INSTRUCTION MANUAL

COPY NO. 008

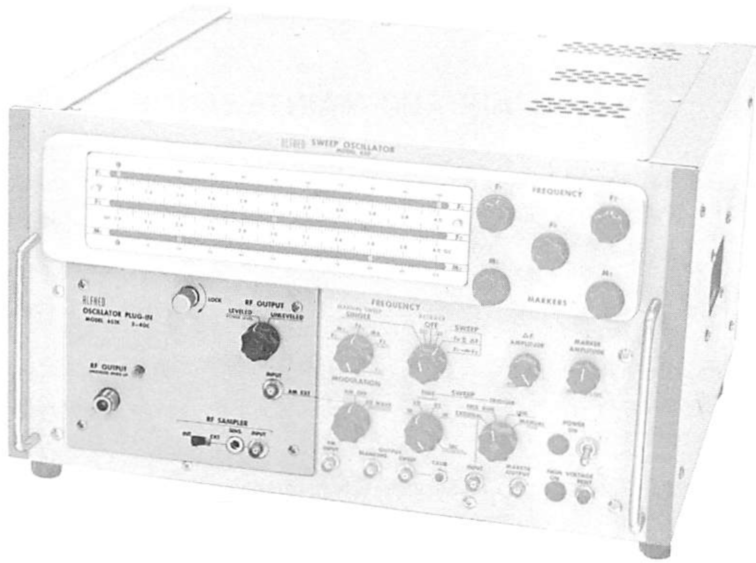
R/C MAINTENANCE DEPOT

4→8 GHZ MODEL 650
SWEEP OSCILLATOR

plug-in units

653C MODEL   1625 SERIAL

USING BWO TUBES WITH PIN DIODE LEVELING
Tube type: Stewart ☒ Varian ☐
Leveling capability: Int-Ext ☐ Ext only ☒



ALFRED ELECTRONICS • STANFORD INDUSTRIAL PARK • PALO ALTO, CALIFORNIA

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Manual 650-6

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Instruments should be returned only on prior written authorization from the Singer Representative or the factory(1). Warranty repair will be made upon written request. Please provide the following information in order to expedite our processing of your instrument:

1. Model or Type
2. Serial Number
3. Approximate date instrument was placed in operation
4. Approximate number of hours of use
5. Description of trouble(2)
6. Has maintenance action been previously requested?
7. Other comments

Upon receipt of this information our Service Department will send you service data or shipping instructions. Upon receipt of shipping instructions forward the instrument prepaid to the specified center or factory. If requested, an estimate of charges will be made before work begins.

(1) Contact East Coast Service Center, 915 Pembroke Street, Bridgeport, Connecticut 06608, Telephone (203) 366-3201 or West Coast Service Center, 3211 S. LaCienega Blvd., Los Angeles, California 90016, Telephone (213) 839-2201 for all Singer Instrumentation equipment. If convenient, contact Ballantine Operation, P.O. Box 97, Boonton, New Jersey 07005, Telephone (201) 334-1432 for Ballantine Instruments and Alfred Operation, 3176 Porter Drive, Palo Alto, California 94304, Telephone (415) 326-6496 for Alfred Instruments.
(2) Include data on symptoms, measurements taken, test instruments used, suspected location of trouble, maintenance action taken, and any other relevant data.

MANUAL CHANGES

FOR

SWEEP OSCILLATOR PLUG-IN

MODEL 650-6

Make corrections to errata listed below and make applicable changes(s) listed in the table below according to instrument serial number.

