube currents during warmup.

Table 3-1. Maximum Operating Currents for Models 492A and 494A.

CAUTION: DO NOT EXCEED:

Cathode current	3 ma
Helix current	0.5 ma
Collector current	3 ma
Anode current	50 μa

3-5. If, following tube replacement, or for some other reason, the cathode current can be increased with the GRID BIAS control to slightly above the safe maximum current (see table 3-1), readjust the anode voltage control, paragraph 5-26. The anode voltage control is set to limit the twt to its normal cathode current when the bias voltage on the twt is zero. If the cathode current is limited to its normal value, but the current to another electrode is excessive, the amplifier requires service or adjustment, see paragraphs 5-21 or 5-30.

3-6. HELIX CONTROL.

3-7. The HELIX voltage control on the front panel maximizes the gain and power output of the twt at a selected frequency or optimizes the gain and power output over the entire band; see figures 3-2A and 3-2B. Adjusting the HELIX voltage control for maximum gain at the upper frequency limit usually produces the flattest frequency response over the band. Maximizing the gain at frequencies below the upper frequency limit usually results in additional gain and power output over that obtained when adjusted for flattest broadband operation. The final setting of the HELIX control is independent of the type of signal amplified.

3-8. SATURATION POWER OUTPUT.

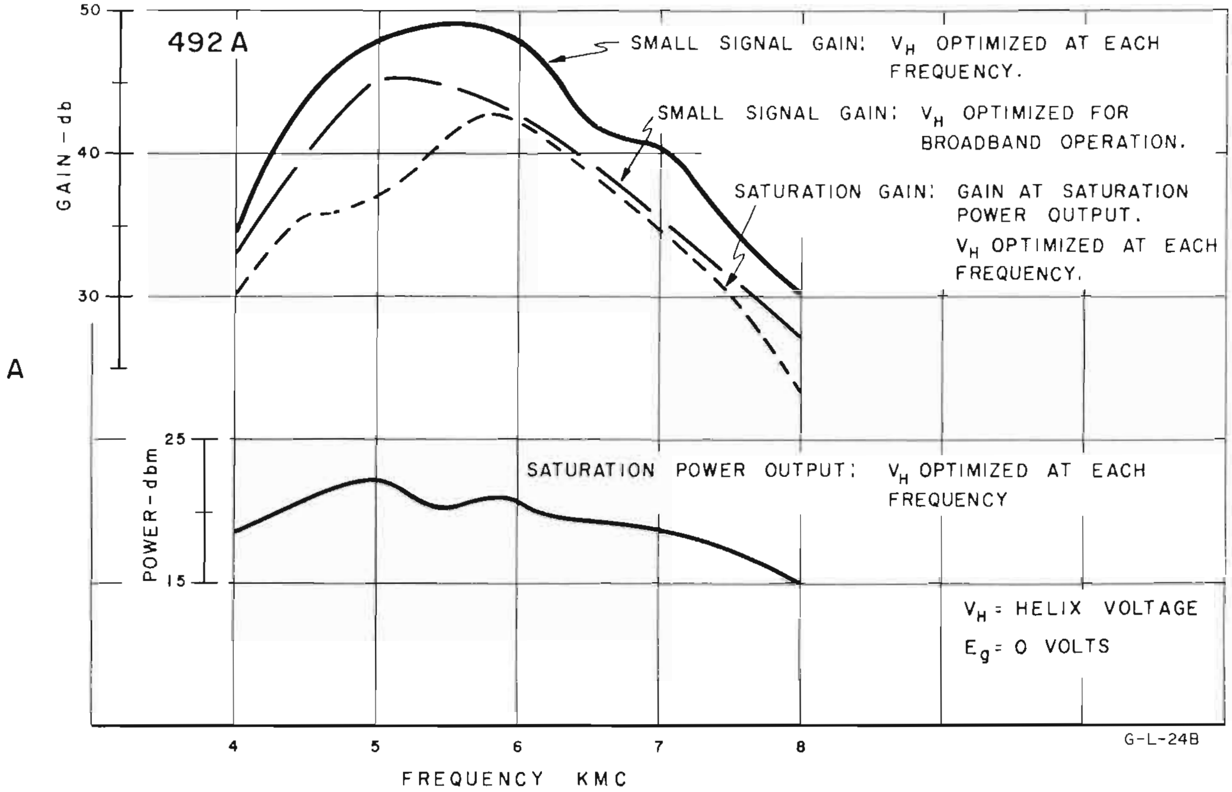
3-9. Saturation power output is the maximum output power obtainable with a given collector current and optimized helix voltage. As the input signal is increased from the noise level, the output-vs-input characteristic is linear until saturation is approached and the gain begins to decrease. Eventually the output reaches a peak which is the saturation power output and any further increase in the input causes the output to decrease. If the collector current is reduced, the power output at which saturation occurs will be decreased. The primary effects which lead to saturation are: 1) the forces between the electrons in the beam begin to limit the electron density in the bunches 2) the energy transfer from the electron beam to the helix causes the beam velocity to decrease and gradually lose synchronism with the wave on the helix. These effects become more pronounced as saturation is approached, and cause the gain of the twt to decrease.

3-10. Operating the 492A or 494A near saturation power output will produce second harmonic content in the output. To obtain maximum power output from the twt without excessive second harmonic content in the output, increase the input signal level until saturation is reached, then reduce the input until the output decreases approximately 6 db (an input reduction of 10 to 15 db). If second harmonic content is unimportant, operation at saturation is usually very satisfactory.

3-11. One advantage of operating the twt near saturation is the constant output characteristic exhibited by a twt at saturation. At saturation the gain of a twt varies inversely with the input level and input variations of 10 to 15 db cause the output to vary only 4 to 6 db. If a more nearly constant output is desired, see paragraph 3-14.

3-12. BANDWIDTH CONSIDERATIONS.

3-13. The graphs in figures 3-2A and B show typical gain vs frequency and saturation power output curves for the 492A and the 494A amplifiers using two different conditions of helix voltage. One set of curves shows the gain and saturation power output when the helix voltage is optimized at each frequency. The other set of curves shows the gain and saturation power output when the HELIX control is set to the broadband



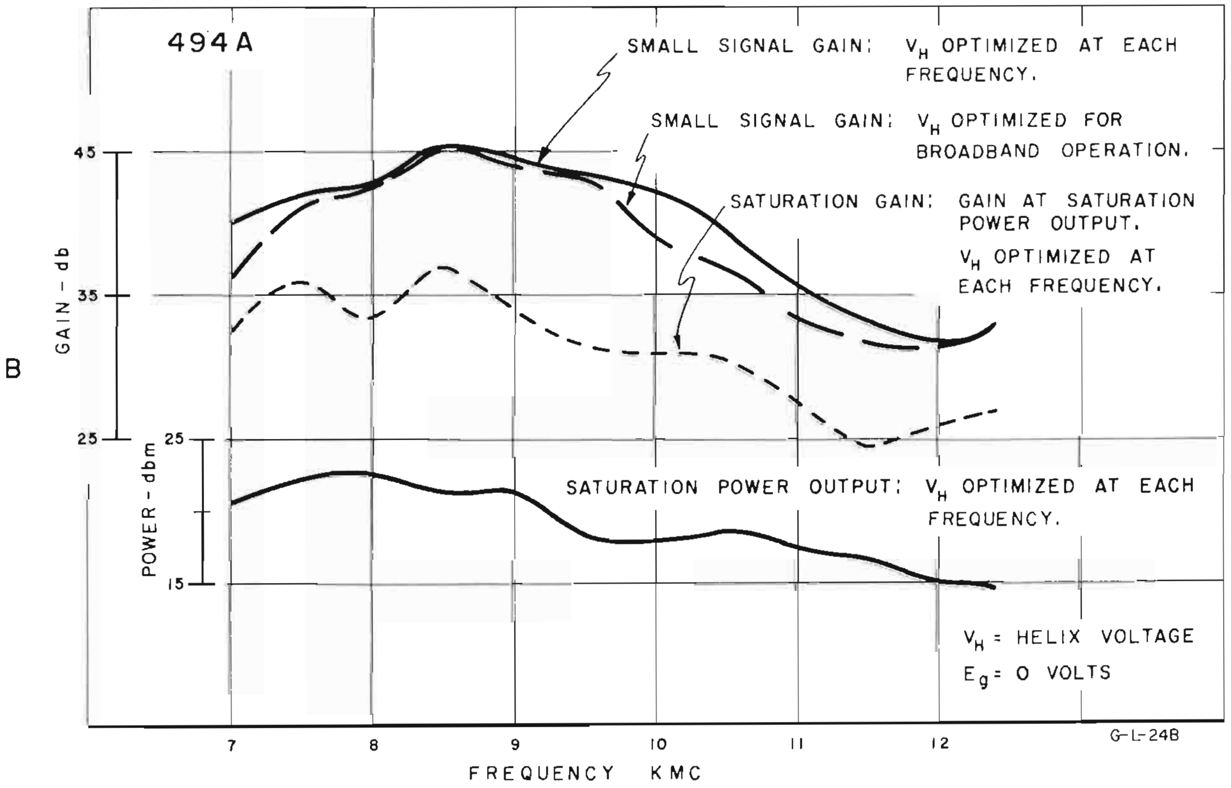


Figure 3-2. Typical Gain and Power Output Characteristics

position. To obtain the most nearly constant amplifier gain over the full frequency range set the HELIX control to 5, the setting which yields the optimum broadband helix voltage. Since noise power is directly proportional to bandwidth, it may be desirable to limit the bandwidth and therefore noise by maximizing the gain at a particular frequency with the HELIX control and by installing suitable filters at the output.

3-14. CONSTANT GAIN OR CONSTANT OUTPUT AMPLIFICATION.

3-15. Although the traveling wave tube amplifier's saturated power output characteristic can be used to provide nearly constant output power, installing suitable feedback circuitry provides a constant output for input signal variations as great as 20 db.

3-16. An arrangement for obtaining a constant-level output signal from the twt, in spite of variations in input signal level or variations in amplifier gain, is illustrated in figure 3-3. In this circuit a portion of the rf signal is coupled from the traveling-wave tube output, through a directional coupler to a detector such as a crystal rectifier. The rectified voltage is then amplified in a dc coupled amplifier and applied to the GRID MOD. connector on the twt. Any tendency for the output level from the twt to increase is immediately detected, amplified, and fed back to reduce the gain of the traveling wave tube amplifier in proportion. Conversely, any reduction in output level increases the gain of the amplifier to hold the output level constant. The flatness of the rf output power level will be affected by the frequency response of the detector, directional coupler and the amplifier gain. The bandwidth of the amplifier must be great enough to pass any rate of change at which the output level may vary.

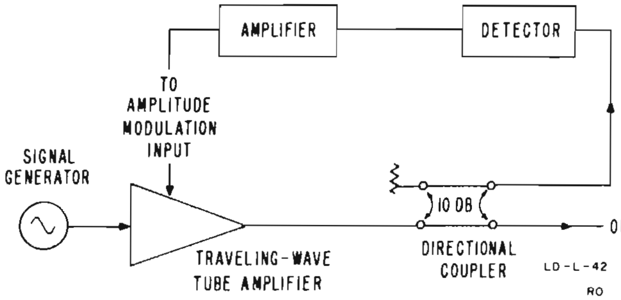


Figure 3-3. Block Diagram of a Circuit used to Maintain Constant-Level Output Power from a TWT Amplifier

3-17. A variation of the basic automatic power level control circuit can be used to obtain constant amplification with a twt even though the gain changes with frequency, power line voltage and tube characteristics. This circuit is illustrated in figure 3-4. The circuit operates as follows: The rf input and output signals are sampled, rectified, and the resulting dc voltages amplified and compared. The gain or output from each half of the circuit can be adjusted to establish the desired ratio of input to output level. If the rf input to output ratio changes, a difference voltage is developed which is then applied to the twt grid to hold its amplification constant.

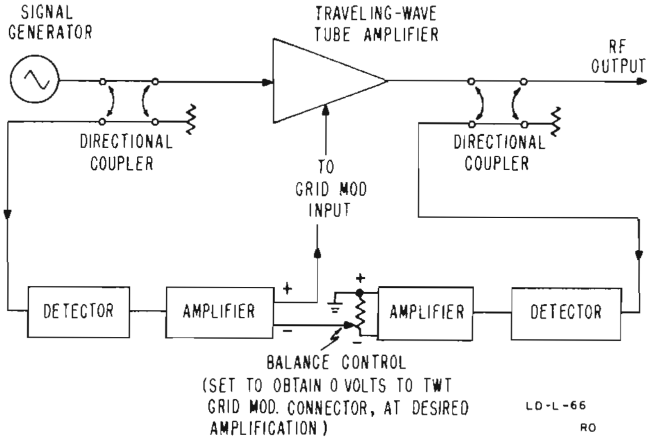


Figure 3-4. Block Diagram of an Automatic Gain Control to Maintain Constant Amplification from a TWT Amplifier

3-18. BUFFER AMPLIFICATIONS.

3-19. The 492A and 494A serve as very effective buffers to isolate a microwave signal source from a load. Mismatches, changes in external circuitry, or the introduction of modulation do not affect the constant 50-ohm input impedance of the twt and thus will not affect a signal source connected to the input. The attenuation between the output and input terminals is 60 db due to attenuators placed along the helix. However, when the output signal is reflected from a mismatched load back to the input, the effective signal isolation is the 60 db minus the gain of the amplifier. For example: with an amplifier gain of 25 db, an open or short circuit on the twt output can result in a maximum reflected signal 35 db below the input level (approximately 1/56 of the input signal), which corresponds to a swr of less than 1.04.

3-20. AMPLITUDE MODULATION.

3-21. To amplitude modulate an rf signal applied to the twt amplifier with a minimum of envelope distortion in the output signal, carefully establish the optimum rf drive, grid bias, and modulating signal amplitude for a given setup.

Note

> The GRID MOD. connector is direct-coupled to the grid of the twt amplifier. If a dc potential accompanies a modulating voltage applied to this connector, the grid-bias voltage will be altered. The GRID BIAS control may be used to compensate for the change in grid bias voltage due to a dc component at the input.

