HP 690A SERIES

691A
692A
693A
694A
SWEEP OSCILLATORS

OPERATING AND SERVICE MANUAL

HEWLETT hp PACKARD

HP 690A SERIES

OPERATING AND SERVICE MANUAL

MODELS
691A
692A
693A
694A

SWEEP OSCILLATORS

SERIALS PREFIXED: 524-, AND 507-

ALSO SERIALS PREFIXED

424-, 429-, 435-, 500-, AND 501-

SEE APPENDIX I

02280-1

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MODEL 691A

POWER CABLE

RACK MOUNTING KIT

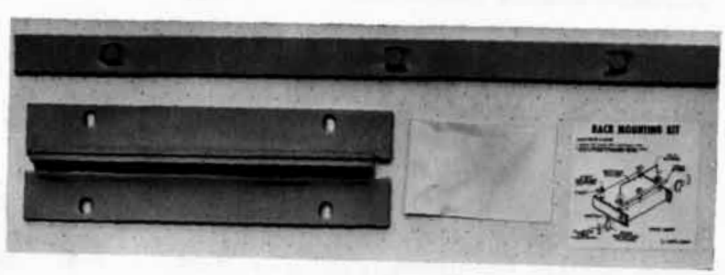


Figure 1-1. Model 691A and Supplied Accessories

SECTION I
GENERAL INFORMATION

1-1. DESCRIPTION.

1-2. The ℏp 690 series Sweep Oscillators are electronically tuned microwave signal sources. Detailed specifications of the Models 691A, 692A, 693A, and 694A are given in Table 1-1.

1-3. These sweep oscillators provide three linear automatic sweeps: two broadband, and one narrowband. The broadband sweeps each have independent, calibrated start and stop frequencies which are continuously adjustable over the entire frequency range of the oscillator to permit sweeping up or down in frequency. The narrowband sweep varies the RF output upward through a 0 to 10% segment of the oscillator frequency range, the segment being centered anywhere in the oscillator range.

1-4. One of the broadband sweeps has two internally-generated, calibrated frequency markers. The markers, individually activated and separately tuned, occur as triangular notches in the RF output. The markers may also be used with the narrowband sweep and with external frequency modulation.

1-5. Modulation capability includes internal square wave, external amplitude and external frequency modulation. Square-wave frequency is continuously variable between 950 and 1050 cps.

1-6. RF output power level is manually adjustable and there is provision for automatic output leveling. Separate, compensated inputs accept power meter and crystal detector leveling signals. As an indication of leveling performance, a panel light flashes automatically if any segment of the sweep is unleveled. Option 01 Sweep Oscillators are completely equipped internally for automatic output leveling.

1-7. Provision for oscilloscope and graphic recorder display of swept-frequency measurements includes

Table 1-1. Specifications

FREQUENCY RANGE

691A: 1 to 2 Gc
692A: 2 to 4 Gc
693A: 4 to 8 Gc
694A: 8 to 12.4 Gc

SWEEP FUNCTIONS

Start-Stop Sweep

Sweeps from "start" to "stop" frequency setting
Range: Both settings continuously adjustable over entire frequency range
End-Point Accuracy: 691A, 692A: ±10 Mc; 693A: ±20 Mc; 694A: ±30 Mc

Marker Sweep

Sweeps from "Marker 1" to "Marker 2" frequency setting
Range: Both settings continuously adjustable over entire frequency range
End-Point Accuracy: 691A, 692A: ±10 Mc; 693A: ±20 Mc; 694A: ±30 Mc

ΔF Sweep

Sweeps from lower to higher frequency, centered on CW setting
Width: Continuously adjustable from zero to 10% of the frequency range
Width Accuracy: 691A: ±20% of ΔF being swept ±2% of maximum ΔF; 692A, 693A, 694A: ±10% of ΔF being swept ±1% of maximum ΔF
Center-Frequency Accuracy:
691A, 692A: ±10 Mc; 693A: ±20 Mc, 694A: ±30 Mc

FREQUENCY MARKERS

Two frequency markers, independently adjustable over entire frequency range, amplitude modulate RF output. Marker amplitude adjustable from front panel. Markers also available for external use.
Accuracy: 691A, 692A: ±10 Mc; 693A: ±20 Mc; 694A: ±30 Mc
Resolution: Better than 0.05% at any frequency
Marker Output: Triangular pulse, typically -5V peak into 1000-ohm load

CW OPERATION

Single-frequency RF output selected by START STOP or MARKER 1 control, depending upon sweep function selected.
Accuracy: 691A, 692A: ±10 Mc; 693A: ±20 Mc; 694A: ±30 Mc
Preset Frequencies: Start-stop sweep endpoints and marker frequencies can be used as four preset CW frequencies.

RF OUTPUT CHARACTERISTICS

Frequency Stability:
With Temperature: ± 0.01%/° C
With 10% Line Voltage Change:
691A, 692A: ±1 Mc; 693A, 694A: ±2 Mc
With 10-db Power Level Change:
691A, 692A: ±500 kc; 693A, 694A: ±1 Mc
Residual FM: 691A, 692A: < 30 kc peak; 693A, 694A: < 50 kc peak
Residual AM: At least 40 db below CW output
Spurious Signals:
Harmonics, at least 20 db below CW output; non-harmonics, at least 40db below CW output.

Table 1-1. Specifications (cont'd)

SWEEP CHARACTERISTICS

Sweep Mode

Auto: Sweep recurs automatically
Manual: Front-panel control varies RF frequency between the end-frequency settings of any of the sweep functions.
Triggered: Sweep actuated by front-panel pushbutton or by externally applied signal, less than -25 volts peak, greater than 1 μsec pulse width, greater than 0.1 volt/μsec rise.

Sweep Time: Continuously adjustable in four decade ranges, 0.01 to 100 seconds. Can be synchronized with power line frequency.

Sweep Output: Direct-coupled sawtooth, 0 to approximately +15 volts, concurrent with swept RF output. Source impedance, 10,000 ohms.

Reference Output: Direct-coupled voltage proportional to RF frequency, approximately +4 volts at low end of band, approximately +70 volts at high end. Output impedance, 2000 ohms.

Frequency Linearity: 691A, 692A: ±10 Mc; 693A: ±20 Mc; 694A: ±30 Mc with respect to either sweep output or reference output.

Blanking: RF automatically turned off during retrace, on during trace. On auto sweeps, RF on long enough before sweep starts to stabilize external circuits and equipment having response compatible with selected sweep rate. Blanking disable switch provided. Blanking disables automatically for Power Meter leveling.

Penlift: For use with X-Y graphic recorder. Penlift terminals shorted during sweep, open during retrace.

RF OUTPUT POWER

Maximum Leveled Power:
691A: at least 100 mw; 692A: at least 70 mw; 693A: at least 20 mw (15 mw option 01); 694A: at least 20 mw (15 mw option 01)

Power Variation, Unleveled: Less than 10 db over entire frequency range

Power Variation External Leveling: ±0.1 db excluding coupler and detector variations

Power Variation, Internal Leveling (Option 01):
691A, 692A: ±0.3 db
693A: ±0.5 db (into matched load)
694A: ±1.0 db (into matched load)

Power Leveling Amplifier: Internal DC-coupled leveling amplifier provided

EQUIVALENT SOURCE MATCH

Unleveled: Less than 2.5:1

Externally Leveled: Depends upon coupler

Internally Leveled: 691A: 1.13:1; 692A: 1.16:1; 693A: approx. 1.5:1; 694: approx. 2:1

Output Impedance and/or Connector: 50 ohms/type N (precision type N with Option 01)

MODULATION

Internal AM: Square-wave modulation continuously adjustable from 950 to 1050 cps, all sweep times. On/off ratio is greater than 20 db at rated output.

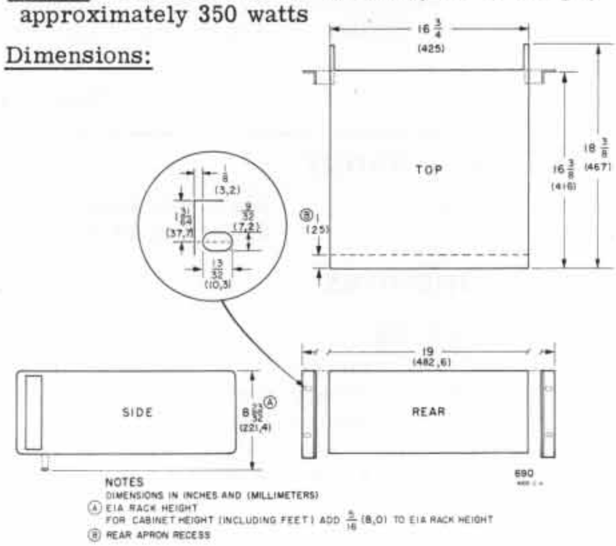
External AM
Frequency Response: DC to 350 kc unleveled, DC to 50 kc leveled
Sensitivity: -10 volts reduces RF output level at least 30 db below rated CW output
Input Impedance: Approximately 1000 ohms

External FM
Frequency Response: DC to 20 kc
Sensitivity: Deviation from CW setting approximately 3% of frequency range per volt
Maximum Range: Full band for modulation frequencies up to 150 cps (approx 35 volts peak-to-peak input), decreases to about 1% of the band for 20-kc modulation
Input Impedance: Approximately 100,000 ohms

GENERAL

Power: 115 or 230 volts ±10%, 50 to 60 cps, approximately 350 watts

Dimensions:



Weight: Net 75 lb (34 kg)

Accessories Furnished: 7-1/2 ft (2290 mm) power cable with NEMA plug; rack mounting kit

External Leveling Accessories (not supplied):

	691A	692A	693A	694A
Directional Detector	786D	787D	788C	789C
Directional Coupler	796D	797D	798C	H/X752
Crystal Detector	423A	423A	423A	H/X424A
Power Meter-Thermistor Detector	431B-478A	431B-478A	431B-478A	431B-H/X486A

Option 02: Rear-panel RF output

RF shut-off (blanking) during retrace, pen lift during the off interval of the sweep, manual sweep control, a linear sawtooth voltage output concurrent with the sweep (to provide frequency reference for the display), and visual indication of sweep duration.

1-8. The microwave source used in the Sweep Oscillators is a backward-wave oscillator tube (BWO), a self-contained, voltage-tunable oscillator. Fail-safe, overload, and time delay circuits protect the BWO from power supply malfunctions and turn-on transients. For tube life record, an internal time indicator registers hours of BWO operation.

1-9. The 690 series Sweep Oscillators permit rapid, broadband evaluation of microwave device performance, serving as the swept-frequency source for measuring such transmission properties as reflection coefficient, attenuation, gain, directivity, and other network transfer characteristics.

1-10. INSTRUMENT OPTIONS.

1-11. OPTION 01.

1-12. DESCRIPTION. Option 01 Sweep Oscillators are equipped internally to provide automatically leveled RF output, and are distinguishable from standard Sweep Oscillator by the label INT ALC on the pushbutton under the POWER LEVEL control.

1-13. RF OUTPUT CONNECTOR. Option 01 Oscillators have precision type N RF output connectors which are intended for use with standard type N connectors (e.g., UG-21 D/U) only. CAUTION: DO NOT COUPLE TWO PRECISION CONNECTORS. The male connector center conductor has larger diameter than the center conductor receptacle in the female connector. Consequently, coupling precision connectors can cause severe connector damage.

1-14. OPTION 02.

1-15. Option 02 Sweep Oscillators have rear-mounted RF output connectors. In all other respects, they are identical to the standard models.

1-16. INSTRUMENT IDENTIFICATION.

1-17. Each Sweep Oscillator carries a two-section, eight-digit serial number (000-00000) of which the first three digits are a prefix. The contents of this manual apply to those Sweep Oscillators having the serial number prefixes listed on the title page. Revisions required to adapt this manual to serial number prefixes not listed on the title page are contained in a yellow-sheet Manual Changes insert supplied with the manual. For information concerning serial number prefixes not listed either on the title page or in an insert, contact one of the Hewlett-Packard sales and service offices listed at the rear of this manual.

1-18. BWO TUBE WARRANTY.

1-19. The backward-wave oscillator tube (BWO) used as the microwave source in the Sweep Oscillators is not manufactured by the Hewlett-Packard Company. Separate terms of warranty, specified by the tube manufacturer, apply to the performance of the BWO. Warranty claim and adjustment procedures for the BWO are given on a separate form at the rear of this manual. Use this form and follow claim instructions exactly as given when returning a BWO tube for warranty adjustment.

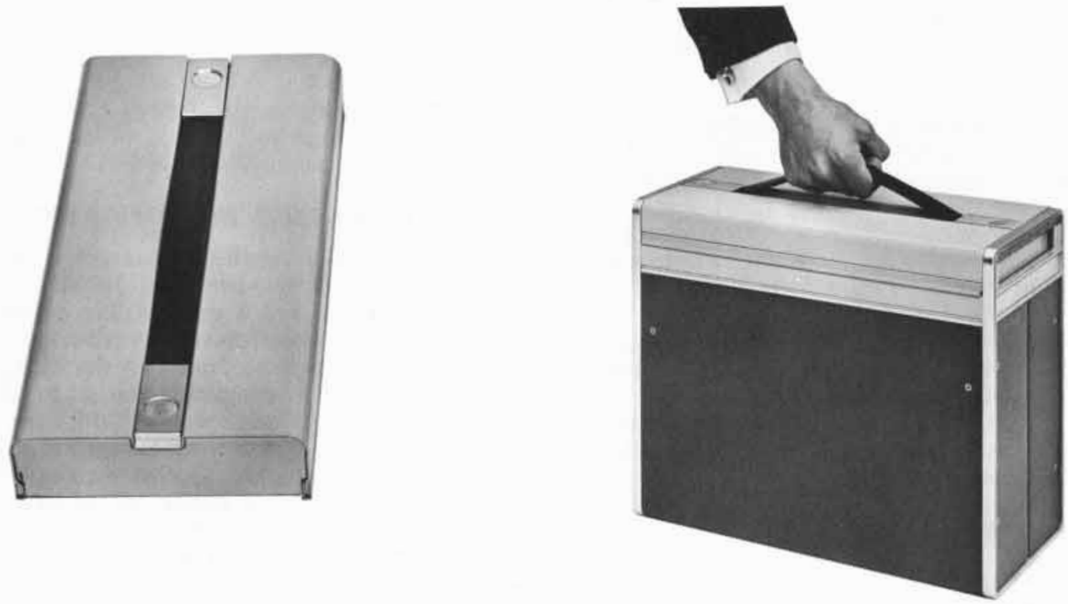


Figure 2-1. Accessory Control Panel Cover

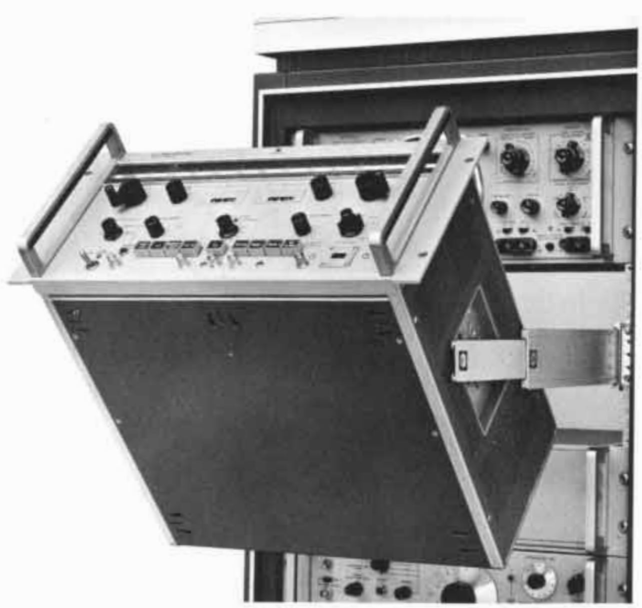


Figure 2-2. Accessory Extension Slides for Rack Mounting

SECTION II
INSTALLATION

2-1. INCOMING INSPECTION.

2-2. The Sweep Oscillator was carefully inspected, both mechanically and electrically, prior to shipment. Inspect for mechanical damage received in transit, check for supplied accessories, and test electrical performance using the procedure given in Paragraph 5-13. If there is damage or deficiency, or if electrical performance is not within specifications, see the warranty inside the front cover of this manual.

2-3. PREPARATION FOR USE.

2-4. POWER REQUIREMENTS.

2-5. The Sweep Oscillator requires a power source of 115 or 230 volts ac ±10%, single phase, which can supply approximately 350 watts.

2-6. 115/230 VOLT OPERATION.

2-7. A two-position slide switch, on the rear panel above the power cable receptacle, permits operation from either a 115- or 230-volt power source. The number visible on the switch slider indicates the line voltage for which the Oscillator is connected. Adjacent to the switch is the correct fuse rating for each line voltage.

2-8. To prepare the Sweep Oscillator for operation, position the 115-230 volt switch so that the number visible on the slider corresponds to the available line voltage, and install a fuse of correct rating.

CAUTION

To avoid damage to the Sweep Oscillator, before connecting the power cable, set the 115-230 volt switch for the line voltage to be used.

2-9. POWER CABLE.

2-10. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the instrument panel and cabinet be grounded. This instrument is equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument. The offset pin of the three-prong connector is the ground pin.

2-11. To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter (hp Stock No. 1251-0048) and connect the green pigtail on the adapter to ground.

2-12. COOLING.

2-13. Forced air cooling is used to maintain safe operating temperatures within the Sweep Oscillator cabinet. Filtered air is drawn into the cabinet by a fan and exhausted through the cabinet side covers. The air intake, fan, and filter are located at the rear of the cabinet. To ensure adequate ventilation, maintain about three inches of clearance at the sides and rear of the cabinet.

CAUTION

Do not operate the Sweep Oscillator if the fan is not operational.

2-14. AIR FILTER.

2-15. The air filter, as received with a new Sweep Oscillator, has a coating of dust-catching substance which improves air cleaning action. To maintain adequate ventilation, clean and recoat the air filter at regular intervals. See Paragraph 5-5 for cleaning instructions.

2-16. MAGNETIC INTERFERENCE.

2-17. Do not locate the Sweep Oscillator in the vicinity of a strong magnetic field; magnetic interference can be detrimental to performance.

Note

The Sweep Oscillator contains a permanent magnet; consequently, there is a strong magnetic field within the instrument whether or not it is operating, and devices sensitive to magnetism should not be placed near the Oscillator.

2-18. BENCH USE.

2-19. The Sweep Oscillator cabinets have plastic feet and foldaway tilt stands for convenience in bench operation. The tilt stand permits raising the front of the instrument, and the plastic feet are shaped to make full width modular instruments self-aligning when stacked.

2-20. For portability and protection in transit, accessory Control Panel Covers (Figure 2-1) are available for the Sweep Oscillators. These are metal covers which fit between the handles at the front of the instrument. Each cover has a carrying handle and is readily fastened in place by two pushbutton latches. To obtain a Control Cover for the Model 691A, 692A, 693A, or 694A, order hp Stock No. 5060-0829.

2-21. RACK MOUNTING.

2-22. Preparation for rack mounting is illustrated in Figure 2-3. All necessary hardware is contained in the rack mounting kit supplied with the Sweep Oscillator.

Note

If the rack-mounted Oscillator will be subjected to shock or vibration, provide additional bracing at the rear of the cabinet.

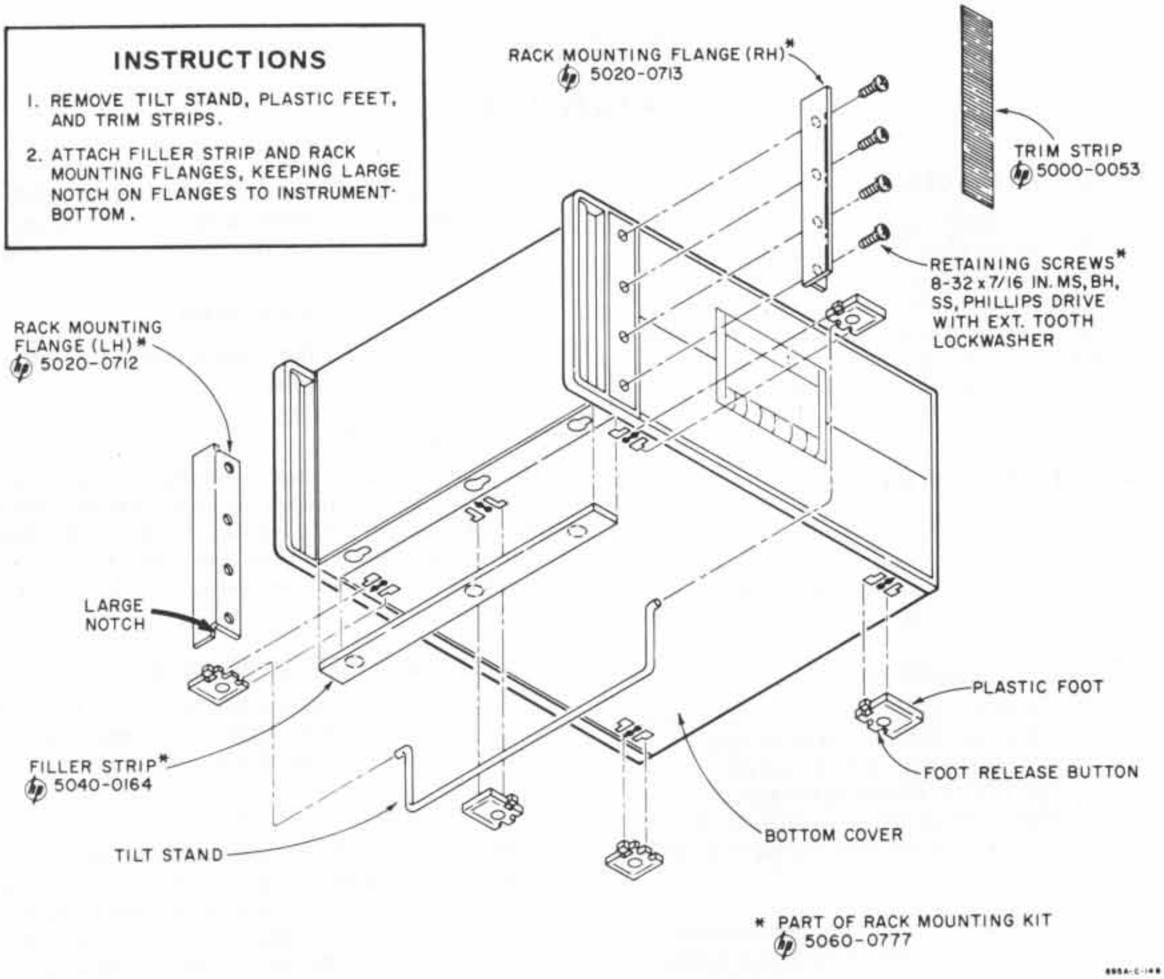


Figure 2-3. Preparation for Rack Mounting

2-23. EXTENSION SLIDES. Accessory ⓗⓟ Extension Slides for rack-mounting permit withdrawing and tilting the Sweep Oscillator free of the rack for in-rack servicing (Figure 2-2). The slides operate on ball bearings and latch at the closed position, fully extended position, and at each 45° of tilt. Pushbutton latches hold the Oscillator firmly in the slides, yet permit easy removal and replacement. The extension slides are available in stationary-member lengths of 16-7/32 inches and 22-7/32 inches to accommodate various distances between front and rear supports. To obtain a 16-7/32 inch kit order ⓗⓟ 0403-0500 and ⓗⓟ 0403-0052. To obtain a 22-7/32 inch kit order ⓗⓟ 0403-0051 and 0403-0052.

2-24. REPACKAGING FOR SHIPMENT.

2-25. If the Sweep Oscillator is to be packaged for shipment use the original shipping container and packing materials. If these have been discarded or are not in condition for reuse, obtain new materials from your local Hewlett-Packard sales and service office (see rear of this manual for locations), or follow these general instructions:

a. Wrap the Sweep Oscillator in heavy paper or plastic. (If the Oscillator is being shipped to a Hewlett-Packard service facility, attach a tag indicating type of servicing required, return address, model number, and full serial number.)

b. Use a strong shipping container. A carton made of 500-600 pound test material will usually provide adequate protection.

c. Use enough shock-absorbing material (3 to 4 inch layer) around all sides of instrument to provide firm cushion and prevent movement inside the container. Protect the control panel with cardboard. With Hewlett-Packard "floater pack" packaging, the foam blocks provide sufficient shock protection, and additional material is unnecessary.

d. Seal the shipping container securely.

e. Mark the shipping container "FRAGILE" to assure careful handling.

Note

Because of the permanent magnetic field of the BWO, the Sweep Oscillator should not be shipped by air unless packaged to conform with air shipment regulations.

2-26. In any correspondence refer to the Sweep Oscillator by model number and full serial number.

SECTION III
OPERATION

3-1. INTRODUCTION.

3-2. The 690 series Sweep Oscillators are electronically tuned microwave signal sources. Each Oscillator is capable of four types of sweep: start-stop, marker, Δ F, and external FM. The first three sweeps are internally generated, while external FM permits remote tuning. The internally-generated sweeps have adjustable, calibrated end points and sweep times as well as a choice of sweep modes. The FM sweep has adjustable rest (CW) frequency.

3-3. For start-stop sweep independent controls determine the start and stop frequencies. Each frequency can be set anywhere within the Oscillator frequency range allowing output frequency to increase or decrease with time.

3-4. Marker sweep is the same as start-stop sweep except for a separate set of tuning controls and frequency registers.

3-5. ΔF sweep is a narrowband, variable-width sweep centered on a CW frequency. The CW frequency can be set anywhere within the range of the Oscillator, and sweep width is variable from 0 to 10 per cent of the full frequency range.

3-6. For external FM sweep operation any frequency within the Oscillator frequency range can be selected as the no-signal (CW) frequency with RF sweep width, rate and symmetry controlled by the externally-generated FM signal.

3-7. For start-stop sweeping, two internal RF frequency markers can be individually positioned anywhere within the selected sweep range. Each marker is produced by amplitude modulation of the RF output at the frequency selected. Since each marker is pushbutton-selected, one or both markers can be used. The triangular marker pulses are available at a rear-panel output and there is amplitude control for the RF-modulating pulses.

3-8. Common to all three internal sweeps are the sweep modes, the sweep time selector, and modulation capabilities. Each sweep may be automatically recurrent, manual, or triggered. Automatically recurrent sweeping can be synchronized with the power line frequency by rotating the vernier of the sweep time selector to a detent position. In the manual sweep mode output frequency variation is operator-controlled. In the trigger mode sweeping is initiated either by a front-panel pushbutton or by external negative signals.

3-9. For fixed-frequency (CW) operation, either of two controls can be used to set the output frequency: the start control of the start-stop sweep or the start control of the marker sweep. Each control is calibrated and has the full frequency range of the Oscillator.

3-10. The Sweep Oscillator has provision for automatic leveling of output power. Normally, however, output power is unleveled and has the power-frequency characteristic of the RF oscillator. For both leveled and unleveled operation POWER LEVEL is an uncalibrated output attenuator.

3-11. Automatic leveling maintains output power constant as frequency changes and is achieved by a closed loop feedback system. A typical leveling system consists of a directional coupler for obtaining an RF sample of known proportion, a crystal detector to sense the RF level variations, and an amplifier to furnish a signal of appropriate polarity and magnitude to control the RF source and maintain RF output constant. In practice, power is not held absolutely constant, but variations can be confined within narrow limits.

3-12. Standard Sweep Oscillators contain the loop amplifier mentioned above, other components of the leveling loop being provided externally.

3-13. Provisions for oscilloscope or graphic recorder display of swept-frequency measurements include a sawtooth voltage output of constant amplitude which can be used as a time base or frequency axis, pen lift on the two slowest sweeps to raise X-Y recorder pens between sweeps, RF shut-off (blanking) between sweeps, manual trigger and manual sweep for display calibration, and visual indication of sweep duration for positive determination of sweep start and stop.

3-14. GENERAL OPERATING INFORMATION.

3-15. OUTPUT POWER RANGE.

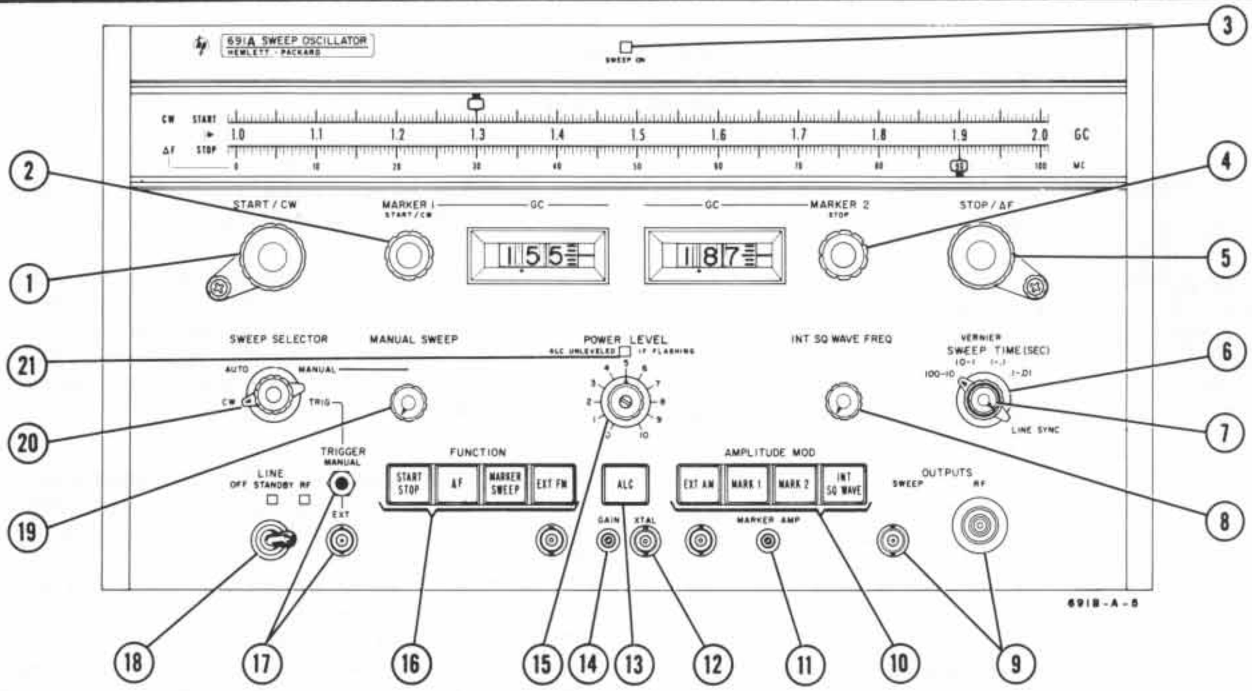
3-16. Typical maximum unleveled RF power output of the Sweep Oscillator considerably exceeds the minimum specified in Table 1-1. While actual maximums depend upon the individual BWO tube, typical maximum unleveled RF output is about 800 mw for the Models 691A and 692A, and 200 mw for the Models 693A and 694A.

3-17. RF INPUT LIMITATION.

3-18. NEVER APPLY MORE THAN 1 WATT RF (CW OR PEAK PULSE) FROM AN EXTERNAL SOURCE TO THE SWEEP OSCILLATOR RF OUTPUT.

3-19. BWO LIFE.

3-20. The backward-wave oscillator tube (BWO), used as the RF source in the Sweep Oscillator, is warranted against electrical failure for a limited



1. START/CW. Selects start frequency for start-stop sweep, CW frequency for CW operation, mid-frequency for Δ F sweep on slide-rule GC scale.
2. MARKER 1. Selects marker 1 frequency or marker sweep start frequency.
3. SWEEP ON. Lights during sweep.
4. MARKER 2. Selects marker 2 frequency or marker sweep stop frequency.
5. STOP/ΔF. Selects stop frequency for start-stop sweep on slide-rule GC scale, frequency range for Δ F sweep on MC scale.
6. SWEEP TIME (SEC). Selects range of sweep time.
7. VERNIER. Varies sweep time within selected range (sweep time decreases with clockwise rotation). Detent position at clockwise extreme synchronizes sweep with power line frequency.
8. INT SQ WAVE FREQ. Adjusts frequency of internal square wave modulation.
9. OUTPUTS. RF:RF output. SWEEP: Sweep voltage output (0 to +15V regardless of RF sweep width or direction).
10. AMPLITUDE MOD. Select any combination of amplitude modulation: external amplitude modulation (apply signal to connector), markers, and internal square wave.
11. MARKER AMP. Adjusts amplitude of RF-modulating frequency markers, but does not affect rear-panel MARKER output.
12. XTAL. Accepts leveling signal from crystal detector.
13. ALC (INT ALC on Option 01 Models). Selects automatic RF leveling.
14. GAIN. Gain adjust for RF leveling loop.
15. POWER LEVEL. Adjusts RF amplitude.
16. FUNCTION. Selects an internal sweep or external FM (SWEEP SELECTOR must be set to CW for external FM; apply FM signal to connector).
17. TRIGGER. Triggered sweep started with MANUAL pushbutton or signal applied to EXT connector.
18. LINE. Controls line power to Oscillator; RF off in STANDBY; 1-min delay between OFF and RF.
19. MANUAL SWEEP. Manually varies frequency between end points of start-stop, ΔF, or marker sweep (counterclockwise extreme gives start frequency).
20. SWEEP SELECTOR. Selects mode of operation: CW, automatic (free running) sweep, manual sweep, or triggered sweep.
21. ALC UNLEVELED IF FLASHING. Light flashes if POWER LEVEL set too high for leveling across selected frequency range.

Figure 3-1. Front Panel Controls, Connectors, and Indicators period of time, usually specified in hours of heater operation. Accordingly, an internal meter registers hours of heater operation to a maximum of 4000 hours.

3-21. Since operating practices affect useful tube life,

a. always provide adequate ventilation for the interior of the Oscillator by maintaining at least three inches of clearance at the sides and rear of the cabinet;

b. ensure that the air filter is clean; and

c. avoid prolonged operation of the Sweep Oscillator with the LINE switch at STANDBY. Although there is no RF output in this state, both the BWO heater and the time meter are energized.

3-22. MAGNETIC INTERFERENCE.

3-23. Sweep Oscillator performance can be adversely affected by strong external magnetic fields such as those produced by magnetrons and large transformers. Conversely, a strong permanent magnetic field exists near the Sweep Oscillator whether or not it is operating. Therefore, devices sensitive to magnetism should not be used close to the Sweep Oscillator.

3-24 CONTROLS, CONNECTORS & INDICATORS.

3-25. Front- and rear-panel controls, connectors, and indicators are shown and described in Figures 3-1 and 3-2. Locations and descriptions apply to each of the Models 691A, 692A, 693A, and 694A.

3-26. BASIC OPERATING PROCEDURES.

3-27. TURN-ON.

a. Set rear-panel 115-230 switch to match line voltage, and check that the fuse has correct rating. (Correct fuse rating is directly above the visible number on the switch slider.)

b. Connect Sweep Oscillator to power source.

c. Set front-panel LINE switch to RF. After about one minute delay the RF indicator should glow. Failure of the indicator to glow is an indication of trouble within the instrument.

CAUTION

Do not use the Sweep Oscillator if the cooling fan does not operate at turn-on.

3-28. STANDBY OPERATION.

3-29. When the LINE switch is set to STANDBY there is no RF output, but heaters of all electron tubes are heated and operating potentials are supplied to all circuits except the RF oscillator. This permits nearly immediate RF output when the LINE switch is set to RF, provided at least one minute has elapsed between OFF and STANDBY.

3-30. With no FUNCTION selectors depressed, the CW dial lamp will glow regardless of the settings of other controls.

3-31. SWEEP FUNCTIONS.

3-32. The Sweep Oscillators have four sweep functions which are designated Start-Stop, ΔF, Marker, and External FM. Four separate pushbuttons, each labeled for the function it selects, determine the type of swept-frequency operation.

3-33. START-STOP SWEEP.

3-34. For the start-stop sweep function, the sweep start and stop frequencies are separately adjustable to any frequency within the range of the Sweep Oscillator. Since the output frequency of the Oscillator varies from the start frequency to the stop frequency, sweeping can be either up or down with time. In addition, sweeping can be automatically recurrent, triggered or manual, with variable sweep time for recurrent and triggered sweeping. All amplitude modulation capabilities can be used with the start-stop sweep and output power may be leveled or unleveled. Instructions for obtaining start-stop sweep are given in Figure 3-3.

3-35. ΔF SWEEP.

3-36. With ΔF sweep, output frequency varies upward through a band segment adjustable in width from zero to 10% of full band and centered on any frequency within the range of the Oscillator. All trigger and amplitude modulation capabilities may be used and sweep time, in the automatic and triggered modes, can be varied from 10 milliseconds to 100 seconds. RF output power may be leveled or unleveled. Figure 3-4 gives instructions for obtaining ΔF sweep.

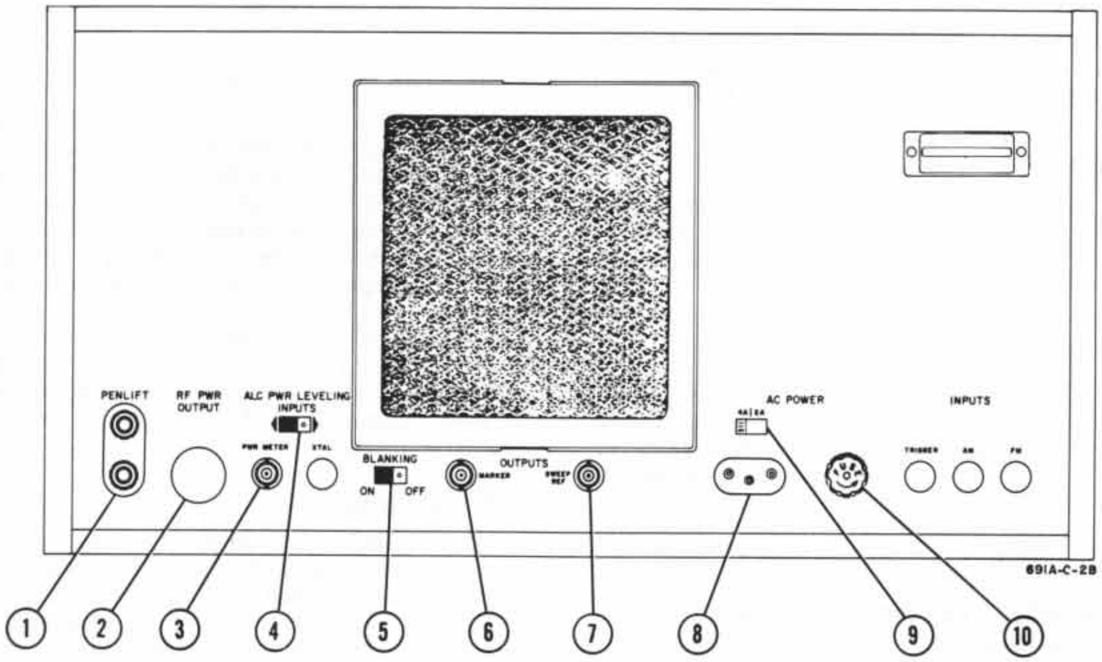
3-37. MARKER SWEEP.

3-38. Marker sweep is similar to start-stop sweep with individual start and stop frequency controls and frequency registers which are separate from those of the start-stop sweep. The only functional difference between start-stop and marker sweep is that the RF frequency markers cannot be used with the marker sweep. Figure 3-5 gives instructions for obtaining marker sweep.

3-39. EXT FM.

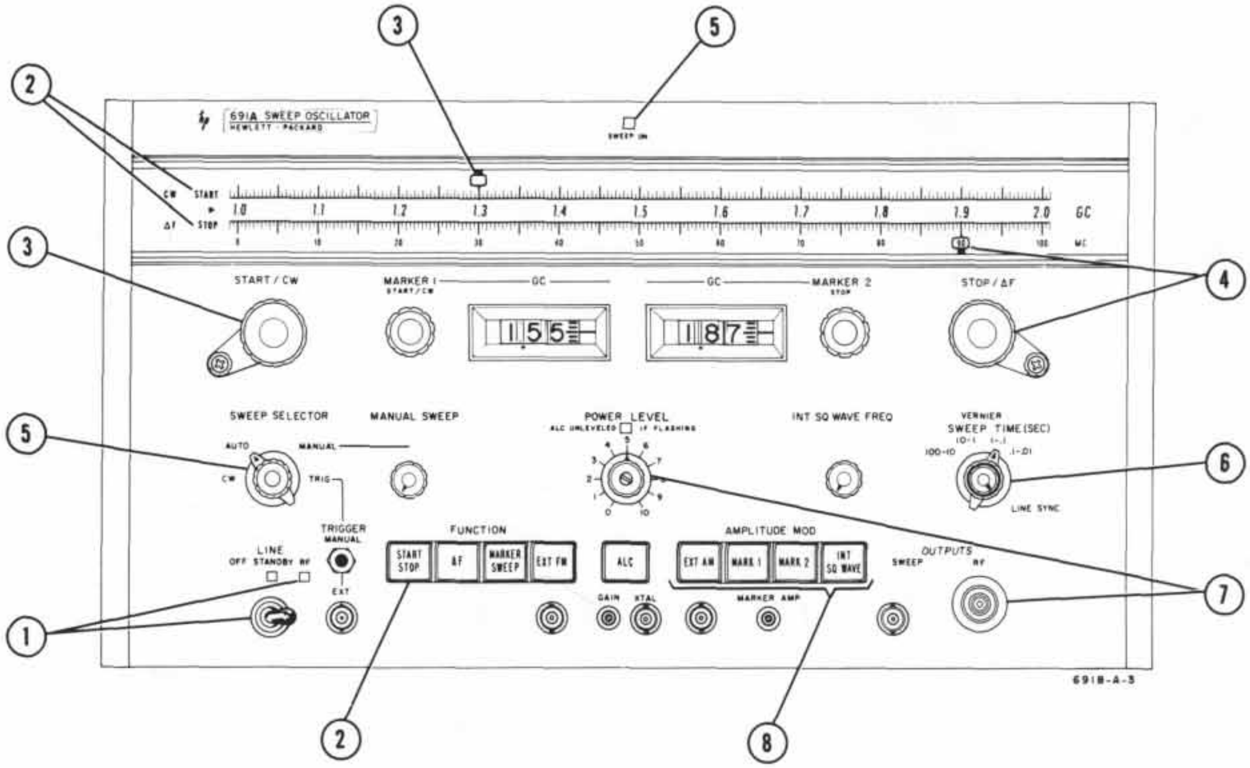
3-40. The External FM function provides a means of obtaining output frequency which varies under the control of an externally-produced signal. Output frequency variation which is linear with time results from application of a voltage variation which is also linear with time. Positive-going voltage causes output frequency to increase while negative-going voltage has the opposite effect. Maximum upward deviation obtainable is the full frequency range of the Oscillator, but downward deviation is restricted to approximately one-half the Oscillator's frequency range. Rest (CW) frequency of the FM sweep is calibrated and manually adjustable over the full frequency range. When rest frequency is set below mid-range, total deviation can be full band. The external FM input is direct-coupled to permit remote frequency programming.

3-41. During external FM operation both the SWEEP SELECTOR and SWEEP TIME switch are inoperative, but there is full amplitude modulation capability and



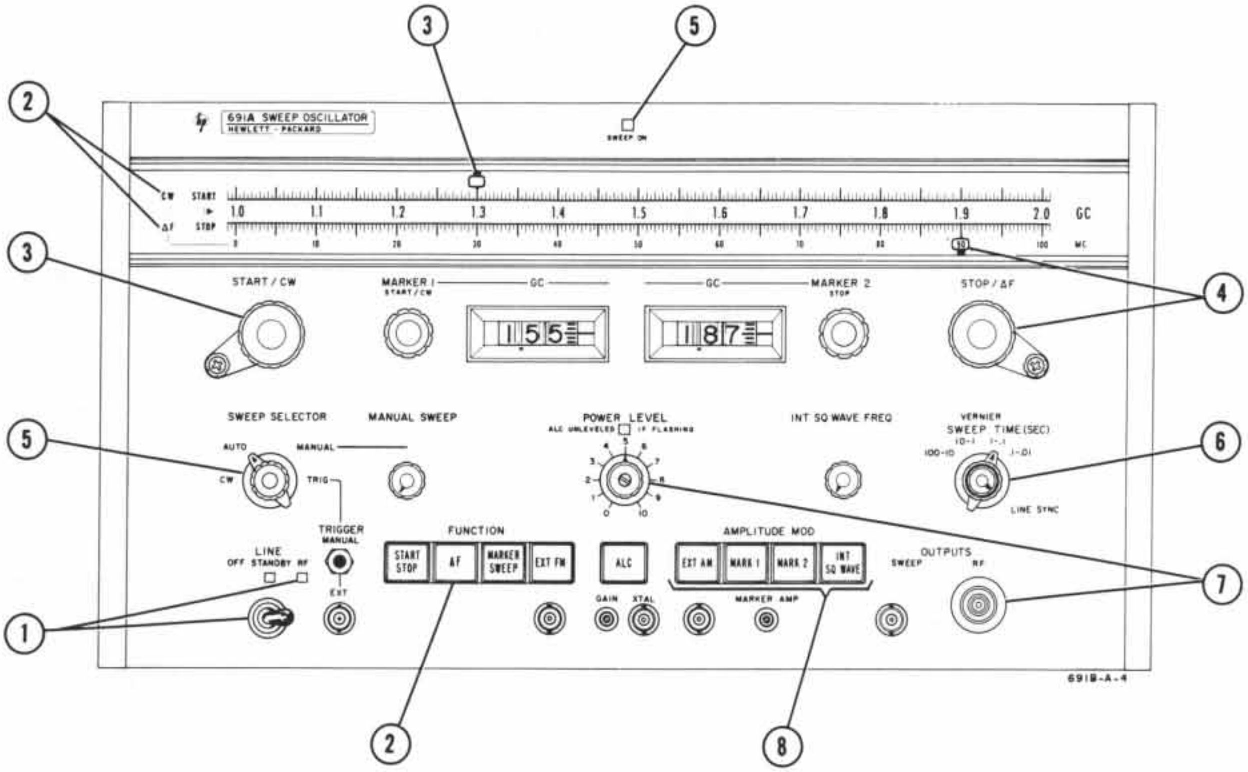
1. PENLIFT. Terminals shorted during sweep (AUTO or TRIG sweep, two slowest sweep time ranges only).
2. RF PWR OUTPUT (Option 02 only). RF output on rear panel.
3. PWR METER. Accepts leveling signal from power meter output. (Disconnect any external load from XTAL connector when using power meter leveling.)
4. ALC PWR LEVELING INPUTS. Selects crystal detector or power meter as leveling signal source.
5. BLANKING. Allows RF to remain on during sweep recovery (OFF position). Blanking is automatically disabled during power meter leveling.
6. MARKER. Frequency markers output. Pulses are triangular, typically -5 volts amplitude. Pulse amplitude is not affected by front-panel MARKER AMP control.
7. SWEEP REF. Output voltage proportional to RF frequency.
8. Power cable receptacle (offset pin connected to Oscillator cabinet).
9. 115/230. Permits operation from 115 or 230 volts ac.
10. FUSE. Select rating to match line voltage (correct rating above number visible on 115/230 switch slider).

Figure 3-2. Rear Panel Controls and Connectors



1. Set LINE to RF; RF indicator glows.
2. Press START-STOP; on dial START and STOP glow. Check that all other pushbuttons are released.
3. Select sweep start frequency with START/CW.
4. Select sweep stop frequency with STOP/ΔF.
5. Choose AUTO, MANUAL or TRIGgered sweep mode with SWEEP SELECTOR. See Sweep Modes for mode characteristics.
6. With AUTO or TRIG mode set SWEEP TIME to desired range. Vary time within selected range with red VERNIER: clockwise rotation decreases time. To synchronize AUTO sweep with power-line frequency, switch VERNIER into LINE SYNC position. (LINE SYNC gives shortest sweep time of the range selected.)
7. Use POWER LEVEL as an uncalibrated output attenuator. RF output is maximum at 10, minimum at 0. Attenuation range depends on whether RF is leveled or unleveled. With unleveled operation range is 30 db minimum. See RF Power Leveling for leveled operation characteristics.
8. Start-stop sweep has full amplitude modulation capability. See Amplitude Modulation.

Figure 3-3. Start-Stop Sweep Operation



1. Set LINE to RF; RF indicator glows.

2. Press ΔF; on dial, CW and Δ F glow. Check that all other pushbuttons are released.

3. Select sweep center frequency with START/CW.

4. Select sweep width on MC scale with STOP/ΔF.

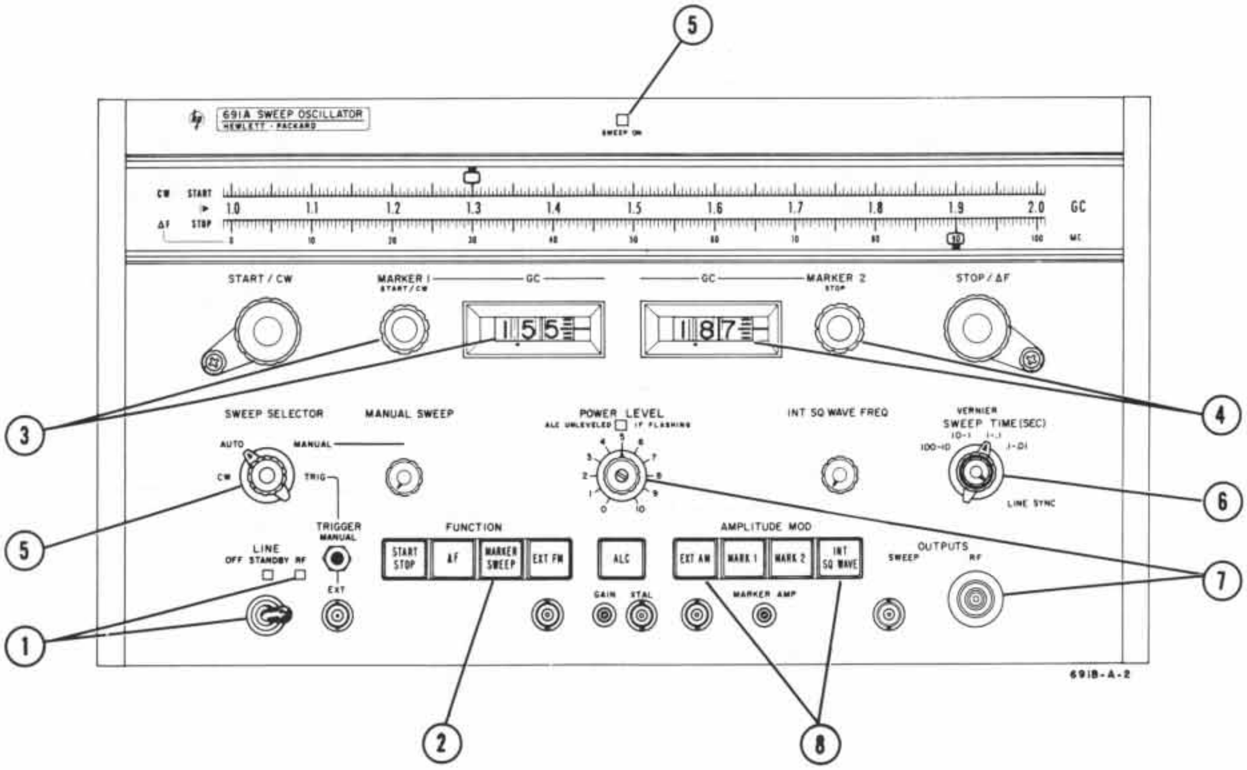
5. Choose AUTO, MANUAL, or TRIGgered sweep mode with SWEEP SELECTOR. See Sweep Modes for mode characteristics.

6. With AUTO or TRIG mode set SWEEP TIME to desired range. Vary time within selected range with red VERNIER: clockwise rotation decreases time. To synchronize AUTO sweep with power-line frequency, switch VERNIER into LINE SYNC position. (LINE SYNC gives shortest sweep time of the range selected.)

7. Use POWER LEVEL as an uncalibrated output attenuator. RF output is maximum at 10, minimum at 0. Attenuation range depends on whether RF is leveled or unleveled. With unleveled operation range is 30 db minimum. See RF Power Leveling for leveled operation characteristics.

8. ΔF sweep has full amplitude modulation capability. See Amplitude Modulation.

Figure 3-4. ΔF Sweep Operation



1. Set LINE to RF; RF indicator glows.

2. Press MARKER SWEEP. Check that all other pushbuttons are released.

3. With MARKER 1 START/CW set start frequency on adjacent GC digital counter.

4. With MARKER 2 STOP set stop frequency on adjacent GC digital counter.

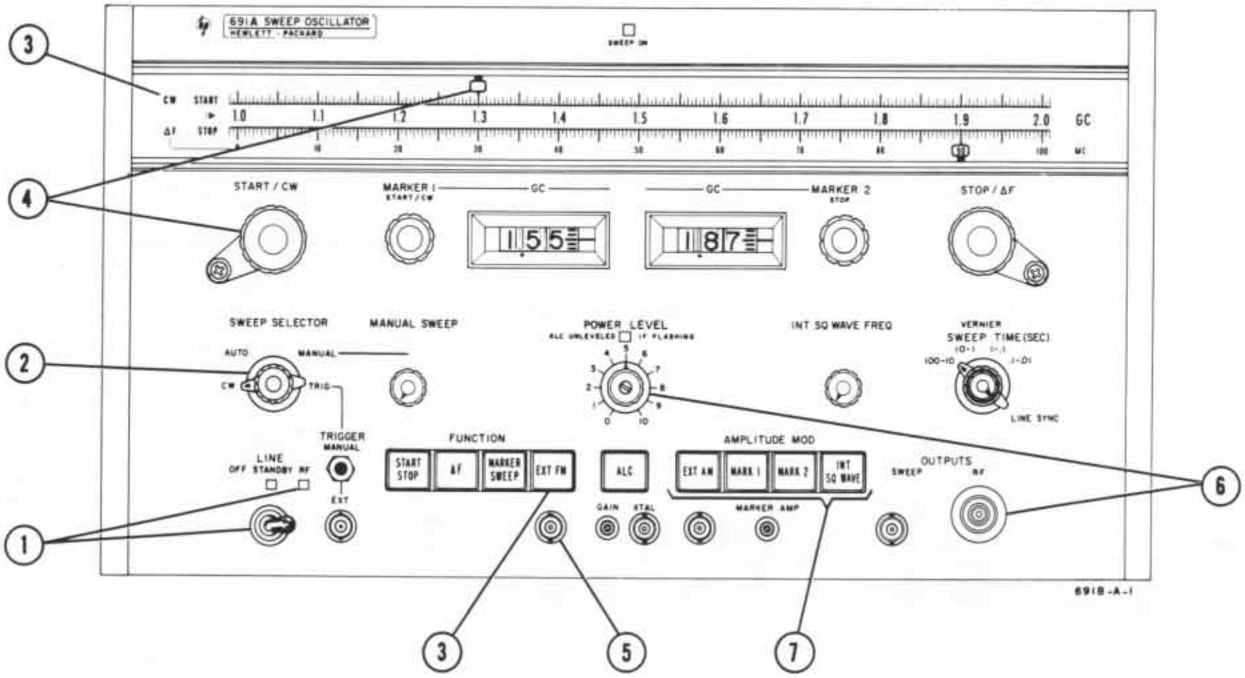
5. Choose AUTO, MANUAL, or TRIGgered sweep mode with SWEEP SELECTOR. See Sweep Modes for mode characteristics.

6. With AUTO or TRIG mode set SWEEP TIME to desired range. Vary time within selected range with red VERNIER: clockwise rotation decreases time. To synchronize AUTO sweep with power-line frequency, switch VERNIER into LINE SYNC position. (LINE SYNC gives shortest sweep time of the range selected.)

7. Use POWER LEVEL as an uncalibrated output attenuator. RF output is maximum at 10, minimum at 0. Attenuation range depends on whether RF is leveled or unleveled. With unleveled operation range is 30 db minimum. See RF Power Leveling for leveled operation characteristics.

8. Marker sweep has external amplitude and internal square wave modulation capability. See Amplitude Modulation.

Figure 3-5. Marker Sweep Operation



1. Set LINE to RF; RF indicator glows.

2. Set SWEEP SELECTOR to CW.

3. Press EXT FM; on dial, CW glows. Check that all other pushbuttons are released.

4. Select rest frequency with START/CW. Rest frequency is the output frequency with 0 volts applied to external FM input.

5. Connect frequency-modulating voltage to external FM input.

CAUTION

Observe voltage and frequency limits given in Figure 3-7.

6. Use POWER LEVEL as an uncalibrated output attenuator. RF output is maximum at 10, minimum at 0. Attenuation range depends on whether RF is leveled or unleveled. With unleveled operation range is 30 db minimum. See RF Power Leveling for leveled operation characteristics.

7. External FM operation has full amplitude modulation capability. See Amplitude Modulation.

Figure 3-6. External FM Operation

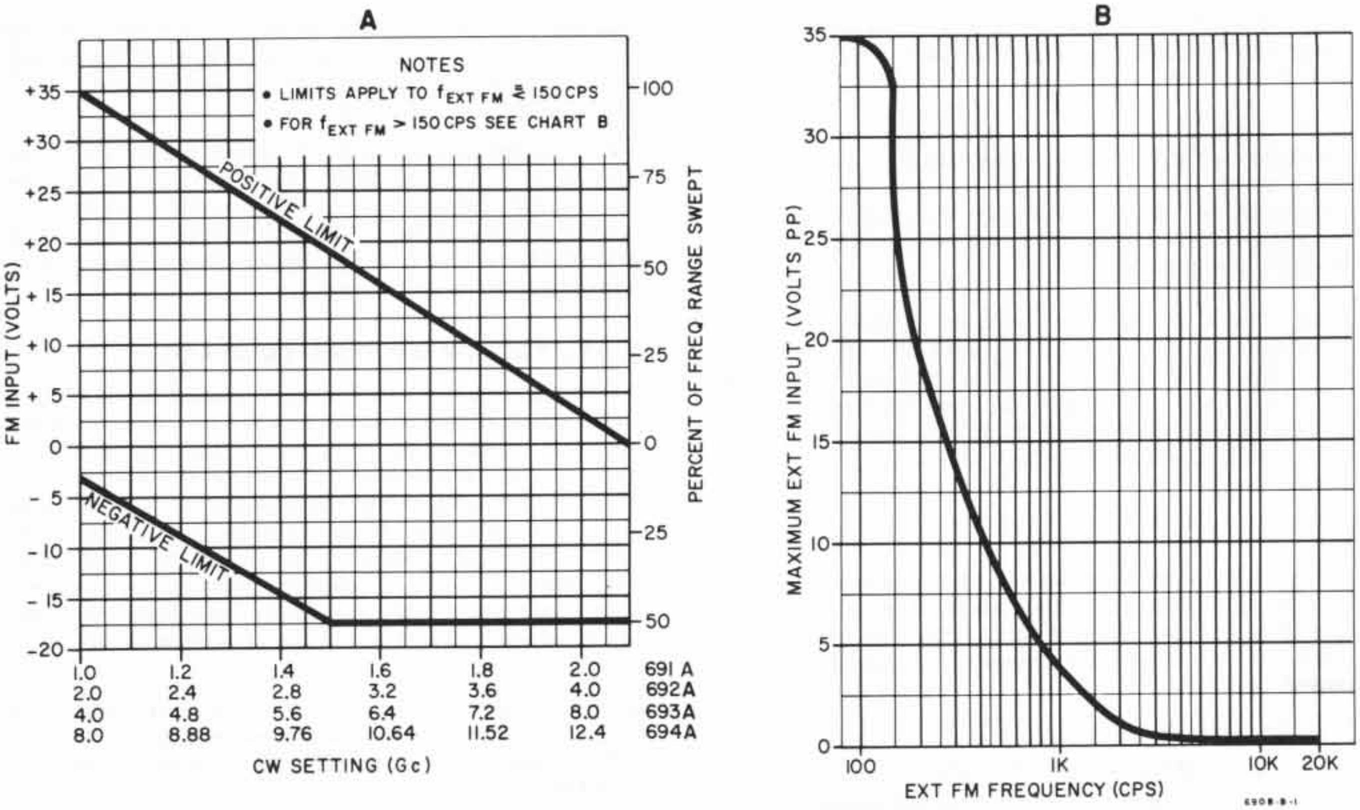


Figure 3-7. External FM Limitations

RF output power may be leveled or unleveled. Instructions for external FM operation are given in Figure 3-6.

3-42. FM LIMITATIONS.

CAUTION

The Sweep Oscillator can be damaged by application of FM signals which exceed the safe operating limits given in the charts of Figure 3-7.

Chart A gives the per cent of frequency range swept for each CW setting and FM input voltage (external FM signal frequencies less than 150 cps). Chart B gives voltage limits for external FM signal frequencies above 150 cps. Note: maximum allowable FM voltage at 20 kc is 0.35 volts peak-to-peak (total deviation 1% of the Oscillator frequency range).

3-43. NEVER EXCEED THE FM VOLTAGE LIMITS GIVEN IN CHARTS A AND B OF FIGURE 3-7. Where there is a difference between limits indicated by charts A and B always use the smaller amplitude.

3-44. SWEEP MODES.

3-45. The sweep modes are designated CW, AUTO, MANUAL, and TRIG, the mode in use being determined by the setting of the SWEEP SELECTOR.

3-46. AUTO.

3-47. The AUTO sweep mode provides automatically recurrent sweeping for any sweep time selected by the SWEEP TIME controls and may be used with any sweep function except external FM. When the red SWEEP TIME vernier is in the detent LINE SYNC position, automatic sweeping is synchronized with the power-line frequency.

3-48. During AUTO sweeping the oscillator output frequency changes linearly with time and SWEEP ON is lighted during each sweep.

3-49. Three sweep-synchronized outputs are activated during AUTO operation: SWEEP, SWEEP REF and PENLIFT. In addition, the Oscillator RF output is automatically turned off, or blanked, between sweeps if the rear-panel BLANKING and ALC PWR LEVELING INPUTS switches are at ON and XTAL, respectively.

3-50. TRIGGERED.

3-51. The triggered sweep mode permits manual one-shot sweeping and recurrent sweeping synchronized with an externally-produced signal, and may be used with any sweep function except external FM. A single sweep starts each time the front-panel MANUAL push-button is pressed and/or each time a suitable negative pulse is applied to the EXT input. Sweeping time is determined by the SWEEP TIME (SEC) controls but LINE SYNC is inoperative during triggered sweeping.

3-52. During a triggered sweep Oscillator output frequency changes linearly with time, and SWEEP ON is lighted.

3-53. Externally-produced trigger signals must have negative polarity, width greater than 1 μsec and rise time of at least 0.1 volt/μsec. Less than 25 volts amplitude will trigger a sweep. During slow sweeps a sweep can be interrupted and reset by pressing the MANUAL pushbutton.

3-54. Three sweep-synchronized outputs are activated during TRIG operation: SWEEP, SWEEP REF and PENLIFT. In addition, the Oscillator RF output is automatically turned off, or blanked between sweeps if the rear-panel BLANKING and ALC PWR LEVELING INPUTS switches are at ON and XTAL, respectively.

3-55. CW.

3-56. The CW mode gives single-frequency operation and may be used with either the start-stop or marker sweep functions. Output frequency can be set anywhere in the Oscillator frequency range. Obtain CW output as follows:

a. Set LINE to RF.

b. Set SWEEP SELECTOR to CW.

c. Press START-STOP or MARKER SWEEP.

d. Tune to desired frequency using START/CW or MARKER 1 as indicated by the sweep function selected.

e. Control output power with POWER LEVEL: output power is maximum at 10, minimum at 0. POWER LEVEL is uncalibrated but has an attenuation range of at least 30 db with unleveled output, 10 db with leveled output.

f. Internally square wave or externally amplitude modulate the RF output. See Amplitude Modulation.

g. Use automatic RF power leveling to stabilize output level and improve source match. See RF Power Leveling.

3-57. During CW operation RF blanking, pen lift, SWEEP ON, and SWEEP output are not operational. However, a voltage proportional to output frequency is available at the rear-panel SWEEP REF output.

3-58. MANUAL.

3-59. The manual sweep mode permits manual tuning between the end frequencies of the start-stop, marker, or Δ F sweep. Any of the amplitude modulation functions may be used with manual sweep, and RF output can be leveled or unleveled. Both the SWEEP and SWEEP REF outputs are operational during manual sweeping, but RF blanking, pen lift and the SWEEP ON indicator do not function.

3-60. To sweep a frequency range manually, set controls for the desired sweep function using the appropriate instructions from Figures 3-3, 3-4, or 3-5 but set SWEEP SELECTOR to MANUAL and use MANUAL SWEEP to vary output frequency. Clockwise rotation varies output frequency toward the stop frequency of the selected sweep. Counterclockwise rotation varies output frequency toward the sweep start frequency. The SWEEP ON light does not function with manual sweeping.

3-61. Manual sweep is particularly useful for calibration of a display device such as an oscilloscope or graphic recorder prior to automatic swept-frequency measurements. Its use in this application is described in more detail under Displaying Swept-Frequency Measurements.

3-62. THE SWEEP TIME CONTROL.

3-63. The sweep time control consists of a four-position range selector and a vernier for continuous adjustment of sweeping time within the limits of each time range. Clockwise rotation of the vernier decreases sweeping time, the clockwise rotation limit giving the minimum time, and the counterclockwise limit giving the maximum time of the range selected. The detent LINE SYNC position of the vernier synchronizes sweeping with the power line frequency, but restricts sweeping time to the minimum of the range selected.

3-64. The sweep time controls are operational with start-stop, Δ F, and marker sweeps in the AUTO and TRIG modes. However, LINE SYNC does not function with triggered sweeps.

3-65. THE SWEEP OUTPUT.

3-66. The SWEEP output is an output frequency-related positive voltage to provide a time-frequency axis for displaying swept-frequency measurements. This positive voltage has fixed range, typically 0 to 15 volts, irrespective of sweep width with zero always coincident with the sweep start frequency and +15 volts always coincident with the sweep stop frequency. With automatic and triggered sweeps SWEEP output is a linear ramp synchronized with the RF sweep. During manual sweeps the SWEEP output voltage change is concurrent with output frequency change. SWEEP output functions with start-stop, marker, and Δ F sweeps in the AUTO, MANUAL and TRIG modes.

3-67. THE SWEEP REFERENCE OUTPUT.

3-68. The rear-panel SWEEP REF output is a direct-coupled positive voltage proportional to Oscillator output frequency. SWEEP REF is typically +4 volts at the lowest frequency in the Oscillator range, +70 volts at the highest frequency. Voltage change is concurrent with output frequency change, the actual range and dc limits being determined by the RF sweep width and its location in the Oscillator frequency range. SWEEP REF is operational with all sweep functions and modes.

3-69. THE PENLIFT.

3-70. The rear-panel PENLIFT terminals furnish a sweep-synchronized writing control for graphic recorders equipped to write in response to a remote short circuit. The PENLIFT terminals are shorted during the RF sweep, open between sweeps. The pen lift control is operational during AUTO and TRIG sweeps in the two slowest sweep time ranges only.

3-71. RF BLANKING.

3-72. The RF blanking automatically attenuates the Oscillator output at least 30 db between sweeps giving a no-output reference trace on an oscilloscope display of swept-frequency measurement. Blanking can be used with start-stop, marker, and Δ F sweeps in the AUTO and TRIG modes. With AUTO sweeps the blanking interval ends slightly in advance of RF sweep start to allow external circuits and equipment to stabilize. Blanking can be disabled with the rear-panel BLANKING on-off switch except during power meter RF leveling when blanking is automatically disabled.

3-73. EXPANDED SWEEP OPERATION.

3-74. Certain swept-frequency measurements, such as bandpass filter evaluation, require rapid examination of more than one frequency band (e.g., filter overall response characteristic, pass and stop bands).

3-75. Because the start-stop and marker sweeps are independent they can be used in combination with the internal frequency markers to obtain expanded sweep presentation. For instance, start-stop sweep can be used to cover a broad frequency range such as the overall response characteristic of the filter mentioned above. If a segment of this range (the stop band, for example) merits detailed examination, the internal frequency markers can be activated and tuned to bracket the important segment. Then, pressing MARKER SWEEP expands the bracketed segment to occupy the full presentation and sweep time. Without further adjustment, the original sweep may be restored at will by pressing START-STOP.

3-76. The foregoing example of expanded sweep operation assumes one sweep range within another. However, the two sweep ranges need not be one within the other or even overlap; they may each cover separate, remote segments of the total frequency range.

3-77. FOUR PRESET CW FREQUENCIES.

3-78. The manual sweep control, in conjunction with the CW mode and the start-stop and marker sweep functions, can be used to obtain four preset CW frequencies.

a. Select four different frequencies using START/CW, STOP/Δ F, MARKER 1, and MARKER 2 controls.

b. Rotate MANUAL SWEEP fully clockwise.

c. Set SWEEP SELECTOR to CW.

d. Press START-STOP to obtain CW output at frequency indicated by start dial pointer.

e. Press MARKER SWEEP to obtain CW output at frequency indicated by MARKER 1 digital counter.

f. Set SWEEP SELECTOR to MANUAL to obtain CW output at frequency indicated by MARKER 2 digital counter.

g. Press START-STOP to obtain CW output at frequency indicated by stop dial pointer.

3-79. AMPLITUDE MODULATION.

3-80. EXTERNAL AM.

3-81. The Sweep Oscillator RF output may be amplitude modulated by signals applied to the front-panel connector under the EXT AM pushbutton. External amplitude modulation is possible with any sweep mode or function. Frequency response is dc to 350 Kc for unleveled RF output and dc to 50 Kc for leveled output. Negative 10 volts reduces RF output at least 30 db below rated CW output.

3-82. INTERNAL FREQUENCY MARKERS.

3-83. Two calibrated frequency markers can be independently adjusted over the full frequency range of the Sweep Oscillator. One is tuned by the MARKER 1 control and the other by the MARKER 2 control. Each marker amplitude-modulates the RF output with a wedge-shaped notch at the frequency indicated on the digital counter adjacent to the tuning control. The front-panel MARKER AMP control permits amplitude adjustment of the RF-modulating marker but does not affect the amplitude of the pulses at the rear-panel MARKER output. The amplitude of these pulses is typically -5 volts into a 1000-ohm load.

3-84. Activated separately by the MARK 1 and MARK 2 pushbuttons, the markers can be used individually or simultaneously during start-stop, Δ F, or external FM operation with auto, manual, or triggered mode. In addition, markers may be used in combination with external amplitude or internal square-wave modulation.

3-85. INTERNAL SQUARE WAVE.

3-86. Internally-generated square-wave modulation can be used with any sweep function or sweep mode and with marker or external amplitude modulation. At rated RF output the square wave on-off ratio exceeds 20 db. The INT SQ WAVE pushbutton selects square wave modulation, and INT SQ WAVE FREQ permits continuous adjustment of frequency from 950 to 1050 cps.

3-87. RF POWER LEVELING.

3-88. A microwave signal source which tunes automatically through a preset frequency range in a preset time, such as the ⓗⓟ 690 series Sweep Oscillator, facilitates rapid, broadband evaluation of microwave devices. An additional requirement for such measurements is constant RF power in the frequency range of interest. Characteristically, however, the backward-wave oscillator (BWO) used as the microwave source in the Sweep Oscillator does not generate constant RF power throughout the operating frequency range. The RF power output of a BWO usually consists of minor, narrowband variations superimposed on a gross variation, as illustrated in Figure 3-8. Minor variations are less than 3 db while the gross variation may be as great as 10 db. By deriving a signal which is the inverse of this power characteristic and applying it as amplitude control, the RF power output of the Sweep Oscillator can be maintained essentially constant with changing frequency. This control of output power is called leveling.

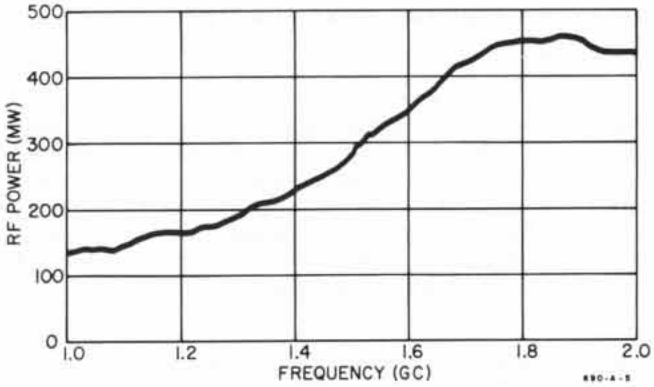


Figure 3-8. Typical RF Power Output Characteristic of 1 - 2 Gc BWO

3-89. The leveling system provided for in the Sweep Oscillator is the negative feedback closed loop, a system which senses RF power variations and produces amplitude-control signals which reduce the variations.

3-90. A typical negative feedback closed leveling loop (Figure 3-9) consists of a directional coupler to sample RF output, a crystal detector to convert instantaneous RF power variations in the sample to proportional dc, and a differential amplifier to compare the dc against a reference and furnish an amplified difference signal. This difference signal, applied as RF amplitude control, determines magnitude of leveled power and reduces power variations.

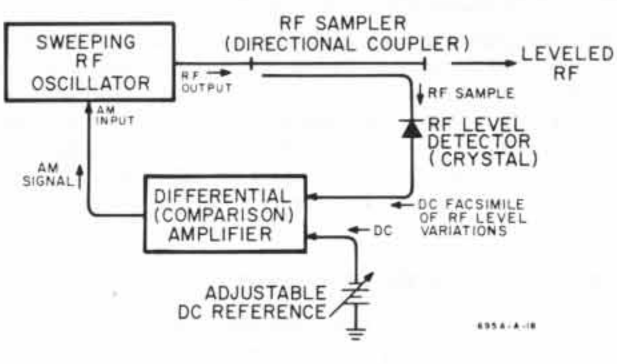


Figure 3-9. Typical Leveling Loop

3-91. In the leveling loop the differential amplifier acts to keep the input from the crystal detector equal to the dc reference and, by feedback action, causes the leveling loop to maintain crystal detector output constant. The same feedback action would also maintain RF power in the coupler main line constant, but between the detector output and the coupler main line are several frequency-dependent variables which prevent main line power from being absolutely constant. Detector frequency response, coupling variation with frequency, coupler-to-detector match, and coupler directivity each affect the flatness of RF power in the coupler main line. Nevertheless, the leveling loop can reduce power variations from a deviation as great as 10 db to less than 1 db over the Oscillator tuning range.

3-92. In addition to holding RF power constant with changing frequency, the leveling loop also improves source match. The amount of improvement is determined by the directivity and main-line SWR of the RF-sampling directional coupler: the greater the directivity and the smaller the main-line SWR, the greater the source match improvement. The practical limit to the effect of directivity, however, is usually the coupler main-line SWR. For coaxial couplers having main-line SWR of 1.2:1, for instance, directivity exceeding 26 to 30db produces no significant source match improvement. Similarly, for a waveguide coupler having main-line SWR of 1.05:1 the practical directivity limit is about 40db.

3-93. Standard Sweep Oscillators include the differential amplifier required for RF power leveling. Other components of the leveling system, such as the directional coupler and detector, are not part of the standard Sweep Oscillator. Option 01 Sweep Oscillators, however, contain a complete leveling system. Leveling capability and equivalent source match of Option 01 Sweep Oscillators is given in Table 1-1.

3-94. LEVELING POINT CONSIDERATIONS.

3-95. The closed leveling loop holds RF power constant at the point of RF sampling. Thus, if sampling is done at the Sweep Oscillator RF output, discontinuities in the transmission system between Oscillator and load cause uncontrollable power variations at the load. However, if the sampling point is located as near the load as possible transmission system discontinuities are contained within the leveling loop and their effects are automatically compensated.

3-96. The effect of leveling point location on power variations at the load is shown in Figure 3-10. Although X-Y recorder plot A was obtained with the coupler-detector external to the Sweep Oscillator, the plot is also valid for Option 01 Sweep Oscillators which have internal coupler-detectors.

3-97. Recorder plot A was made with a hp 360C Low-Pass Filter (arrow, Figure 3-10) connected between the sampling coupler and load to simulate transmission irregularity between leveling loop and load. The filter has maximum SWR of 1.4:1 and the load, consisting of a 50-ohm termination and hp 478 Thermistor Mount, has an SWR of about 2:1. The resultant power variation in the frequency range swept is approximately 1 db. In contrast, recorder plot B shows power variation at the load reduced to 0.25 db with the leveling point at the load.

3-98. Option 01 Sweep Oscillators can be used for remote-point leveling by disabling the internal leveling loop as described in Paragraph 3-139.