SERIAL NO.	MAKE CHANGES

SERIAL NO.	MAKE CHANGES

ERRATA: On Table adjacent to schematic 900713C, make the following changes of resistor values for the respective frequency ranges:

1.7 - 4.2 GHz	R2 from 102K to 107K, part no. 56-107K R7 from 210K to 200K, part no. 56-200K
2 - 4 GHz (W-J)	R2 from 121K to 130K, part no. 56-130K
3.5 - 6.75 GHz (Varian)	R2 from 340K to 422K, part no. 56-422K
7 - 12.4 GHz (W-J)	R2 from 154 to 182K, part no. 56-182K
8 - 12.4 GHz (W-J)	R2 from 340K to 402K, part no. 56-402K

Nov. 7, 1970

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NOTE: This Manual Applies to 650 Models with C Suffix

Table 1-1. Specifications of 650-C Oscillator Plug-in Units Using PIN Diode Leveling

Frequency GHz	650 Model No.t	Tube Type**	Alfred Tube No.	Power Output (mw)yy	Power Variation Leveled dbtt	Residual FM (KHz - Pk)	Diode Shaper PC Board	Samplery	Sampler Attenuator	Low Pass Filter
1 to 2	651C* 651CK*	Stewart Varian	112-029	60 40	± 0.3	30	950636	951099	1151x	256-6y
1.4 to 2.5	651C-S1 651CK-S1	Stewart Varian	112-034	50 50	± 0.3	30	950637	950781	1151-1x	
1.7 to 4.2	652C-S5 652CK-S5	Stewart Varian	112-033	15 15	± 0.5	30	950858	950908		256-9y
2 to 4	652C 652CK	W/J Stewart' Varian	112-095 112-031 112-015	40 30	± 0.3	30	951877 950638 951601	951100	1152x	256-2y xxxx
3.5 to 6.75	653C-S1 653CK-S1	Stewart Varian	112-035 112-016	20 15	± 0.4	50	950640 951602	950783	1153-1x	256-4y xxxx
3.7 to 8.3	653C-S2 653CK-S2	Stewart Varian	112-028 112-017	5 5	± 0.5	50	950965 951610	950896		256-8y xxxx
4 to 8	653C 653CK	W/J Stewart Varian	112-105 112-027 112-006	15 15	± 0.5	50	951909 950639 950932	950784	1153x	256-1y
7 to 11	654C 654CK	Varian Watkins-Johnson	112-012 112-039	10 10	± 0.5	50	950641 951699	951101		256-5y
7 to 12.4	654C-S1 654CK-S1	Varian Watkins-Johnson	112-012 112-039	10 10	± 0.75	50	950647 951603	·951101		256-5y
8 to 12.4	655C 655CK	Varian Watkins-Johnson	112-013 112-038	20 20	xxx	50	950642 951604	950786		256-5y

* C suffix indicates PIN DIODE Attenuator.
** All Varian tubes use Anode protection fuse.

x For External use with Model 650.
xxx ± 0.5 (8.2 to 12.4 GHz.); ± 0.7 (8.0 to 12.4 GHz.)
xxxx Self-contained in BWO
t K suffix indicates rf leveling sampler mounted internally. Basic model requires an external sampler for leveling.
tt Level variation limits shown for units with internal leveler-sampler can be achieved with at-the-load leveling in all units, by use of a suitable external sampler.
y Used only on units (with K suffix) having internal sampling.
yy Upper figure indicates rated maximum unleveled output from units without internal sampling; lower figure indicates rated maximum leveled output from units with internal sampling.

PULSE MODULATION VOLTAGE REQUIRED AT AM EXT JACK: The pulse modulation voltage required for external on-off modulation varies with the response speed required. A signal of + 10V will turn the rf output on with a rise and fall time of about 1μs in all units, in the unleveled mode. For high-speed, ac-coupled pulse modulation in the unleveled mode with rise and fall time of ≈0.1 μs, a pulse amplitude of typically + 45 volts with 50Ω source impedance is required in all units having Stewart (or Watkins-Johnson) BWO tubes; and a pulse amplitude of typically + 100 V with 50Ω source impedance is required in all units having Varian BWO tubes. During leveled operation, a signal of + 10V will turn the rf output on with a rise time of about 10 μs in units having PIN diode leveling, and about 20 μs in units having grid leveling.
Specifications subject to change without notice. Data not shown was unavailable at press time.