3-22. For minimum distortion, the twt grid voltage must not leave the linear region of the grid voltage vs rf output characteristic (see figures 3-5 and 3-6). Also, the rf drive must be adjusted so that the modulation peaks are at least 2 db below saturation power

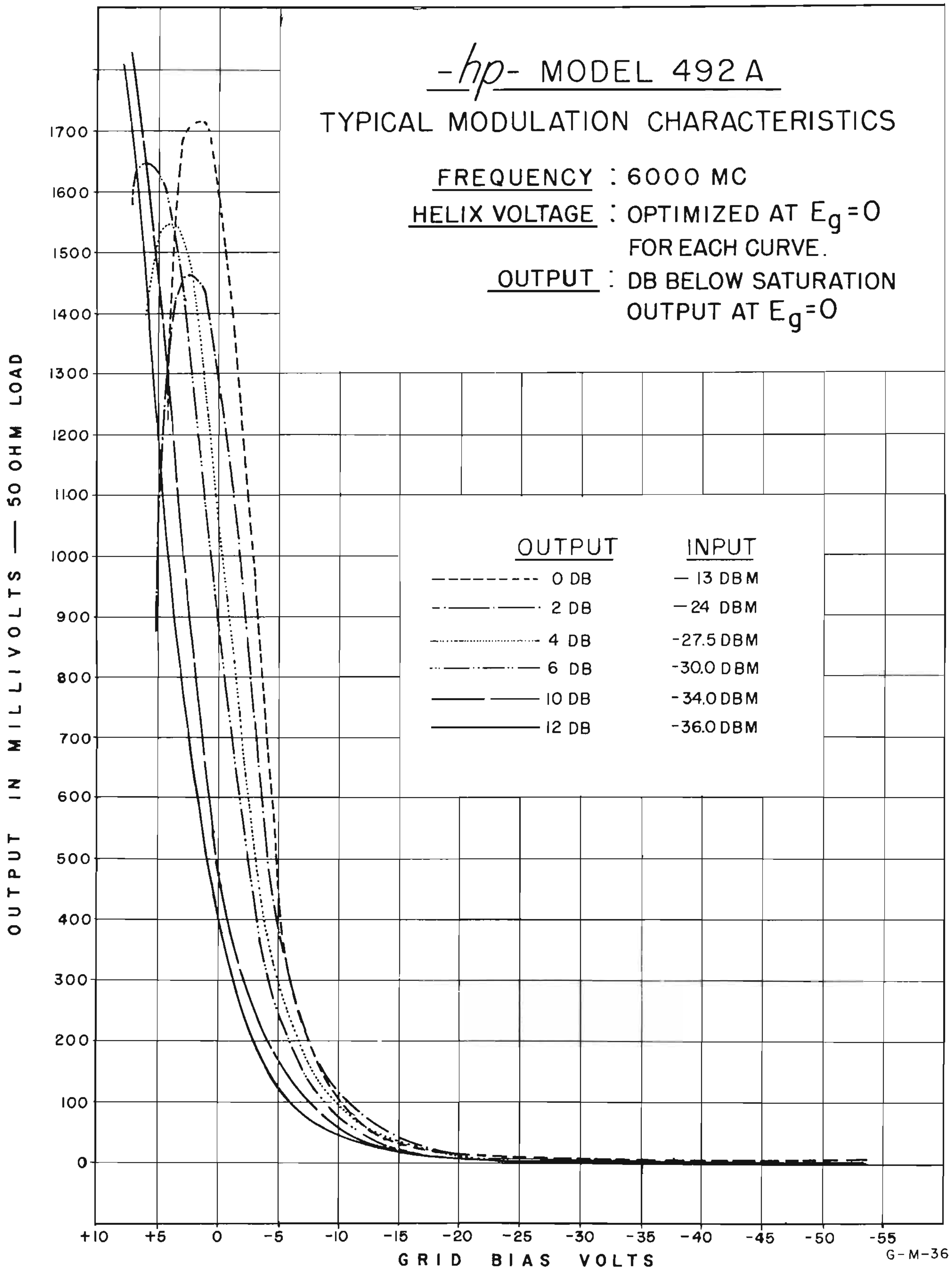


Figure 3-5. Typical Plot of Output Voltage vs Grid Voltage of a Model 492A

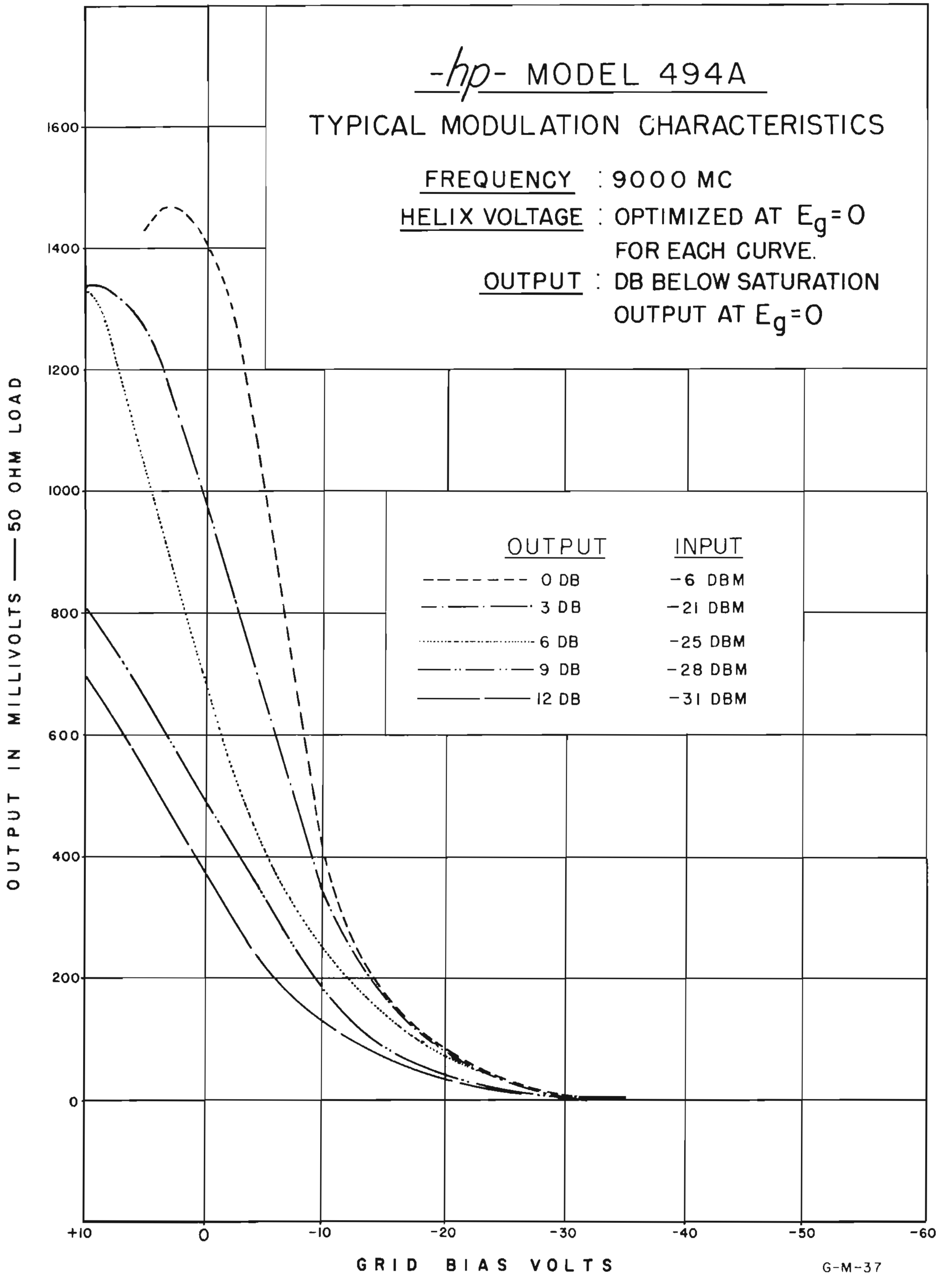


Figure 3-6. Typical Plot of Output Voltage vs Grid Voltage of a Model 494A

output. The linear modulation region extends from approximately +4 volts (where beam de-focusing occurs) to approximately -15 volts (where the rf output becomes an exponential function of the grid voltage). This linear operating region permits up to 30% modulation with less than 2.5% envelope distortion and up to 50% modulation with less than 5% distortion. Envelope distortion increases rapidly above 50% modulation. In pulse work the twt may be biased near or below cut-off and the rf drive adjusted for saturation output at the peak amplitude of the modulating pulse. However, the grid voltage at the peak of the modulating signal must not cause de-focusing (approximately +4 to +8 volts) nor excessive average electrode current, see table 3-1. The transient response of the 492A or 494A to a step function applied to the grid is approximately 15 nsec.

3-23. Amplitude modulation is accompanied by some incidental phase modulation of the rf signal, amounting to approximately 90° phase shift of the rf carrier for a 10 db change in the modulated rf output level. In practice this phase modulation is unimportant when using the conventional square-law crystal detectors, but is important in detection systems where the output is a function of the rf carrier phase.

3-24. PULSE MODULATION.

3-25. There is considerably latitude in the adjustment of modulation characteristics when pulse modulating an rf signal using the 492A or the 494A; see figures 3-5 and 3-6. The cw input level, the modulation-pulse amplitude, and the grid bias determine the characteristics of the rf output pulse as follows:

a. The cw input signal primarily determines the maximum possible level of the rf output pulse and whether or not the twt can be operated into saturation.

b. The peak-to-peak amplitude of the modulating pulse primarily determines the on-off ratio of the rf output pulse.

c. The grid bias level primarily determines the rf output levels attained during the pulse-on and pulse-off times and also, in conjunction with the modulating pulse, determines the rf input level necessary to saturate the twt. The GRID BIAS control always should be set so that the twt grid will not draw current (approximately 4 volts positive) during the pulse-on period.

3-26. To pulse modulate the rf signal being amplified in the 492A or 494A, refer to figures 3-5 or 3-6 and proceed as follows:

a. Determine if the twt is to be driven into saturation and if the rf output must be at a specific level.

b. Set the GRID BIAS control for zero bias.

c. Connect the rf input signal to the twt and adjust its level to produce the desired rf pulse output level.

d. Determine the on-off voltage ratio required in the rf output pulse.

e. Using the graph in figure 3-5 determine the magnitude of modulation pulse required to produce the desired on-off ratio.

f. Set the GRID BIAS control to obtain the voltage determined in step e., i.e., the peak voltage of the modulating pulse. The bias voltage may be measured at the pin jack on the front panel.

g. Connect the modulating pulse to the GRID MOD. connector and adjust its amplitude to the voltage determined in step e to produce the desired on-off ratio in the rf output pulse. Since the grid of the twt is connected directly to the GRID MOD. jack, a dc component in the modulating signal will affect the grid bias. Also, if capacitive coupling is used the modulating signal will drive the grid of the twt above and below the dc level established by the grid bias, an amount determined by the duty cycle of the modulating signal. The GRID BIAS control must be adjusted to compensate for both of these effects.

h. To increase the on-off ratio of the rf output pulse, increase the amplitude of the modulation pulse, at the same time adjust the grid bias so that the grid will not be driven beyond 4 volts positive, see the Note paragraph 3-21.

Note

> Large input modulating pulses, above 15 volts, tend to shock-excite the helix, producing ringing on the top of the rf output pulse and a slow rise time. If the traveling-wave tube is operated near saturation this effect is minimized and better pulse characteristics are obtained.

3-27. LIMITED PHASE MODULATION.

3-28. The signal being amplified in the 492A or 494A can be phase-modulated by applying voltage to the HELIX MOD. connector. This voltage varies the electron-beam velocity by changing the potential between the cathode and the helix--a positive voltage change accelerates the electron bunches and advances the phase of the rf output signal; a negative change slows them and retards the phase of the output signal. The resultant phase deviation in the output signal is directly proportional to the applied voltage. The degree of phase deviation produced is limited by the range of helix voltages that produces amplification, and by the amount of incidental amplitude modulation permissible in the rf output. Phase deviation of 360° is possible with the output amplitude held to variations of approximately 1-1/2 db and is obtained with a helix voltage variation of less than 50 volts. The actual voltage required for a phase shift of 360° varies with the operating frequency and from tube-to-tube.

3-29. UNLIMITED PHASE MODULATION AND FREQUENCY SHIFTING.

3-30. Although the limited phase deviation described in paragraph 3-27 is useful in some applications, unlimited phase deviation has a much wider range of usage. It is particularly useful because the frequency of the input signal can be shifted by a predetermined amount. Unlimited phase deviation is effectively simulated by continuously repeating exact 360° phase deviations. This is accomplished by modulating the traveling wave tube helix with a sawtooth waveform, each sawtooth producing 360° phase shift, as shown in figure 3-7. An rf output frequency that is shifted in relation to the input frequency is thus produced, as shown in figure 3-8.

3-31. In practical applications, a constant amplitude linear-slope sawtooth generator is used to produce the sawtooth waveforms. If the amplitude of the sawtooth voltage is adjusted to produce a 360° shift, one cycle of the cw signal will be added or subtracted during each sawtooth, and the frequency shift produced in the output will be equal to the sawtooth repetition rate. Sawtooth voltages having negative slopes (see figure 3-7) produce a decrease in the output frequency (delay in phase). Conversely, sawtooth voltages of the opposite slope cause an increase in output frequency.

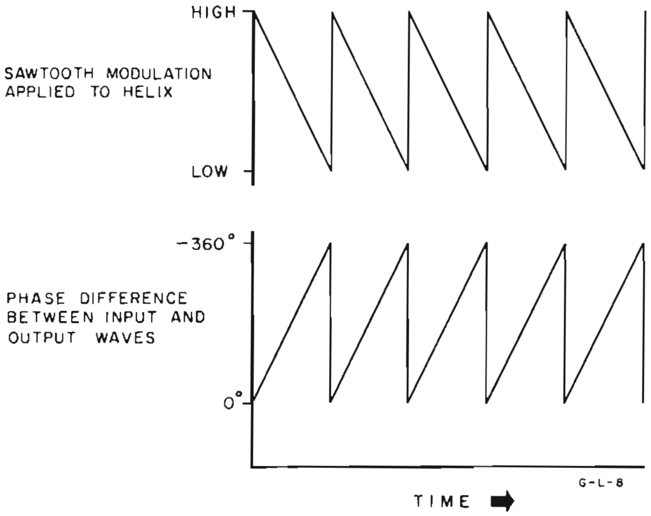


Figure 3-7. RF Phase Shift Produced by Helix Modulation

3-32. With sawtooth modulation, the desired output frequency shift (F_1 in figure 3-8) occurs during the sawtooth formation time, and is proportional to the rate of change of voltage. During the sawtooth flyback time the output phase is shifted in the opposite direction producing an undesired frequency shift (F_2 in figure 3-8). If the flyback time is made extremely short, this frequency is far removed from the desired frequency since the degree of frequency shift is inversely proportional to the flyback time. In addition to being far removed from the desired frequency the power in the undesired frequency is very small since it is proportional to the ratio of flyback time to sawtooth time.

3-33. In a typical case involving a desired 50-kc frequency shift, a 1-microsecond flyback time would produce a 1-megacycle frequency shift in the opposite direction and would contain only 5% of the total power in the output wave. In practice, this undesired frequency shift with its relatively small power content would be rejected by most narrow band circuits. In systems where the undesired frequency shift falls within the pass band of the equipment under test, a negative pulse can be applied to the GRID MOD. connector to cut off the twt beam current during the flyback time. This method reduces the undesired frequency shift although it produces some small transients and leaves small time intervals during which there is no signal output. Practical applications of offset frequencies include the measurement of extremely high swr's accurate calibration of attenuators over wide amplitude ranges (paragraph 3-34), frequency shifting of microwave radio relay channels for retransmission, production of mixer frequencies for radar and other microwave receivers, etc.

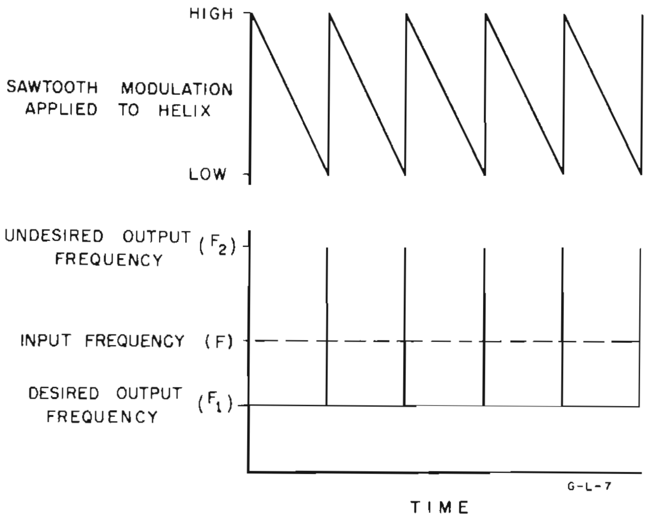


Figure 3-8. Offset Frequency Produced by Sawtooth Modulation of the Helix

3-34. HOMODYNE DETECTION.

3-35. The ability of a twt to produce an offset frequency that is stable with respect to the signal source makes it an ideal instrument to use in a homodyne (linear) detection system. The difference frequency will be dependent upon the stability of the sawtooth generator used to modulate the twt helix, a problem of no consequence at the low modulating frequencies involved.