3-99. Remote-point leveling is accomplished using the same systems and procedures as those given in succeeding paragraphs for leveling at the RF output, the only difference being that the RF-sampling directional coupler and the RF detector are located at the system point where leveled RF is required, not at the Sweep Oscillator RF output.

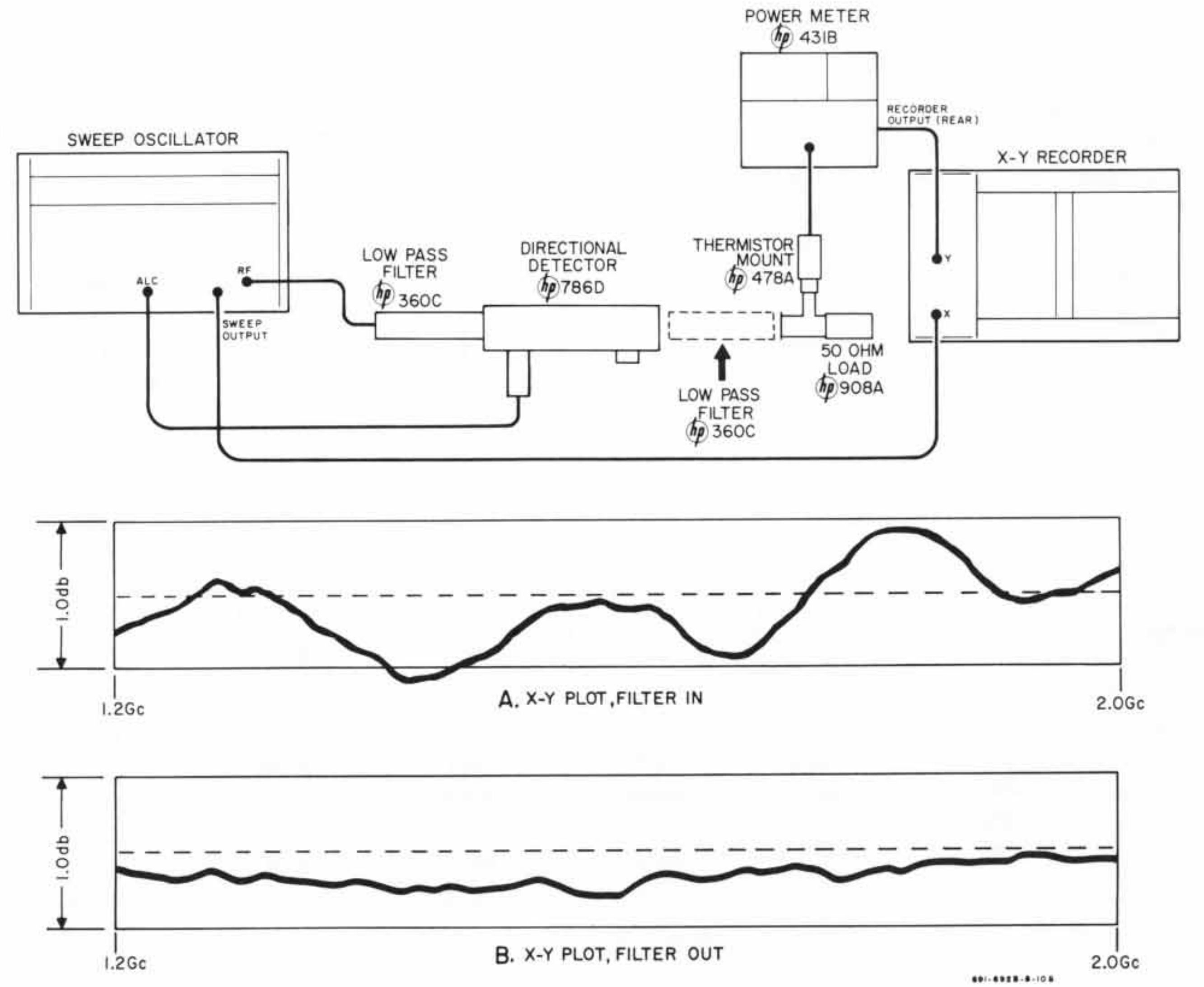


Figure 3-10. Effect of Leveling Point on Power Variation

3-100. DEPENDENCY OF MAXIMUM LEVELED POWER ON FREQUENCY.

3-101. Maximum leveled RF power cannot exceed the minimum available from the BWO in the frequency range being swept. Also, the maximum leveled RF power available from a particular Sweep Oscillator depends upon the frequency range being swept and the output power characteristic of the microwave oscillator (BWO). Figure 3-11 shows the output power characteristic of a typical 1 - 2 Gc oscillator and indicates the maximum leveled RF power available for three sweep ranges. Dot shading indicates maximum leveled power available over the full frequency range; diagonal shading shows additional leveled power available in segments of the frequency range. Microwave oscillators in the frequency range 2 - 12.4 Gc have similar output power characteristics; that is, RF output is minimum toward the lower frequency limit of the tuning range and increases with frequency to a maximum at, or near, the upper limit of the tuning range. However, actual maximum and minimum RF power available varies from frequency range to frequency range and from BWO to BWO in the same frequency range. Therefore, a microwave power meter such as the hp 431B with appropriate thermistor mount is required both for determining maximum leveled RF power and for obtaining required RF power.

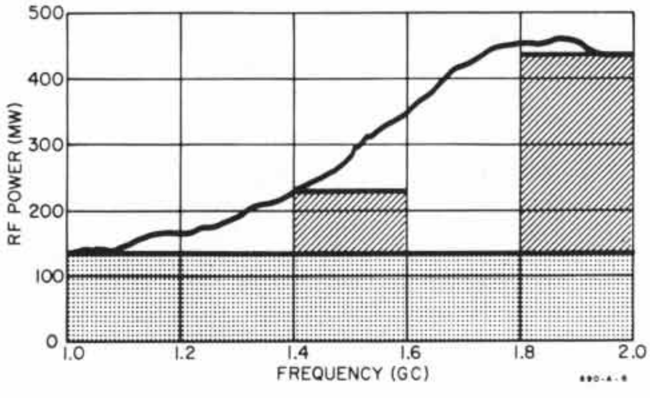


Figure 3-11. Comparison of Maximum Leveled RF Power and Frequency Range Swept

Table 3-1. Coaxial Leveling Equipment

hp EQUIPMENT	FREQUENCY RANGE			
	1 - 2 Gc	2 - 4 Gc	4 - 8 Gc	8 - 12.4 Gc
Sweep Oscillator	691A	692A	693A	694A
Low-Pass Filter	360C	360D		
Bandpass Filter	8430A	8431A	8435A	8436A
Directional Coupler	796D	797D	798C	
Crystal Detector	423A	423A	423A	423A
Directional Detector	786D	787D	788D	789C
Power Meter	431B	431B	431B	431B
Thermistor Detector	478A	478A	478A	478A (to 10 Gc)

Table 3-2. Waveguide Leveling Equipment

hp EQUIPMENT	FREQUENCY RANGE				
	2.60 - 3.95 Gc	3.95 - 5.85 Gc	5.85 - 8.2 Gc	7.05 - 10.0 Gc	8.2 - 12.4 Gc
Sweep Oscillator	692A	693A	693A	693A, 694A	694A
Waveguide-to-Coaxial Adapter	S281A	G281A	J281A	H281A	X281A
Low-Pass Filter	360D				X362A
Bandpass Filter	8431A				8436A
Directional Coupler	S752D	G752C	J752C	H752C	X752C
Crystal Detector	S424A	G424A	J424A	H424A	X424A
Directional Detector					X781A
Power Meter	431B	431B	431B	431B	431B
Thermistor Detector	S486A	G486A	J486A	H486A	X486A
Matched Directional Couplers[1]	SE01-752D	GE01-752C	JE01-752C	HE01-752C	XE01-752C

[1] Consist of 3-db coupler with load matched to 10 (752C) or 20 (752D) db coupler.

3-102. LEVELING EQUIPMENT.

3-103. The leveling amplifier in the Sweep Oscillator is intended for use with hp 423A and 424A Crystal Detectors, hp Directional Detectors, and the hp 431B Power Meter. Since these components are available in both coaxial and waveguide models, RF leveling is possible in either transmission system. Components for coaxial RF leveling systems are listed in Table 3-1, components for waveguide leveling systems in Tabel 3-2.

3-104. THE RF SAMPLER. The RF power output of the Sweep Oscillator can be sampled either by a directional coupler or a directional detector. A directional detector is a directional coupler matched to a sensitive, flat-responding crystal detector. With the directional detector, performance variables such as coupling variation with frequency, detector frequency response, and coupler-detector match are grouped and specified as frequency response.

3-105. Whether the RF sampler is a directional coupler or directional detector there is a critical coupling attenuation required to assure proper operation of the leveling loop. Coupling attenuation should be 20 to 23 db with the Models 691A and 692A, and 10 to 13 db with the Models 693A and 694A. In addition, the smaller the coupling variation with frequency and the greater the directivity, the better the leveling.

3-106. THE RF DETECTOR. Either a crystal detector or microwave power meter may be used to derive the dc signal proportional to RF power variations required to operate the leveling amplifier in the Sweep Oscillator. The leveling amplifier, which must receive a negative polarity signal, is intended for use with hp 423A and 424A Crystal Detectors, the hp 431B Power Meter and hp Directional Detectors.

3-107. A crystal detector permits use of the full sweep time range of the Sweep Oscillator. Thus, sweeping time can be short enough to give steady oscilloscope display of swept-frequency measurements, a capability especially useful for continuous display of the effects of tuning or adjusting a device under test.

Table 3-3. Leveling Performance of Coaxial Leveling Loops

Leveling Loop	Maximum Power Variation (db)[1]							
	Load SWR = 1				Load SWR = 1.5			
	1 - 2 Gc	2 - 4 Gc	4 - 8 Gc	8-12.4 Gc	1 - 2 Gc	2 - 4 Gc	4 - 8 Gc	8-12.4 Gc
Figure 3-12 with Coupler and Detector	±0.66	±0.68	±0.72		±0.82	±0.88	±0.92	
Figure 3-12 with Directional Detector	±0.40	±0.40	±0.40	±0.60	±0.56	±0.60	±0.60	±0.80
Figure 3-15	±0.46	±0.48	±0.50		±0.62	±0.68	±0.70	

[1] Worst case: Errors summed arithmetically (see Paragraph 3-112).

Table 3-4. Leveling Performance of Waveguide Leveling Loops

Leveling Loop	Maximum Power Variation (db)[1]									
	Load SWR = 1					Load SWR = 1.5				
	2.60 - 3.95 Gc	3.95 - 5.85 Gc	5.85 - 8.2 Gc	7.05 - 10.0 Gc	8.2 - 12.4 Gc	2.60 - 3.95 Gc	3.95 - 5.85 Gc	5.85 - 8.2 Gc	7.05 - 10.0 Gc	8.2 - 12.4 Gc
Fig. 3-13 with Coupler and Detector	±0.94	±0.94	±0.94	±0.94	±1.04	±0.98	±0.98	±0.98	±0.98	±1.08
Fig. 3-13 with Directional Detector					±0.60					±0.64
Fig. 3-14	±0.64	±0.64	±0.64	±0.64	±0.74	±0.68	±0.68	±0.68	±0.68	±0.78
Fig. 3-16	±0.68	±0.72	±0.72	±0.72	±0.72	±0.72	±0.76	±0.76	±0.76	±0.76
Fig. 3-17	±0.46	±0.50	±0.50	±0.50	±0.50	±0.50	±0.54	±0.54	±0.54	±0.54

[1] Worst case: Errors summed arithmetically (see Paragraph 3-112).

3-108. The microwave power meter/thermistor detector combination gives continuous indication of both leveling performance and actual RF output of the leveling system, but characteristic slower response to RF variations requires sweep times longer than 30 seconds. A power meter leveling system is particularly well-suited to the slow sweeping used with graphic recording of swept-frequency measurements.

3-109. LOW-PASS OR BANDPASS FILTER. To minimize the effects of RF harmonics, which can degrade leveling and cause measurement errors, a low-pass or bandpass filter should be inserted into the RF main line within the leveling loop. Including the filter in the leveling loop provides automatic compensation for its transmission properties.

3-110. OSCILLOSCOPE MONITOR. For RF power leveling using a crystal detector, an oscilloscope should be used to indicate when the POWER LEVEL and GAIN controls are set to give optimum leveling. The oscilloscope can be connected to display leveling performance in the dc section of the leveling loop. A convenient monitor point on internally-leveled (Option 01) Sweep Oscillators is the rear-panel PWR METER connector. For standard Sweep Oscillators loop performance can be monitored at the rear-panel PWR METER connector or by means of a type BNC tee connector at the crystal detector video output or at the Sweep Oscillator XTAL input.

3-111. <u>LEVELING PERFORMANCE.</u>

3-112. The RF power leveling capability of the systems illustrated in Figures 3-12 through 3-17 is determined mainly by the frequency-dependent performance variables of the RF sampler and RF detector. Coupling variation with frequency, coupler-to-detector mismatch, coupler directivity and detector frequency response all affect leveling. The level variations given in Tables 3-3 and 3-4 are those resulting from the maximum effect of the error sources present in leveling loops assembled from components listed in Tables 3-1 and 3-2. However, the error effects in such leveling systems are vector quantities having phase relationships which vary with frequency and do not always cause maximum error. Rather, total error is more usually the rms of the error quantities. Therefore, leveling likely will be better than indicated but the performance figures given permit comparing the capabilities of the systems illustrated in Figures 3-12 through 3-17.

3-113. Two values of load SWR are included in the tables to indicate how the load on the leveling system influences leveling performance. This loading effect

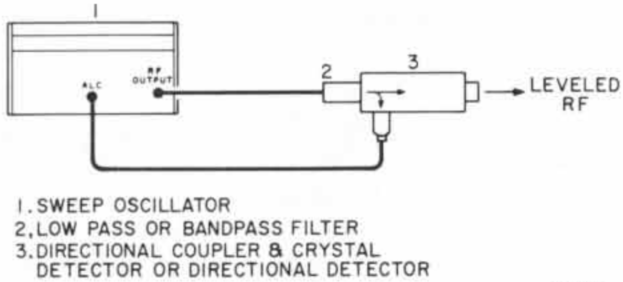


Figure 3-12. Coaxial Leveling Loop Using Crystal Detector

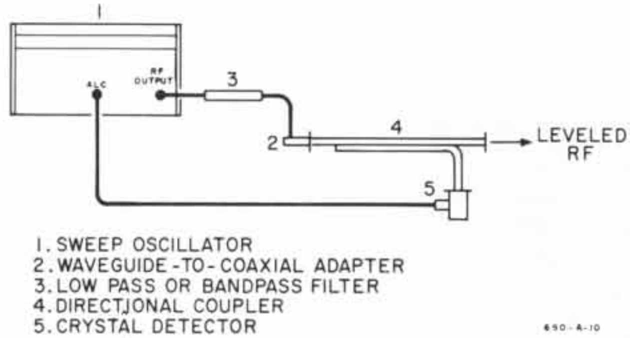


Figure 3-13. Waveguide Leveling Loop Using Crystal Detector

results from the imperfect directivity of the RF-sampling coupler which allows some of the power reflected from the load to reach the RF detector and cause level variations. For a given coupler load-produced level variation is proportional to load SWR.

3-114. LEVELING CONTROLS, INDICATORS AND INPUTS.

3-115. ALC PUSHBUTTON. The ALC pushbutton activates the internal leveling amplifier.

3-116. INT ALC PUSHBUTTON. On Option 01 Sweep Oscillators only, the INT ALC pushbutton activates an internal leveling system.

3-117. POWER LEVEL CONTROL. The two-section POWER LEVEL control sets magnitude of leveled RF power.

3-118. GAIN CONTROL. The GAIN control varies leveling loop sensitivity to RF level variations.

3-119. ALC PWR LEVELING INPUTS. The rear-panel ALC PWR LEVELING INPUTS switch sets the internal leveling amplifier to accept a power meter or crystal detector-derived leveling signal.

3-120. LEVELING SIGNAL INPUTS. The front-panel XTAL input accepts crystal detector-derived leveling signals, and the rear-panel PWR METER input accepts power meter-derived leveling signals. (The PWR METER input is a convenient oscilloscope monitor point during crystal detector leveling for both standard and Option 01 Sweep Oscillators.)

3-121. POWER LEVEL INDICATOR. The POWER LEVEL indicator functions only when the ALC (or INT ALC) pushbutton is pressed. When glowing steadily it indicates the entire sweep is leveled. When flashing it signifies all or part of the sweep is unleveled.

3-122. In general, the GAIN control determines the ability of the leveling system to reduce RF power variations and POWER LEVEL controls the magnitude of leveled power. Thus, GAIN can be considered an RF flatness control and POWER LEVEL an RF amplitude control. However, there is enough function overlap between GAIN and POWER LEVEL that the settings of both controls must be optimized during initial leveling adjustments and thereafter whenever RF amplitude is changed. Clockwise rotation of GAIN improves RF flatness but can cause the leveling loop to oscillate; hence, the optimum GAIN setting is just counterclockwise of that which causes loop oscillation.

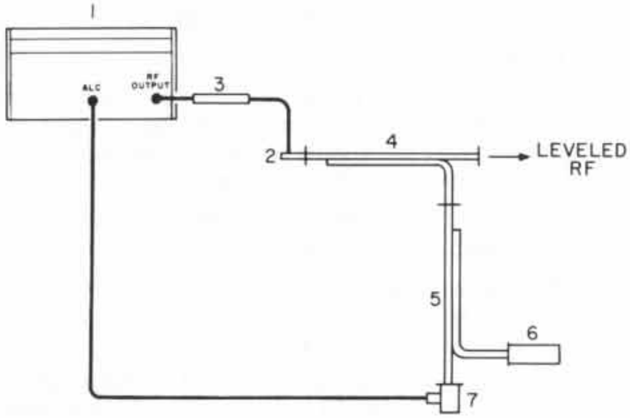
3-123. POWER LEVEL is a two-section control consisting of a screwdriver-operated shaft centered in a knob. The screwdriver-operated section is a coarse power level adjustment, the knob a fine or vernier adjustment. During leveling, if POWER LEVEL is set for more RF power than is available in some part of the selected sweep range the POWER LEVEL light flashes.

3-124. OPERATING MODES FOR RF POWER LEVELING.

3-125. RF power leveling imposes only two restrictions on the operating capability of the Sweep Oscillator, and both apply to leveling using a microwave power meter. During power meter leveling RF blanking is inoperative and sweep time must be longer than 30 seconds. Disabling of RF blanking is automatic and a function of the Sweep Oscillator whereas the sweep time restriction is due to the response characteristic of the power meter.

3-126. LEVELING AT THE RF OUTPUT.

3-127. Figures 3-12 through 3-17 illustrate closed loop leveling systems for automatically leveling the Sweep Oscillator RF power output. The systems of Figures 3-14 and 3-17 each use two directional couplers to minimize coupling variation with frequency. The coupling variation of one coupler compensates for the coupling variation of the other, reducing coupling inaccuracy to the difference in coupling characteristics between the couplers. This remaining factor can be effectively eliminated with couplers selected for nearly identical coupling characteristics. Such matched couplers are available from Hewlett-Packard in various combinations of coupling attenuation. For each combination, attenuation accuracy between main and secondary line output is specified and is typically ±0.2 db or better. Matched coupler model numbers for the waveguide frequency ranges covered by the Models 691A, 692A, 693A, and 694A are given in Table 3-2. Model numbers given provide correct coupling attenuation for the Sweep Oscillator of the same frequency range.



1. SWEEP OSCILLATOR
2. WAVEGUIDE-TO-COAXIAL ADAPTER
3. LOW PASS OR BANDPASS FILTER
4-5. MATCHED DIRECTIONAL COUPLERS
6. LOAD
7. CRYSTAL DETECTOR

690-A-8

Figure 3-14. Coupler-Compensated Waveguide Leveling Loop Using Crystal Detector

3-128. STANDARD SWEEP OSCILLATOR USING CRYSTAL DETECTOR.

3-129. LOOP ASSEMBLY.

a. Assemble the leveling loop of Figure 3-12, 3-13, or 3-14 using appropriate equipment from Table 3-1 or Table 3-2.

b. Connect crystal detector video output to Sweep Oscillator XTAL input.

c. Connect an oscilloscope to monitor leveling loop performance. Connect the oscilloscope vertical input (dc-coupled) to the rear-panel PWR METER connector or to a BNC tee connector at the crystal detector video output, and connect the horizontal input (dc-coupled) to the Sweep Oscillator SWEEP output.

3-130. LOOP OPERATION.

a. Set rear-panel ALC PWR LEVELING INPUTS to XTAL.

b. Obtain desired mode of operation from the Sweep Oscillator.

c. Rotate GAIN maximum clockwise.

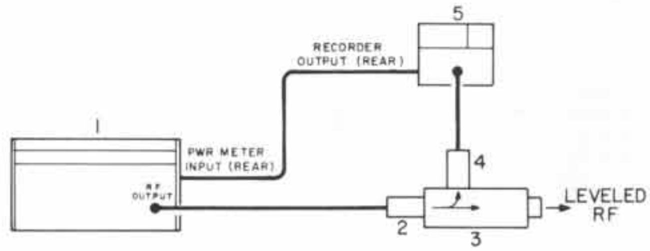
d. Press ALC.

e. Rotate POWER LEVEL knob to a convenient reference on the 0 to 10 scale. (For maximum resolution set to 10.)

f. If POWER LEVEL is set for more RF power than the least available in the selected sweep range, the POWER LEVEL light flashes. To level the entire sweep, rotate POWER LEVEL screwdriver-operated control until the POWER LEVEL light stops flashing. Leveled RF power is now the maximum available in the selected frequency range.

g. If the oscilloscope monitoring loop performance shows loop oscillation, adjust GAIN until oscillation just ceases. Always adjust GAIN and POWER LEVEL screwdriver-operated control in combination to assure maximum leveled RF power without loop oscillation.

h. To reduce leveled RF power rotate POWER LEVEL knob counterclockwise: attenuation range is 10 db, minimum. Readjust GAIN after each change of power level.



1. SWEEP OSCILLATOR
2. LOW PASS OR BANDPASS FILTER
3. DIRECTIONAL COUPLER
4. THERMISTOR DETECTOR
5. POWER METER

690-A-12

Figure 3-15. Coaxial Leveling Loop Using Power Meter

3-131. STANDARD SWEEP OSCILLATOR USING POWER METER.

3-132. LOOP ASSEMBLY. Assemble the leveling loop of Figure 3-15, 3-16, or 3-17 using appropriate equipment from Table 3-1 or Table 3-2.

3-133. LOOP OPERATION.

a. Set rear-panel ALC PWR LEVELING INPUTS to PWR METER.

b. Rotate both POWER LEVEL controls maximum clockwise and manually sweep the frequency range of interest noting the minimum RF power indicated by the power meter.

c. Rotate screwdriver-operated POWER LEVEL control maximum counterclockwise.

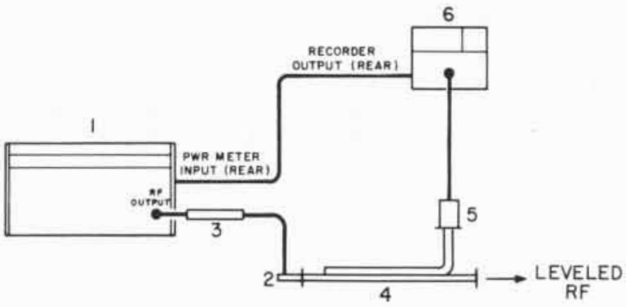
d. Rotate GAIN maximum clockwise.

e. Press ALC.

f. Set Sweep Oscillator to sweep the frequency range of interest. (Sweep time should be longer than 30 seconds when the ℏ 431B Power Meter is used.)

g. Rotate POWER LEVEL knob to some convenient reference on the 0 to 10 scale. (For maximum resolution set to 10.)

h. Allowing for the coupling attenuation of the directional coupler, rotate screwdriver-operated POWER LEVEL control clockwise until the power meter indicates the desired leveled power. Note that this power cannot exceed the minimum RF power in the frequency range being swept. If the POWER LEVEL light flashes during any portion of the sweep, selected power exceeds power available, and the RF power in a segment of the sweep is unleveled. To



1. SWEEP OSCILLATOR
2. WAVEGUIDE-TO-COAXIAL ADAPTER
3. LOW PASS OR BANDPASS FILTER
4. DIRECTIONAL COUPLER
5. THERMISTOR MOUNT
6. POWER METER

Figure 3-16. Waveguide Leveling Loop Using Power Meter

level the entire sweep, rotate POWER LEVEL knob counterclockwise in small increments, pausing a few seconds after each rotation to permit the loop to stabilize. When the entire sweep is leveled the POWER LEVEL light glows steadily during the sweeping interval.

i. To reduce leveled power rotate POWER LEVEL knob counterclockwise. POWER LEVEL attenuation range is 10 db, minimum.

j. The Model 431B Power Meter can be used to reduce leveled output in accurate 5-db steps. Switching the RANGE (MW) selector to successively more sensitive ranges decreases leveled RF power 5 db per range. Thus, from maximum, leveled output can be reduced at least 10 db. Within each 5-db step use POWER LEVEL for fine adjustment of leveled output.

k. The GAIN control permits optimizing leveling loop sensitivity to RF power variations. Clockwise rotation increases sensitivity. For optimum leveling set sensitivity as high as possible without causing the leveling loop to oscillate. Oscillation of a power meter leveling loop may cause erratic fluttering of the meter pointer on the power meter or may be evident only on an oscilloscope display of the leveled RF power.

3-134. <u>OPTION 01 SWEEP OSCILLATOR.</u>

3-135. LOOP ASSEMBLY.

3-136. Option 01 Sweep Oscillators, having internal leveling loops, require no external equipment to furnish leveled RF power. However, Option 01 Oscillators do require a power meter to indicate actual leveled power, and an oscilloscope to indicate optimum leveling. Note: Internal INT-EXT switch must be at INT to activate internal leveling loop.

3-137. LOOP OPERATION.

a. Set Sweep Oscillator for desired mode of operation.

b. Set rear-panel ALC PWR LEVELING INPUTS to XTAL.

c. Rotate GAIN maximum clockwise.

d. Press INT ALC.

e. If POWER LEVEL is set for more RF power than available in the frequency range being swept the POWER LEVEL light flashes. To obtain leveled RF power across the entire sweep range:

(1) Rotate screwdriver-operated POWER LEVEL maximum clockwise.

(2) Rotate POWER LEVEL knob to some convenient reference on the 0 to 10 scale. (Set to 10 for maximum resolution.)

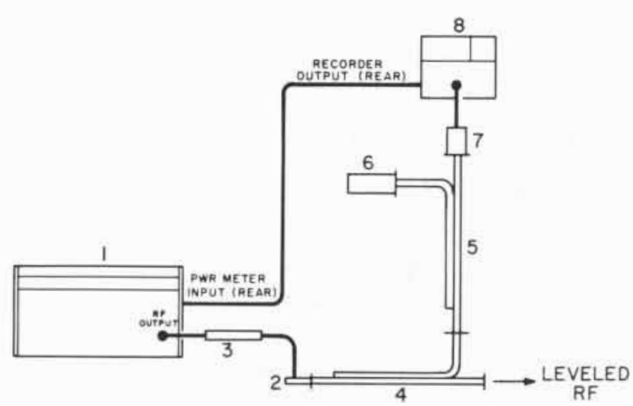
(3) Rotate screwdriver-operated POWER LEVEL until the POWER LEVEL light stops flashing and glows steadily during the sweep interval. Output RF power is now leveled at maximum possible in the selected frequency range.

f. To reduce leveled output rotate POWER LEVEL counterclockwise: attenuation range is 10db, minimum.

3-138. The GAIN control permits optimizing leveling loop sensitivity to RF power variations. Clockwise rotation increases sensitivity. For optimum leveling set sensitivity as high as possible without causing oscillation within the leveling loop. Because of function overlap between the POWER LEVEL and GAIN controls both should be adjusted to obtain optimum RF power flatness at desired RF output without evidence of loop oscillation. These adjustments can be made using an oscilloscope display of loop performance obtained at the rear-panel PWR METER connector.

3-139. <u>PREPARING OPTION 01 SWEEP OSCILLATORS FOR REMOTE-POINT LEVELING.</u>

3-140. Option 01 Sweep Oscillators can be readily adapted for use in a remote-point leveling system by disabling the internal leveling loop. Then the Oscillator can be used in the same way a standard Oscillator is used.



1. SWEEP OSCILLATOR
2. WAVEGUIDE-TO-COAXIAL ADAPTER
3. LOW PASS OR BANDPASS FILTER
4-5. MATCHED DIRECTIONAL COUPLERS
6. LOAD
7. THERMISTOR MOUNT
8. POWER METER

Figure 3-17. Coupler-Compensated Waveguide Leveling Loop Using Power Meter

3-141. To disable the internal leveling loop:

a. Remove the cabinet bottom cover.

b. On the directional detector mounting assembly, located behind the RF output, set the INT-EXT switch to EXT. The internal leveling loop is disabled and the Sweep Oscillator may be used as if there were no internal leveling loop. To restore internal leveling capability merely reposition the INT-EXT switch to INT.

3-142. DISPLAYING SWEPT-FREQUENCY MEASUREMENTS.

3-143. OSCILLOSCOPE DISPLAY.

3-144. The use of an oscilloscope in conjunction with a sensitive, fast-responding detector such as a crystal permits continuous visual display of swept-frequency measurements, a capability which is especially useful if a device is to be adjusted while under test.

3-145. For oscilloscope display the Sweep Oscillator SWEEP output furnishes the horizontal deflection signal. Since SWEEP output is a linear sawtooth voltage synchronized with the sweep, it provides an accurate axis of frequency for the display. In addition, automatic blanking of the RF output during retrace results in a continuous zero-power reference trace for the display.

3-146. The display oscilloscope should have direct-coupled vertical and horizontal inputs and 10-kc minimum vertical bandwidth. Reflection measurements can require vertical sensitivity of microvolts per centimeter: 50 to 100 $\mu v/cm$ is usually adequate. The ⓗ 140A Oscilloscope with 1400A and 1420A horizontal plug-ins satisfies these requirements.

3-147. Detailed information about improved measurement systems and calibration techniques for transmission studies using the Sweep Oscillator is available in ⓗ Application Note 65, Swept-Frequency Techniques with Oscilloscope Display. The Note contains: procedures for assembling, calibrating, and operating systems for transmission and reflection measurement using leveled ⓗ 690 series Sweep Oscillators with oscilloscope display of measurements; a list of measuring equipment for the 1 to 40 Gc frequency range; and a set of scales calibrated in reflection and transmission units which can be affixed directly to the oscilloscope graticule. Copies of Application Note 65 are available at no charge from your local Hewlett-Packard sales and service office.

3-148. X-Y RECORDER DISPLAY.

3-149. The X-Y graphic recorder affords a convenient means of permanently recording swept-frequency measurements, providing a plot of transmission variations with time or frequency. To facilitate X-Y recording, the Sweep Oscillator has manual sweep for recorder calibration; a linear ramp voltage output synchronized with output frequency to operate the recorder X-system; indication of sweep duration for positive determination of sweep start and stop; internally-generated, tunable frequency markers for accurate calibration of frequency range; and automatic pen lift to raise the recorder pen between sweeps.

3-150. Pen lift is intended for recorders equipped to raise the pen in response to an open circuit. The Sweep Oscillator rear-panel PENLIFT terminals are open-circuit in the interval between sweeps during CW and triggered sweep operation with either of the two slowest sweep time ranges.

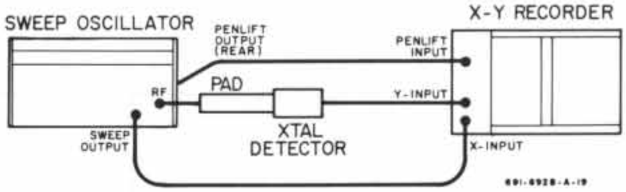


Figure 3-18. Typical X-Y Recorder Setup to Plot Sweep Oscillator Power Output Characteristic

3-151. RECORDER CALIBRATION.

3-152. Figure 3-18 shows a setup for X-Y plotting of the unleveled output power-frequency characteristic of the Sweep Oscillator. Other swept-frequency measurements for which the recorder is a popular display device include SWR, attenuation, gain, directivity, and leveling performance.

3-153. Calibrate the recorder as follows:

a. Set the Sweep Oscillator to sweep the frequency range of interest using a sweep time compatible with recorder response.

b. Set SWEEP SELECTOR to MANUAL.

c. Rotate MANUAL SWEEP maximum counterclockwise (for CW output at sweep start frequency), and adjust recorder Y-zero for convenient pen position.

d. Adjust recorder X-system to locate pen at a convenient start point.

e. Rotate MANUAL SWEEP from full counterclockwise to full clockwise (for CW output at sweep stop frequency) observing maximum vertical displacement of the pen during the sweep. Sweep termination is coincident with extinguishing of the SWEEP ON light.

f. Set recorder X-sensitivity to terminate recorder pen traverse at a convenient location on the chart, and adjust Y-sensitivity to give required resolution.

g. If sensitivity and zero of the recorder X and Y systems are interdependent, repeat steps d through f to ensure desired chart calibration.

h. Set SWEEP SELECTOR to AUTO or TRIG, depending on whether recurrent or triggered sweeping is required. For one-shot sweeps, set SWEEP SELECTOR to TRIG and press MANUAL TRIGGER to start sweep. (A sweep can be terminated and restarted by pressing MANUAL TRIGGER while a sweep is in progress.) The recorder pen lifts automatically during retrace if the recorder is equipped for pen lift in response to an open circuit.

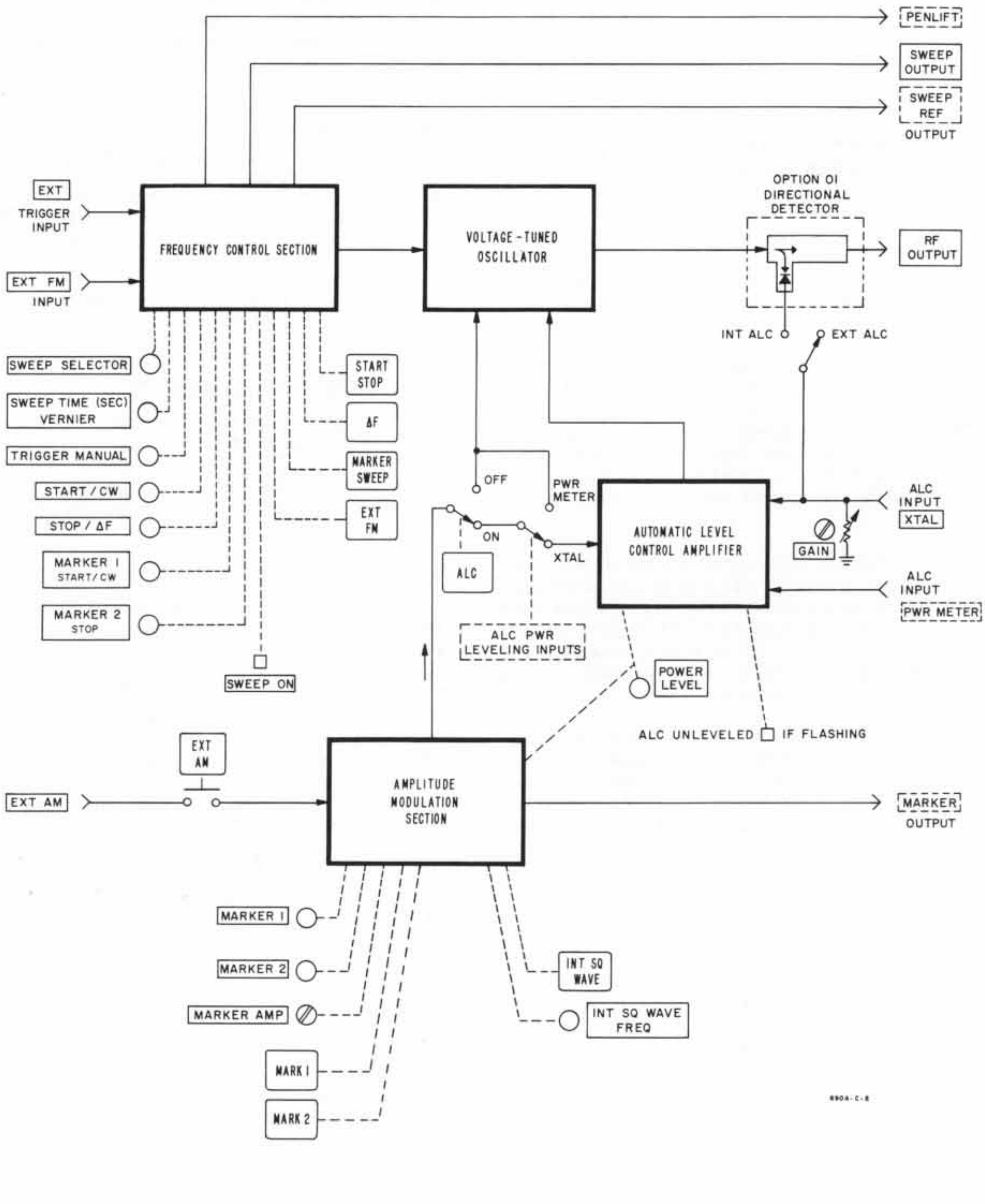


Figure 4-1. Simplified Block Diagram

SECTION IV
PRINCIPLES OF OPERATION

4-1. INTRODUCTION.

4-2. This section contains explanations of the operation of the Sweep Oscillator circuits. Figure 4-1 is a simplified block diagram showing principal circuit sections and operating controls. Figure 4-2, a more complete block diagram, shows the main constituents of the circuit sections. Each circuit section and important individual circuits are explained in succeeding paragraphs.

4-3. As illustrated in Figure 4-2, the Sweep Oscillator consists of a Voltage-Tuned Oscillator, a Frequency Control Section, an Amplitude Modulation Section, and a Power Supply Section. The Frequency Control Section includes the frequency-modulating circuits. The Amplitude Modulation Section includes a square-wave generator, two marker generators, and circuits for automatic RF output level control (ALC). The Power Supply Section includes automatic over-current and over-voltage protection for the Voltage-Tuned Oscillator.

4-4. THE VOLTAGE-TUNED OSCILLATOR.

4-5. The Voltage-Tuned Oscillator section (Figure 4-2) consists of Backward-Wave Oscillator Tube V4.

4-6. THE BACKWARD-WAVE OSCILLATOR TUBE.

4-7. The Backward-Wave Oscillator (BWO) tube, a voltage-tunable microwave oscillator, is the radio-frequency source in the Sweep Oscillator.

4-8. The BWO tube is an electron tube in which an electron beam interacts with a guided electromagnetic wave in a way to transfer energy from the beam to the wave. The elements of the tube and their arrangement are shown in Figure 4-3.

4-9. The tube consists of an electron gun, a wire helix through which an electron beam is directed, and a collector to receive the beam, all within a vacuum tube. The electron beam is hollow and focused to travel as close as possible to the helix without touching it. Beam focus is maintained by the field of a cylindrical permanent magnet encircling the vacuum tube. Physical construction is such that the magnet or its housing completely covers the tube and cannot be removed or adjusted in any way. Operating potentials are supplied to the tube elements through wire leads.

4-10. The wire helix is a microwave transmission line equal in length to several wavelengths of the lowest output frequency. The RF output signal is generated on the helix and is coupled out of the tube at the gun end through a dc blocking capacitor or balun. Approximate potentials required to operate the BWO are shown in Figure 4-3. Typical cathode current is less than 30 milliamperes and divides between anode and helix in BWO tubes having no collector, between helix and collector in BWO tubes having a collector. Helix and anode operating currents are critical operating parameters and must not exceed the power dissipating capability of the element.

4-11. Operating current maximums for the anode and helix are specified on the data sheet accompanying each new BWO tube. Because of wide variations in optimum operating currents and current division among BWO tubes of the same type, RF power output is the primary indicator of tube performance.

4-12. As the BWO is turned on, oscillation evolves from the shot noise in the electron beam. The shot noise in the beam induces noise voltages on the helix, and the noise voltages on the helix produce electron bunches in the beam. These electron bunches move toward the collector at a velocity controlled by accelerating potentials. As the electron bunches pass the spaces between helix turns their electric fields appear outside the helix. At some frequency these electric fields are in step (resonate) with the electron bunches along the helix and a backward-moving wave is generated. The backward wave further bunches the beam, the beam in turn amplifies the backward wave, and so on, until a maximum bunch density is reached. At this state the backward wave has maximum amplitude for the existing operating conditions.

4-13. Frequency of oscillation, a function of beam velocity, is set by the accelerating electrode which has the same potential as the helix. Frequency of oscillation varies linearly with time as helix voltage varies exponentially with time: the more positive the voltage, the higher the frequency of oscillation. In the Sweep Oscillator, the frequency-changing voltage is applied to both the helix and collector. In some BWO tubes the helix and collector are connected internally; in others, the collector element is operated at a more positive potential than the helix.

4-14. Output power is a function of beam current. Beam current is primarily controlled by grid bias or by the current supplied to the cathode. A secondary control of beam current is anode voltage, but anode voltage also affects output frequency. Power output increases noticeably as the frequency is increased, peaks near the center of the band and decreases slightly at the high end of the band.

4-15. Amplitude modulation is accomplished by a current generator in series with the BWO cathode. Cathode (beam) current can thus be controlled without changing the accelerating anode-cathode voltage, thus avoiding frequency pulling.

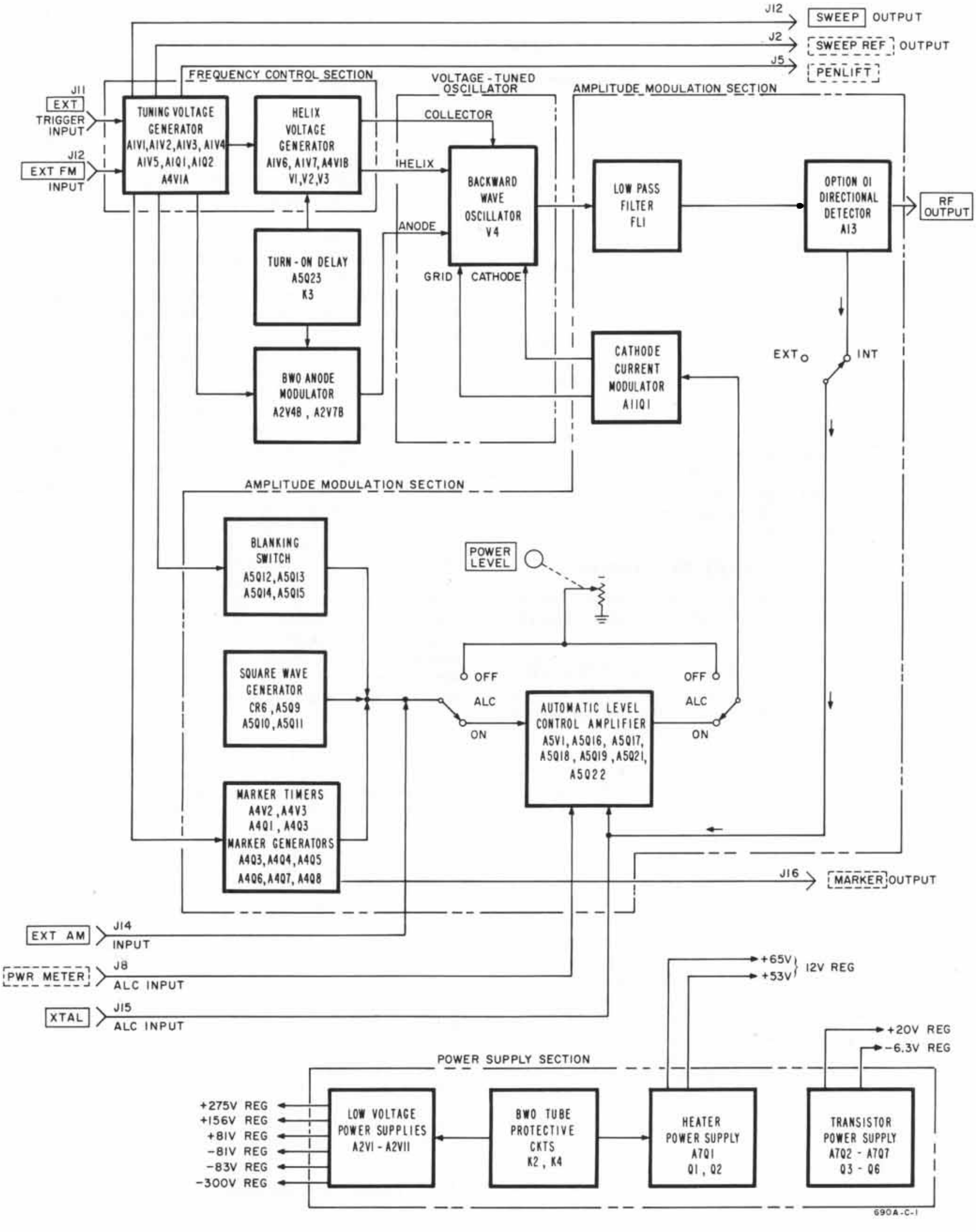


Figure 4-2. Block Diagram Showing Section Constituents

4-16. THE FREQUENCY CONTROL SECTION.

4-17. The Frequency Control Section determines the Sweep Oscillator output frequency. It generates a ramp that sweeps the RF output, or a dc voltage that produces single frequency output, or a combination ramp and dc voltage for narrowband sweeps, or a combination of a dc voltage and an external signal to give external frequency modulation. The section also furnishes automatically repetitive or triggered sweeps, and permits manual sweeping by a front-panel control as well as individual tuning of the frequency markers. The Frequency Control Section includes all of etched circuit board A1 and parts of etched circuit boards A4 and A8.

4-18. The Frequency Control Section consists of a Tuning Voltage Generator and a Helix Voltage Generator. The Tuning Voltage Generator (Figure 4-4) consists of a Ramp Generator that generates a linear, negative-going sawtooth, a Unity Gain Inverter that produces a mirror-image positive-going ramp, and a Ramp Combining Circuit that combines the two ramps and produces a continuously-adjustable ramp that is supplied to the Helix Voltage Generator for application to the BWO helix. This adjustable ramp controls the RF output connector for testing purposes. The approximate ramp voltage vs RF output frequency is shown by the graph in Figure 4-10.

4-19. The Frequency Control Section also supplies a positive-going sweep voltage for operating the X-system of graphic recorders and oscilloscopes, a penlift contact for lifting the pen of a recorder between sweeps, and an internal RF output blanking pluse that cuts off output power between sweeps.

4-21. THE RAMP GENERATOR.

4-22. GENERAL. The complete Ramp Generator (Figure 4-4) consists of Ramp Generator tube A1V1, Cathode Follower A1V2A with ramp limiting diodes A1CR8, A1CR9, and A1CR10 on etched circuit A1. The ramp generator tube produces a linear, negative-going sawtooth of fixed amplitude and adjustable period which is applied through switching circuits to the cathode follower and limiting diodes. These diodes establish the dc voltage limits at the start and stop ends of the ramp. The low-voltage end is clamped to near 0 volts by diodes A1CR9, A1CR10, and is

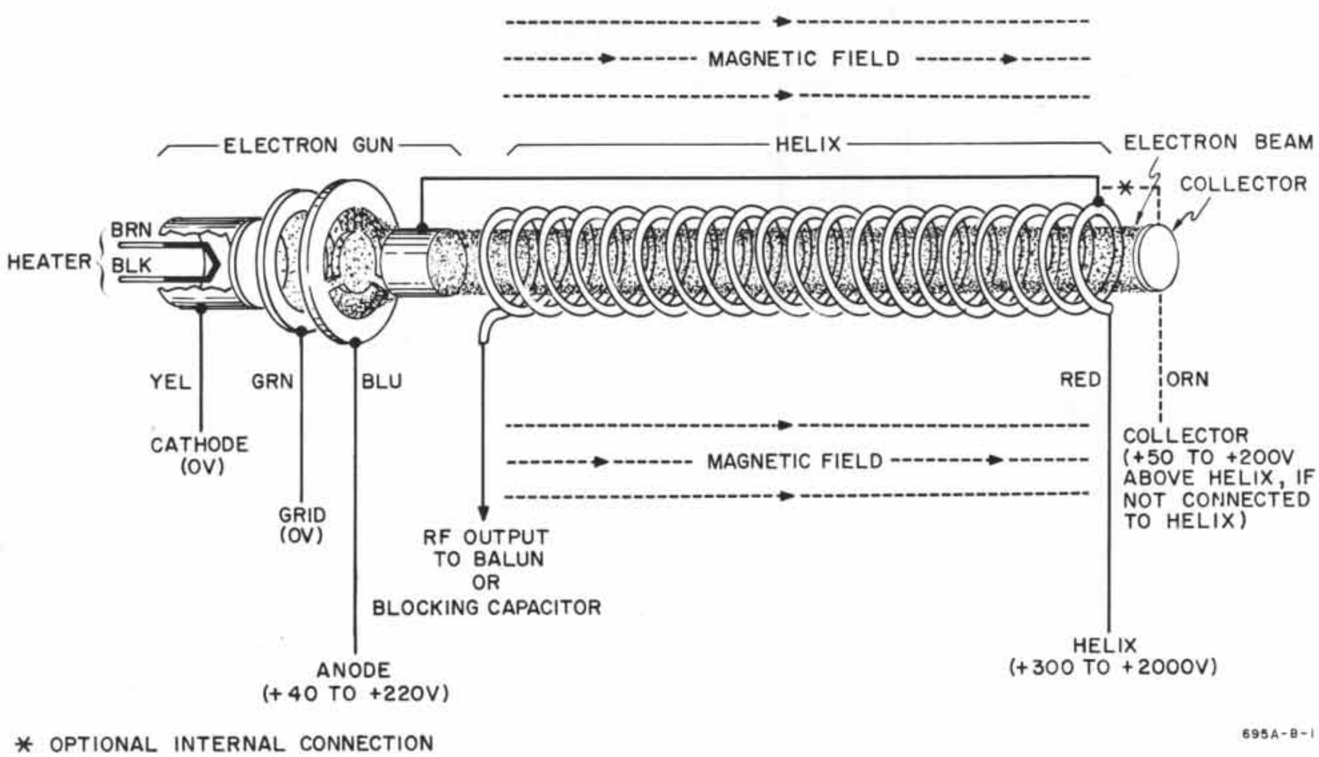


Figure 4-3. The Backward-Wave Oscillator Tube

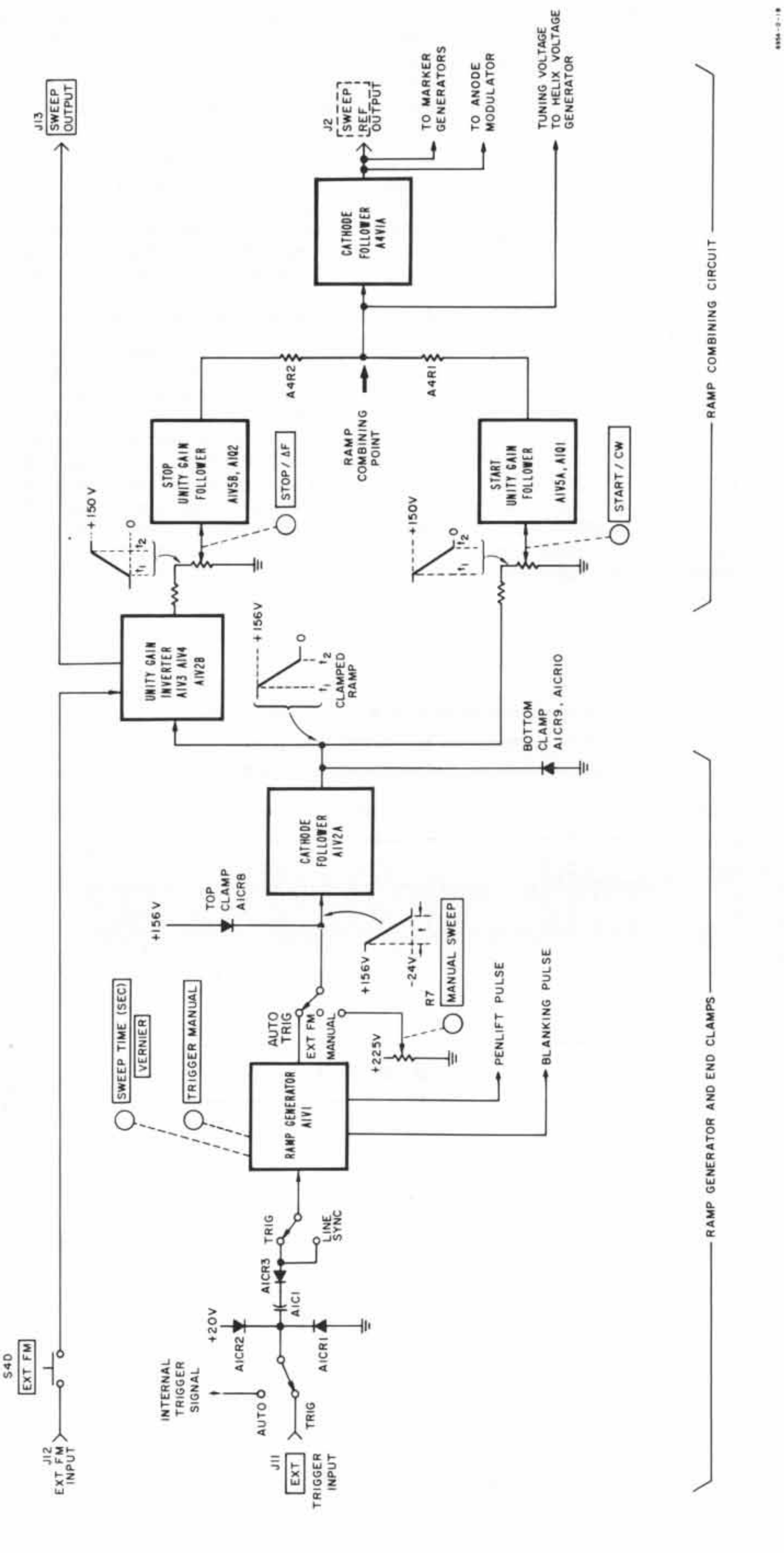


Figure 4-4. Tuning Voltage Generator Block Diagram

adjusted by A1R35. The high-voltage end is clamped by A1CR8 to the regulated +156-volt (±4 volts) supply. The clamped ramp is then applied to the START/CW side of the Ramp Combining Circuit and to the Unity Gain Inverter.

4-23. The Ramp Generator also supplies two output pulses during its flyback period: 1) a short negative pulse to the Blanking Switch to turn off the RF output during the flyback and, 2) a longer negative pulse to the Penlift Circuit that in turn provides a contact opening for lifting the pen of an external graphic recorder between sweeps.

4-24. The ramp generator tube operates in a free-run mode for automatically repetitive sweeps, in a trigger mode to start a ramp from a trigger received, or it can be switched off to permit manual frequency control.

4-25. RAMP GENERATOR OPERATION. Ramp Generator tube A1V1, a phantastron, has a two-stage cycle: 1) plate current cutoff, and 2) plate conducting current and producing a negative-going voltage slope.

4-26. The switching grid (pin 7) switches the tube from one stage to the other. Bias more negative than about -5 volts cuts off plate current and causes the screen grid (half of which is located ahead of the switching grid) to conduct heavily. Bias more positive than about -5 volts allows 1), plate current to flow and start a negative-going ramp and 2), screen current to decrease causing screen voltage to rise and light the SWEEP ON indicator. Note that although the SWEEP ON indicator lights at the start of a ramp, the RF sweep does not start until the ramp voltage crosses the + clamp voltage.

4-27. During AUTO operation, the switching grid receives plate current cutoff bias of about -13 volts from voltage divider A1R10, A1R11; during trigger operation, -40 volt bias is supplied from divider A1R16, A1R17. The bias required to turn plate current on is received from one of three places: 1) for manual trigger operation, pressing the TRIGGER MANUAL button applies a positive-going pulse from A1C7 directly to the switching grid; 2) for external triggering, an external negative pulse applied through C (Figure 4-5) to the control grid, causes a positive-going pulse on the screen grid which is coupled through A1R16 to the switching grid; and 3) for AUTO operation, the positive-going plate flyback is delayed by A1R8, A1C4, and applied through A1CR4 to the switching grid. The delay allows the Helix Voltage Generator to recover between sweeps. After plate current has been turned on by any of the foregoing methods, increased screen voltage forward-biases A1CR7 and A1CR6. A1CR6 maintains a positive voltage at switching grid pin 7 to keep A1V1 plate current flowing and complete the ramp.

4-28. After triggering, a "feedback integrator" circuit produces a linear, negative-going, voltage ramp at A1V1 plate. In the circuit, shown simplified in Figure 4-6, C is an integrating capacitor initially charged to the grid-plate voltage of A1V1 (about +235 volts).

4-29. At the instant of triggering, plate current is turned on abruptly by switching grid pin 7. The

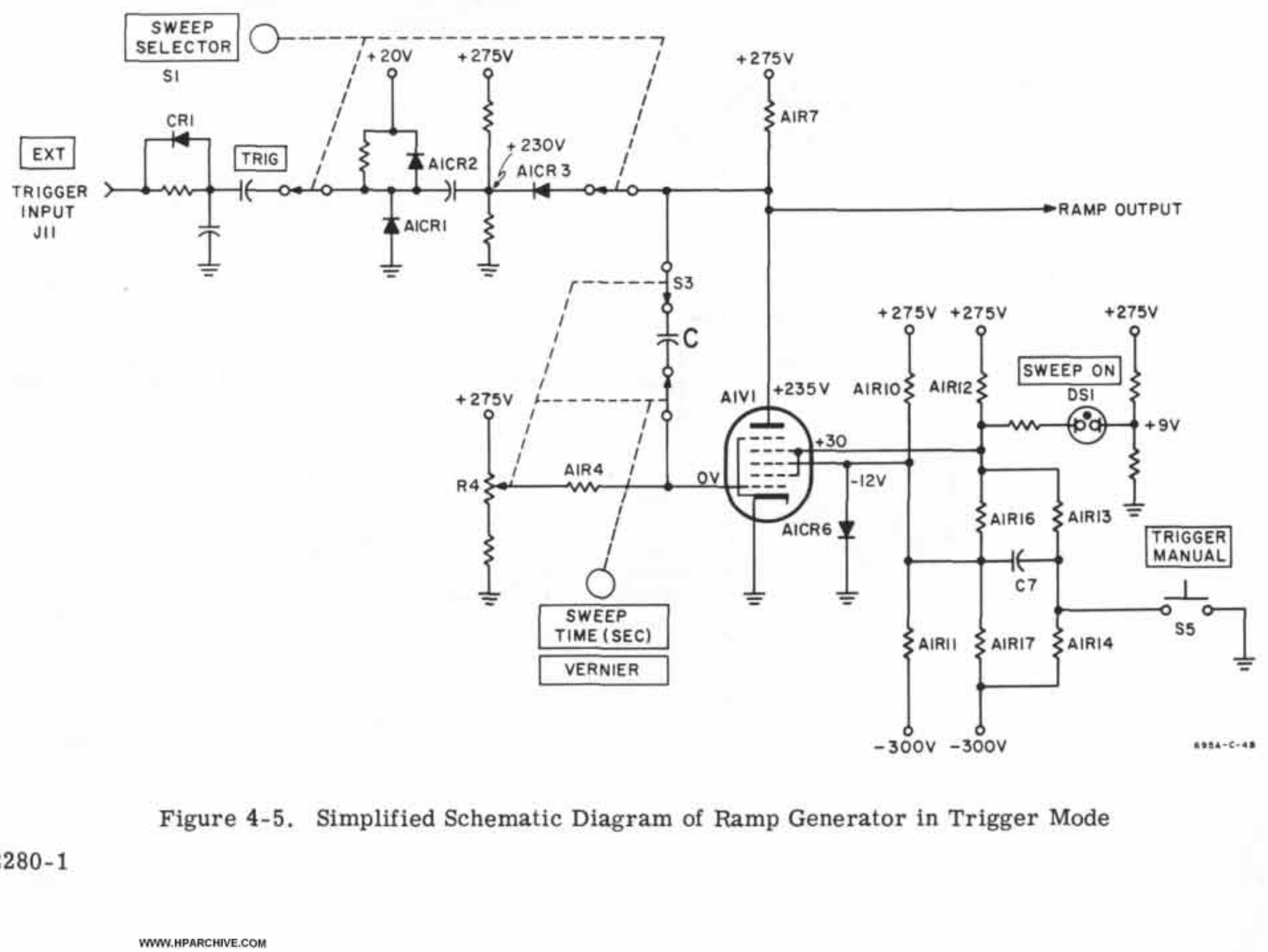


Figure 4-5. Simplified Schematic Diagram of Ramp Generator in Trigger Mode

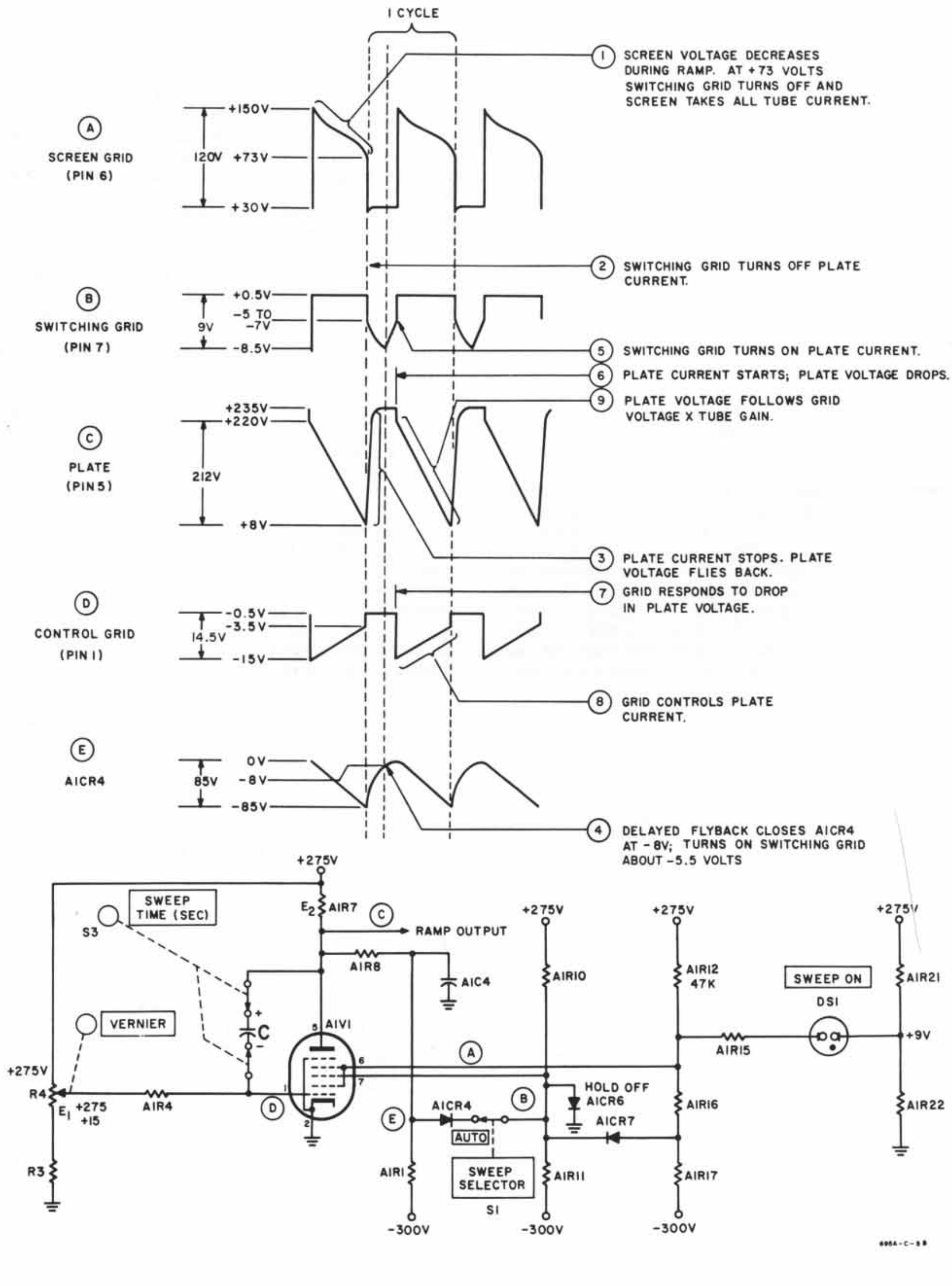


Figure 4-6. Simplified Schematic Diagram of Ramp Generator in Auto Mode

resultant sharp drop in plate voltage is coupled by grid-plate capacitor C to A1V1 control grid and steps grid voltage enough negative to cause the control grid to assume control of tube current. Capacitor C then begins discharging through the tube and resistors A1R4, R4 at a rate determined by the gain of the tube and the RC time constant.

4-30. As plate voltage falls, screen current increases and screen voltage decreases. At a screen voltage of about +73V the reduced voltage at A1R16, A1R17 junction opens diodes A1CR6 and A1CR7. A negative voltage from the A1R10, A1R11 junction is then applied to switching grid pin 7 and cuts off plate current. Plate voltage, control grid voltage and tube current rise sharply. The increased tube current goes to the screen grid reducing screen voltage to a saturation level of +30 volts. Capacitor C recharges through A1R7 and the circuit is ready for another cycle.

4-31. SWEEP TIMING. To provide the four decade sweep time ranges, the SWEEP TIME (SEC) selector connects a different capacitor in the circuit for each range. To provide continuous adjustment of time between ranges, the VERNIER potentiometer adjusts the voltage supplied to the grid circuit; the more positive the voltage, the faster the grid return, and the shorter the sweep time. To prevent a large transient from occurring as one of the four capacitors is switched into the circuit, those capacitors not in use are connected into a charging circuit that holds their charge equal to the plate-grid voltage before triggering.

4-32. EXTERNAL TRIGGER CIRCUIT. In the external trigger input circuit, Figure 4-5, diode CR1 passes only negative-going pulses from the EXT input connector, while clamp diodes A1CR1 and A1CR2 limit the amplitude of the input pulse to 20 volts. Coupling diode A1CR3 is forward-biased by A1V1 plate voltage between ramps to pass negative-going trigger pulses. After triggering, the plate voltage drops and back-biases A1CR3, disconnecting the trigger circuit from the integrator circuit. At the end of the plate flyback, plate voltage again forward-biases A1CR3 and the trigger circuit is reactivated.

4-33. MANUAL TRIGGER CIRCUIT. Manual triggers are generated by S5 (Figure 4-5). Before triggering, the junction of A1R16 and A1R17 is about -30 volts and the junction of A1R13 and A1R14 is about -45 volts, putting a 15-volt charge on A1C7. Pressing S5 grounds the negative side of this charge, thus applying the +15 volt charge to the switching grid (previously about -12 volts) to start a sweep.

4-34. During the Sweep, the A1R13, A1R14 junction is near +15 volts, the switching grid is +0.6 volt, and the charge on A1C7 is about 15 volts. Pressing S5 grounds the + end of A1C7, thus applying a -15 volt pulse to the switching grid which stops the sweep and returns the plate voltage to the start condition. Pressing S5 again starts another sweep.

4-35. BLANKING PULSES. The Ramp Generator produces two pulses, one for the penlift circuit, the other for internal blanking of the RF output signal. Both pulses are initiated from voltage divider A1R18 and A1R20 between A1V1 screen grid and -300 volts (Figure 4-7, point D). The lowered voltage of the screen grid between sweeps starts both pulses. The penlift pulse is taken directly from point D and lasts until the screen voltage again rises at the start of the next sweep. At the PENLIFT output connector, the penlift signal is an opening of relay contacts for the entire period between sweeps. The RF blanking pulse, obtained through A1CR5 (point C, Figure 4-7), is terminated before the end of the penlift pulse by the plate flyback voltage delayed by A1R5 and A1C3.

4-36. During the sweep, screen grid voltage drops in step with the plate voltage; point D is clamped to about +1.7 volts through A1CR5 to the bases of A5Q12 and A5Q13. At the end of the sweep, screen grid voltage drops to about +30 volts, and point D drops to about -7 volts cutting off emitter followers A5Q1, A5Q2 to de-energize K1 and open the penlift contacts.

4-37. During the sweep, point B is moving from positive to negative, but is clamped by A1CR5 to +1.7 volts at point D. At the end of the sweep, when A1CR5 is opened by the drop in screen voltage, point D is pulled negatively by point C to about -0.5 volt (the clamping voltage of A5CR13) initiating the blanking signal fed to A5Q12.

4-38. During plate voltage flyback point C voltage moves positive and, near the end of the flyback, moves through 0 volts opening A5CR13. Point C excursion stops at +1.2 volts ending the blanking pulse fed to A5Q12. Refer to the explanation of the Blanking Switch for further blanking action.

4-39. THE UNITY GAIN INVERTER.

4-40. For AUTO, Δ F, and MANUAL operation, the Unity Gain Inverter receives the negative-going ramp from the Ramp Generator. It produces a mirror-image, positive-going ramp having exactly the same period and dc voltage limits. This ramp is applied to the STOP/Δ F side of the Ramp Combining Circuit as shown in Figure 4-4.

4-41. The Unity Gain Inverter consists of differential amplifier V3, inverter amplifier V4, and cathode follower V2B located on etched circuit board A1 (upper chassis). Unity gain is achieved by using a degenerative feedback circuit around the entire inverter as shown in Figure 4-8. The gain of A1V4 is 70 to 75 db, but the net gain of the circuit is equal to the ratio of feedback resistor A1R65 to input (series) resistor A1R36. For swept and CW RF output signals, equal resistors give unity gain. For external frequency modulation, unequal resistors A1R52 and A1R53 are substituted to obtain amplification.

4-42. The voltage at (2), Figure 4-8, is preset to +78V, half the amplitude of the linear ramp from the Ramp Generator. When operating as a unity gain inverter, the circuit acts to maintain the voltage at (1) equal to the voltage at (2). To achieve this, the circuit produces a positive-going ramp at (3). The instantaneous ramp voltages at (3) and (4) are averaged by resistors A1R36 and A1R65 to produce about

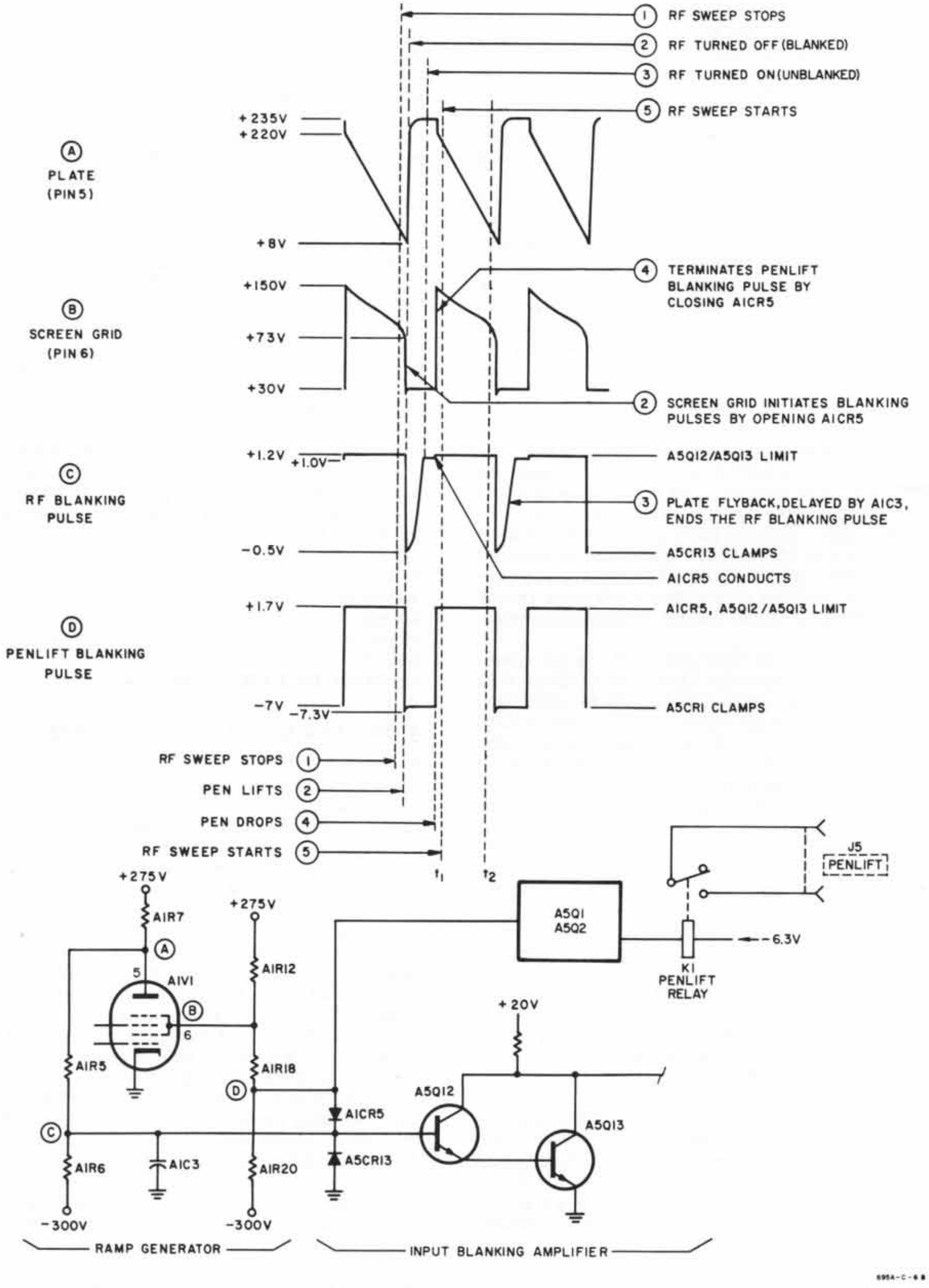


Figure 4-7. Simplified Schematic of Ramp Generator Blanking Pulse Circuit

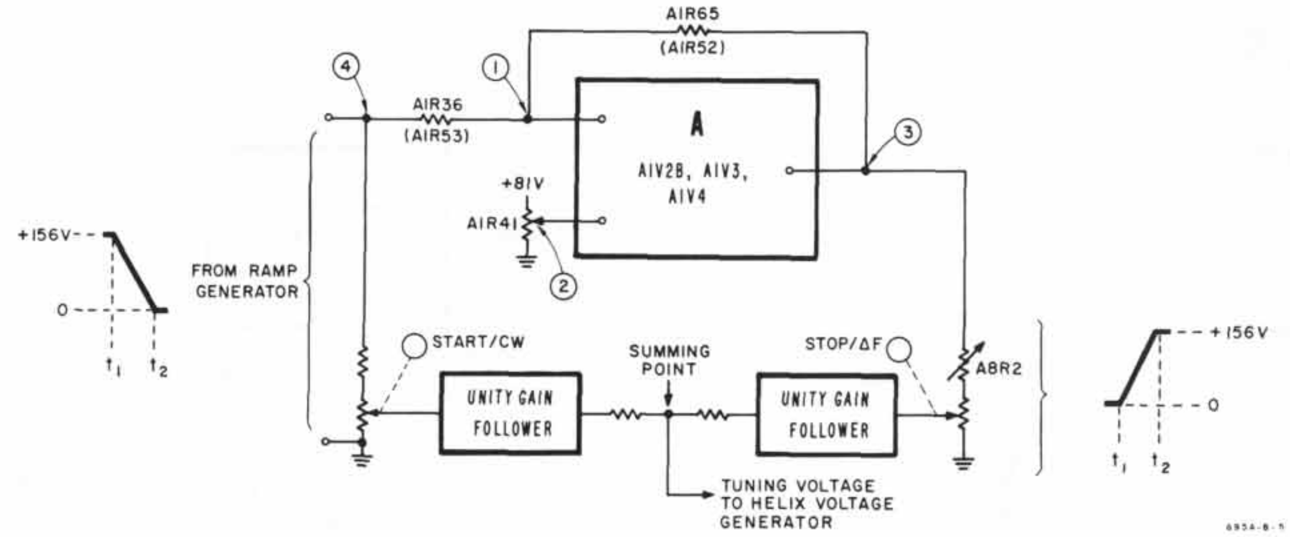


Figure 4-8. Unity Gain Inverter Functional Schematic Diagram

+78V at (1). The negative- and positive-going ramps supplied to the Ramp Combining Circuit must have exactly the same dc voltage limits. To obtain this equality, the dc voltage limits of the positive ramp from the Inverter are adjustable. A1R41 sets the low voltage limit, and A8R2 sets the high voltage limit.