NOTE: All BWO tubes are "Source Controlled" and should be ordered from Alfred using the Alfred Tube No.

SECTION 1

GENERAL INFORMATION

1.1 SCOPE OF MANUAL.

This manual covers the group of Oscillator Plug-in units of the ALFRED Model 650 Series using BWO tubes with PIN diode leveling. All standard plug-in units covered by this manual are listed in Table 1-1.

Table 1-1 also includes performance information pertinent to each plug-in unit, and identifies the components which constitute the main differences between each plug-in unit of the group. These are the backward-wave oscillator (BWO) tube, the diode shaper board which matches the high voltage cathode supply output to the tube characteristic, the rf output low-pass filter and the internal sampler for K-suffix plug-in units. These component differences are required for operation in the different frequency bands shown in Table 1-1.

This manual should be used as a supplement to the basic Model 650 Instruction Manual. That manual includes all necessary information for operating the Model 650 with any plug-in unit installed. This plug-in unit manual gives supplemental descriptive, theory, and maintenance information pertinent to the plug-in units using BWO tubes with PIN diode leveling.

1.2 DESCRIPTION OF PLUG-IN UNIT.

Each plug-in unit is a modular rf head assembly designed to operate with the ALFRED Model 650 main frame to constitute a microwave sweep oscillator. All plug-in units can be operated interchangeably in any Model 650, and no adjustments are required, either on the Model 650 or the plug-in unit, when interchanging plug-in units. Thus, by using several plug-in units interchangeably, a versatile, wide-range oscillator capability is provided at minimum expense, and operation can be extended into additional bands when desired by purchasing additional plug-in units.

The plug-in units using BWO tubes with PIN diode leveling, covered in this manual, operate in frequency bands from 1 GHz to 12.4 GHz as listed on Table 1-1. Other plug-in units are available covering frequencies from 0.25 GHz to 40 GHz (see Table 1-2 in the Model 650 manual). All the plug-in units are equipped with an internal leveler-amplifier, and can provide leveled rf output when used with an external sampler. Those plug-in units with model numbers having a "K" suffix are also equipped with an internal sampler to permit self-contained leveling. These units have a front panel RF SAMPLER INT-EXT switch to select either internal or external sampling.

The plug-in unit chassis is fabricated from aluminum to avoid interference with the magnetic field of the BWO tube, and the top and bottom panels of the plug-in unit completely enclose the tube for shielding and mechanical protection. The tube and the plug-in leveler-amplifier PC board are mounted on a center plate in the forward portion of the chassis. The diode shaper plug-in PC board is located in the rear compartment of the chassis.

The frequency dial plate corresponding to the rf output band of each plug-in unit is stored in the top storage compartment of that plug-in unit, as shown in Figure 2-1 of the Model 650 Instruction Manual. Installation of this plate onto the dial plate area of the Model 650 calibrates the Model 650 for operation with the corresponding plug-in unit.

1.3 OTHER DOCUMENTATION FURNISHED WITH MANUAL.

An envelope at the rear of this manual contains factory performance-test data for the instrument and data for the BWO tube, as follows:

a. "ADDENDUM A" listing instrument model and serial number of the instrument and the particular values of factory-selected components used; and also listing the tube parameters pertinent to the tube originally shipped in the instrument.

b. A maximum power output performance plot of the plug-in unit made during final swept-frequency testing at ALFRED.

c. For units with internal leveling (K suffix models) a plot similar to b but showing performance in the leveled condition.

SECTION 2

INITIAL INSTRUCTIONS

2.1 GENERAL. Refer to Section 2 of the Model 650 Instruction Manual.

CAUTION

The BWO tube housing contains a strong permanent magnet. This magnet will attract magnetic materials brought near it, and the tube may be damaged (1) by being struck by such materials, and (2) by permanent alteration of its magnetic field by being exposed to such materials. Use only non-magnetic screwdrivers and other tools when working around the plug-in unit, and remove your wrist watch to avoid magnetic damage to it. The plug-in unit should be kept at least six inches from magnetic materials.