3-36. A typical linear detector system suitable for calibrating microwave attenuators is illustrated in figure 3-9. The signal generator supplies a signal (f) both to a crystal mixer and to a traveling wave tube amplifier. The traveling wave tube amplifier is sawtooth modulated to produce an offset frequency ($f-f_1$) which is applied to the attenuator to be calibrated. The output signal from the attenuator is then combined with the original signal (f) in the mixer to produce a beat frequency (f_1) whose amplitude is directly proportional to the amplitude of ($f-f_1$) so long as the amplitude of ($f-f_1$) remains within the square-law region of the crystal. This beat frequency is amplified by the tuned amplifier and the output is indicated by an ac voltmeter. The lower sensitivity

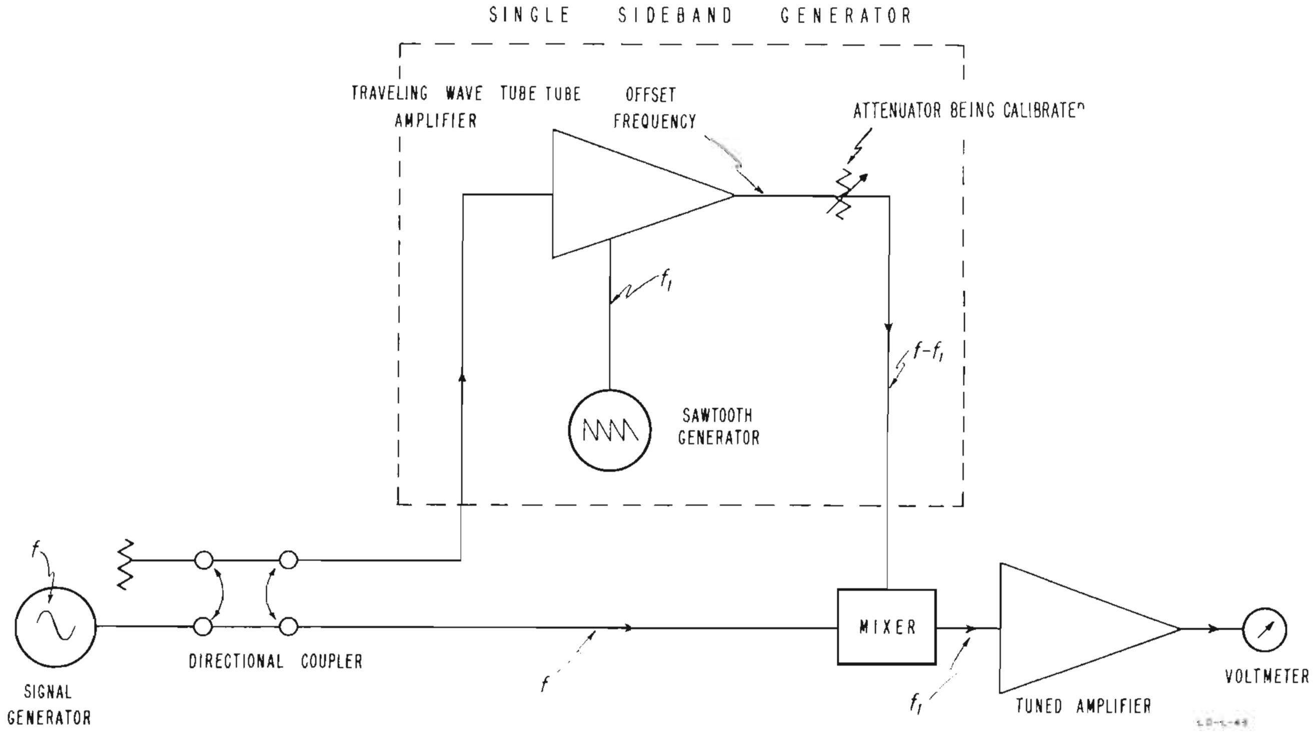
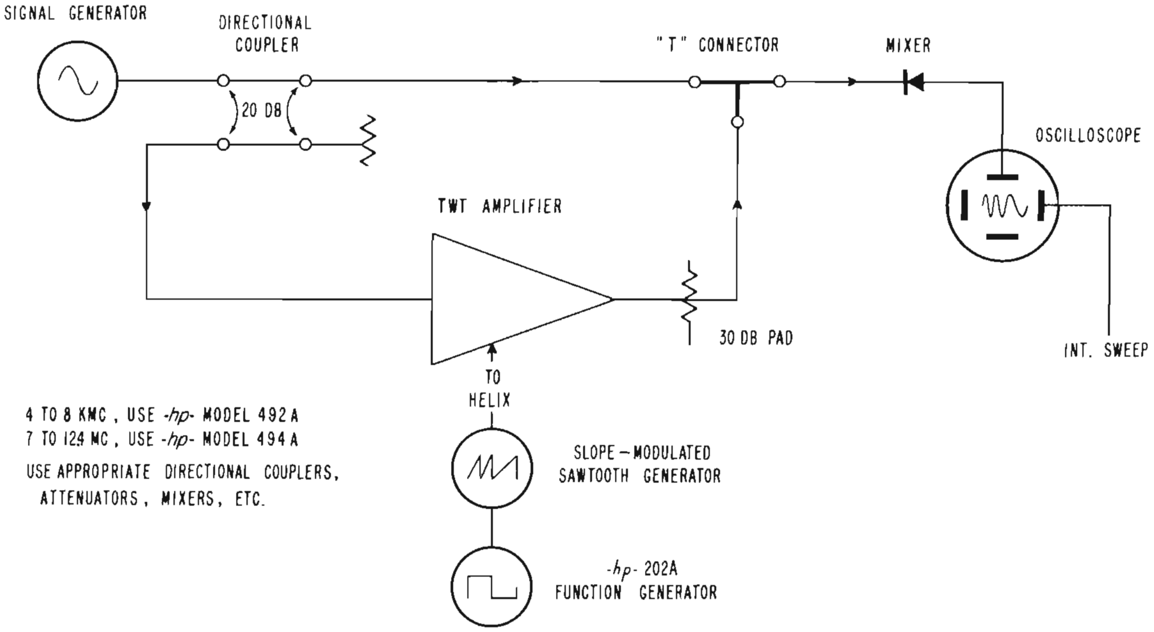


Figure 3-9. Block Diagram of a Linear (Homodyne) Detection System



M.O.P.A. MICROWAVE FREQUENCY MODULATION SYSTEM

LD-L-40B

Figure 3-10. Block Diagram of a Circuit to Produce an FM Signal with a TWT Amplifier limit is determined by the crystal and IF amplifier noise and is approximately -100 dbm.

Note

When a swr indicator (such as the ℎ𝑝 Model 415B) calibrated for use with a square-law detector is used in place of the tuned amplifier and voltmeter, the db readings must be doubled.

3-37. FREQUENCY MODULATION.

3-38. Narrow-band frequency modulation can be obtained by applying the modulation signal directly to the helix of the twt; however, to frequency modulate with an appreciable frequency deviation it is first necessary to produce an offset frequency as described in paragraph 3-29. The deviation of the offset frequency should be slightly greater than 1/2 the total frequency deviation desired. The offset frequency is then varied by varying the slope of the sawtooth.

3-39. A sawtooth waveform produced by the special generator described in paragraph 4-20 can be slope-modulated by any waveform before being applied to the traveling wave tube helix. In this manner complex signals can be used to frequency-modulate the signal applied to the twt and the center of the output frequency will be fixed by the sawtooth repetition rate without slope modulation. In no case should the phase shift due to a single sawtooth cycle exceed 360° so that the amplification properties of the traveling wave tube amplifier will not be adversely affected regardless of the magnitude of the apparent phase deviation when the sawtooth wave is modulated.

3-40. Figure 3-10 is a block diagram of a system for the generation of frequency-modulated offset signals. In this arrangement, the slope-modulated sawtooth voltage which is applied to the twt helix produces an offset frequency, the instantaneous frequency of which is proportional to the slope of the sawtooth. Varying the slope of the sawtooth voltage varies the offset frequency. Thus the output signal from the twt is an fm signal. The detected fm signal (the difference between the signal generator frequency and the frequency-modulated offset frequency) is shown on the oscilloscope.

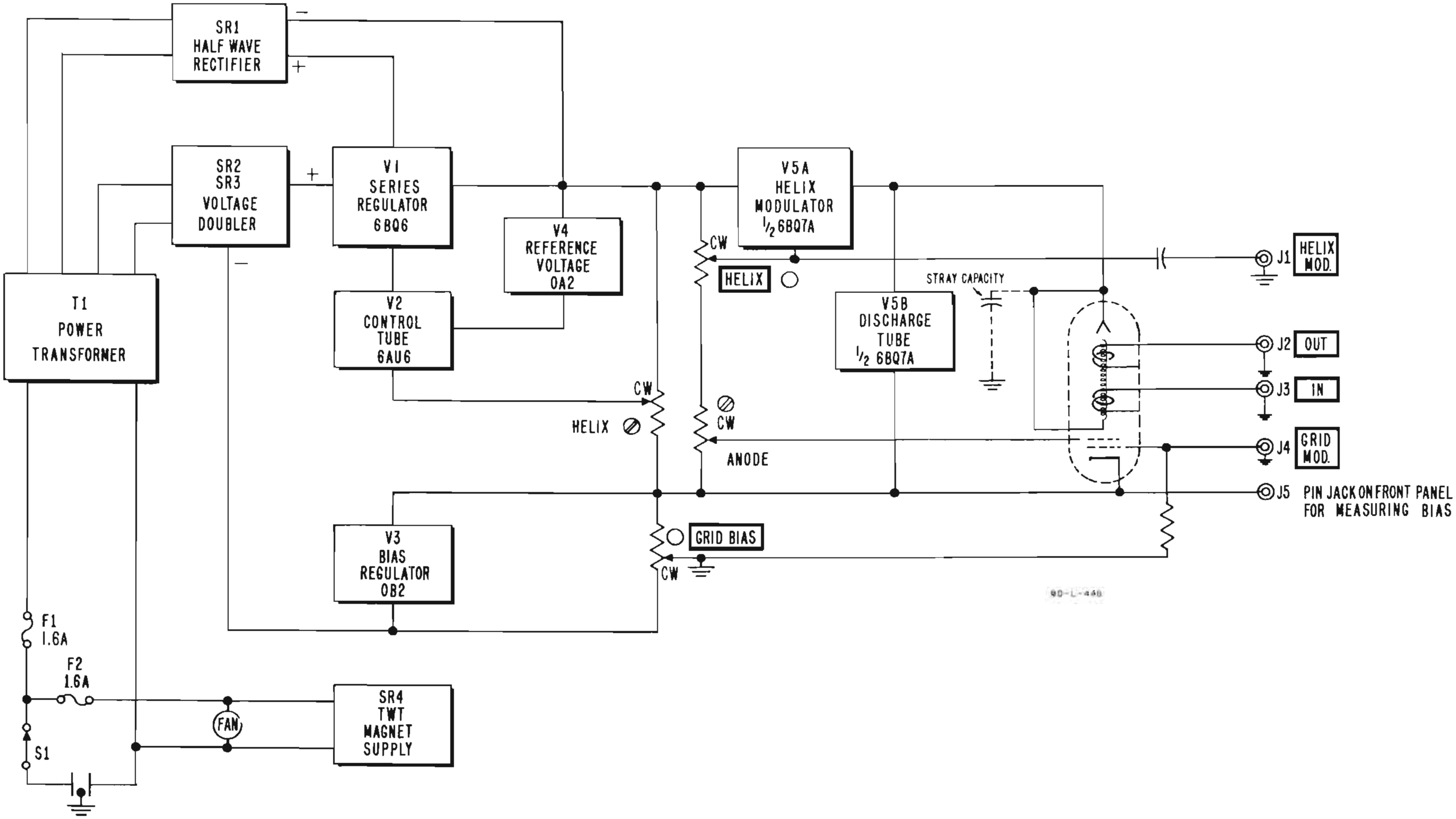


Figure 4-1. Block Diagram ⓗⓟ Models 492A and 494A

SECTION IV
PRINCIPLES OF OPERATION

4-1. INTRODUCTION.

4-2. The twt amplifier contains very little signal circuitry external to the twt itself. The electrical circuits in the instrument provide the operating voltages and the means for modulating the twt, as shown in the block diagram, figure 4-1.

4-3. MAGNET POWER SUPPLY.

4-4. The 492A and 494A utilize a 400-gauss electromagnet (surrounding the traveling wave tube capsule) to hold the emitted electrons in a very narrow beam. The power supply for the magnet consists of a full-wave selenium bridge rectifier connected directly across the 115-volt line and a capacitive-input filter, and supplies approximately 0.7 ampere at an output voltage of 120 volts dc with less than 1 volt rms ripple when connected to the magnet. The magnet is covered by a shield as a protection against stray magnetic fields.

4-5. REGULATED POWER SUPPLY.

4-6. The operating voltages applied to the twt are obtained from a voltage doubler followed by a voltage regulator, V1, V2, and V4. The regulation is accomplished by varying the plate resistance of V1 in accordance with the output voltage in the following manner, see figure 4-1. V4 is a constant voltage tube which holds the voltage at the grid of V2 constant with respect to the cathode of V1. The cathode of V2 is connected to a voltage divider between the cathode of V1 and the minus side of the supply. If the cathode voltage of V1 increases, the grid voltage of V2 will also increase the same amount. However, the cathode voltage of V2 will increase only by an amount equal to the ratio of resistance below the potentiometer arm to the total resistance times the total voltage change. Thus, a signal appears on the grid of V2 which is proportional to the rise of voltage on the cathode of V1. This signal on the grid of V2 is amplified and inverted by V2 and applied to the grid of V1, increasing the plate resistance of V1 and lowering the voltage at the cathode of V1 which results in a substantially constant output voltage. If the voltage at the cathode of V1 tends to decrease, the plate resistance of V1 decreases, holding the voltage at the cathode of V1 substantially constant.

4-7. The chassis Helix control (R25) adjusts the level of the regulated dc output to compensate for the variations in twt characteristics. The switch, S2, and the associated voltage dividers permit the use of the same power supply with two twt types and allows the operator to use the same instrument as a 492A (4-8 gc) or as a 494A (7-12.4 gc) by changing the twt. Changing the tube type is no more difficult than replacing the twt with another tube of the same type (see para. 5-17).

4-8. The bias voltage for the twt is supplied by V3 and controlled by the GRID BIAS control on the front panel. The grid of the twt is grounded through a 3900-ohm resistor, and the voltage on the cathode is varied. The circuit is arranged so that all the twt electrode voltages except the control grid vary as the cathode voltage is varied and therefore remain constant with respect to the twt cathode. If the grid were not grounded, but connected to a source of variable negative voltage a blocking capacitor would be required which would impair the response of the twt to low-frequency modulating signals. A pin jack on the front panel allows the bias voltage to be measured; an external voltmeter having 20,000 ohm/volt sensitivity or higher should be used.

4-9. The anode voltage is controlled by a potentiometer on the chassis of the instrument and is adjusted to obtain normal cathode current for the twt amplifier; see paragraph 5-26. The front panel HELIX control adjusts the helix voltage of the twt to obtain either maximum gain and power at a particular frequency or optimum broadband response.

4-10. TRAVELING WAVE TUBE.

4-11. The basic traveling wave tube consists of an electron gun which projects a focused electron beam through a helically-wound coil to a collector electrode, shown in figure 4-3. The focused electrons are held in a pin-like beam through the center of the helix by a powerful magnet around the full length of the capsule.

4-12. A cw signal coupled into the input end of the helix travels around the turns of the helix and thus has its linear velocity reduced by the amount equal to the ratio of the length of wire in the helix to the axial length of the helix. 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 cw signal. The electric field of the cw signal on the helix interacts with the electric field created by the electron beam and increases the amplitude of the signal on the helix, thus producing the desired amplification.

4-13. Figure 4-2 is a diagram showing the principal elements of a typical traveling wave tube in the upper portion and the important steps in the amplification process in the lower portion. The steps should be followed by referring to the numbered captions below.

(1) An electron beam is directed through the center of the helix.

(2) A cw signal is coupled into the helix. Arrows in the detail show the direction and magnitude of force exerted on the electron beam by the cw signal.