4-43. When the Sweep Oscillator is set for external frequency modulation, the inverter circuit is modified by 1) replacing the dc reference voltage at A1V3, pin 7 with the modulation signal, 2) replacing equal resistors A1R36 and A1R65 with unequal resistors A1R52 and A1R53 to obtain 3:1 gain, and 3) substituting a dc reference from A1R55 for the ramp voltage. The A1R55 reference is adjusted so that there is no RF frequency shift when EXT FM is pressed and no modulating signal is applied. The amplified external FM signal, applied to the STOP/Δ F side of the Ramp Combining Circuit, modulates the dc level at the combining point.

4-44. Diodes A1CR13 and A1CR14 provide the voltage drop necessary to dc-couple the plate of the Inverter Amplifier A1V4 to the grid of cathode follower A1V2B or A1V5B.

4-45. When the Sweep Oscillator is set to produce a single frequency (CW mode of operation), the inverter is disconnected and the STOP/Δ F side of the combining circuit is grounded. The CW output frequency is then selected only by the START/CW side.

4-46. THE UNITY GAIN FOLLOWER.

4-47. The Unity Gain Followers A1V5A/A1Q1 and A1V5B/A1Q2 provide near unity coupling of the negative-going ramp from the START/CW potentiometer to the Ramp Combining Circuit, and of the positive-going ramp from the STOP/Δ F potentiometer to the other side of the Ramp Combining Circuit. The purpose of each follower is to couple the large (up to -150 volt) dc swing of the ramp input to the combining circuit with minimum loss in signal linearity and minimum loading of the potentiometers. This is done for the START/CW side through the emitter follower and diode A1Q1/A1CR11, with cathode follower A1V5A supplying a relatively constant base-collector voltage for the transistor. Diode A1CR11 provides a voltage across its junction that is equal and opposite to that across A1Q1 emitter-base junction and counteracts any voltage change in the emitter-base junction due to temperature. A1Q2/A1CR12 and A1V5B function in the same way for the STOP/Δ F side.

4-48. THE RAMP COMBINING CIRCUIT.

4-49. The Ramp Combining Circuit controls the dc voltage levels that determine the RF output frequency. The Ramp Combining Circuit consists of the START/CW and STOP/Δ F potentiometers R9 and R10 on the frequency dial mechanism, Unity Gain Followers Q1/V5A and Q2/V5B on etched circuit A1 (upper chassis) and combining resistors R1, R2 on etched circuit board A4 (upper chassis). Figure 4-9 shows how the FUNCTION pushbuttons and SWEEP SELECTOR connect the Ramp Combining Circuit for the different modes of operation.

4-50. During swept-frequency operation, the Ramp Combining Circuit receives the clamped, negative-going ramp from the Ramp Generator and the mirror-image, positive-going ramp from the Unity Gain Inverter, adjusts their amplitudes and feeds the adjusted amplitude through Unity Gain Followers to the ramp combining resistors. A resultant ramp of controllable amplitude and direction is produced and fed to the Helix Voltage Generator. By adjusting the amplitude of either or both ramps, the resultant ramp is made continuously adjustable and either positive- or negative-going. Figure 4-10 shows the combining circuit and a graph of two sample input ramps (E_1, E_2) and the resultant ramp (E_3). The instantaneous voltage at any point along the resultant ramp is equal to one half the sum of the voltages at E_1 and E_2 at the same instant. The approximate RF output frequency produced by the resultant ramp is shown by the scale on the right side of the graph.

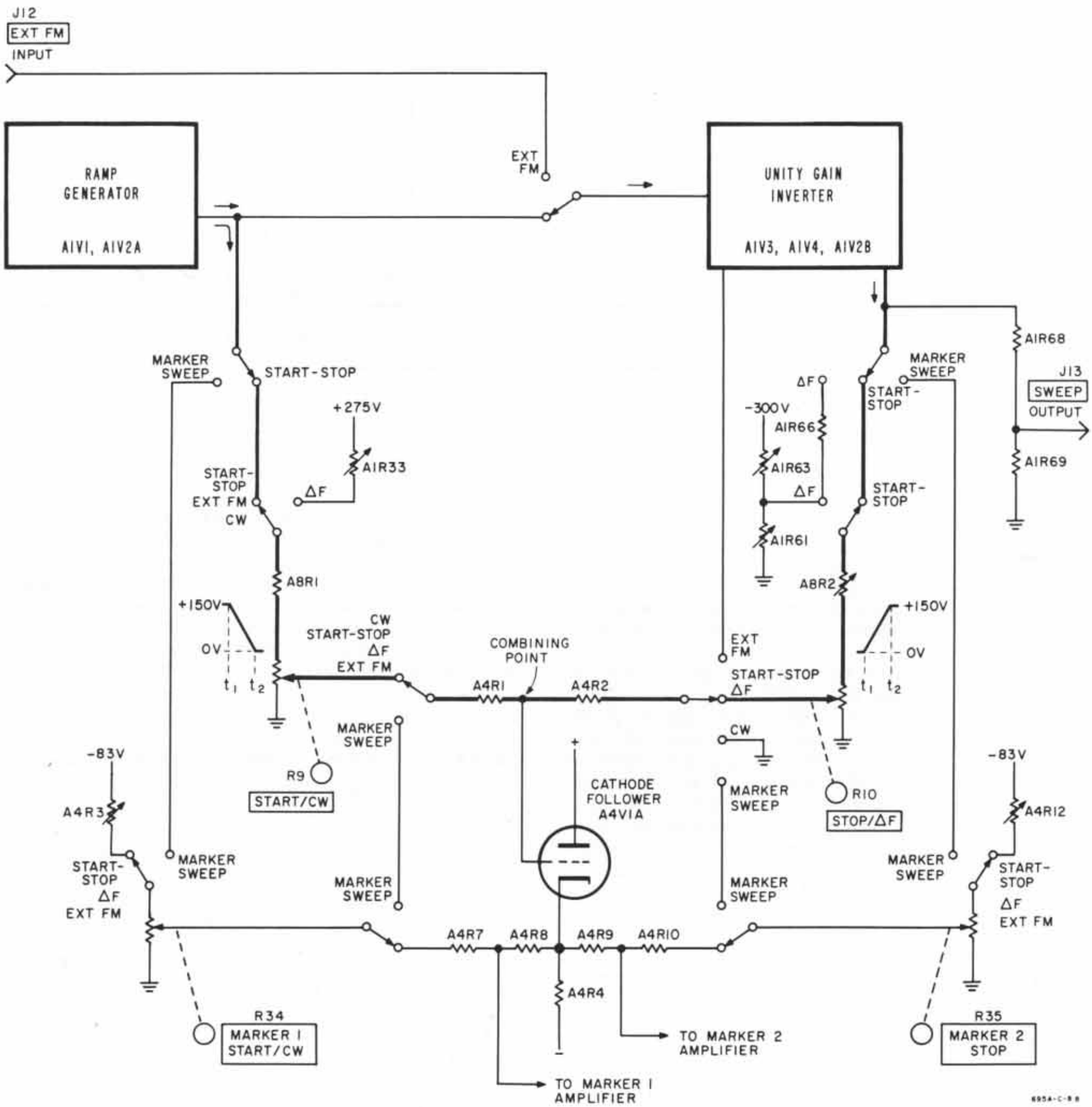


Figure 4-9. Function Switch Simplified Schematic Diagram

4-51. During ΔF operation, the ramp to the START/CW potentiometer is disconnected and replaced by a steady dc voltage equal to the upper limit of the ramp obtained from A1R33 (Figure 4-9). The ramp from the inverter is attenuated and applied to the STOP/ΔF potentiometer. The voltage at the combining point, selected by the START/CW potentiometer, is thus modulated by an amount set by the STOP/ΔF potentiometer. A1R61 adjusts the amplitude of the modulating ramp fed to the STOP/ΔF potentiometer to give a maximum ΔF sweep equal to 10% of the full bandwidth (about 15 volts at R10). To prevent shifting the CW (center) frequency set by the START/CW potentiometer as the amount of ΔF is changed, the voltage center of the modulating ramp must be set to exactly 0 volts. The attenuated ramp from A1V2B is all positive potential; A1R63 shifts the dc limits of the ramp negatively until they are equally above and below zero.

4-52. During CW operation, the Ramp Generator is turned off and the signal fed to the START/CW potentiometer is a steady dc voltage equal to the upper voltage limit of the ramp (+150 volts at R9) obtained from V2A cathode. The STOP/ΔF potentiometer is replaced by a ground. The voltage at the combining

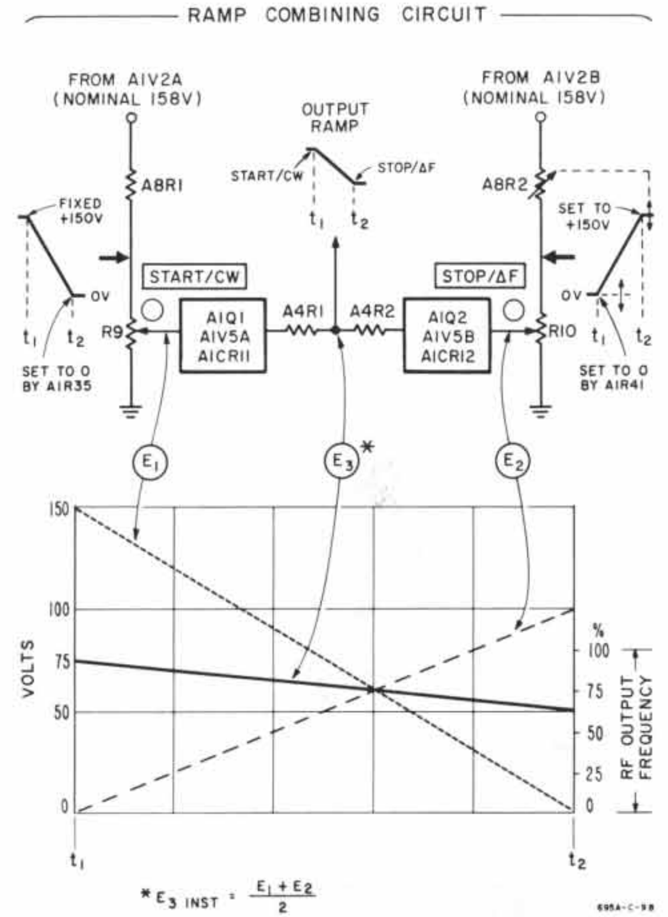


Figure 4-10. Ramp Combining Circuit Simplified Diagram

point is adjustable from 0 to +75 volts (giving full band coverage) by the START/CW potentiometer.

4-53. During EXT FM operation, the Ramp Generator is disconnected and the signal to the START/CW potentiometer is a steady dc voltage equal to the upper voltage limit of the ramp (+150 volts at R9) obtained from V2A cathode. The STOP/ΔF potentiometer is disconnected and replaced by the external modulation signal. The signal fed to the Helix Voltage Generator is thus a dc voltage that is continuously adjustable, by R9, from 0 to +75 volts and which is modulated by the external modulation signal.

4-54. During MARKER SWEEP operation, the MARKER 1 potentiometer is substituted for the START/CW potentiometer, and the MARKER 2 potentiometer is substituted for the STOP/ΔF potentiometer, without changing any other circuitry.

4-55. THE HELIX VOLTAGE GENERATOR.

4-56. To sweep the RF output frequency from the backward-wave oscillator tube linearly with time, the voltage applied to the helix must change exponentially with time. The Helix Voltage Generator (Figure 4-11) receives the linear sweep ramp or dc voltage from the Tuning Voltage Generator and converts it to an exponential voltage change within the limits required by the BWO helix and collector.

4-57. The Helix Voltage Generator consists of an electronically regulated power supply (similar to the +275-volt supply) for which V1, V2 and V3 on the lower chassis are the series regulators, A1V6 and A4V1B on the upper chassis are the differential "Comparison" amplifier, and A1V7 is the Control Amplifier.

4-58. There are two main differences between the Helix Voltage Generator and the power supply shown in Figure 4-14: 1) the dc reference voltage applied to one side of the Comparison Amplifier is replaced by the linear ramp from the Tuning Voltage Generator, and 2) the feedback voltage from the regulator output is obtained through a non-linear voltage divider (shown simplified in Figure 4-11); R_a is a linear element, R_b is the non-linear element. R_b consists of 9 diodes, each with a potentiometer in series, connected in parallel to the steps of a voltage divider. At the low-frequency end of the band, when the helix voltage is lowest, all diodes are non-conducting; R_b is potentiometers R1, R2. As the RF output frequency is tuned upward through the band, helix voltage increases, the diodes conduct one-by-one shunting R1, R2 with their series potentiometers and decreasing the value of R_b. Since the gain of the Differential "Comparison" Amplifier is proportional to the ratio R_a/R_b, as R_b decreases the gain increases.

4-59. Since BWO tuning characteristics vary slightly from tube to tube, the potentiometers adjust helix voltage to track the RF output frequency with the frequency dial. Note that as the output frequency increases, more diodes conduct; thus, setting of a lower frequency affects potentiometer settings for all higher frequencies.

4-60. Some BWO tubes require collector potential higher than helix potential. For these tubes, the additional collector voltage is supplied by an unregulated power supply (A6CR1, C12 and R16), the negative side of which is connected to the helix voltage. The collector thus tracks with the helix between 50 and 200 volts more positive.

4-61. In the regulator circuit, amplifier A1V7 provides the output voltage swing needed to produce the approximate 1000-volt variation from the series regulators. Clamp diode A1CR17 limits A1V7 grid-cathode voltage to about 7 volts during STANDBY operation when the helix voltage supply is disabled and grid voltage would otherwise drop to a very low level. Diode A1CR16 maintains a constant screen-cathode voltage to hold A1V6 gain constant with changing cathode voltage.

4-62. THE ANODE VOLTAGE GENERATOR.

4-63. Anode Voltage Generator A2V4B, A2V7B receives the tuning voltage from A4V1A and automatically raises BWO tube anode voltage in the lower half of the RF tuning range to coarse-level BWO output power. Tuning voltages for RF frequencies below midband are shifted negatively relative to ground potential in

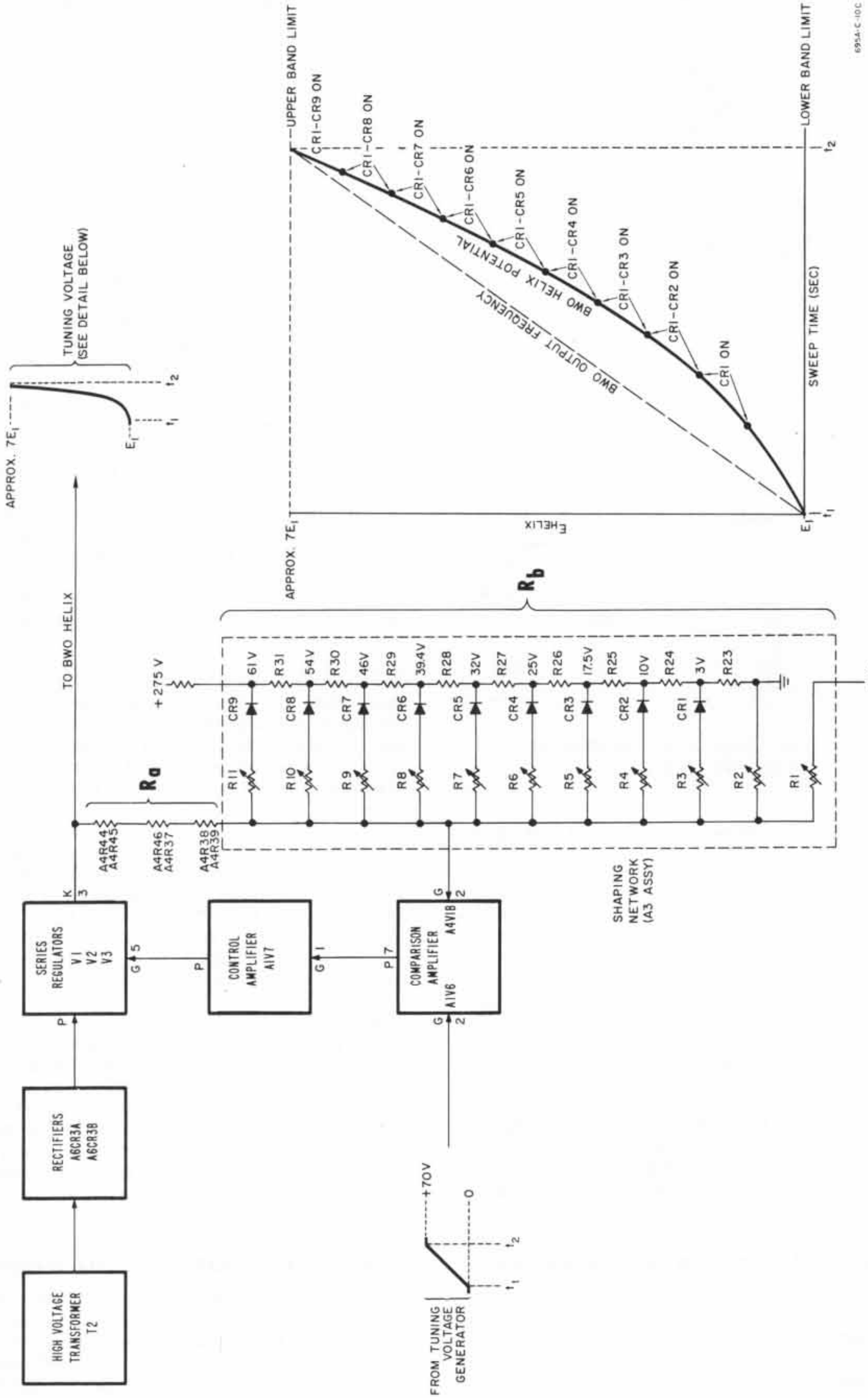


Figure 4-11. Helix Voltage Generator Block Diagram

divider A2R46, A2R47. Tuning voltages for RF frequencies above midband are clamped to ground by A2CR10. Tuning voltage at A2V4B grid is most negative at the lowest RF frequency, diminishes to near 0 volts about midband, and is static above midband. Anode Shape A2R48 sets the amount of anode voltage increase and A2R50, Anode Voltage, adjusts anode voltage to obtain cathode current specified by the BWO tube manufacturer.

4-64. During the turn-on time delay period, and during STANDBY operation, the BWO anode voltage obtained from A2V7B cathode is a low positive voltage that holds BWO cathode current cutoff. Relay K5 grounds A2V7B grid through A2R53, and holds the charge on C19A to low positive voltage. At the end of the turn-on time delay period K5 is energized, A2V7B grid is connected to A2R50 to establish operating voltage, but is clamped to the charge voltage on C19A. C19A charges through A2CR11 and A2R49 until A2CR11 is back-biased isolating A2V7B grid from C19A and allowing the anode voltage preset by A2R50 to be applied to the BWO tube anode. C19A then continues to charge through A2R54 and eventually opens A11CR3 and lights the RF on indicator DS3.

4-65. THE AMPLITUDE MODULATION SECTION.

4-66. The Amplitude Modulation Section consists of the BWO Cathode Current Modulator, Blanking Switch, Square-Wave Generator, Frequency Marker Section, ALC Amplifier, and the Option 01 Low-Pass Filter and Directional Detector.

4-67. All amplitude modulation and power level control signals are combined and fed to the Cathode Current Modulator. When the Automatic Level Control amplifier is in use, all amplitude modulation and power level control signals are routed with the ALC signal through the ALC amplifier before application to the Cathode Current Modulator.

4-68. THE BWO CATHODE CURRENT MODULATOR.

4-69. The BWO Cathode Current Modulator receives all amplitude modulation signals and applies them to the BWO cathode circuit. It consists of Q1 on etched circuit board A11 (lower chassis). Q1 is connected in series with the BWO cathode current. The RF power output is thus modulated without changing the BWO cathode-anode voltage and avoids the frequency pulling associated with grid modulation.

4-70. Clamp diode A11CR2 prevents excessive base-emitter voltages from being applied to A11Q1. Clamp diode A11CR1 prevents the BWO cathode from being driven negative. Diode A11CR4 provides a low-impedance path for grid current thus preventing negative self bias at the grid. Potentiometer A11R1 adjusts the grid-to-cathode voltage over a small range to minimize the RF frequency shift when the BWO cathode is driven to maximum current during a modulation cycle.

4-71. THE BLANKING SWITCH.

4-72. The Blanking Switch consists of transistors Q12 through A15 on lower chassis etched circuit board A5. The purpose of the switch is to provide automatic turn-off of the Sweep Oscillator RF power during automatically recurrent and triggered sweeping when the rear-panel BLANKING switch S15 is set to ON. Automatic RF blanking is possible with automatically leveled RF power, but only when the level-controlling signal is obtained from a crystal detector because the rear-panel ALC PWR LEVELING INPUTS switch S10 disconnects the blanking signal when set to PWR METER.

4-73. The Blanking Switch receives a 1.7-volt pulse from the Ramp Generator and supplies a concurrent negative 6-volt pulse for application directly to the BWO Cathode Current Modulator. The blanking pulse shape and timing with respect to the RF sweep is shown in Figure 4-7. The switch circuit presents a high input impedance to prevent loading A1R5 in the Ramp Generator and a low output impedance to drive the Modulator. Clamp diode A5CR13 terminates the pulse received from the Ramp Generator at -0.5volts and prevents excessive negative voltage at the base of A5Q12. The output pulse starts at ground potential and ends at -6 volts.

4-74 THE SQUARE-WAVE GENERATOR.

4-75. The Square-Wave Generator produces a square wave modulation signal that is adjustable over a small range centered on 1000 cps, and is supplied to the BWO Cathode Current Modulator. It consists of relaxation oscillator CR6, C8, R61, R43, and R44: Schmitt Trigger A5Q9, A5Q10; and Emitter Follower A5Q11 on etched circuit board A5.

4-76. In the relaxation oscillator, C8 charges through R43 and R44 toward +275 volts. At +20 volts, four-layer diode CR6 triggers itself into conduction, discharges C8, and the cycle repeats.

4-77. The sawtooth from the relaxation oscillator is coupled through A5C1 to A5Q9 switching A5Q9 in and out of conduction as the integrated sawtooth passes through 0 volts. Diode A5CR12 protects the base of A5Q9 from excessive negative voltage.

4-78. The output square wave from Emitter Follower A5Q11 is combined with Marker Modulation and fed through switching circuits to the Cathode Current Modulator.

4-79. THE FREQUENCY MARKER SECTION.

4-80. The Frequency Marker Circuits produce two independent frequency markers on the swept RF output at frequencies selected separately on the MARKER 1 and MARKER 2 controls. The complete Frequency Marker Section consists of two identical channels, one for MARKER 1, another for MARKER 2. In the following explanation, references to parts and circuits in the MARKER 1 channel apply equally to the MARKER 2 channel. The MARKER 1 channel consists of precision potentiometer R34 (MARKER 1) with digital indicator, a summing circuit A4R7, A4R8. Cathode Follower A4V3A, Amplifier A4Q1, Marker Generator A5Q3, A5Q4, and Emitter Follower A5Q5 (upper chassis).

4-81. The frequency marker pulses can be added to the START STOP sweep, Δ F, or external frequency modulation. Markers cannot be added to the MARKER sweep. To locate the marker at the desired RF output frequency, a duplicate of the RF frequency-controlling signal from A4V1A in the Ramp Combining Circuit is fed to the two marker channels in parallel. The instantaneous values along this ramp are compared against a dc reference voltage from the MARKER 1 control through equal resistors A4R7. A4R8 and a difference voltage is obtained from their junction. When this difference voltage passes through 0 volts, a frequency marker pulse is generated. The dc reference is adjustable so that the zero crossing can be positioned at the point on the input ramp that corresponds to the selected RF output frequency. For example, for a full band sweep upward in frequency, the ramp voltage input from the Frequency Control Section increases linearly from about +1 volt to about +76 volts. If, for instance, the selected Marker frequency is exactly midband, the voltage at the A4R7, A4R8 junction must cross zero when the input ramp crosses +38.5 volts. For this to happen, the voltage from the marker 1 control must be set for -38.5 volts. (Actually, the marker 1 control voltage must be slightly more negative to compensate for the grid-cathode voltage of Cathode Follower A4V2A). Frequency markers are obtained at any other frequency within the Oscillator tuning range by setting the MARKER 1 reference to equal the instantaneous ramp voltage which corresponds to the output frequency at which a marker is desired.

4-82. Although the foregoing explanation of marker triggering assumes START STOP sweep operation, marker triggering occurs in the same manner for ΔF and EXT FM operation.

4-83. The voltage at the junction of A4R7, A4R8 is amplified by A4Q1, and applied to Marker Generator A5Q3, A5Q4. As the voltage at the A4R7, A4R8 junction crosses zero going positive, it causes A5Q3 collector voltage to fall, and thus form the leading edge of the frequency marker pulse at the junction of A5R7, A5R10. At the same time, this positive-going input is coupled through A5Q3 to the emitter of A5Q4 and causes A5Q4 collector voltage to rise, and thus form the trailing edge of the frequency marker pulse at the junction of A5R7, A5R10.

4-84. The rise and fall of the collector voltages as the input signal goes from negative to positive, or positive to negative, and the resultant voltage at the resistor junction are shown in the graph in Figure 4-12. The resultant voltage, shown as a perfect "V" is the marker pulse obtained when the A5R12, A5R13 junction voltage is optimum. If the junction voltage

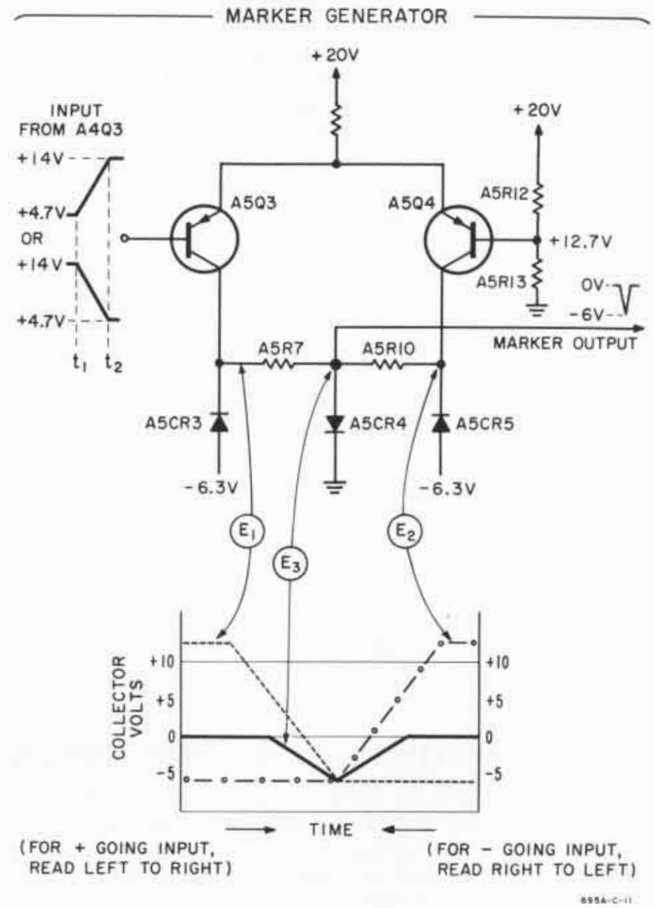


Figure 4-12. Marker Generator Simplified Schematic Diagram

is lower, the marker pulse will have a flat bottom; if higher, the pulse will be reduced in amplitude. During the ramp flyback, the Marker Generator is returned to its previous state and a second marker pulse is produced but is obscured by the blanking pulse.

4-85. Clamp diodes A5CR3 and A5CR5 limit the amplitude of the marker pulse and protect A5Q3 and A5Q4 from excessive negative collector voltages. Clamp diode A5CR2 prevents excessive negative voltage at the base of A5Q3; A5CR4 holds A5Q5 base voltage near 0 volts between marker pulses. A5CR6 couples the marker pulse to the BWO Cathode Current Modulator. Before and after the marker pulse, A5CR6 is back-biased to prevent amplitude modulation signals from being fed back into the Marker Generator.

4-86. The voltage at the A4R7, A4R8 junction is limited to between approximately -5 and -6 volts by clamp diodes A4CR1, A4CR2 to prevent excessive voltages from being applied to A4Q1. Cathode Follower A4V3A isolates the summing circuit from the transistor amplifier A4Q1. A4C4 (MARKER 1 Linearity) compensates for the input capacitance of A4V3A and is adjusted for minimum frequency shift with sweep time changes. A4R3 (MARKER 1 HF) sets marker 1 frequency equal to the MARKER 1 counter reading at the high end of the Oscillator tuning range. A4R20 (MARKER 1 LF) sets marker 1 frequency equal to the MARKER 1 counter reading at the low end of the Oscillator tuning range.

4-87. When MARKER SWEEP is selected, the grids of A4V2A and A4V2B are grounded, disabling the Frequency Marker Section. Frequency markers are thus not available when using the Marker Sweep. The marker sweep is simply a second sweep having all the characteristics of the START STOP sweep except that its start and stop frequencies are selected on the digital indicators instead of the slide rule dial, and it cannot include markers.

4-88. The marker sweep circuit consists of the MARKER 1 START/CW (R34) and MARKER 2 STOP (R35) potentiometers with calibration adjustments A8R3 and A8R4 respectively. When MARKER SWEEP is selected, R34 is connected into the Ramp Combining Circuit in place of R9 START/CW (see Figure 4-9) and performs all the functions of R9; R35 is connected into the Ramp Combining Circuit in place of R10; no other marker circuitry is operational. A8R3 and A8R4 calibrate the MARKER SWEEP so there is no difference in RF output frequency between the START STOP and MARKER sweeps for identical end-point settings.

4-89. THE AUTOMATIC LEVEL CONTROL AMPLIFIER.

4-90. The Automatic Level Control (ALC) Amplifier is for use in a negative-feedback system for reducing power level variations at the Sweep Oscillator RF output. In the feedback system, the ALC amplifier receives a negative dc signal voltage directly proportional to RF power from an external crystal detector or power meter. It compares this dc voltage against an internal dc reference voltage and develops a difference signal which is amplified, inverted, and applied to the BWO Cathode Current Modulator. The effect of this difference signal is to hold RF output power nearly constant as output frequency changes. The internal dc reference voltage is adjustable by the POWER LEVEL control R42B to provide manual control of RF output power.

4-91. The ALC Amplifier consists of a modulator, a differential amplifier, a leveling loop monitor and an output amplifier. The differential amplifier compares a voltage proportional to RF level to an internal reference voltage and provides a difference voltage. This difference voltage is applied to the BWO Cathode Current Modulator to reduce power level variations at the Sweep Oscillator output. For amplitude modulation of RF power leveled by a system using a crystal detector, modulator A5Q22 super-imposes amplitude modulation signals on the reference voltage. Leveling loop monitor A5Q21 flashes lamp DS2 when the differential amplifier output indicates the RF leveling loop is open. When the leveling loop is closed, A5Q21 holds DS2 lighted steadily. Output amplifier A5Q19 inverts and amplifies the differential amplifier output.

4-92. THE DIFFERENTIAL AMPLIFIER. The differential amplifier consists of two differential amplifiers that function as one. Double transistor A5Q16 forms an input differential amplifier, and A5Q17, A5Q18 form an output differential amplifier. A5V1 couples the high impedance collectors of the input amplifier to the low impedance base circuits of the output amplifier. Reference voltage for the differential amplifier, obtained from POWER LEVEL control R42B, is applied to A5Q16B base. A voltage proportional to RF power is applied to A5Q16A base, and a difference voltage is obtained at A5Q18 collector.

4-93. Screwdriver-operated POWER LEVEL R42C, shunting R42B, determines the range of reference voltage available from R42B.

4-94. The effectiveness of the RF power leveling system depends upon the gain of the ALC amplifier and the sensitivity of the RF power-sensing device. GAIN control R59 compensates the sensitivity of the RF power-sensing device to (1), prevent leveling system oscillation at high POWER LEVEL settings when system gain is high, and (2), to optimize leveling performance at low POWER LEVEL settings when system gain is reduced. GAIN potentiometer R59 attenuates the signal from both crystal detectors and power meters.

4-95. Typical power meters using thermistor RF detectors have extremely narrow bandwidth, while the ALC Amplifier normally has much greater bandwidth. To prevent the leveling loop from oscillating when the ALC Amplifier is set to level from a power meter, gain-shaping networks A5C4, A5R43 and A5C8, A5R57 reduce the bandwidth of the ALC Amplifier to nearly equal that of the power meter. Diodes A5CR14 and A5CR15 prevent reverse voltage from being applied to electrolytic capacitors A5C4 and A5C8.

4-96. A5Q16 is a dual transistor to equalize dc drift with temperature between the two sides of the input differential amplifier. ALC BALANCE potentiometer A1R48 balances voltage distribution in the input and output differential amplifiers. The effect of this balance is voltages within 0.1 mv of equal at the bases of A5Q16A and A5Q16B during RF power leveling. An indication of significant difference between these voltages is a step in the normally straight-line, between-sweep Oscilloscope display of blanked RF power.

4-97. THE LEVELING LOOP MONITOR. The leveling loop monitor consists of A5Q21 and lamp DS2. A5Q21 monitors the difference signal output of the differential amplifier at A5Q19 collector and lights DS2 when the ALC Amplifier is leveling the Sweep Oscillator RF power output. During leveling A5Q19 collector voltage reduces current through A5Q21 and

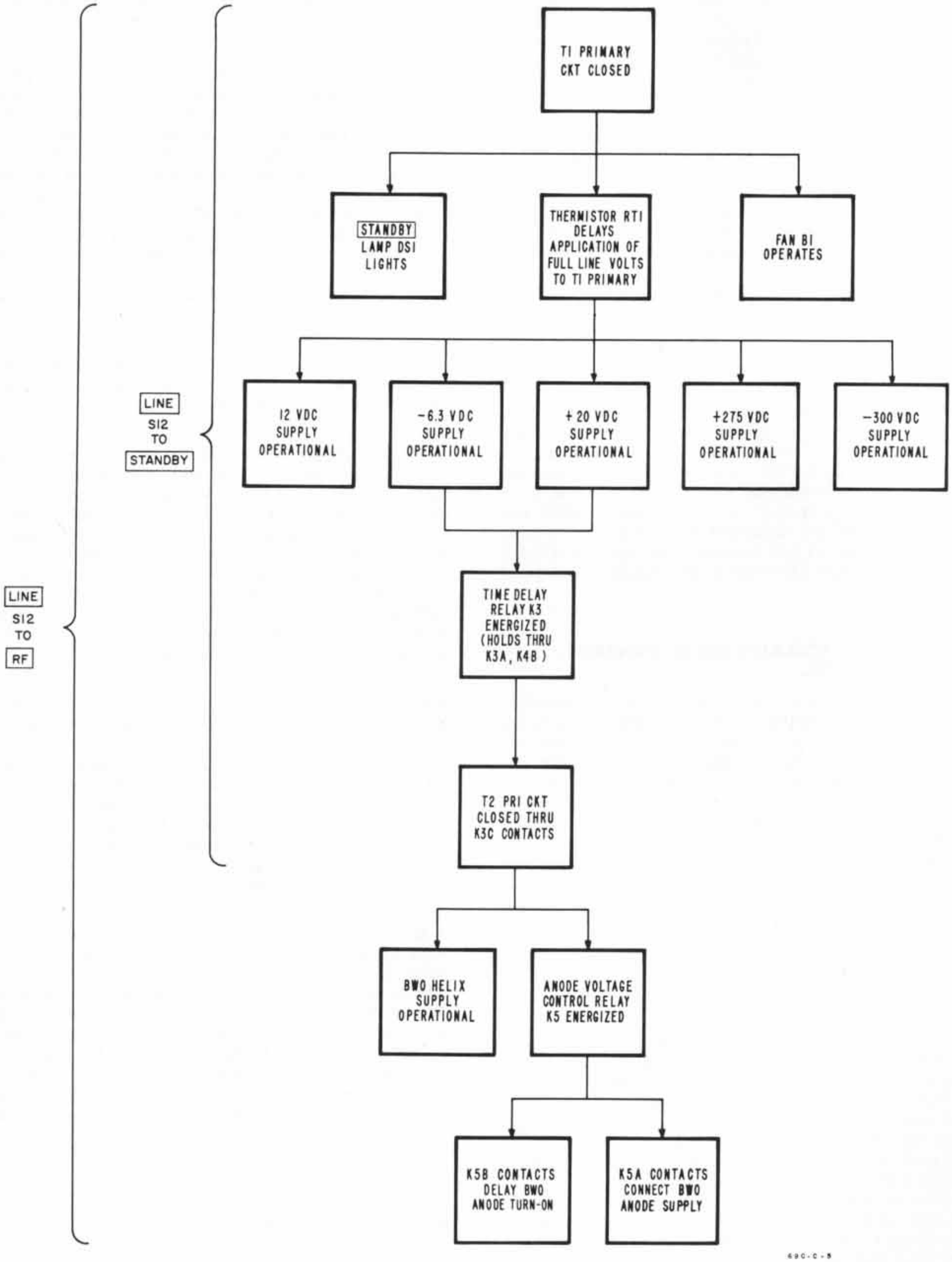


Figure 4-13. Turn-On Sequence Diagram

allows DS2 to glow from current supplied through A5R68 and A5R69. If the RF leveling loop opens, A5Q19 collector voltage rises and turns on A5Q21 placing DS2 directly across A5C11 to form a relaxation oscillator. The relaxation oscillator flashes DS2 to indicate an open condition in the leveling loop.

4-98. OPTION 01 DIRECTIONAL DETECTOR.

4-99. Directional Detector unit A13, supplied with Option 01 Sweep Oscillators only, completes an internal RF power leveling loop. The Directional Detector is a directional coupler with a crystal detector at the secondary line output. Located between the output of the BWO tube and the Sweep Oscillator RF output, the Directional Detector samples RF power output and converts level variations in the sample to proportional dc. During automatic leveling, this dc signal is applied to the ALC Leveling Amplifier which reduces RF level variations. INT-EXT switch A12S1, on the Directional Detector mounting bracket, must be at INTernal for internal RF power leveling. The EXTernal position opens the internal leveling loop to permit external remote-point and power meter leveling.

4-100. LOW-PASS FILTER.

4-101. Low-Pass Filter FL1, supplied with Option 01 Models 692A, 693A and 694A Sweep Oscillators, is a passive low-pass RF filter with cut-off frequency close to the upper limit of the Sweep Oscillator frequency range. The filter eliminates harmonic effects which degrade RF power leveling.

4-102. THE PRIMARY POWER TURN-ON SEQUENCE.

4-103. Primary power turn-on to the Sweep Oscillator circuits occurs in timed stages to provide longer life and protection for the expensive BWO tube and other components. At turn-on, thermistor RT1 prevents a high-current surge in the ac-operated tube heaters and power supplies connected to T1. Initially, there is a 40-volt drop across RT1 that diminishes to 1 volt in about 15 seconds. Time delay circuit A5C12, A5R70, A5Q23, K3 prevents application of operating helix and anode voltages to the BWO tube before the BWO tube cathode reaches operating temperature. The delay period starts after the -6.3 and +20 volt supplies are turned on. A5C12 then begins to charge toward these voltages through A5R70. Eventually (60-90 seconds), the charge on A5C12 forward-biases A5Q23 which actuates K3. Contacts of K3 energize T2 primary winding and actuate K5 to energize the helix and anode voltage generators. The primary power turn-on sequence is shown in the diagram of Figure 4-13.

4-104. To protect the BWO tube from excessive heater voltage or helix current, the turn-on circuits are held operational by safe values of helix current and heater voltage, and are released if either is excessive. This power shut-off results in a lock-out condition that requires the LINE switch to be turned off and on again to restore operation. These protective circuits are explained in Paragraphs 4-117 and 4-124.

4-105. THE POWER SUPPLIES.

4-106. GENERAL OPERATING PRINCIPLES.

4-107. All the dc operating voltages shown in Figure 4-2 are electronically regulated. Some are obtained directly from regulated supplies, others are derived by voltage division from regulated supplies.

4-108. There are five electronic regulators, two vacuum tube types supplying +275 volts and -300 volts, and three transistor types supplying +20, 12.6 and -6.3 volts. All of the regulators operate as follows. As shown in Figure 4-14, a regulating element (Series Regulator) is connected in series with the load and the dc power source (Rectifier). The resistance of the regulating element is made adjustable so that the voltage at its output will be adjustable. The resistance is adjusted by a control voltage; the higher the control voltage, the higher the output voltage. A sample of the Series Regulator output voltage is compared against a stable dc reference voltage by a Comparison Amplifier and the difference voltage is inverted and fed to the Series Regulator. As a result, any tendency for output voltage to change is immediately counteracted by the control voltage, and the output voltage remains constant.

4-109. Since the gain of the Comparison Amplifier determines the degree of regulation, it may be followed by an additional Control, or Driver, amplifier to improve regulation. The Comparison Amplifier is a differential type for temperature stability. The dc reference voltage used for comparison is obtained from voltage regulator electron tubes, from semi-conductor voltage reference diodes, or by voltage division from a regulated power supply. When an adjustable power supply is used as the reference for another supply, changing its output level also changes the level of the supply for which it is the reference. For example, the -300 volt supply has voltage regulator tube A2V11 for reference, but its -300 volt output is the reference for the +275 and -6.3 volt supplies. Consequently, if this -300 volt reference varies, the output levels of both the +275 and -6.3 volt supplies change. Since +275 volts is the reference for the +20 volt supply, the output of the +20 volt supply will be affected as well.

4-110. THE -300 VOLT SUPPLY.

4-111. The -300 volt supply (A2 circuit board, lower deck) has separate voltage reference (A2V11) and functions independent of other supplies. The supply operates as explained under General Operating Principles with the Comparison Amplifier driving the Series Regulator directly. Voltage reference tube A2V11 supplies -81 volts to the helix voltage shaping

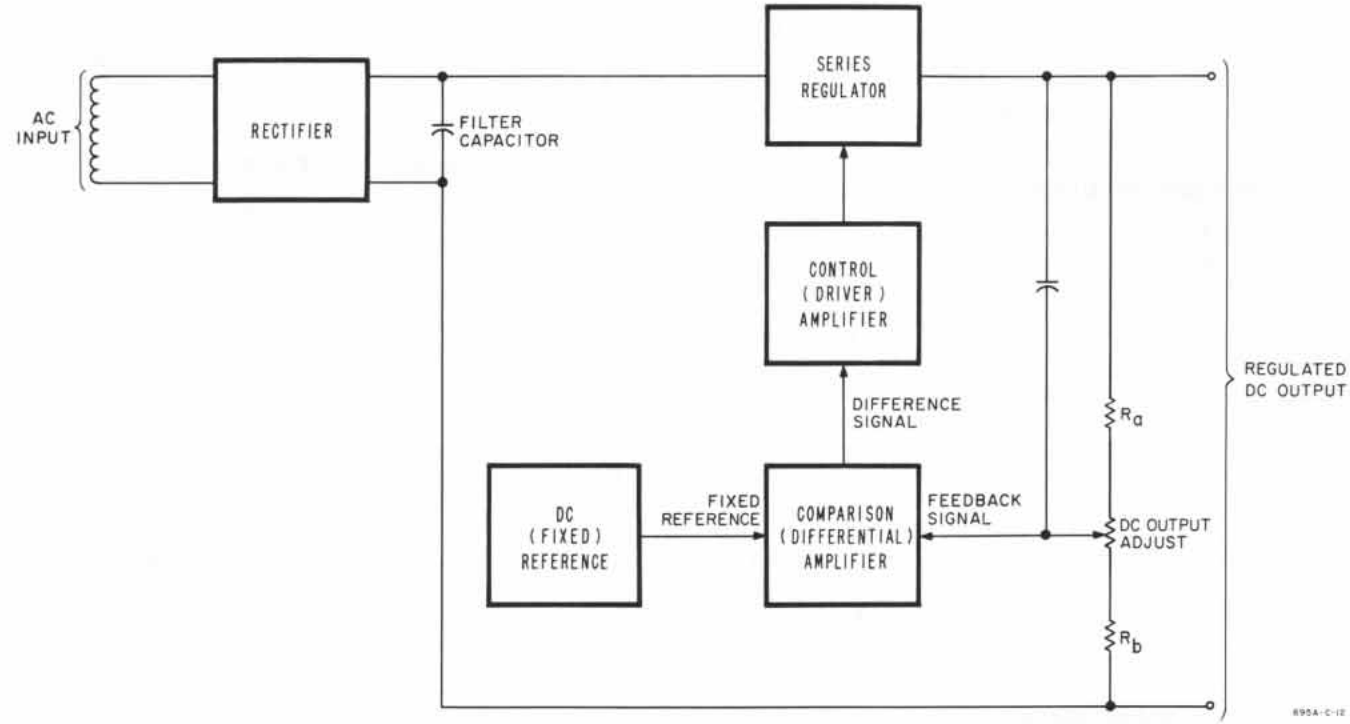


Figure 4-14. Regulated Power Supply Block Diagram

network, and operating potential for cathode follower A2V10B. Cathode follower A2V10B furnishes -83 volts to the MARKER 1 and MARKER 2 potentiometers. Series Regulator A2V8 obtains screen voltage from the +275 volt supply. The -300 volt supply is the reference voltage source for the +275 and -6.3 volt supplies.

4-112. THE +275 VOLT SUPPLY.

4-113. The +275 volt supply (etched circuit board A2, lower deck) operates as explained under General Operating Principles but depends upon the -300 volt supply for reference potential. Consequently, any change in output voltage from the -300 volt supply causes a change in the +275 volt supply output. Plate voltage for A2V3B in the Differential (Comparison) Amplifier is provided by voltage regulator tube A2V1 which also furnishes screen grid potential for the -300 volt supply series regulator.

4-114. The +275 volt supply provides reference potential for the +20 and 12.6 volt supplies in addition to operating potentials for the BWO Anode Voltage Generator and the +81 and +156 volt supplies.

4-115. THE -6.3 VOLT SUPPLY.

4-116. The -6.3 volt supply provides heater power for five tubes on etched circuit board A1, two tubes on etched circuit board A2, one tube on etched circuit board A4, and BWO tube V4. In addition, it furnishes transistor operating power and clamp reference voltages for various circuits. The supply operates as explained under General Operating Principles except that it uses the -300 volt supply as the dc reference and requires three series regulators (Q4, 5, and 6) in parallel to supply the required current. It also includes elapsed time indicator M1. The time indicator is a mercury column sealed in a glass tube. As direct current flows through the column, an air bubble travels in the direction of electron flow at a rate determined by current magnitude. Registor A8R5 sets the current flow from the -6.3 volts supply to give a 4000-hour time scale calibration.

4-117. The -6.3 volt supply has over-voltage prevention to protect the BWO tube heater from excessive voltage resulting from a short-circuit of one of the series regulator transistors. The over-voltage prevention circuit, K4, CR12, R56 and R57, disconnects the supply from its rectifier and initiates an action which removes the other BWO tube operating voltages. If a series regulator transistor short circuits, the supply output voltage rises enough to cause breakdown diode CR12 to conduct and provide an operate circuit for heater Over-Voltage relay K4. K4 energizes. K4A contacts disconnect rectifiers CR10 and CR11 from the -6.3 volt regulator and connect CR10, CR11 output directly to the coil of K4, holding K4 operated. The complete sequence for removing the BWO tube operating voltages is shown diagrammatically in Figure 4-15. The Sweep Oscillator remains in the state shown in Figure 4-15 until LINE S12 is set to the off position, allowing the relays to reset for a normal turn-on cycle. However, a turn-on cycle should not be restarted until the cause of shutdown has been investigated.

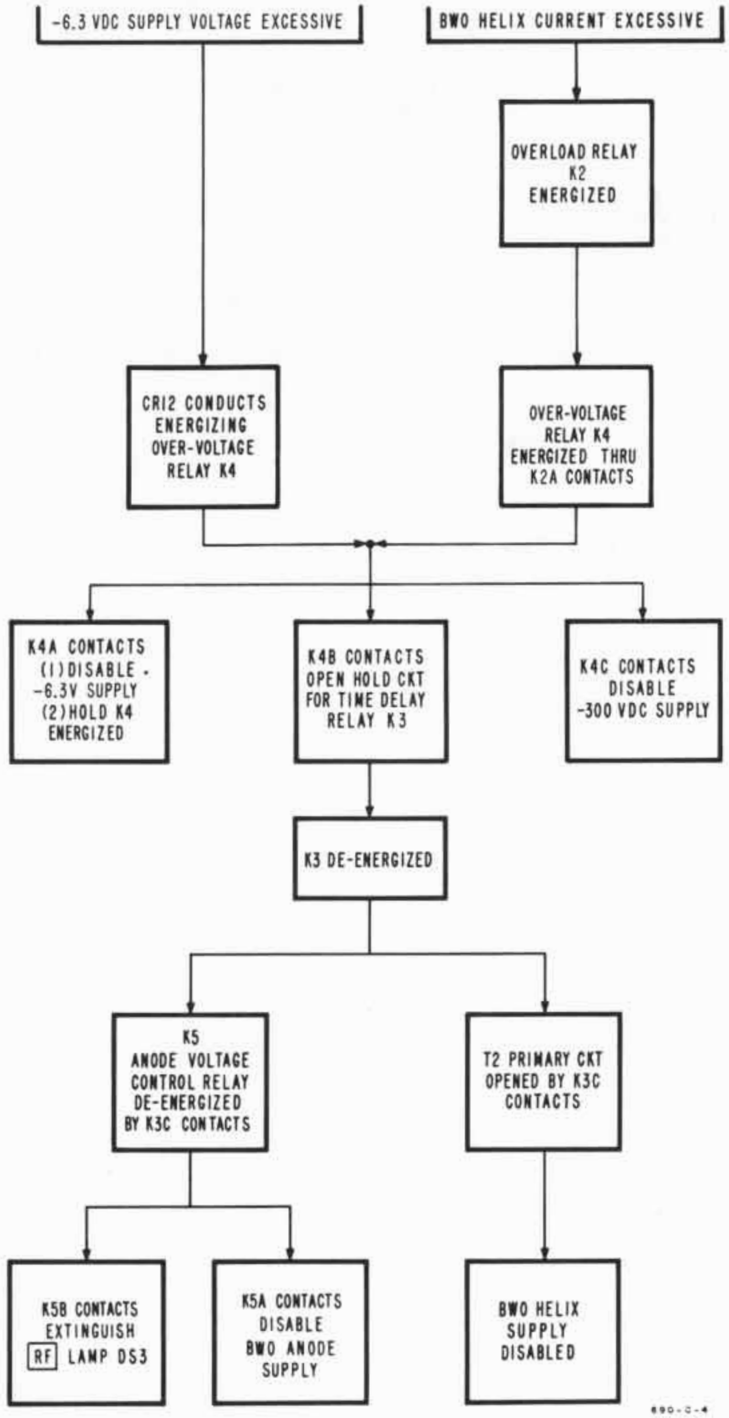


Figure 4-15. Sequence Diagram for BWO Tube Heater Over-Voltage and Helix Over-Current Protection

4-118. THE 12.6 VOLT SUPPLY.

4-119. The 12.6 volt supply provides regulated heater power for two tubes on etched circuit board A1, four tubes on etched circuit board A2, two tubes on etched circuit board A4 and one tube on etched circuit board A5.

4-120. The positive side of the supply is connected to a +65 volt tap on voltage divider A7R3, A7R4 from which the supply maintains a -12.6 volt difference. Breakdown diode A7CR3 furnishes regulated base voltage for driver transistor A7A1 which controls parallel-connected series regulators Q1 and Q2. Diodes A7CR1 and A7CR2, which have response to temperature change opposite to A7CR3, counteract reference voltage variation caused by temperature.

4-121. THE +20 VOLT SUPPLY.

4-122. The +20 volt supply provides regulated operating power for transistors on etched circuit boards A1, A4, and A5. The regulator circuit operates as explained under General Operating Principles. Dc reference for the Comparison Amplifier is obtained from voltage divider A7R8, A7R9 connected between the regulated +275 volts and ground potential. The Comparison Amplifier A7Q4, A7Q5 is followed by current amplifier (Driver) A7Q3 which supplies base current to Series Regulator A7Q2. Diodes A7CR10, A7CR11, and A7CR12, in conjunction with A7R6, form a current limiting circuit. When Series Regulator current is excessive, the voltage at A7R6, A7CR10 junction is negative enough to cause the three diodes to conduct and drive A7Q3 base negative by the amount of their voltage drop. This negative voltage at A7Q3 base prevents any further increase in Series Regulator current.

4-123. BWO TUBE HELIX OVER-CURRENT PROTECTION.

4-124. The BWO tube helix is protected from excessive current by Overload Relay K2. Each type of backward-wave oscillator tube has a maximum helix current rating which is specified by the tube manufacturer. This rating insures that helix power dissipation remains within safe operating limits. Over-load Relay K2, in series with the Helix Voltage Generator, disconnects operating voltage from the helix if helix current exceeds the tube manufacturer's specified maximum. The operate current for K2 is determined by the value of R26 in shunt with the relay coil. If helix current exceeds the operate value for the overload relay, the relay is energized to remove all operating voltages from the BWO tube as shown diagrammatically in Figure 4-15. The Sweep Oscillator remains in the state shown at the end of the sequence in Figure 4-15 until LINE S12 is set to the off position, allowing the relays to reset for a normal turn-on cycle. However, a turn-on cycle should not be restarted until the cause of shut-down has been investigated.

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section provides instructions for performance testing, calibrating, troubleshooting, and repairing the Sweep Oscillator.

5-3. MAINTENANCE PRECAUTIONS.

WARNINGS

VOLTAGES IN EXCESS OF 1000 VOLTS INSIDE CABINET

- hinged upper chassis under metal shield
- right side on terminal strip TB1
- lower chassis on etched circuit A6, deck-mounted capacitors C10-C14, and T2.

STRONG, PERMANENT MAGENTIC FIELD AROUND BWO TUBE

Remove wristwatch before working near BWO tube. Keep metal tools clear of BWO tube.

DO NOT SHORT - CIRCUIT CASES OF CHASSIS - MOUNTED TRANSISTORS TO CHASSIS.

5-4. PERIODIC MAINTENANCE.

5-5. CLEANING THE AIR FILTER.

5-6. Inspect the air filter regularly and, if necessary, remove and wash it in detergent and water. Dry filter and coat with air-filter oil such as "Filter Coat" by Research Products Corp (see Table 6-1 for HP stock number). Unrestricted air flow gives longest component life. Keep the filter clean.

5-7. LUBRICATION.

5-8. No routine lubrication is needed. Lubricate mechanical parts (e.g., marker, slide rule dial assemblies) only when necessary, using light machine oil on marker assembly shaft bearings and dry molybdenum or graphite lubricant on frequency dial pointer traverse rods.

5-9. PERFORMANCE TESTS.

5-10. PURPOSE. The procedures of Paragraphs 5-12 through 5-38 check Sweep Oscillator performance for incoming inspection, periodic evaluation, troubleshooting, and calibration. The tests can be performed without access to the Sweep Oscillator interior. The specifications of Table 1-1 are the performance standards.

5-11. TEST EQUIPMENT REQUIRED. The test instruments required to make the performance tests are listed in Table 5-1. Test instruments other than those listed may be used provided performance equals or exceeds Critical Specifications.

5-12. FREQUENCY CALIBRATION AND STABILITY TESTS.

5-13. The following procedure tests the calibration of the Sweep Oscillator frequency registers: the START/CW, STOP, and ΔF scales, the MARKER 1 and MARKER 2 counters. The procedure also includes tests for residual frequency modulation and frequency drift with line voltage variation. A preliminary check of RF power output and tuning range precedes the detailed frequency accuracy measurements.

5-14. RF POWER OUTPUT TEST. Test unleveled RF power output as follows:

a. Connect test equipment as shown in Figure 5-1. Add an adjustable transformer (Table 5-1) to control the line voltage applied to the Sweep Oscillator.

b. Set Sweep Oscillator controls as follows:

LINE . . . . OFF
SWEEP SELECTOR . . . . AUTO
SWEEP TIME (SEC) . . . . . 100-10 LINE SYNC
START/CW . . . . low end of Swp Osc range
STOP/ΔF . . . . .high end of Swp Osc range
POWER LEVEL . . . . max cw
START STOP . . . . depressed
BLANKING (rear panel) . . . . OFF
AMPLITUDE MOD selectors . . . . all released

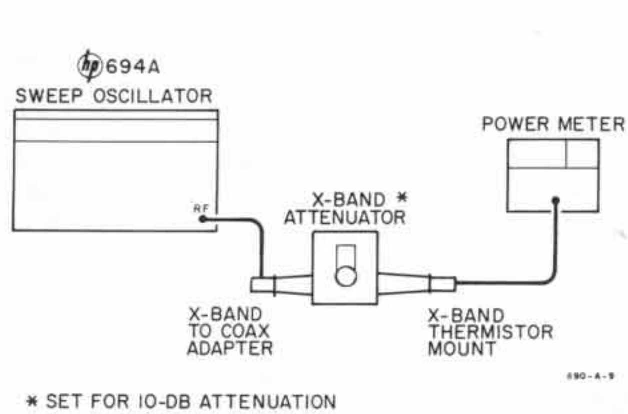


Figure 5-1. Setup to Measure Unleveled RF Output

Table 5-1. Test Equipment Required for Performance Testing

Instrument	Critical Specifications	Recommended Models
Adjustable line voltage transformer	Voltage Range: 90 to 130 volts Current: 7.5 amperes Voltmeter Accuracy: ± 1 volt	General Radio W10MT3A Superior Electric UC1M
Oscilloscope	Vertical Bandwidth: 5 Mc Vertical Sensitivity: 5 mv/cm Sweep Time Accuracy: ± 3%	hp 140A with 1402A & 1420A Plug-Ins hp 175A with 1752A Plug-In
Crystal Detector	Frequency Range: 10 mc - 12.4 gc Sensitivity: 100 mv dc from < 0.35 mw, high level; > 0.4 mv dc/μw, low level Frequency Response: ± 0.5 db or better	hp 423A[1] for Models 691A, 692A, 693A, hp 424A[1] for Model 694A
Variable Attenuator	Frequency Range: Same as Sweep Oscillator Attenuation Range: 0 - 20 db	hp X382A for Model 694A
Fixed Attenuator	Frequency Range: Same as Sweep Oscillator Attenuation: 20 db ± 0.5 db 10 db ± 0.5 db	Weinschel Model 1-20N (20 db), Model 1-10N (10 db)
Frequency Meter	Frequency Range: Same as Sweep Oscillator Accuracy: ± 0.08%	hp 536A[2] for Models 691A, 692A hp 537[2] for Models 693A, 694A
Power Meter and Thermistor Mount	Frequency Range: Same as Sweep Oscillator Power Range: 1 μw to 10 mw	hp 431B with hp 478A for Models 691A, 692A, 693A hp X486A for Model 694A
Waveguide-to-Coaxial Adapter	Frequency Range: 8.2 to 12.4 gc	hp X281A for Model 694A
Square-Wave Generator	Frequency Range: 40 to 1200 cps Output: -13 volts peak Symmetry: 50-50	hp 211A
Audio Oscillator	Frequency Range: 100 cps ± 10 cps Output: 0 - 14 vrms	hp 200 AB, 201C
AC Voltmeter	Average - responding, rms calibrated Range: -28 to -60 dbm, minimum Accuracy: ± 5%	hp 400D
DC Voltmeter	Range: 0 to -30 volts Accuracy: ± 3% Input Impedance: 20K ohms/volt	Simpson Model 260
DC Voltage Source	Output: regulated, variable Range: 0 - 20 volts Polarity: negative	hp 721A Transistor Power Supply

1 Option 02 (square law compensated)
2 Calibrated to specified accuracy

c. Set line voltage transformer to deliver 115 (or 230) volts. Be sure 115-230 volt switch on rear of Oscillator is set correctly.

d. Set LINE to RF: STANDBY indicator lights and cooling fan operates. Between 1 and 2 minutes later the RF indicator lights. During this interval the START STOP and SWEEP ON indicators light, signifying the sweep circuits are functioning.

e. During the sweep (SWEEP ON lit), note the minimum and maximum power indications on the Power Meter. Minimum power must be greater than 100 milliwatts for the model 691A, 70 milliwatts for the Model 692A, 20 milliwatts for the Model 693A, and 20 milliwatts for the Model 694A. Maximum RF power output must not exceed minimum RF power by more than 10 db.

f. Set SWEEP SELECTOR to CW. At the lowest frequency in the Oscillator range, rotate POWER LEVEL maximum cw (maximum RF power) and measure RF power output. Then rotate POWER LEVEL maximum ccw and measure minimum RF power output. Minimum power should be at least 30 db below maximum power.

g. Repeat step f at the highest frequency in the Oscillator range.

5-15. OPTION 01 RF LEVELING TEST. The following procedure tests the power leveling capability of Sweep Oscillators having internal leveling systems (Option 01).

a. Connect test equipment as shown in Figure 5-1.

b. Set Sweep Oscillator controls as follows:

START STOP	depressed
START/CW	low end of Swp Osc range
STOP/ΔF	high end of Swp Osc range
SWEEP SELECTOR	AUTO
ALC PWR LEVELING INPUTS (rear panel)	XTAL
INT ALC	depressed

c. Obtain maximum leveled RF power for the full frequency range sweep.

d. Measure the leveled power using a sweep time compatible with the Power Meter response. Leveled power must not be less than 100 mw for the Model 691A, 70 mw for the Model 692A, 20 mw for the Model 693A, and 20 mw for the Model 694A. Reminder: allow for power reduction caused by the Attenuator when measuring the leveled power.

e. During a sweep, note total RF power variation indicated by the Power Meter. Total variation, excluding any variation caused by the Attenuator, must not exceed 0.8 db for the Models 691A and 692A, 1 db for the Model 693A and 2 db for the Model 694A.

f. Check POWER LEVEL light operation. Light should flash when POWER LEVEL is rotated clockwise from maximum leveled power setting but should not flash with counterclockwise rotation.

5-16. FREQUENCY CALIBRATION TESTS. The following procedure tests the calibration accuracy of each frequency indicator and scale at the Oscillator range end-frequencies. Instruction is given for end-frequencies only, beginning at the low end of each range. However, accuracy specifications are the same for all frequencies in the Oscillator range. Unless otherwise noted, the calibration accuracy tests are performed with the Sweep Oscillator operating from 115 (or 230) volts, 60 cps.

a. Connect test equipment as shown in Figure 5-2, omitting connections A and B. Allow about 15 minutes for the equipment to stabilize.

b. Set Sweep Oscillator controls as follows:

LINE	RF
SWEEP SELECTOR	CW
START/CW	low end of Swp Osc range
STOP/ΔF	low end of Swp Osc range
MARKER 1	low end of Swp Osc range
MARKER 2	low end of Swp Osc range
MANUAL SWEEP	max cw
POWER LEVEL	max cw
AMPLITUDE MOD selectors	all released
START STOP	depressed
BLANKING (rear panel)	ON

c. Adjust the Oscilloscope to observe CRT beam dot displacement as Frequency Meter is tuned through the Oscillator output frequency. No sweep is required for the frequency calibration measurements.

d. With SWEEP SELECTOR at CW, CW on slide rule dial should be lighted. Tune Frequency Meter to obtain maximum displacement of Oscilloscope dot display. The START/CW and Frequency Meter readings must agree within ±1%.

e. Set SWEEP SELECTOR to MANUAL. On dial, CW extinguishes, START and STOP light. Tune Frequency Meter to obtain maximum displacement of Oscilloscope dot display. The STOP/ΔF and Frequency Meter readings must agree within ±1%.

f. With SWEEP SELECTOR still at MANUAL, rotate MANUAL SWEEP maximum ccw to obtain output frequency at START/CW setting. Tune Frequency Meter to obtain maximum displacement of Oscilloscope dot display. The START/CW and Frequency Meter readings must agree within ±1%.

g. Depress MARKER SWEEP. On dial, START and STOP extinguish. Rotate MANUAL SWEEP maximum cw. Tune Frequency Meter to obtain maximum displacement of Oscilloscope dot display. The MARKER 2 counter and Frequency Meter readings must agree within ±1%.

h. Set SWEEP SELECTOR to CW. Tune Frequency Meter to obtain maximum displacement of Oscilloscope dot display. The MARKER 1 counter and Frequency Meter readings must agree within ±1%.

i. Depress START STOP and MARK 1. Tune MARKER 1 to obtain maximum displacement of the Oscilloscope dot display. The START/CW dial and MARKER 1 counter readings must agree within ±1%.

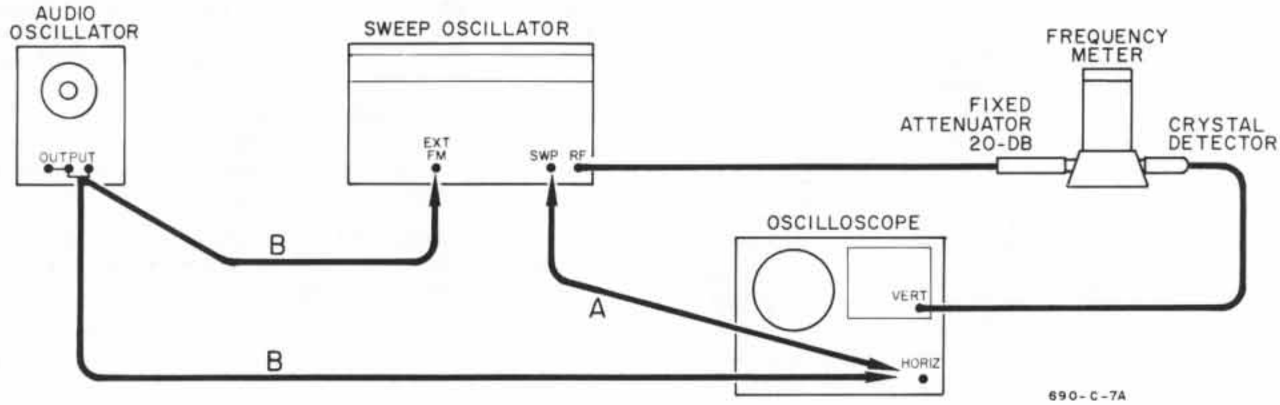


Figure 5-2. Setup for Frequency Calibration and External FM Tests

j. Release MARK 1 and depress MARK 2. Tune MARKER 2 to obtain maximum displacement of Oscilloscope dot display. The START/CW dial and MARKER 2 counter readings must agree within ±1%.

k. Release MARK 2 and depress Δ F. Tune Frequency Meter to obtain maximum displacement of Oscilloscope dot display. The START/CW and Fre quency Meter dial readings must agree within ±1%.

m. This completes the frequency calibration accuracy tests at the lowest frequency in the Sweep Oscillator range. To test calibration accuracy at the high end of the Oscillator frequency range, repeat steps d through k above, starting with the controls set as follows:

LINE	RF
SWEEP SELECTOR	CW
START/CW	high end of Swp Osc range
STOP/ΔF	high end of Swp Osc range
MARKER 1	high end of Swp Osc range
MARKER 2	high end of Swp Osc range
MANUAL SWEEP	maximum cw
POWER LEVEL	maximum cw
AMPLITUDE MOD selectors	all released

n. To test frequency calibration accuracy at intermediate frequencies in the Sweep Oscillator range, set SWEEP SELECTOR to CW and tune START/CW to frequencies of interest. At each frequency, CW dial and Frequency Meter readings must agree within ±1%.

p. To test frequency stability with line voltage changes:

(1) Obtain CW operation at any frequency.

(2) Set line voltage to 115.

(3) Wait 2 minutes for stabilization, then tune Frequency Meter to obtain maximum displacement of Oscilloscope dot display. Note Frequency Meter reading.

(4) Set line voltage to 103 and repeat step (3).

(5) Set line voltage to 127 and repeat step (3).

(6) The Frequency Meter reading obtained at 115 line volts should not differ from the reading obtained at 103 or 127 line volts by more than 1 Mc for the Models 691A and 692A, 2 Mc for the Models 693A and 694A.

q. To test ΔF frequency deviation, calibration accuracy, centering and center-frequency accuracy, add connection A in Figure 5-2, then proceed as follows:

(1) Depress Δ F. On dial, CW and Δ F light.

(2) Set SWEEP SELECTOR to AUTO, tune START/CW frequency to the middle of the Oscillator range, tune STOP/ΔF to the highest numbered MC calibration, and set SWEEP TIME (SEC) to .1-.01 (red knob to LINE SYNC).

(3) Set Oscilloscope display width to exactly 10 cm. This display represents maximum ΔF deviation.

(4) Tune Frequency Meter to measure frequency at center and at each end of the Oscilloscope display. Total Δ F deviation in megacycles, as given by the difference between the frequencies measured at the ends of the Oscilloscope display, must be within 10% (20%, 691A) of the actual Δ F MC setting with an acceptable additional error of 1% (2%, 691A) of maximum ΔF. For example, both maximum ΔF and the highest numbered ΔF scale calibration on the Model 691A are 100 Mc. Maximum acceptable Model 691A ΔF error is then 20% of 100 Mc (the ΔF setting) plus 2% of 100 Mc (maximum ΔF), or ±22 Mc total. Similarly, if the Δ F setting were 50 Mc, maximum acceptable error would be 20% of 50 Mc (the ΔF setting) plus 2% of 100 Mc (maximum ΔF), or ±12 Mc total.

(5) The ΔF center (CW) frequency must equal the START/CW dial reading within ±1%.

r. To test external frequency modulation capability:

(1) Add connections B in Figure 5-2, and set Audio Oscillator to 100 cps.

(2) Set START/CW to the middle of the Sweep Oscillator frequency range.

(3) Set the Frequency Meter to the highest frequency in the Oscillator range.

(4) Depress EXT FM.

(5) Increase Audio Oscillator output until the Frequency Meter notch appears at the right-hand end of the Oscilloscope display. Audio Oscillator output must not exceed 14 volts rms.

5-17. FREQUENCY STABILITY TESTS. A test of frequency stability with line voltage variation is included with the frequency calibration tests. Since an absorption frequency meter does not provide resolution sufficient to measure residual frequency modulation and frequency stability with power output changes, these tests should be made using transfer oscillator techniques or a microwave spectrum analyzer. Measuring systems including the Dymec 5796 Transfer Oscillator Synchronizer with HP H06-540B Transfer Oscillator, or the Dymec 2590A Microwave Frequency Converter provide the accuracy required for these measurements.

5-18. Frequency stability measurements using the HP 8551A/851A Spectrum Analyzer are described in HP Application Note 63, available free of charge from your HP Sales and Service Office.

5-19. Because time-varying magnetic fields of transformers and electric motors (in particular cooling fan motors) can frequency modulate the backward-wave oscillator, do not operate these devices close to the Sweep Oscillator, especially during a test for residual FM.

5-20. SPURIOUS SIGNALS TEST.

5-21. The most convenient means of measuring Sweep Oscillator harmonic and spurious signal output is a microwave spectrum analyzer such as the HP Model 8551A/851A which provides visual display of spurious signals together with the fundamental on a scale direct-reading in db.

5-22. When performing the test, operate the Sweep Oscillator in the CW mode and tune through the Oscillator frequency range noting the amplitude of harmonics and other spurious output relative to the Sweep Oscillator fundamental. Harmonics must be at least 20 db below the fundamental, non-harmonics must be at least 40 db below the fundamental.

5-23. CRYSTAL DETECTOR ALC, AM FREQUENCY RESPONSE, AND SWEEP TRIGGERING TESTS.

5-24. The following procedures test: 1) Sweep Oscillator capability to automatically maintain RF output power constant with charging output frequency; 2) internal and external amplitude modulation capability with leveled and unleveled RF output; and 3) manual and external sweep triggering.

5-25. LEVELING TESTS. Connect test equipment as shown in Figure 5-3 excluding the Square Wave Generator and proceed as follows:

a. Set Sweep Oscillator controls as follows:

LINE	OFF
SWEEP SELECTOR	AUTO
SWEEP TIME (SEC) (red knob in LINE SYNC detent)	.1 - .01
START/CW	low end of Swp Osc range
STOP/ΔF	low end of Swp Osc range
START STOP	depressed
ALC	depressed
POWER LEVEL (screwdriver adjust max cw)	approx. 5
GAIN	1/4 cw rotation
BLANKING (rear panel)	ON
ALC PWR LEVELING INPUTS (rear panel)	XTAL

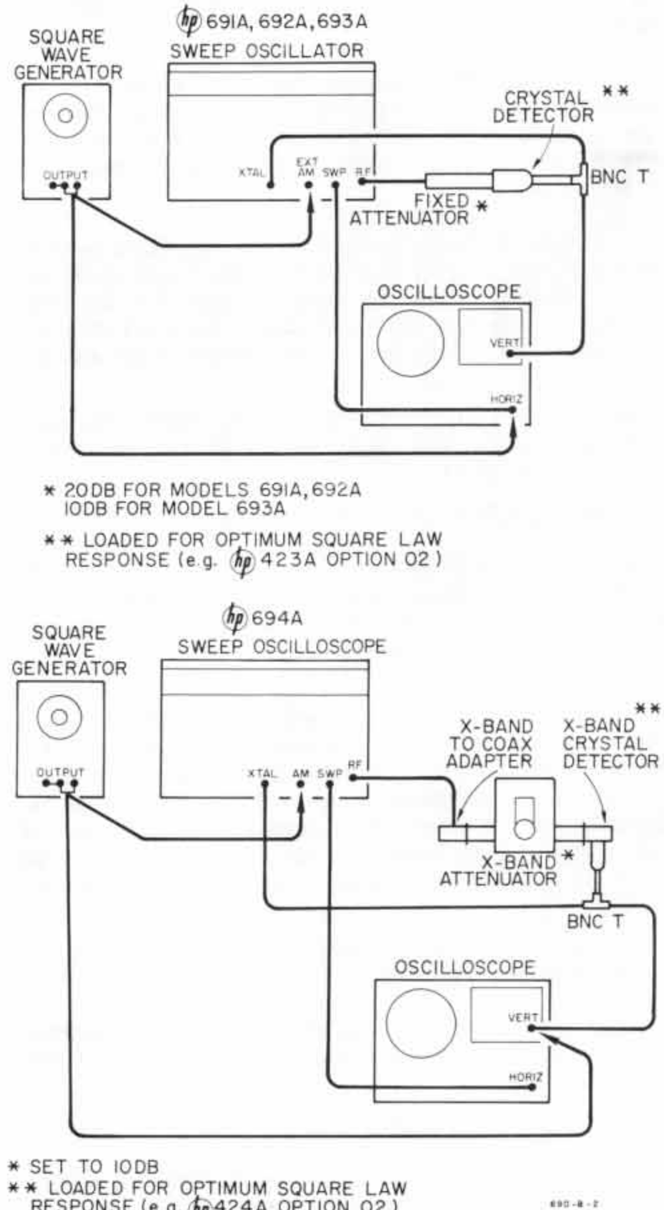


Figure 5-3. Setup for Testing Crystal Detector RF Leveling

b. Set LINE to RF. Allow a few minutes for stabilization, then adjust Oscilloscope to display RF output level.

c. Rotate POWER LEVEL screwdriver-operated control ccw until Oscilloscope display shows entire sweep is leveled.

d. While examining Oscilloscope display for any sign of oscillation, rotate GAIN maximum clockwise. If oscillation appears, rotate GAIN ccw (decrease gain) until oscillation just ceases. The Sweep Oscillator RF output is now leveled at maximum possible output for a full-band sweep.

e. Set Oscilloscope display of the zero-power reference (retrace) and detected RF levels to obtain calibrated voltage measurement. Record detected RF voltage as V1. Note POWER LEVEL light: it should glow steadily.

f. Increase Oscilloscope vertical sensitivity to measure peak-to-peak power level variations. Record the peak-to-peak variation as V2. For standard Models 691A, 692A, 693A, and 694A, V2 must not exceed 0.08V1.

g. Check POWER LEVEL light operation by rotating POWER LEVEL from 0 to 10. Light must not flash when Oscilloscope display indicates the full sweep is leveled, but must flash whenever display indicates loss of leveling in any segment of the sweep.