When a plug-in unit is removed from the Model 650, or if a unit is received separately, store it in a suitable shielding container, such as the ALFRED Model 9000 Storage Container, or on wood and at least six inches from magnetic sources.

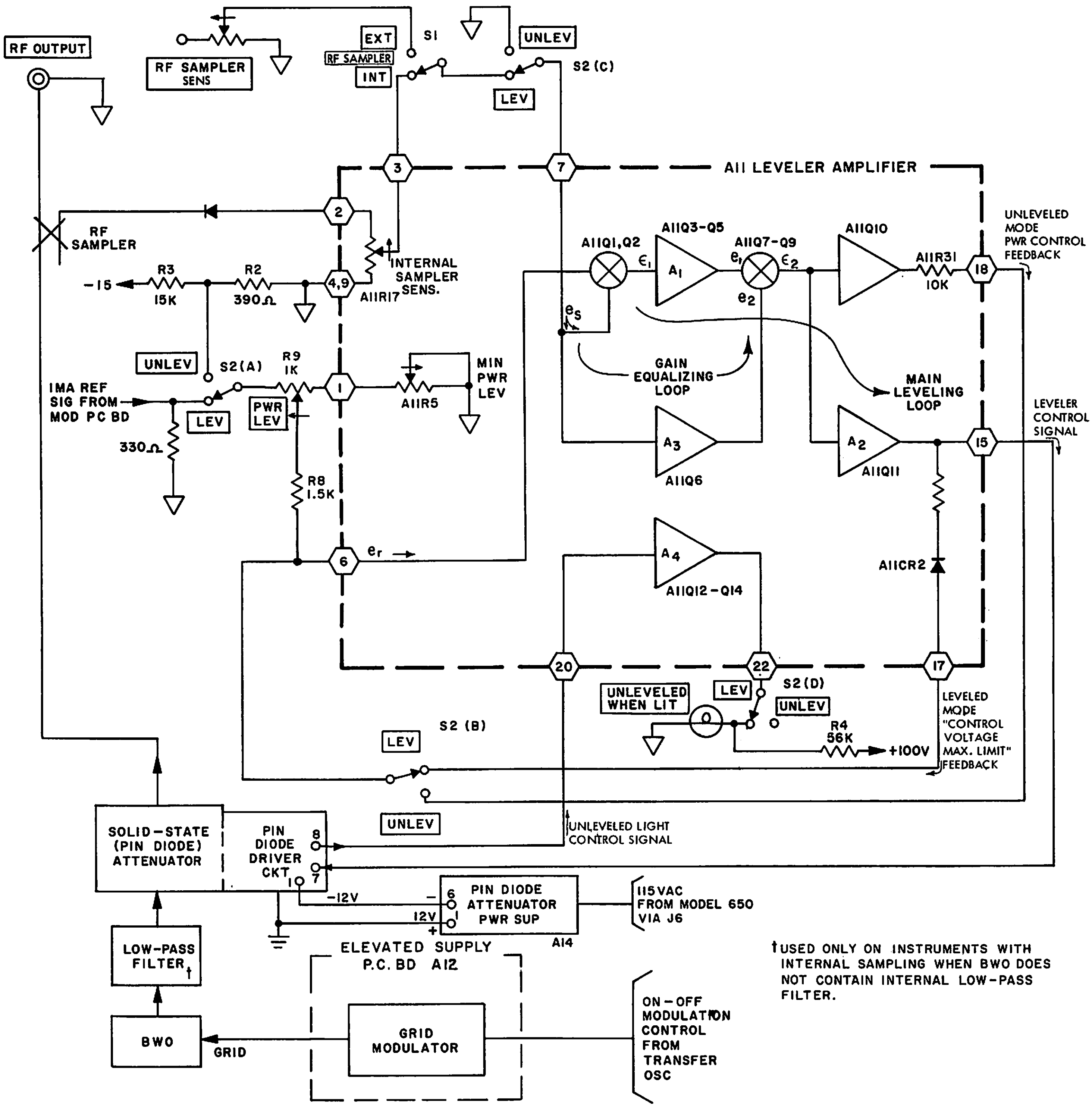


FIGURE 4-0. SIMPLIFIED DIAGRAM OF RF OUTPUT AND LEVEL CONTROL CIRCUITS

the leveling diodes so that the PIN attenuator rf network yields a fixed 50-ohm input and output impedance.

The sensitivity of the feedback-stabilized leveler-amplifier is high enough that it levels the rf output to within a fraction of a db regardless of the unleveled characteristic of the tube. As the output sweeps through frequencies where the unleveled characteristic is several db higher than the minimum-power point in the band, the leveler increases the correction signal in response to the increased crystal output, and prevents the level from increasing more than about 0.3 db.

Whenever power is leveled over the full range being swept, a negative signal is continually supplied from the PIN diode attenuator driver to a two-stage amplifier to cut off power from the UNLEVELED WHEN LIT light. The absence of a suitable driver output signal during any portion of the swept band, indicating that the rf output signal is totally or partially unleveled, is sufficient to allow this amplifier to energize the UNLEVELED light.

The signal level applied to the leveler-amplifier from the internal or external detectors is adjustable with individual SENSITIVITY controls to provide optimum response in the leveled loop.

For control of output level in the unleveled mode, the leveler-amplifier drives the PIN attenuator to provide a fixed output attenuation with a magnitude controlled by the setting of the POWER LEVEL control. The crystal detector signal to the differential input for A_1 is grounded, and the main leveling loop consisting of A_1 and A_2 acts as a single-ended amplifier for the level-control signal supplied by the POWER LEVEL control. The reference signal supplied to the POWER LEVEL control in this mode is developed by a voltage divider from the -15 V supply. The feedback signal for the unleveled mode is developed by the A11Q10 amplifier stage which samples the voltage supplied to A_2. This feedback permits closed-loop operation of the leveler-amplifier to provide the proper leveling control voltage (and therefore output attenuation) in response to any setting of the POWER LEVEL control.