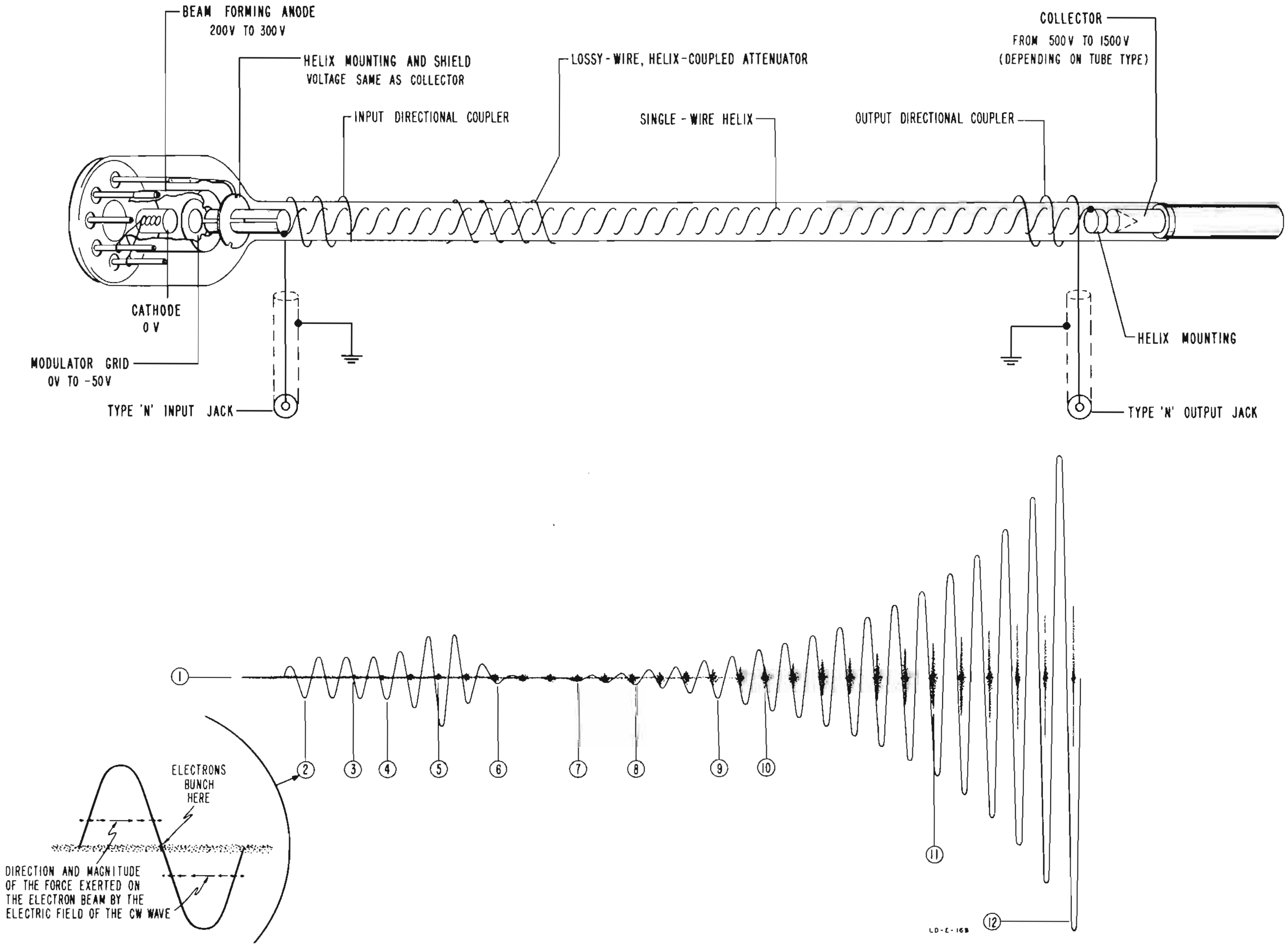


Figure 4-2. Traveling Wave Tube and How It Works

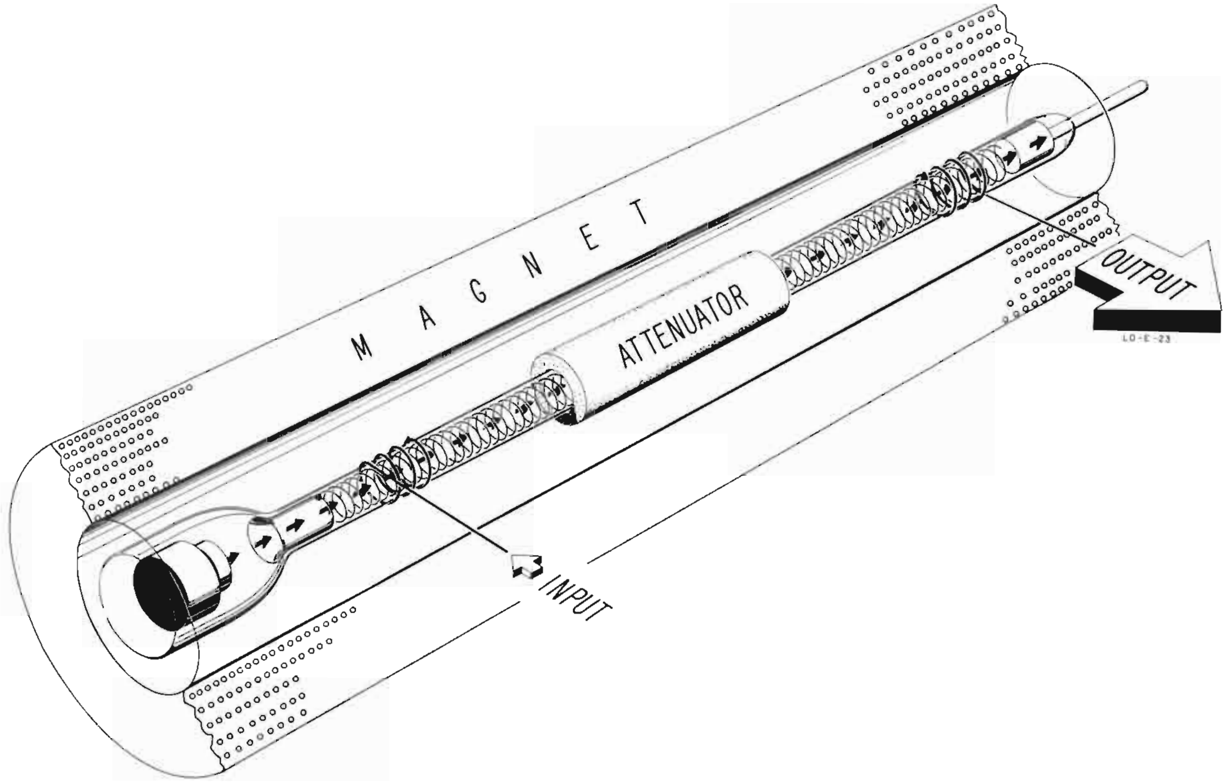


Figure 4-3. Cutaway View of a Traveling Wave Tube Capsule and Magnet Showing the Important Elements

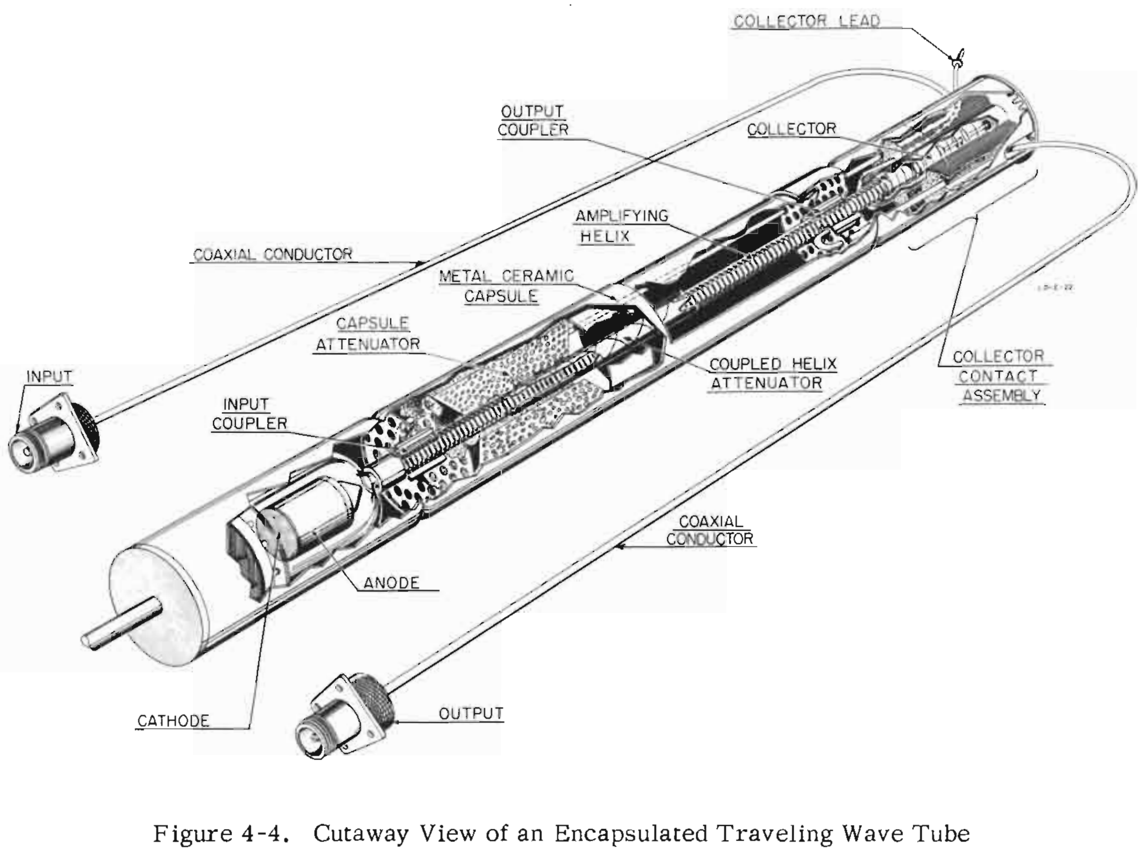


Figure 4-4. Cutaway View of an Encapsulated Traveling Wave Tube

(3) Electron bunching caused by the electric field of the cw signal (see detail).

(4) Amplification of the signal on the helix begins as the field formed by the electron bunches interacts with the electric field of the cw signal. The newly formed electron bunch adds a small amount of voltage to the cw signal on the helix. The slightly amplified cw signal then produces a denser electron bunch which in turn adds a still greater voltage to the cw 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 cw signal. The additive effect of the two fields exactly in phase produces the greatest resultant amplification.

(6) Attenuators placed near the beginning of the helix reduce all the waves traveling along the helix near to zero. This attenuator prevents regeneration and possible oscillation due to undesired backward waves, such as reflected waves from mismatched loads.

(7) The electron bunches travel through the attenuator unaffected.

(8) The electron bunches emerging from attenuator induce a new cw signal on the helix. The new cw signal is the same frequency as the original cw signal applied.

(9) The field of the newly induced cw signal interacts with the 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 cw signal on the helix.

(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 cw signal.

(12) At the point of the desired amplification the amplified cw signal is coupled out of the helix. Note that the "amplified" cw signal is a new signal whose energy is wholly supplied by the bunched electron beam.

4-14. The traveling wave tube is completely enclosed in the capsule shown in figure 4-4. The capsule supports and shields the tube and rigidly mounts the capsule attenuator and the input-output couplers, cables and connectors. The capsule attenuator prevents energy from being propagated down the capsule in a coaxial mode using the helix as a center conductor and the shield as the outer conductor. The front-panel INPUT connector connects through a coaxial cable to the helically-wound directional coupler at the gun end of the helix; the OUTPUT connector connects through a similar cable to an identical coupler at the collector end of the helix. Impedance matching over the extremely wide frequency range of the twt, is obtained by cavity-coupling. For an explanation of cavity-coupling refer to "The Use of Quasi-Static Mode Approximations in the Design of Slow Wave Structure Impedance Matches" by Wayne E. Raub, dated August 1961. Manual number 27-3. Reprints available from Microwave Electronics Laboratory, 4061 Transport Street, Palo Alto, California.

4-15. GRID MODULATION.

4-16. The signal being amplified in the traveling wave tube is amplitude-modulated by applying the modulating signal between the cathode and first grid. Making the potential on the grid more positive increases the current passing through the center of the helix without changing the velocity and results in greater density of the electron bunches which in turn contribute more energy to the rf wave being amplified on the helix, and correspondingly increases the level of the output signal. Conversely, making the grid more negative decreases the rf output.

4-17. HELIX MODULATION.

4-18. The Helix Modulator, V5A, is a cathode follower connected between the regulated voltage and the helix. The front panel HELIX control varies the bias on V5A, and hence the voltage applied to the helix. When the twt amplifier is helix-modulated, the modulating signal is connected to the grid of the helix modulator from the front panel BNC connector labeled HELIX MOD.

4-19. The rf signal on the helix is phase-modulated by superimposing the modulating signal on the normal dc helix voltage. Changing the helix voltage changes the velocity of the electrons in the beam through the helix without changing beam density. A negative voltage slows the beam down and retards the phase of the output signal; a positive voltage speeds up the beam and advances the phase. Since the final signal taken from the helix is the result of electron bunching in the beam, altering the velocity of beam alters the relative position of the bunches and results in a phase shift between the input and output signals.

4-20. Since the amount of energy transferred from the electron beam to the wave on the helix is in part a function of the phase difference between the fields of the helix and the electron bunches, altering the electron velocity has some effect upon the energy given to the signal on the helix resulting in some incidental amplitude modulation. Special tubes are available which sacrifice gain to minimize this incidental amplitude modulation, see paragraph 5-14.

4-21. A certain amount of stray and wiring capacity exists between the helix of the twt and chassis which must be charged and discharged as the helix is modulated. When the helix modulating signal goes positive this capacity can be charged very rapidly through the low impedance of the helix modulator tube, V5A, and the power supply. However, if the modulating signal were a fast negative-going signal, V5A could be cut off and the stray capacity would discharge through the insulation (leakage) resistance which exists between the helix and the chassis. This is a relatively long time constant circuit. The discharge tube, V5B, is connected between the helix of the twt and chassis to form a low-impedance and therefore a rapid-discharge circuit for this capacity. A negative-going modulating signal applied to the HELIX MOD. is coupled to the helix through the cathode follower, V5A, and simultaneously inverted by V5A and applied to the grid of V5B. The stray capacity is thus able to discharge rapidly through V5B, allowing a rapid decay time when fast pulses are applied to the HELIX MOD. jack.

4-22. CONSTANT-AMPLITUDE, LINEAR SAWTOOTH GENERATOR.

4-23. To shift the phase or frequency of the rf signal in a traveling wave tube amplifier, a sawtooth such as is used in oscilloscope sweep circuits can be applied to the traveling wave tube helix. If the rf output signal is to be a nearly pure offset frequency and contain a minimum of spurious components, the sawtooth waveform applied to the helix must be constant in amplitude, must be linear, must not contain noise or ripple and must have a fast flyback time. In addition to frequency-modulate an rf signal, the sawtooth amplitude and the sawtooth repetition rate must be completely independent and separately adjustable and the repetition rate should be adjustable over a wide range. To frequency-modulate an rf signal with a traveling wave tube amplifier it is necessary to modulate the slope or repetition rate of the sawtooth wave without affecting the sawtooth amplitude.

4-24. A sawtooth generator having these characteristics is shown in simplified form in figure 4-5. This generator consists of an adjustable, regulated power supply, a charging capacitor, a blocking oscillator to charge the capacitor, a pentode tube to discharge the capacitor, and a cathode follower to isolate the generator from the output.