5-26. AM FREQUENCY RESPONSE TEST. To test internal square wave amplitude modulation capability with leveled output:

a. Set Oscilloscope for internal sweep.

b. Set SWEEP SELECTOR to CW and POWER LEVEL for maximum leveled output. (Readjust GAIN, if necessary, to prevent leveling loop oscillation.) Depress INT SQ WAVE.

c. Using Oscilloscope sweep time calibration to measure square wave frequency, rotate INT SQ WAVE FREQ from maximum cw to maximum ccw. Frequency range must be 950 to 1050 cps, minimum. During RF off intervals of square wave, display of RF output must equal the dc level obtained with POWER LEVEL maximum ccw (see step f, Paragraph 5-14).

d. To test internal square wave amplitude modulation capability without RF leveling:

(1) Release ALC (INT ALC, Option 01), set POWER LEVEL maximum cw, and depress INT SQ WAVE.

(2) Repeat step c above.

e. To test external amplitude modulation capability with and without automatic leveling:

(1) Connect test equipment as shown in Figure 5-3, including the Square Wave Generator.

(2) Set the Sweep Oscillator to deliver maximum leveled RF power for a full band sweep, then set SWEEP SELECTOR to CW and depress EXT AM.

(3) Connect Square Wave Generator output to Sweep Oscillator external AM input. Monitoring Square Wave Generator output with the Oscilloscope, set amplitude to 10 volts peak-to-peak and frequency to 1000 cps.

(4) Disconnect Square Wave Generator from Oscilloscope and reconnect Crystal Detector. Connect in parallel with the Oscilloscope vertical input a resistance which gives minimum decay time and overshoot for the displayed square wave.

(5) Tune Sweep Oscillator to output frequency at which detected square wave display shows maximum rise time. Rise time must not exceed 10 microseconds.

(6) Release ALC (INT ALC, Option 01) pushbutton, and repeat step (5). Rise time must not exceed one microsecond.

5-27. SWEEP TRIGGERING TESTS. To test sweep triggering:

a. Connect test equipment as shown in Figure 5-3.

b. Set Sweep Oscillator for a full frequency range START STOP sweep at maximum leveled output, SWEEP TIME at .1 - .01 LINE SYNC.

c. Set SWEEP SELECTOR to TRIG.

d. Set Square Wave Generator output frequency to 50 cps at minimum amplitude.

e. Connect Square Wave Generator output to Sweep Oscillator external trigger input. Omit connection between Square Wave Generator and Oscilloscope.

f. Increase Square Wave Generator output amplitude slowly until a sweep triggers. Use Oscilloscope to measure square wave amplitude. Amplitude must not exceed 25 volts peak-to-peak.

g. Disconnect Square Wave Generator from Sweep Oscillator. Press MANUAL TRIGGER button several times. A sweep should occur each time button is pressed. Manual triggering must be possible with all sweep times.

5-28. POWER METER RF LEVELING AND AM SENSITIVITY TESTS.

5-29. LEVELING TEST. The following procedure tests the Sweep Oscillator capability to automatically maintain RF power output constant with changing frequency using a leveling signal derived by a microwave power meter. Option 01 Sweep Oscillators cannot be tested for this capability unless the INT-EXT switch on the internal directional detector mounting bracket is set to EXT.

5-30. Connect the test equipment as shown in Figure 5-4 without the DC Voltage Source, and proceed as follows:

a. Set Sweep Oscillator controls as follows:

LINE . . . . STANDBY
SWEEP SELECTOR . . . . AUTO
START STOP . . . . depressed
START/CW . . . . low end of Swp Osc range
STOP/ΔF . . . . high end of Swp Osc range
SWEEP TIME (SEC) 10-100
SWEEP TIME (SEC) VERNIER . . . . . . max ccw
ALC PWR LEVELING INPUTS
(rear panel) . . . . PWR METER
AMPLITUDE MOD selectors . . . . . all released
ALC (INT ALC, Option 01) . . . . depressed
GAIN . . . . max cw
POWER LEVEL . . . . approx. 5

b. Set Power Meter RANGE (MW) selector to 1 MW range for the Models 691A and 692A, to 3 MW range for the Models 693A and 694A. With Sweep Oscillator LINE switch at STANDBY, zero the Power Meter.

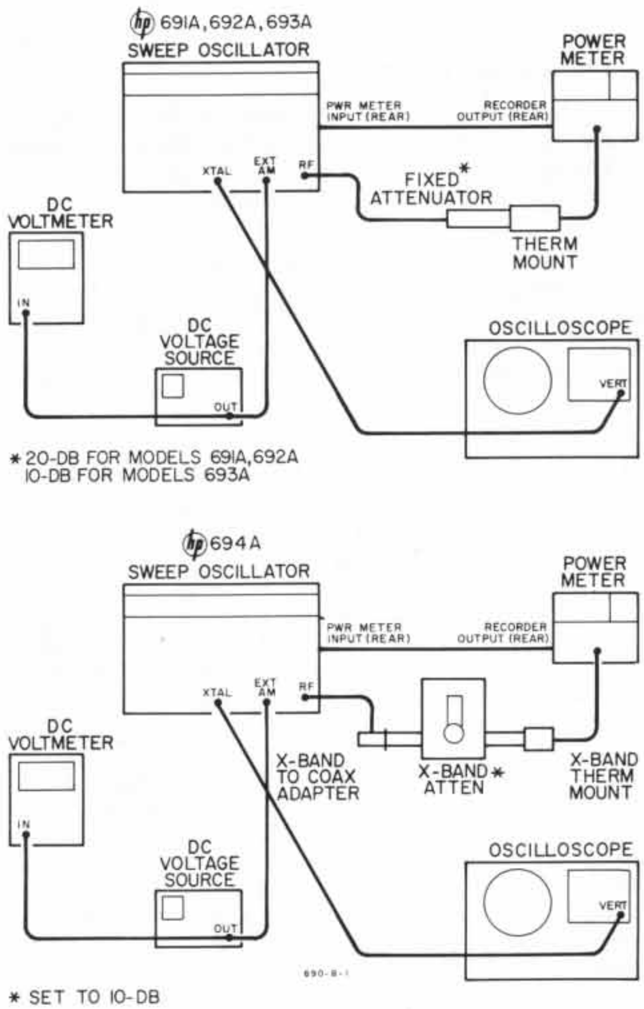


Figure 5-4. Setup for Testing Power Meter Leveling and External AM

c. Set Sweep Oscillator LINE to RF and adjust POWER LEVEL to obtain maximum leveled RF power over the full frequency range.

d. Measure the maximum leveled RF power output available from the Sweep Oscillator during a full frequency range sweep. Allowing for the attenuation of the pad shown in Figure 5-4, RF power indicated by the Power Meter must be as indicated below.

Model	Power Meter Reading
691A	1.0 mw minimum (20db pad)
692A	0.7 mw minimum (20db pad)
693A	2.0 mw minimum (10db pad)
694A	2.0 mw minimum (10db pad)

e. During a full range sweep, note maximum and minimum power indicated by Power Meter. Difference between maximum and minimum power must not exceed 0.2 db.

5-31. AM SENSITIVITY TEST. To test AM sensitivity:

a. Connect test equipment as shown in Figure 5-4 omitting connection to Oscilloscope.

b. Set Sweep Oscillator for CW operation at the lowest frequency in the Oscillator range, ALC released, POWER LEVEL maximum cw. Note Power Meter reading.

c. Set DC Voltage Source for minimum output and connect to Sweep Oscillator external AM input.

d. Depress EXT AM and increase Voltage Source output to -10 volts. Note Power Meter reading. Oscillator power output should be a minimum of 30 db less than measured in step b above.

5-32. PENLIFT TEST.

5-33. Test penlift function as follows:

a. Connect an ohmmeter to measure resistance between the rear-panel PENLIFT terminals.

b. Set Sweep Oscillator for full frequency range auto sweep, sweep time range 100-10 seconds (LINE SYNC optional). Ohmmeter should register short circuit between PENLIFT terminals when SWEEP ON is lighted, open circuit when SWEEP ON is not lighted.

c. Repeat step b with 10-1 second sweep time range.

d. Repeat steps b and c with SWEEP SELECTOR at TRIG.

e. Ohmmeter should register an open circuit between the PENLIFT terminals when the SWEEP SELECTOR is set to any position except AUTO or TRIG and when SWEEP TIME (SEC) is set to any position except 100-10 and 10-1.

5-34. SWEEP TIME, LINE SYNC, SWEEP AND SWEEP REF OUTPUT TESTS.

a. Connect SWEEP output to the vertical input of an oscilloscope set for internal sweeping synchronized with the AC line frequency.

b. Set Sweep Oscillator for a full frequency range automatic sweep, sweep time range .1 - .01 second, SWEEP TIME (SEC) VERNIER switched to LINE SYNC. If LINE SYNC is functioning the waveform displayed by the oscilloscope will be synchronized with the oscilloscope sweep.

c. To check sweep time accuracy and SWEEP output, measure the period and amplitude of the ramp portion of the waveform displayed by the oscilloscope. Ramp period should be 10 ±3 milliseconds, and ramp amplitude should be 15V ±2V. Check sweep time at the limits of other time ranges of interest, taking time from the ramp portion of the waveform. Time accuracy should be ±30%. SWEEP output should be activated for START STOP, MARKER and ΔF sweep functions with AUTO, MANUAL or TRIG modes. SWEEP output amplitude should not change with sweep time, sweep direction, or sweep width.

d. Connect rear-panel SWEEP REF output to the oscilloscope vertical input and measure voltage limits of linear ramp portion of displayed waveform. During a full frequency range sweep, ramp voltage limits should be +4 ±2 volts and +80 ±3 volts, +4 volts being coincident with the lowest frequency in the Oscillator range and +80 volts being coincident with the highest frequency in the Oscillator range. SWEEP REF output is activated for all sweep modes and functions. SWEEP REF voltage is always proportional to output frequency.

5-35. FREQUENCY LINEARITY TEST.

5-36. LINEARITY RELATIVE TO SWEEP OUTPUT. Using test setup of Figure 5-2, omitting the Audio Oscillator, proceed as follows:

a. Connect SWEEP output to Oscilloscope horizontal input.

b. Set Sweep Oscillator for a full frequency range manual sweep.

c. Adjust Oscilloscope horizontal sensitivity so that 10 cm of beam traverse equals full rotation of MANUAL SWEEP.

d. While manually tuning Sweep Oscillator, tune Frequency Meter to locate absorption notches on convenient calibration marks of the Oscilloscope graticule (e.g., 1 cm). Note actual Frequency Marker readings corresponding to graticule marks.

e. Switch to AUTO sweep and adjust Frequency Meter to realign absorption notches with graticule marks. Note Frequency Meter readings. Difference between Frequency Meter readings obtained at each graticule mark must not exceed 10 Mc for the Models 691A and 692A, 20 Mc for the Model 693A, and 30 Mc for the Model 694A.

f. Repeat step e at various sweep times.

5-37. LINEARITY RELATIVE TO SWEEP REF OUTPUT. Repeat test of Paragraph 5-40, except connect rear-panel SWEEP REF to Oscilloscope horizontal input and use CW mode instead of MANUAL mode.

5-38. RESIDUAL AM TEST.

a. Connect equipment as shown in Figure 5-5.

b. Set Sweep Oscillator for single-frequency (CW) operation, any frequency.

c. Depress INT SQ WAVE.

d. Vary POWER LEVEL to obtain -28 db reading on AC Voltmeter.

e. Release INT SQ WAVE. Voltmeter reading should decrease at least 32 db (e.g., to -60 db). Due to Voltmeter response to a square wave and crystal detector square law response, a 32-db reduction in reading equals a 40-db reduction in signal level.

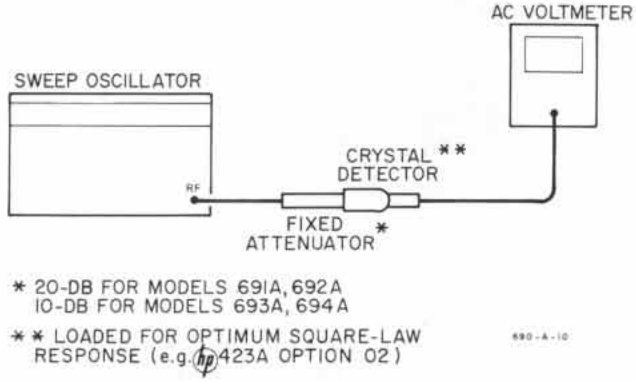


Figure 5-5. Setup for Measuring Residual AM

5-39. ADJUSTMENTS.

5-40. PURPOSE. The following adjustment procedures include instructions for setting the dc operating voltages, calibrating the Sweep Oscillator tuning functions, and balancing the ALC Amplifier.

5-41. TEST EQUIPMENT REQUIRED. Test instruments required to perform the adjustments and calibrations are listed in Table 5-2. Instruments other than those listed may be substituted, provided their specifications equal or exceed the Critical Specifications.

5-42. ADJUSTING THE DC OPERATING VOLTAGES.

5-43. There are four adjustable dc operating voltages: -300, +275, +20, and -6.3 volts. Adjust these voltages only if proven by accurate measurement to be significantly outside the tolerances specified on the schematic diagrams and Figure 5-6, and only if the voltage error is not caused either by excessive current being drawn through the regulator or by inadequate voltage being supplied to the regulator from the power supply rectifiers.

5-44. Because the -300 and +275 volt supplies are interdependent, and because the +275 volt supply is used as a reference in the Helix Voltage Generator, any adjustment to either of these regulators will change the frequency dial calibration. Also because of the interdependence of these power supplies, the -300 volt regulator must be set first, the +275 volt regulator second, and the +20 and -6.3 volt regulators last. After adjusting any of these regulators, check the output voltage of each other regulator to be sure it is still within specified tolerances. Do not attempt adjustment of the -300 and +275 volt regulators with a voltmeter having more than ±0.3% error. See Figure 5-7 for locations of the power supply adjustments and Figure 5-6 for convenient measurement points.

5-45. There are four major causes of out-of-tolerance power supply voltages: 1) maladjustment, 2) excessive current drawn by the load, 3) low line voltage, and 4) defective component in the power supply. Only in the first case should the power supply be adjusted. For each of the other causes, repair of the malfunction will likely restore the output voltage within tolerance. Reset a slightly out-of-tolerance supply voltage only if improved frequency calibration results.

Table 5-2. Test Equipment Required for Calibration and Troubleshooting

Test Instrument	Critical Specification	Recommended Model
All instruments in Table 5-1		
DC Voltmeter	Range: 0 to ± 300V Accuracy: ± 0.2% min. Input Impedance: 10 megohms	hp 405BR hp 3440A/ 3441A
Clip-On DC Ammeter	Range: 10 ma-5 amps Accuracy: ± 5%	hp 428B
CW Signal Source	Frequency Range: same as Sweep Oscillator Output: + 10 to -10 dbm	hp 8614A hp 8614B (1-2 GC) hp 8616A hp 8616B (2-4 Gc) hp 618B (4-7.6 Gc) hp 620A, hp 626A (8-12.4 Gc)
DC Voltmeter*	Range: + 100 to + 2200V Accuracy: ± 3% Input Impedance: 20K ohms/volt	Simpson Model 260
Capacitor**	Capacitance: .01 μfd DCVW: 2000	

* For BWO tube helix, collector voltage measurement. Must be capable of "floating" meas.
** DC block for BWO tube helix voltage ripple measurement.

5-46. <u>BWO ANODE VOLTAGE GENERATOR ADJUSTMENT.</u>

5-47. NEW BWO TUBE.

a. Connect Sweep Oscillator in RF power measuring setup of Figure 5-1.

b. Turn on Sweep Oscillator and allow a few minutes for warmup.

c. Remove Sweep Oscillator right side and top covers for access to terminal strip TB1 and etched circuit A2.

d. Connect a dc voltmeter (Table 5-2) to BWO anode terminal and clip-on dc ammeter (Table 5-2) to BWO helix lead (see Figure 5-6).

e. Set Sweep Oscillator for CW operation and tune RF output to highest frequency.

f. Set A2R48 maximum counterclockwise (viewed from side opposite components). Adjust A2R50 to obtain anode voltage on BWO tube label.

g. Tune RF output to frequency below midband at which RF power output is least.

h. Adjust A2R48 to obtain maximum RF power. Do not exceed either anode voltage or helix current maximums given in the table below.

i. Measuring anode voltage and helix current, tune RF output through full band. Voltage and current must not exceed maximums given in the table below. If either is excessive, correct by readjusting A2R48 below midband, A2R50 full band.

Model	BWO Tube Mfr	Max Anode Volts*	Max Helix Current	Max Cathode Current	Max Anode Current
691A	Stewart	+220	4 ma	17 ma	1.5 ma
692A	Stewart	+220	3.5 ma	15 ma	1.5 ma
693A	Stewart	+220	3.0 ma	12 ma	2 ma
694A	Stewart	+220	3.0 ma	12 ma	2 ma

* measured with respect to Sweep Oscillator chassis

j. Connect current meter to BWO cathode lead. While measuring current, tune RF output through full band: current must not exceed maximum given in step i. If current is excessive, correct by adjusting A2R48 below midband, A2R50 full band.

k. Recalibrate CW-START dial using procedure in Paragraph 5-53.

5-48. OLDER BWO TUBE. If a BWO tube which has exceeded the warranty period performs satisfactorily except that RF power output is not sufficient, try increasing power output by raising anode voltage. Use Figure 5-1 setup to measure RF output during full-band manual sweep. Measuring helix current, adjust A2R50 to obtain sufficient RF output without exceeding the maximum helix current given in Paragraph 5-47 table. Recheck CW-START scale calibration (Paragraph 5-53).

5-49. <u>TUNING VOLTAGE GENERATOR CALIBRATION.</u>

5-50. Complete calibration of the Tuning Voltage Generator consists of the following series of adjustments:

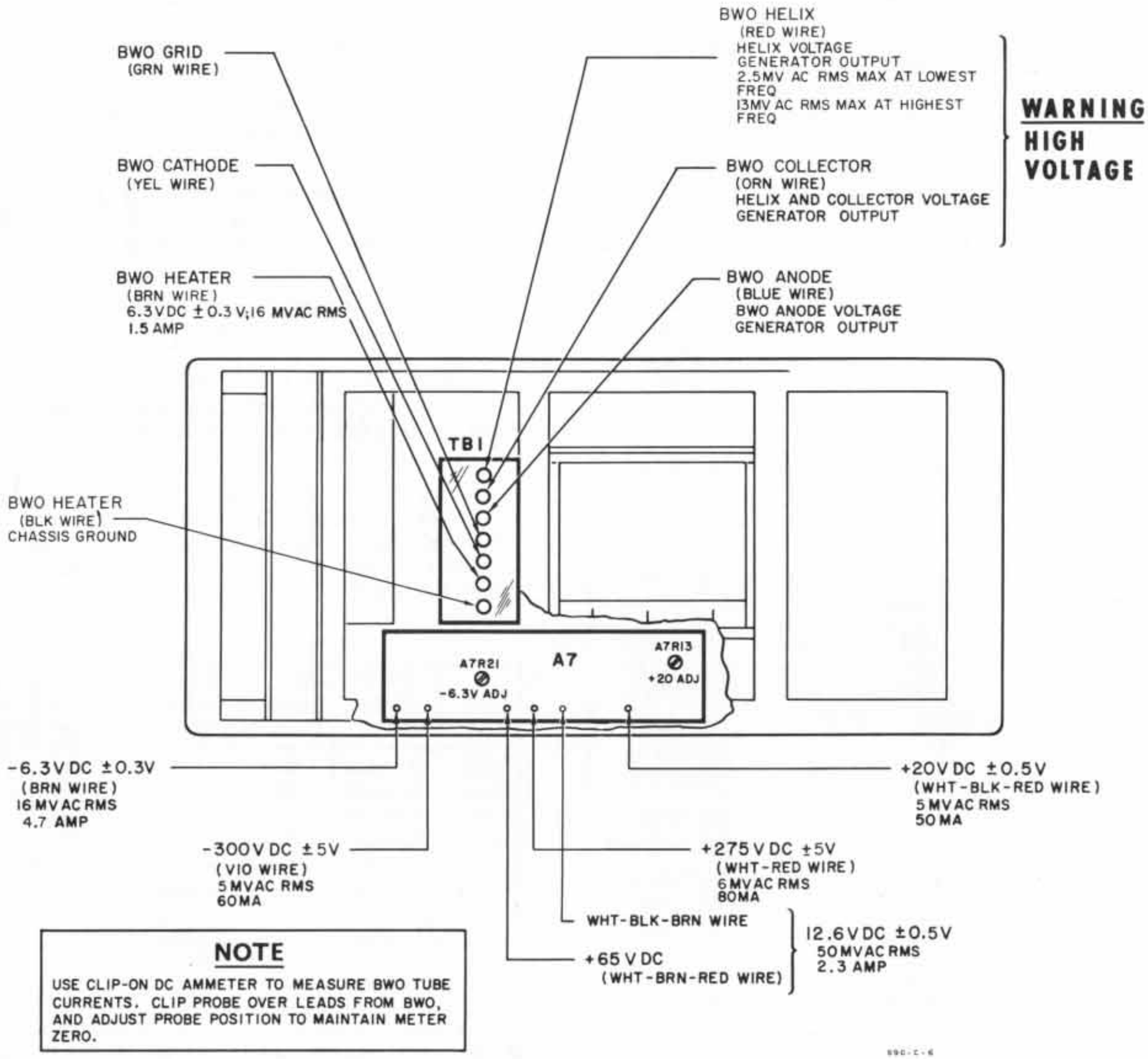


Figure 5-6. Right Side View Showing Convenient Points for Measuring BWO Tube and Principal Operating Voltages

Paragraph	Subject
5-51	Manual sweep calibration. Basic adjustments that set minimum tuning voltage for all frequency calibrations.
5-53	CW-START scale calibration. Tracks RF output frequency with the START/CW scale, sets midband RF frequency accuracy for all other frequency scales and indicators.
5-57	Fast Sweep Linearity. Minimizes RF output frequency shift with fast sweeps.
5-58	ΔF scale calibration. Sets frequency deviation limits and sets ΔF center frequency equal to CW setting.
5-60	MARKER SWEEP calibration. Calibrates MARKER SWEEP start and stop controls at highest frequency in Oscillator range.
5-62	Frequency marker calibration. Calibrates MARK 1 and MARK 2 at highest frequency in Oscillator range.

5-51. MANUAL SWEEP CALIBRATION.

5-52. The following adjustments affect all subsequent frequency calibration settings and must be accurately set before any other frequency calibration adjustments are attempted. Proceed as follows:

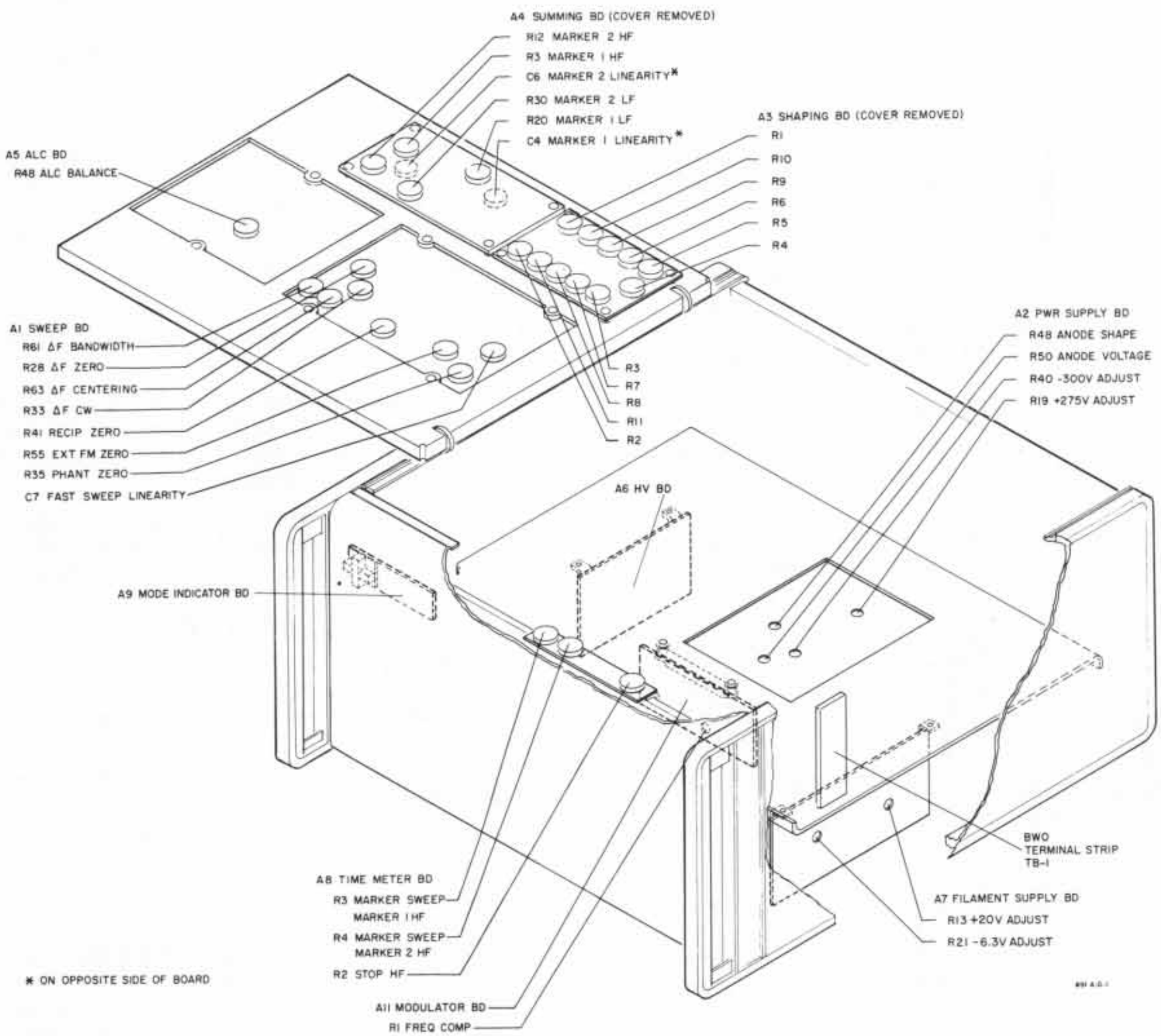


Figure 5-7. Locations of Internal Adjustments and Etched Circuits

a. Turn on Sweep Oscillator and allow two-minute warmup. Remove cabinet top cover for access to etched circuit A1 (see Figure 5-7).

b. Set SWEEP SELECTOR to MANUAL and with the dc voltmeter recommended in Table 5-2, make the following measurements and adjustments:

MANUAL SWEEP	DC Voltage at	Adjust	Test Limit
1) Full cw	A1V2A, pin 8	A1R35	0 vdc ±0.05 vdc
2) Full ccw	A1V2B, pin 3	A1R41	-0.070 ±0.05 vdc
3) Full ccw	A1V2A, pin 8		+156 ±4 vdc
4) Full cw	SWEEP OUT connector		+15 ±2 vdc

5-53. <u>CW-START SCALE CALIBRATION.</u>

5-54. Before calibrating the CW-START scale be sure that the MANUAL SWEEP is properly calibrated (see Paragraph 5-51). The following procedure must be properly executed before all subsequent frequency calibrations are attempted because resultant changes in frequency calibration affect the calibration of other Sweep Oscillator functions.

a. Connect Sweep Oscillator in test setup shown in Figure 5-2 omitting connections A and B.

b. Set Sweep Oscillator controls as follows and allow 15-minute warmup.

LINE . . . . RF
SWEEP TIME (SEC) . . . . 1 - .1 (LINE SYNC)
SWEEP SELECTOR . . . . AUTO
START STOP . . . . depressed
START/CW . . . . low end of Swp Osc range
STOP/ΔF . . . . high end of Swp Osc range
POWER LEVEL . . . . maximum clockwise

c. Remove cabinet top cover for access to etched circuit A3 (Figure 5-7).

d. Set SWEEP SELECTOR to CW and set START/CW and Frequency Meter to the frequency stenciled by A3R1 on the metal shield over etched circuit A3. Adjust A3R1 so that Oscilloscope dot display rests on peak of Frequency Meter notch.

e. Set START/CW and Frequency Meter to low end of Sweep Oscillator frequency range. Set A3R2 so that Oscilloscope dot display rests on peak of Frequency Meter absorption notch.

f. Repeat this procedure at frequencies listed in the table below. The table also lists the adjustment that sets each frequency. This concludes calibration of the GC scale for the CW and START frequencies.

5-55. STOP SCALE CALIBRATION.

5-56. Before calibrating the STOP scale be sure that the CW-START scale is properly calibrated (see Paragraph 5-53).

a. Connect Sweep Oscillator in test setup shown in Figure 5-2 omitting connections A and B.

Adjust	To Calibrate START/CW Setting of			
	691A (Gc)	692A (Gc)	693A (Gc)	694A (Gc)
A3R1	1.05	2.1	4.2	8.2
A3R2	1.0	2.0	4.0	8.0
A3R3	1.2	2.4	4.8	8.9
A3R4	1.3	2.6	5.2	9.3
A3R5	1.4	2.8	5.6	9.8
A3R6	1.4	3.0	6.0	10.2
A3R7	1.6	3.2	6.4	10.6
A3R8	1.7	3.4	6.8	11.1
A3R9	1.8	3.6	7.2	11.5
A3R10	1.9	3.8	7.6	12.0
A3R11	2.0	4.0	8.0	12.4

Select A4-V1 for above if you have Trouble

b. Set Sweep Oscillator controls as follows and allow a 15-minute warmup.

LINE . . . . RF
SWEEP SELECTOR . . . . MANUAL
MANUAL SWEEP . . . . maximum clockwise
STOP/ΔF . . . . high end of Swp Osc range
POWER LEVEL . . . . maximum clockwise

c. Remove cabinet top cover for access to etched circuit A8 (see Figure 5-7).

d. Set Frequency Meter to high end of Oscillator range. Set A8R2 to position Oscilloscope dot display on peak of Frequency Meter absorption notch. This concludes calibration of the STOP scale. If the START/CW control has noticeable effect on the frequency set by the STOP/ΔF control, A1Q1 or A1Q2 may be marginally defective (low Beta).

5-57. FAST SWEEP LINEARITY.

a. Connect Sweep Oscillator in test setup shown in Figure 5-2 omitting connections A and B.

b. Set Sweep Oscillator controls as follows and allow a 5-minute warmup.

LINE . . . . RF
SWEEP TIME (SEC) . . . . . . 1 - .1 (vernier to LINE SYNC)
SWEEP SELECTOR . . . . AUTO
START STOP . . . . depressed

c. Remove cabinet top cover for access to etched circuit A1.

d. Set Frequency Meter to highest frequency in Sweep Oscillator range.

e. Set START/CW and STOP/ΔF for narrow start-stop sweep (e.g., 5 to 10 Mc) centered on Frequency Meter setting. Note location of Frequency Meter notch on Oscilloscope display.

f. While observing Oscilloscope display, switch SWEEP TIME (SEC) between 1 - .1 and .1 - .01. Adjust A1C7 for no apparent shift of Frequency Meter notch.

5-58. ΔF SCALE CALIBRATION.

5-59. Adjusting ΔF scale calibration does not affect any other calibration, but the CW scale must be properly calibrated before the ΔF scale is calibrated.

a. Connect Sweep Oscillator in test setup shown in Figure 5-2 omitting connections A and B.

b. Set Sweep Oscillator controls as follows, and allow a 15-minute warmup.

LINE . . . . RF
SWEEP SELECTOR . . . . MANUAL
START/CW . . . . . . low end of Swp Osc range
STOP/ΔF . . . . high end of Swp Osc range
MANUAL SWEEP . . . . maximum ccw
POWER LEVEL . . . . maximum cw

c. Remove cabinet top cover for access to etched circuit A1 (see Figure 5-7).

d. Using Digital Voltmeter recommended in Table 5-2, measure the dc voltage between A1V6, pin 2 and ground. Record as V_1.

e. Set MANUAL SWEEP fully clockwise and repeat measurement of step d. Record as V_2.

f. Depress ΔF and repeat measurements of steps d and c. Adjust A1R61 so that V2 - V1 with ΔF depressed is one-tenth of V2 - V1 with START STOP depressed.

g. Measure voltage at A1R36, A1R65 junction, and record as V_3.

h. Measuring voltage at A1V2A, pin 8, set MANUAL SWEEP so voltmeter reading equals V_3.

i. Measure voltage at A1R62, A1R63, A1R66 junction. Set A1R63 to obtain 0 volts.

j. Set STOP/ΔF to 0 MC. Measure voltage between A1V6, pin 2, and chassis ground. Adjust A1R28 so there is no change in voltmeter reading with full rotation of MANUAL SWEEP.

k. Set SWEEP SELECTOR to CW, Frequency Meter and START/CW to high end of Oscillator range. Adjust A1R33 so that Oscilloscope dot display rests on point of Frequency Meter notch.

m. Set SWEEP SELECTOR to AUTO, STOP/ΔF to 0 MC, START/CW and Frequency Meter to low end of Oscillator range. START/CW setting and Frequency Meter reading must agree within ±1%.

5-60. MARKER SWEEP CALIBRATION.

5-61. Before calibrating MARKER SWEEP operation be sure that the CW-START scale is properly calibrated (see Paragraph 5-53). Changing either MARKER SWEEP calibration adjustment affects the calibration of the corresponding frequency marker, but subsequent correction of the frequency marker calibration does not affect MARKER SWEEP calibration.

a. Connect Sweep Oscillator in test setup shown in Figure 5-2 with connection A.

b. Set Sweep Oscillator controls as follows, and allow a 15-minute warmup.

LINE	RF
SWEEP SELECTOR	CW
MARKER SWEEP	depressed
MARKER 1 START/CW	highest numbered RF frequency
POWER LEVEL	maximum cw
MARKER 2 STOP	highest numbered RF frequency
MANUAL SWEEP	maximum cw

c. Remove cabinet top cover for access to etched circuit A4 (see Figure 5-7).

d. Set Frequency Meter to highest numbered frequency on the MARKER 1 START/CW indicator and adjust A8R3 to locate Oscilloscope dot display on point of Frequency Meter notch. This completes calibration of the START/CW indicator for MARKER SWEEP operation.

e. Set SWEEP SELECTOR to MANUAL and adjust A8R4 to locate Oscilloscope dot display on point of Frequency Meter notch. This completes calibration of the STOP indicator for MARKER SWEEP operation.

5-62. MARKER CALIBRATION.

5-63. Before calibrating the frequency markers be sure that MARKER SWEEP is properly calibrated (see Paragraph 5-60). Adjusting frequency marker calibration does not affect MARKER SWEEP calibration.

a. Connect Sweep Oscillator in test setup shown in Figure 5-2 with connection A.

b. Set Sweep Oscillator controls as follows and allow a 15-minute warmup.

LINE	RF
SWEEP SELECTOR	AUTO
SWEEP TIME (SEC)	.1 - .01 (VERNIER mid-rotation)
ΔF	depressed
START/CW	low end of Swp Osc range
STOP/ΔF	50 Mc ΔF
MARK 1	depressed
MARKER 1	lowest numbered frequency
MARKER 2	lowest numbered frequency
POWER LEVEL	maximum cw

c. Remove cabinet top cover for access to etched circuit A4 (see Figure 5-7).

d. Set Frequency Meter to lowest numbered frequency on the MARKER 1 indicator. Adjust A4R20 to superimpose MARK 1 notch and Frequency Meter notch on Oscilloscope display.

e. Release MARK 1, depress MARK 2, and repeat step d, adjusting A4R30.

f. Set MARKER 1, MARKER 2, START/CW and the Frequency Meter to the highest frequency in the Sweep Oscillator frequency range. Adjust A4R12 to superimpose the MARK 2 and Frequency Meter notch on the Oscilloscope display.

g. Release MARK 2, depress MARK 1, and adjust A4R3 to superimpose MARK 1 and Frequency Meter notches on Oscilloscope display.

h. Set START/CW to high end of Oscillator range, STOP/ΔF to low end of Oscillator range, depress START STOP (ΔF releases), and set SWEEP TIME (SEC) VERNIER to LINE SYNC. Adjust A4C4 to superimpose MARK 1 and Frequency Meter notches on Oscilloscope display.

i. Release MARK 1, depress MARK 2, and adjust A4C6 to superimpose MARK 2 and Frequency Meter notches on Oscilloscope display. Both frequency markers are now calibrated.

5-64. ZERO EXTERNAL FM ADJUSTMENT.

a. Connect Sweep Oscillator in test setup shown in Figure 5-2 omitting connections A and B.

b. Set Sweep Oscillator controls as follows:

LINE	RF
SWEEP SELECTOR	CW
START/CW	middle of Swp Osc range
START STOP	depressed

c. Adjust Oscilloscope to observe displacement of dot display of RF output is tuned through frequency meter notch. No sweep required.

d. Set Frequency Meter to START/CW setting, short circuit EXT FM input J12, and depress EXT FM.

e. Adjust A1R55 (Ext FM Zero Adj) to position Oscilloscope dot display on point of Frequency Meter notch.

5-65. ALC AMPLIFIER BALANCE.

a. Connect Sweep Oscillator in test setup shown in Figure 5-3 omitting the Square Wave Generator. For standard Sweep Oscillators, include connection A.

b. Remove cabinet top cover for access to etched circuit A5 (see Figure 5-7).

c. Set Sweep Oscillator controls as follows and allow a 15-minute warmup.

START/CW	high end of Swp Osc range
STOP/ΔF	low end of Swp Osc range
START STOP	depressed
SWEEP SELECTOR	AUTO
SWEEP TIME (SEC)	1 - .01 (LINE SYNC)
POWER LEVEL	5
GAIN	1/4 cw rotation
ALC (INT ALC)	depressed
LINE	RF

d. Adjust POWER LEVEL screwdriver adjust to obtain Oscilloscope indication of full-band leveled RF output.

e. Adjust A5R48 until a step appears in the zero power (retrace) line. Then adjust A5R48 to move step to the left-hand edge of the retrace line. At this point the step becomes a small, bright vertical displacement. A5R48 is correctly adjusted when this displacement just disappears.

5-66. TROUBLESHOOTING.

5-67. PURPOSE. The following paragraphs explain: first, how to isolate a malfunction to a circuit section of the Sweep Oscillator; second, how to isolate a malfunction to a circuit within a section using test points shown on schematic diagrams and etched circuit illustrations; and third, how to test transistors in operating circuits using a voltmeter (Paragraph 5-122).

5-68. TEST EQUIPMENT REQUIRED. The test equipment required to troubleshoot the Sweep Oscillator is listed in Table 5-2. Instruments other than those listed may be used provided their specifications equal or exceed the Critical Specifications.

5-69. ISOLATING A TROUBLE TO A CIRCUIT SECTION.

5-70. To locate a source of trouble in the Sweep Oscillator, use the Performance Tests to define the trouble(s); i.e., whether related to RF tuning, RF power output, RF amplitude modulation, RF amplitude and frequency stability, loss of one or more functions, or some combination of these. In the block diagram, Figure 4-2, the Sweep Oscillator is divided into circuit sections: the Frequency Control Section, the Voltage Tuned Oscillator, the Amplitude Modulation Section, and the Power Supply Section. Each section can be tested individually for proper operation.

5-71. The Frequency Control Section has two parts, the Tuning Voltage Generator and the Helix Voltage Generator. To test the Tuning Voltage Generator, see Paragraph 5-75. To test the Helix Voltage Generator, see Paragraph 5-80.

5-72. To test the Voltage Tuned Oscillator (BWO tube) see Paragraph 5-86.

5-73. The Amplitude Modulation Section has seven parts: the Blanking Switch, Square Wave Generator, Marker Timers and Marker Generators, Automatic Level Control Amplifier, Low Pass Filter, Modulator and Option 01 Directional Detector. Notice that the ALC Amplifier can be isolated from the rest of the Amplitude Modulation Section by simply releasing the ALC pushbutton. To test the Amplitude Modulation Section, excluding the ALC Amplifier, see Paragraph 5-91. To test the ALC Amplifier, see Paragraph 5-107.

5-74. The Power Supply Section furnishes dc operating voltages for all sections of the Sweep Oscillator. Therefore, a fault in this section can result in a trouble indication in any other section. For troubleshooting, the Power Supply Section is divided into two main parts: transistor-operated power supplies, and electron tube-operated power supplies. To test the transistor-operated supplies see Paragraph 5-111. To test the electron tube-operated supplies, see Paragraph 5-118.

5-75. ISOLATING A TROUBLE IN THE TUNING VOLTAGE GENERATOR.

5-76. Test Point 1, Figure 5-16, is a key check point for the Tuning Voltage Generator. Since it is at a monitor point for the tuning signals to the Helix Voltage Generator, a proper indication at Test Point 1 eliminates the Tuning Voltage Generator as a source of trouble. To test the Generator, first set LINE to STANDBY and remove A1V6. Then, with LINE still at STANDBY, observe the waveforms at Test Point 1 during full-band, AUTO, START STOP sweeps, first upward, then downward in frequency. For an upward sweep, the waveform should be a linear sawtooth voltage of +70, ±0.5 volts amplitude having a dc level of about 7 volts coincident with START frequency. For a downward sweep, the waveform should be the inverse of the upward sweep waveform. If both waveforms are satisfactory, the Tuning Voltage Generator may be eliminated as the source of trouble.

5-77. If both waveforms are absent, use the MANUAL SWEEP mode to repeat the two full-band sweeps. The limits of dc voltage variation during MANUAL SWEEP should be the same as those given for the AUTO sweep waveforms. If MANUAL SWEEP is normal, check the Ramp Generator, A1V1.

5-78. Absence of one waveform during the AUTO sweep test indicates normal operation of the Ramp Generator, but malfunction of one signal path between the Ramp Generator and the Test Point.

Test Point	MANUAL SWEEP Control Setting	Voltage	
1	ccw limit cw limit	+ 7.3 ± 1 +76.4 ± 1	+76.4 ± 1* + 7.3 ± 1*
2	ccw limit cw limit	+ 242 ± 24 0 to + 1	
3	ccw limit cw limit	+ 158 ± 3 0	
4	ccw limit cw limit	+ 145 ± 2 0 ± 0.1	
5	ccw limit cw limit	+ 145 ± 2 0 ± 0.1	
6	ccw limit cw limit	0 ± 0.1 + 145 ± 2	
7	ccw limit cw limit	0 ± 0.1 + 145 ± 2	
8	ccw limit cw limit	+ 80 ± 5 + 250 ± 5	
9	ccw limit cw limit	+ 198 ± 2 + 195 ± 2	
10	ccw limit cw limit	+ 78.6 ± 0.5 + 78.6 ± 0.5	

5-79. Test Points 2 through 10, Figures 5-12 and 5-16, are given as guides to orderly trouble-localizing within the Tuning Voltage Generator. Test Point 2, the output of the Ramp Generator, is the key checkpoint for the Ramp Generator. Typical Ramp Generator waveforms are shown in Figure 4-6. The MANUAL SWEEP tuning mode is recommended for trouble-localizing using Test Points 1 through 10. MANUAL SWEEP permits dc voltage measurements at the operating limits corresponding to the RF tuning range end frequencies. Set SWEEP SELECTOR to MANAUL, START/CW and STOP/ΔF to the high frequency limit, depress START STOP and measure dc voltages as in the table above. With the exception of the starred values, all voltages are given for controls set as above. Measure the starred voltages after setting START/CW and STOP/ΔF to the low frequency limit.

5-80. ISOLATING A TROUBLE IN THE HELIX VOLTAGE GENERATOR.

5-81. The Helix Voltage Generator is shown schematically in Figure 5-20. Numbered stars indicate recommended test points. Set up a full-band manual sweep and rotate MANUAL SWEEP through its range while measuring the helix voltage variation at TB1 (Test Point 1, Figure 5-20). The helix voltage limits should be within ±10% of those listed below. If not, check at Test Point 2 for proper tuning voltage input from the Tuning Voltage Generator. The tuning voltage input should range between zero and +70 volts ±1 volt with full rotation of MANUAL SWEEP.

Model	BWO	Helix Voltage Range
691A	Stewart	+ 325V to + 1440V
692A	Stewart	+ 325V to + 1725V
693A	Stewart	+ 310V to + 1805V
694A	Stewart	+ 350V to + 2150V

5-82. Test Points 3 and 4 are given as guides for sectionalizing the Helix Voltage Generator.

5-83. Out-of-tolerance frequency calibration in a segment of the tuning range indicates a malfunction in one or more branches of the shaping network, etched circuit A3. In addition, a noisy diode in the shaping network can cause residual FM of the RF output. The residual FM will begin at the RF frequency at which the noisy diode first begins to conduct and will be present at all RF frequencies for which the diode is conducting.

5-84. Residual FM of the RF output may be caused by excessive ripple from the Tuning Voltage Generator. To isolate the trouble source, set up CW operation, tune the RF output to the low frequency limit of the RF tuning range, and short-circuit pin 2 of A1V6 to the chassis. If the residual FM decreases significantly, check the Tuning Voltage Generator for excessive ripple. If FM is unchanged, check the BWO tube operating voltages for excessive ripple.

5-85. To isolate the cause of non-linear auto-tuning of the RF output,

a. Check for proper helix voltage variation.

b. Check for linear ramp from Tuning Voltage Generator at Test Point 2, the input to the Helix Voltage Generator. If the ramp is non-linear, set LINE switch to STANDBY, remove A1V6, and recheck ramp linearity at Test Point 2. If the ramp is linear, check the Helix Voltage Generator. If it is still non-linear, check the Tuning Voltage Generator.

5-86. ISOLATING TROUBLE TO THE BWO TUBE.

5-87. Three common signs of BWO tube aging are 1) reduced RF output throughout the tuning range, 2) complete loss of RF output at some frequency, and 3) persistent shutdown due to helix overcurrent relay operation during unleveled, full RF power operation in the upper half of the RF tuning range. The first two indications are usually due to reduced cathode current, while the third is usually caused by gas ionization in the BWO tube. Normal aging of the BWO tube does not show as frequency calibration error.

5-88. To determine whether the cause of one of the foregoing symptoms is actually the BWO tube, begin by measuring BWO tube heater voltage and current at TB1 (see Figure 5-6). If heater voltage and current are correct, optimize anode voltage and operating currents using the procedure of Paragraph 5-47. If this procedure does not restore normal operation of a BWO tube still in warranty, return the tube for adjustment as instructed in the Warranty Claim and Adjustment Procedure at the rear of this manual. If the tube warranty has expired, try the procedure of Paragraph 5-48 before discarding the tube.

5-89. If the cause of symptom 3) above is gas ionization, no adjustment of operating voltages will restore normal, full-band operation. However, the tube may continue to give acceptable performance within a restricted tuning range. To define the tuning limits, set the Sweep Oscillator for CW operation (POWER LEVEL at 10) and measure helix current while tuning upward in frequency through the full band. Restrict the upper tuning limit to the frequency just below the excessive helix current point.

5-90. If there is no RF output over a segment of the tuning range near one limit, check for proper tuning range using an RF Frequency Meter. If the range of tuning voltage applied to the BWO helix shifts so that a portion is outside the specified operating range for the tube, the result is usually abrupt loss of RF output where the tuning voltage goes beyond the operating limit of the tube.

5-91. ISOLATING A TROUBLE IN THE AMPLITUDE MODULATION SECTION.

5-92. The Amplitude Modulation Section is shown schematically in Figure 5-22 and 5-26. The numbered stars on the diagram indicate key check points in signal paths, and the sequence of numbers is intended as a guide to orderly trouble-localizing. Test Point 2, at the input to the BWO Cathode Current Modulator is common to all amplitude modulation signals, automatic level control signals, and the POWER LEVEL control voltage. From Test Point 2, the Test Points are numbered for localizing trouble to the various amplitude modulation function. For instance, Test Points 4 and 5 are located at the input and output of the circuit which forms the RF blanking pulse; Test Points 3 and 6 bracket the circuit which forms the internal square wave modulation signal; Test Points 7,9,12 and 14 subdivide the circuit which generates frequency MARKER 1; and Test Points 8,10,13 and 15 subdivide the circuit which generates frequency MARKER 2. Following paragraphs contain the data required to test performance of the individual amplitude modulation circuits.

5-93. LOW PASS FILTER (692A, 693A, 694A).

5-94. Low Pass Filter FL1 (Option 01) is a passive device included to attenuate RF harmonics generated by the BWO tube. To determine whether the filter is a trouble source, remove it and connect the BWO tube output directly to the Directional Detector RF input.

5-95. OPTION 01 DIRECTIONAL DETECTOR.

5-96. Sweep Oscillators equipped to furnish leveled RF power are designated Option 01, and are distinguished from standard Sweep Oscillators by the label INT ALC on the pushbutton under the POWER LEVEL control.

5-97. Option 01 Sweep Oscillators are supplied with internal directional coupler-crystal detector combinations which are mounted directly behind the RF output. In the Models 691A and 692A these combinations are standard HP 786D and 787D Directional Detectors. In the Models 693A and 694A the unit consist of a coaxial 10-db directional coupler with a standard HP 423A crystal detector at the secondary line output.

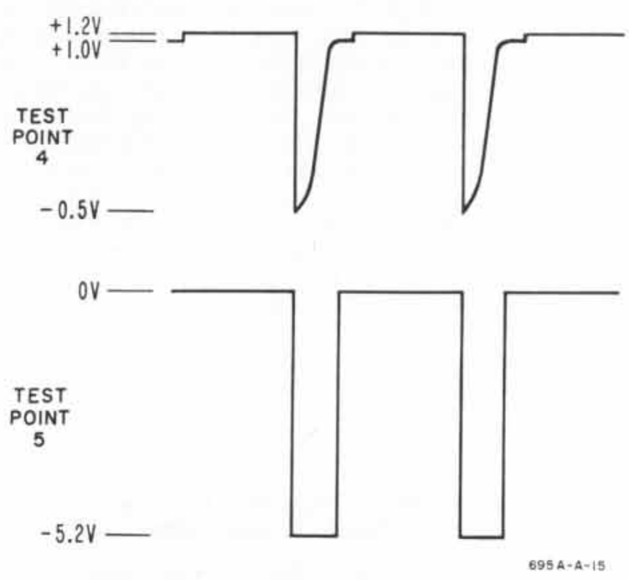
5-98. In the process of localizing the cause of substandard performance the Option 01 directional detector units may be isolated and tested individually. To test the performance of the Model 691A and 692A units use the Performance Checks from the Operating Note included as Appendix II in this manual. In the case of the Model 693A and 694A units remove the HP 423A Crystal Detector from the unit and test it separately using the information in the Operating Note included as Appendix III in this manual. If the directional coupler proves defective, return it to Hewlett-Packard for repair.

5-99. BLANKING CIRCUIT.

5-100. To check for proper operation of this circuit compare with the first pair of typical input and output waveforms as shown. Formation of the RF blanking pulse is explained in Paragraph 4-35 through 4-38, and Paragraphs 4-72 and 4-73. Timing of the blanking pulse is illustrated in Figure 4-7. For oscilloscope display of the blanking pulse, set the Sweep Oscillator for an automatic sweep with sweep time suitable for viewing and the sweep time vernier in the LINE SYNC detent position.

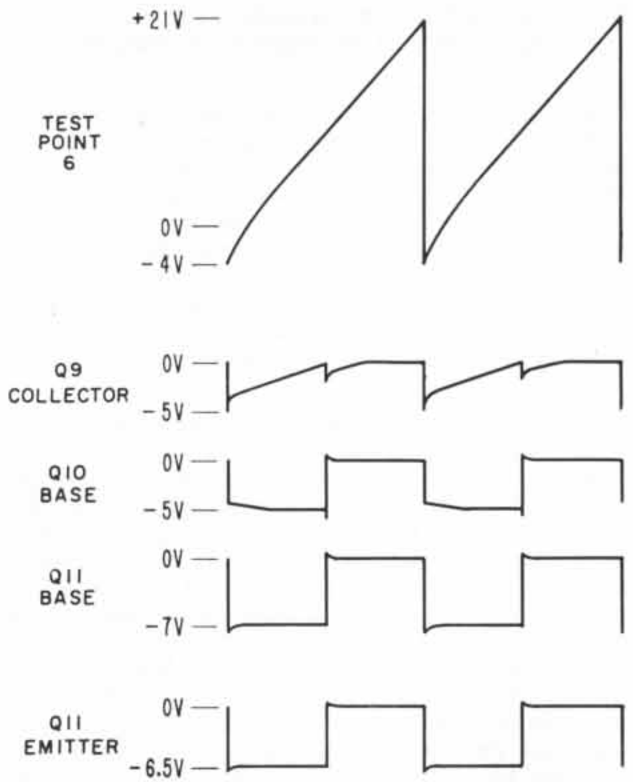
5-101. SQUARE WAVE GENERATOR.

5-102. To check for normal operation of the square wave generator, depress INT SQ WAVE and compare waveforms as shown in the second set.



5-103. FREQUENCY MARKER CIRCUITS.

5-104. To check signal flow in a marker channel set the Sweep Oscillator for automatic start-stop sweep operation with sweep time suitable for oscilloscope display and set MARKER 1 and MARKER 2 to the same frequency. Then compare signal flow, point-by-point, between the operational and defective marker channels.



5-105. For troubleshooting using dc voltage measurements:

a. Set Sweep Oscillator controls as follows:

LINE . . . . RF
SWEEP SELECTOR . . . . MANUAL
START/CW . . . . low end of Swp Osc range
STOP/ΔF . . . . high end of Swp Osc range
START STOP . . . . depressed
MARKER 1 . . . . midband frequency
MARKER 2 . . . . midband frequency

b. Compare dc voltages measured at points listed below to typical voltages given. Voltages are given for MARKER 1 channel test points only. However, voltages at corresponding points in the Marker 2 channel should be nearly similar.

MARKER 1 Channel Test Point	DC VOLTAGE (volts) MANUAL SWEEP Max cw	MANUAL SWEEP Max ccw
A4V1A, pin 8	+ 78 ± 3	+ 8 ± 3
A4V2A, pin 8	- 35 ± 2*	- 35 ± 2*
A4V3A, pin 2	+ 5.5 ± 0.5	- 6.8 ± 0.2
A4Q1 base	- 0.7 + 0.3	- 9.5 ± 2
A4Q1 collector	+ 5 ± 1	+ 15 ± 1
A5Q3 base	+ 12.4 ± 0.5	+ 14 ± 0.5
A5Q3 emitter	+ 12.6 ± 0.5	+ 13.0 ± 0.5
A5Q3 collector	+ 12.4 ± 0.5	- 6.8 ± 0.2
A5Q4 base	+ 12.8 ± 0.2	+ 12.8 ± 0.2
A5Q4 emitter	+ 12.6 ± 0.5	+ 13.0 ± 0.5
A5Q4 collector	- 6.8 ± 0.2	+ 11.5 ± 0.5
A5Q5 base	+ 0.4 ± 0.2	+ 0.4 ± 0.2
A5Q5 emitter	+ 0.6 ± 0.2	+ 0.6 ± 0.2

* actual voltages should be equal.

5-106. If, during a narrow sweep, oscilloscope display of a frequency marker shows horizontal jitter, check for noise in resistors A4R7 and A4R8 (MARKER 1), and A4R9 and A4R10 (MARKER 2).

5-107. ISOLATING A TROUBLE IN THE ALC AMPLIFIER.

5-108. The ALC Amplifier is shown schematically in Figure 5-30. Numbered stars suggest a logical sequence for localizing the cause of trouble within the amplifier. For trouble isolation, the ALC Amplifier can be divided into four parts: Differential Amplifier A5V1, A5Q16, A5Q17 and A5Q18, Amplifier A5Q19, Switch A5Q21 and Inverter A5Q22. Of these, the two principal parts are the Differential Amplifier and the Amplifier. The Differential Amplifier develops the RF leveling signal while the Amplifier inverts and amplifies this signal for application to the Gain Shaping Circuit. Inverter A5Q22 impresses amplitude modulation signals onto the dc reference side of the Differential Amplifier. Switch Q21 flashes DS2 to warn of an open condition in the RF leveling system.

5-109. The Differential Amplifier consists of two sides: the reference side and the signal side. A5Q16B, A5V1B and A5Q18 comprise the reference side. The signal side consists of A5Q16A, A5V1A and A5Q17. For proper operation of the Differential Amplifier, both these sides must operate as balanced units. Normal unbalance is compensated for by A5R48, ALC Balance. To isolate unbalance due to a defective component in one side:

a. connect the base of A5Q16A and the base of A5Q16B to the Oscillator chassis,

b. adjust A5R48 to give equal dc voltages at A5R42, A5R47 junction and A5R49, A5R58 junction, then

c. compare dc voltage measurements at corresponding points in each side of the Differential Amplifier.

Some discrepancy between readings is accounted for by normal gain difference between transistors. However, a defective active component (i.e., transistor or electron tube) will usually produce a marked difference between readings.

5-110. Operational balance of the ALC Amplifier must be restored as described in Paragraph 5-65 following the above procedure.

5-111. ISOLATING A TROUBLE IN THE TRANSISTORIZED POWER SUPPLIES.

5-112. The +20 volt, -6.3 and 12.6 volt power supplies, shown schematically in Figure 5-33, are fully transistorized power supplies. The schematic diagrams show typical, normal operating voltages within the supply. Normal operating characteristics (e.g., output voltage, ripple and current) of each supply are given at the supply output. The typical output voltages and currents assume Sweep Oscillator operation from a 115 VAC supply. Output ripple, however, should not exceed the value given over a 10% line voltage variation.

Note

Never adjust a supply if the DC output is only slightly out of tolerance while Sweep Oscillator performance, supply ripple, and regulation are normal. Adjustment of a slightly out-of-tolerance supply can upset the calibration of one or more Sweep Oscillator functions.

5-113. Normal variation in component operating characteristics will account for nominal variation in normal operating voltages from Sweep Oscillator to Sweep Oscillator. For instance, ±10% variation in the voltages shown at the collectors of A7Q2 (+20 volt supply) and Q6 in the -6.3 volt supply would be normal while normal variation in dc voltages within the regulators of these supplies would be ±0.2 volt for the +20 volt supply and ±0.1 volt for the -6.3 volt supply.

5-114. Normal variation in voltages within the 12.6 volt supply would be ±10% at the collectors of Series Regulators Q1 and Q2, and ±5% for voltages within the regulator circuit.

5-115. Make measurements within the transistorized supplies using the Sweep Oscillator chassis as the reference potential. This practice avoids damage to transistors by loop currents which might result if the measuring device (voltmeter) reference potential is not chassis (ground) potential.

5-116. Numbered stars on the schematic diagrams indicate measurement points. Corresponding numbered stars on the etched circuit illustration show convenient places to make the measurements. The sequence of numbers within each supply suggests a logical trouble-localizing sequence.

5-117. Table 5-3 lists possible causes of high and low output voltages from the transistorized power supplies.

Table 5-3. Trouble Locating Guide for Transistorized Power Supplies

Symptom	Power Supply and Possible Cause		
	+20 VOLT	-6.3 VOLT	12.6 VOLT
High Output Voltage	+275V Supply	-300V Supply	Shorted
	Shorted A7Q2, A7Q3 A7Q4	Shorted A7Q6 Q3, Q4, Q5, Q6	A7Q1 Q1 Q2
	Open A7Q5	Open A7Q7	Open A7CR1, 2, 3
Low Output Voltage	+275V Supply	-300V Supply	Shorted
	Shorted A7Q5	Shorted A7Q6	A7CR1 A7CR2 A7CR3
	Open A7Q2, A7Q3 A7Q4	Open A6Q6 Q3, Q4, Q5, Q6	Open A7Q1 Q1 Q2

5-118. ISOLATING A TROUBLE IN THE ELECTRON TUBE POWER SUPPLIES.

5-119. The electron tube power supplies are shown schematically in Figure 5-36. Seven dc operating voltages originate in these supplies: they are +275 volts, +156 volts, +81 volts, -300 volts, -83 volts, -81 volts and a positive voltage for the BWO tube anode. Of these, the principal two are the +275 volts and -300 volt supplies. The remaining five are derived from +275 and -300 volts. In addition, proper operation of the +275 volt supply depends upon proper operation of the -300 volt supply because -300 volts is the +275 volt supply reference potential.

5-120. Typical, normal operating voltages within each supply are given on the schematic diagram. These voltages assume operation of the Sweep Oscillator from a 115 VAC supply. Normal variation in component operating characteristics will produce variations in normal operating voltages from Sweep Oscillator to Sweep Oscillator, yet circuit function will be normal. Therefore, ±3% difference between voltages given and voltages measured is tolerable except for the dc voltages between rectifiers and Series Regulators. Here the variation can be ±10%. The ripple given at the output of the +275 and -300 volt supplies must not exceed the value given on the schematic diagram for 10% line voltage variation. Increased ripple with line voltage variation usually signifies marginal operation of the supply.

5-121. Numbered stars on the schematic diagram indicate measurement points. Corresponding numbered stars on the etched circuit illustration indicate convenient measurement points. The sequence of numbers suggests a logical order for trouble-localizing.

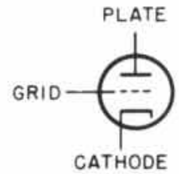
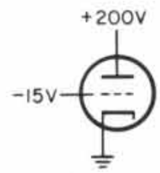
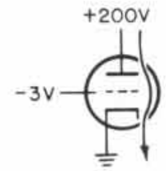
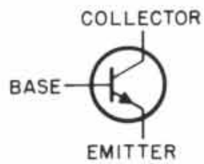
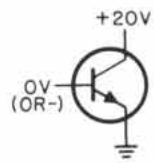
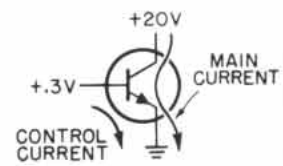
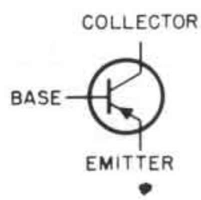
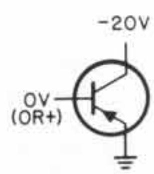
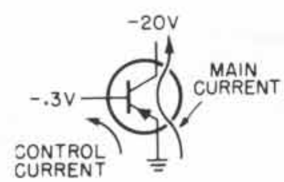
5-122. ISOLATING TROUBLE IN TRANSISTOR CIRCUITS.

5-123. The following procedures and data are given to aid in determining whether a transistor is operational. Tests are given for both in-circuit and out-of-circuit transistors.

5-124. IN-CIRCUIT TESTING.

5-125. The common causes of transistor failures are internal short- and open-circuits. In transistor circuit testing the most important consideration is the transistor base-emitter junction. Like the control grid of a vacuum tube, this is the operational control point in the transistor. This junction is essentially a solid state diode. For the transistor to conduct, the diode must conduct; that is, the diode must be forward biased. As with simple diodes, the forward-bias polarity is determined by the materials forming the junction. Use the transistor symbol on the schematic diagram to determine the bias polarity required to forward-bias the base-emitter junction. The A part of Figure 5-8 shows transistor symbols with terminals labeled. Notice that the emitter arrow conventionally points toward the type N material. The other two columns of the illustration compare the biasing required to cause conduction and cut-off in

A. TRANSISTOR BIASING

DEVICE	SYMBOL	CUT OFF	CONDUCTING
VACUUM TUBE			
N P N TRANSISTOR			
P N P TRANSISTOR			

B. AMPLIFIER CHARACTERISTICS

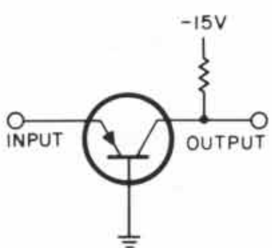
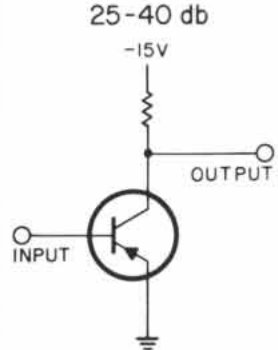
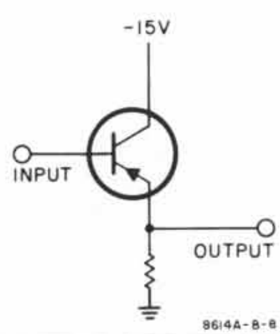
CHARACTERISTIC	COMMON BASE	COMMON EMITTER	COMMON COLLECTOR
INPUT Z	30-50 Ω	500-1500 Ω	20-500K Ω
OUTPUT Z	300-500K Ω	30-50K Ω	50-1000 Ω
VOLTAGE GAIN	500-1500	300-1000	< 1
CURRENT GAIN	< 1	25-50	25-50
POWER GAIN	20-30 db	25-40 db	10-20 db
			

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Figure 5-8. Transistor Biasing and Operating Characteristics transistors and vacuum tubes. If the transistor base-emitter diode (junction) is forward-biased the transistor conducts. If the diode is heavily forward-biased, the transistor saturates. However, if the base-emitter diode is reverse-biased the transistor is cut-off. The voltage drop across a forward-biased emitter-base diode varies with transistor collector current. For example, a germanium transistor has a typical forward-bais, base-emitter voltage of 0.2-0.3 volts when collector current is 1-10 ma, and 0.4-0.5 volts when collector current is 10-100 ma. In contrast, forward bias voltage for silicon transistors is about twice that for germanium types: about 0.5-0.6 volts when collector current is low, and about 0.8-0.9 volts when collector current is high.

5-126. Figure 5-8, part B, shows simplified versions of the three basic transistor circuits and gives the operating characteristics of each. When examining a transistor stage, first determine if the emitter-base diode is biased for conduction (forward-biased) by measuring the voltage difference between emitter and base. When using an electronic voltmeter, do not measure directly between emitter and base: there may be sufficent loop current between the voltmeter leads to damage the transistor. Instead, measure each voltage separately with respect to a voltage common point (e.g., chassis). If the emitter-base diode is forward-biased, check for amplifier action by short-circuiting base to emitter while observing collector voltage. The short-circuit eliminates base-emitter bias and should cause the transistor to stop conducting (cut off). Collector voltage should then shift to near the supply voltage. Any difference is due to leakage current through the transistor and, in general, the smaller this current, the better the transistor. If collector voltage does not change, the transistor has either an emitter-collector short circuit or emitter-base open circuit.

5-127. TESTING TRANSISTORS WITH AN OHMMETER.

5-128. The two common causes of transistor failure are internal short- and open-circuits. Remove the transistor from the circuit and use an ohmmeter to measure internal resistance. See Table 5-4 for measurement data.

CAUTION

Most ohmmeters can supply enough current or voltage to damage a transistor. Before using an ohmmeter to measure transistor forward or reverse resistance, check open-circuit voltage and short-circuit current output ON THE RANGE TO BE USED. Open-circuit voltage must not exceed 1.5 volts and short-circuit current must be less than 3 ma. See Table 5-5 for safe resistance ranges for some common ohmmeters.

Table 5-4. Out-of-Circuit Transistor Resistance Measurement

Transistor Type		Connect Ohmmeter		Measure Resistance (ohms)
		Pos. lead to	Neg. lead to	
PNP Germanium	Small Signal	emitter	base*	200-500
		emitter	collector	10K-100K
	Power	emitter	base*	30-50
		emitter	collector	several hundred
NPN Silicon	Small Signal	base	emitter	1K-3K
		collector	emitter	very high (might read open)
	Power	base	emitter	200-1000
		collector	emitter	high, often greater than 1M

*To test for transistor action, add collector-base short. Measured resistance should decrease.

Table 5-5. Safe Ohmmeter Ranges for Transistor Resistance Measurements

Ohmmeter	Safe Range(s)	Open Ckt Voltage	Short Ckt Current	Lead Color	Lead Polarity
HP 412A	R x 1K R x 10K R x 100K R x 1M R x 10M	1.0V 1.0V 1.0V 1.0V 1.0V	1 ma 100 μa 10 μa 1 μa 0.1 μa	Red Black	+ -
HP 410C	R x 1K R x 10K R x 100K R x 1M R x 10M	1.3V 1.3V 1.3V 1.3V 1.3V	0.57 ma 57 μa 5.7 μa 0.5 μa 0.05 μa	Red Black	+ -
HP 410B	R x 100 R x 1K R x 10K R x 100K R x 1M	1.1V 1.1V 1.1V 1.1V 1.1V	1.1 ma 110 μa 11 μa 1.1 μa 0.11 μa	Black Red	+ -
Simpson 260	R x 100	1.5V	1 ma	Red Black	+ -
Simpson 269	R x 1K	1.5V	0.82ma	Black Red	+ -
Triplett 630	R x 100 R x 1K	1.5V 1.5V	3.25 ma 325 ma	Varies with Serial Number	
Triplett 310	R x 10 R x 100	1.5V 1.5V	750 μa 75 μa		

5-129. REPLACING POWER SUPPLY TRANSISTORS AND DIODE CR12.

5-130. Transistors Q1, Q2, Q3, Q4, Q5, Q6 (Series Regulators, transistorized power supplies) and BWO heater over-voltage protection diode CR12 are high current types which require good thermal contact with mounting surfaces for adequate heat dissipation. To assure good thermal contact for a replacement transistor, coat both sides of the black insulator with Dow Corning #5 silicone compound or equivalent before fastening the transistor to the chassis. When replacing diode CR12, coat the diode case outside surface before adding the heat dissipater, and coat both sides of both black insulators before bolting the dissipater assembly to the sub-chassis. Dow Corning #5 compound is available in 8-oz. tubes from Hewlett-Packard: order HP Stock No. 8500-0059.

5-131. A5Q16 LEAD IDENTIFICATION.

5-132. ALC Amplifier transistor A5Q16 is a dual transistor (i.e., two transistors in one case). For this configuration, the locating tab which protudes from the rim of the transistor case identifies the collectors, not the emitters.

5-133. ALIGNING V1, V2, V3 PLATE CONNECTORS TO AVOID BREAKAGE.

5-134. To prevent breakage of the V1, V2, V3 Series Regulator ceramic plate connectors when the hinged chassis is closed, always check that they are positioned to provide clearance for the metal bracket attached to the hinged deck.

5-135. BWO TUBE REPLACEMENT.

5-136. WARRANTY.

5-137. BWO tube V4 is not manufactured by Hewlett-Packard and therefore is not covered by the Sweep Oscillator Warranty. A separate, manufacturer's warranty covers the BWO tube. BWO tubes are warranted for 2500 hours, or one year, of heater operation, whichever occurs first. If the BWO tube fails within this warranty period, see the Warranty Claim and Adjustment Procedure at the rear of this manual. Always detach and return Time Meter A8M1 when returning a BWO tube for warranty adjustment.

5-138. ORDERING A REPLACEMENT BWO TUBE.

5-139. When ordering a replacement BWO tube from Hewlett-Packard order, in addition, a replacement Time Meter (A8M1).

5-140. BWO TUBE REMOVAL.

a. Disconnect Sweep Oscillator from AC line power.

b. Remove top, bottom and right side cabinet covers.

c. Disconnect BWO tube RF output from Low Pass Filter or Directional Detector. The BWO tubes are equipped with impedance-matching balun units attached to the two white RF output leads. The balun consists of a brass-colored assembly and a flanged female-to-female type N adapter. IMPORTANT: Do not disassemble the balun unit nor detach the adapter from the balun. Both units are part of the BWO tube and must be included with a BWO tube returned for warranty adjustment. New and replacement BWO tubes are supplied with a balun and adapter attached.

d. Disconnect BWO tube leads from terminal strip TB1.

e. Remove 4 screws fastening BWO tube to chassis. Detach both aluminum mounting blocks from BWO tube. Save blocks.

f. Remove BWO tube.

5-141. BWO TUBE INSTALLATION.

5-142. MECHANICAL.

a. Be sure Sweep Oscillator is disconnected from AC line power.

b. Fasten two aluminum mounting blocks to BWO, inserting screws so heads are recessed in countersunk holes. Tighten screws securely.

c. Bolt BWO tube to chassis. Tighten mounting bolts.

d. Connect BWO tube RF output to Low Pass Filter or Directional Detector.

e. Install replacement Time Meter (A8M1) on A8 etched circuit, locating timing gap over time scale zero line.

5-143. ELECTRICAL ADJUSTMENTS.

a. Before connecting BWO tube leads to TB1, coarse-set anode voltage as follows:

(1) Set Sweep Oscillator for CW (single-frequency) operation at some frequency above the middle of the RF tuning range.

(2) Measure anode voltage at TB1 terminal, and adjust A2R50 (Anode Voltage) to give anode voltage within ±5 volts of the operating value on the BWO tube manufacturer's data sheet.

b. Disconnect Sweep Oscillator from AC line power: then connect BWO tube leads to appropriate TB1 terminals. (Use tube data sheet or schematic diagram to identify leads.)

c. Turn on Sweep Oscillator and allow a few minutes for the BWO tube to reach operating temperature.

d. Set Sweep Oscillator for CW operation at the highest frequency in the RF tuning range. Set POWER LEVEL to 10.

e. Measure BWO tube anode voltage at TB1 anode terminal, and monitor current in BWO tube cathode lead (see Figure 5-6). Adjust A2R50 (Anode Voltage) to obtain top frequency cathode current specified on tube data sheet.

f. Equalize RF power output over tuning range as follows:

(1) Connect equipment as in Figure 5-1 to measure RF power output. Set Sweep Oscillator for CW operation, POWER LEVEL at 10.

(2) Measuring current in BWO tube cathode and helix leads, tune RF output to frequency in lower half of RF tuning range at which RF output is minimum. Adjust A2R48 for maximum RF output without exceeding maximum cathode and helix currents specified on tube data sheet.

Note

Excessive helix current actuates Overload Relay A6K1, starting a sequence which disconnects BWO operating voltages. To reconnect voltages, set LINE to OFF, then back to RF and wait for time delay to recycle.

(3) Manually tune through the full band checking that neither cathode nor helix current exceeds data sheet maximum. If maximum exceeded, readjust A2R50 (Anode Voltage) and/or A2R48 (Anode Shape) to reduce current. Anode Shape affects lower half of RF tuning range; Anode Voltage affects full band.

(4) Repeat steps (2) and (3) to obtain best full-band RF power flatness within the data sheet current limits.

g. Calibrate the CW-START dial using the procedure of Paragraph 5-57. Note: for maximum frequency calibration accuracy during leveled RF (ALC) operation, perform the procedure of Paragraph 5-57, but use the setup of Figure 5-3, placing the calibrating Frequency Meter between the Attenuator and the Crystal Detector. (Set the Sweep Oscillator for maximum, full-band, leveled RF operation.)

h. Use setup of Figure 5-1 to measure RF power output of the BWO tube.

(1) Set Sweep Oscillator for CW operation, POWER LEVEL at 10.

(2) While measuring RF power output, tune through Oscillator frequency range. Minimum measured RF power must be at least 100 mw for the Model 691A, 70 mw for the Model 692A, 20 mw for the Model 693A, and 20 mw for the Model 694A. Maximum measured RF power must not exceed measured minimum by more than 10 db.

5-144. TUBE SEMICONDUCTOR REPLACEMENT.

5-145. Table 5-6 lists checks to be made after replacement of certain electron tubes and semiconductors (e.g., diodes, transistors). Replacement of unlisted items does not affect critical Sweep Oscillator functions or operating voltages.

Note

Do not change an operating voltage or calibration adjustment unless it is either definitely outside specified tolerance or calibration accuracy of a dependent function is unsatisfactory. Improving a marginal adjustment can adversely affect calibration.

5-146. ETCHED CIRCUITS.

5-147. The etched circuit boards in the Sweep Oscillator are of the plated-through type consisting of metallic conductors bonded to both sides of insulating material. The metallic conductors are extended through the component mounting holes by a plating process. Soldering can be done from either side of the board with equally good results. Table 5-7 lists recommended tools and materials. Following are recommendations and precautions pertinent to etched circuit repair work.

a. Avoid unnecessary component substitution: it can result in damage to the circuit board and/or adjacent components.

b. Do not use a high-power soldering iron on etched circuit boards. Excessive heat may lift a conductor or damage the board.

c. Use a suction device (Table 5-7) or wooden toothpick to remove solder from component mounting holes. DO NOT USE A SHARP METAL OBJECT SUCH AS AN AWL OR TWIST DRILL FOR THIS PURPOSE. SHARP OBJECTS MAY DAMAGE THE PLATED-THROUGH CONDUCTOR.

d. After soldering, remove excess flux from the soldered areas and apply a protective coating to prevent contamination and corrosion. See Table 5-7 for recommendations.

e. When removing a multiple-connection component held tightly in a socket, such as a vacuum tube, loosen it gradually using gentle side-to-side or rotary motion to avoid damage to the plated-through conductors.

5-148. COMPONENT REPLACEMENT.

a. Remove defective component from circuit board.

b. Remove solder from mounting holes using a suction desoldering aid (Table 5-7) or wooden toothpick.

c. Shape leads of replacement component to match mounting hole spacing.

d. Insert component leads into mounting holes, and position component as original was positioned. DO NOT FORCE LEADS OF REPLACEMENT COMPONENT INTO MOUNTING HOLES. Sharp lead ends may damage plated-through conductor.