4-25. The broken line in figure 4-5 indicates the capacitor-charging circuit, the solid line the discharge circuit. When power is applied to the generator, the grid bias on the blocking oscillator tube is zero and the oscillator goes through one cycle of operation. During the oscillation cycle, the tube conducts heavily and rapidly charges the capacitor to the B+ voltage,

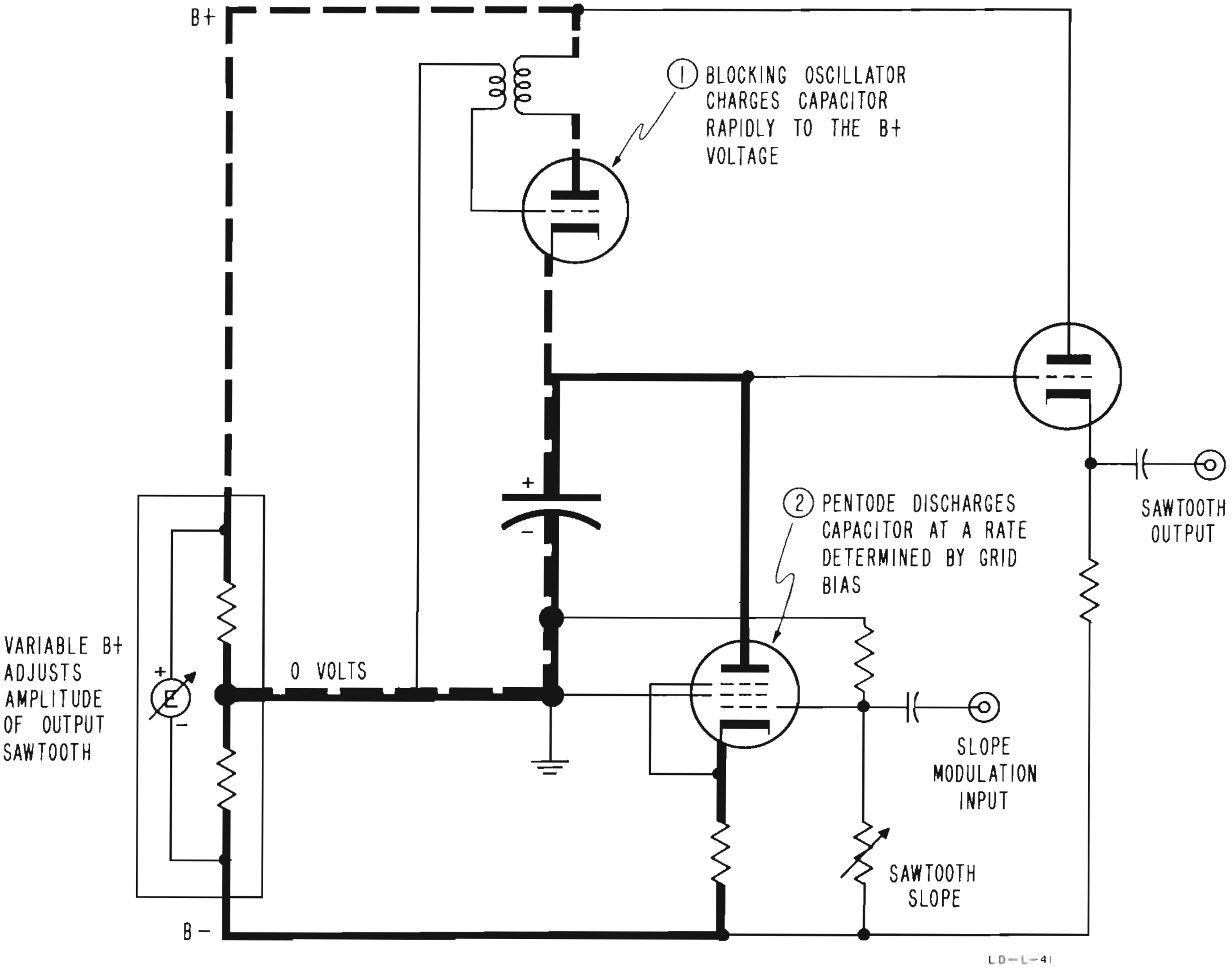


Figure 4-5. Simplified Circuit of a Constant Amplitude, Variable Slope Sawtooth Generator

producing a rapid flyback. The charge on the capacitor biases the blocking oscillator tube beyond cutoff and prevents further operation until the charge is removed.

4-26. The instant the blocking oscillator is biased to cutoff, the capacitor begins to discharge through the pentode tube at a rate determined by the grid bias. The capacitor is discharged at a linear rate due to the constant current characteristic of the pentode and thus produces an output voltage with a linear slope. As the capacitor is discharged, the grid bias on the blocking oscillator returns toward cutoff and at some value the tube conducts sufficiently to start the blocking oscillator on another cycle of operation, thus again recharging the capacitor.

4-27. The amplitude of the output sawtooth waveform is adjusted by changing the regulated B+ to vary the charge placed on the capacitor. The repetition rate or slope is adjusted by changing the pentode grid bias to control the rate at which the capacitor is discharged. Modulating signals applied to the control grid of the pentode modify the nominal grid bias level and change the capacitor's discharge rate, and in turn, the sawtooth slope and repetition rate.

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section provides maintenance and service information for Models 492A and 494A Traveling Wave Tube Amplifiers. The section includes replacement procedures for tubes, recommended test equipment, adjustment procedures, and troubleshooting. This section also includes performance checks which verify proper instrument operation.

5-3. CLEANING THE AIR FILTER.

5-4. Inspect the air filter regularly, and clean it before it becomes dirty enough to restrict air flow.

a. Remove filter from instrument rear, and wash it in warm water and detergent.

b. Dry filter thoroughly and coat it with filter adhesive. We recommend Filter Coat No. 3 from Research Products Company, Inc. This adhesive comes in "Handi-Koter" sprayer cans and is available from most heating supply stores or from your authorized Hewlett-Packard sales representative.

5-5. TEST EQUIPMENT.

5-6. Test equipment recommended for use in maintaining and checking performance of the Models 492A and 494A is listed in table 5-1. Equipment having similar characteristics can be substituted for the equipment listed.

Table 5-1. Recommended Test Equipment

Instrument Type	Required Characteristics	Use	Model
AC Voltmeter	Voltage Range: 1.0 mv to 1 volt Voltage Accuracy: 2% Input Impedance: 10 megohoms	Power supply ripple Spurious modulation check	hp Model 400D
DC Voltmeter/ Ohmmeter	Voltage Range: to 1000 volts Voltage Accuracy: 3% Imput Impedance: 100 megohms	Power supply measurements	hp Model 410B
Crystal Detector	Frequency Range: to 12.4 gc Sensitivity: approximately 0.1 V/mw	Spurious modulation check	hp Model 420A
Power Meter	Power Range: up to 10 mw Scale must read in dbm and milliwatts	Gain check Power check Noise figure check	hp Model 430C
DC Voltage Divider	Division ratio: 100:1 or 3:1 Input Impedance: 12,000 megohms Maximum Voltage: 2000 volts	Power supply measurements	hp Model 459A
Thermistor Mount	Power Range: to 10 mw Frequency Range: to 10 gc	Gain check Power check Noise figure check	hp Model 477B
Signal Generator	Frequency Range: 4 to 12.4 gc Output Amplitude: at least 1 mw	Power source for performance checks	hp Models 618B 620A, 626A
Waveguide Coax Adapter	SWR less than 1.25	With all checks at 10 gc and above	hp Model X281A
Waveguide Thermistor Mount	Power Range: to 10 mw Frequency Range: to 12.4 gc	Gain check Power check	hp Model X487B
Attenuator	10 db power attenuation	Power check	Weinschel 210-10

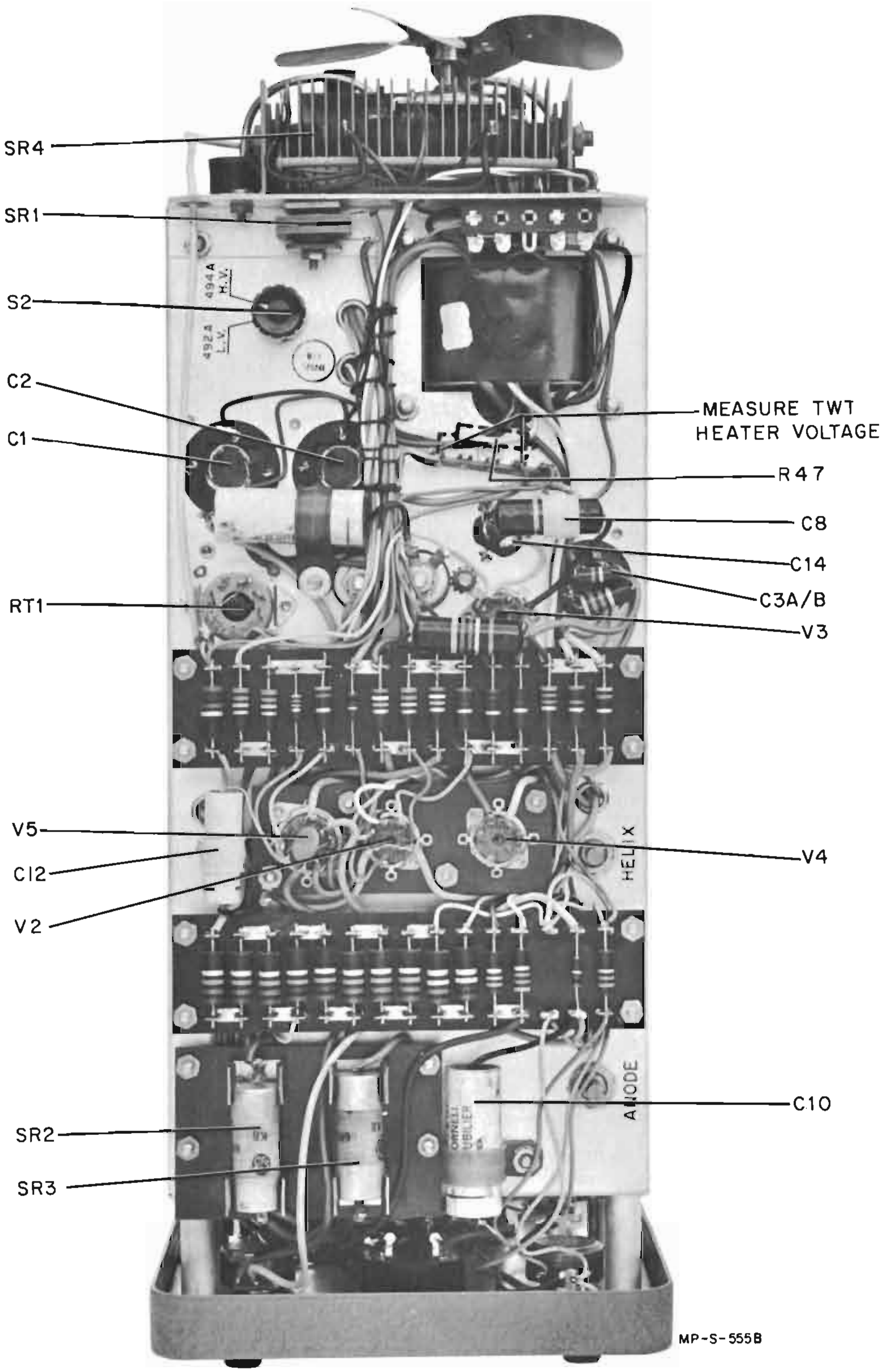


Figure 5-1. Top View of Models 492A and 494A

5-7. REPAIR.

5-8. CABINET REMOVAL.

5-9. To remove the instrument chassis from the cabinet proceed as follows:

a. Place the twt panel down on a soft pad.

b. Remove the two 10-32 round head machine screws which secure the rear of the cabinet to the instrument chassis.

c. Lift the cabinet up and off the chassis. The panel bezel remains attached to the panel.

5-10. TUBE REPLACEMENT.

5-11. A list of tubes in the 492A and 494A and the checks and adjustments that must be made following replacement, are in table 5-2.

Table 5-2. Tube Replacement List

Tube Type	Function	Adjustment
V1	Series Regulator	Check voltage range of HELIX control (see schematic) Adj. R25 if necessary see paragraph 5-24.
V2	Control Tube	Same as V1.
V3	Bias Regulator	Check range of GRID BIAS control.
V4	Reference Tube	Same as V1.
V5A, B	a. Helix Modulator b. Discharge Tube	Same as V1.
V6	Traveling Wave Tube	See para. 5-12.

5-12. TRAVELING WAVE TUBE CAPSULE REPLACEMENT.

5-13. Because the traveling wave tube is fragile and adjustment of the coupling helices is critical, replacement tubes are furnished in the complete capsule assembly which includes the tube, coupling helices, coaxial cables, and panel connectors complete in a single unit. Refer to the "Conditions of Warranty" page in the manual.

5-14. Special traveling wave tubes in which gain has been sacrificed to obtain a more constant output over the full frequency range and a very low value of incidental amplitude modulation during phase modulation are available on special order.

5-15. REMOVAL. To remove the encapsulated traveling wave tube from the 492A or 494A proceed as follows:

a. Remove the instrument from the cabinet. (See paragraph 5-8.)

b. Disconnect the twt collector lead connector at the rear of the capsule, shown in figure 5-3.

c. Remove the screws mounting the INPUT and OUTPUT connectors to the panel.

d. Loosen all the capsule alignment screws. The front alignment screws are shown in figure 5-2 and the rear alignment screws are shown in figure 5-3.

e. Remove twt plug from socket. This plug is located on bottom of instrument. Refer to figure 5-2. Grasp the rear of the capsule and carefully pull it out of the magnet.

5-16. INSTALLATION AND ALIGNMENT. To install and align a traveling wave tube capsule proceed as follows:

a. Hold the twt capsule so the recessed hole in collar is turned upward; insert the capsule into the magnet and be sure the spring-loaded ball (bullet catch) seats into the recessed hole.

b. Plug the collector lead into its connector as shown in figure 5-3.

c. Reconnect twt plug to socket as shown in figure 5-2.

d. Turn the GRID BIAS control completely clockwise for the most negative bias voltage (cathode positive); turn the power ON. If necessary adjust R47 to obtain correct heater voltage. Refer to twt data sheet (supplied with new tubes) and figure 5-1.

e. The alignment screws determine the position of the capsule in the magnet. When the capsule is correctly positioned the helix current will be minimum (near zero). Therefore the relative level of the current flowing in the helix is an indication of correct capsule positioning.

f. Set meter switch to HELIX. If the meter indication is near zero, there is insufficient current flow to check the alignment. Reduce the grid bias voltage until the meter indicates some small readable helix current; at the same time be sure that the cathode current is below its safe maximum for continuous operation after warmup, see table 3-1.

g. Adjust the alignment screws to the setting which minimizes the helix current.

h. Reduce the cathode current with the anode control and turn the GRID BIAS control to 0, then adjust the anode control to obtain the normal cathode current (see the meter plate that came with the new tube).

i. Readjust the alignment screws; note the electrode currents. If any currents are abnormal see paragraph 5-30.

j. Lock the alignment screws, at the same time watching the meter to see that the helix current does not increase. Note the meter reading.

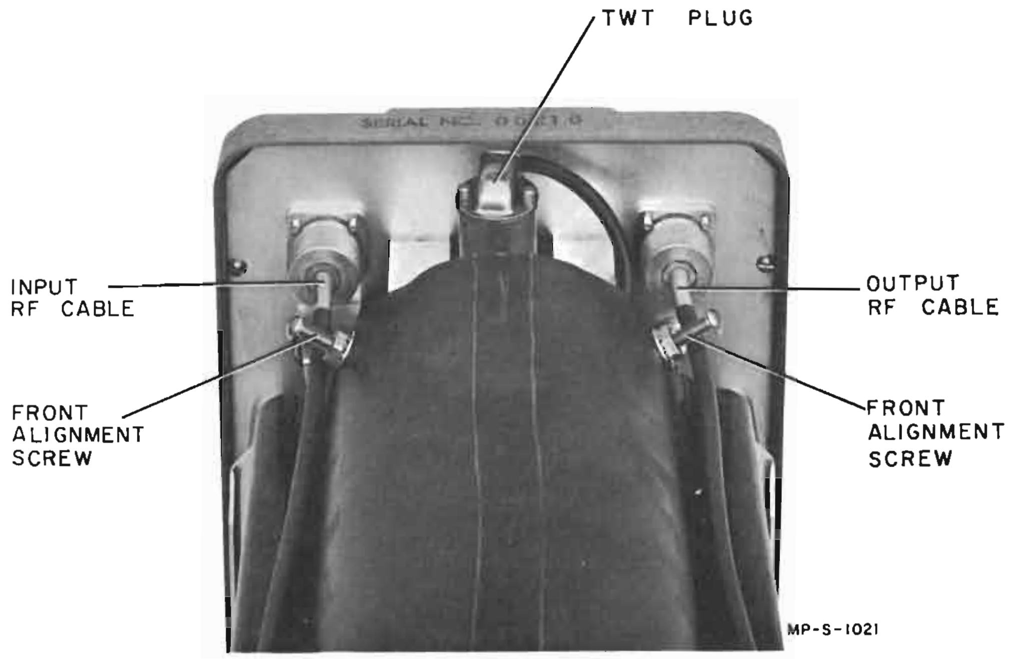


Figure 5-2. Bottom View Looking Towards the Front Panel of Models 492A and 494A

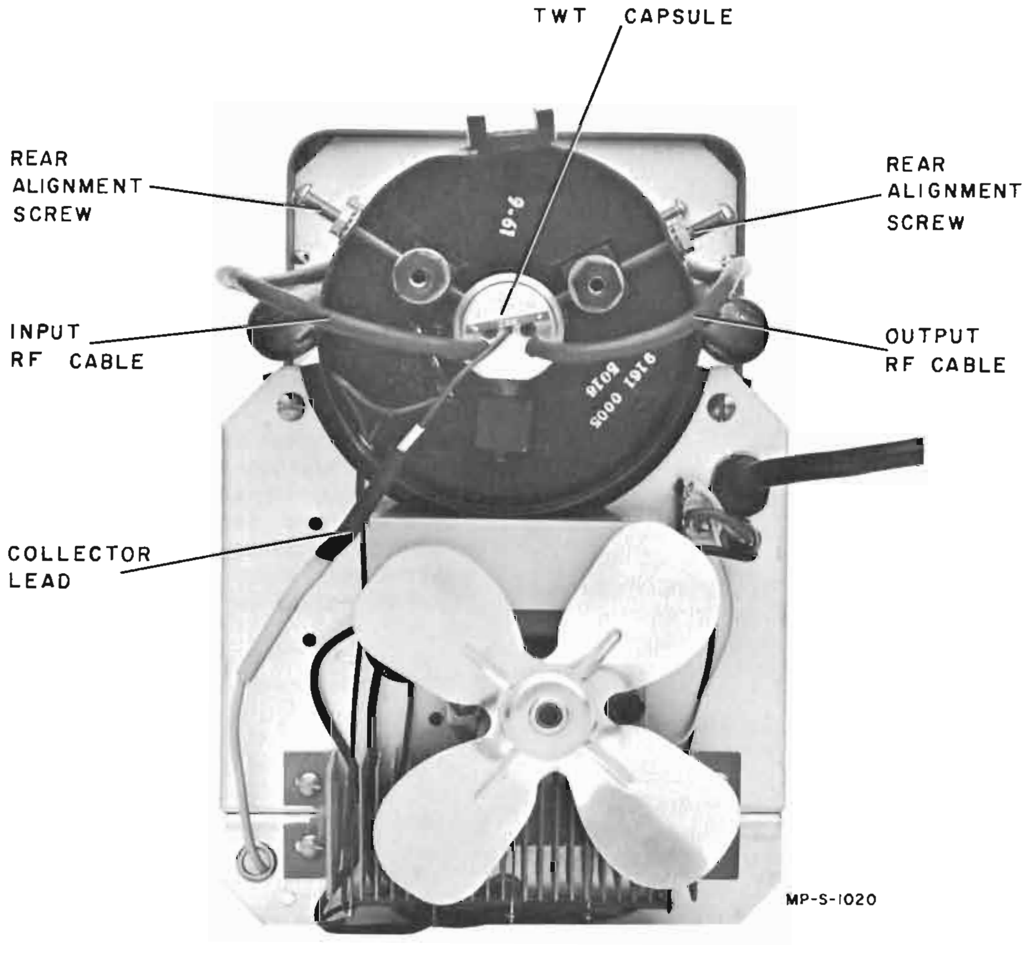


Figure 5-3. Rear View of Models 492A and 494A

k. Remove the meter plate which indicates the normal cathode current for the old tube and install the new plate.

m. Perform the chassis Helix control adjustment, see paragraph 5-24.

n. Turn the power off and install the cabinet.

p. Set the meter switch to HELIX and turn the power ON. The meter reading should be the same as in step j; if not, the setting of the capsule was disturbed when the cabinet was replaced. Turn off the power, remove the cabinet, and reposition the capsule as before, starting with step f. Replace cabinet; again measure the cathode and helix currents, which should be the same as with cabinet removed.

5-17. CHANGING THE FREQUENCY RANGE OF THE 492A OR 494A.

5-18. The ⓗⓟ Models 492A and 494A are identical except for the traveling wave tube type supplied and the operating voltage adjustments. The proper range of dc operating voltages for one tube type or the other is selected by S2 on the instrument chassis (figure 5-1).

5-19. To change a 492A to a 494A proceed as follows:

a. Remove the cabinet; see paragraph 5-8.

b. Remove the twt capsule; see paragraph 5-15.

c. Turn S2 to the 494A position; see figure 5-1.

d. Install the type M2201-K (HP1952-0009) installation procedure is the same as type M2207-A except S2 should be in 494A position. (See paragraph 5-16.)

5-20. To change a 494A to a 492A proceed as follows:

a. Remove the cabinet; see paragraph 5-8.

b. Remove the twt capsule; see paragraph 5-15.

c. Turn S2 to the 492A position, see figure 5-1.

d. Install the type M2207-A (HP1952-0012) installation procedure is the same as type M2201-K, except S2 should be in 492A position. (See paragraph 5-16.)

5-21. ADJUSTMENTS.

5-22. EXCESSIVE HELIX CURRENT.

5-23. If excessive helix current is indicated on the front panel meter with normal currents in the other twt electrodes, the electron beam is not being focused accurately through the center of the helix. Measure the dc voltage and current supplied to the magnet at 115 volt line, which should be approximately 120 volts at 700 ma. The ac ripple on the magnet supply should be less than 1 volt rms. If these measurements do not reveal the cause of the trouble, check the alignment of the twt in the magnet. See paragraph 5-16.

5-24. CHASSIS HELIX CONTROL.

5-25. The chassis Helix control, R25, determines the range of the front panel HELIX control by governing the output voltage of the regulated power supply. This adjustment should be performed whenever a new twt capsule is installed or the gain of the amplifier is less than 30 db. To adjust, proceed as follows:

a. Remove the cabinet, see paragraph 5-8.

b. Set twt HELIX control to position 5, and adjust GRID BIAS control to obtain normal cathode current.

c. Connect a test setup as shown in figure 5-4.

d. Set the generator for the Model 492A to 4 gc, for the Model 494A to 7 gc. For both models set the generator attenuator to -30 dbm, in cw operation.

e. Adjust the chassis Helix control, R25, for maximum gain, as read on the 430C.

f. Change the frequency of the generator, for the Model 492A to 8 gc, for the Model 494A to 12.4 gc, maintaining the same power level.

g. The 430C should read greater than 0 dbm. If the 430C doesn't read greater than 0 dbm, readjust the chassis Helix control, R25, to obtain from 0 dbm to +2 dbm. Recheck the gain for the Model 492A at 4 gc, for the Model 494A at 7 gc, and readjust R25, if necessary, to obtain nearly equal gain at both frequencies.

5-26. ANODE VOLTAGE CONTROL.

5-27. The Anode control, R30, on the chassis of the instrument, (see figure 5-1), is provided so that the two cathode current can be maintained at its normal level (as indicated on the plate attached to the meter face) as the tube ages. To adjust proceed as follows:

a. Place meter selector switch to CATH. position and GRID BIAS control to 0.

b. Rotate Anode control adjust, R30, to obtain normal cathode current. Also note that other tube-element currents do not exceed their safe maximum limits (see table 3-1).

5-28. REGULATED POWER SUPPLY.

5-29. To check the regulated power supply, proceed as follows:

a. Set GRID BIAS control to 0.

b. Connect a dc voltmeter to the output of the power supply, at pin 3 of V1.

c. Adjust the line voltage from low to high line (103 - 127 volts). Power supply voltage should not change more than 10 volts.

d. Connect an ac voltmeter to the output of the power supply, at pin 3 of V1.

e. Adjust the line voltage from low to high line (103 - 127 volts). Ripple voltage should not be greater than 7 mv.

5-30. TROUBLESHOOTING.

5-31. If the twt amplifier is suspected of unsatisfactory operation, proceed as follows:

a. Remove all the external connections to the instrument and set GRID BIAS to zero.

b. Measure the electrode currents of the twt using the front panel meter.

c. If the electrode currents are abnormal, remove the instrument from the cabinet (see paragraph 5-8) and with the indication observed, determine the possible cause and action from table 5-3.

Table 5-3. Troubleshooting Chart

Indication	Possible Cause	Action	Check
Cathode current low	Regulated voltage low	Replace V1 Check regulation	Table 5-2 Para. 5-28
	Low or no helix voltage	Replace V5	Table 5-2
	Low anode voltage	Adjust anode voltage	Para. 5-26
	Low twt emission	Replace capsule	Para. 5-12
Cathode current high	High anode voltage	Adjust anode voltage	Para. 5-26
	Gassy twt	Replace capsule	Para. 5-12
Anode current high	Low helix voltage	Adjust chassis helix voltage Replace V5	Para. 5-24 Table 5-2
	Gassy twt	Replace capsule	Para. 5-12
	High anode voltage	Adjust anode voltage	Para. 5-26
Helix current high Collector current low	Misalignment of the twt	Align capsule	Para. 5-16
	Low, or no twt magnet current (low field).	Replace F2 (if fan does not turn) Replace defective magnet power supply components.	
		No voltage on collector (disconnected at connector), Fig. 5-3	
No or little control of Cathode current with GRID BIAS control.	High impedance path between the anode and grid. May be 40 megohms or more.	Replace capsule	Para. 5-12
Low gain.	Misadjustment of anode voltage. The anode may have been adjusted to obtain the correct cathode current with some grid bias on the tube.	Adjust anode voltage	Para. 5-26
	Wrong value of helix voltage	Adjust chassis helix voltage	Para. 5-24
	Low cathode current	See cathode current low (in indication column)	
Oscillation	Defective Helical Attenuator	Replace capsule	Para. 5-12
	Excessive cathode current	See cathode current high (in indication column)	

5-32. PERFORMANCE CHECKS.

5-33. GAIN CHECK.

5-34. For Model 492A proceed as follows:

a. Set the twt HELIX control to position 5, and position the GRID BIAS control to full counterclockwise.

b. Connect test set up as shown in figure 5-4.

c. Set the generator attenuator to -30 dbm, with a frequency output of 4 gc, in cw operation.

d. The 430C should read greater than 0 dbm.

e. Change the frequency of the generator to 8 gc, maintaining the same power level.

f. The 430C should read greater than 0 dbm.

5-35. For Model 494A proceed as for Model 492A, except, generator to be used in figure 5-4 to have a frequency range from 7 to 12.4 gc, and the test should be made at these frequencies.

5-36. OUTPUT POWER CHECK.

5-37. For Model 492A proceed as follows:

a. Connect test set up as shown in figure 5-4 and insert a 10 db attenuator between the twt amplifier and the 477B Thermistor Mount.

b. Set the 430C to the 3 mw range.

c. Set the generator to a frequency output of 4 gc, in cw operation.

d. Set the two HELIX control to position 5, and position the GRID BIAS control to full counterclockwise.

e. Adjust the output power of the generator until the 430C reads 2 milliwatts.

f. Repeat steps c through e throughout the frequency band of the twt amplifier, up to 8 gc.

5-38. For Model 494A as for Model 492A, except, generator to be used in figure 5-4 to have a frequency range from 7 to 12.4 gc, and the test should start at 7 gc and end at 12.4 gc.

5-39. NOISE FIGURE CHECK.

5-40. For Model 492A proceed as follows:

a. Connect test set up as shown in figure 5-4.

b. Set generator to 6 gc, in cw operation.

c. With generator output power turned off, adjust the twt HELIX control for a maximum dbm indication on the 430C. Record this reading.

d. With generator output power turned on, adjust the generator attenuator to obtain a reading on the 430C that is 3 db greater than that recorded in step c.

e. Record the reading on the generator attenuator dial.

f. Take the reading obtained in step e and subtract it from -78 dbm, for the Model 492A. The result is the noise figure for this 492A.

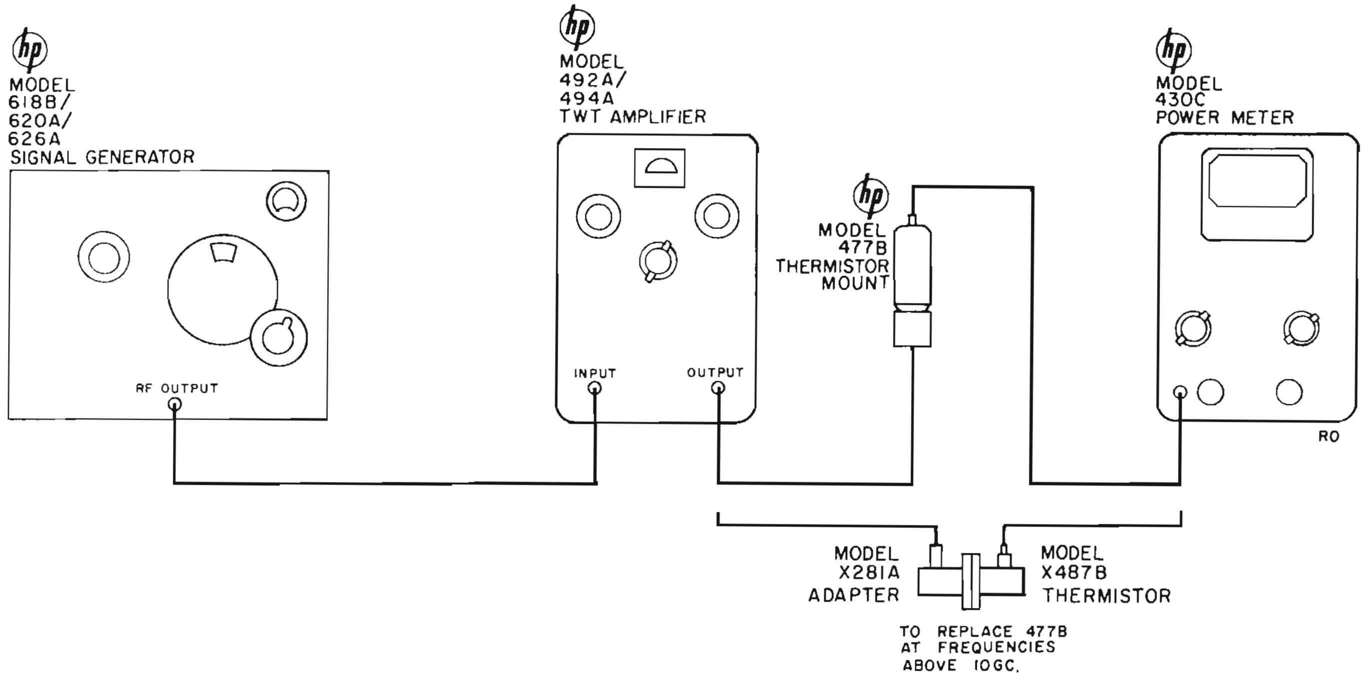


Figure 5-4. Test Setup for Gain, Output Power, and Noise Figure Performance Checks

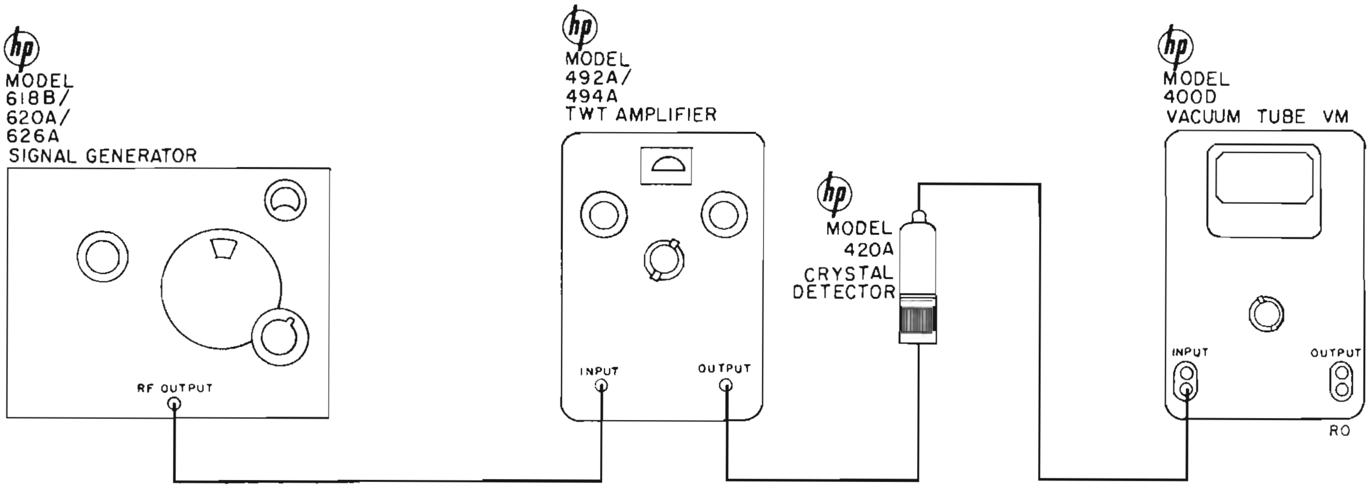


Figure 5-5. Test Setup for Hum and Spurious Modulation Performance Check

5-41. For Model 494A proceed as for Model 492A, except, the generator to be used in figure 5-4 is to be set at a frequency of 9.7 gc. The value from which the attenuator dial reading is to be subtracted, is -76.7 dbm for the Model 494A.