Note

Axial lead components, such as resistors and tubular capacitors, can be replaced without unsoldering. Clip leads near body of defective component, remove component and straighten leads left in board. Wrap leads of replacement component one turn around original leads. Solder wrapped connection, and clip off excess lead.

5-149. TUBE SOCKET REPLACEMENT. There are three ways to remove a tube socket from the etched circuit board:

a. Cut terminals attaching socket to circuit board, remove socket, and unsolder remaining terminal pieces individually.

b. Using long nose pliers, break insulating material of socket away from its metal connectors, then unsolder connectors from board individually.

Table 5-6. Checks Following Tube, Semiconductor Replacement

Assembly	Reference Designation	Check	Paragraphs
A1	A1CR9	Minimum tuning voltage	5-52 b., 1)
	A1CR10	Minimum tuning voltage	5-52 b., 1)
	A1CR13	Reciprocal Zero & Zero Ext. FM	5-52 b., 2), 5-64
	A1CR14	Reciprocal Zero & Zero Ext. FM	5-52 b., 2), 5-64
	A1CR16	CW-START dial calibration	5-53
	A1Q1	Minimum tuning voltage	5-52 b., 1) & 2)
	A1Q2	Minimum tuning voltage	5-52 b., 1) & 2)
	A1V2	Minimum tuning voltage	5-52 b., 1) & 2)
	A1V3	Reciprocal Zero & Zero Ext. FM	5-52 b., 2), 5-64
	A1V4	Reciprocal Zero & Zero Ext. FM	5-52 b., 2), 5-64
	A1V5	Minimum tuning voltage	5-52 b., 1) & 2)
	A1V6	CW-START dial calibration	5-53
	A1V7	CW-START dial calibration	5-53
A2	A2V1	+275V supply voltage, ripple, regulation	5-42
	A2V2	+275V supply voltage, ripple, regulation	5-42
	A2V3	+275V supply voltage, ripple, regulation	5-42
	A2V4	+275V supply voltage, ripple, regulation BWO tube anode voltage	5-42 5-46
	A2V5	+156V supply	
	A2V6	+156V, +81V supply	
	A2V7	+156V supply BWO tube anode voltage	 5-46
	A2V8	-300V supply voltage, ripple, regulation	5-42
	A2V9	-300V supply voltage, ripple, regulation	5-42
	A2V10	-300V supply voltage, ripple, regulation -83V supply	5-42
	A2V11	-81V supply	
A3	A3CR1 thru A3CR9	CW-START dial calibration	5-53
A4	A4Q1	MARK 1 calibration	5-62
	A4Q3	MARK 2 calibration	5-62
	A4V1	CW-START dial calibration	5-53
	A4V2	Marker calibration	5-62
	A4V3	Marker calibration	5-62
A5	A5Q16 thru A5Q19	ALC Amplifier balance	5-65
	A5Q23	Turn-on time delay	5-14d
	A5V1	ALC Amplifier balance	5-65
A7	A7CR3	12.6V supply output voltage	5-42
	A7Q1	12.6V supply	5-42
	A7Q2 thru A7Q5	+20V supply	5-42
	A7Q6, A7Q7	-6.3V supply	5-42
A11	A11Q1	RF Leveling and Amplitude Modulation	5-24
MISC	CR12	BWO Heater Over-Voltage Relay (K4) operation	*
	CR16	Internal square wave modulation	5-42
	Q1, Q2	12.6V supply	5-42
	Q3, 4, 5, 6	-6.3V supply	

* To check CR12: 1) Remove WHT-BRN-YEL wires from CR12; 2) Momentarily connect CR12 anode to Q6 collector (WHT-YEL-BLU wire). K4 should operate.

Table 5-7. Etched Circuit Soldering Equipment

Item	Use	Specification	Item Recommended
Soldering Tool	Soldering Unsoldering	Wattage rating: 37.5 Tip Temp: 750 - 800° F Tip Size: 1/8" OD	Ungar #776 Handle with Ungar #1237 Heating Unit
Soldering Tip, general purpose	Soldering Unsoldering	Shape: chisel Size: 1/8"	Ungar #PL113
De-soldering aid	Unsoldering multi-connection components (e.g., tube sockets)	Suction device to remove multen solder from connection	Soldapullt by the Edsyn Company, Arleta, California
Resin (flux) solvent	Remove excess flux from soldered area before application of protective coating	Must not dissolve etched circuit base board material or conductor bonding agent	Freon Acetone Lacquer Thinner Isopropyl Alcohol (100% dry)
Solder	Component replacement Circuit board repair Wiring	Resin (flux) core, high tin content (60/40 tin/lead), 18 gauge (SWG) preferred	
Protective Coating	Contamination, corrosion protection after soldering	Good electrical insulation, corrosion-prevention properties	Krylon ® #1302* Humiseal Protective Coating, Type 1B12 by Columbia Technical Corp. Woodside 77, New York

* Krylon, Inc., Norristown, Pennsylvania

c. Use a special soldering iron tip designed to heat all socket connections simultaneously and remove socket as a unit; or use a suction device (Table 5-7) to desolder all connections and remove socket.

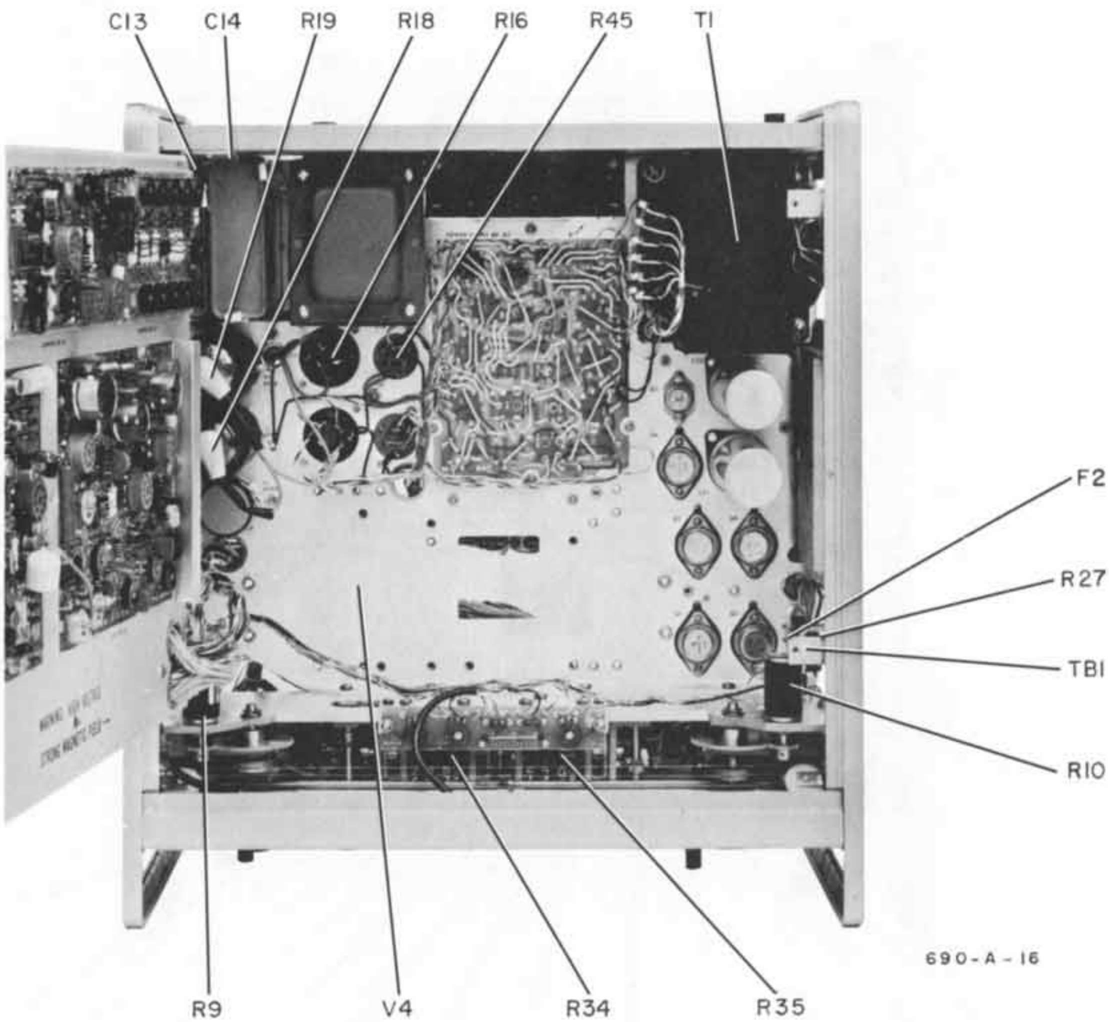
5-150. ETCHED CONDUCTOR REPAIR. A broken or burned section of conductor can be repaired by bridging the damaged section with a length of tinned copper wire. Allow adequate overlap and remove any varnish from etched conductor before soldering wire into place.

5-151. TRANSISTOR REPLACEMENT.

a. Do not apply excessive heat. See Table 5-7 for soldering tool specifications.

b. Use a heat sink such as pliers or hemostat between transistor body and hot soldering iron.

c. When installing a replacement transistor, ensure sufficient lead length to dissipate heat of soldering by maintaining about the same length of exposed lead as used for original transistor.

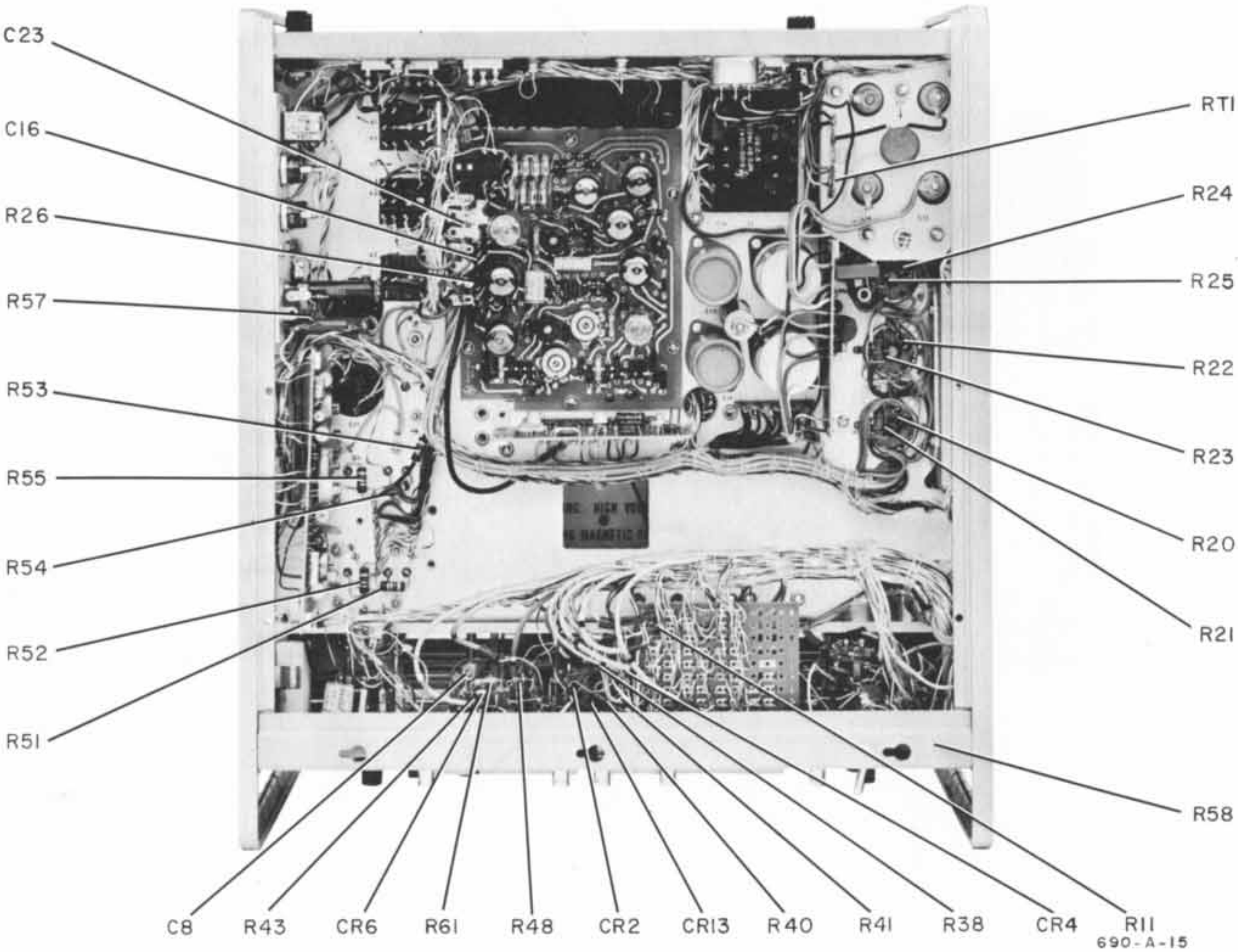


TOP VIEW

LABELED COMPONENTS

B1	C12	Q1	V1
	C17	Q2	V2
	C18	Q3	V3
	C19	Q4	
	C21	Q5	
	C22	Q6	

Figure 5-9. Interior View Showing Locations of Unlabeled Chassis Components



BOTTOM VIEW

LABELED COMPONENTS

B1	C10	CR8	K1	Q1	R46	T2	V1
	C11	CR9	K2	Q2	R56		V2
	C12	CR10	K3	Q3			V3
	C13	CR11	K4	Q4			
	C14	CR12	K5	Q5			
	C17			Q6			
	C18						
	C19						
	C21						
	C22						

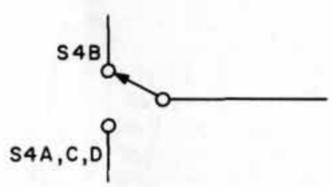
Figure 5-10. Interior View Showing Locations of Unlabeled Chassis Components

1. Resistance in ohms, capacitance in microfarads unless otherwise indicated
2. screwdriver adjust

   panel control
3. front panel designation

   rear panel designation
4. etched circuit borderline

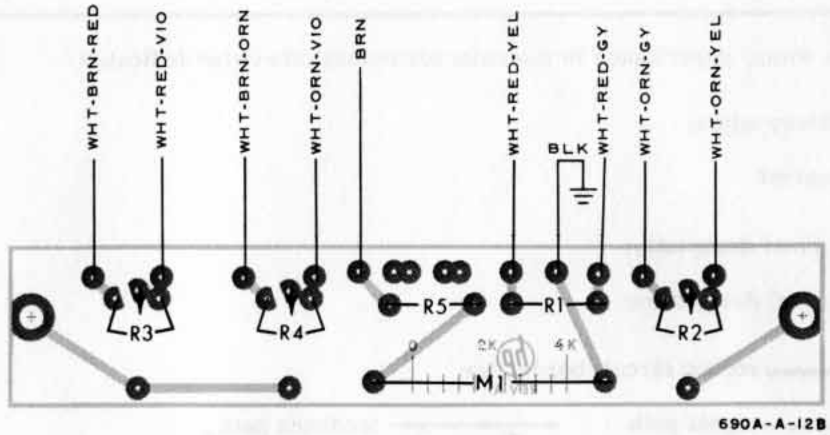
   signal path — feedback path
5. CW indicates movable contact position at clockwise rotation limit of control shaft (shaft viewed from knob or slotted end)
6. Resistance value factory-selected to give correct Series Regulator (V1, 2, 3) screen grid voltage for BWO tube installed. Nominal values: Stewart BWO - 15K, 2W, fxd, comp
7. * denotes a factory-selected value. Typical value shown. Part may be omitted.
8. J15 wired directly to A5 Assy for standard Sweep Oscillators, through A12 Assy for Option 01 Sweep Oscillators.
9. When MARKER SWEEP depressed A4R3 grounded through A8R1 and START/CW R9
10. When MARKER SWEEP depressed A4R12 grounded through A8R2 and STOP/ΔF R10
11. Switch symbols for S4 represent switching functions only. Symbols show circuit condition when the designated pushbutton is pressed. For example,



indicates one circuit condition when ΔF (S4B) is depressed, another when either START STOP (S4A), MARKER SWEEP (S4C), or EXT FM (S4D) is depressed.

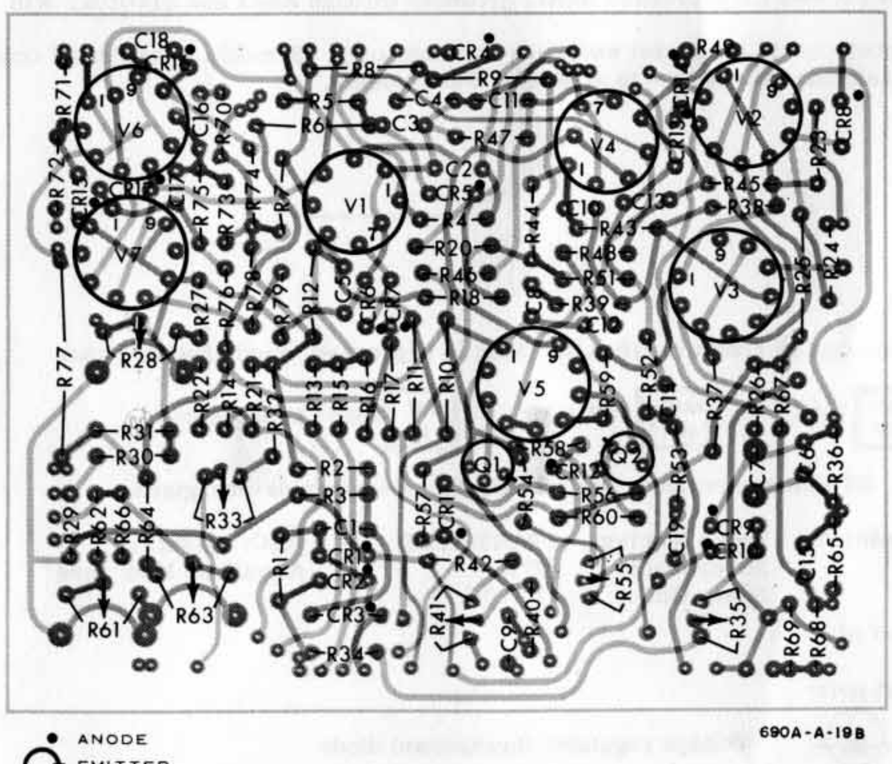
12. Relays K3, K5 shown energized. Relays K1, K2, K4 shown de-energized.
13. Circuit condition: Sweep function: START STOP; Sweep mode: AUTO; Sweep time: .1 - .01; ALC: operating; Amplitude Mod: none
14. P/O = part of
15. = test point
16. Voltage regulator (breakdown) diode

Figure 5-11. Schematic Diagram Notes



BOARD VIEWED FROM COMPONENT SIDE
DARKER PATHS ON COMPONENT SIDE

Figure 5-13. Etched Circuit A8 Component Location



BOARD VIEWED FROM COMPONENT SIDE
DARKER PATHS ON COMPONENT SIDE

Figure 5-14. Etched Circuit A1 Component Location

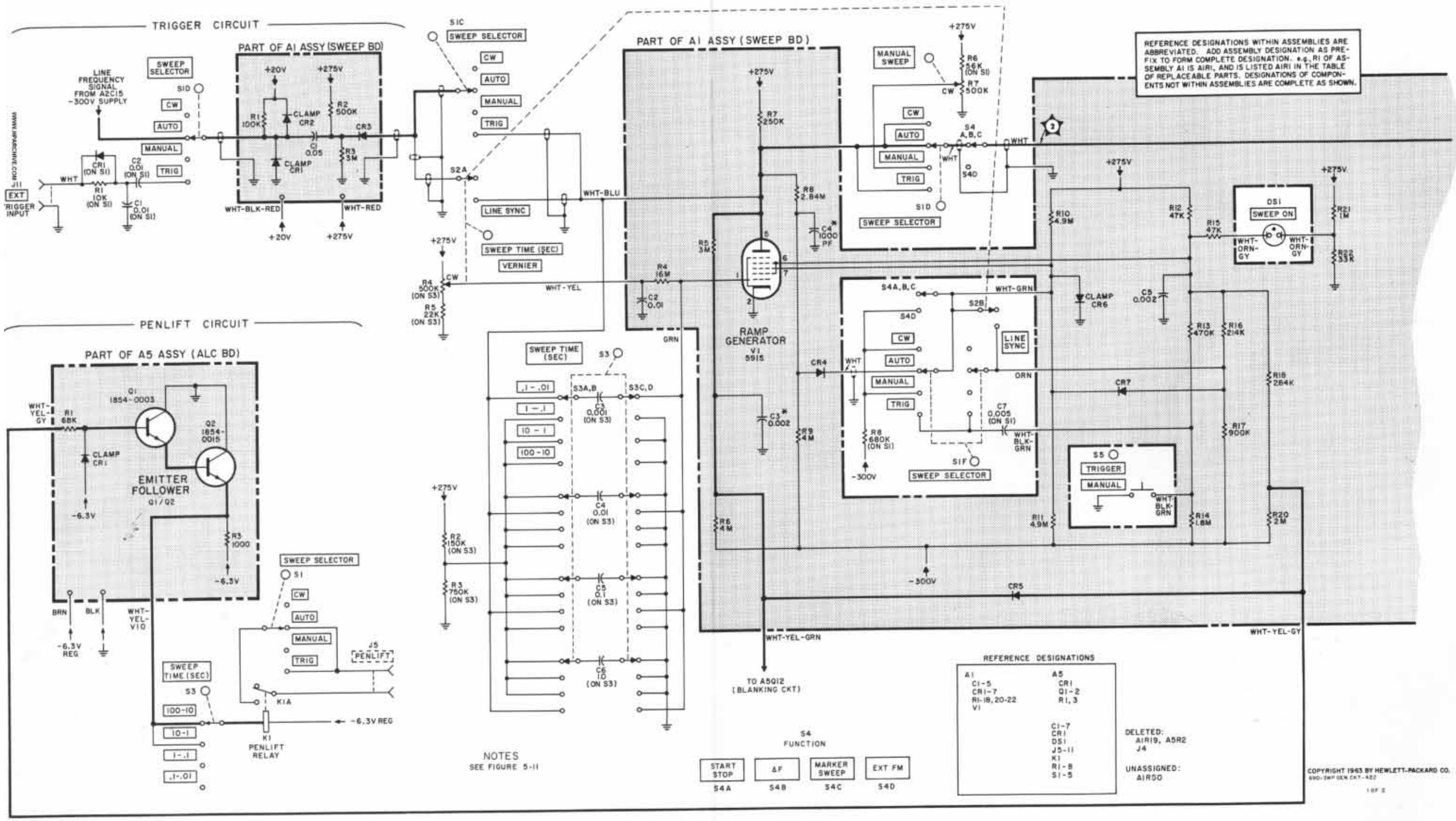


Figure 5-12. Tuning Voltage Generator
(Part 1 of 2)

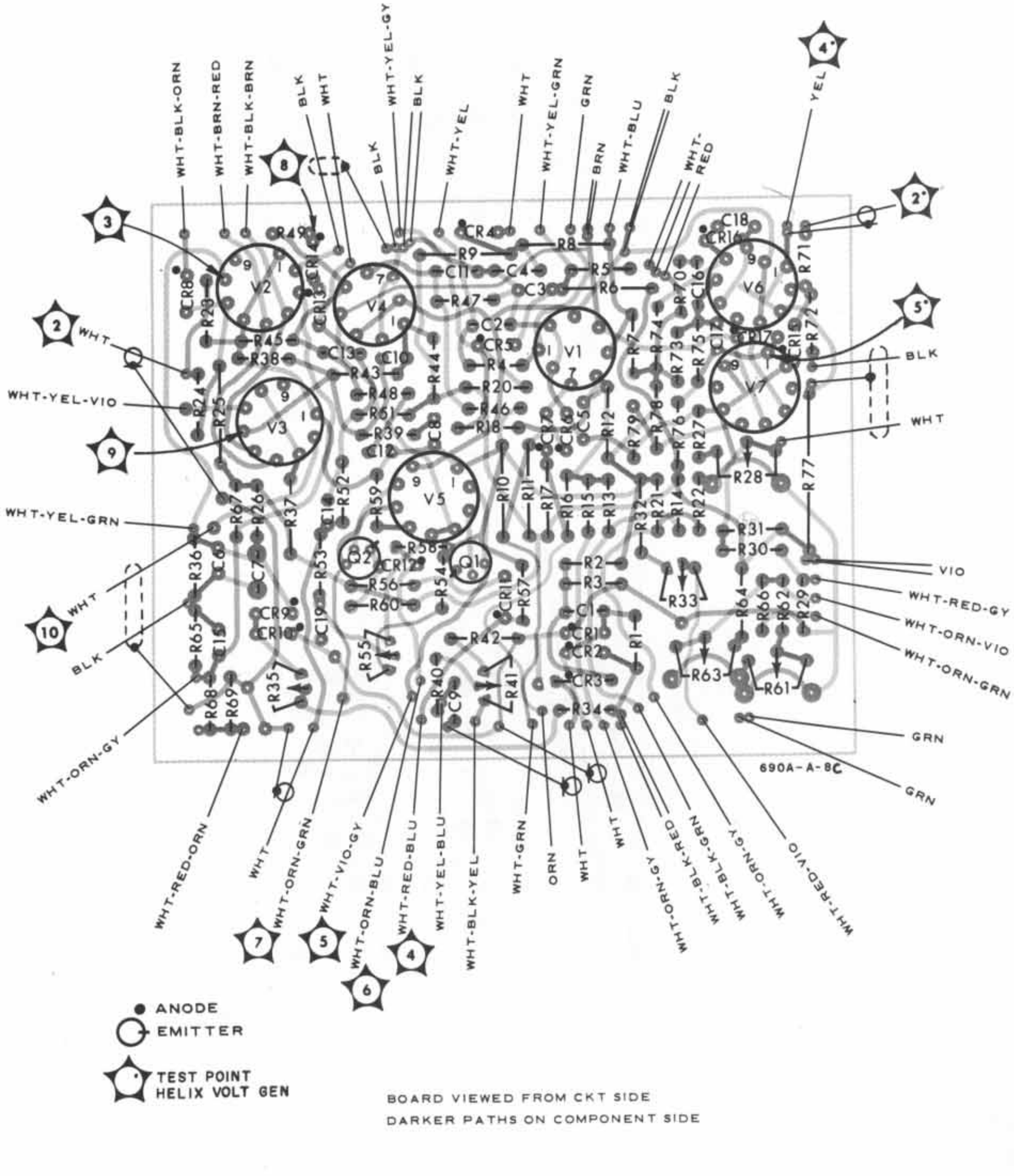
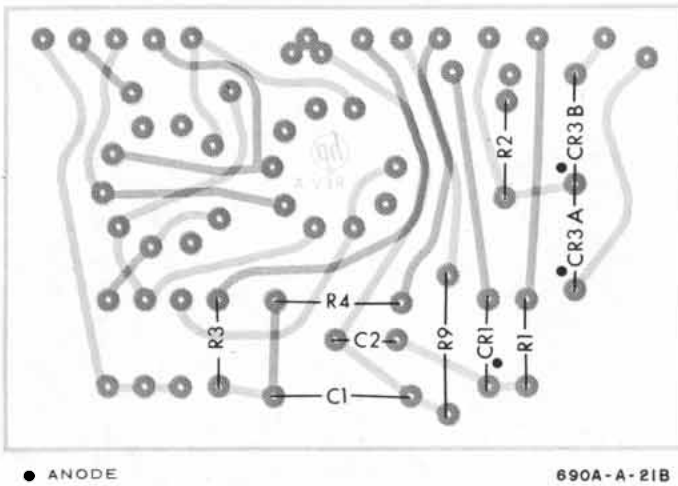
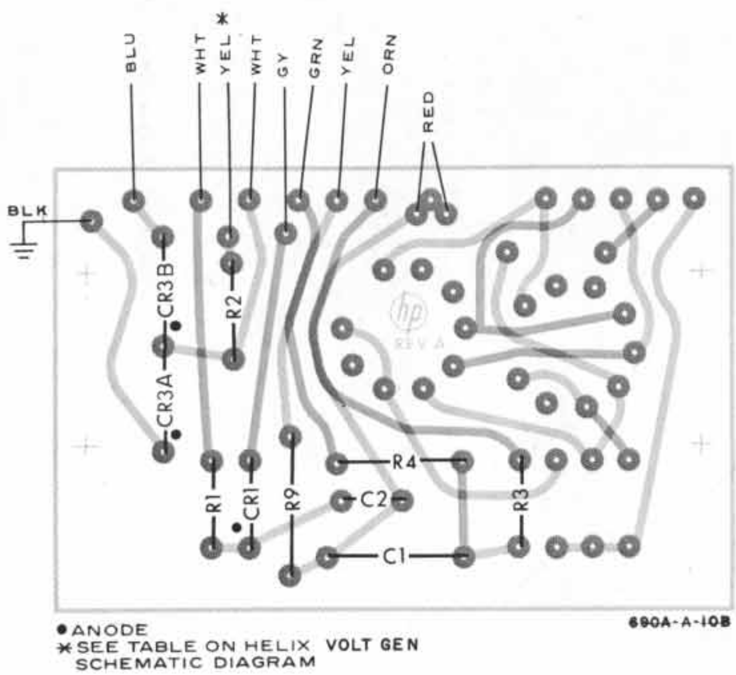


Figure 5-15. Etched Circuit A1 Component Location



BOARD VIEWED FROM COMPONENT SIDE
DARKER PATHS ON COMPONENT SIDE



BOARD VIEWED FROM CKT SIDE
DARKER PATHS ON COMPONENT SIDE

Figure 5-18. Etched Circuit A6 Component Location

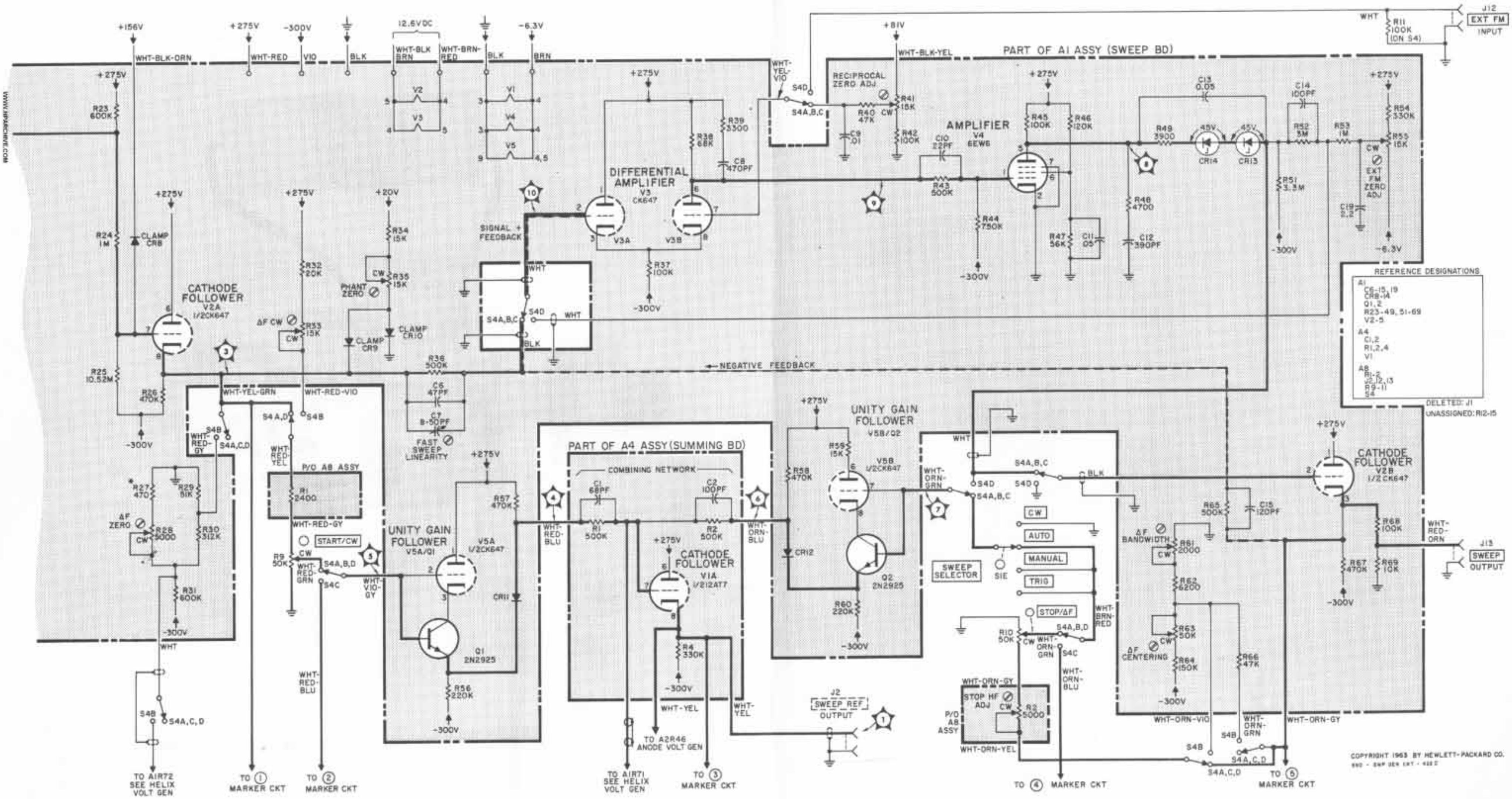


Figure 5-16. Tuning Voltage Generator
(Part 2 of 2)

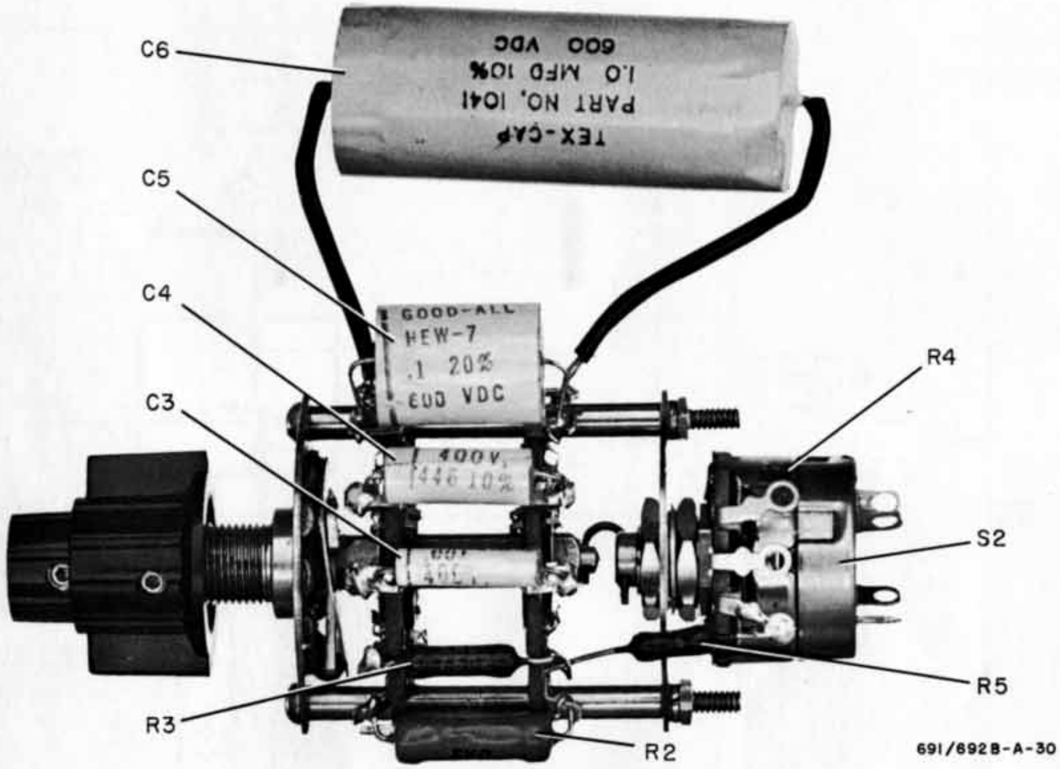
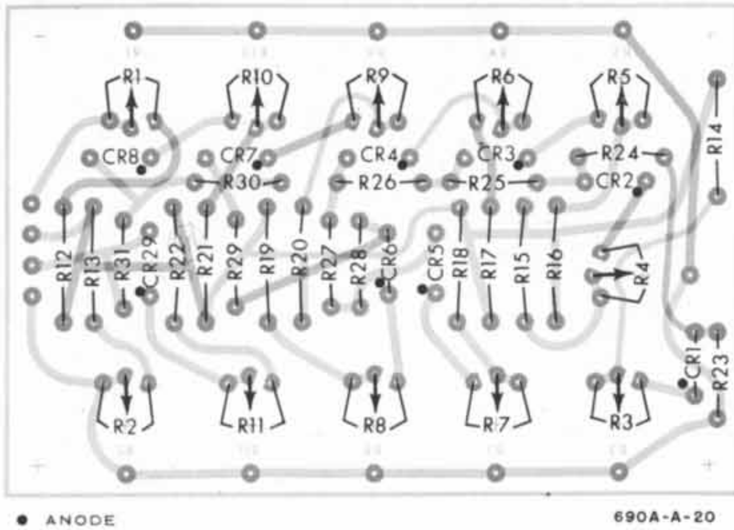


Figure 5-17. SWEEP TIME (SEC) Switch S3 Showing Attached Components

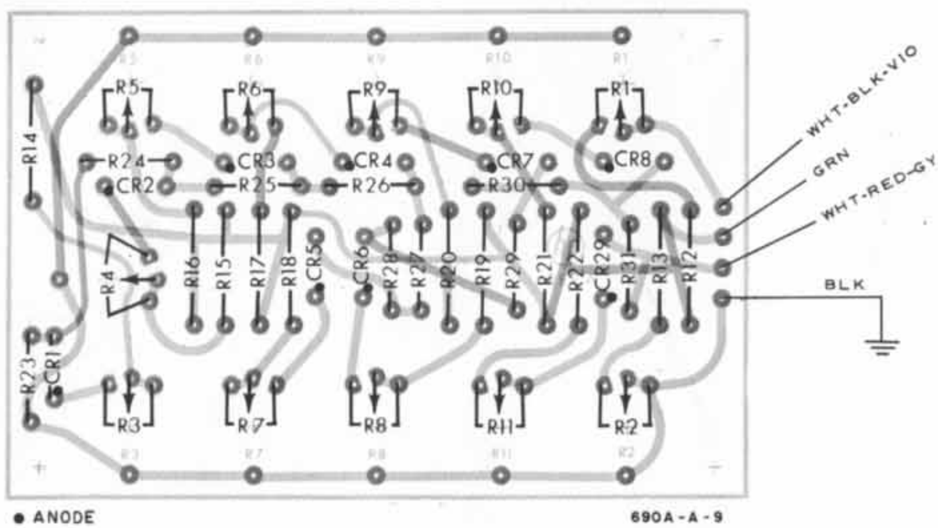
Figure 5-16

TUNING VOLTAGE GENERATOR

Part 2 of 2



BOARD VIEWED FROM COMPONENT SIDE
DARKER PATHS ON COMPONENT SIDE



BOARD VIEWED FROM CKT SIDE
DARKER PATHS ON COMPONENT SIDE

Figure 5-19. Etched Circuit A3 Component Location

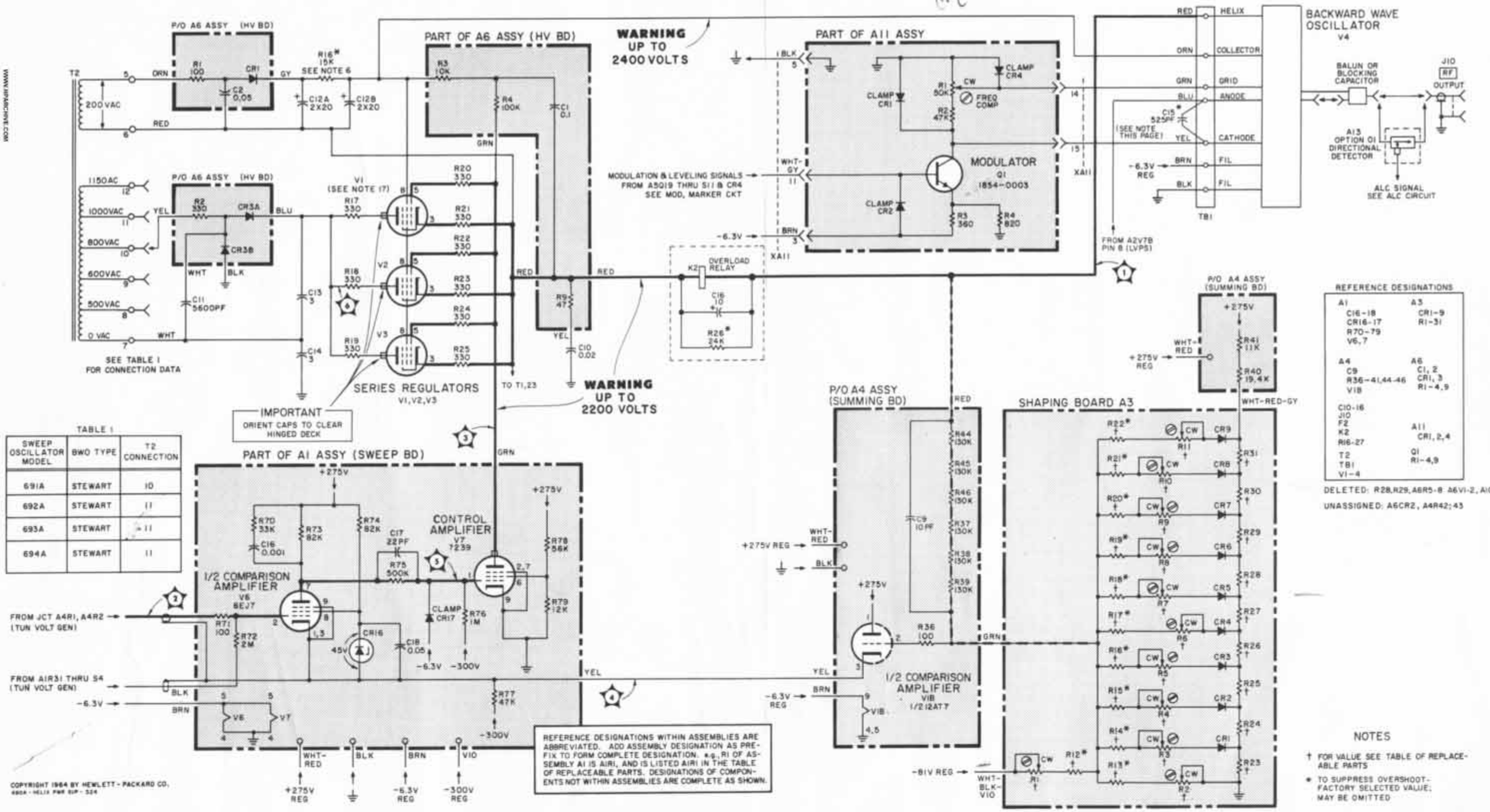


TABLE I

SWEEP OSCILLATOR MODEL	BWO TYPE	T2 CONNECTION
691A	STEWART	10
692A	STEWART	11
693A	STEWART	11
694A	STEWART	11

REFERENCE DESIGNATIONS

A1: C16-18, CR16-17, R70-79, V6,7	A3: CR1-9, R1-31
A4: C9, R36-41,44-46, V1B	A6: C1, 2, CR1, 3, R1-4, 9
C10-16, J10, F2, K2, R16-27, T2, TB1, V1-4	A11: CR1, 2, 4; Q1, R1-4, 9

DELETED: R28,R29,A6R5-8 A6V1-2, A1CR15

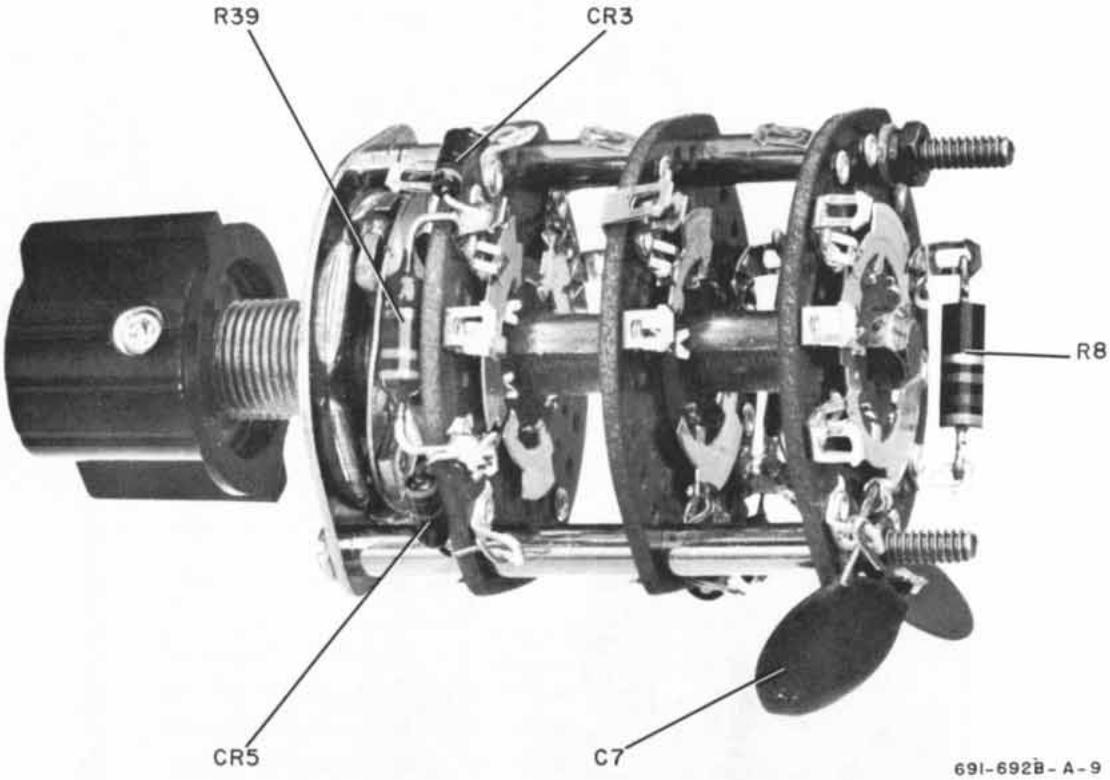
UNASSIGNED: A6CR2, A4R42; 43

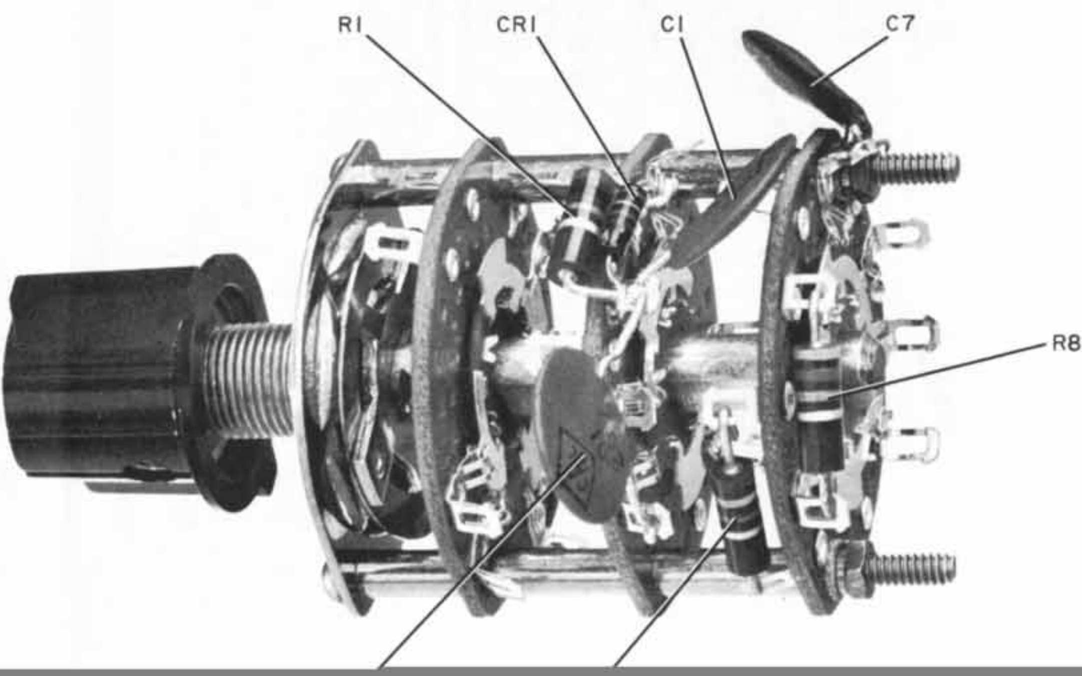
NOTES

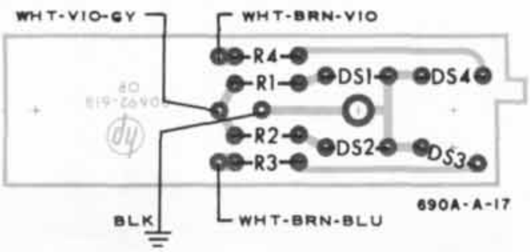
† FOR VALUE SEE TABLE OF REPLACEABLE PARTS

* TO SUPPRESS OVERSHOOT-FACTORY SELECTED VALUE; MAY BE OMITTED

Figure 5-20. Helix Voltage Generator

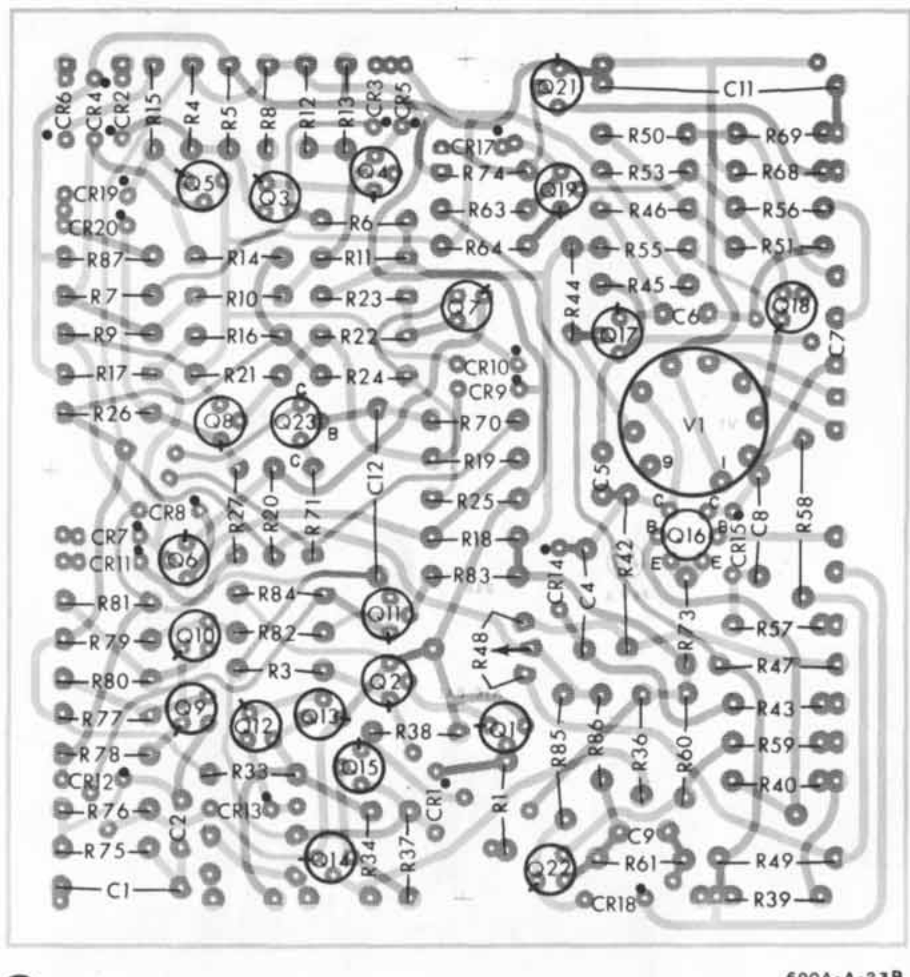

R39
CR3
R8
CR5
C7
691-692B-A-9


R1
CR1
C1
C7
R8



BOARD VIEWED FROM CKT SIDE
DARKER PATHS ON COMPONENT SIDE

Figure 5-23. Etched Circuit A9 Component Location



EMITTER

ANODE

BOARD VIEWED FROM COMPONENT SIDE
DARKER PATHS ON COMPONENT SIDE

NOTE
TAB ON Q16 IDENTIFIES COLLECTOR, NOT EMITTER

Figure 5-24. Etched Circuit A5 Component Location

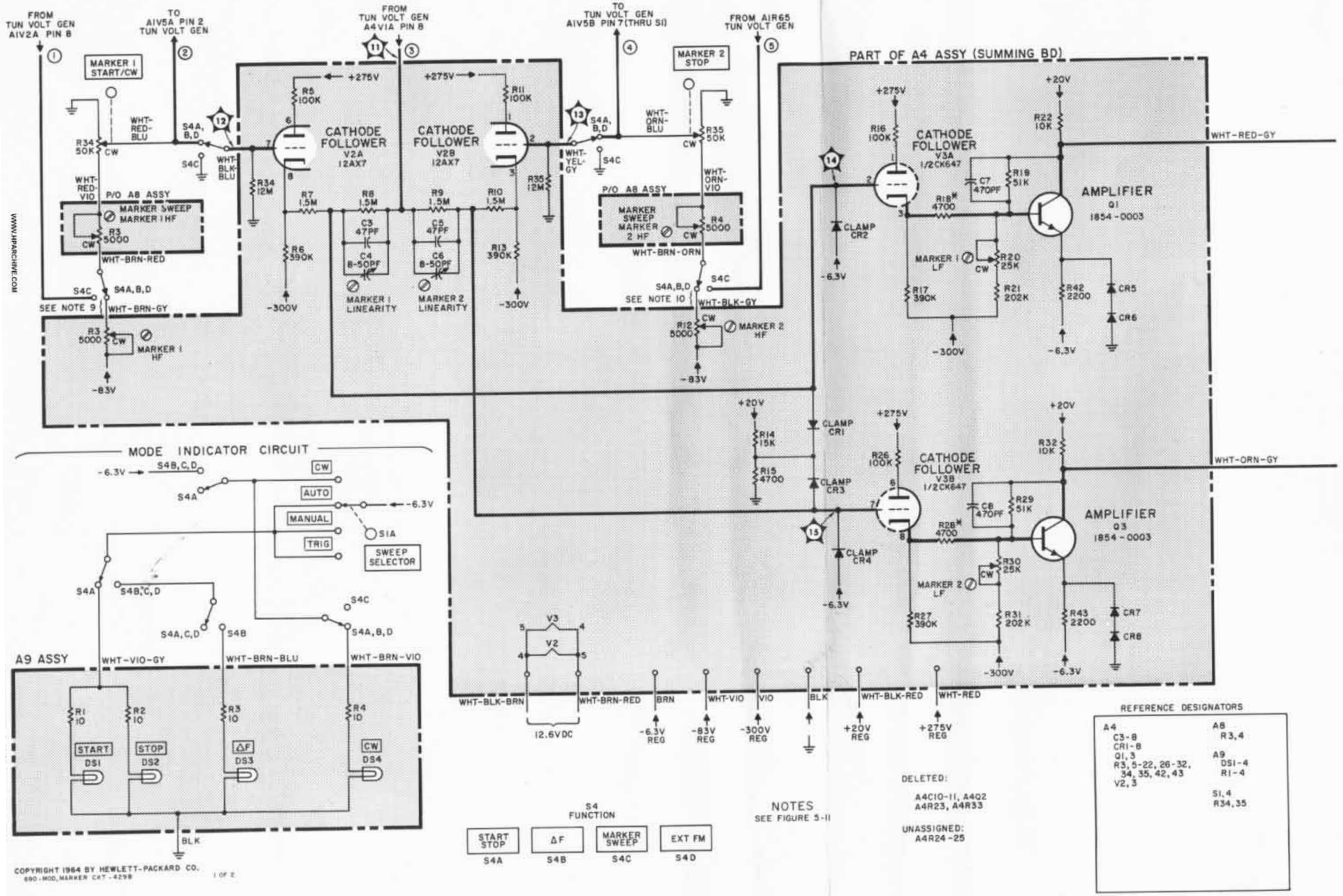


Figure 5-22. Amplitude Modulation Section
(Part 1 of 2)
For A4 Assy Component Locations, see Figure 5-31

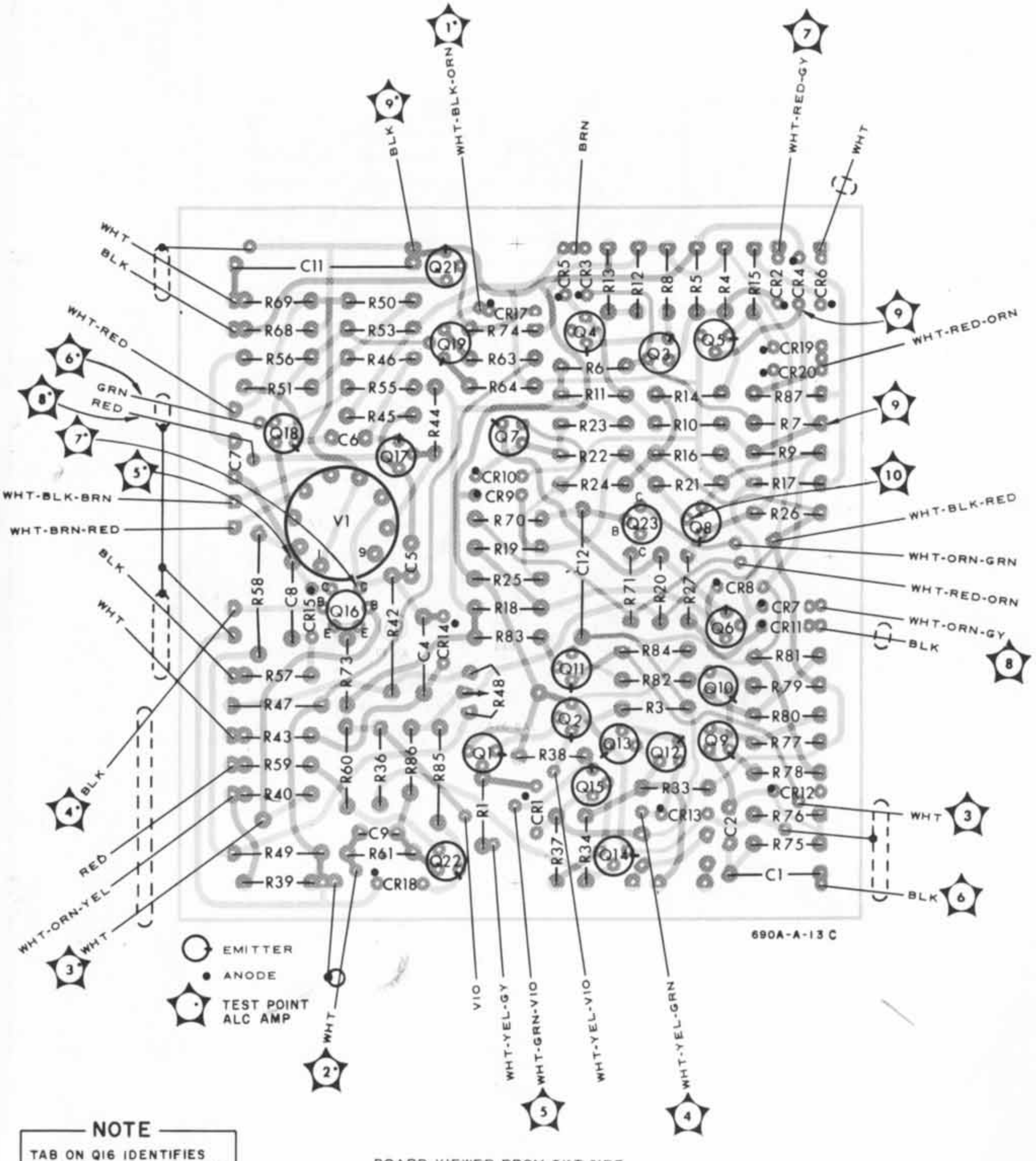
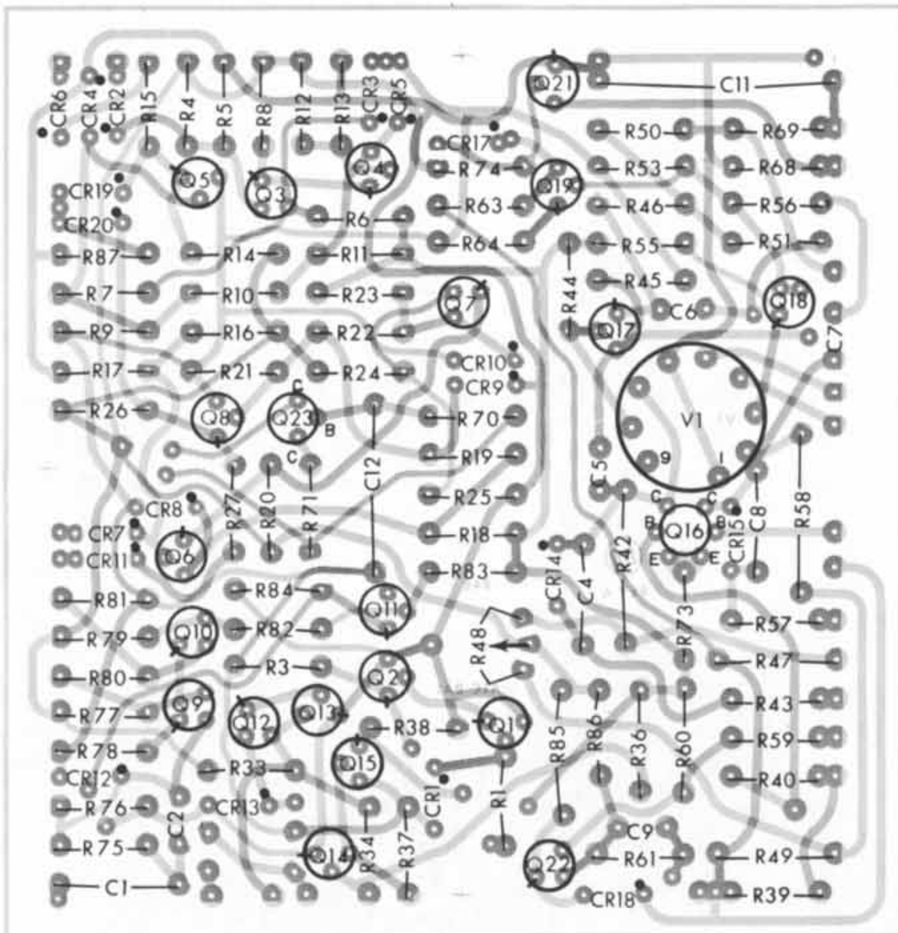


Figure 5-25. Etched Circuit A5 Component Location



690A-A-23B

EMITTER

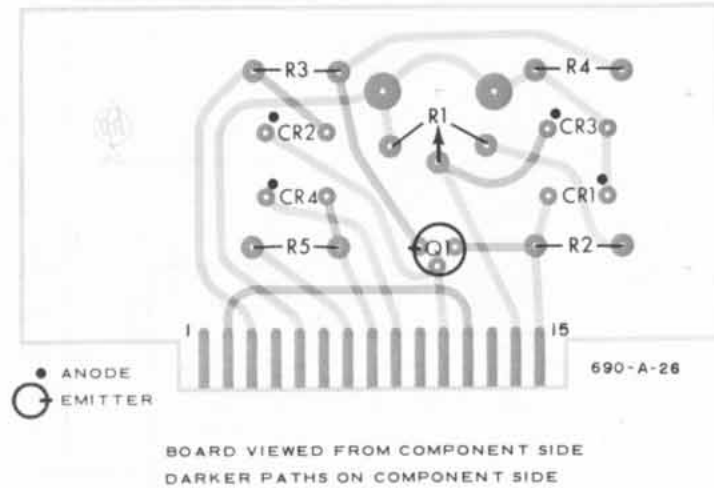
ANODE

BOARD VIEWED FROM COMPONENT SIDE

DARKER PATHS ON COMPONENT SIDE

NOTE
TAB ON Q16 IDENTIFIES COLLECTOR, NOT EMITTER

Figure 5-28. Etched Circuit A5 Component Location



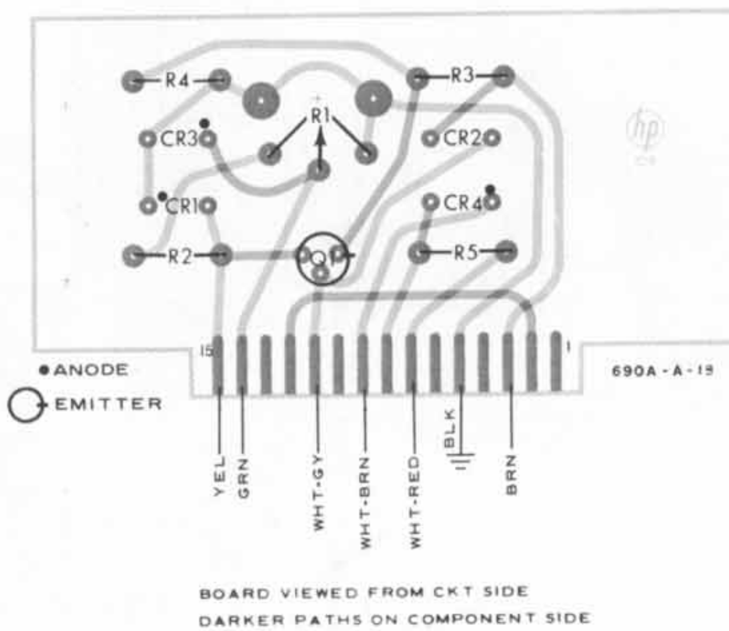


Figure 5-27. Etched Circuit A11 Component Location

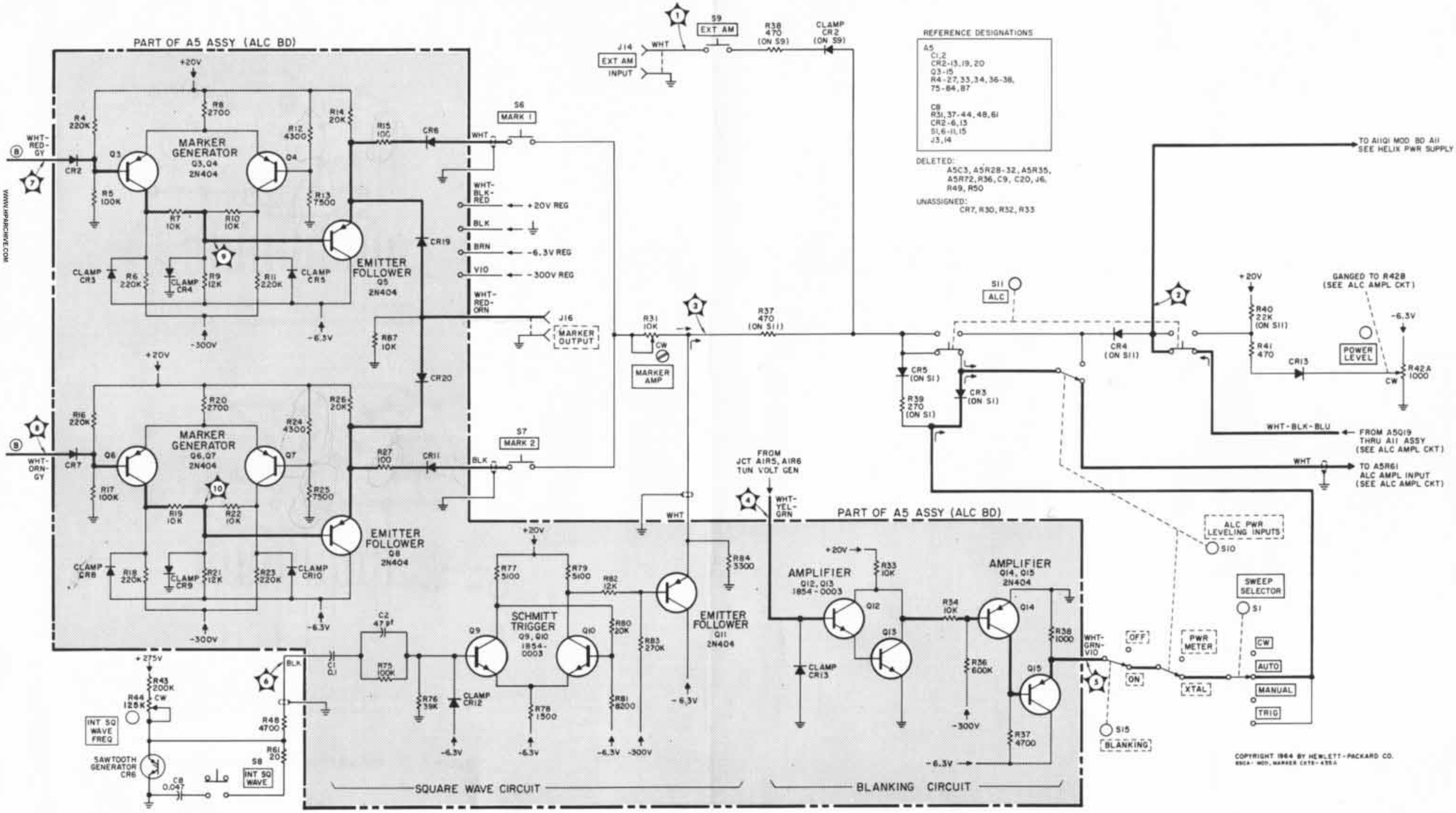
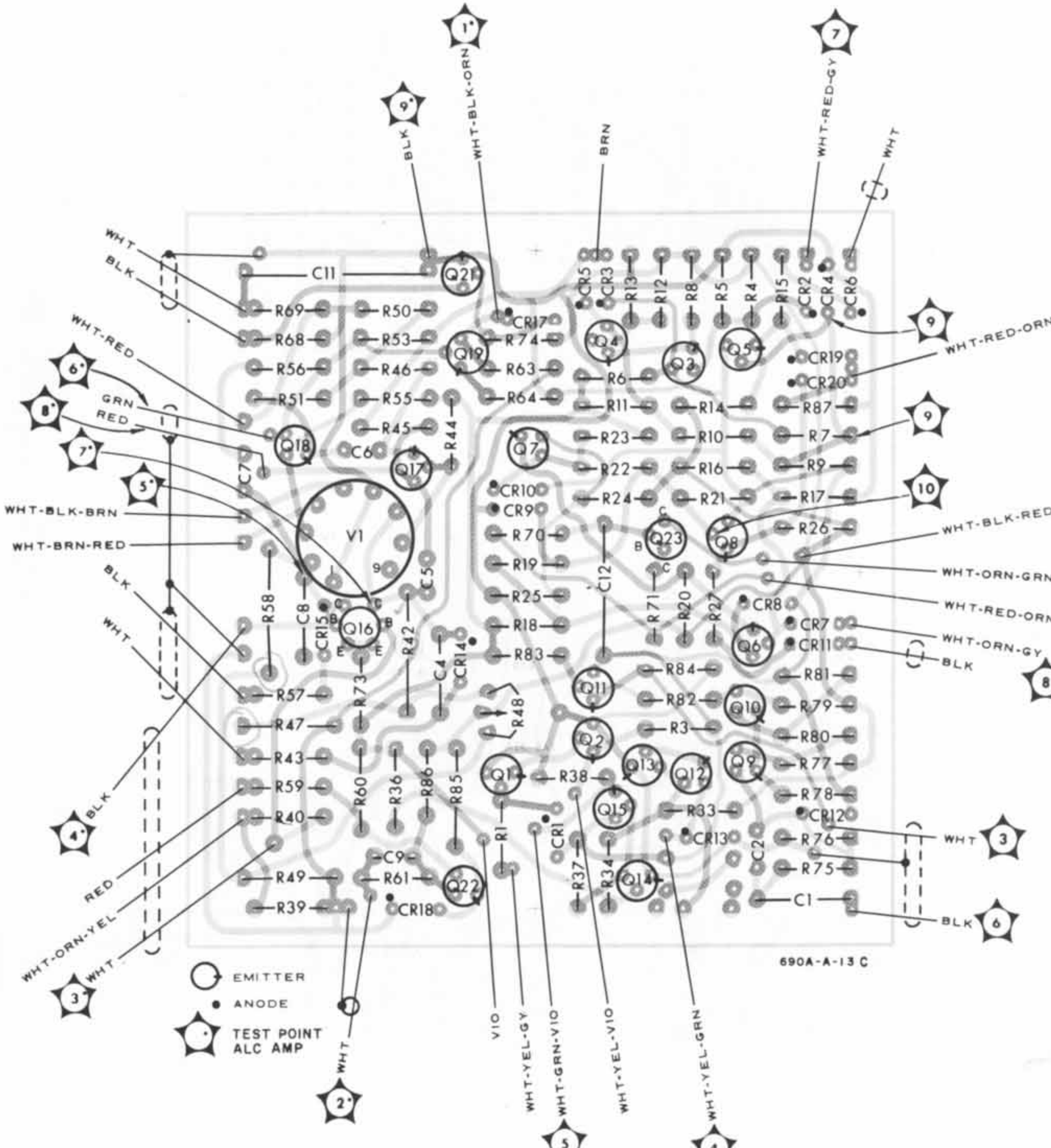


Figure 5-26. Amplitude Modulation Section (Part 2 of 2)

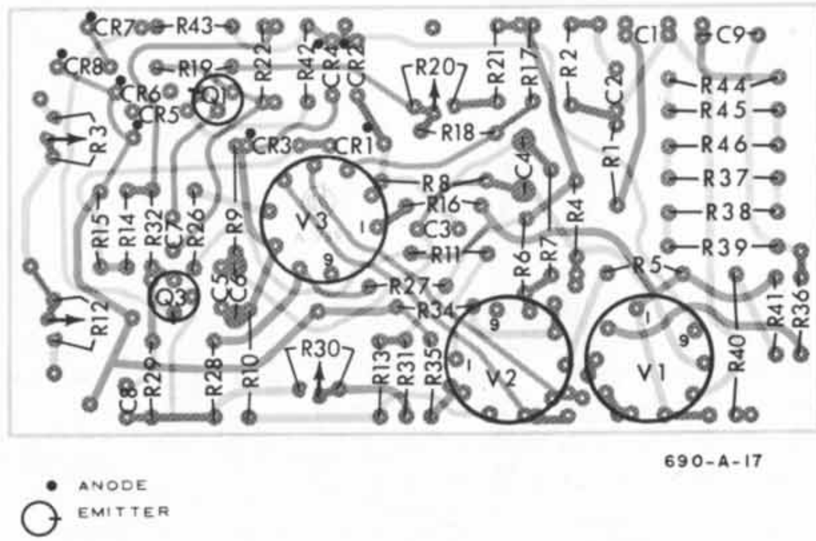


NOTE

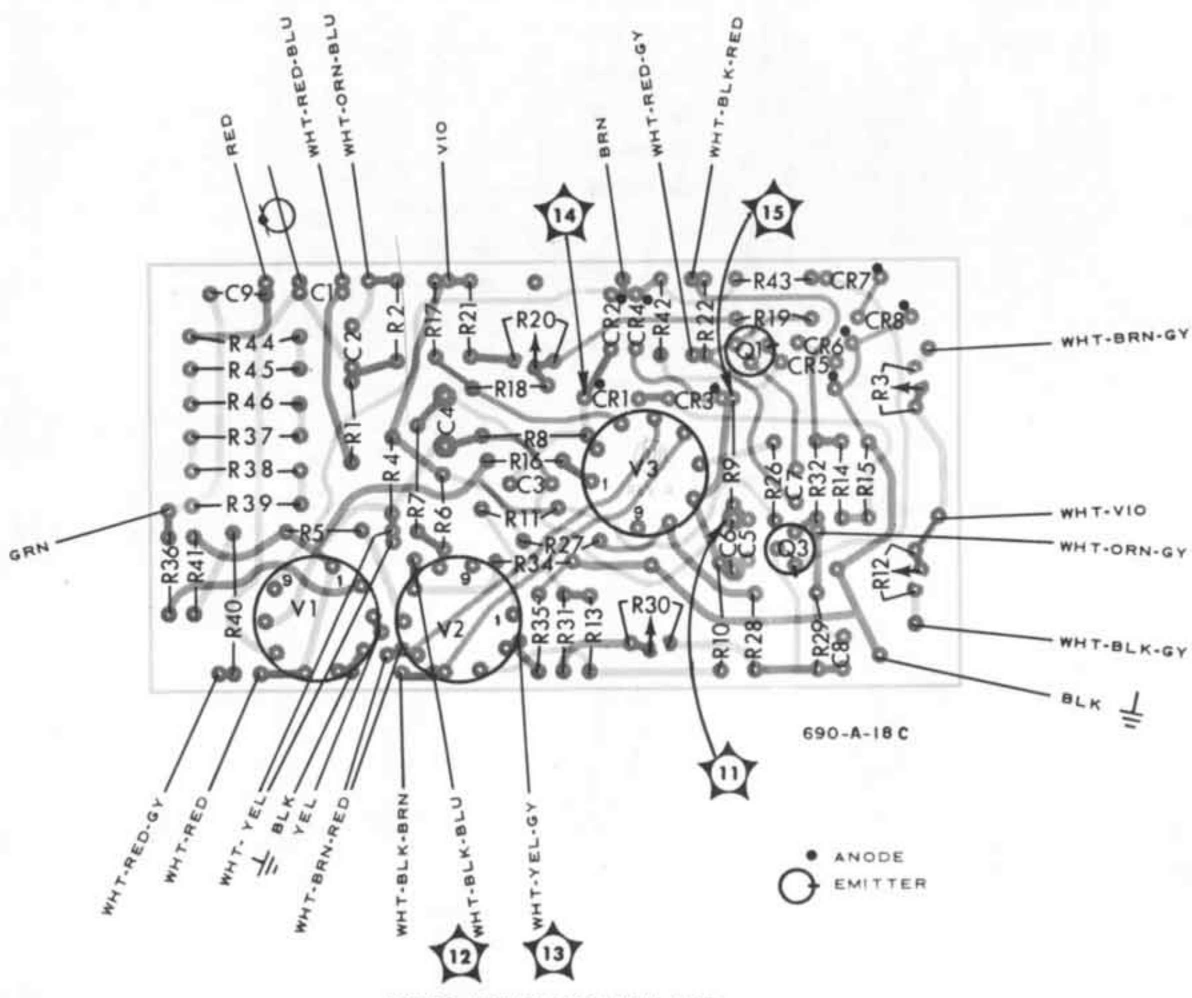
TAB ON Q16 IDENTIFIES COLLECTOR, NOT EMITTER

BOARD VIEWED FROM CKT SIDE
DARKER PATHS ON COMPONENT SIDE

Figure 5-29. Etched Circuit A5 Component Location

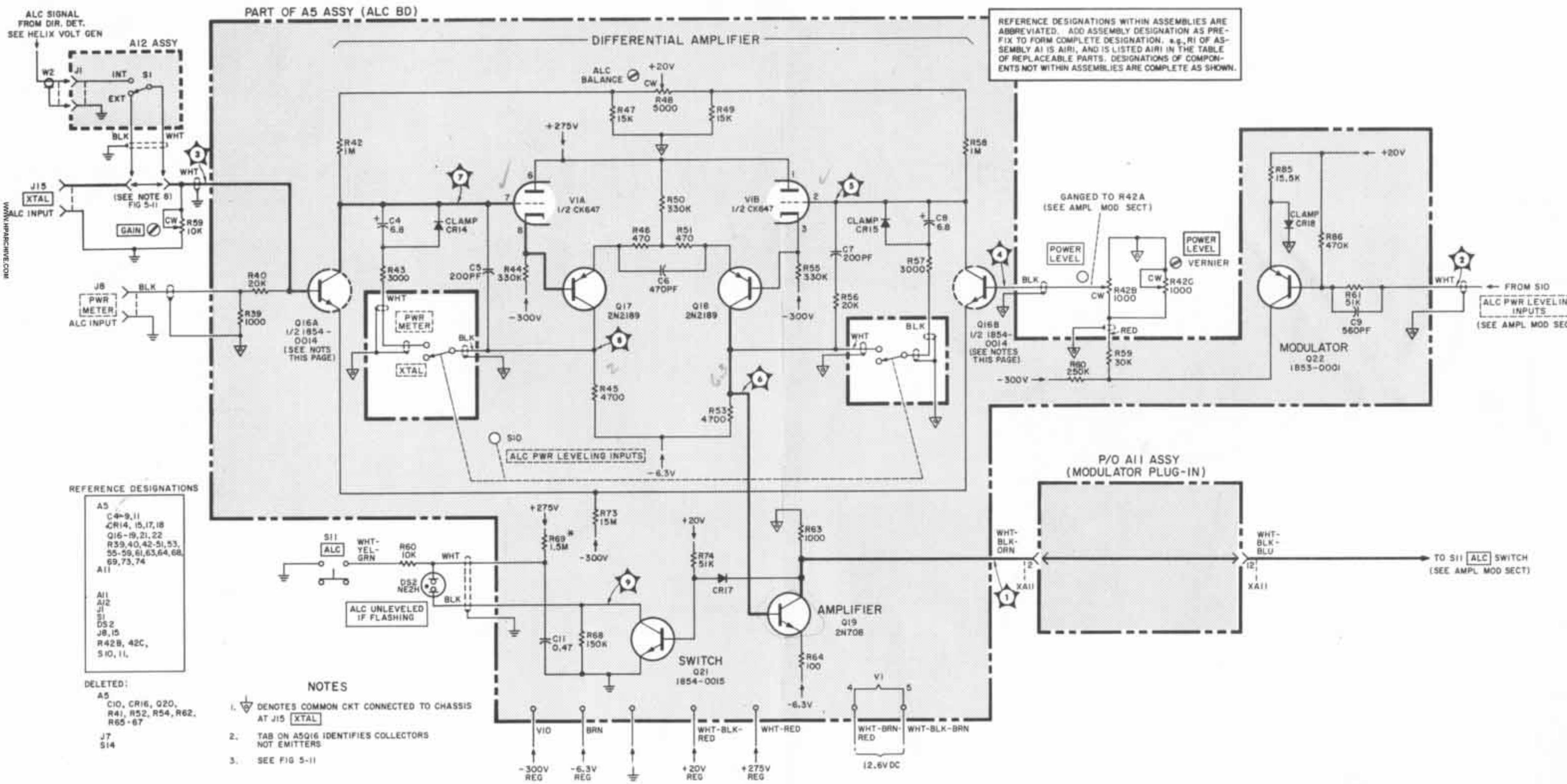


BOARD VIEWED FROM COMPONENT SIDE
DARKER PATHS ON COMPONENT SIDE



BOARD VIEWED FROM CKT SIDE
DARKER PATHS ON COMPONENT SIDE

Figure 5-31. Etched Circuit A4 Component Location



REFERENCE DESIGNATIONS

A5: C4-9, 11; CR14, 15, 17, 18; Q16-19, 21, 22; R39, 40, 42-51, 53, 55-59, 61, 63, 64, 68, 69, 73, 74
A11

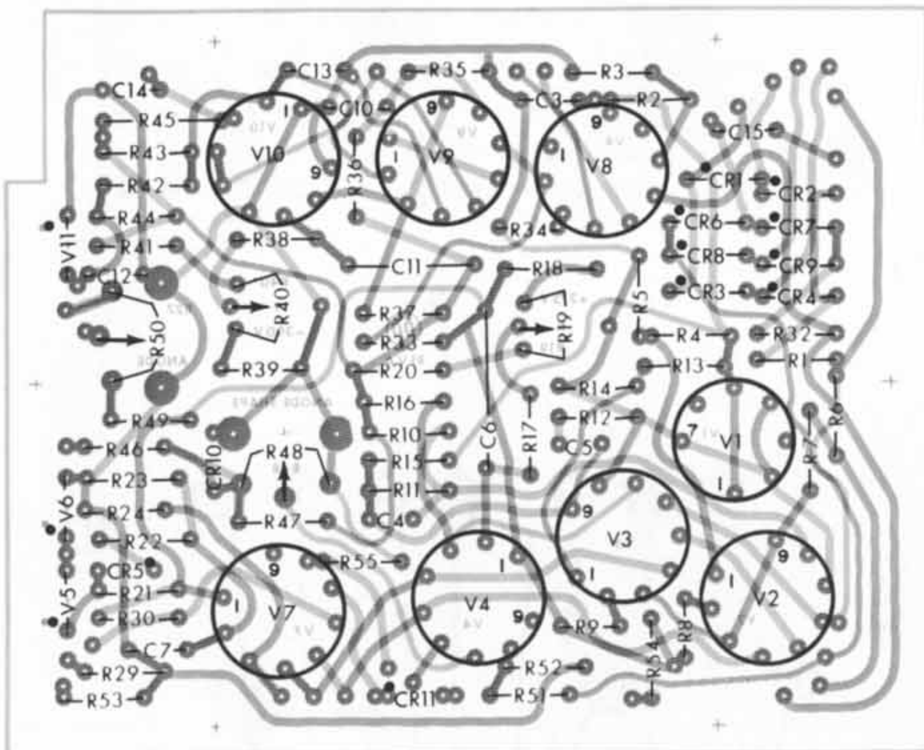
A1, A12, J1, S1, DS2, J8, 15, R42B, 42C, S10, 11.