5-42. HUM AND SPURIOUS MODULATION CHECK.

5-43. For Model 492A proceed as follows:

a. Connect test setup as shown in figure 5-5.

b. Set the generator to 8 gc and to square wave modulation, 1000 pps.

c. Set the twt HELIX control to position 5, and position the GRID BIAS control to full counterclockwise.

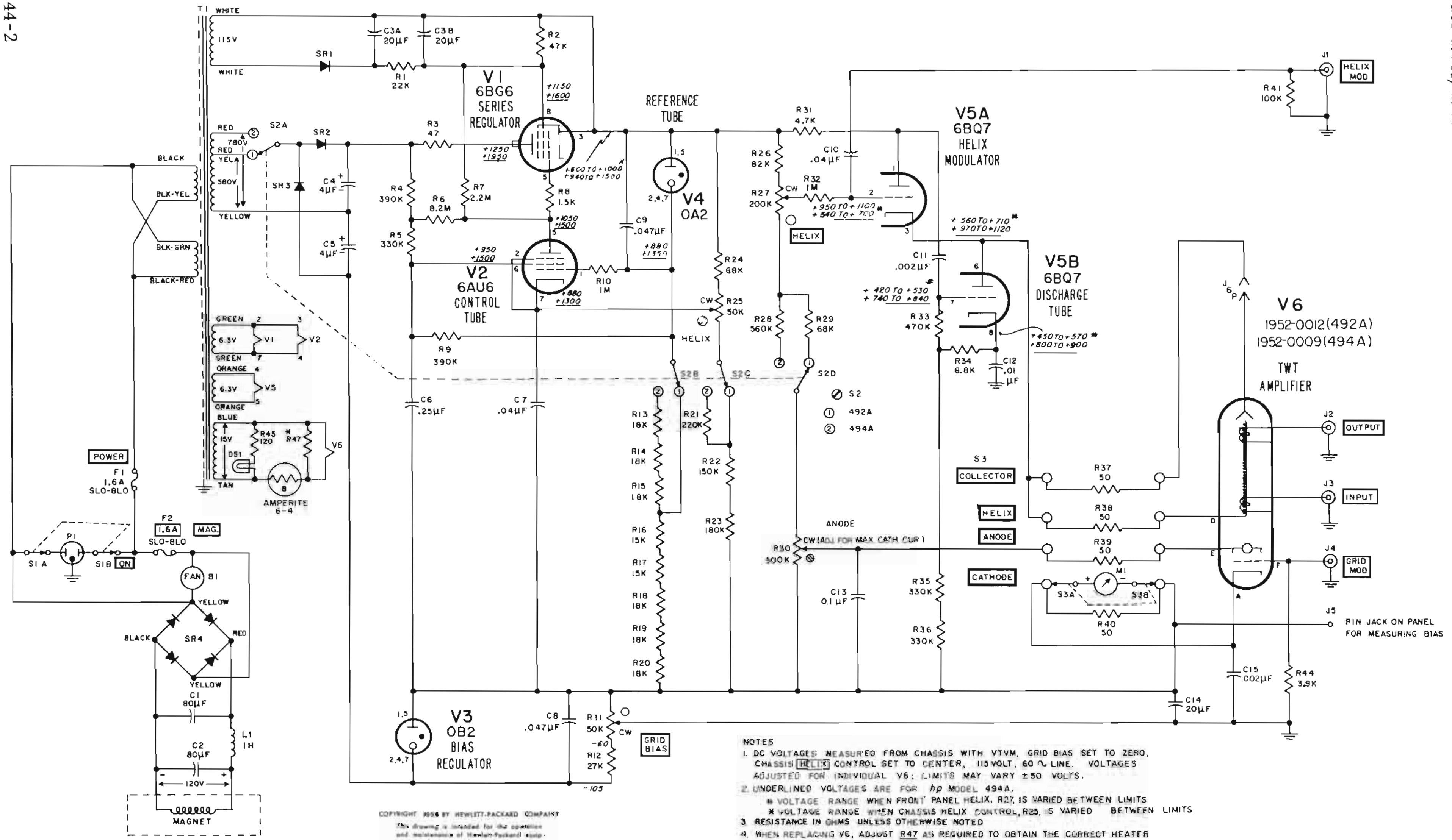
d. Adjust the generator attenuator until the output is indicated as a -20 db on the 400D.

e. Switch the generator to cw operation.

f. Record the reading on the 400D.

g. Take the difference, in db's, in the readings in steps d and f and add to it 8 db. The sum of these two numbers should be greater than 45 db.

5-44. For Model 494A proceed as for Model 492A, except, the generator to be used in figure 5-5 is to be set at a frequency of 12.4 gc.



NOTES
1. DC VOLTAGES MEASURED FROM CHASSIS WITH VTVM, GRID BIAS SET TO ZERO, CHASSIS **HELIX** CONTROL SET TO CENTER, 115 VOLT, 60 ∿ LINE. VOLTAGES ADJUSTED FOR INDIVIDUAL V6; LIMITS MAY VARY ±50 VOLTS.
2. UNDERLINED VOLTAGES ARE FOR *hp* MODEL 494A.
   - ✱ VOLTAGE RANGE WHEN FRONT PANEL HELIX, R27, IS VARIED BETWEEN LIMITS
   - ✱ VOLTAGE RANGE WHEN CHASSIS HELIX CONTROL, R25, IS VARIED BETWEEN LIMITS
3. RESISTANCE IN OHMS UNLESS OTHERWISE NOTED
4. WHEN REPLACING V6, ADJUST R47 AS REQUIRED TO OBTAIN THE CORRECT HEATER VOLTAGE FOR V6.
5. HEAVY BOX INDICATES FRONT PANEL ENGRAVING.

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This drawing is intended for the operation and maintenance of Hewlett-Packard equipment and is not to be used otherwise or reproduced without written consent of the Hewlett-Packard Company. 492A-TWTA-1-[illegible]

Figure 5-6. Models 492A and 494A Traveling-Wave Amplifiers

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts. Table 6-1 lists parts in alpha-numerical order of their reference designators and indicates the description and hp stock number of each part, together with any applicable notes. Table 6-2 lists parts in alpha-numerical order of their hp stock numbers and provides the following information on each part:

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

b. Manufacturer of the part in a five-digit code; see list of manufacturers in appendix.

c. Typical manufacturer's stock number.

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

e. Recommended spare part quantity for complete maintenance during one year of isolated service (RS column).

6-3. Miscellaneous parts not indexed in table 6-1 are listed at the end of table 6-2.

6-4. ORDERING INFORMATION.

6-5. To order a replacement part, address order or inquiry either to your authorized Hewlett-Packard sales representative or to

CUSTOMER SERVICE
Hewlett-Packard Company
395 Page Mill Road
Palo Alto, California

or, in Western Europe, to

Hewlett-Packard S.A.
Rue du Vieux Billard No. 1
Geneva, Switzerland.

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
B = motor
C = capacitor
CR = diode
DL = delay line
DS = device signaling (lamp)
E = misc electronic part

F = fuse
FL = filter
J = jack
K = relay
L = inductor
M = meter

P = plug
Q = transistor
R = resistor
RT = thermistor
S = switch
T = transformer

V = vacuum tube, neon bulb, photocell, etc.
W = cable
X = socket
XF = fuseholder
XV = tube socket
XDS = lampholder

ABBREVIATIONS

bp = bandpass
bwo = backward wave oscillator

c = carbon
cer = ceramic
cmo = cabinet mount only
coef = coefficient
com = common
comp = composition
conn = connection
crt = cathode-ray tube

dep = deposited
det = detector

EIA = Tubes and transistors selected for best performance will be supplied if ordered by hp stock numbers; tubes or transistors meeting Electronic Industries' Association standards will normally result in instrument operating within specifications

elect = electrolytic
encap = encapsulated

f = farads
fxd = fixed

Ge = germanium
grd = ground (ed)

h = henries
Hg = mercury

impg = impregnated
incd = incandescent
ins = insulation (ed)

K = kilo

lin = linear taper
log = logarithmic taper

m = milli = 10^{-3}
M = megohms
ma = milliamperes
minat = miniature
mfg = metal film on glass
mfr = manufacturer

mtg = mounting
my = mylar

NC = normally closed
Ne = neon
NO = normally open
NPO = negative positive zero-zero temperature coefficient
nsr = not separately replaceable

obd = order by description

p = peak
pc = printed circuit board
pf = picofarads = 10^{-12} farads
pp = peak-to-peak
piv = peak inverse voltage
pos = position(s)
poly = polystyrene
pot = potentiometer

rect = rectifier

rot = rotary
rms = root-mean-square
rmo = rack mount only

s-b = slow-blow
Se = selenium
sect = section(s)
Si = silicon
sl = slide

td = time delay
TiO_2 = titanium dioxide

tog = toggle
tol = tolerance
trim = trimmer
twt = traveling wave tube

var = variable
w/ = with
W = watts
ww = wirewound
w/o = without

* = optimum value selected at factory, average value shown (part may be omitted)

01194-2

Table 6-1. Reference Designation Index

Circuit Reference	ⓗⓟ Stock No.	Description[#]	Note
B1	3140-0010	Motor, AC	
B1A	3160-0014	Fan blade	
C1, 2	0180-0025	fxd, elect, 4 sect, 20 μf/sect, 450 vdcw	
C3AB	0180-0012	fxd, elect, 2 sect, 20 μf/sect, 450 vdcw	
C4, 5	0160-0082	fxd, paper, 4 μf ±10%, 1000 vdcw	
C6	0160-0097	fxd, paper, 0.25 μf ±10%, 2000 vdcw	
C7	0160-0037	fxd, paper, 0.04 μf ±20%, 1600 vdcw	
C8, 9	0160-0005	fxd, paper, 0.047 μf ±10%, 600 vdcw	
C10	0160-0037	fxd, paper, 0.04 μf ±20%, 1600 vdcw	
C11	0150-0023	fxd, cer, 0.002 μf ±20%, 1000 vdcw	
C12	0160-0040	fxd, paper, 0.01 μf ±10%, 1000 vdcw	
C13	0160-0001	fxd, paper, 0.1 μf ±10%, 600 vdcw	
C14	0180-0011	fxd, elect, 20 μf, 450 vdcw	
C15	490A-82	Cathode Bypass Assembly: 0.002 μf	
DS1	2140-0009	Lamp, incd: 6-8V, 0.15 amp, #47	
F1, 2	2110-0005	Fuse, cartridge: 1.6 amp s-b	
J1	1250-0083	Connector, BNC: female	
J2, 3		nsr; part of V6	
J4	1250-0083	Connector, BNC: female	
J5	1251-0073	Jack, telephone tip: for single conductor	
J6	1251-0027	Connector, female	
L1	9110-0019	Choke: 1 H	
M1	1120-0060	Meter: ammeter	
P1	8120-0015	Power cable	
P2 thru P5		Not Assigned	
R1	0690-2231	fxd, comp, 22K ohms ±10%, 1 W	
R2	0693-4731	fxd, comp, 47K ohms ±10%, 2 W	
R3	0690-4701	fxd, comp, 47 ohms ±10%, 1 W	
R4	0690-3941	fxd, comp, 390K ohms ±10%, 1 W	
R5	0690-3341	fxd, comp, 330K ohms ±10%, 1 W	
R6	0690-8251	fxd, comp, 8.2M ±10%, 1 W	
R7	0690-2251	fxd, comp, 2.2M ±10%, 1 W	
R8	0690-1521	fxd, comp, 1500 ohms ±10%, 1 W	
R9	0690-3941	fxd, comp, 390K ohms ±10%, 1 W	
R10	0687-1051	fxd, comp, 1M ±10%, 1/2 W	
R11	2100-0044	var, comp, lin, 50K ohms ±10%	
R12	0690-2731	fxd, comp, 27K ohms ±10%, 1 W	

See introduction to this section

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

Circuit Reference	ⓗⓟ Stock No.	Description#	Note
R13, 14, 15	0693-1831	fxd, comp, 18K ohms ±10%, 2 W	
R16, 17	0693-1531	fxd, comp, 15K ohms ±10%, 2 W	
R18, 19, 20	0693-1831	fxd, comp, 18K ohms ±10%, 2 W	
R21	0693-2241	fxd, comp, 220K ohms ±10%, 2 W	
R22	0693-1541	fxd, comp, 150K ohms ±10%, 2 W	
R23	0693-1841	fxd, comp, 180K ohms ±10%, 2 W	
R24	0690-6831	fxd, comp, 68K ohms ±10%, 1 W	
R25	2100-0044	var, comp, lin, 50K ohms ±10%	
R26	0690-8231	fxd, comp, 82K ohms ±10%, 1 W	
R27	2100-0133	var, comp, 200K ohms ±20%, 2 W	
R28	0690-5641	fxd, comp, 560K ohms ±10%, 1 W	
R29	0690-6831	fxd, comp, 68K ohms ±10%, 1 W	
R30	2100-0043	var, comp, lin, 500K ohms ±10%	
R31	0690-4721	fxd, comp, 4.7K ohms ±10%, 1 W	
R32	0687-1051	fxd, comp, 1M ±10%, 1/2 W	
R33	0687-4741	fxd, comp, 470K ohms ±10%, 1/2 W	
R34	0690-6821	fxd, comp, 6800 ohms ±10%, 1 W	
R35, 36	0690-3341	fxd, comp, 330K ohms ±10%, 1 W	
R37 thru R40	492A-26A	fxd, ww, 50 ohms	
R41	0690-1041	fxd, comp, 100K ohms ±10%, 1 W	
R42, 43		Not Assigned	
R44	0690-3921	fxd, comp, 3900 ohms ±10%, 1 W	
R45	0693-1211	fxd, comp, 120 ohms ±10%, 2 W	
R46		Not Assigned	
R47	0693-4701*	fxd, comp, 47 ohms ±5%, 2 W	
RT1	0852-0003	Ballast tube, Amperite type 6-4	
S1	3101-0003	Switch, tog: DPST	
S2	3100-0055	Switch, rot: 4 pole, 2 pos	
S3	3100-0099	Switch, rot: 1 sect, 4 pos	
SR1	1882-0007	Rectifier, metallic: 620 ma	
SR2, 3	1880-0007	Rectifier, metallic: 1430 V	
SR4	1880-0003	Rectifier, metallic: 130 V	
T1	9100-0109	Transformer, power	
V1	1923-0026	Tube, electron: 6BG6	
V2	1923-0021	Tube, electron: 6AU6	
V3	1940-0007	Tube, electron: OB2	
V4	1940-0004	Tube, electron: OA2	

See introduction to this section

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

Circuit Reference	ⓗ Stock No.	Description #	Note
V5	1932-0021	Tube, electron: 6BQ7A	
V6	1952-0012	encap TWT, (492A only) includes J2, 3	
	1952-0009	encap TWT, (494A only) includes J2, 3	
		MISCELLANEOUS	
	G-74D	Knob: METER SELECTOR switch	
	G-74N	Knob: CATH. COL.	
	1200-0009	Socket, tube: 7 pin	
	1200-0020	Socket, tube: octal	
	1251-0044	Connector: female and male contacts	
	1400-0084	Fuseholder	
	1401-0006	Clip, tube: plate and grid, cer, ins	
	1450-0027	Lamp holder, bayonet type	
	3150-0005	Filter, air: 6X6"	
	9161-0005	Solenoid Assembly	

See introduction to this section

Table 6-2. Replaceable Parts

Stock No.	Description#	Mfr.	Mfr. Part No.	TQ	RS		
490A-82	Cathode Bypass Assembly: 0.002 μf	28480	490A-82	1	1		
492A-26A	fxd, ww, 50 ohms	28480	492A-26A	4	1		
0150-0023	fxd, cer, 0.002 μf ±20%, 1000 vdcw	91418	JF.002	1	1		
0160-0001	fxd, paper, 0.1 μf ±10%, 600 vdcw	56289	160P10496	1	1		
0160-0005	fxd, paper, 0.047 μf ±10%, 600 vdcw	56289	160P47390	2	1		
0160-0037	fxd, paper, 0.04 μf ±20%, 1600 vdcw	14655	ST16S4-20	2	1		
0160-0040	fxd, paper, 0.01 μf ±10%, 1000 vdcw	14655	TST-100	1	1		
0160-0082	fxd, paper, 4 μf ±10%, 1000 vdcw	00656	JP09	2	1		
0160-0097	fxd, paper, 0.25 μf ±10%, 2000 vdcw	00656	2009	1	1		
0180-0011	fxd, elect, 20 μf, 450 vdcw	56289	D32550	1	1		
0180-0012	fxd, elect, 2 sect, 20 μf/sect, 450 vdcw	00853	LPI (obd)	1	1		
0180-0025	fxd, elect, 4 sect, 20 μf/sect, 450 vdcw	56289	D32452	2	1		
0687-1051	fxd, comp, 1M ±10%, 1/2 W	01121	EB-1051	2	1		
0687-4741	fxd, comp, 470K ohms ±10%, 1/2 W	01121	EB-4741	1	1		
0690-1041	fxd, comp, 100K ohms ±10%, 1 W	01121	GB-1041	1	1		
0690-1521	fxd, comp, 8.2M ±10%, 1 W	01121	GB-1521	1	1		
0690-2231	fxd, comp, 22K ohms ±10%, 1 W	01121	GB-2231	1	1		
0690-2251	fxd, comp, 2.2M ±10%, 1 W	01121	GB-2251	1	1		
0690-2731	fxd, comp, 27K ohms ±10%, 1 W	01121	GB-2731	1	1		
0690-3341	fxd, comp, 330K ohms ±10%, 1 W	01121	GB-3341	3	1		
0690-3921	fxd, comp, 3900 ohms ±10%, 1 W	01121	GB-3921	1	1		
0690-3941	fxd, comp, 390K ohms ±10%, 1 W	01121	GB-3941	2	1		
0690-4701	fxd, comp, 47 ohms ±10%, 1 W	01121	GB-4701	1	1		
0690-4721	fxd, comp, 4.7K ohms ±10%, 1 W	01121	GB-4721	1	1		
0690-5641	fxd, comp, 560K ohms ±10%, 1 W	01121	GB-5641	1	1		
0690-6821	fxd, comp, 6800 ohms ±10%, 1 W	01121	GB-6821	1	1		
0690-6831	fxd, comp, 68K ohms ± 10%, 1 W	01121	GB-6831	2	1		
0690-8231	fxd, comp, 82K ohms ±10%, 1 W	01121	GB-8231	1	1		
0690-8251	fxd, comp, 8.2M ±10%, 1 W	01121	GB-8251	1	1		
0693-1211	fxd, comp, 120 ohms ±10%, 2 W	01121	HB-1211	1	1		
0693-1531	fxd, comp, 15K ohms ±10%, 2 W	01121	HB-1531	2	1		
0693-1541	fxd, comp, 150K ohms ±10%, 2 W	01121	HB-1541	1	1		
0693-1831	fxd, comp, 18K ohms ±10%, 2 W	01121	HB-1831	6	2		
0693-1841	fxd, comp, 180K ohms ±10%, 2 W	01121	HB-1841	1	1		
0693-4701*	fxd, comp, 47 ohms ±5%, 2 W	01121	HB-4701	1	1		
0693-4731	fxd, comp, 47K ohms ±10%, 2 W	01121	HB-4731	1	1		
0852-0003	Tube, ballast: Amperite type 6-4	70563	6-4	1	1		

See introduction to this section

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

Stock No.	Description#	Mfr.	Mfr. Part No.	TQ	RS		
1120-0060	Meter: ammeter	55026	Model 182	1	1		
1250-0083	Connector, BNC: female	91737	UG-1094/U	2	1		
1251-0027	Connector, female	08145	1700D	1	1		
1251-0073	Jack, telephone tip: for single conductor	74970	105-521	1	1		
1880-0003	Rectifier, metallic: 130 V	84970	Model 65	1	1		
1880-0007	Rectifier, metallic: 1430 V	89473	6RS20GH55TED1	2	2		
1882-0007	Rectifier, metallic: 620 ma	89473	6RS22GB5BFD1	1	1		
1923-0021	Tube, electron: 6AU6	33173	6AU6	1	1		
1923-0026	Tube, electron: 6BG6	86684	6BG6	1	1		
1932-0021	Tube, electron: 6BQ7A	86684	6BQ7A	1	1		
1940-0004	Tube, electron: OA2	86684	OA2	1	1		
1940-0007	Tube, electron: OB2	86684	OB2	1	1		
1952-0009	Encapsulated TWT (494A only) includes J2, 3	11312	M2201-K	1	1		
1952-0012	Encapsulated TWT (492A only) includes J2, 3	11312	M2207	1	1		
2100-0043	var, comp, lin, 500K ohms ±10%	01121	JA4NO568504UA	1	1		
2100-0044	var, comp, lin, 50K ohms ±10%	01121	JA1N0565503UA	2	1		
2100-0133	var, comp, 200K ohms ±20%, 2 W	11237	95CV	1	1		
2110-0005	Fuse, cartridge: 1.6 amp s-b	71400	MDL1.6	2	20		
2140-0005	Lamp, incd: 6-8V, 0.15 amp, #47	24455	#47 Frosted	1	1		
3100-0055	Switch, rot: 4 pole, 2 pos	76854	47809-F2	1	1		
3100-0099	Switch, rot: 1 sect, 4 pos	76854	161711-H1	1	1		
3101-0003	Switch, tog: DPST	88140	8908K434	1	1		
3140-0010	Motor, AC	73793	G5-CW- ER-6667	1	1		
3160-0014	Fan blade	06812	(obd)	1	1		
8120-0015	Power cable	70903	KH 3981/PH70/7.5ft	1	1		
9100-0015	Transformer, power	98734	8656	1	1		
9110-0019	Choke, 1 h	98734	1010	1	1		
	MISCELLANEOUS						
G-74D	Knob: METER SELECTOR switch	28480	G-74D	1	0		
G-74N	Knob: Cath. COL.	28480	G-74N	1	0		
1200-0009	Socket, tube: 7 pin	91662	316PH-3702	1	1		
1200-0020	Socket, tube: octal	71785	51A12272	1	1		
1251-0044	Connector: female and male contacts	0000L	PM6S	1	1		
1401-0084	Fuseholder	75915	342014	2	1		
1401-0006	Clip tube: plate and grid, cer ins	76487	36002	1	0		
1450-0027	Lamp holder, bayonet type	72619	810B-1	1	1		
3150-0005	Filter, air: 6X6"	82866	806340	1	0		
9161-0005	Solenoid assembly	98734	5016	1	1		

See introduction to this section

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

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
00334	Humidial Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00373	Garlock Packing Co., Electronic Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00853	Sangamo Electric Company, Ordill Division (Capacitors)	Marion, Ill.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	Pacific Semiconductors, Inc.	Culver City, Calif.
01295	Texas Instruments, Inc. Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Ind.
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.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co.	Morristown, N.J.
03954	Air Marine Motors, Inc.	Los Angeles, Calif.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04062	Elmenco Products Co.	New York, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04298	Elgin National Watch Co., Electronics Division	Burbank, Calif.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Prods., Inc. Electronic Tube Div.	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc. Western Division	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04870	P M Motor Co.	Chicago, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.
05593	Illumitronic Engineering Co.	Sunnyvale, Calif.
05624	Barber Colman Co.	Rockford, Ill.
05729	Metropolitan Telecommunications Corp., Metro Cap. Div.	Brooklyn, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
06004	The Bassick Co.	Bridgeport, Conn.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada
08717	Sloan Company	Burbank, Calif.
08718	Cannon Electric Co. Phoenix Div.	Phoenix, Ariz.
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S. Inc.	Lowell, Mass.
09026	Babcdck Relays, Inc.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
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.
11312	Microwave Electronics Corp.	Palo Alto, Calif.
11711	General Instrument Corporation Semiconductor Division	Newark, N.J.
11717	Imperial Electronics, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12697	Clarostat Mfg. Co.	Dover, N.H.
14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.
15909	The Daven Co.	Livingston, N.J.
16758	Delco Radio Div. of G. M. Corp.	Kokomo, Ind.
18873	E. I. DuPont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19701	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
21964	Fed. Telephone and Radio Corp.	Clifton, N.J.
24446	General Electric Co.	Schenectady, N.Y.
24455	G.E., Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
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.
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.
44655	Ohmite Mfg. Co.	Skokie, Ill.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
49956	Raytheon Company	Lexington, Mass.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Swissvale, Pa.
62119	Universal Electric Co.	Owosso, Mich.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
66346	Wollensak Optical Co.	Rochester, N.Y.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	New York, N.Y.
70903	Belden 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.	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Electronic Prod. Corp.	Plainville, Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
71450	CTS Corp.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C. P. Clare & Co.	Chicago, Ill.
71528	Standard-Thomson Corp., Clifford Mfg. Co. Div.	Waltham, Mass.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A. O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72354	John E. Fast & Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72758	Girard-Hopkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co., Inc.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	Hamden, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74455	J. H. Winns, and Sons	Winchester, Mass.

00015-19
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H4-1 Dated October 1961
H4-2 Dated November 1961

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

CODE NO.	MANUFACTURER	ADDRESS
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.
75173	Jones, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.
75378	James Knights Co.	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.
76210	C. W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J. W. Miller Co.	Los Angeles, Calif.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76854	Oak Manufacturing Co.	Chicago, Ill.
77068	Bendix Pacific Division of Bendix Corp.	No. Hollywood, Calif.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77342	Potter and Brumfield, Div. of American Machine and Foundry	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
78283	Signal Indicator Corp.	New York, N.Y.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	Pasadena, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79142	Veeder 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.
80130	Times Facsimile Corp.	New York, N.Y.
80131	Electronic Industries Association Any brand tube meeting EIA standards	Washington, D.C.
80207	Unimax Switch, Div. of W. L. Maxson Corp.	Wallingford, Conn.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Laboratories, Inc.	Riverside, Calif.
80411	Acro Div. of Robertshaw Fulton Controls Co.	Columbus 16, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Components Div., Industr. Tube Operations	Newton, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Ill.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Allen B. DuMont Labs., Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc., Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls, Inc., Div. of Texas Instruments, Inc., Spencer Prods.	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Manufacturing Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83125	Pyramid Electric Co.	Darlington, S.C.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Union, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronics, Inc.	New York, N.Y.
84396	A. J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85474	R. M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
87216	Philco Corp. (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
89636	Carter Parts Div. of Economy Baler Co.	Chicago, Ill.
89665	United Transformer Co.	Chicago, Ill.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Brothers, Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91921	Minneapolis-Honeywell Regulator Co., Micro-Switch Division	Freeport, Ill.
92196	Universal Metal Products, Inc.	Bassett Puente, Calif.
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
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94144	Raytheon Mfg. Co., Industrial Components Div., Receiving Tube Operation	Quincy, Mass.
94145	Raytheon Mfg. Co., Semiconductor Div., California Street Plant	Newton, Mass.
94148	Scientific Radio Products, Inc	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	East Paterson, N.J.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95264	Lerco Electronics, Inc.	Burbank, Calif.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95354	Methode Mfg. Co.	Chicago, Ill.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Division of Aerovox	Olean, N.Y.
96256	Thordarson-Meissner Div. of Maguire Industries, 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.
97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
98141	Axel Brothers Inc.	Jamaica, N.Y.
98220	Francis L. Mosley	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98405	Carad Corp.	Redwood City, Calif.
98734	Palo Alto Engineering Co., Inc.	Palo Alto, Calif.
98821	North Hills Electric Co.	Mineola, N.Y.
98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99515	Marshall Industries, Electron Products Division	Pasadena, 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	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Semiconductor Div. of Hoffman Electronics Corp.	Evanston, Ill.
99957	Technology Instrument Corp. of Calif.	Newbury Park, Calif.

THE FOLLOWING H-P 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.
0000I	Telefunken (c/o American Elite)	New York, N.Y.
0000L	Winchester Electronics, Inc.	Santa Monica, Calif.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000N	Nahm-Bros. Spring Co.	San Leandro, Calif.
0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
0000T	Texas Instruments, Inc. Metals and Controls Div.	Versailles, Ky.
0000U	Tower Mfg. Corp.	Providence, R.I.
0000W	Webster Electronics Co. Inc.	New York, N.Y.
0000X	Spruce Pine Mica Co.	Spruce Pine, N.C.
0000Y	Midland Mfg. Co. Inc.	Kansas City, Kans.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AA	British Radio Electronics Ltd.	Washington, D.C.
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000CC	Computer Diode Corp.	Lodi, N.J.
000DD	General Transistor	Los Angeles, Calif.
000EE	A. Williams Manufacturing Co.	San Jose, Calif.
000FF	Carmichael Corrugated Specialties	Richmond, Calif.
000GG	Goshen Die Cutting Service	Goshen, Ind.

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MANUAL CHANGES

MODEL 492A/494A

TRAVELING-WAVE AMPLIFIER

Manual Serial Prefixed: 010-
Manual Printed: 1/62

To adapt this manual to instruments with other serial prefixes check for errata below, and make changes shown in tables.

Instrument Serial Prefix	Make Manual Changes	Instrument Serial Prefix	Make Manual Changes
ALL	ERRATA		

ERRATA:

Table 6-1,
SR1: Change to rectifier, metallic: 65 ma, 130V; hp Stock No. 1880-0003.
SR4: Change to rectifier, metallic: 620 ma, 130V; hp Stock No. 1882-0007.

Page 3-1, Table 3-1,
Change HELIX CURRENT to read: 492A.......0.5 ma
494A.......1.0 ma

Table 6-1,
V1: Change description to "tube, electron: 6BG6G".

Table 6-2,
hp Stock No. 0690-1521: Change description to "fxd, comp, 1500 ohms ±10%, 1W".
hp Stock No. 1923-0026: Change description to "tube, electron: 6BG6G".

Under MISCELLANEOUS, change hp Stock No. 1401-0084 to 1400-0084.

Section V, Paragraph 5-29e,
Line 3 should read as follows: "greater than 50 mv".

Table 1-1, Specifications,
Hum and Spurious Modulation: Change to "At least 40db below signal level" for Model 492A and 494A.

1/8/63

Supplement A for
492A/494A-900

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