DELETED:
A5: C10, CR16, Q20, R41, R52, R54, R62, R65-67
J7, S14

NOTES

1. ⏚ DENOTES COMMON CKT CONNECTED TO CHASSIS AT J15 XTAL
2. TAB ON A5Q16 IDENTIFIES COLLECTORS NOT EMITTERS
3. SEE FIG 5-11

Figure 5-30. Automatic Level Control (ALC) Amplifier

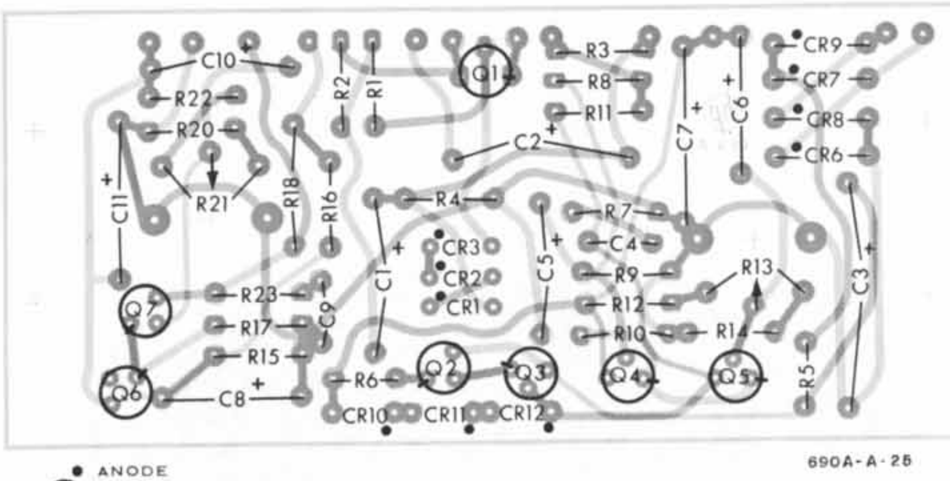


● ANODE

690A-A-24

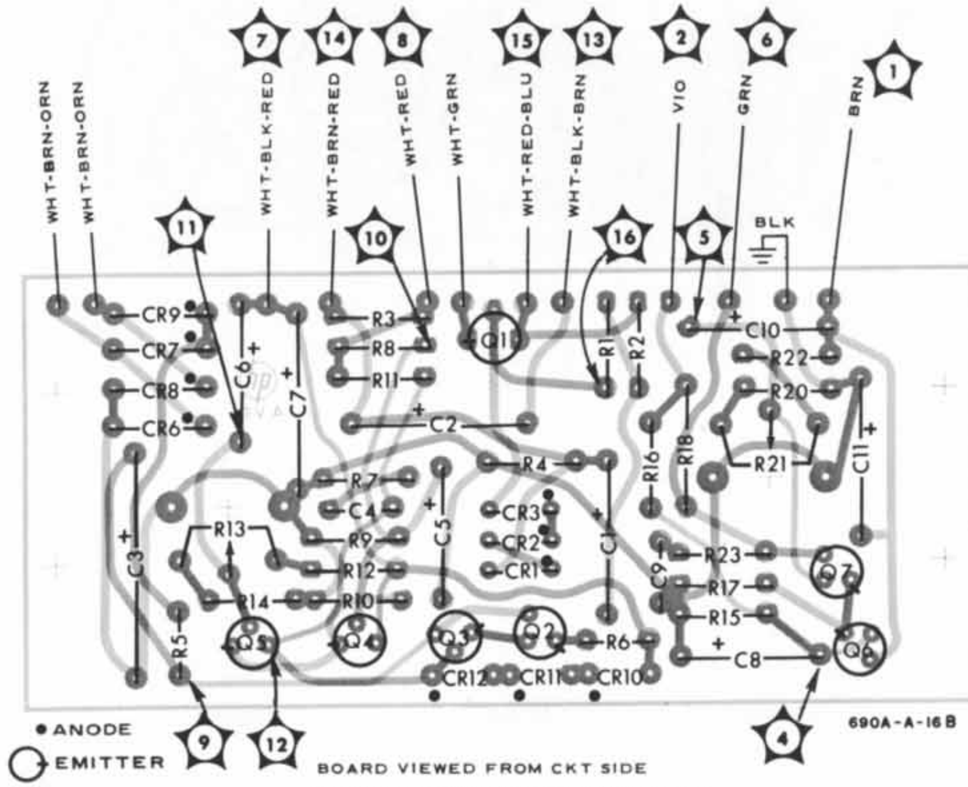
BOARD VIEWED FROM COMPONENT SIDE
DARKER PATHS ON COMPONENT SIDE

Figure 5-34. Etched Circuit A2 Component Location



ANODE
EMITTER

BOARD VIEWED FROM COMPONENT SIDE
DARKER PATHS ON COMPONENT SIDE



BOARD VIEWED FROM CKT SIDE
DARKER PATHS ON COMPONENT SIDE

Figure 5-32. Etched Circuit A7 Component Location

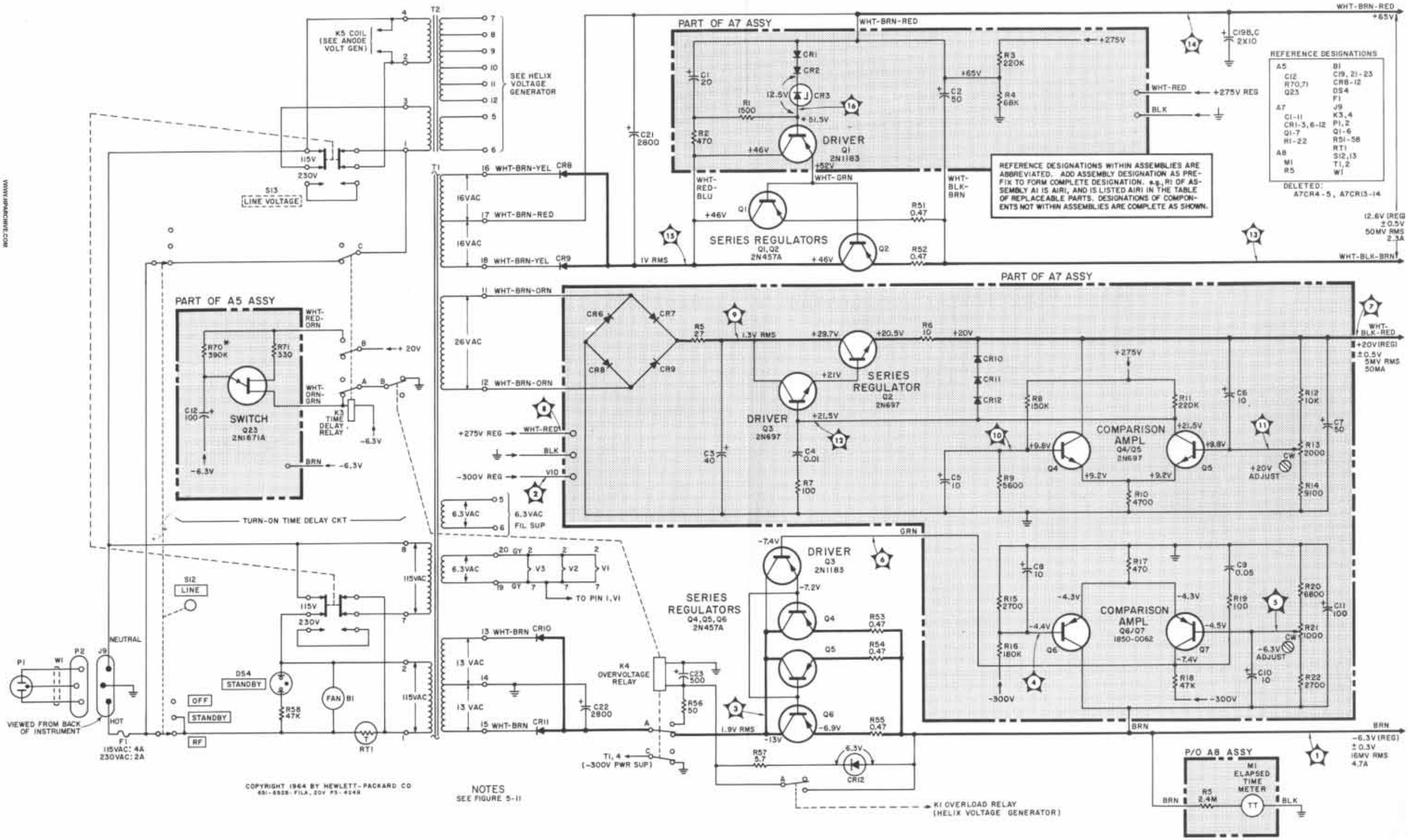


Figure 5-33. 12.6, + 20, -6.3 Volt Power Supplies
Primary Power Circuit

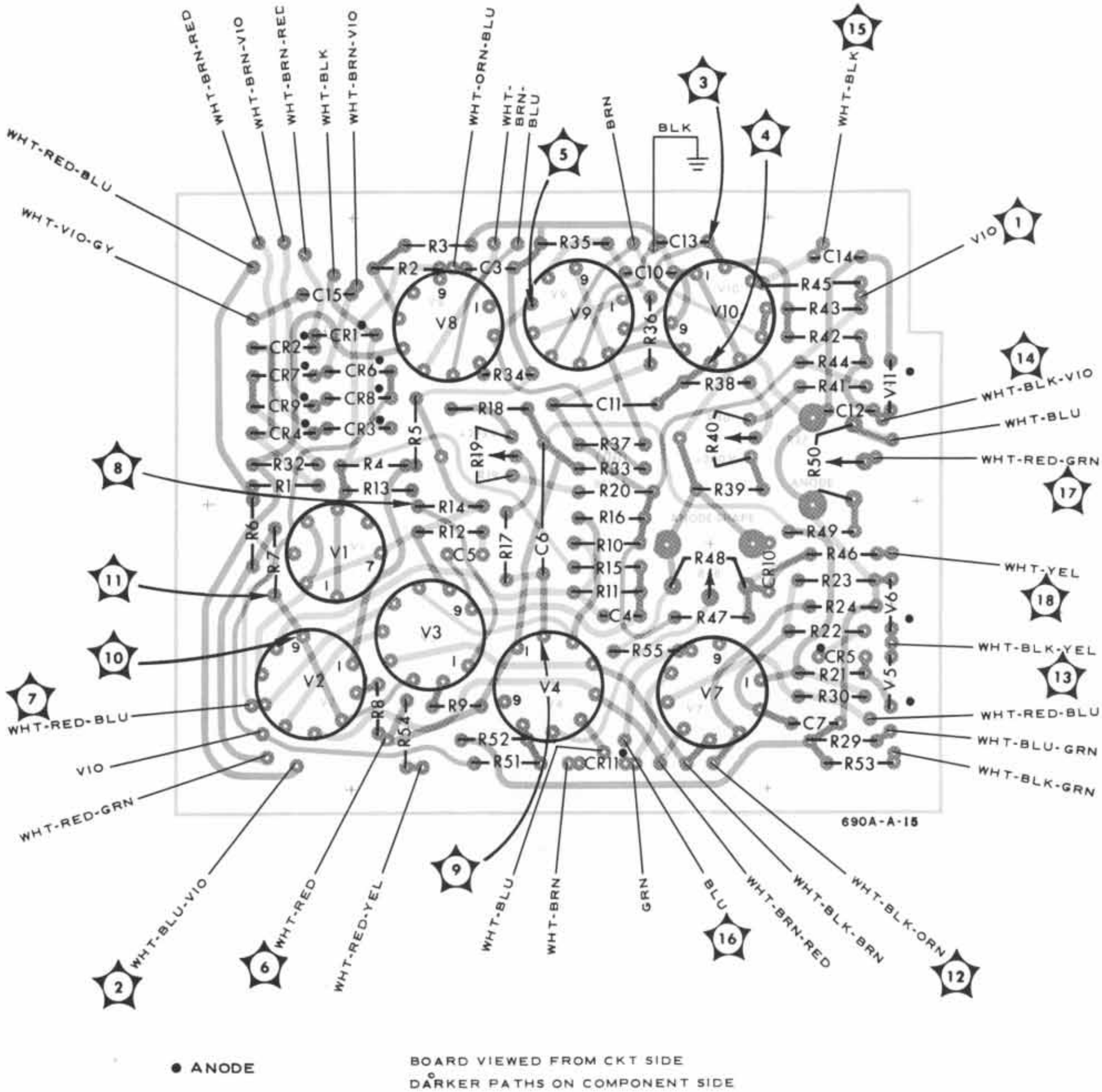


Figure 5-35. Etched Circuit A2 Component Location

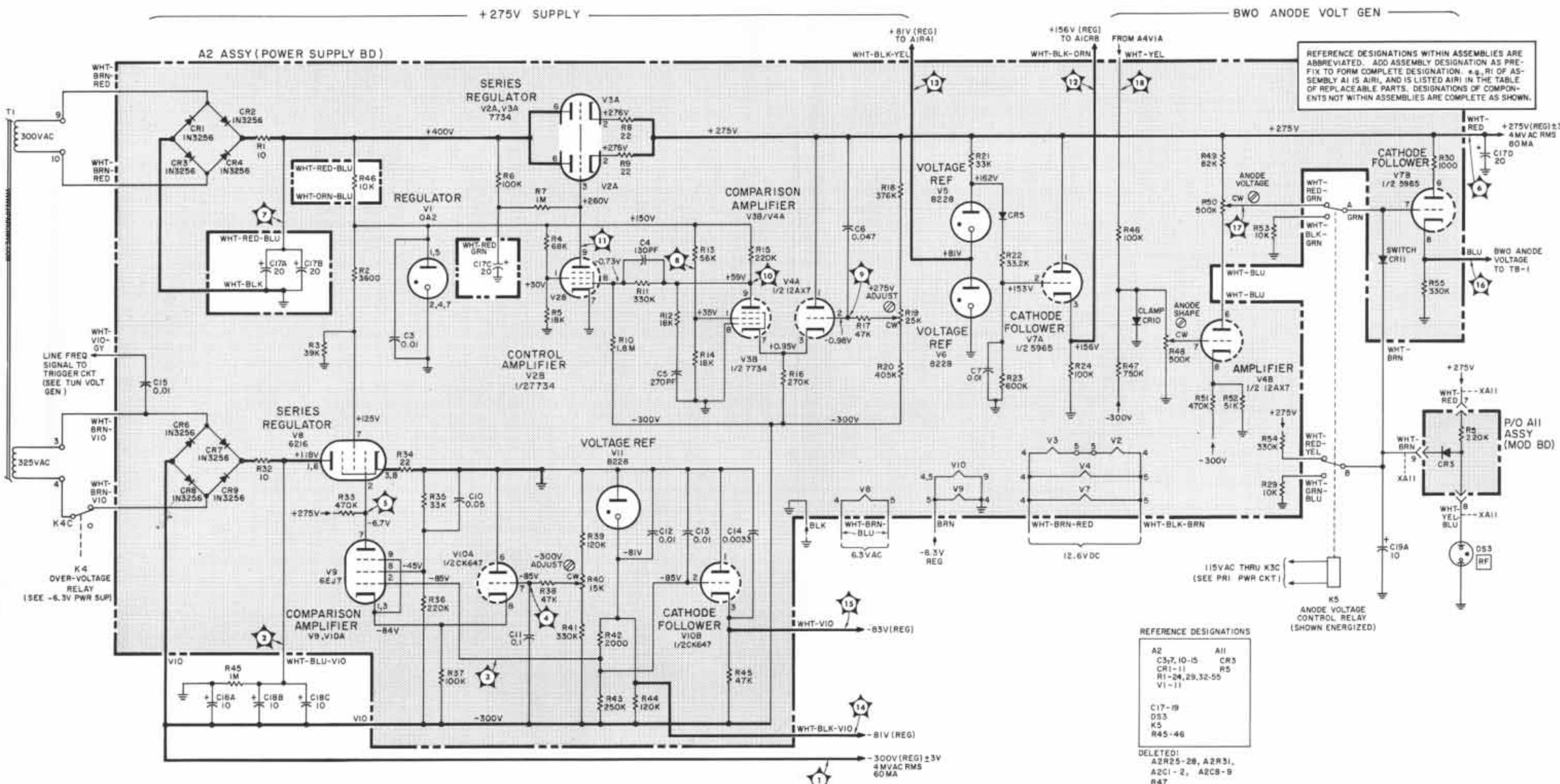
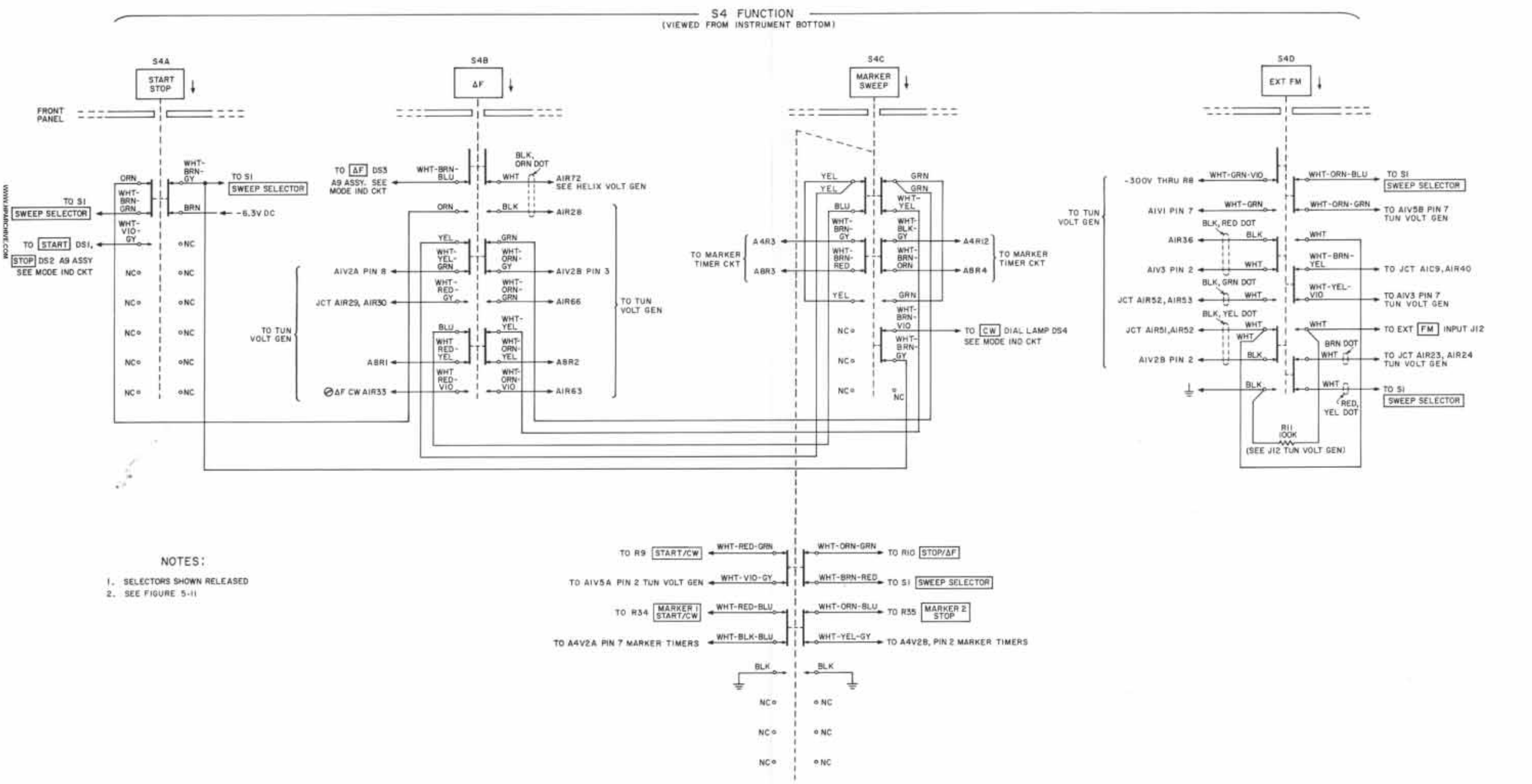


Figure 5-36. BWO Tube Anode, +275 and -300 Volt Power Supplies



NOTES:

1. SELECTORS SHOWN RELEASED
2. SEE FIGURE 5-11

Figure 5-37. FUNCTION Selector Wiring Diagram

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION.

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

a. Description (see list of abbreviations below).

b. Typical manufacturer in a five-digit code; see Code List of Manufacturers in Table 6-3.

c. Manufacturer's stock number.

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

NOTE

Total quantity given for the Model 691A is the same for the Models 692A, 693A, and 694A, unless otherwise indicated.

6-3. There are four lists of parts for the A3 assembly, one each for the 691A, 692A, 693A, and 694A.

6-4. Miscellaneous parts not indexed by reference designations are listed at the end of Table 6-1.

6-5. ORDERING INFORMATION.

6-6. When ordering a replacement part listed in Table 6-1:

a. Quote the Hewlett-Packard stock number for the part.

b. Address order or inquiry to your nearest Hewlett-Packard sales and service office (see lists at the rear of this manual for addresses).

6-7. To order a part not listed in Tables 6-1 and 6-2:

a. Give a complete description of the part including its function and location.

b. Give Sweep Oscillator model number and complete serial number.

c. Address order or inquiry to your nearest Hewlett-Packard sales and service office (see lists at the rear of this manual for addresses).

REFERENCE DESIGNATORS

A = assembly
B = motor
C = capacitor
CP = coupling
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

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

TB = terminal board
TP = test point
V = vacuum tube, neon bulb, photocell, etc.
W = cable
X = socket
Y = crystal

ABBREVIATIONS

A = amperes
A.F.C = automatic frequency control
AMPL = amplifier

B. F. O. = beat frequency oscillator
BE CU = beryllium copper
BH = binder head
BP = bandpass
BRS = brass
BWO = backward wave oscillator

CCW = counter-clockwise
CER = ceramic
CMO = cabinet mount only
COEF = coefficient
COM = common
COMP = composition
CONN = connector
CP = cadmium plate
CRT = cathode-ray tube
CW = clockwise

DEPC = deposited carbon
DR = drive

ELECT = electrolytic
ENCAP = encapsulated
EXT = external

F = farads
FH = flat head
FIL H = fillister head
FXD = fixed

GE = germanium
GL = glass
GRD = ground(ed)

H = henries
HEX = hexagonal
HG = mercury
HR = hour(s)

IF = intermediate freq
IMPG = impregnated
INCD = incandescent
INCL = include(s)
INS = insulation(ed)
INT = internal

K = kilo = 1000

LIN = linear taper
LK WASH = lock washer
LOG = logarithmic taper
LPF = low pass filter

M = milli = 10^{-3}
MEG = meg = 10^{6}
METFLM = metal film
MFR = manufacturer
MINAT = miniature
MOM = momentary
MTG = mounting
MY = "mylar"

N = nano (10^{-9})

N/C = normally closed
NE = neon
NI PL = nickel plate
N/O = normally open
NPO = negative positive zero (zero temperature coefficient)
NRFR = not recommended for field replacement
NSR = not separately replaceable

OBD = order by description
OH = oval head
OX = oxide

P = peak
PC = printed circuit
PF = picofarads = 10^{-12} farads
PH BRZ = phosphor bronze
PHL = Phillips
PIV = peak inverse voltage
P/O = part of
POLY = polystyrene
PORC = porcelain
POS = position(s)
POT = potentiometer
PP = peak-to-peak
PT = point
RECT = rectifier
RF = radio frequency
RH = round head

RMO = rack mount only
RMS = root-mean-square

S-B = slow-blow
SCR = screw
SE = selenium
SECT = section(s)
SEMICON = semiconductor
SI = silicon
SIL = silver
SL = slide
SPL = special
SST = stainless steel
SR = split ring
STL = steel

TA = tantalum
TD = time delay
TGL = toggle
TI = titanium
TOL = tolerance
TRIM = trimmer
TWT = traveling wave tube

U = micro = 10^{-6}

VAR = variable
VDCW = dc working volts

W/ = with
W = watts
WW = wirewound
W/O = without

01194-10

Table 6-1. Reference Designation Index

Reference Designation	ⓗ Stock No.	Description #	Note
A1	00692-604	ASSY: SWEEP GENERATOR	
A1C1	0150-0052	C:FXD CER 0.05 UF 20% 400VDCW	
A1C2	0150-0012	C:FXD CER 0.01UF 20% 1000VDCW	
A1C3	0150-0023	C:FXD CER 2000PF 20% 1000VDCW FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A1C4	0140-0152	C:FXD MICA 1000 PF 5% 300 VDCW FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A1C5	0150-0023	C:FXD CER 2000PF 20% 1000VDCW	
A1C6	0160-0182	C:FXD MICA 47PF 5% 300VDCW	
A1C7	0130-0017	C:VAR CER 8-50 PF N750	
A1C8	0140-0149	C:FXD MICA 470 PF 5% 300 VDCW	
A1C9	0150-0012	C:FXD CER 0.01UF 20% 1000VDCW	
A1C10	0140-0145	C:FXD MICA 22 PF 5% 500 VDCW	
A1C11	0150-0052	C:FXD CER 0.05 UF 20% 400VDCW	
A1C12	0140-0200	C:FXD MICA 390PF 5% 300VDCW	
A1C13	0150-0052	C:FXD CER 0.05 UF 20% 400VDCW	
A1C14	0140-0176	C:FXD MICA 100 PF 2% 300 VDCW	
A1C15	0140-0216	C:FXD MICA 120PF 2% 300VDCW	
A1C16	0140-0152	C:FXD MICA 1000 PF 5% 300 VDCW	
A1C17	0140-0145	C:FXD MICA 22 PF 5% 500 VDCW	
A1C18	0150-0052	C:FXD CER 0.05 UF 20% 400VDCW	
A1C19	0160-0128	C:FXD CER 2.2UF 20% 25VDCW	
A1CR1	1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	
A1CR2	1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	
A1CR3	1901-0028	DIODE,SILICON:0.5A 400PIV	
A1CR4	1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	
A1CR5	1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	
A1CR6	1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	
A1CR7	1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	
A1CR8	1901-0033	DIODE,SILICON:1N485B	
A1CR9	1901-0033	DIODE,SILICON:1N485B	
A1CR10	1901-0033	DIODE,SILICON:1N485B	
A1CR11	1901-0033	DIODE,SILICON:1N485B	
A1CR12	1901-0033	DIODE,SILICON:1N485B	
A1CR13	1902-0038	DIODE,BREAKDOWN: 45.3V 5%	
A1CR14	1902-0065	DIODE,BREAKDOWN:46.4V 10%	
A1CR15		DELETED	
A1CR16	1902-0038	DIODE,BREAKDOWN: 45.3V 5%	
A1CR17	1901-0033	DIODE,SILICON:1N485B	
A1Q1	1854-0033	TRANSISTOR:NPN SI 2N3391	
A1Q2	1854-0033	TRANSISTOR:NPN SI 2N3391	
A1R1	0687-1041	R:FXD COMP 100K OHM 10% 1/2W	
A1R2	0727-0245	R:FXD DEPC 500K OHM 1% 1/2W	
A1R3	0727-0292	R:FXD DEPC 3 MEGOHM 1% 1/2W	
A1R4	0686-1665	R:FXD COMP 16 MEGOHM 5% 1/2W	
A1R5	0727-0292	R:FXD DEPC 3 MEGOHM 1% 1/2W	
A1R6	0727-0298	R:FXD DEPC 4 MEGOHM 1% 1/2W	
A1R7	0727-0226	R:FXD DEPC 250K OHM 1% 1/2W	

See list of abbreviations in introduction to this section

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

Reference Designation	ⓗ Stock No.	Description #	Note
A1R8	0727-0291	R:FXD DEPC 2.84 MEGOHM 1% 1/2W	
A1R9	0727-0298	R:FXD DEPC 4 MEGOHM 1% 1/2W	
A1R10	0727-0299	R:FXD DEPC 4.9 MEGOHM 1% 1/2W	
A1R11	0727-0299	R:FXD DEPC 4.9 MEGOHM 1% 1/2W	
A1R12	0764-0031	R:FXD MET OX FLM 47K OHM 2W	
A1R13	0687-4741	R:FXD COMP 470K OHM 10% 1/2W	
A1R14	0687-1851	R:FXD COMP 1.8 MEGOHM 10% 1/2W	
A1R15	0687-4731	R:FXD COMP 47K OHM 10% 1/2W	
A1R16	0727-0222	R:FXD DEPC 214K OHM 1% 1/2W	
A1R17	0727-0259	R:FXD DEPC 900K OHM 1% 1/2W	
A1R18	0727-0230	R:FXD DEPC 284K OHM 1% 1/2W	
A1R19		NOT ASSIGNED	
A1R20	0727-0287	R:FXD DEPC 2 MEGOHM 1% 1/2W	
A1R21	0687-1051	R:FXD COMP 1MEG OHM 10% 1/2W	
A1R22	0687-3331	R:FXD COMP 33K OHM 10% 1/2W	
A1R23	0727-0246	R:FXD DEPC 600K OHM 1% 1/2W	
A1R24	0727-0276	R:FXD DEPC 1 MEGOHM 1% 1/2W	
A1R25	0730-0144	R:FXD DEPC 10.52 MEGOHM 1% 1W	
A1R26	0758-0087	R:FXD MET OX 470K OHM 5% 1/2W	
A1R27	0758-0029	R:FXD MET FLM 470 OHM 5% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A1R28	2100-0091	R:VAR COMP 5000 OHM 30% LIN 1/3W	
A1R29	0758-0021	R:FXD MET FLM 51K OHM 5% 1/2W	
A1R30	0727-0232	R:FXD DEPC 312K OHM 1% 1/2W	
A1R31	0727-0246	R:FXD DEPC 600K OHM 1% 1/2W	
A1R32	0727-0173	R:FXD DEPC 20K OHM 1% 1/2W	
A1R33	2100-0913	R:VAR COMP 15K OHM 20% LIN 1/5W	
A1R34	0758-0018	R:FXD MET FLM 15K OHM 5% 1/2W	
A1R35	2100-0913	R:VAR COMP 15K OHM 20% LIN 1/5W	
A1R36	0812-0053	R:FXD WW 500K OHM 1% 1/4W	
A1R37	0764-0028	R:FXD MET FLM 100K OHM 5% 2W	
A1R38	0758-0076	R:FXD MET FLM 68K OHM 5% 1/2W	
A1R39	0687-3321	R:FXD COMP 3300 OHM 10% 1/2W	
A1R40	0687-4731	R:FXD COMP 47K OHM 10% 1/2W	
A1R41	2100-0913	R:VAR COMP 15K OHM 20% LIN 1/5W	
A1R42	0727-0208	R:FXD DEPC 100K OHM 1% 1/2W	
A1R43	0727-0245	R:FXD DEPC 500K OHM 1% 1/2W	
A1R44	0727-0254	R:FXD DEPC 750K OHM 1% 1/2W	
A1R45	0758-0053	R:FXD MET FLM 100K OHM 5% 1/2W	
A1R46	0758-0061	R:FXD MET FLM 120K OHM 5% 1/2W	
A1R47	0687-5631	R:FXD COMP 56K OHM 10% 1/2W	
A1R48	0687-4721	R:FXD COMP 4700 OHM 10% 1/2W	
A1R49	0684-3921	R:FXD COMP 3900 OHM 10% 1/4W	
A1R50		NOT ASSIGNED	
A1R51	0687-3351	R:FXD COMP 3.3 MEGOHM 10% 1/2W	
A1R52	0727-0292	R:FXD DEPC 3 MEGOHM 1% 1/2W	
A1R53	0727-0276	R:FXD DEPC 1 MEGOHM 1% 1/2W	
A1R54	0758-0100	R:FXD MET OX 330K OHM 5% 1/2W	
A1R55	2100-0913	R:VAR COMP 15K OHM 20% LIN 1/5W	
A1R56	0761-0033	R:FXD MET OX 220K OHM 5% 1W	
A1R57	0687-4741	R:FXD COMP 470K OHM 10% 1/2W	
A1R58	0687-4741	R:FXD COMP 470K OHM 10% 1/2W	

See list of abbreviations in introduction to this section

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

Reference Designation	Stock No.	Description #	Note
A1R59	0758-0018	R:FXD MET FLM 15K OHM 5% 1/2W	
A1R60	0761-0033	R:FXD MET OX 220K OHM 5% 1W	
A1R61	2100-0090	R:VAR COMP 2000 OHM 30% LIN 1/3W	
A1R62	0758-0046	R:FXD MET FLM 6200 OHM 5% 1/2W	
A1R63	2100-0094	R:VAR COMP 50K OHM 30% LIN 1/5W	
A1R64	0761-0040	R:FXD MET OX 150K OHM 5% 1W	
A1R65	0812-0053	R:FXD WW 500K OHM 1% 1/4W	
A1R66	0758-0040	R:FXD MET FLM 47K OHM 5% 1/2W	
A1R67	0758-0087	R:FXD MET OX 470K OHM 5% 1/2W	
A1R68	0758-0053	R:FXD MET FLM 100K OHM 5% 1/2W	
A1R69	0758-0006	R:FXD MET FLM 10K OHM 5% 1/2W	
A1R70	0687-3331	R:FXD COMP 33K OHM 10% 1/2W	
A1R71	0687-1011	R:FXD COMP 100 OHM 10% 1/2W	
A1R72	0727-0287	R:FXD DEPC 2 MEGOHM 1% 1/2W	
A1R73	0758-0022	R:FXD MET FLM 82K OHM 5% 1/2W	
A1R74	0761-0031	R:FXD MET OX 82K OHM 5% 1W	
A1R75	0727-0245	R:FXD DEPC 500K OHM 1% 1/2W	
A1R76	0727-0276	R:FXD DEPC 1 MEGOHM 1% 1/2W	
A1R77	0770-0009	R:FXD MET OX 47K OHM 5% 4W	
A1R78	0761-0032	R:FXD MET OX 56K OHM 5% 1W	
A1R79	0687-1231	R:FXD COMP 12K OHM 10% 1/2W	
A1V1	1924-0001	ELECTRON TUBE:5915 PENTAGRID	
A1V1	1220-0010	SHIELD:ELECTRON TUBE	
A1V2	1932-0049	ELECTRON TUBE:CK 647	
A1V3	1932-0049	ELECTRON TUBE:CK 647	
A1V4	1923-0043	ELECTRON TUBE: 6EW6 PENTODE	
A1V4	1220-0010	SHIELD:ELECTRON TUBE	
A1V5	1932-0049	ELECTRON TUBE:CK 647	
A1V6	1923-0046	ELECTRON TUBE: 6EJ7 (EF 184) PENTODE	
A1V6	1220-0009	SHIELD-TUBE	
A1V7	1923-0045	ELECTRON TUBE: 7239 PENTODE	
A1XV1	1200-0049	SOCKET:TUBE 7 PIN MINIATURE	
A1XV2	1200-0062	SOCKET:TUBE 9 PIN MINIATURE	
A1XV3	1200-0062	SOCKET:TUBE 9 PIN MINIATURE	
A1XV4	1200-0049	SOCKET:TUBE 7 PIN MINIATURE	
A1XV5	1200-0062	SOCKET:TUBE 9 PIN MINIATURE	
A1XV6	1200-0059	SOCKET-TUBE	
A1XV7	1200-0062	SOCKET:TUBE 9 PIN MINIATURE	
A2	00692-602	ASSY: POWER SUPPLY	
A2C1		DELETED	
A2C2		DELETED	
A2C3	0150-0012	C:FXD CER 0.01UF 20% 1000VDCW	
A2C4	0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	
A2C5	0140-0206	C:FXD MICA 270PF 5% 500VDCW	
A2C6	0170-0060	C:FXD MY 0.047UF 10% 400VDCW	
A2C7	0150-0012	C:FXD CER 0.01UF 20% 1000VDCW	
A2C8 THRU A2C9		NOT ASSIGNED	
A2C10	0150-0096	C:FXD CER 0.05UF 100VDCW	

See list of abbreviations in introduction to this section

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

Reference Designation	ⓗ Stock No.	Description #	Note
A2C11	0170-0022	C:FXD MY 0.1UF 20% 600VDCW	
A2C12	0150-0012	C:FXD CER 0.01UF 20% 1000VDCW	
A2C13	0150-0012	C:FXD CER 0.01UF 20% 1000VDCW	
A2C14	0150-0079	C:FXD CER 3300 PF 10% 500 VDCW	
A2C15	0150-0012	C:FXD CER 0.01UF 20% 1000VDCW	
A2CR1	1901-0030	DIODE,SILICON:800 PIV	
A2CR2	1901-0030	DIODE,SILICON:800 PIV	
A2CR3	1901-0030	DIODE,SILICON:800 PIV	
A2CR4	1901-0030	DIODE,SILICON:800 PIV	
A2CR5	1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	
A2CR6	1901-0030	DIODE,SILICON:800 PIV	
A2CR7	1901-0030	DIODE,SILICON:800 PIV	
A2CR8	1901-0030	DIODE,SILICON:800 PIV	
A2CR9	1901-0030	DIODE,SILICON:800 PIV	
A2CR10	1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	
A2CR11	1901-0033	DIODE,SILICON:1N485B	
A2R1	0687-1001	R:FXD COMP 10 OHM 10% 1/2W	
A2R2	0758-0036	R:FXD MET FLM 3600 OHM 5% 1/2W	
A2R3	0758-0050	R:FXD MET FLM 39K OHM 5% 1/2W	
A2R4	0687-6831	R:FXD COMP 68K OHM 10% 1/2W	
A2R5	0687-1831	R:FXD COMP 18K OHM 10% 1/2W	
A2R6	0687-1041	R:FXD COMP 100K OHM 10% 1/2W	
A2R7	0687-1051	R:FXD COMP 1MEG OHM 10% 1/2W	
A2R8	0684-2201	R:FXD COMP 22 OHM 10% 1/4W	
A2R9	0684-2201	R:FXD COMP 22 OHM 10% 1/4W	
A2R10	0687-1851	R:FXD COMP 1.8 MEGOHM 10% 1/2W	
A2R11	0687-3341	R:FXD COMP 330K OHM 10% 1/2W	
A2R12	0687-1831	R:FXD COMP 18K OHM 10% 1/2W	
A2R13	0687-5631	R:FXD COMP 56K OHM 10% 1/2W	
A2R14	0687-1831	R:FXD COMP 18K OHM 10% 1/2W	
A2R15	0687-2241	R:FXD COMP 220K OHM 10% 1/2W	
A2R16	0758-0102	R:FXD MET OX 270K OHM 5% 1/2W	
A2R17	0687-4731	R:FXD COMP 47K OHM 10% 1/2W	
A2R18	0727-0237	R:FXD DEPC 376K OHM 1% 1/2W	
A2R19	2100-0914	R:VAR COMP 25K OHM 20% LIN 1/5W	
A2R20	0727-0240	R:FXD DEPC 405K OHM 1% 1/2W	
A2R21	0758-0049	R:FXD MET FLM 33K OHM 1/2W	
A2R22	0727-0186	R:FXD DEPC 33.2K OHM 1% 1/2W	
A2R23	0727-0246	R:FXD DEPC 600K OHM 1% 1/2W	
A2R24	0758-0053	R:FXD MET FLM 100K OHM 5% 1/2W	
A2R25		DELETED	
A2R26		DELETED	
A2R27		DELETED	
A2R28		DELETED	
A2R29	0758-0006	R:FXD MET FLM 10K OHM 5% 1/2W	
A2R30	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A2R31		DELETED	
A2R32	0687-1001	R:FXD COMP 10 OHM 10% 1/2W	
A2R33	0687-4741	R:FXD COMP 470K OHM 10% 1/2W	
A2R34	0684-2201	R:FXD COMP 22 OHM 10% 1/4W	

See list of abbreviations in introduction to this section

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

Reference Designation	Stock No.	Description #	Note
A2R35	0687-3331	R:FXD COMP 33K OHM 10% 1/2W	
A2R36	0687-2241	R:FXD COMP 220K OHM 10% 1/2W	
A2R37	0758-0053	R:FXD MET FLM 100K OHM 5% 1/2W	
A2R38	0687-4731	R:FXD COMP 47K OHM 10% 1/2W	
A2R39	0758-0061	R:FXD MET FLM 120K OHM 5% 1/2W	
A2R40	2100-0913	R:VAR COMP 15K OHM 20% LIN 1/5W	
A2R41	0758-0100	R:FXD MET OX 330K OHM 5% 1/2W	
A2R42	0727-0115	R:FXD DEPC 2000 OHM 1% 1/2W	
A2R43	0727-0226	R:FXD DEPC 250K OHM 1% 1/2W	
A2R44	0758-0061	R:FXD MET FLM 120K OHM 5% 1/2W	
A2R45	0764-0031	R:FXD MET OX FLM 47K OHM 2W	
A2R46	0758-0053	R:FXD MET FLM 100K OHM 5% 1/2W	
A2R47	0727-0254	R:FXD DEPC 750K OHM 1% 1/2W	
A2R48	2100-0102	R:VAR COMP 500K OHM 30% LIN 1/5W	
A2R49	0758-0022	R:FXD MET FLM 82K OHM 5% 1/2W	
A2R50	2100-0102	R:VAR COMP 500K OHM 30% LIN 1/5W	
A2R51	0758-0087	R:FXD MET OX 470K OHM 5% 1/2W	
A2R52	0758-0021	R:FXD MET FLM 51K OHM 5% 1/2W	
A2R53	0758-0006	R:FXD MET FLM 10K OHM 5% 1/2W	
A2R54	0687-3341	R:FXD COMP 330K OHM 10% 1/2W	
A2R55	0687-3341	R:FXD COMP 330K OHM 10% 1/2W	
A2V1	1940-0004	ELECTRON TUBE: OA2 VOLTAGE REGULATOR	
A2V2	1933-0005	ELECTRON TUBE: 7734 TRIODE PENTODE	
A2V3	1933-0005	ELECTRON TUBE: 7734 TRIODE PENTODE	
A2V4	1932-0030	ELECTRON TUBE: 12AX7 TWIN TRIODE	
A2V5	1940-0012	ELECTRON TUBE:VOLTAGE REFERENCE 8228 81V	
A2V6	1940-0012	ELECTRON TUBE:VOLTAGE REFERENCE 8228 81V	
A2V7	1932-0009	ELECTRON TUBE: 5965 DUAL TRIODE	
A2V8	1923-0006	ELECTRON TUBE: 6216 PENTODE	
A2V9	1923-0046	ELECTRON TUBE: 6EJ7 (EF 184) PENTODE	
A2V10	1932-0049	ELECTRON TUBE:CK 647	
A2V11	1940-0012	ELECTRON TUBE:VOLTAGE REFERENCE 8228 81V	
A2XV1	1200-0053	SOCKET:TUBE 7 PIN MINIATURE	
A2XV2	1200-0062	SOCKET:TUBE 9 PIN MINIATURE	
A2XV3	1200-0062	SOCKET:TUBE 9 PIN MINIATURE	
A2XV4	1200-0062	SOCKET:TUBE 9 PIN MINIATURE	
A2XV5 THRU A2XV6		NOT ASSIGNED	
A2XV7	1200-0062	SOCKET:TUBE 9 PIN MINIATURE	
A2XV8	1200-0062	SOCKET:TUBE 9 PIN MINIATURE	
A2XV9	1200-0062	SOCKET:TUBE 9 PIN MINIATURE	
A2XV10	1200-0062	SOCKET:TUBE 9 PIN MINIATURE	
A3	00691-606	ASSY:SHAPING(MODEL 691A ONLY)	
A3CR1	1901-0033	DIODE,SILICON:1N485B	
A3CR2	1901-0033	DIODE,SILICON:1N485B	
A3CR3	1901-0033	DIODE,SILICON:1N485B	
A3CR4	1901-0033	DIODE,SILICON:1N485B	
A3CR5	1901-0033	DIODE,SILICON:1N485B	
A3CR6	1901-0033	DIODE,SILICON:1N485B	

See list of abbreviations in introduction to this section

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

Reference Designation	Stock No.	Description #	Note
A3CR7	1901-0033	DIODE,SILICON:1N485B	
A3CR8	1901-0033	DIODE,SILICON:1N485B	
A3CR9	1901-0033	DIODE,SILICON:1N485B	
A3R1	2100-0914	R:VAR COMP 25K OHM 20% LIN 1/5W	
A3R2	2100-0915	R:VAR COMP 100K OHM 20% LIN 1/5W	
A3R3	2100-0917	R:VAR COMP 500K OHM LIN 1/5W	
A3R4	2100-0917	R:VAR COMP 500K OHM LIN 1/5W	
A3R5	2100-0917	R:VAR COMP 500K OHM LIN 1/5W	
A3R6	2100-0918	R:VAR COMP 1 MEGOHM 20% LIN 1/5W	
A3R7	2100-0918	R:VAR COMP 1 MEGOHM 20% LIN 1/5W	
A3R8	2100-0918	R:VAR COMP 1 MEGOHM 20% LIN 1/5W	
A3R9	2100-0917	R:VAR COMP 500K OHM 20% LIN 1/5W	
A3R10	2100-0918	R:VAR COMP 1 MEGOHM 20% LIN 1/5W	
A3R11	2100-0917	R:VAR COMP 500K OHM LIN 1/5W	
A3R12	0757-0130	R:FXD MET FLM 162K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R13	0757-0353	R:FXD MET FLM 249K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R14	0757-0191	R:FXD MET FLM 80.6K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R15	0757-0353	R:FXD MET FLM 249K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R16	0757-0312	R:FXD MET FLM 309K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R17	0757-0135	R:FXD MET FLM 511K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R18	0757-0135	R:FXD MET FLM 511 K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R19	0757-0310	R:FXD MET FLM 133K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R20	0757-0310	R:FXD MET FLM 133K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R21	0757-0353	R:FXD MET FLM 249K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R22	0757-0312	R:FXD MET FLM 309K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R23	0758-0025	R:FXD MET FLM 160 OHM 5% 1/2W	
A3R24	0758-0017	R:FXD MET FLM 1500 OHM 5% 1/2W	
A3R25	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A3R26	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A3R27	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A3R28	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A3R29	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A3R30	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A3R31	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A3	00692-606	ASSY:SHAPING(MODEL 692A ONLY)	
A3CR1	1901-0033	DIODE,SILICON:1N485B	
A3CR2	1901-0033	DIODE,SILICON:1N485B	
A3CR3	1901-0033	DIODE,SILICON:1N485B	
A3CR4	1901-0033	DIODE,SILICON:1N485B	
A3CR5	1901-0033	DIODE,SILICON:1N485B	

See list of abbreviations in introduction to this section

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

Reference Designation	ⓗⓟ Stock No.	Description #	Note
A3CR6	1901-0033	DIODE,SILICON:1N485B	
A3CR7	1901-0033	DIODE,SILICON:1N485B	
A3CR8	1901-0033	DIODE,SILICON:1N485B	
A3CR9	1901-0033	DIODE,SILICON:1N485B	
A3R1	2100-0914	R:VAR COMP 25K OHM 20% LIN 1/5W	
A3R2	2100-0915	R:VAR COMP 100K OHM 20% LIN 1/5W	
A3R3	2100-0917	R:VAR COMP 500K OHM LIN 1/5W	
A3R4	2100-0917	R:VAR COMP 500K OHM LIN 1/5W	
A3R5	2100-0917	R:VAR COMP 500K OHM LIN 1/5W	
A3R6	2100-0917	R:VAR COMP 500K OHM LIN 1/5W	
A3R7	2100-0917	R:VAR COMP 500K OHM LIN 1/5W	
A3R8	2100-0917	R:VAR COMP 500K OHM LIN 1/5W	
A3R9	2100-0917	R:VAR COMP 500K OHM LIN 1/5W	
A3R10	2100-0916	R:VAR COMP 250K OHM 20% LIN 1/5W	
A3R11	2100-0916	R:VAR COMP 250K OHM 20% LIN 1/5W	
A3R12	0757-0130	R:FXD MET FLM 162K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R13	0757-0310	R:FXD MET FLM 133K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R14	0757-0353	R:FXD MET FLM 249K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R15	0757-0312	R:FXD MET FLM 309K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R16	0757-0353	R:FXD MET FLM 249K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R17	0757-0353	R:FXD MET FLM 249K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R18	0757-0311	R:FXD MET FLM 182K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R19	0757-0310	R:FXD MET FLM 133K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R20	0757-0311	R:FXD MET FLM 182K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R21	0757-0191	R:FXD MET FLM 80.6K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R22	0757-0310	R:FXD MET FLM 133K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R23	0757-0076	R:FXD MET FLM 560 OHM 2% 1/2W	
A3R24	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A3R25	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A3R26	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A3R27	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A3R28	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A3R29	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A3R30	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A3R31	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A3	00693-606	ASSY:SHAPING(MODEL 693A ONLY)	
A3CR1	1901-0033	DIODE,SILICON:1N485B	
A3CR2	1901-0033	DIODE,SILICON:1N485B	
A3CR3	1901-0033	DIODE,SILICON:1N485B	
A3CR4	1901-0033	DIODE,SILICON:1N485B	

See list of abbreviations in introduction to this section

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

Reference Designation	ⓗ Stock No.	Description #	Note
A3CR5	1901-0033	DIODE,SILICON:1N485B	
A3CR6	1901-0033	DIODE,SILICON:1N485B	
A3CR7	1901-0033	DIODE,SILICON:1N485B	
A3CR8	1901-0033	DIODE,SILICON:1N485B	
A3CR9	1901-0033	DIODE,SILICON:1N485B	
A3R1	2100-0914	R:VAR COMP 25K OHM 20% LIN 1/5W	
A3R2	2100-0915	R:VAR COMP 100K OHM 20% LIN 1/5W	
A3R3	2100-0916	R:VAR COMP 250K OHM 20% LIN 1/5W	
A3R4	2100-0916	R:VAR COMP 250K OHM 20% LIN 1/5W	
A3R5	2100-0916	R:VAR COMP 250K OHM 20% LIN 1/5W	
A3R6	2100-0916	R:VAR COMP 250K OHM 20% LIN 1/5W	
A3R7	2100-0916	R:VAR COMP 250K OHM 20% LIN 1/5W	
A3R8	2100-0916	R:VAR COMP 250K OHM 20% LIN 1/5W	
A3R9	2100-0916	R:VAR COMP 250K OHM 20% LIN 1/5W	
A3R10	2100-0916	R:VAR COMP 250K OHM 20% LIN 1/5W	
A3R11	2100-0916	R:VAR COMP 250K OHM 20% LIN 1/5W	
A3R12	0757-0311	R:FXD MET FLM 182K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R13	0757-0130	R:FXD MET FLM 162K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R14	0757-0367	R:FXD MET FLM 100K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R15	0757-0312	R:FXD MET FLM 309K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R16	0757-0312	R:FXD MET FLM 309K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R17	0757-0311	R:FXD MET FLM 182K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R18	0757-0311	R:FXD MET FLM 182K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R19	0757-0130	R:FXD MET FLM 162K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R20	0757-0311	R:FXD MET FLM 182K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R21	0757-0191	R:FXD MET FLM 80.6K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R22	0757-0130	R:FXD MET FLM 162K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R23	0757-0076	R:FXD MET FLM 560 OHM 2% 1/2W	
A3R24	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A3R25	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A3R26	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A3R27	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A3R28	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A3R29	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A3R30	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A3R31	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A3	00694-606	ASSY:SHAPING(MODEL 694A ONLY)	
A3CR1	1901-0033	DIODE,SILICON:1N485B	
A3CR2	1901-0033	DIODE,SILICON:1N485B	
A3CR3	1901-0033	DIODE,SILICON:1N485B	

See list of abbreviations in introduction to this section

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

Reference Designation	ⓗ Stock No.	Description #	Note
A3CR4	1901-0033	DIODE,SILICON:1N485B	
A3CR5	1901-0033	DIODE,SILICON:1N485B	
A3CR6	1901-0033	DIODE,SILICON:1N485B	
A3CR7	1901-0033	DIODE,SILICON:1N485B	
A3CR8	1901-0033	DIODE,SILICON:1N485B	
A3CR9	1901-0033	DIODE,SILICON:1N485B	
A3R1	2100-0914	R:VAR COMP 25K OHM 20% LIN 1/5W	
A3R2	2100-0918	R:VAR COMP 1 MEGOHM 20% LIN 1/5W	
A3R3	2100-0917	R:VAR COMP 500K OHM 20% LIN 1/5W	
A3R4	2100-0916	R:VAR COMP 1 MEGOHM 20% LIN 1/5W	
A3R5	2100-0918	R:VAR COMP 1 MEGOHM 20% LIN 1/5W	
A3R6	2100-0916	R:VAR COMP 250K OHM 20% LIN 1/5W	
A3R7	2100-0916	R:VAR COMP 250K OHM LIN 1/5W	
A3R8	2100-0917	R:VAR COMP 500K OHM 20% LIN 1/5W	
A3R9	2100-0916	R:VAR COMP 250K OHM 20% LIN 1/5W	
A3R10	2100-0916	R:VAR COMP 250K OHM 20% LIN 1/5W	
A3R11	2100-0916	R:VAR COMP 250K OHM 20% LIN 1/5W	
A3R12	0757-0311	R:FXD MET FLM 182K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R13	0757-0135	R:FXD MET FLM 511K OHM 2% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R14	0757-0313	R:FXD MET FLM 392 OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R15	0757-0137	R:FXD MET FLM 750K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R16	0757-0137	R:FXD MET FLM 750K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R17	0757-0311	R:FXD MET FLM 182K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R18	0757-0191	R:FXD MET FLM 80.6KOHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R19	0757-0135	R:FXD MET FLM 511K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R20	0757-0311	R:FXD MET FLM 182K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R21	0757-0367	R:FXD MET FLM 100K OHM 1% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R22	0757-0191	R:FXD MET FLM 80.6K OHM 1% 11W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A3R23	0757-0076	R:FXD MET FLM 560 OHM 2% 1/2W	
A3R24	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A3R25	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A3R26	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A3R27	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A3R28	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A3R29	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A3R30	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A3R31	0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	
A4	00692-617	ASSY: SUMMING	
A4C1	0140-0192	C:FXD MICA 68PF 5% 300VDCW	

See list of abbreviations in introduction to this section

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

Reference Designation	ⓗ Stock No.	Description #	Note
A4C2	0140-0176	C:FXD MICA 100 PF 2% 300 VDCW	
A4C3	0140-0204	C:FXD MICA 47PF 5% NPO 500VDCW	
A4C4	0130-0017	C:VAR CER 8-50 PF N750	
A4C5	0140-0204	C:FXD MICA 47PF 5% NPO 500VDCW	
A4C6	0130-0017	C:VAR CER 8-50 PF N750	
A4C7	0140-0149	C:FXD MICA 470 PF 5% 300 VDCW	
A4C8	0140-0149	C:FXD MICA 470 PF 5% 300 VDCW	
A4C9	0160-0383	C:FXD MICA 10PF 10%	
A4CR1	1901-0033	DIODE,SILICON:1N485B	
A4CR2	1901-0033	DIODE,SILICON:1N485B	
A4CR3	1901-0033	DIODE,SILICON:1N485B	
A4CR4	1901-0033	DIODE,SILICON:1N485B	
A4CR5	1901-0033	DIODE,SILICON:1N485B	
A4CR6	1901-0033	DIODE,SILICON:1N485B	
A4CR7	1901-0033	DIODE,SILICON:1N485B	
A4CR8	1901-0033	DIODE,SILICON:1N485B	
A4Q1	1854-0003	TRANSISTOR:NPN SILICON	
A4Q2		DELETED	
A4Q3	1854-0003	TRANSISTOR:NPN SILICON	
A4Q4		DELETED	
A4R1	0812-0053	R:FXD WW 500K OHM 1% 1/4W	
A4R2	0812-0053	R:FXD WW 500K OHM 1% 1/4W	
A4R3	2100-0912	R:VAR COMP 5K OHM 20% LIN 1/5W	
A4R4	0758-0100	R:FXD MET OX 330K OHM 5% 1/2W	
A4R5	0758-0053	R:FXD MET FLM 100K OHM 5% 1/2W	
A4R6	0687-3941	R:FXD COMP 390K OHM 10% 1/2W	
A4R7	0757-0308	R:FXD MET FLM 1.50 MEGOHM 1% 1/2W	
A4R8	0757-0308	R:FXD MET FLM 1.50 MEGOHM 1% 1/2W	
A4R9	0757-0308	R:FXD MET FLM 1.50 MEGOHM 1% 1/2W	
A4R10	0757-0308	R:FXD MET FLM 1.50 MEGOHM 1% 1/2W	
A4R11	0758-0053	R:FXD MET FLM 100K OHM 5% 1/2W	
A4R12	2100-0912	R:VAR COMP 5K OHM 20% LIN 1/5W	
A4R13	0687-3941	R:FXD COMP 390K OHM 10% 1/2W	
A4R14	0758-0018	R:FXD MET FLM 15K OHM 5% 1/2W	
A4R15	0758-0005	R:FXD MET OX 4700 OHM 5% 1/2W	
A4R16	0758-0053	R:FXD MET FLM 100K OHM 5% 1/2W	
A4R17	0687-3941	R:FXD COMP 390K OHM 10% 1/2W	
A4R18	0758-0037	R:FXD MET FLM 5100 OHM 5% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A4R19	0758-0021	R:FXD MET FLM 51K OHM 5% 1/2W	
A4R20	2100-0914	R:VAR COMP 25K OHM 20% LIN 1/5W	
A4R21	0757-0321	R:FXD MET FLM 202K OHM 1% 1/4W	
A4R22	0758-0006	R:FXD MET FLM 10K OHM 5% 1/2W	
A4R23		DELETED	
A4R24 THRU A4R25		NOT ASSIGNED	
A4R26	0758-0053	R:FXD MET FLM 100K OHM 5% 1/2W	
A4R27	0687-3941	R:FXD COMP 390K OHM 10% 1/2W	
A4R28	0758-0037	R:FXD MET FLM 5100 OHM 5% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	

See list of abbreviations in introduction to this section

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

Reference Designation	Stock No.	Description #	Note
A4R29	0758-0021	R:FXD MET FLM 51K OHM 5% 1/2W	
A4R30	2100-0914	R:VAR COMP 25K OHM 20% LIN 1/5W	
A4R31	0757-0321	R:FXD MET FLM 202K OHM 1% 1/4W	
A4R32	0758-0006	R:FXD MET FLM 10K OHM 5% 1/2W	
A4R33		DELETED	
A4R34	0687-1261	R:FXD COMP 12 MEGOHM 10% 1/2W	
A4R35	0687-1261	R:FXD COMP 12 MEGOHM 10% 1/2W	
A4R36	0687-1011	R:FXD COMP 100 OHM 10% 1/2W	
A4R37	0698-3304	R:FXD MET FLM 130K OHM 1% 1/2W	
A4R38	0698-3304	R:FXD MET FLM 130K OHM 1% 1/2W	
A4R39	0698-3304	R:FXD MET FLM 130K OHM 1% 1/2W	
A4R40	0730-0038	R:FXD DEPC 19.4K OHM 1%	
A4R41	0758-0059	R:FXD MET FLM 11K OHM 5% 1/2W	
A4R42	0758-0044	R:FXD MET FLM 2200 OHM 5% 1/2W	
A4R43	0758-0044	R:FXD MET FLM 2200 OHM 5% 1/2W	
A4R44-46	0698-3304	R:FXD MET FLM 130K OHM 1% 1/2W	
A4V1	1932-0027	ELECTRON TUBE:12AT7	
A4V2	1932-0030	ELECTRON TUBE: 12AX7	
A4V3	1932-0049	ELECTRON TUBE:CK 647	
A4XV1	1200-0062	SOCKET:TUBE 9 PIN MINIATURE	
A4XV2	1200-0062	SOCKET:TUBE 9 PIN MINIATURE	
A4XV3	1200-0062	SOCKET:TUBE 9 PIN MINIATURE	
A5	00692-605	ASSY:ALC AMPLIFIER	
A5C1	0170-0019	C:FXD MY 0.1 UF 5% 200VDCW	
A5C2	0140-0204	C:FXD MICA 47PF 5% NPO 500VDCW	
A5C3		DELETED	
A5C4	0180-0116	C:FXD ELECT TA 6.8UF 10% 35VDCW	
A5C5	0140-0198	C:FXD MICA 200PF 5% 300VDCW	
A5C6	0140-0149	C:FXD MICA 470 PF 5% 300 VDCW	
A5C7	0140-0198	C:FXD MICA 200PF 5% 300VDCW	
A5C8	0180-0116	C:FXD ELECT TA 6.8UF 10% 35VDCW	
A5C9	0140-0178	C:FXD MICA 560 PF 2% 300 VDCW	
A5C10		NOT ASSIGNED	
A5C11	0170-0078	C:FXD MY 0.47UF 5% 150VDCW	
A5C12	0180-0061	C:FXD ELECT 100UF +100%-10% 15VDCW	
A5CR1	1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	
A5CR2	1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	
A5CR3	1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	
A5CR4	1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	
A5CR5	1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	
A5CR6	1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	
A5CR7	1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	
A5CR8	1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	
A5CR9	1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	
A5CR10	1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	
A5CR11	1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	
A5CR12	1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	
A5CR13	1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	
A5CR14	1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	
A5CR15	1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	

See list of abbreviations in introduction to this section

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

Reference Designation	Stock No.	Description #	Note
A5CR16		DELETED	
A5CR17	1901-0033	DIODE,SILICON:1N485B	
A5CR18	1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	
A5CR19	1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	
A5CR20	1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	
A5Q1	1854-0003	TRANSISTOR:NPN SILICON	
A5Q2	1854-0015	TRANSISTOR:NPN SILICON	
A5Q3	1850-0062	TRANSISTOR:GERMANIUM SPL2N404 PNP	
A5Q4	1850-0062	TRANSISTOR:GERMANIUM SPL2N404 PNP	
A5Q5	1850-0062	TRANSISTOR:GERMANIUM SPL2N404 PNP	
A5Q6	1850-0062	TRANSISTOR:GERMANIUM SPL2N404 PNP	
A5Q7	1850-0062	TRANSISTOR:GERMANIUM SPL2N404 PNP	
A5Q8	1850-0062	TRANSISTOR:GERMANIUM SPL2N404 PNP	
A5Q9	1854-0003	TRANSISTOR:NPN SILICON	
A5Q10	1854-0003	TRANSISTOR:NPN SILICON	
A5Q11	1850-0062	TRANSISTOR:GERMANIUM SPL2N404 PNP	
A5Q12	1854-0003	TRANSISTOR:NPN SILICON	
A5Q13	1854-0003	TRANSISTOR:NPN SILICON	
A5Q14	1850-0062	TRANSISTOR:GERMANIUM SPL2N404 PNP	
A5Q15	1850-0062	TRANSISTOR:GERMANIUM SPL2N404 PNP	
A5Q16	1854-0014	TRANSISTOR:DUAL NPN SILICON	
A5Q17	1850-0096	TRANSISTOR:GERMANIUM 2N2189 PNP	
A5Q18	1850-0096	TRANSISTOR:GERMANIUM 2N2189 PNP	
A5Q19	1854-0005	TRANSISTOR:2N708 NPN SILICON	
A5Q20		DELETED	
A5Q21	1854-0015	TRANSISTOR:NPN SILICON BVCBO 50V	
A5Q22	1853-0001	TRANSISTOR:PNP SILICON 30V 900MW	
A5Q23	1855-0001	TRANSISTOR:SIL UNIJUNCTION 2N1671A	
A5R1	0758-0076	R:FXD MET FLM 68K OHM 5% 1/2W	
A5R2		DELETED	
A5R3	0758-0003	R:FXD MET FLM 1000 OHM 5% 1/2W	
A5R4	0758-0098	R:FXD MET OX 220K OHM 5% 1/2W	
A5R5	0758-0053	R:FXD MET FLM 100K OHM 5% 1/2W	
A5R6	0758-0098	R:FXD MET OX 220K OHM 5% 1/2W	
A5R7	0758-0006	R:FXD MET FLM 10K OHM 5% 1/2W	
A5R8	0757-0079	R:FXD MET FLM 2700 OHM 2% 1/2W	
A5R9	0758-0012	R:FXD MET FLM 12K OHM 5% 1/2W	
A5R10	0758-0006	R:FXD MET FLM 10K OHM 5% 1/2W	
A5R11	0758-0098	R:FXD MET OX 220K OHM 5% 1/2W	
A5R12	0758-0071	R:FXD MET FLM 4300 OHM 5% 1/2W	
A5R13	0758-0047	R:FXD MET FLM 7500 OHM 5% 1/2W	
A5R14	0758-0039	R:FXD MET FLM 20K OHM 5% 1/2W	
A5R15	0758-0024	R:FXD MET FLM 100 OHM 5% 1/2W	
A5R16	0758-0098	R:FXD MET OX 220K OHM 5% 1/2W	
A5R17	0758-0053	R:FXD MET FLM 100K OHM 5% 1/2W	
A5R18	0758-0098	R:FXD MET OX 220K OHM 5% 1/2W	
A5R19	0758-0006	R:FXD MET FLM 10K OHM 5% 1/2W	
A5R20	0757-0079	R:FXD MET FLM 2700 OHM 2% 1/2W	
A5R21	0758-0012	R:FXD MET FLM 12K OHM 5% 1/2W	
A5R22	0758-0006	R:FXD MET FLM 10K OHM 5% 1/2W	

See list of abbreviations in introduction to this section

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

Reference Designation	Stock No.	Description #	Note
A5R23	0758-0098	R:FXD MET OX 220K OHM 5% 1/2W	
A5R24	0758-0071	R:FXD MET FLM 4300 OHM 5% 1/2W	
A5R25	0758-0047	R:FXD MET FLM 7500 OHM 5% 1/2W	
A5R26	0758-0039	R:FXD MET FLM 20K OHM 5% 1/2W	
A5R27	0758-0024	R:FXD MET FLM 100 OHM 5% 1/2W	
A5R28		DELETED	
A5R29		DELETED	
A5R30		DELETED	
A5R31		DELETED	
A5R32		DELETED	
A5R33	0758-0006	R:FXD MET FLM 10K OHM 5% 1/2W	
A5R34	0758-0006	R:FXD MET FLM 10K OHM 5% 1/2W	
A5R35		DELETED	
A5R36	0727-0246	R:FXD DEPC 600K OHM 1% 1/2W	
A5R37	0758-0005	R:FXD MET OX 4700 OHM 5% 1/2W	
A5R38	0758-0003	R:FXD MET FLM 1000 OHM 5% 1/2W	
A5R39	0758-0003	R:FXD MET FLM 1000 OHM 5% 1/2W	
A5R40	0758-0039	R:FXD MET FLM 20K OHM 5% 1/2W	
A5R41		DELETED	
A5R42	0757-0017	R:FXD MET FLM 1 MEGOHM 1/2% 1/2W	
A5R43	0758-0035	R:FXD MET FLM 3000 OHM 5% 1/2W	
A5R44	0687-3341	R:FXD COMP 330K OHM 10% 1/2W	
A5R45	0758-0005	R:FXD MET OX 4700 OHM 5% 1/2W	
A5R46	0758-0029	R:FXD MET FLM 470 OHM 5% 1/2W	
A5R47	0812-0051	R:FXD WW 15K OHM 3% 3W	
A5R48	2100-0912	R:VAR COMP 5K OHM 20% LIN 1/5W	
A5R49	0812-0051	R:FXD WW 15K OHM 3% 3W	
A5R50	0687-3341	R:FXD COMP 330K OHM 10% 1/2W	
A5R51	0758-0029	R:FXD MET FLM 470 OHM 5% 1/2W	
A5R52		DELETED	
A5R53	0758-0005	R:FXD MET OX 4700 OHM 5% 1/2W	
A5R54		DELETED	
A5R55	0687-3341	R:FXD COMP 330K OHM 10% 1/2W	
A5R56	0758-0039	R:FXD MET FLM 20K OHM 5% 1/2W	
A5R57	0758-0035	R:FXD MET FLM 3000 OHM 5% 1/2W	
A5R58	0757-0017	R:FXD MET FLM 1 MEGOHM 1/2% 1/2W	
A5R59	0758-0079	R:FXD MET FLM 30K OHM 5% 1/2W	
A5R60	0727-0226	R:FXD DEPC 250K OHM 1% 1/2W	
A5R61	0758-0021	R:FXD MET FLM 51K OHM 5% 1/2W	
A5R62		DELETED	
A5R63	0758-0003	R:FXD MET FLM 1000 OHM 5% 1/2W	
A5R64	0758-0024	R:FXD MET FLM 100 OHM 5% 1/2W	
A5R65		DELETED	
A5R66		DELETED	
A5R67		DELETED	
A5R68	0687-1541	R:FXD COMP 150K OHM 10% 1/2W	
A5R69	0687-1551	R:FXD COMP 1.5 MEGOHM 10% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A5R70	0687-4741	R:FXD COMP 470K OHM 10% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A5R71	0687-3311	R:FXD COMP 330 OHM 10% 1/2W	

See list of abbreviations in introduction to this section

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

Reference Designation	Stock No.	Description #	Note
A5R72		DELETED	
A5R73	0687-1561	R:FXD COMP 15 MEGOHM 10% 1/2W	
A5R74	0758-0021	R:FXD MET FLM 51K OHM 5% 1/2W	
A5R75	0758-0053	R:FXD MET FLM 100K OHM 5% 1/2W	
A5R76	0758-0050	R:FXD MET FLM 39K OHM 5% 1/2W	
A5R77	0758-0037	R:FXD MET FLM 5100 OHM 5% 1/2W	
A5R78	0758-0017	R:FXD MET FLM 1500 OHM 5% 1/2W	
A5R79	0758-0037	R:FXD MET FLM 5100 OHM 5% 1/2W	
A5R80	0758-0039	R:FXD MET FLM 20K OHM 5% 1/2W	
A5R81	0758-0048	R:FXD MET FLM 8200 OHM 5% 1/2W	
A5R82	0758-0012	R:FXD MET FLM 12K OHM 5% 1/2W	
A5R83	0758-0102	R:FXD MET OX 270K OHM 5% 1/2W	
A5R84	0758-0010	R:FXD MET OX FLM 3300 OHM 5% 1/2W	
A5R85	0727-0169	R:FXD DEPC 15.5K OHM 1% 1/2W	
A5R86	0758-0087	R:FXD MET OX 470K OHM 5% 1/2W	
A5R87	0758-0006	R:FXD MET FLM 10K OHM 5% 1/2W	
A5V1	1932-0049	ELECTRON TUBE:CK 647	
A5XV1	1200-0062	SOCKET:TUBE 9 PIN MINIATURE	
A6	00692-603	ASSY:HIGH VOLTAGE	
A6C1	0170-0022	C:FXD MY 0.1UF 20% 600VDCW	
A6C2	0150-0052	C:FXD CER 0.05 UF 20% 400VDCW	
A6CR1	1901-0030	DIODE,SILICON:800 PIV	
A6CR2		NOT ASSIGNED	
A6CR3	1901-0084	RECTIFIER:SILICON 50MA 4000PIV	
A6R1	0758-0024	R:FXD MET FLM 100 OHM 5% 1/2W	
A6R2	0813-0011	R:FXD WW 330 OHM 5% 5W	
A6R3	0758-0006	R:FXD MET FLM 10K OHM 5% 1/2W	
A6R4	0764-0028	R:FXD MET FLM 100K OHM 5% 2W	
A6R5		DELETED	
A6R6		DELETED	
A6R7		DELETED	
A6R8		DELETED	
A6R9	0693-4701	R:FXD COMP 47 OHM 10% 2W	
A6V1		DELETED	
A6V2		DELETED	
A6XV1		DELETED	
A6XV2		DELETED	
A7	00692-601	ASSY:FILAMENT POWER SUPPLY	
A7C1	0180-0049	C:FXD ELECT 20UF 50VDCW	
A7C2	0180-0105	C:FXD ELECT SEMI-POLARIZED 50UF 25VDCW	
A7C3	0180-0050	C:FXD ELECT 40UF -15%+100% 50VDCW	
A7C4	0150-0012	C:FXD CER 0.01UF 20% 1000VDCW	
A7C5	0180-0059	C:FXD ELECT 10UF -10%+100% 25VDCW	
A7C6	0180-0059	C:FXD ELECT 10UF -10%+100% 25VDCW	
A7C7	0180-0105	C:FXD ELECT SEMI-POLARIZED 50UF 25VDCW	

See list of abbreviations in introduction to this section

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

Reference Designation	ⓗⓟ Stock No.	Description #	Note
A7C8	0180-0059	C:FXD ELECT 10UF -10%+100% 25VDCW	
A7C9	0150-0096	C:FXD CER 0.05UF 100VDCW	
A7C10	0180-0059	C:FXD ELECT 10UF -10%+100% 25VDCW	
A7C11	0180-0039	C:FXD ELECT 100UF 12VDCW	
A7CR1	1901-0025	SEMICON DEVICE:DIODE SILICON	
A7CR2	1901-0025	SEMICON DEVICE:DIODE SILICON	
A7CR3	1902-0031	DIODE,BREAKDOWN:12.7V 5%	
A7CR4		DELETED	
A7CR5		DELETED	
A7CR6	1901-0026	DIODE,SILICON:0.5A 200PIV	
A7CR7	1901-0026	DIODE,SILICON:0.5A 200PIV	
A7CR8	1901-0026	DIODE,SILICON:0.5A 200PIV	
A7CR9	1901-0026	DIODE,SILICON:0.5A 200PIV	
A7CR10	1901-0025	SEMICON DEVICE:DIODE SILICON	
A7CR11	1901-0025	SEMICON DEVICE:DIODE SILICON	
A7CR12	1901-0025	SEMICON DEVICE:DIODE SILICON	
A7CR13		DELETED	
A7CR14		DELETED	
A7Q1	1850-0064	TRANSISTOR:GERMANIUM 2N1183 PNP	
A7Q2	1854-0015	TRANSISTOR:NPN SILICON	
A7Q3	1854-0015	TRANSISTOR:NPN SILICON	
A7Q4	1854-0015	TRANSISTOR:NPN SILICON	
A7Q5	1854-0015	TRANSISTOR:NPN SILICON	
A7Q6	1850-0062	TRANSISTOR:GERMANIUM SPL2N404 PNP	
A7Q7	1850-0062	TRANSISTOR:GERMANIUM SPL2N404 PNP	
A7R1	0687-1521	R:FXD COMP 1500 OHM 10% 1/2W	
A7R2	0687-4711	R:FXD COMP 470 OHM 10% 1/2W	
A7R3	0687-2241	R:FXD COMP 220K OHM 10% 1/2W	
A7R4	0687-6831	R:FXD COMP 68K OHM 10% 1/2W	
A7R5	0684-2701	R:FXD COMP 27 OHM 10% 1/4W	
A7R6	0684-1001	R:FXD COMP 10 OHM 10% 1/4W	
A7R7	0687-1011	R:FXD COMP 100 OHM 10% 1/2W	
A7R8	0758-0101	R:FXD MET OX 150K OHM 5% 1/2W	
A7R9	0758-0057	R:FXD MET FLM 5600 OHM 5% 1/2W	
A7R10	0758-0005	R:FXD MET OX 4700 OHM 5% 1/2W	
A7R11	0758-0098	R:FXD MET OX 220K OHM 5% 1/2W	
A7R12	0758-0006	R:FXD MET FLM 10K OHM 5% 1/2W	
A7R13	2100-0090	R:VAR COMP 2000 OHM 30% LIN 1/3W	
A7R14	0758-0038	R:FXD MET FLM 9100 OHM 5% 1/2W	
A7R15	0758-0004	R:FXD MET FLM 2700 OHM 5% 1/2W	
A7R16	0758-0104	R:FXD MET OX 180K OHM 5% 1/2W	
A7R17	0758-0029	R:FXD MET FLM 470 OHM 5% 1/2W	
A7R18	0764-0031	R:FXD MET OX FLM 47K OHM 2W	
A7R19	0687-1011	R:FXD COMP 100 OHM 10% 1/2W	
A7R20	0758-0009	R:FXD MET FLM 6800 OHM 5% 1/2W	
A7R21	2100-0154	R:VAR COMP 1K OHM 30% LIN 0.15W	
A7R22	0758-0004	R:FXD MET FLM 2700 OHM 5% 1/2W	
A8	00692-608	ASSY: TIME METER	
A8M1	1010-0005	INDICATOR:ELAPSED TIME	

See list of abbreviations in introduction to this section

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

Reference Designation	Stock No.	Description #	Note
A8R1	0758-0034	R:FXD MET FLM 2400 OHM 5% 1/2W	
A8R2	2100-0912	R:VAR COMP 5K OHM 20% LIN 1/5W	
A8R3	2100-0912	R:VAR COMP 5K OHM 20% LIN 1/5W	
A8R4	2100-0912	R:VAR COMP 5K OHM 20% LIN 1/5W	
A8R5	0686-2455	R:FXD COMP 2.4 MEGOHM 5% 1/2W	
A9	00692-618	ASSY: MODE INDICATOR BOARD	
A9DS1	2140-0043	LAMP:INCANDESCENT 6V 0.04 AMP	
A9DS2	2140-0043	LAMP:INCANDESCENT 6V 0.04 AMP	
A9DS3	2140-0043	LAMP:INCANDESCENT 6V 0.04 AMP	
A9DS4	2140-0043	LAMP:INCANDESCENT 6V 0.04 AMP	
A9R1	0684-1001	R:FXD COMP 10 OHM 10% 1/4W	
A9R2	0684-1001	R:FXD COMP 10 OHM 10% 1/4W	
A9R3	0684-1001	R:FXD COMP 10 OHM 10% 1/4W	
A9R4	0684-1001	R:FXD COMP 10 OHM 10% 1/4W	
A10		NOT ASSIGNED	
A11	00692-661	ASSY:MODULATOR BOARD	
A11CR1	1910-0014	SEMICON DEVICE:DIODE GERMANIUM 1N277	
A11CR2	1901-0033	DIODE,SILICON:1N485B	
A11CR3	1901-0033	DIODE,SILICON:1N485B	
A11CR4	1910-0014	SEMICON DEVICE:DIODE GERMANIUM 1N277	
A11Q1	1854-0003	TRANSISTOR:NPN SILICON	
A11R1	2100-0094	R:VAR COMP 50K OHM 30% LIN 1/5W	
A11R2	0758-0040	R:FXD MET FLM 47K OHM 5% 1/2W FACTORY SELECTED PART::TYPICAL VALUE GIVEN	
A11R3	0758-0055	R:FXD MET FLM 360 OHM 5% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A11R4	0758-0032	R:FXD MET OX 820 OHM 5% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
A11R5	0687-2241	R:FXD COMP 220K OHM 10% 1/2W	
A12	00691-610	ASSY:COUPLER BRACKET,INCLUDES A12J1, A12S1 BRACKET AND 2-CONDUCTOR CABLE (OPTION 01 MODELS 691A, 692A, 694A ONLY)	
A12	00693-610	ASSY:COUPLER BRACKET INCLUDES A12J1, A12S1 BRACKET BRACKET AND 2 CONDUCTOR CABLE (OPTION 01 MODEL 693A ONLY)	
A12J1	1250-0083	CONNECTOR:BNC	
A12S1	3101-0011	SWITCH:SLIDE DPDT 0.5 AMP 125 VDC	
A13	786D	DIRECTIONAL DETECTOR, MODEL 691A ONLY	
A13	787D	DIRECTIONAL DETECTOR, MODEL 692A ONLY	
A13°		DIRECTIONAL COUPLER/DETECTOR-CONSISTS OF NARDA 3044-10 DIRECTIONAL COUPLER/ HP 423A CRYSTAL DETECTOR	
A13°		DIRECTIONAL COUPLER/DETECTOR-CONSISTS OF NARDA 3045B-10 DIRECTIONAL COUPLER/ HP 423A CRYSTAL DETECTOR	
B1	3160-0026	FAN:BLADE 105-120 V, 50-60 CPS	
B1	5060-0878	FILTER:AIR	
C1	0150-0012	C:FXD CER 0.01UF 20% 1000VDCW	

See list of abbreviations in introduction to this section

• ORDER BY DESCRIPTION

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

Reference Designation	Stock No.	Description #	Note
C2	0150-0012	C:FXD CER 0.01UF 20% 1000VDCW	
C3	0160-0382	C:FXD MYLAR 0.001UF 10% 400VDCW	
C4	0160-0381	C:FXD MYLAR 0.01UF 10% 400VDCW	
C5	0170-0022	C:FXD MY 0.1UF 20% 600VDCW	
C6	0170-0073	C:FXD MY 1UF 10% 600VDCW	
C7	0150-0014	C:FXD CER 5000PF MIN 500VDCW	
C8	0160-0798	C:FXD POLY 0.047UF 10% 30VDCW	
C9		DELETED	
C10	0160-0779	C:FXD MY 0.02UF 10% 3000VDCW	
C11	0160-0384	C:FXD CER 5600PF +80-20% 3KVDCW	
C12	0180-0025	C:FXD ELECT 4 SECT 20UF 450VDCW	
C13	0160-0083	C:FXD PAPER 3UF 20% -10% 2000VDCW	
C14	0160-0083	C:FXD PAPER 3UF 20% -10% 2000VDCW	
C15	0160-0192	C:FXD MICA 525PF 5% 300VDCW(FACTORY SELECTED VALUE)	
C16	0180-0136	C:FXD ELECT 10UF -10+100% 50VDCW	
C17	0180-0125	C:FXD ELECT 4 SECT 20UF +30 -10% 450VDCW	
C18	0180-0016	C:FXD ELECT 3X10UF -10/+50% 450VDCW	
C19	0180-0016	C:FXD ELECT 3X10UF -10/+50% 450VDCW	
C20		NOT ASSIGNED	
C21	0180-0128	C:FXD ELECT 2800UF -10+30% 30VDCW	
C22	0180-0128	C:FXD ELECT 2800UF -10+30% 30VDCW	
C23	0180-0063	C:FXD ELECT 500UF -10%+100% 3VDCW	
CR1	1901-0033	DIODE,SILICON:1N485B	
CR2	1901-0033	DIODE,SILICON:1N485B	
CR3	1901-0025	SEMICON DEVICE:DIODE SILICON	
CR4	1901-0040	SEMICON DEVICE:DIODE SILICON	
CR5	1901-0025	SEMICON DEVICE:DIODE SILICON	
CR6	1903-0002	DIODE,4 LAYER: SILICON 20V	
CR7		NOT ASSIGNED	
CR8	1901-0032	RECTIFIER:SILICON 15 AMP 1N3209	
CR8	1200-0088	INSULATOR:DIODE ANODIZED ALUMINUM	
CR9	1901-0032	RECTIFIER:SILICON 15 AMP 1N3209	
CR9	1200-0088	INSULATOR:DIODE ANODIZED ALUMINUM	
CR10	1901-0032	RECTIFIER:SILICON 15 AMP 1N3209	
CR10	1200-0088	INSULATOR:DIODE ANODIZED ALUMINUM	
CR11	1901-0032	RECTIFIER:SILICON 15 AMP 1N3209	
CR11	1200-0088	INSULATOR:DIODE ANODIZED ALUMINUM	
CR12	1902-0215	DIODE,BREAKDOWN: 6.49V 5% 1.5W	
CR12	1200-0080	WASHER:FLAT INSULATING ANODIZED AL 0.531OD	
CR12	1205-0003	BUSHING:HEAT SINK NYLON	
CR12	1205-0007	NUT:HEAT DISSIPATOR	
CR12	1205-0008	HEAT DISSIPATOR:BODY	
CR13	1901-0025	SEMICON DEVICE:DIODE SILICON	
DS1	2140-0047	LAMP:GLOW NEON 1/10W	
DS1	5040-0234	LAMPHOLDER:(FOR 4 LAMPS)	
DS1	5040-0235	BASE:LAMPHOLDER	
DS2	2140-0047	LAMP:GLOW NEON 1/10W	
DS2	5040-0234	LAMPHOLDER:(FOR 4 LAMPS)	
DS2	5040-0235	BASE:LAMPHOLDER	

See list of abbreviations in introduction to this section

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

Reference Designation	Stock No.	Description #	Note
DS3	2140-0047	LAMP:GLOW NEON 1/10W	
DS3	5040-0234	LAMPHOLDER:(FOR 4 LAMPS)	
DS3	5040-0235	BASE:LAMPHOLDER	
DS4	2140-0047	LAMP:GLOW NEON 1/10W	
DS4	5040-0234	LAMPHOLDER:(FOR 4 LAMPS)	
DS4	5040-0235	BASE:LAMPHOLDER	
F1	2110-0055	FUSE:CARTRIDGE 4 AMP 250V 115 VOLT OPERATION	
F1	2110-0002	FUSE:CARTRIDGE 2 AMP 3 AG 230 VOLT OPERATION	
F1	1400-0084	FUSEHOLDER:EXTRACTOR POST TYPE	
FL1	360D	RF LOW PASS FILTER(MODEL 692A ONLY)SEE OPTION 01 LIST	
FL1	00693-604	RF LOW PASS FILTER(MODEL 693A ONLY) SEE OPTION 01 LIST	
FL1	00694-604	RF LOW PASS FILTER(MODEL 694A ONLY) SEE OPTION 01 LIST	
J1		DELETED	
J2		DELETED	
J3	1250-0123	CONNECTOR:BNC(MARKER OUTPUT)	
J4		DELETED	
J5		CONNECTOR:PENLIFT,CONSISTS OF:	
	1510-0008	BINDING POST:RED	
	1510-0009	BINDING POST:BLACK	
	0340-0086	EXTERIOR INSULATOR:BINDING POST BLACK	
	0340-0090	INTERIOR INSULATOR:BINDING POST BLACK	
	0340-0090	INSULATOR:BINDING-POST DOUBLE	
J6		DELETED	
J7		DELETED	
J8	1250-0123	CONNECTOR:BNC(POWER METER INPUT)	
J9	1251-0148	CONNECTOR:POWER 3 PIN MALE	
J10	00692-211	CONNECTOR:N TYPE (RF OUTPUT)	
J10	08731-210	NUT:LOCK FOR J10	
J11	1250-0123	CONNECTOR:BNC	
J12	1250-0123	CONNECTOR:BNC	
J13	1250-0123	CONNECTOR:BNC	
J14	1250-0123	CONNECTOR:BNC	
J15	1250-0123	CONNECTOR:BNC	
J16	1250-0123	CONNECTOR:BNC	
K1	0490-0123	RELAY:ARMATURE SPDT 2-AMP/COIL 6VDC (PENLIFT)	
K2	0490-0114	RELAY:ARMATURE SPDT/COIL 125MW SENSITIVITY (HELIX OVERLOAD)	
K3	0490-0115	RELAY:ARMATURE 3PDT/COIL 6VDC (TIME DELAY)	
K4	0490-0124	RELAY:3PDT 6V 5.1 OHM COIL (HEATER OVER-VOLTAGE)	
K5	0490-0026	RELAY:DPDT 115V AC (ANODE VOLTAGE CONTROL)	
P1		NSR PART OF W1	
P2		NSR PART OF W1	
Q1	1850-0050	TRANSISTOR:GERMANIUM 2N457A PNP	
Q1	1200-0043	INSULATOR:TRANSISTOR ANODIZED ALUMINUM	

See list of abbreviations in introduction to this section

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

Reference Designation	ⓗⓟ Stock No.	Description #	Note
Q1	1200-0081	BUSHING:INSULATOR NYLON	
Q2	1850-0050	TRANSISTOR:GERMANIUM 2N457A PNP	
Q2	1200-0043	INSULATOR:TRANSISTOR ANODIZED ALUMINUM	
Q2	1200-0081	BUSHING:INSULATOR NYLON	
Q3	1850-0064	TRANSISTOR:GERMANIUM 2N1183 PNP	
Q3	1200-0076	INSULATOR:TRANSISTOR	
Q3	1200-0092	BUSHING:TRANSISTOR	
Q3	1200-0087	CLAMP:TRANSISTOR	
Q4	1850-0050	TRANSISTOR:GERMANIUM 2N457A PNP	
Q4	1200-0043	INSULATOR:TRANSISTOR ANODIZED ALUMINUM	
Q4	1200-0081	BUSHING:INSULATOR NYLON	
Q5	1850-0050	TRANSISTOR:GERMANIUM 2N457A PNP	
Q5	1200-0043	INSULATOR:TRANSISTOR ANODIZED ALUMINUM	
Q5	1200-0081	BUSHING:INSULATOR NYLON	
Q6	1850-0050	TRANSISTOR:GERMANIUM 2N457A PNP	
Q6	1200-0043	INSULATOR:TRANSISTOR ANODIZED ALUMINUM	
Q6	1200-0081	BUSHING:INSULATOR NYLON	
R1	0687-1031	R:FXD COMP 10K OHM 10% 1/2W	
R2	0727-0332	R:FXD DEPC 150K OHM 1% 1/2W	
R3	0727-0254	R:FXD DEPC 750K OHM 1% 1/2W	
R4	2100-0753	R:VAR COMP 500K OHM 20% LIN 1/2W W/DPST SW	
R5	0758-0020	R:FXD MET FLM 22K OHM 5% 1/2W	
R6	0687-5631	R:FXD COMP 56K OHM 10% 1/2W	
R7	2100-0043	R:VAR COMP 500K OHM 10% LIN 2W	
R8	0687-6841	R:FXD COMP 680K OHM 10% 1/2W	
R9	2100-0752	R:VAR WW 50K OHM 3% LIN 1.5W 10-TURN	
R10	2100-0752	R:VAR WW 50K OHM 3% LIN 1.5W 10-TURN	
R11	0687-1041	R:FXD COMP 100K OHM 10% 1/2W	
R12 THRU R15		NOT ASSIGNED	
R16	0693-1531	R:FXD COMP 15K OHM 10% 2W	
R17	0687-3311	R:FXD COMP 330 OHM 10% 1/2W	
R18	0687-3311	R:FXD COMP 330 OHM 10% 1/2W	
R19	0687-3311	R:FXD COMP 330 OHM 10% 1/2W	
R20	0687-3311	R:FXD COMP 330 OHM 10% 1/2W	
R21	0687-3311	R:FXD COMP 330 OHM 10% 1/2W	
R22	0687-3311	R:FXD COMP 330 OHM 10% 1/2W	
R23	0687-3311	R:FXD COMP 330 OHM 10% 1/2W	
R24	0687-3311	R:FXD COMP 330 OHM 10% 1/2W	
R25	0687-3311	R:FXD COMP 330 OHM 10% 1/2W	
R26	0758-0073	R:FXD MET FLM 24K OHM 5% 1/2W (FACTORY SELECTED VALUE)	
R27	0727-0100	R:FXD DEPC 1000 OHM 1% 1/2W (FACTORY SELECTED VALUE)	
R28		DELETED	
R29		DELETED	
R30		NOT ASSIGNED	
R31	2100-0968	R:VAR COMP 10K OHM 30% 20CCWLOG 1/8W	
R31	1410-0112	BUSHING:SLEEVE BRS NP 0.3750DX0.4385/16-32	
R31	5020-0446	NUT:HEX BRS 5/16 X 32 0.438	
R32 THRU R33		NOT ASSIGNED	

See list of abbreviations in introduction to this section

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

Reference Designation	ⓗ Stock No.	Description #	Note
R34	2100-0752	R:VAR WW 50K OHM 3% LIN 1.5W 10-TURN	
R35	2100-0752	R:VAR WW 50K OHM 3% LIN 1.5W 10-TURN	
R36		DELETED	
R37	0758-0029	R:FXD MET FLM 470 OHM 5% 1/2W	
R38	0758-0029	R:FXD MET FLM 470 OHM 5% 1/2W	
R39	0758-0028	R:FXD MET FLM 270 OHM 5% 1/2W	
R40	0758-0020	R:FXD MET FLM 22K OHM 5% 1/2W	
R41	0758-0029	R:FXD MET FLM 470 OHM 5% 1/2W	
R42	2100-0751	R:VAR COMP 3X1K OHM 20% LIN 1W GANGED	
R43	0757-0128	R:FXD MET FLM 200K OHM 1% 1/2W	
R44	2100-0073	R:VAR COMP 125K OHM 20% LIN 1/3W	
R45	0687-1051	R:FXD COMP 1 MEGOHM 10% 1/2W	
R46	0818-0025	R:FXD WW 10K OHM 5% 25W	
R47		DELETED	
R48	0687-4721	R:FXD COMP 4700 OHM 10% 1/2W	
R49		DELETED	
R50		DELETED	
R51	0813-0019	R:FXD WW 0.47 OHM 10% 1/2W	
R52	0813-0019	R:FXD WW 0.47 OHM 10% 1/2W	
R53	0813-0019	R:FXD WW 0.47 OHM 10% 1/2W	
R54	0813-0019	R:FXD WW 0.47 OHM 10% 1/2W	
R55	0813-0019	R:FXD WW 0.47 OHM 10% 1/2W	
R56	0816-0015	R:FXD WW 50 OHM 10% 10W	
R57	0699-0001	R:FXD COMP 2.7 OHM 10% 1/2W	
R58	0684-4731	R:FXD COMP 47K OHM 10% 1/4W	
R59	2100-0953	R:VAR COMP 10K OHM 30% 10CWLOG 1/8W	
R59	1410-0112	BUSHING:SLEEVE BRS NP 0.3750DX0.4385/16-32	
R59	5020-0446	NUT:HEX BRS 5/16 X 32 0.438	
R60	0684-1031	R:FXD COMP 10K OHM 10% 1/4W	
R61	0727-0012	R:FXD DEPC 20 OHM 1% 1/2W	
RT1	0839-0006	THERMISTOR: 10 OHM 10% AT 25C	
S1	00692-624	SWITCH:SWEEP SELECTOR ASSEMBLY INCL: C1,C2,C7,R1,R6,R8,R39,CR1,CR3,CR5,S1	
S2		NSR PART OF R4	
S3	00692-625	SWITCH:SWEEP TIME(SEC) ASSY INCLUDES- C3,C4,C5,C6,R2,R3,R4,R5,S3	
S4	3101-0091	SWITCH:4-PUSHBUTTON ASSY:PUSHBUTTON FUNCTION 4 SECTION	
S5	3101-0052	SWITCH:PUSHBUTTON SPST NORMALLY OPEN (MANUAL TRIGGER)	
S6	3101-0042	SWITCH:PUSHBUTTON SPST MARK 1	
S7	3101-0042	SWITCH:PUSHBUTTON SPST MARK 2	
S8	3101-0042	SWITCH:PUSHBUTTON SPST INT. SQ. WAVE	
S9	3101-0042	SWITCH:PUSHBUTTON SPST EXT AM	
S10	3101-0032	SWITCH:SLIDE 4 PDT 0.5 AMP 125 VDC ALC PWR LEVELING INPUTS	
S11	3101-0078	SWITCH:PUSHBUTTON 3PDT ALC	

See list of abbreviations in introduction to this section

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

Reference Designation	ⓗ Stock No.	Description #	Note
S12	3101-0041	SWITCH:TOG DPDT 3 POS 15 AMP 125VAC LINE	
S13	3101-0034	SWITCH:SLIDE 4 PDT 0.5 AMP 125 VDC LINE VOLTAGE	
S14		DELETED	
S15	3101-0011	SWITCH:SLIDE DPDT 0.5 AMP 125 VDC BLANKING	
T1	9100-0243	TRANSFORMER:POWER (LOW VOLTAGE)	
T2	9100-0242	TRANSFORMER:POWER (HIGH VOLTAGE)	
TB1	00692-275	SHIELD:SAFETY	
TB1	0360-0361	TERMINAL BOARD:7-TERMINAL	
V1	1923-0048	ELECTRON TUBE: 8068 BEAM PENTODE	
V1	1401-0006	CLIP:TUBE	
V1	1401-0007	CLIP:ELECTRON TUBE CER INS 1/4ID	
V1	1400-0019	CLAMP:TUBE	
V1	1600-0030	SHIELD:ELECTRON TUBE FINGER LINER 5 X 2	
V1	00692-016	SHIELD TUBE MU-METAL	
V2	1923-0048	ELECTRON TUBE: 8068 BEAM PENTODE	
V2	1400-0019	CLAMP:TUBE	
V2	1401-0007	CLIP:ELECTRON TUBE CER INS 1/4ID	
V2	1600-0030	SHIELD:ELECTRON TUBE FINGER LINER 5 X 2	
V2	1401-0006	CLIP:TUBE	
V2	00692-016	SHIELD:TUBE MU-METAL	
V3			
V4	1951-0017	ELECTRON TUBE:BWO 2.0-4.0 GC (STEWART) MODEL 692A ONLY	
V4	1951-0020	ELECTRON TUBE:BWO 1-2 GC (STEWART) MODEL 691A ONLY	
V4	1951-0021	ELECTRON TUBE:BWO 4-8GC (STEWART) MODEL 693A ONLY	
V4	1951-0023	ELECTRON TUBE:BWO 8-12.4GC (STEWART) MODEL 694A ONLY	
V4	00691-213	BWO MOUNTING PLATE STEWART BWO ONLY	
W1	8120-0078	CABLE:POWER 7.5FT.	
W2	00691-616	ASSY:CABLE BNC (OPTION 01 ONLY)	
XA11	1251-0194	CONNECTOR:PRINTED CIRCUIT 15-CONTACT	
XV1	1200-0005	SOCKET:TUBE	
XV2	1200-0005	SOCKET:TUBE	
XV3	1200-0005	SOCKET:TUBE	

See list of abbreviations in introduction to this section

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

Reference Designation	ⓗⓟ Stock No.	Description #	Note
		MISCELLANEOUS	
	0370-0025	KNOB: BLACK ¾ DIA ¼ DIA SHAFT MARKER 1, MARKER 2,	
	0730-0084	KNOB: BLACK 5/8 IN WITH ARROW MANUAL SWEEP INT SQ WAVE FREQ	
	0370-0099	KNOB: BLACK CONCENTRIC 13/16 DIA ¼ SHAFT SWEEP TIME (SEC)	
	0370-0104	KNOB: BLACK BAR W/ARROW 13/16 DIA SWEEP SELECTOR	
	0370-0118	KNOB: GREY PUSHBUTTON 11/16 DIA ALC-FUNCTION-AMPLITUDE-MOD SELECTORS	
	0370-0134	KNOB: RED, ARROW ½ DIA SWEEP TIME (SEC) VERNIER	
	0370-0138	KNOB: BLACK W/WHITE ARROW 5/8 DIA POWER LEVEL	
	0370-0149	KNOB: BLACK CRANK ASSY START/CW, STOP/ΔF CRANK ASSY INCLUDES: HANDLE, CRANK, BLACK BUSHING, CRANK HANDLE SCREW, CRANK HANDLE	
	00691-681	MARKER ASSY: LEFT (MODEL 691A ONLY)	
	00691-682	MARKER ASSY: RIGHT (MODEL 691A ONLY)	
	00692-244	WINDOW: SCALE, LUCITE FOR MAIN DIAL	
	00692-282	NUT: KNURLED (OPTION 01 ONLY) MOUNTS RF OUTPUT CONN.	
	00692-681	MARKER ASSY: LEFT (MODEL 692A ONLY)	
	00692-682	MARKER ASSY: RIGHT (MODEL 692A ONLY)	
	00693-621	MARKER ASSY: LEFT (MODEL 693A ONLY)	
	00693-622	MARKER ASSY: RIGHT (MODEL 693A ONLY)	
	00694-621	MARKER ASSY: LEFT (MODEL 694A ONLY)	
	00694-622	MARKER ASSY: RIGHT (MODEL 694A ONLY)	
	3150-0002	OIL: AIR FILTER, WATER SOLUBLE OIL	
	5000-0235	LABEL: PUSHBUTTON (START/STOP)	
	5000-0236	LABEL: PUSHBUTTON (EXT FM)	
	5000-0237	LABEL: PUSHBUTTON (ALC)	
	5000-0238	LABEL: PUSHBUTTON (ΔF)	
	5000-0239	LABEL: PUSHBUTTON (EXT AM)	
	5000-0240	LABEL: PUSHBUTTON (MARK 1)	
	5000-0241	LABEL: PUSHBUTTON (MARK 2)	
	5000-0242	LABEL: PUSHBUTTON (INT SQ WAVE)	
	5000-0243	LABEL: PUSHBUTTON (MARKER SWEEP)	
	5000-0286	LABEL: PUSHBUTTON (INT ALC) (OPTION 01 ONLY)	
	5000-0200	WINDOW: COUNTER GREY PLASTIC (MARKER 1 & 2)	
	8500-0059	SILICONE GREASE FOR SEMICONDUCTOR HEAT SINKS, DISSIPATER	

See list of abbreviations in introduction to this section

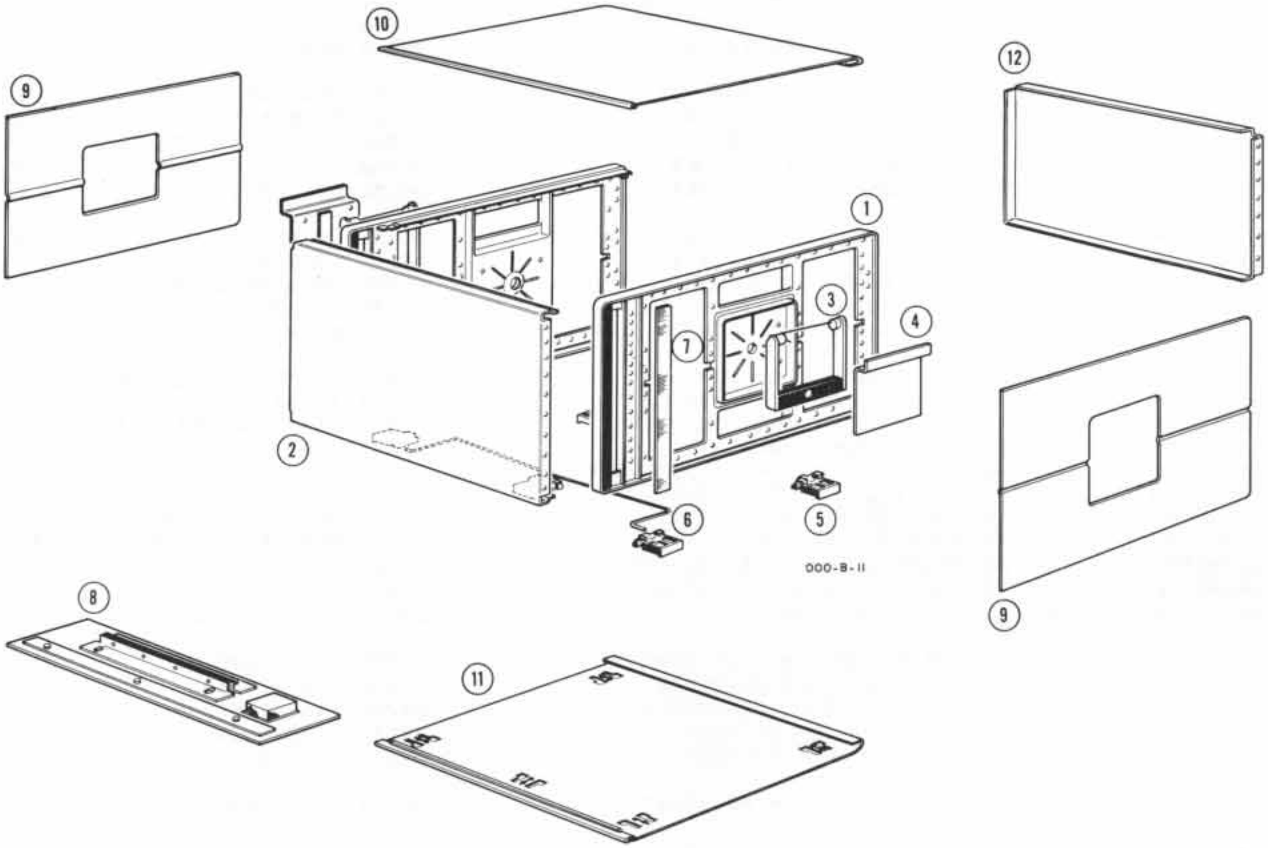
Table 6-1. Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description #	Note
		OPTION 01 PARTS	
		MODEL 691A	
A12	00691-610	ASSY:COUPLER BRACKET, INCLUDES A12J1, A12S1 BRACKET, AND 2-CONDUCTOR CABLE	
A12J1	1250-0083	CONNECTOR:BNC	
A12S1	3101-0011	SWITCH:SLIDE DPDT 0.5 AMP 125VDCW	
A13	786D	DIRECTIONAL DETECTOR	
W2	00691-616	ASSY:CABLE BNC	
	5000-0286	LABEL:PUSHBUTTON(INT ALC)	
	00692-282	NUT:KNURLED, MOUNTS RF OUTPUT CONNECTOR	
		MODEL 692A	
A12	00691-610	ASSY:COUPLER BRACKET INCLUDES A12J1, A12S1 BRACKET, AND 2-CONDUCTOR CABLE	
A12J1	1250-0083	CONNECTOR:BNC	
A12S1	3101-0011	SWITCH:SLIDE DPDT 0.5 AMP 125VDCW	
A13	787D	DIRECTIONAL DETECTOR	
FL1	360D	RF LOW-PASS FILTER	
W2	00691-616	ASSY:CABLE BNC	
	5000-0286	LABEL:PUSHBUTTON(INT ALC)	
	00692-282	NUT:KNURLED, MOUNTS RF OUTPUT CONNECTOR	
		MODEL 693A	
A12	00693-610	ASSY:COUPLER BRACKET INCLUDES A12T1, A12S1 BRACKET, AND 2-CONDUCTOR CABLE	
A12J1	1250-0083	CONNECTOR:BNC	
A12S1	3101-0011	SWITCH:SLIDE DPDT 0.5 AMP 125VDCW	
A13°		DIRECTIONAL COUPLER/DETECTOR FOR MODEL 693A CONSISTS OF DIRECTIONAL COUPLER AND -HP- 423A CRYSTAL DETECTOR	
FL1	00693-604	RF LOW-PASS FILTER	
W2	00691-616	ASSY:CABLE BNC	
	5000-286	LABEL:PUSHBUTTON(INT ALC)	
	00692-282	NUT:KNURLED, MOUNTS RF OUTPUT CONNECTOR	
		MODEL 694A	
A12	00691-610	ASSY:COUPLER BRACKET, INCLUDES A12J1, A12S1 BRACKET, AND 2-CONDUCTOR CABLE	
A12J1	1250-0083	CONNECTOR:BNC	
A12S1	3101-0011	SWITCH:SLIDE DPDT 0.% AMP 125VDCW	
A13°		DIRECTIONAL COUPLER/DETECTOR FOR MODEL 694A CONSISTS OF DIRECTIONAL COUPLER AND -HP- 423A CRYSTAL DETECTOR	
FL1	00694-604	RF LOW-PASS FILTER	
W2	00691-616	ASSY:CABLE BNC	
	5000-0286	LABEL:PUSHBUTTON(INT ALC)	
	00692-282	NUT:KNURLED, MOUNTS RF OUTPUT CONNECTOR	

See list of abbreviations in introduction to this section

Reference Designation Index

CABINET PARTS



Reference Designation	Stock No.	Description #	Note
1	5060-0736	FRAME ASSEMBLY	
2	00692-026	PANEL:FRONT	
ATTACHING HDW	2530-0012	#8-32 X 1/2",FLAT HEAD,SLOT DR W/INTEGRAL EXT TOOTH LOCKWASHER	
3	5060-0763	HANDLE ASSEMBLY:SIDE	
4	5060-0765	RETAINER:HANDLE	
ATTACHING HDW	2550-0013	#8-32 X 5/16" BINDING HEAD,PHILLIPS DRIVE	
5	5060-0767	FOOT ASSEMBLY	
6	1490-0030	STAND:TILT	
7	5000-0053	TRIM:STRIP	
8	5060-0777	KIT:RACK MOUNTING	
9	5000-0747	COVER:SIDE,PERFORATED	
ATTACHING HDW	2370-0020	#6-32 X 3/16",100° FLAT HEAD,PHILLIPS DRIVE	
10	00692-654	COVER ASSEMBLY:TOP UNPERFORATED	
ATTACHING HDW	2370-0013	#6-32 X 3/8",100° FLAT HEAD,PHILLIPS DRIVE	
	0590-0053	#6-32" NUT CAPTIVE,"J" TYPE FOR .125" MATERIAL	
11	5060-0752	COVER ASSEMBLY:BOTTOM UNPERFORATED	
ATTACHING HDW	2370-0013	#6-32 X 3/8",100° FLAT HEAD PHILLIPS DRIVE	
	0590-0053	#6-32" NUT CAPTIVE,"J" TYPE FOR .125" MATERIAL	
12	00692-019	PANEL:REAR	
ATTACHING HDW	2515-0019	#8-32 X 1/4" PHILLIPS,PANHEAD ,W/INT LOCKWASHER	

See list of abbreviations in introduction to this section

Table 6-2. Replaceable Parts

ⓗⓟ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ
0130-0017	C:VAR CER 8-50 PF N750	28480	0130 0017	3
0140-0145	C:FXD MICA 22 PF 5% 500 VDCW	04062	DM15C220J	2
0140-0149	C:FXD MICA 470 PF 5% 300 VDCW	04062	DM15F471J	4
0140-0152	C:FXD MICA 1000 PF 5% 300 VDCW	04062	DM16F102J	2
0140-0176	C:FXD MICA 100 PF 2% 300 VDCW	04062	DM15F101G 300V	2
0140-0178	C:FXD MICA 560 PF 2% 300 VDCW	04062	DM15F561G 300V	1
0140-0192	C:FXD MICA 68PF 5% 300VDCW	04062	DM15E680J	1
0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	04062	DM15F131J 300V	1
0140-0198	C:FXD MICA 200PF 5% 300VDCW	04062	DM15F201J 300V	2
0140-0200	C:FXD MICA 390PF 5% 300VDCW	04062	DM15F391J 300V	1
0140-0204	C:FXD MICA 47PF 5% NPO 500VDCW	04062	DM15E470J	3
0140-0206	C:FXD MICA 270PF 5% 500VDCW	04062	DM15F271J 500V	1
0140-0216	C:FXD MICA 120PF 2% 300VDCW	04062	DM15F121G 300V	1
0150-0012	C:FXD CER 0.01UF 20% 1000VDCW	56289	H 1038	10
0150-0014	C:FXD CER 5000PF MIN 500VDCW	04222	D1 4	1
0150-0023	C:FXD CER 2000PF 20% 1000VDCW	91418	TYPE JF .002 20%	2
0150-0052	C:FXD CER 0.05 UF 20% 400VDCW	56289	33C17A	5
0150-0079	C:FXD CER 3300 PF 10% 500 VDCW	72982	#811 000 Y5F0332K	1
0150-0096	C:FXD CER 0.05UF 100VDCW	91418	-TA	2
0160-0083	C:FXD PAPER 3UF 20% -10% 2000VDCW	00853	71	2
0160-0128	C:FXD CER 2.2 UF 20% 25VDCW	56289	5C15	1
0160-0182	C:FXD MICA 47 PF 5% 300VDCW	14655	CD15E 470J 300V	1
0160-0192	C:FXD MICA 525 PF 5% 300VDCW	04062	RDM19E(525)J3C	1
0160-0381	C:FXD MYLAR 0.01UF 10% 400VDCW	01281	663UW	1
0160-0382	C:FXD MYLAR 0.001UF 10% 400VDCW	01281	663UW	1
0160-0383	C:FXD MICA 10PF 10%	04062	RDM20C100K25S	1
0160-0384	C:FXD CER 5600PF +80-20% 3KVDCW	71590	DA172-098CB	1
0160-0779	C:FXD MY 0.02UF 10% 3000VDCW	71436	PMS 203-3M	1
0160-0798	C:FXD POLY 0.047UF 10% 30VDCW	56289	114F4739R3S4	1
0170-0019	C:FXD MY 0.1 UF 5% 200VDCW	28480	0170-0019	1
0170-0022	C:FXD MY 0.1UF 20% 600VDCW	09134	TYPE 27	3
0170-0060	C:FXD MY 0.047UF 10% 400VDCW	84411	TYPE 663 UW	1
0170-0073	C:FXD MY 1UF 10% 600VDCW	09134	1041	1
0170-0078	C:FXD MY 0.47UF 5% 150VDCW	83125	107V474J	1
0180-0016	C:FXD ELECT 3X10UF -10/+50% 450VDCW	37942	TYPE FP 103090	2
0180-0025	C:FXD ELECT 4 SECT 20UF 450VDCW	56289	D32452	2
0180-0039	C:FXD ELECT 100UF 12VDCW	56289	30D154A1	1
0180-0049	C:FXD ELECT 20UF 50VDCW	56289	30D198A1	1
0180-0050	C:FXD ELECT 40UF -15%+100% 50VDCW	56289	D32538	1
0180-0059	C:FXD ELECT 10UF -10%+100% 25VDCW	28480	0180-0059	4
0180-0061	C:FXD ELECT 100UF +100%-10% 15VDCW	56289	30D172A1	1
0180-0063	C:FXD ELECT 500UF -10%+100% 3VDCW	56289	30D120A1	1
0180-0105	C:FXD ELECT SEMI-POLARIZED 50UF 25VDCW	56289	S97441	2
0180-0116	C:FXD ELECT TA 6.8UF 10% 35VDCW	56289	150D685X9035B2	2
0180-0125	C:FXD ELECT 4 SECT 20 UF +30-10% 450VDCW	28480	0180-0125	1
0180-0128	C:FXD ELECT 2800 UF +30-10% 30VDCW	00853	505 1010 02	2
0180-0136	C:FXD ELECT 10 UF +100-10% 50VDCW	56289	40D193A2	1
0340-0086	INSULATOR:BINDING POST(EXTERIOR INSULATOR)	28480	0340-0086	2
0340-0090	INTERIOR INSULATOR:BINDING POST BLACK	28480	0340-0090	2
0360-0361	TERMINAL BOARD:7-TERMINAL	75173	353-16-07-001	1
0370-0025	KNOB:BLACK 3/4 DIA 1/4 DIA SHAFT	28480	0370-0025	1
0370-0084	KNOB:BLACK 5/8 IN WITH ARROW	28480	0370-0084	1

See list of abbreviations in introduction to this section

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

ⓗⓟ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ
0370-0099	KNOB:BLACK CONCENTRIC 13/16 DIA 1/4SHAFT	28480	0370-0099	1
0370-0104	KNOB:BLACK BAR W/ARROW 13/16 DIA	28480	0370-0104	1
0370-0118	KNOB:GRAY PUSHBUTTON 11/16 DIA	28480	0370-0118	1
0370-0134	KNOB:RED ARROW 1/2 DIA	28480	0370-0134	1
0370-0138	KNOB:BLACK W/WHITE ARROW 5/8 DIA	28480	0370-0138	1
0370-0149	KNOB:BLACK CRANK ASSY	28480	0370-0149	1
0490-0026	RELAY:DPDT 115 VAC	77342	KA11AY	1
0490-0114	RELAY:ARMATURE SPDT/COIL 125MW SENSITIVITY	77342	KA 2577-1	1
0490-0115	RELAY:ARMATURE 3PDT/COIL 6VDC	77342	KA14DY	1
0490-0123	RELAY:ARMATURE SPDT 2-AMP/COIL 6VDC	77342	RS5D	1
0490-0124	RELAY:3PDT 6V 5.1 OHM COIL	77342	KA 14AY	1
0684-1001	R:FXD COMP 10 OHM 10% 1/4W	01121	CB 1001	5
0684-1031	R:FXD COMP 10K OHM 10% 1/4W	01121	CB-1031	1
0684-2201	R:FXD COMP 22 OHM 10% 1/4W	01121	CB 2201	3
0684-2701	R:FXD COMP 27 OHM 10% 1/4W	01121	CB 2701	1
0684-3921	R:FXD COMP 3900 OHM 10% 1/4W	01121	CB 3921	1
0684-4731	R:FXD COMP 47K OHM 10% 1/4W	01121	CB 4731	1
0686-1665	R:FXD COMP 16 MEGOHM 5% 1/2W	01121	EB 1665	1
0686-2455	R:FXD COMP 2.4 MEGOHM 5% 1/2W	01121	EB 2455	1
0687-1001	R:FXD COMP 10 OHM 10% 1/2W	01121	EB1001	2
0687-1011	R:FXD COMP 100 OHM 10% 1/2W	01121	EB 1011	4
0687-1031	R:FXD COMP 10K OHM 10% 1/2W	01121	EB 1031	1
0687-1041	R:FXD COMP 100K OHM 10% 1/2W	01121	EB 1041	3
0687-1051	R:FXD COMP 1MEG OHM 10% 1/2W	01121	EB 1051	3
0687-1231	R:FXD COMP 12K OHM 10% 1/2W	01121	EB 1231	1
0687-1261	R:FXD COMP 12 MEGOHM 10% 1/2W	01121	EB 1261	2
0687-1521	R:FXD COMP 1500 OHM 10% 1/2W	01121	EB 1521	1
0687-1541	R:FXD COMP 150K OHM 10% 1/2W	01121	EB 1541	1
0687-1551	R:FXD COMP 1.5 MEGOHM 10% 1/2W	01121	EB 1551	1
0687-1561	R:FXD COMP 15 MEGOHM 10% 1/2W	01121	EB 1561	1
0687-1831	R:FXD COMP 18K OHM 10% 1/2W	01121	EB 1831	3
0687-1851	R:FXD COMP 1.8 MEGOHM 10% 1/2W	01121	EB 1851	2
0687-2241	R:FXD COMP 220K OHM 10% 1/2W	01121	EB 2241	4
0687-3311	R:FXD COMP 330 OHM 10% 1/2W	01121	EB 3311	7
0687-3321	R:FXD COMP 3300 OHM 10% 1/2W	01121	EB 3321	1
0687-3331	R:FXD COMP 33K OHM 10% 1/2W	01121	EB 3331	3
0687-3341	R:FXD COMP 330K OHM 10% 1/2W	01121	EB 3341	6
0687-3351	R:FXD COMP 3.3 MEGOHM 10% 1/2W	01121	EB 3351	1
0687-3941	R:FXD COMP 390K OHM 10% 1/2W	01121	EB 3941	4
0687-4711	R:FXD COMP 470 OHM 10% 1/2W	01121	EB-4711	1
0687-4721	R:FXD COMP 4700 OHM 10% 1/2W	01121	EB 4721	2
0687-4731	R:FXD COMP 47K OHM 10% 1/2W	01121	EB 4731	4
0687-4741	R:FXD COMP 470K OHM 10% 1/2W	01121	EB 4741	5
0687-5631	R:FXD COMP 56K OHM 10% 1/2W	01121	EB 5631	3
0687-6831	R:FXD COMP 68K OHM 10% 1/2W	01121	EB-6831	2
0687-6841	R:FXD COMP 680K OHM 10% 1/2W	01121	EB 6841	1
0693-1531	R:FXD COMP 15K OHM 10% 2W	01121	HB 1531	1
0693-4701	R:FXD COMP 47 OHM 10% 2W	01121	HB 4701	1
0698-3304	R:FXD MET FLM 130K OHM 1% 1/2W	28480	0698-3304	6
0699-0001	R:FXD COMP 2.7 OHM 10% 1/2W	01121	EB 27G1	1
00691-213	BWO MOUNTING PLATE	28480	00691-213	1
00691-606	ASSY:SHAPING(MODEL 691A ONLY)	28480	00691-606	1
00691-610	ASSY:COUPLER BRACKET, INCLUDES A12J1, A12S1	28480	00691-610	2
00691-616	CABLE ASSY. BNC (OPTION 01 ONLY)	28480	00691-616	1

See list of abbreviations in introduction to this section

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

ⓗ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ
00691-681	MARKER ASSY:LEFT(MODEL 691A ONLY)	28480	00691-681	1
00691-682	MARKER ASSY:RIGHT(MODEL 691A ONLY)	28480	00691-682	1
00692-016	SHIELD TUBE MU-METAL	28480	00692-016	2
00692-211	CONNECTOR:N TYPE (RF OUTPUT)	28480	00692-211	1
00692-244	WINDOW:SCALE, LUCITE FOR MAIN DIAL	28480	00692-244	1
00692-275	SHIELD:SAFETY	28480	00692-275	1
00692-282	NUT:KNURLED(01 MODELS ONLY)	28480	00692-282	1
00692-601	ASSY:FILAMENT POWER SUPPLY	28480	00692-601	1
00692-602	ASSY: POWER SUPPLY	28480	00692-602	1
00692-603	ASSY:HIGH VOLTAGE	28480	00692-603	1
00692-604	ASSY: SWEEP GENERATOR	28480	00692-604	1
00692-605	ASSY:ALC AMPLIFIER	28480	00692-605	1
00692-606	ASSY:SHAPING(MODEL 692A ONLY)	28480	00692-606	
00692-608	ASSY: TIME METER	28480	00692-608	1
00692-617	ASSY: SUMMING	28480	00692-617	1
00692-618	ASSY: MODE INDICATOR BOARD	28480	00692-618	1
00692-624	SWITCH:SWEEP SELECTOR ASSEMBLY	28480	00692-624	1
00692-625	SWITCH:SWEEP TIME(SEC) ASSY	28480	00692-625	1
00692-661	ASSY)MODULATOR BOARD	28480	00692-661	1
00692-681	MARKER ASSY:LEFT(MODEL 692A ONLY)	28480	00692-681	1
00692-682	MARKER ASSY:RIGHT(MODEL 692A ONLY)	28480	00692-682	1
00693-604	RF LOW PASS FILTER(MODEL 693A ONLY)	28480	00693-604	1
00693-610	ASSY:COUPLER BRACKET INCLUDES A12J1,A12S1	28480	00693-610	2
00693-621	MARKER ASSY:LEFT(MODEL 693A ONLY)	28480	00693-621	1
00693-622	MARKER ASSY:RIGHT(MODEL 693A ONLY)	28480	00693-622	1
00694-604	RF LOW PASS FILTER(MODEL 694A ONLY)	28480	00694-604	1
00694-621	MARKER ASSY:LEFT(MODEL 693A ONLY)	28480	00694-621	2
00694-622	MARKER ASSY:RIGHT(MODEL 694A ONLY)	28480	00694-622	1
0727-0012	R:FXD DEPC 20 OHM 1% 1/2W	28480	0727-0012	1
0727-0100	R:FXD DEPC 1000 OHM 1% 1/2W	28480	0727-0100	1
0727-0115	R:FXD DEPC 2000 OHM 1% 1/2W	28480	0727-0115	1
0727-0169	R:FXD DEPC 15.5K OHM 1% 1/2W	28480	0727-0169	1
0727-0173	R:FXD DEPC 20K OHM 1% 1/2W	28480	0727-0173	1
0727-0186	R:FXD DEPC 33.2K OHM 1% 1/2W	28480	0727-0186	1
0727-0208	R:FXD DEPC 100K OHM 1% 1/2W	28480	0727-0208	1
0727-0222	R:FXD DEPC 214K OHM 1% 1/2W	28480	0727-0222	1
0727-0226	R:FXD DEPC 250K OHM 1% 1/2W	28480	0727-0226	3
0727-0230	R:FXD DEPC 284K OHM 1% 1/2W	28480	0727-0230	1
0727-0232	R:FXD DEPC 312K OHM 1% 1/2W	28480	0727-0232	1
0727-0237	R:FXD DEPC 376K OHM 1% 1/2W	28480	0727-0237	1
0727-0240	R:FXD DEPC 405K OHM 1% 1/2W	28480	0727-0240	1
0727-0245	R:FXD DEPC 500K OHM 1% 1/2W	28480	0727-0245	3
0727-0246	R:FXD DEPC 600K OHM 1% 1/2W	28480	0727-0246	4
0727-0254	R:FXD DEPC 750K OHM 1% 1/2W	28480	0727-0254	3
0727-0259	R:FXD DEPC 900K OHM 1% 1/2W	28480	0727-0259	1
0727-0276	R:FXD DEPC 1 MEGOHM 1% 1/2W	28480	0727-0276	3

See list of abbreviations in introduction to this section

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

℗ Stock No.	Description #	Mfr.		691A TQ	692A TQ	693A TQ	694A TQ
0727-0287	R:FXD DEPC 2 MEGOHM 1% 1/2W	28480	0727-0287	2			
0727-0291	R:FXD DEPC 2.84 MEGOHM 1% 1/2W	28480	0727-0291	1			
0727-0292	R:FXD DEPC 3 MEGOHM 1% 1/2W	28480	0727-0292	3			
0727-0298	R:FXD DEPC 4 MEGOHM 1% 1/2W	28480	0727-0298	2			
0727-0299	R:FXD DEPC 4.9 MEGOHM 1% 1/2W	28480	0727-0299	2			
0727-0332	R:FXD DEPC 150K OHM 1% 1/2W	28480	0727-0332	1			
0730-0038	R:FXD DEPC 19.4K OHM 1%	28480	0730-0038	1			
0730-0144	R:FXD DEPC 10.52 MEGOHM 1% 1W	28480	0730-0144	1			
0757-0017	R:FXD MET FLM 1 MEGOHM 1/2% 1/2W	65092	9851 VAMISTOR	2			
0757-0076	R:FXD MET FLM 560 OHM 2% 1/2W	07115	C 20				
0757-0079	R:FXD MET FLM 2700 OHM 2% 1/2W	07115	C 20	2			
0757-0089	R:FXD MET FLM 1K OHM 2% 1/2W	07115	C 20	8			
0757-0128	R:FXD MET FLM 200K OHM 1% 1/2W	28480	0757-0128	1			
0757-0130	R:FXD MET FLM 162K OHM 1% 1/2W	75042	CEC T-0	1			
0757-0135	R:FXD MET FLM 511K OHM 1% 1/2W	28480	0757-0135	2	0	0	2
0757-0137	R:FXD MET FLM 750K OHM 1% 1/2W	28480	0757-0137				2
0757-0191	R:FXD MET FLM 80.6K OHM 1% 1/2W	75042	CEC T-0	2	1		2
0757-0308	R:FXD MET FLM 1.50 MEGOHM 1% 1/2W	28480	0757-0308	4			
0757-0310	R:FXD MET FLM 133K OHM 1% 1/2W	28480	0757-0310	2	3		2
0757-0311	R:FXD MET FLM 182K OHM 1% 1/2W	28480	0757-0311	0	2	4	2
0757-0312	R:FXD MET FLM 309K OHM 1% 1/2W	28480	0757-0312	2	1		2
0757-0321	R:FXD MET FLM 202K OHM 1% 1/4W	28480	0757-0321	2			
0757-0353	R:FXD MET FLM 249K OHM 1% 1/2W	28480	0757-0353	3	3	0	2
0757-0367	R:FXD MET FLM 100K OHM 1% 1/2W	28480	0757-0367				
0758-0003	R:FXD MET FLM 1000 OHM 5% 1/2W	07115	C 20	4			
0758-0004	R:FXD MET FLM 2700 OHM 5% 1/2W	07115	C 20	2			
0758-0005	R:FXD MET OX 4700 OHM 5% 1/2W	28480	0758-0005	5			
0758-0006	R:FXD MET FLM 10K OHM 5% 1/2W	07115	C 20	14			
0758-0009	R:FXD MET FLM 6800 OHM 5% 1/2W	07115	C 20	1			
0758-0010	R:FXD MET OX FLM 3300 OHM 5% 1/2W	28480	0758-0010	1			
0758-0012	R:FXD MET FLM 12K OHM 5% 1/2W	07115	C 20	3			
0758-0017	R:FXD MET FLM 1500 OHM 5% 1/2W	07115	C 20	2			
0758-0018	R:FXD MET FLM 15K OHM 5% 1/2W	07115	C 20	3			
0758-0020	R:FXD MET FLM 22K OHM 5% 1/2W	07115	C 20/22K-5%	2			
0758-0021	R:FXD MET FLM 51K OHM 5% 1/2W	07115	C 20/51K-5%	6			
0758-0022	R:FXD MET FLM 82K OHM 5% 1/2W	07115	C 20	2			
0758-0024	R:FXD MET FLM 100 OHM 5% 1/2W	07115	C 20	4			
0758-0025	R:FXD MET FLM 160 OHM 5% 1/2W	07115	C 20	1			
0758-0028	R:FXD MET FLM 270 OHM 5% 1/2W	07115	C 20	1			
0758-0029	R:FXD MET FLM 470 OHM 5% 1/2W	07115	C 20	7			
0758-0032	R:FXD MET OX 820 OHM 5%	28480	0758-0032	1			
0758-0034	R:FXD MET FLM 2400 OHM 5% 1/2W	07115	C 20	1			
0758-0035	R:FXD MET FLM 3000 OHM 5% 1/2W	07115	C 20	2			
0758-0036	R:FXD MET FLM 3600 OHM 5% 1/2W	07115	C 20	1			
0758-0037	R:FXD MET FLM 5100 OHM 5% 1/2W	28480	0758-0037	1			
0758-0038	R:FXD MET FLM 9100 OHM 5% 1/2W	07115	C 20	1			
0758-0039	R:FXD MET FLM 20K OHM 5% 1/2W	07115	C 20	5			
0758-0040	R:FXD MET FLM 47K OHM 5% 1/2W	07115	C 20	1			
0758-0044	R:FXD MET FLM 2200 OHM 5% 1/2W	07115	C 20	2			
0758-0046	R:FXD MET FLM 6200 OHM 5% 1/2W	07115	C 20	1			

See list of abbreviations in introduction to this section

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

ⓗ Stock No.	Description #	Mfr.		TQ	
0758-0047	R:FXD MET FLM 7500 OHM 5% 1/2W	07115	C 20	2	
0758-0048	R:FXD MET FLM 8200 OHM 5% 1/2W	07115	C 20	1	
0758-0049	R:FXD MET FLM 33K OHM 1/2W	07115	C20	1	
0758-0050	R:FXD MET FLM 39K OHM 5% 1/2W	07115	C 20	2	
0758-0053	R:FXD MET FLM 100K OHM 5% 1/2W	07115	C20	12	
0758-0055	R:FXD MET FLM 360 OHM 5% 1/2W	28480	0758-0055	1	
0758-0057	R:FXD MET FLM 5600 OHM 5% 1/2W	07115	C 20	1	
0758-0059	R:FXD MET FLM 11K OHM 5% 1/2W	07115	C 20	1	
0758-0061	R:FXD MET FLM 120K OHM 5% 1/2W	07115	C 20	3	
0758-0071	R:FXD MET FLM 4300 OHM 5% 1/2W	07115	C 20	2	
0758-0073	R:FXD MET FLM 24K OHM 5% 1/2W	07115	C 20	1	
0758-0076	R:FXD MET FLM 68K OHM 5% 1/2W	07115	C 20	2	
0758-0079	R:FXD MET FLM 30K OHM 5% 1/2W	07115	C 20	1	
0758-0087	R:FXD MET OX 470K OHM 5% 1/2W	28480	0758-0087	4	
0758-0098	R:FXD MET OX 220K OHM 5% 1/2W	28480	0758-0098	7	
0758-0100	R:FXD MET OX 330K OHM 5% 1/2W	07115	C 20	3	
0758-0101	R:FXD MET OX 150K OHM 5% 1/2W	28480	0758-0101	1	
0758-0102	R:FXD MET OX 270K OHM 5% 1/2W	28480	0758-0102	2	
0758-0104	R:FXD MET OX 180K OHM 5% 1/2W	28480	0758-0104	1	

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

Stock No.	Description #	Mfr.		TQ
1220-0009	SHIELD-TUBE	71785	12627	1
1220-0010	SHIELD:ELECTRON TUBE	71785	12621	2
1250-0083	CONNECTOR:BNC	28480	1250-0083	1
1250-0123	CONNECTOR:BNC	91737	UG-1-94/U NI RH	8
1251-0148	CONNECTOR:POWER 3 PIN MALE	60427	H-10611G-3L	1
1251-0194	CONNECTOR:PRINTED CIRCUIT 15-CONTACT	95354	SD-615TS	1
1400-0019	CLAMP:TUBE	91506	120F5-63A	2
1400-0084	FUSEHOLDER:EXTRACTOR POST TYPE	75915	342014	1
1401-0006	CLIP:TUBE	91418	SPP-3	2
1401-0007	CLIP:ELECTRON TUBE CER INS 1/4ID	76487	36004	2
1410-0112	BUSHING:SLEEVE BRS NP 0.3750DX0.4385/16-32	28480	1410-0112	2
1510-0008	BINDING POST:RED	28480	1510-0008	1
1510-0009	BINDING POST:BLACK	28480	1510-0009	1
1600-0030	SHIELD:ELECTRON TUBE FINGER LINER 5 X 2	98978	T12-1220-5H	2
1850-0050	TRANSISTOR:GERMANIUM 2N457A PNP	01295	2N457A	5
1850-0062	TRANSISTOR:GERMANIUM SPL2N404 PNP	28480	1850-0062	11
1850-0064	TRANSISTOR:GERMANIUM 2N1183 PNP	02735	2N1183	2
1850-0096	TRANSISTOR:GERMANIUM 2N2189 PNP	01295	2N2189	2
1853-0001	TRANSISTOR:PNP SILICON 30V 900MW	28480	1853-0001	1
1854-0003	TRANSISTOR:NPN SILICON	28480	1854-0003	8
1854-0005	TRANSISTOR:2N708 NPN SILICON	07263	2N708	1
1854-0014	TRANSISTOR:DUAL NPN SILICON	28480	1854-0014	1
1854-0015	TRANSISTOR:NPN SILICON	28480	1854-0015	6
1854-0033	TRANSISTOR:NPN SI 2N3391	03508	2N3392	2
1855-0001	TRANSISTOR:SIL UNIJUNCTION 2N1671A	03508	2N1671A	1
1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	28480	1901-0025	34
1901-0026	DIODE,SILICON:0.5A 200PIV	28480	1901-0026	4
1901-0028	DIODE,SILICON:0.5A 400PIV	28480	1901-0028	1
1901-0030	DIODE,SILICON:800 PIV	28480	1901-0030	9
1901-0032	RECTIFIER:SILICON 15 AMP 1N3209	04713	1N3209	4
1901-0033	DIODE,SILICON:1N485B	28480	1901-0033	38
1901-0040	SEMICON DEVICE:DIODE SILICON	28480	1901-0040	1
1901-0084	RECTIFIER:SILICON 50MA 4000PIV	12060	DI-1163	1
1902-0031	DIODE,BREAKDOWN:12.7V 5%	28480	1902-0031	1
1902-0038	DIODE,BREAKDOWN: 45.3V 5%	28480	1902-0038	2
1902-0065	DIODE,BREAKDOWN:46.4V 10%	28480	1902-0065	1
1902-0215	DIODE,BREAKDOWN:6.49V 5% 1.5W	28480	1902-0215	1
1903-0002	DIODE,4 LAYER: SILICON 20V	28480	1903-0002	1
1910-0014	SEMICON DEVICE:DIODE GERMANIUM 1N277	03877	1N277	2
1923-0006	ELECTRON TUBE: 6216 PENTODE	93332	6216	1
1923-0043	ELECTRON TUBE: 6EW6 PENTODE	33173	6EW6	1
1923-0045	ELECTRON TUBE: 7239 PENTODE	33173	7239	1
1923-0046	ELECTRON TUBE: 6EJ7 (EF 184) PENTODE	73445	6EJ7(EF184)	2
1923-0048	ELECTRON TUBE: 8068 BEAM PENTODE	33173	8068	2
1924-0001	ELECTRON TUBE:5915 PENTAGRID	86684	5915	1
1932-0009	ELECTRON TUBE: 5965 DUAL TRIODE	33173	5965	1
1932-0027	ELECTRON TUBE:12AT7	80131	12AT7	1
1932-0030	ELECTRON TUBE: 12AX7 TWIN TRIODE	0000I	12AX7	2
1932-0049	ELECTRON TUBE:CK 647	94144	CK 647	6
1933-0005	ELECTRON TUBE: 7734 TRIODE PENTODE	07138	7734	2

See list of abbreviations in introduction to this section

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

ⓗ Stock No.	Description #	Mfr.		691A TQ	692A TQ	693A TQ	694A TQ
1940-0004	ELECTRON TUBE: OA2 VOLTAGE REGULATOR	86684	OA2			1	
1940-0012	ELECTRON TUBE:VOLTAGE REFERENCE 8228 81V	73445	8228/ZZ1000			3	
1951-0017	ELECTRON TUBE:BWO 2.0-4.0 GC	28480	1951-0017			1	
1951-0020	ELECTRON TUBE:BWO 1-2 GC	28480	1951-0020			1	
1951-0021	ELECTRON TUBE:BWO 4-8GC	28480	1951-0021			1	
1951-0023	ELECTRON TUBE:BWO 8-12.4GC	28480	1951-0023			1	
2100-0043	R:VAR COMP 500K OHM 10% LIN 2W	28480	2100-0043			1	
2100-0073	R:VAR COMP 125K OHM 20% LIN 1/3W	28480	2100-0073			1	
2100-0090	R:VAR COMP 2000 OHM 30% LIN 1/3W	28480	2100-0090			2	
2100-0091	R:VAR COMP 5000 OHM 30% LIN 1/3W	28480	2100-0091			1	
2100-0094	R:VAR COMP 50K OHM 30% LIN 1/5W	28480	2100-0094			2	
2100-0102	R:VAR COMP 500K OHM 30% LIN 1/5W	28480	2100-0102			2	
2100-0154	R:VAR COMP 1K OHM 30% LIN 0.15W	28480	2100-0154			1	
2100-0751	R:VAR COMP 3X1K OHM 20% LIN 1W GANGED	28480	2100-0751			1	
2100-0752	R:VAR WW 50K OHM 3% LIN 1.5W 10-TURN	28480	2100-0752			4	
2100-0753	R:VAR COMP 500K OHM 20% LIN 1/2W W/DPST SW	28480	2100-0753			1	
2100-0912	R:VAR COMP 5K OHM 20% LIN 1/5W	28480	2100-0912			6	
2100-0913	R:VAR COMP 15K OHM 20% LIN 1/5W	28480	2100-0913			5	
2100-0914	R:VAR COMP 25K OHM 20% LIN 1/5W	28480	2100-0914			4	
2100-0915	R:VAR COMP 100K OHM 20% LIN 1/5W	28480	2100-0915			1	
2100-0916	R:VAR COMP 250K OHM 20% LIN 1/5W	28480	2100-0916	0	2	9	8
2100-0917	R:VAR COMP 500K OHM 20% LIN 1/5W	28480	2100-0917	5	7	9	
2100-0918	R:VAR COMP 1 MEGOHM 20% LIN 1/5W	28480	2100-0918			4	
2100-0953	R:VAR COMP 10K OHM 30% 10CWLOG 1/8W	28480	2100-0953			1	
2100-0968	R:VAR COMP 10K OHM 30% 20CCWLOG 1/8W	28480	2100-0968			1	
2110-0002	FUSE:CARTRIDGE 2 AMP 3 AG	75915	312.002			1	
2110-0055	FUSE:CARTRIDGE 4 AMP 250V	75915	312006			1	
2140-0043	LAMP:INCANDESCENT 6V 0.04 AMP	24455	1730			4	
2140-0047	LAMP:GLOW NEON 1/10W	24455	OBD			4	
3101-0011	SWITCH:SLIDE DPDT 0.5 AMP 125 VDC	42190	4603			2	
3101-0032	SWITCH:SLIDE 4 PDT 0.5 AMP 125 VDC	42190	6613 M SPEC			1	
3101-0034	SWITCH:SLIDE 4 PDT 0.5 AMP 125 VDC	42190	6633			1	
3101-0041	SWITCH:TOG DPDT 3 POS 15 AMP 125VAC	88140	8906K370			1	
3101-0042	SWITCH:PUSHBUTTON SPST	28480	3101-0042			4	
3101-0052	SWITCH:PUSHBUTTON SPST NORMALLY OPEN	82389	961 LESS HDW			1	
3101-0078	SWITCH:PUSHBUTTON 3PDT	28480	3101-0078			1	
3101-0091	SWITCH:4-PUSHBUTTON	28480	3101-0041			1	
3150-0002	OIL:AIR FL:WATER SOLUBLE OIL	82866	SN 411			1	
3160-0026	FAN:BLADE 105-120 V, 50-60 CPS	28480	3160-0026			1	
5000-0200	WINDOW:COUNTER GRAY PLASTIC(MARKER 1&2)	28480	5000-0200			1	
5000-0235	LABEL:PUSHBUTTON(START/STOP)	28480	5000-0235			1	
5000-0236	LABEL:PUSHBUTTON(EXT FM)	28480	5000-0236			1	
5000-0237	LABEL:PUSHBUTTON(ALC)	28480	5000-0237			1	
5000-0238	LABEL:PUSHBUTTON(ΔF)	28480	5000-0238			1	
5000-0239	LABEL:PUSHBUTTON(EXT AM)	28480	5000-0239			1	
5000-0240	LABEL:PUSHBUTTON(MARK 1)	28480	5000-0240			1	
5000-0241	LABEL:PUSHBUTTON(MARK 2)	28480	5000-0241			1	
5000-0242	LABEL:PUSHBUTTON(INT SQ WAVE)	28480	5000-0242			1	
5000-0243	LABEL:PUSHBUTTON(MARKER SWEEP)	28480	5000-0243			1	

See list of abbreviations in introduction to this section

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

Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	
5000-0286	LABEL:PUSHBUTTON(INT ALC)	28480	5000-0286	1	
5020-0446	NUT:HEX BRS 5/16 X 32 0.438	28480	5020-0446	2	
5040-0234	LAMPHOLDER:(FOR 4 LAMPS)	28480	5040-0234	4	
5040-0235	BASE:LAMPHOLDER	28480	5040-0235	4	
5060-0878	FILTER:AIR	28480	5060-0878	1	
8120-0078	CABLE:POWER 7.5FT.	70903	KH4147	1	
8500-0059	SILICONE GREASE	71984	#5 COMPOUND	1	
08731-210	NUT:LOCK FOR J10	28480	08731-210	1	
9100-0242	TRANSFORMER:POWER	28480	9100-0242	1	
9100-0243	TRANSFORMER:POWER	28480	9100-0243	1	
786D	DIRECTIONAL DETECTOR, MODEL 691A ONLY	28480	786D	1	
787D	DIRECTIONAL DETECTOR, MODEL 692A ONLY	28480	786D	1	

See list of abbreviations in introduction to this section

Table 6-3. 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
00000	U.S.A. Common	Any supplier of U.S.
00136	McCoy Electronics	Mount Holly Springs, Pa.
00213	Sage Electronics Corp.	Rochester, N. Y.
00334	Humidail 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.
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.
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	TRW Semiconductors Inc.	Lawndale, 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.
04013	Taurus Corp.	Lambertville, N. J.
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.
04354	Precision Paper Tube Co.	Chicago, Ill.
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 Div.	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04777	Automatic Electric Sales Corp.	Northlake, Ill.
04796	Sequoia Wire & Cable Co.	Redwood City, Calif.
04811	Precision Coil Spring Co.	El Monte, Calif.
04870	P. M. Motor Company	Chicago 44, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Calif.
05593	Illumitronic Engineering Co.	Sunnyvale, Calif.
05616	Cosmo Plastic (c/o Electrical Spec. Co.)	Cleveland, Ohio
05624	Barber Colman Co.	Rockford, Ill.
05728	Tiffen Optical Co.	Roslyn Heights, Long Island, N.Y.
05729	Metropolitan Telecommunications Corp., Metro Cap. Division	Brooklyn, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
05820	Wakefield Engineering Inc.	Wakefield, Mass.
06004	The Bassick Co.	Bridgeport, Conn.
06175	Bausch and Lomb Optical Co.	Rochester, N.Y.
06402	E.T.A. Products Co. of America	Chicago, Ill.
06475	Western Devices, Inc.	Inglewood, Calif.
06540	Amatom Electronic Hardware Co. Inc.	New Rochelle, N. Y.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06751	U. S. Semcor Division of Nuclear Corp. of America	Phoenix, Arizona
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07088	Kelvin Electric Co.	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.
07149	Filmohm Corp.	New York, N. Y.
07233	Cinch-Graphik Co.	City of Industry, Calif.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07322	Minnesota Rubber Co.	Minneapolis, Minn.
07387	The Birtcher Corp.	Los Angeles, Calif.
07700	Technical Wire Products	Springfield, N.J.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07966	Shockley Semi-Conductor Laboratories	Palo Alto, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08289	Blinn, Delbert, Co.	Pomona, 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.
08984	Mel-Rain	Indianapolis, Ind.
09026	Babcock Relays, Inc.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09145	Atohm Electronics	Sun Valley, Calif.
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
09664	The Bristol Co.	Waterbury, Conn.
10214	General Transistor Western Corp.	Los Angeles, Calif.
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11312	Microwave Electronics Corp.	Palo Alto, Calif.
11534	Duncan Electronic, Inc.	Santa Ana, Calif.
11711	General Instrument Corporation Semiconductor Division	Newark, N.J.
11717	Imperial Electronic, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12136	Philadelphia Handle Co.	Camden, N. J.
12697	Clarostat Mfg. Co.	Dover, N.H.
12859	Nippon Electric Co., Ltd.	Tokyo, Japan
12930	Delta Semiconductor Inc.	Newport Beach, Calif.
13103	Thermolloy	Dallas, Texas
13396	Telefunken (G.M.B.H.)	Hannover, Germany
13835	Midland Mfg. Co.	Kansas City, Kansas
14099	Sem-Tech	Newbury Park, Calif.
14193	Calif. Resistor Corp.	Santa Monica, Calif.
14298	American Components, Inc.	Conshohocken, Pa.
14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.
14960	Williams Mfg. Co.	San Jose, Calif.
15203	Webster Electronics Co. Inc.	Brooklyn, N.Y.
15291	Adjustable Bushing Co.	N. Hollywood, Calif.
15772	Twentieth Century Coil Spring Co.	Santa Clara, Calif.
15909	The Daven Co.	Livingston, N.J.
16037	Spruce Pine Mica Co.	Spruce Pine, N. C.
16352	Computer Diode Corp.	Lodi, N. J.
16688	De Jur-Amsco Corporation	Long Island City 1, N.Y.
16758	Delco Radio Div. of G.M. Corp.	Kokomo, Ind.
17109	Thermonetics Inc.	Canoga Park, Calif.
17474	Tranex Company	Mountain View, Calif.
18486	Radio Industries	Des Plaines, Ill.
18583	Curtis Instrument Inc.	Mt. Kisco, N.Y.
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.
21226	Executive, Inc.	New York, N.Y.
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.
26365	Gries Reproducer Corp.	New Rochelle, N.Y.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
36196	Stanwyck Corp.	Hawkesbury, Ontario, Canada
37942	P.R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C.A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
49956	Raytheon Company	Lexington, Mass.
52090	Rowan Controller Co.	Baltimore, Md.
63743	Ward Leonard Electric	Mt. Vernon, N.Y.
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.
59730	Thomas & Betts Co.	Elizabeth 1, N.J.
60741	Tripplett Electrical Inc.	Bluffton, Ohio
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Swissvale, Pa.
62119	Universal Electric Co.	Owosso, Mich.
63743	Ward-Leonard Electric Co.	Mt. Vernon, N.Y.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
66295	Wittek Manufacturing Co.	Chicago 23, Ill.
66346	Wollensak Optical Co.	Rochester, N.Y.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70319	Allmetal Screw Prod. Co., Inc.	Garden City, 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.
71436	Chicago Condenser Corp.	Chicago, Ill.
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.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71616	Commercial Plastics Co.	Chicago, Ill.
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.
72092	Eitel-McCullough, Inc.	San Bruno, Calif.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
71707	Coto Coil Co., Inc.	Providence, R.I.
72354	John E. Fast & Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72699	General Instrument Corp., Semiconductor Div.	Newark, 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.
72964	Robert M. Hadley Co.	Los Angeles, Calif.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73076	H.M. Harper Co.	Chicago, Ill.
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.
73490	Beckman Helipot Corp.	So. Pasadena, Calif.
73506	Bradley Semiconductor Corp.	Hamden, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
73734	Federal Screw Prod. Co.	Chicago, Ill.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73846	Goshen Stamping & Tool Co.	Goshen, Ind.
73899	JFD Electronics Corp.	Brooklyn, N. Y.
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74276	Signalite Inc.	Neptune, N.J.
74455	J.H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
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	Littlefuse 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.	Crystal Lake, Ill.
77068	Bendix Pacific Division of Bendix Corp.	No. Hollywood, Calif.
77075	Pacific Metals Co.	San Francisco, Calif.
77221	Phaostran Instrument and Electronic Co.	South Pasadena, Calif.
77250	Phoell Mfg. Co.	Chicago, Ill.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
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.
77969	Rubbercraft Corp. of Calif.	Torrance, Calif.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78283	Signal Indicator Corp.	New York, N.Y.
78290	Struthers-Dunn Inc.	Pitman, N.J.
78452	Thompson-Bremer & Co.	Chicago, Ill.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78493	Standard Thomson Corp.	Waltham, Mass.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	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.
80120	Schnitzer Alloy Products	Elizabeth, 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.
80223	United Transformer Corp.	New York, N.Y.
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
80509	Avery Adhesive Label Corp.	Monrovia, Calif.
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81073	Grayhill Co.	LaGrange, Ill.
81095	Triad Transformer Corp.	Venice, Calif.
81312	Winchester Electronics Co., Inc.	Norwalk, Conn.

Galley 3 – Hewlett Packard Code List

00015-39
Revised: February, 1965

From: FSC. Handbook Supplements
H4-1 Dated DECEMBER 1964
H4-2 Dated MARCH 1962

Table 6-3. Code List of Manufacturers (Sheet 2 of 2)

Code No.	Manufacturer	Address
81349	Military Specification	....
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.
81541	The Airpax Products Co.	Cambridge, Mass.
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.
83053	Western Washer Mfr. Co.	Los Angeles, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	Pyramid Electric Co.	Darlington, S.C.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Springfield, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83315	Hubbell Corp.	Mundelein, Ill.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83740	Eveready Battery	New York, N.Y.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronis, 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.
85471	A.B. Boyd Co.	San Francisco, Calif.
85474	R.M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86197	Clifton Precision Products	Clifton Heights, Pa.
86579	Precision Rubber Products Corp.	Dayton, Ohio
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
87216	Philco Corporation (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
87664	Van Waters & Rogers Inc.	Seattle, Wash.
87930	Tower Mfg. Corp	Providence, R. I.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
88698	General Mills, Inc.	Buffalo, N.Y.
89231	Graybar Electric Co.	Oakland, Calif.
89462	Waldes Kohinoor, Inc.	Cambridge, Mass.
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.
91345	Miller Dial & Nameplate Co.	El Monte, 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.
91929	*Minneapolis-Honeywell Regulator Co.,* Microswitch Div.	Freeport, Ill.
91961	Nahm-Bros. Spring Co.	Oakland, Calif.
92180	Tru-Connector Corp.	Peabody, Mass.
92196	Universal Metal Prod., Inc.	Bassett Puente, Calif.
92367	Elgeet Optical Co., Inc.	Rochester, N.Y.
92607	Tinsolite Insulated Wire Co.	Tarrytown, N.Y.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93788	Howard J. Smith Inc.	Port Monmouth, N. J.
93929	G. V. Controls	Livingston, N. J.
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94137	General Cable Corp.	Bayonne, N.J.
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.
94222	Southco Div. of S. Chester Corp.	Lester, Pa.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
94330	Wire Cloth Products Inc.	Chicago, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
95023	Philbrick Researchers, Inc.	Boston, 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.
95348	Gordos Corp.	Bloomfield, N.J.
95354	Methode Mfg. Co.	Chicago, Ill.
95712	*Dage Electric Co., Inc.*	*Franklin, Ind.*
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.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
97979	Reon Resistor Corp.	Yonkers, N.Y.
98141	Axel Brothers Inc.	Jamaica, N.Y.
98159	Rubber Teck, Inc.	Gardena, Calif.
98220	Francis L. Mosley	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98405	Carad Corp.	Redwood City, Calif.
98731	General Mills	Minneapolis, Minn.
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.

Code No.	Manufacturer	Address
J0000	Winchester Electronics, Inc.	Santa Monica, Calif.
0000F	Malco Tool and Die	Los Angeles, Calif.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AA	British Radio Electronics Ltd.	Washington, D.C.
000AB	ETA	England
000AC	Indiana General Corp., Elect. Div.	Indiana
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000MM	Rubber Eng. & Development	Hayward, Calif.
000NN	A "N" D Manufacturing Co.	San Jose 27, Calif.
000QQ	Cooltron	Oakland, Calif.
000SS	Control of Elgin Watch Co.	Burbank, Calif.
000WW	California Eastern Lab.	Burlingame, Calif.
000YY	S.K. Smith Co.	Los Angeles 45, Calif.

From: FSC. Handbook Supplements
H4-1 Dated DECEMBER 1964
H4-2 Dated MARCH 1962

00015-39
Revised: February, 1965

APPENDIX I

MANUAL CHANGES

This manual applies directly to Model 691A, 692A, 693A, and 694A Sweep Oscillators having serial numbers prefixed 524-, and 507-. To adapt the manual to serial numbers prefixed 501-, 500-, 435-, 429-, and 424-, make the changes indicated in the table below. For serial number prefixed higher than 524-, see the yellow Manual Changes insert included in this manual.

Serial Number	Make Change(s)
501-00861 through 501-01035	1
500-00764 500-00766 500-00770 through 500-00772 500-00822	1, 2
435-00561 through 435-00860 435-00153 435-00154 435-00375 435-00446 435-00448 435-00459 435-00463 435-00498	1, 2, 3
429-00415 through 429-00560	1, 2, 3, 4
424-00361 through 424-00414	1, 2, 3, 4, 5

CHANGE 1

Page 6-12, Table 6-1:
Delete A4R44, A4R45 and A4R46, hp Stock No. 0698-3304.

Change A4R37, A4R38, and A4R39 to hp Stock No. 0760-0029, R:fxd met flm 261 K ohm 1% 1 w

Page 6-27, Table 6-2:
Delete hp Stock No. 0698-3304

Page 6-30, Table 6-2:
Add hp Stock No. 0760-0029, R:fxd met flm 261K ohm 1% 1w

Substitute page I-3 circuit board component location illustrations for Figure 5-31, page 5-38.

Page 5-31/5-32, Figure 5-20:
In the control grid circuit of A4V1B show 3 series connected 261K-ohm resistors shunted by A4C9 instead of 6 130K-ohm.

NOTE

The 130K-ohm resistors are the preferred replacements for all Sweep Oscillators covered by this manual.

CHANGE 2

Page 5-35, Figure 5-26:
Change R44 to 100K ohms

Page 6-21, Table 6-1:
Change R44 to hp Stock No. 2100-0063, R:var comp 100K ohm 20% lin 1/3W

CHANGE 2 (cont'd)

Page 6-32, Table 6-2:
Delete hp Stock No. 2100-0073
Add hp Stock No. 2100-0063, R: var comp 100K-ohm 20% lin 1/3W; Mfr. 28480; Mfr Part No. 2100-0063; TQ1 (691A column)

CHANGE 3

Page 6-24, Table 6-1:
Delete FL1, hp Stock No. 360D

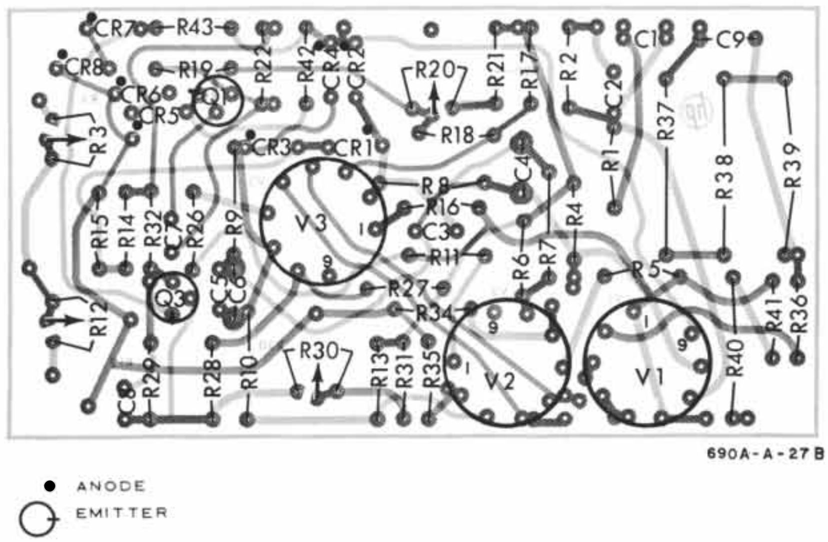
CHANGE 4

Page 6-19, Table 6-1:
Change J10 to hp Stock No. 1250-0144 and delete hp Stock No. 08731-210.

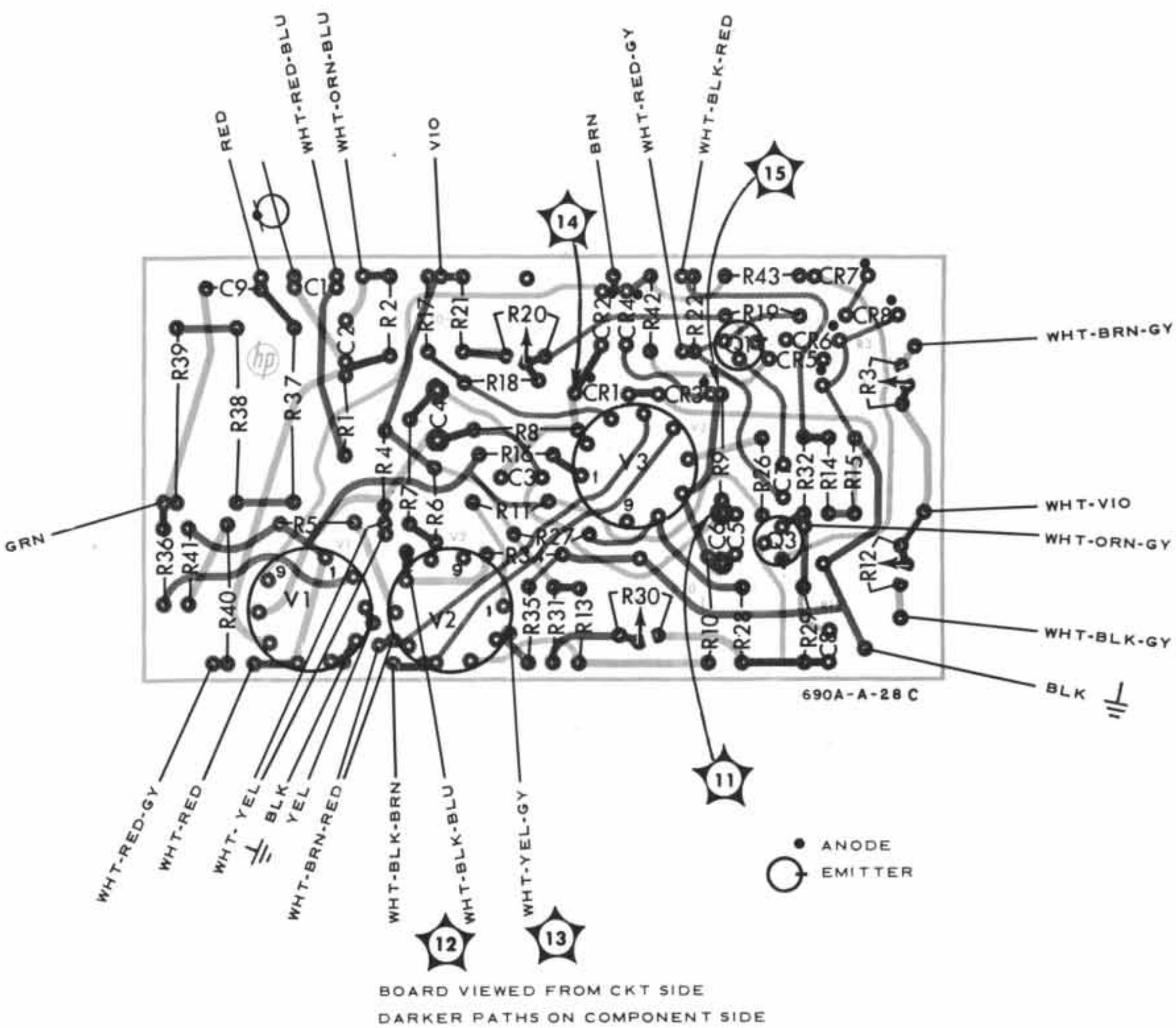
Page 6-31, Table 6-2:
Add hp Stock No. 1250-0144, connector: type N, Mfr. 91737, Mfr. Part No. UG/1094, TQ (691A column) 1.
Page 6-28, Table 6-2:
Delete hp Stock No. 00692-211
Page 6-25, Table 6-1:
Change item 2 to 00692-018, panel, front.
Page 5-35, Figure 5-26:
Delete R61, change R43 to 150K-ohms and R40 to 47K-ohms
Page 6-21, Table 6-1:
Change R40 to hp Stock No. 0758-0040, R:fxd met flm 47K ohm 5% 1/2W
Page 6-29, Table 6-2:
Change TQ to 2 for hp Stock No. 0758-0040.
Change TQ to 1 for hp Stock No. 0758-0020.
Page 6-21, Table 6-1:
Change R43 to hp Stock No. 0761-0040, R:fxd met ox 150K-ohm 5% 1W.
Page 6-30, Table 6-2:
Change TQ to 2 for hp Stock No. 0761-0040.
Page 6-29, Table 6-2:
Delete entire entry for 0757-0128.
Page 6-21, Table 6-1:
Delete entire entry for R61, hp Stock No. 0727-0012
Page 6-28, Table 6-2:
Delete entire entry for hp Stock No. 0727-0012
Page 5-31/5-32, Figure 5-20:
Delete capacitor C15
Page 6-18, Table 6-1:
Delete entire entry for C15, hp Stock No. 0160-0192
Page 6-26, Table 6-2:
Delete entire entry for hp Stock No. 0160-0192

CHANGE 5

Page 5-29, Figure 5-16:
Change A1V2, V3, V5 from type CK647 to type 7728
Change A4V1A from 1/2 12AT7 to 1/2 7728
Page 5-31/5-32, Figure 5-20:
Change A4V1B from 1/2 12AT7 to 1/2 7728
Page 5-34, Figure 5-22:
Change A4V3A and A4V3B from 1/2 CK647 to 1/2 7728.
Page 5-37, Figure 5-30:
Change A5V1A and A5V1B from 1/2CK647 to 1/2 7728
Page 5-41/5-42, Figure 5-36:
Change A2V10A and A2V10B from 1/2CK647 to 1/2 7728
Page 6-4, Table 6-1:
Change A1V2, A1V3, and A1V5 to hp Stock No. 1932-0041, electron tube: 7728
Page 6-6, Table 6-1:
Change A2V10 to hp Stock No. 1932-0041, electron tube: 7728
Page 6-12, Table 6-1:
Change A4V1 to hp Stock No. 1932-0041, electron tube: 7728
Change A4V3 to hp Stock No. 1932-0041, electron tube: 7728
Page 6-15, Table 6-1:
Change A5V1 to hp Stock No. 1932-0041, electron tube: 7728
Page 6-31, Table 6-2:
Add hp Stock No. 1932-0041, electron tube: E1A type 7728, Mfr. 81453, Mfr. Part No. CK7728, TQ 7.
Delete entire entry for 1932-0027, and 1932-0049.



BOARD VIEWED FROM COMPONENT SIDE
DARKER PATHS ON COMPONENT SIDE



BOARD VIEWED FROM CKT SIDE
DARKER PATHS ON COMPONENT SIDE

Etched Circuit A4 Component Location

APPENDIX II

DIRECTIONAL DETECTORS

models
786D
787D
788C

OPERATING NOTE 15 APR 65

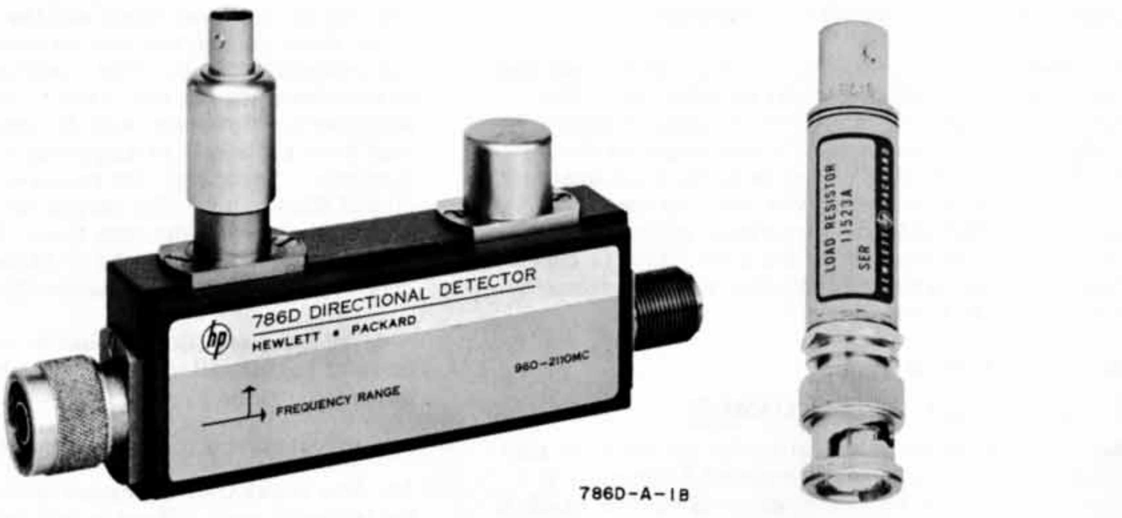


Figure 1. Model 786D and Option 02 Accessory Load Resistor

Table 1. Specifications

Model	Frequency Range (Gc)	Sensitivity[1]		Minimum Directivity	Equivalent Source Reflection Coefficient[6]	Frequency Response[3]	Max Main Line SWR	Max Main Line Input	Insertion Loss[4]
		Low Level	High Level[2]						
786D	0.96 - 2.11	>4 µv/µw CW	35 mw	30 db	≤ 0.06 (1.13 swr)	±0.2 db	1.15	10 w	≈0.25 db
787D	1.9 - 4.1	>4 µv/µw CW	35 mw	26 db	≤ 0.075 (1.16 swr)	±0.2 db	1.15	10 w	≈0.35 db
788C	3.7 - 8.3	>40 µv/µw CW	3.5 mw	20 db	≤ 0.111 (1.25 swr)	±0.3 db	1.20	1 w	≈0.6 db

Noise: Less than 200 µv peak-to-peak with CW power applied to produce 100 mv output

Detector Output Polarity: Negative

Detector Output Connector: BNC female

Detector Output Impedance: 15K max shunted by about 10 pf

Detector Element: Supplied

RF Connectors[5]: precision type N, one male (input), one female

Size: Refer to Figure 2

Net Weight:
786D - 16 oz (450 g)
787D - 12 oz (340 g)
788C - 12 oz (340 g)

Options:
02. Furnished 11523A load resistor for optimum square-law characteristics at 24°C (75°F), <±0.5 db variation from square-law for outputs up to 50 mv peak (working into an external load >75K). Sensitivity when load is used is typically >1 µv/µw CW for 786D and 787D, and >10 µv/µw CW for 788C.
03. Positive polarity detector output.

[1] With respect to power output

[2] Power required to produce at least a 100-mv output

[3] As read on a meter calibrated for square law

[4] Including loss due to coupling

[5] CAUTION: precision type N connectors do not mate with each other. They mate only with standard type N connectors.

[6] The apparent reflection coefficient at the output of an RF generating system, such as the output of a directional detector when it is used in a closed-loop leveling system.

01986-3

1. INTRODUCTION.

2. The Directional Detector, a directional coupler with built-in crystal detector, is designed for use in coaxial systems over a relatively wide frequency range. Applications include closed-loop leveling, observation of RF envelope variation, and power monitoring. Output polarity of detected signal is normally negative, but positive output polarity is available as Option 03. Figure 1 shows Model 786D with Option 02 Load Resistor, available when optimum conformance to square-law characteristics is required. Table 1 lists complete instrument specifications.

3. The directional detector and the optional square-law load (hp 11523A) are separately housed. This arrangement permits choice of directional detector operation for optimum square-law response for detected outputs of up to 50 mv (with the load attached) or maximum output sensitivity (without the load). For proper identification the directional detector carries the same serial number as the load. Always check that the serial number of the load and directional detector are identical.

4. PRECAUTIONS.

5. STATIC ELECTRICAL DAMAGE.

6. The maximum pulse rating for the detector element (diode) used in the directional detector is 0.1 erg of energy. A four-foot length of coaxial RG58/U cable, the equivalent of a 100-pf capacitor, when charged to 14 volts, is the equivalent of 0.1 erg of energy. Be certain that connecting cables are always connected to associated equipment and discharged before connecting to the detector output.

7. HANDLING DAMAGE.

8. DO NOT HANDLE DETECTOR ELEMENT NEEDLESSLY. Static electricity which builds up on the body, especially on cold, dry days, must never be allowed to discharge through the detector element. Avoid exposed leads to or from the detector output, since these are often touched accidentally. Refer to Paragraph 23 for proper precautions.

9. OPERATION.

10. The directional detector is useful as the sampling and detection device in closed-loop leveling setups as described in Paragraph 16. It can also be used as a calibrated power monitor by determining the correlation between detected output and main-line RF output levels, or for relative RF envelope observation with an oscilloscope. If the directional detector is to be permanently mounted for any application, refer to Figure 2, which illustrates the location of the four mounting holes and the general side dimensions. Before installing in any setup, the following should be considered:

a. The type N connectors are hp precision type N connectors which are designed to mate with standard 50-ohm type N connectors. When mating with any other device equipped with hp precision type N connectors, connector damage will result unless an adapter is used. Precision connector dimensions are given in Figure 3.

b. The detector element used is sensitive to either amplitude-modulated or continuous-wave (CW) RF power. If RF power is amplitude modulated at a 1000-cps ±2% rate, the sensitive hp Model 415B or 415D (SWR Meter) can be used as the indicator. For CW detection, a DC milliammeter or millivoltmeter (with an input impedance of at least 100K ohms), such as the hp Model 425A Microvolt-Ammeter can be used as the indicator.

c. When using an oscilloscope to observe waveshapes of rise times less than 5 μsec, the coaxial cable connecting the detected output and the oscilloscope should be as short as possible and terminated with a shunting resistor. Ideally, this resistor should be 50 ohms to terminate the coaxial cable in its characteristic impedance. However, with 50 ohms, the video pulse may have too small an amplitude to drive some oscilloscopes. Typically, the required value is between 50 and 2000 ohms. The larger the resistance, the slower the observable rise time. Oscilloscopes ideal for this application are the hp Models 140A or 175A, depending upon required bandwidth.

d. A low-pass filter should be used in all applications of the directional detector where harmonic frequencies may be present.

11. SENSITIVITY CHARACTERISTICS.

12. The sensitivity characteristics of the Directional Detectors is well defined in two ranges of main line RF power output, a lower range extending up to 500 μw (50 μw for the 788C) and a higher range between 5 and 35 mw (0.5 and 3.5 mw for the 788C). In the lower range the ratio of detected output to main line RF power output (sensitivity), in microvolts per microwatt, is at least 4:1 (40:1 for the 788C). In the higher range the ratio, in millivolts per milliwatt, is at least 2.85:1 (28.5:1 for the 788C). Between ranges, and beyond the higher range, sensitivity characteristics vary from detector element to detector element. Beyond the higher range sensitivity diminishes to a saturation level (a maximum detected output of 300 to 500 mv) where increased main line RF power produces no significant increase in detected output.

13. SQUARE-LAW LOADING.

14. The square-law load (hp 11523A) is selected for optimum response (minimum deviation from square law) at 24°C (75°F). Typically, detected output varies ±0.3 db from exact square law for values of output voltage between 5 mv and 50 mv. At higher temperatures output voltage vs input power deviation is more negative and at lower temperatures the opposite is true. The change with temperature is approximately 0.04 db/°C. For example, a detected output which varies ±0.3 db from exact square law at 24°C would vary about -0.2 to +0.4 db at 22°C (72°F).

15. CLOSED-LOOP LEVELING.

16. TECHNIQUE. The Directional Detector has a direct application in systems employing closed-loop leveling of an RF source. Any variation in the RF output level causes a proportional variation in the detected output level, and this is fed back to maintain a virtually constant RF output level. Generally, an

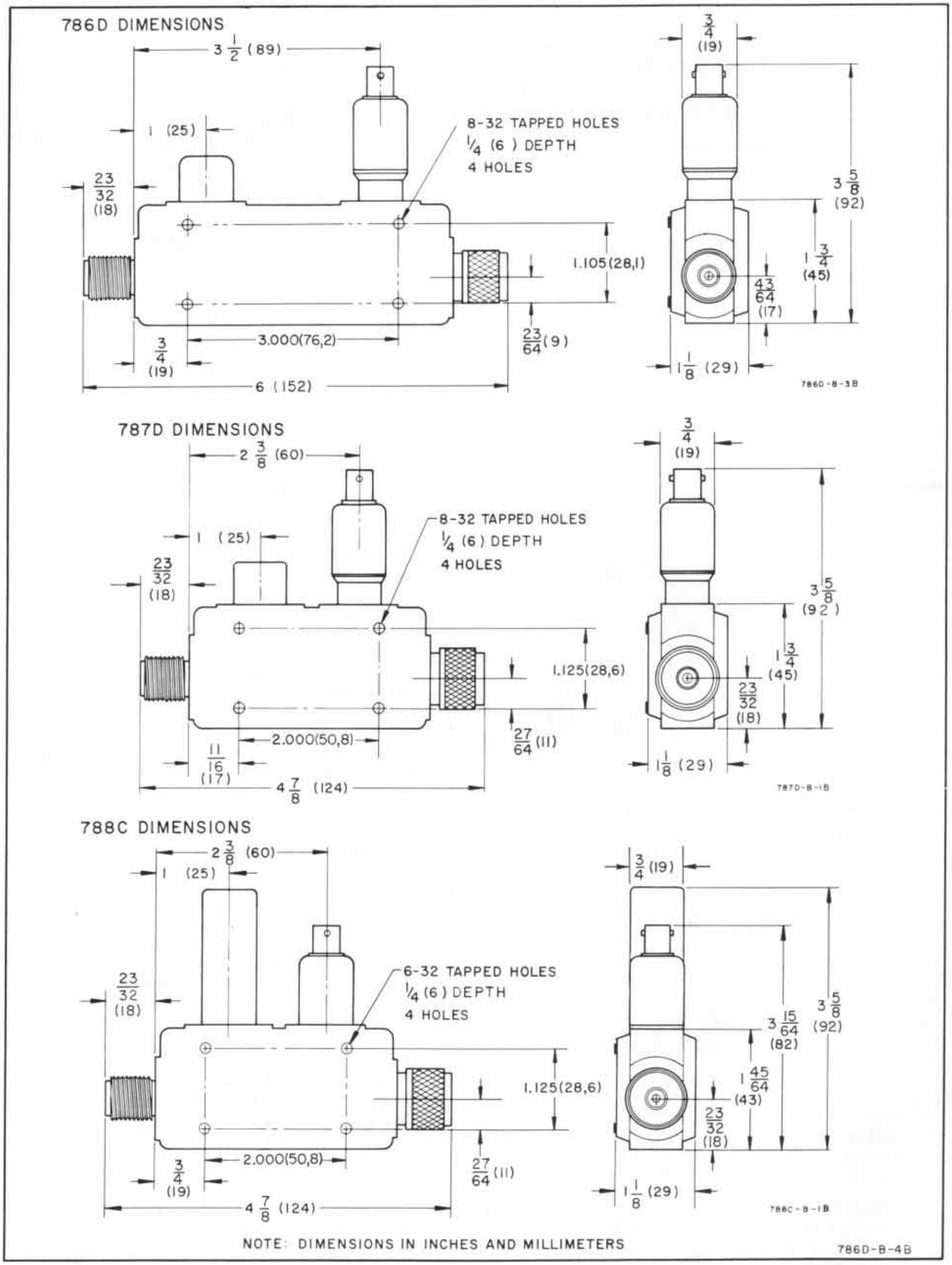


Figure 2. Outside Dimensions

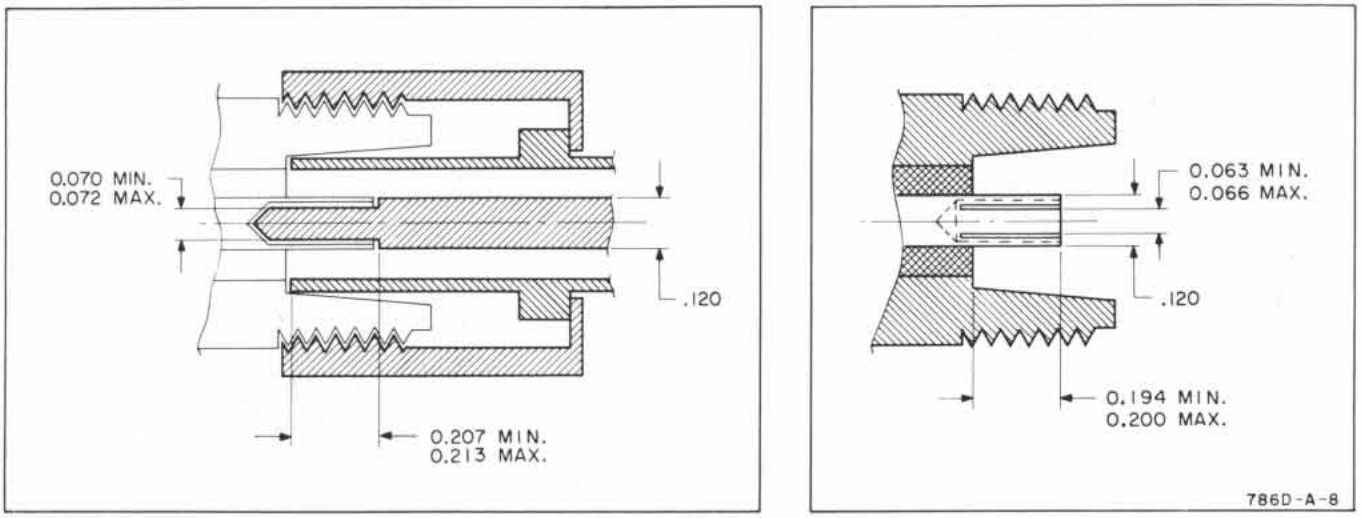
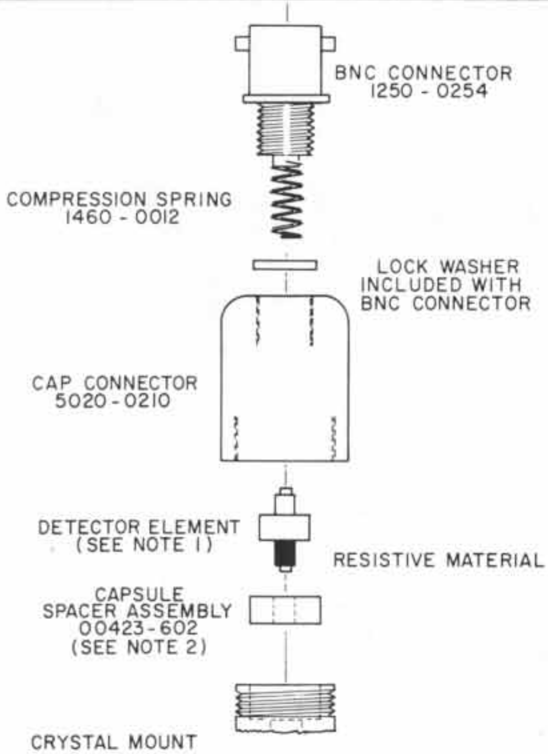


Figure 3. Precision Type N Connector Dimensions

amplifier, such as the hp Model H01-8401A is required between the detector and the RF source, although some sources such as the hp 690 series Sweep Oscillators have built-in leveling amplifiers.



NOTES

1. Negative polarity diode #00423-802 (00423-800 if matched load resistor needed for 11523A); positive polarity diode #00423-803 (00423-801 if matched load resistor needed for 11523A).
2. Capsule spacer includes polyiron insert. Capsule spacer must always be inserted so that black polyiron insert contacts with crystal mount (not under side of diode).

786D-B-5

Figure 4. Detector Unit Assembly

17. LEVELING CAPABILITY. The leveling capability of the leveler-amplifier/directional-detector combination is limited mainly by the frequency response of the detector and the response of the leveler amplifier. When the 786D is used to level the hp Model 691A Sweep Oscillator, RF variations into a matched load are less than ±0.3 db.

18. CALIBRATED POWER MONITOR.

19. The Directional Detector can also be used as a power monitor. By determining the correlation between the detected output and the main-line RF output levels the detected output can be calibrated directly in mv/mw and the directional detector can then be used to sample and indicate RF power levels at any point in a system. A power meter can be used to measure main-line RF output levels for calibration of the detected output. An Oscilloscope, DC Voltmeter, or SWR Meter can be used to measure the detected output.

20. MAINTENANCE.

21. Succeeding paragraphs give instructions for repair of the directional detector and the 11523A (Option 02) Load Resistor. Figure 4 illustrates the replaceable detector assembly for the 786D, 787D, and 788C. Figure 5 illustrates the replaceable load assembly for the 788C, 786D and 787D load assemblies are not field-replaceable. Figure 6 and 7 illustrate the replaceable 11523A load resistor assembly. Stock numbers required when ordering replacement parts are given in the respective assembly illustrations. To order a replacement part, address order of inquiry to your local Hewlett-Packard sales and service office (see listings at the rear of this Note).

22. DETECTOR ELEMENT REPLACEMENT.

CAUTION

The detector element (see Figure 4) can be damaged electrically by incorrect handling. Read the following handling precautions before doing anything which involves detector element.

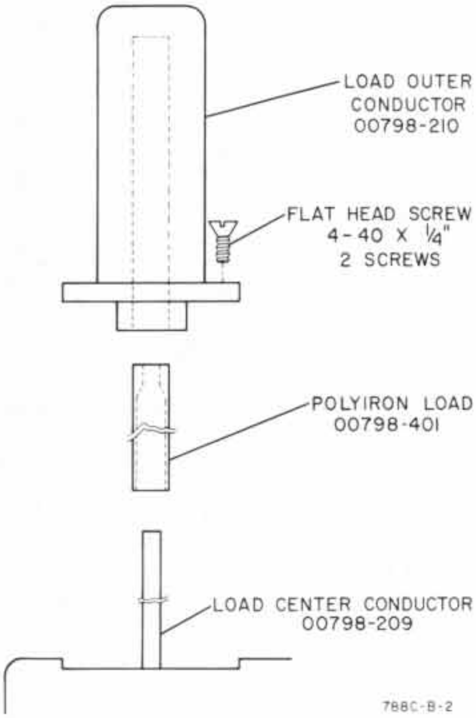


Figure 5. 788C Load Assembly

23. HANDLING PRECAUTIONS.

a. Before installing detector element in mount, touch exposed metal on mount with hand to discharge any static charge. Then insert detector element.

b. When handing crystal to another person, touch hands first to ensure there is no difference in static electrical potential between you.

c. Do not use an ohmmeter to measure forward- and back-resistance. The open-circuit voltages and short-circuit currents from the ohmmeter can damage detector element (diode).

24. PROCEDURE.

a. Note Figure 4 and remove connector cap from body. To remove connector cap, use gas pliers with nylon teeth or protect connector body with heavy paper or tape.

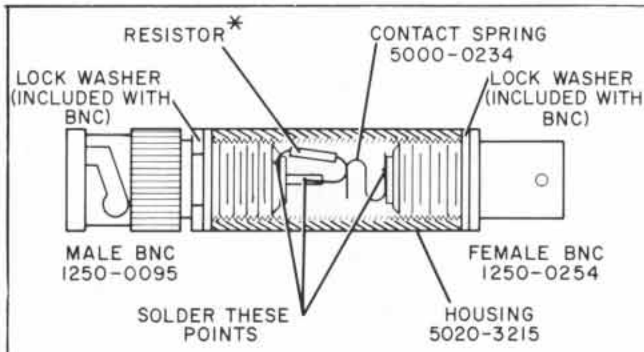
b. Remove old detector element.

c. Install replacement detector element; black resistive end goes into crystal mount (detector element is a snug fit but not a forced fit).

d. Replace connector cap and TIGHTEN FIRMLY.

Note

A resistor is included with each replacement detector element ordered by the -800 or -801 number given in Figure 4. The resistor is for use in 11523A Load Resistor and must be installed to retain proper square-law operation if the directional detector is equipped with this optional load.



* Replacement resistor is supplied with replacement detector elements ordered by the -800 or -801 number given in Figure 4. Note: entire assembly minus resistor is available as 11523-600.

7860-A-12

Figure 6. 11523A Cutaway View

25. DETECTOR BNC REPLACEMENT.

26. TOOLS REQUIRED.

a. Needle-point soldering iron.

b. Gas pliers with nylon teeth.

c. Male BNC mating connector.

d. Tweezers.

27. PROCEDURE.

a. Refer to Figure 4. Remove BNC connector and lockwasher.

b. Unsolder spring soldered to center conductor lead.

c. Slip spring over center conductor lead of new BNC and solder.

d. Let spring cool and then replace lockwasher and connector in connector cap.

28. 788C LOAD REPLACEMENT.

a. Refer to Figure 5. Remove two retaining screws and the load outer conductor.

b. Remove load and any loose or broken portions of the old load from inside the load outer conductor.

c. Replacement is the reverse of removal.

29. REPLACEMENT OF 11523A MALE BNC.

a. Refer to Figure 6. Unscrew male BNC and lockwasher from housing by using a 3/8-inch open-end wrench and holding housing either in a vise or with gas pliers.

Note

If gas pliers do not have nylon teeth, the housing should be protected.

b. Unsolder resistor.

c. Solder resistor to new BNC.

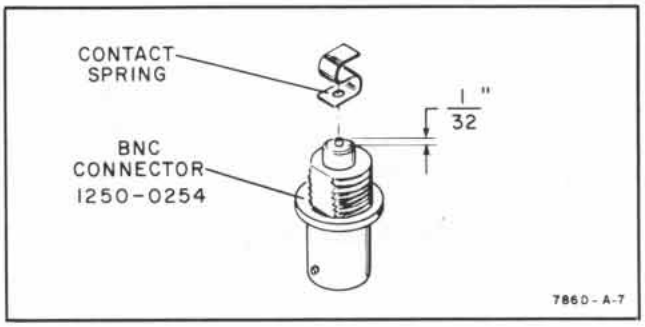


Figure 7. 11523A BNC Assembly

d. Let resistor cool, then check resistance from male BNC pin through resistor; resistance measured should be within 10% of that indicated by the coding.

e. Replace lockwasher and male BNC.

30. REPLACING 11523A FEMALE BNC.

a. Unscrew BNC with a BNC wrench or male BNC used as a wrench.

b. Unsolder contact spring.

c. Prepare replacement BNC connector:

(1) Cut center conductor lead to approximately 1/32 inch (refer to Figure 7).

(2) With flat file, smooth end of lead; wipe off burr with tweezers or similar metal instrument.

d. Slip contact spring over center conductor lead and solder.

CAUTION

Use solder sparingly or it will creep back on spring. Solder on spring destroys its usefulness and is difficult to remove.

e. Let contact spring cool and then screw BNC into housing.

31. PERFORMANCE CHECKS.

32. The performance check procedures given in Paragraphs 33 through 36 verify that the Directional Detector meets its specifications. Test equipment recommended for checking specifications is listed in Table 2. The critical specifications listed are the specific limitations an instrument type must meet and are not meant to be complete instrument specifications. Similar equipment having equal or better specifications than those listed may be substituted for the equipment listed. Test setups and instructions are given only for the 786D. Measurement techniques for the 787D and 788C are similar and differences in specification are mentioned where they exist.

33. FREQUENCY RESPONSE CHECK.

FREQUENCY RESPONSE: ±0.2 db (±0.3 db - 788C)

a. Set up test equipment as shown in Figure 8.

b. Set Sweep Oscillator for a leveled RF output.

c. Set RF output level for a convenient reference near full scale on Power Meter.

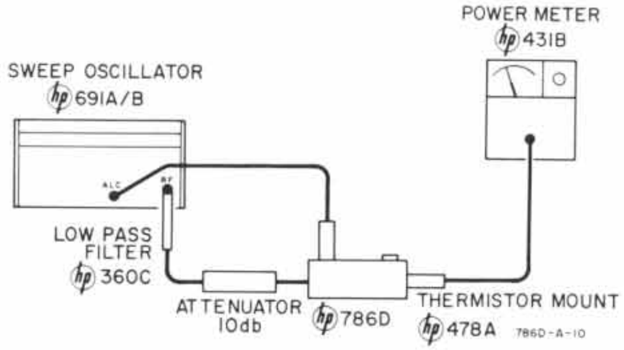


Figure 8. Frequency Response Check

d. Set Sweep Oscillator for 100-second sweep and note Power Meter indication. Specification: variation should not be greater than 0.4 db (0.6 db - 788C).

e. If variation exceeds 0.4 db (0.6 db - 788C), then a single frequency check must be made across the band. A method of checking at single frequencies across the band is to tune from point to point and compare main line RF output against auxiliary line output.

34. SENSITIVITY CHECK.

SENSITIVITY: 100 mv detected output for 35 mw (3.5 mw - 788C) RF output.

a. Set up test equipment as shown in Figure 8 with the following exceptions: the 10-db Pad should be connected between 786D and 478A and detected output connected to a DC Voltmeter through a BNC-to-binding post adapter.

CAUTION

An RF power level exceeding 10 mw will damage Thermistor Mount. Be careful not to exceed 10 mw to mount.

b. Starting at minimum, carefully increase CW-RF power to obtain a 100-mv reading on the DC Voltmeter. Specification: 35 mw (3.5 mw - 788C) or less (Power Meter reading plus attenuation of Attenuator) produces a 100-mv detected output.

c. Repeat above check at all points of interest across the band.

35. SWR CHECK.

MAIN LINE SWR: ≤1.15 (1.20 - 788C)

a. Set up test equipment as shown in Figure 9.

b. Set Sweep Oscillator for a single frequency, 1000-cps square-wave modulated RF output.

c. Adjust square-wave modulation frequency for optimum SWR Meter indication on 40-db NORMAL scale.

d. Phase Sliding Load to obtain minimum SWR scale indication.

e. Adjust Slotted Line carriage for minimum SWR-scale indication as near center of slotted section as possible. Repeat step d, if necessary.

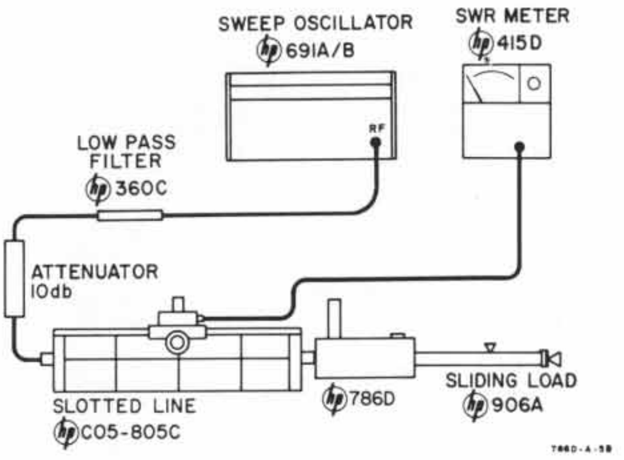


Figure 9. SWR Check

f. Set a 1.0 indication on SWR Meter SWR-EXPAND scale.

g. Adjust Slotted Line for a maximum SWR-scale indication.

h. Phase Sliding Load for a minimum reading and record. Specification: SWR reading must be equal to or less than 1.15 (1.20 - 788C).

36. DIRECTIVITY CHECK.

MINIMUM DIRECTIVITY: 30 db
(26 db - 787D; 20 db - 788C)

a. Set up equipment as shown in Figure 10.

b. Set Sweep Oscillator for leveled, square-wave modulated RF output.

c. Set 0-db reference on SWR Meter.

d. Remove Attenuator from setup.

e. Connect Sliding Load to male connector (786D under test) and using a female-to-female adapter connect 786D under test to 786D.

f. Set Sweep Oscillator for 100-second sweep rate.

g. Note SWR Meter indication and continuously phase Sliding Load. If both minimum and maximum indications are greater than the 0-db reference, the directional detector meets the directivity specification.

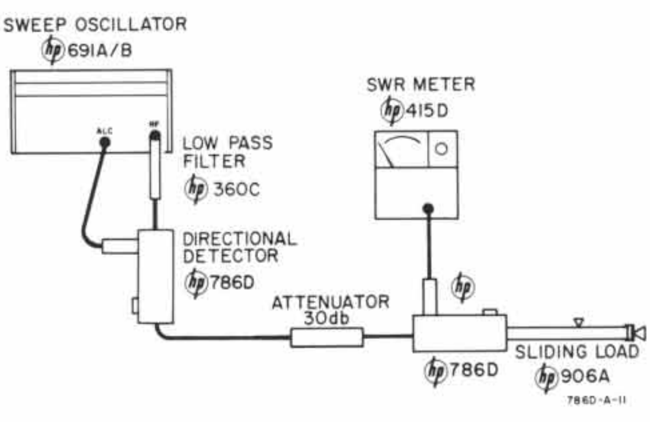


Figure 10. Directivity Check

However, these readings are uncorrected, smaller-than-actual-value readings.

h. To determine actual directivity first add attenuation of Attenuators used in step a to each reading made in step g; then subtract maximum from minimum readings and find difference value (M_1). For example, if readings were 0.5 and 5.4 db and assuming attenuation of Attenuators used is equal to 30 db, then the minimum is 30.5 db and the maximum is 35.4 db. The difference between the two readings is 4.9 db (which is M_1).

i. Refer to Figure 11. Determine values for M_2 which are the two correction factors to be used. Add the minimum reading of step g to each correction (M_2). For example, if the difference in db (M_1) is 4.9 db, then from the graph (Figure 11) the two corrections are 2.1 and 13.3 db. One corrected value is Sliding Load return loss and the other is 786D directivity.

j. To identify directivity reading, loosen Sliding Load center conductor lock and slightly loosen connection to 786D without rotating center conduction. Tighten lock.

k. Repeat steps d through i. The corrected value for Sliding Load return loss should remain practically the same as original corrected reading (within a few tenths of a db). The 786D directivity is the other original corrected reading.

m. The following is an example of measurement steps with actual readings and conclusions.

(1) SWR Meter readings were 0.5 and 5.4 db.

(2) The attenuators used were 20 db and 10 db; hence, the readings indicate 30.5 and 35.4 db.

(3) The difference between the minimum and maximum readings is then 4.9 db.

(4) Referring to Figure 11, the two correction factors are 2.1 and 13.3 db.

(5) The minimum reading (30.5 db) added to each results in two corrected readings: 32.6 and 43.8 db.

(6) To determine which reading represents the Sliding Load, the center conductor is partially unplugged from the 786D.

(7) The above steps were repeated which resulted in SWR Meter indications of 25.5 and 28.0 db. The difference between the two readings is 2.5 db which from Figure 11 determined the two correction factors to be 1.2 and 18.0 db.

(8) The two correction factors added to the 25.5 db minimum gave corrected readings of 26.7 and 43.5 db.

(9) The Sliding Load return loss was 43.5 to 43.8 db, because making a bad connection between the Sliding Load and the 786D did not affect this reading much.

(10) The 786D directivity was 32.6 db, because making a bad connection between the Sliding Load and the 786D did affect this reading causing an erroneous reading which did not agree with either of the previous corrected readings.

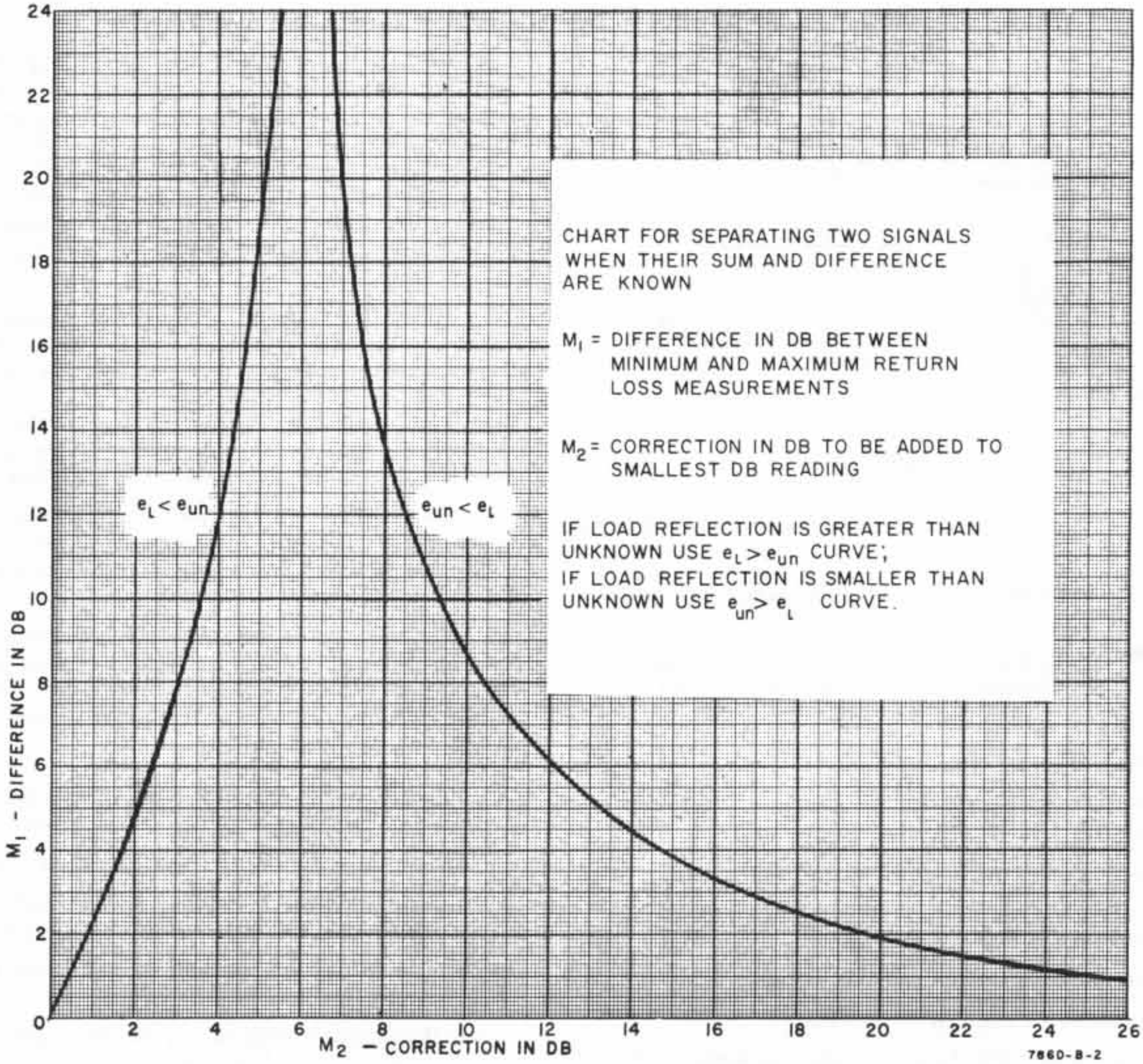


Figure 11. Signal Separation Chart

Table 2. Recommended Test Equipment

Instrument Type	Critical Specifications	Check	Model
Sweep Oscillator	Frequency Range: (directional detector) Power Output: 10 mw Leveled Capability*: ±0.1 db Residual FM: Less than 50 kc	All	691A/B (786D) H01-692A (787D) H01-693A (788C)
Low-Pass or Bandpass Filter	Frequency Range: (directional detector) Rejection: Not less than 40 db	All	360B (786D) 360C (787D & 786D) 360D (787D & 788C) 8435A (788C) 8436A (788C)
Power Meter and Thermistor Mount	Frequency Range: (directional detector) Power Range: -10 to +10 dbm Accuracy: ±3%	Frequency Response Sensitivity	431B (meter)and 478A (mount)
Fixed Attenuator	Frequency Range: (directional detector) Attenuation: 10 db	Frequency Response Sensitivity SWR	Weinschel 210-10
	Frequency Range: (directional detector) Attenuation: (directional detector directivity)	Directivity	Weinschel 210-10 (786D) 210-20 (all) 210-6 (787D)
DC Voltmeter	Range: 20 to 100 mv Input: 10 megohms Accuracy: ±2% of full scale	Sensitivity	410C
SWR Meter	Frequency: 1000 cps ±2% Calibration: Square Law Accuracy: ±0.05 db (on EXPAND scale) Input: 200K ohms	SWR Directivity	415B or 415D
Directional Detector	Frequency Range: (directional detector) Detected Output: Negative Sensitivity: 4 mv/mw Frequency Response: ±0.3 db	Directivity	786D (786D) 787D (787D) 788C (788C)
Sliding Load	Frequency Range: (directional detector) Connectors: Standard type N Residual SWR**: 1.05	SWR Directivity	906A
Slotted Line	Frequency Range: (directional detector) Connectors: Standard type N Residual SWR: 1.04	SWR	C05-805C (786D & 787D) C05-806B (788C) 809B (788C)

* Excluding coupler and detector variation (with the 786D the leveling capability would be ±0.3 db)

** Residual SWR: 1.10 from 1.0 to 1.5 Gc

APPENDIX III

OPERATING NOTE

423A CRYSTAL DETECTOR

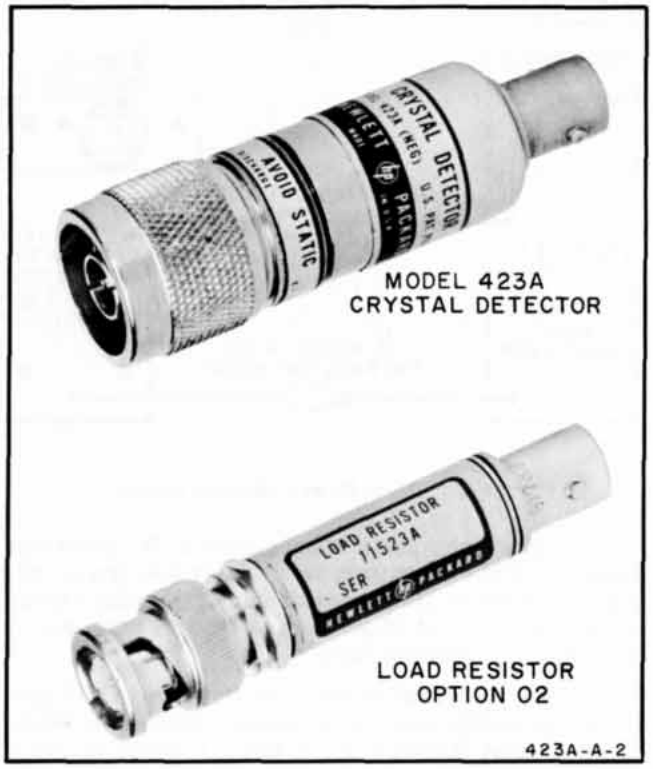


Figure 1. Model 423A Crystal Detector and Option 02 Accessory

1. INTRODUCTION.

2. The Model 423A Crystal Detector is designed for use in coaxial systems in the measurement of relative microwave power up to 100 mw in the range from 10 Mc to 12.4 Gc. Output polarity of the detected signal is normally negative but positive output polarity is available as Option 03. Complete specifications and listed options are given in Table 1. The 423A and Option 02 Load Resistor are shown in Figure 1.

3. Separate housing of square-law load (Load Resistor, Option 02; see Figure 1) and detector permits easy conversion from optimum square-law response operation (with the Load Resistor) to maximum output voltage (without the Load Resistor). Each load is labeled with the serial number of the Model 423A detector to which it is matched. If you have more than one load (hp Model 11523A), always check that you are using the proper 11523A for the 423A in use.

4. Uses of the detector include peak RF power measurement, reflectometer measurements, closed loop leveling, and observation of RF envelope variation.

Table 1. Specifications

FREQUENCY RANGE:
10 Mc to 12.4 Gc. RF leakage through video output connector may be present below a 1.0-Gc operating frequency; leakage may be eliminated, if objectionable, with suitable low-pass filter.

FREQUENCY RESPONSE:*
±0.2 db per octave, 10 Mc to 8 Gc; ±0.5 db over all

MAXIMUM POWER: 100 mw, peak or average

SENSITIVITY:
High Level - less than 0.35 mw produces 100 mv output
Low Level - 0.4 mv dc/μw CW

SWR:		
	10 Mc to 4.5 Gc,	less than 1.20
	4.5 Gc to 7.0 Gc,	less than 1.35
	7.0 Gc to 12.4 Gc,	less than 1.50

OUTPUT IMPEDANCE:
Less than 15K shunted by 10 pf

DETECTOR ELEMENT: Supplied

OUTPUT POLARITY: Negative

NOISE: Less than 200 μv peak-to-peak, with a CW power applied to produce an output of 100 mv

CONNECTORS:
423A - type N male and BNC female
11523A - BNC (one male, one female)

OPTION 01:
Matched pair. Frequency response characteristics (exclusive of basic sensitivity) track within ±0.2 db per octave from 10 Mc to 8 Gc, ±0.3 db from 8 to 12.4 Gc.

OPTION 02:
Furnished with matched load resistor for optimum square law characteristics at 24°C (75°F),* less than ±0.5 db variation from square law from low level up to 50 mv peak output working into an external load greater than 75K. Sensitivity typically greater than 0.1 mv/μw when load resistor is used. Overall length, 423A Option 02, 4-1/2 in. (114 mm).

OPTION 03:
Output polarity positive

* As read on a meter which is calibrated for use with square-law detectors.

5. PRECAUTIONS.

6. ELECTRICAL SHOCK.

7. DISCHARGE OF STORED ELECTRICAL ENERGY CAN EASILY DAMAGE THE CRYSTAL DETECTOR. A 100-pf capacitor, the equivalent of four feet of coaxial cable, charged to 14 volts stores 0.1 erg of energy which is the maximum safe pulse rating of the detector. Be certain that a cable is connected to associated equipment and discharged before connecting it to crystal detector.

8. HANDLING DETECTOR ELEMENT.

9. DO NOT HANDLE DETECTOR ELEMENT USED IN CRYSTAL DETECTOR NEEDLESSLY. Static electricity which builds up on a person, especially on a cold, dry day, must never be allowed to discharge through the Crystal Detector. Avoid exposed leads to or from the crystal detector, since these are often touched accidentally. Refer to Paragraph 24 for proper precautions.

10. GENERAL.

11. The Model 423A Crystal Detector can be used as a demodulator to obtain a pulse envelope which can then be observed on an oscilloscope. The Model 423A can also be used as a general purpose detector.

12. When using the crystal detector with an oscilloscope and the waveshapes to be observed have rise times of less than 5 μsec, the coaxial cable connecting oscilloscope and detector should be as short as possible and shunted with a resistor. Ideally, this resistor should be 50 ohms to terminate the coaxial cable properly. However, with 50 ohms resistance, possibly the output video pulse may be too small to drive some oscilloscopes. Therefore, the cable should be shunted with the smallest value of resistance that will obtain suitable deflection on the oscilloscope; typically the value will lie between 50 and 2K ohms. The larger the resistance the more degradation of rise time.

13. The power applied to the Model 423A Detector can be either modulated or continuous wave (CW). If modulated at a 1000-cps rate the sensitive hp Model 415B/D can be used as the indicator. For CW detection, a dc milliammeter or millivoltmeter such as the hp Model 425A Microvolt-Ammeter can be used as the indicator.

14. PEAK POWER MEASUREMENT.

15. The arrangement of equipment for peak power measurement is shown in Figure 2. The procedure involves calibration of an oscilloscope which in turn is used to calibrate a CW generator. The output of the calibrated CW generator is measured with a power meter; the peak power of a pulse is thereby measured. The procedure is as follows:

a. Connect equipment as shown in Figure 2, step 1.

b. Observe pulse on a dc-coupled oscilloscope. Using a marking pencil, mark on the graticule the base-to-peak amplitude of the pulse envelope.

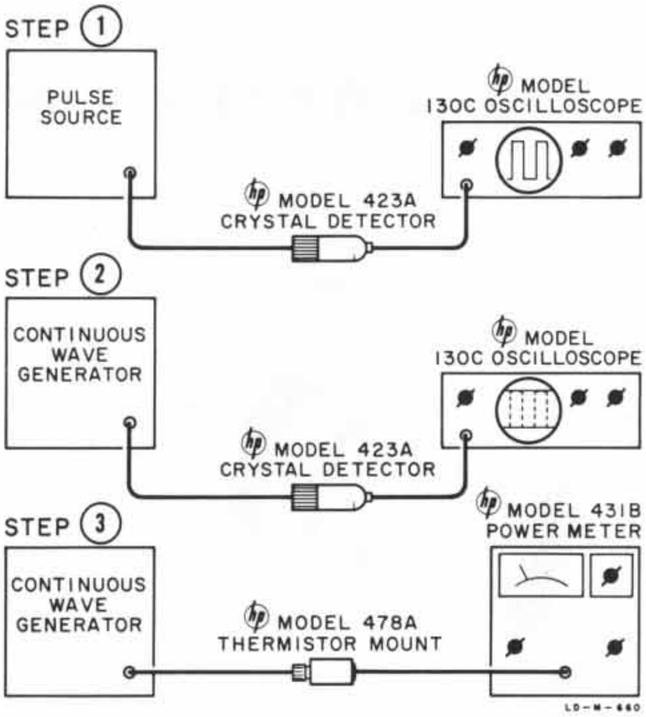


Figure 2. Peak Power Measurement

c. Replace the pulse source with a CW generator (step 2). While observing the oscilloscope trace, adjust amplitude of CW generator output to make crystal output equal to that of pulse generator as indicated by markings on graticule (step b).

d. While performing the next step, leave CW generator at setting obtained in step c. Disconnect Model 423A detector from CW generator. Connect output of CW generator to a thermistor and power meter. Measure adjusted level (step c) of CW generator output.

e. The peak power of the pulse envelope observed in step b is equal to the output power of the CW generator.

16. REFLECTOMETER APPLICATION.

17. For information about reflectometer systems and measurements, see hp Application Notes 54 and 61 and Hewlett-Packard Journal Vol. 12, No. 4, copies of which are available upon request.

18. HARMONIC FREQUENCY-COMPARISON MEASUREMENTS.

19. The Model 423A can be used as a mixer in harmonic-frequency comparison measurements. See hp Application Note 2.

20. REPLACEMENT OF PARTS.

21. Succeeding paragraphs give instructions for repair of the Model 423A, and the Option 02 Load Resistor, Model 11523A. Additional maintenance information can be obtained from your local Hewlett-Packard field office. Stock numbers for replaceable parts are given in Table 2.

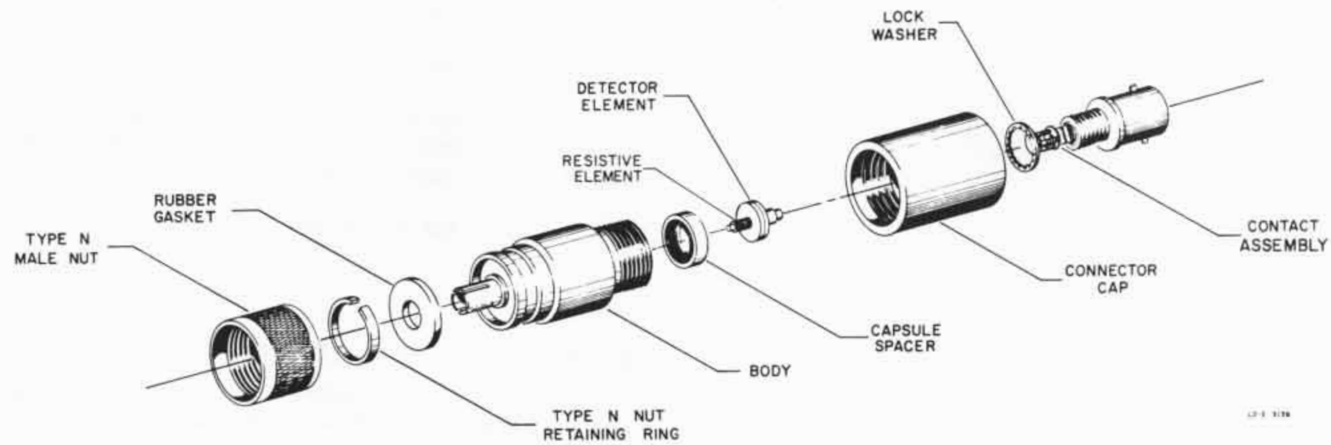


Figure 3. Model 423A Assembly

22. Detector elements as replacement parts are available as listed in Table 2. The Detector Element Assembly includes the detector element and a Load Resistor replacement resistor which must be installed if the detector has a matching load. The replacement resistor may be used in a Load Resistor Body Assembly (see Table 2) should a square-law load be desired for your Model 423A.

23. DETECTOR ELEMENT REPLACEMENT.

WARNING

The special detector element (see Figure 3) contained in the Model 423A can be damaged in handling, removal, or installation if certain precautions are not taken. The handling precautions which follow should be read before performance of any operation with the detector element when it is out of either the Model 423A or the detector element shipping container.

24. DETECTOR ELEMENT HANDLING PRECAUTIONS.

a. Before installing detector into mount, touch exposed metal on mount with your hand to discharge static electricity. Then insert detector into mount.

b. When handing crystal to another person, touch hands first to ensure there is no difference in static electrical potential between you.

c. Ohmmeters should NOT be used to measure forward- and back-resistance since it is rather easy to damage these diodes. (The difficulty arises because of the ohmmeter open-circuit voltages and short-circuit currents. It is easy for these currents or voltages to damage the diode.)

25. REPLACING DETECTOR ELEMENT.

26. Parts mentioned in the following procedure are identified in Figure 3.

a. Remove connector cap from body. To remove connector cap, use a pair of gas pliers with plastic teeth or protect body with heavy paper or tape.

b. Remove old detector element.

c. Install replacement detector element; resistive end goes into body.

CAUTION

When inserting the detector element, do not force the tip (resistive end) into the center conductor in the body as the fingers of the center conductor might be damaged.

d. Replace connector cap and TIGHTEN FIRMLY.

Note

The Detector Element Assembly includes a detector element and a resistor. The resistor is for use in the Model 11523A and must be installed to match it to the Model 423A.

27. REPLACING 423A BNC CONNECTOR.

28. TOOLS REQUIRED.

a. Needle-point soldering iron

b. Wire cutters

c. Flat file, #4

d. Tweezers

29. PROCEDURE. Parts mentioned in the following procedure are identified in Figures 3 and 4.

a. Remove BNC connector and lockwasher.

b. Unsolder contact spring soldered to center conductor lead.

(1) Cut center conductor lead to approximately 1/32 inch (see Figure 4).

(2) With flat file, smooth end of lead; wipe off burr with tweezers or similar metal instrument.

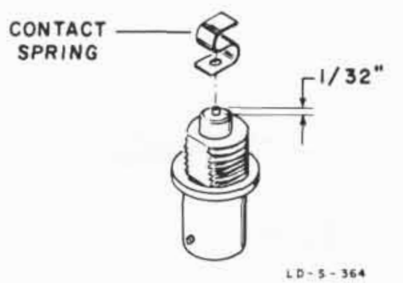


Figure 4. Cutting Center Conductor Lead to Accommodate Contact Spring

c. Slip contact spring over center conductor lead, and solder.

CAUTION

Use solder sparingly or it will creep back on spring. Solder on spring destroys its usefulness, and solder is difficult to remove from spring.

d. Let spring cool, and then replace lockwasher and connector in connector cap.

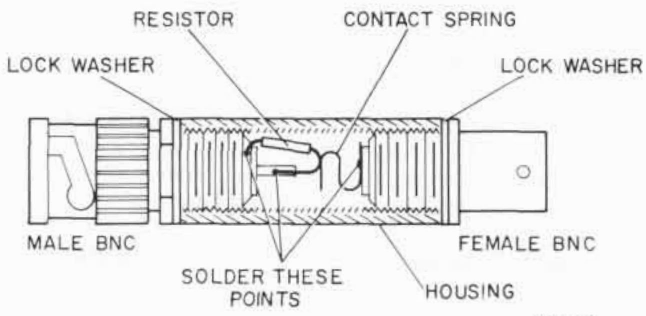


Figure 5. Model 11523A Load Resistor, Cutaway View

30. REPLACEMENT OF 11523A PARTS.

31. Parts mentioned in the following procedure are identified in Figures 4 and 5. Tools required are listed in Paragraph 28.

32. REPLACING MALE BNC CONNECTOR.

a. Remove male BNC connector and lockwasher from housing. To remove BNC, use a 3/8-inch open-end wrench and hold the housing either in a vise or with gas pliers. Before putting pliers on, protect the housing of the 11523A with material such as heavy paper.

b. Unsolder resistor.

c. Solder resistor to new BNC.

d. Let resistor cool and then check resistance from male BNC pin through resistor; resistance measured should be ±10% that indicated by the coding.

e. Replace lockwasher and male BNC.

33. REPLACING FEMALE CONNECTOR.

a. Remove BNC connector. To remove or install BNC, use a BNC wrench or use a male BNC connector as a wrench.

b. Unsolder contact spring.

c. Prepare replacement BNC connector:

(1) Cut center conductor lead to approximately 1/32 inch.

(2) With flat file, smooth end of lead; wipe off burr with tweezers or similar metal instrument.

d. Slip contact spring over center conductor lead, and solder.

CAUTION

Use solder sparingly or it will creep back on spring. Solder on spring destroys its usefulness and is difficult to remove.

e. Let contact spring cool and then screw connector into mount.

34. REPLACEABLE PARTS.

35. This section contains information pertaining to replaceable parts (see Table 2) and the ordering of these parts for the Models 423A and 11523A.

36. To order a replacement part, address order or inquiry to your local Hewlett-Packard field office (see list at rear of this Note).

37. Specify the following information for each part:

a. Model number

b. Hewlett-Packard stock number

c. Description of part

Table 2. Replaceable Parts, Models 423A and 11523A

Description	hp Stock Number 423A	hp Stock Number 11523A	TQ
Connector, male BNC, includes lockwasher	---	1250-0045	1
Connector, female BNC, includes lockwasher	1250-0251	1250-0251	1
Connector Assembly, includes connector, female BNC, and contact assembly	00423-600	---	1
Connector, cap	5020-0210	---	1
Type N Connector Assembly and body	00423-601	---	1
Housing	---	5020-3215	1
Capsule Spacer Assembly	00423-602	---	1
Detector Element (with negative polarity probe)	00423-802	---	1
(with positive polarity probe)	00423-803	---	1
Detector Element Assembly, includes detector element and matching resistor for matching 11523A (replacement for Option 02)			
(with negative polarity diode)	00423-800	---	1
(with positive polarity diode)	00423-801	---	
Load Resistor Assembly without resistor, includes serial number plate to be attached to Crystal Detector	---	11523-600	0

TQ - Total quantity used in the instrument.

WARRANTY CLAIM AND ADJUSTMENT PROCEDURE

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

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

(in Western Europe)

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

(Rest of World)

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

Microwave tubes supplied by the Hewlett-Packard Company, either as original or replacement, for use in Hewlett-Packard instruments are actually warranted by the tube manufacturer and not by Hewlett-Packard. However, Hewlett-Packard 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 from, along with the defective tube, to your Hewlett-Packard Sales and Service Office or to Hewlett-Packard. Please be sure each space on the form is filled in--lack of complete information may delay processing of your claim.

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

SHIPPING INSTRUCTIONS

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

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

Note

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

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

Hewlett-Packard Company
Eastern Service Center
Green Pond Road
Rockaway, New Jersey, 07866
USA

Hewlett-Packard Company
Western Service Center
395 Page Mill Road
Palo Alto, California, 94306
USA

01153-8 Rev 4/1/65

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 ______________________

10/15/62
01153-3

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TWX: 602-949-0111

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Neely Sales Division
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(916) 482-1463
TWX: 916-444-8683

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Neely Sales Division
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TWX-714-276-4263

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San Carlos 94071
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TWX: 910-376-4390

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Lahana Sales Division
7965 East Prentice
(303) 771-3455
TWX: 303-771-3056

CONNECTICUT

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TWX: 203-346-7433

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Florida Sales Division
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(305) 635-6461

Orlando, 32803
Hewlett-Packard
Florida Sales Division
621 Commonwealth Ave.
(305) 425-5541
TWX: 305-275-1234

St. Petersburg, 33708
Hewlett-Packard
Florida Sales Division
410-150th Ave., Madeira Beach
(813) 391-0211
TWX: 813-391-0666

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