4.2 THE BACKWARD WAVE OSCILLATOR TUBE (See Figure 4-1.)

The backward-wave oscillator (BWO) tube is a voltage-tunable microwave oscillator vacuum tube. It consists of an electron gun, a slow wave structure (helix), and a collector at the far end of the slow wave structure. The rf output of the tube is produced by the interaction between the electron beam passing from the gun to the collector end and the electromagnetic field of a microwave signal developed on the slow wave structure. In Stewart tubes the collector collects all electron beam current not intercepted by the helix. In Varian BWO tubes, an ion collector is located at the target end of the slow wave structure. The helix collects all electron current in the tube since there is no electron collecting electrode at the target end of the tube. The ion collector electrode, internally connected to the cathode, is provided to collect positive ions and establish a field gradient that drives the electron current outward for interception by the helix.

Surrounding the evacuated envelope of the tube is a cylindrical permanent magnet which produces a strong axial field. This field focuses the electrons in the beam and allows movement only in the direction of the axis of the tube.

An exterior housing completely covers the magnet and tube, and no magnet adjustments are possible. The tube electrodes are connected to wire leads which are brought out through the housing for connection to the Elevated Supply PC Board A12 of the plug-in unit.

The Stewart tube electron gun contains a heated cathode and two or more aperture disc type control electrodes (grid and anode) which help form the beam and control beam density. The Varian tube electron gun contains a cathode surrounded by an aperture disc control electrode (the grid), and two screen-type electrodes (the anodes) which accelerate, control, and form the beam. Anode_1 is brought out to an external connection. Anode_2 is internally connected to the helix. The heater is a helical coil contained inside the cathode support cylinder.

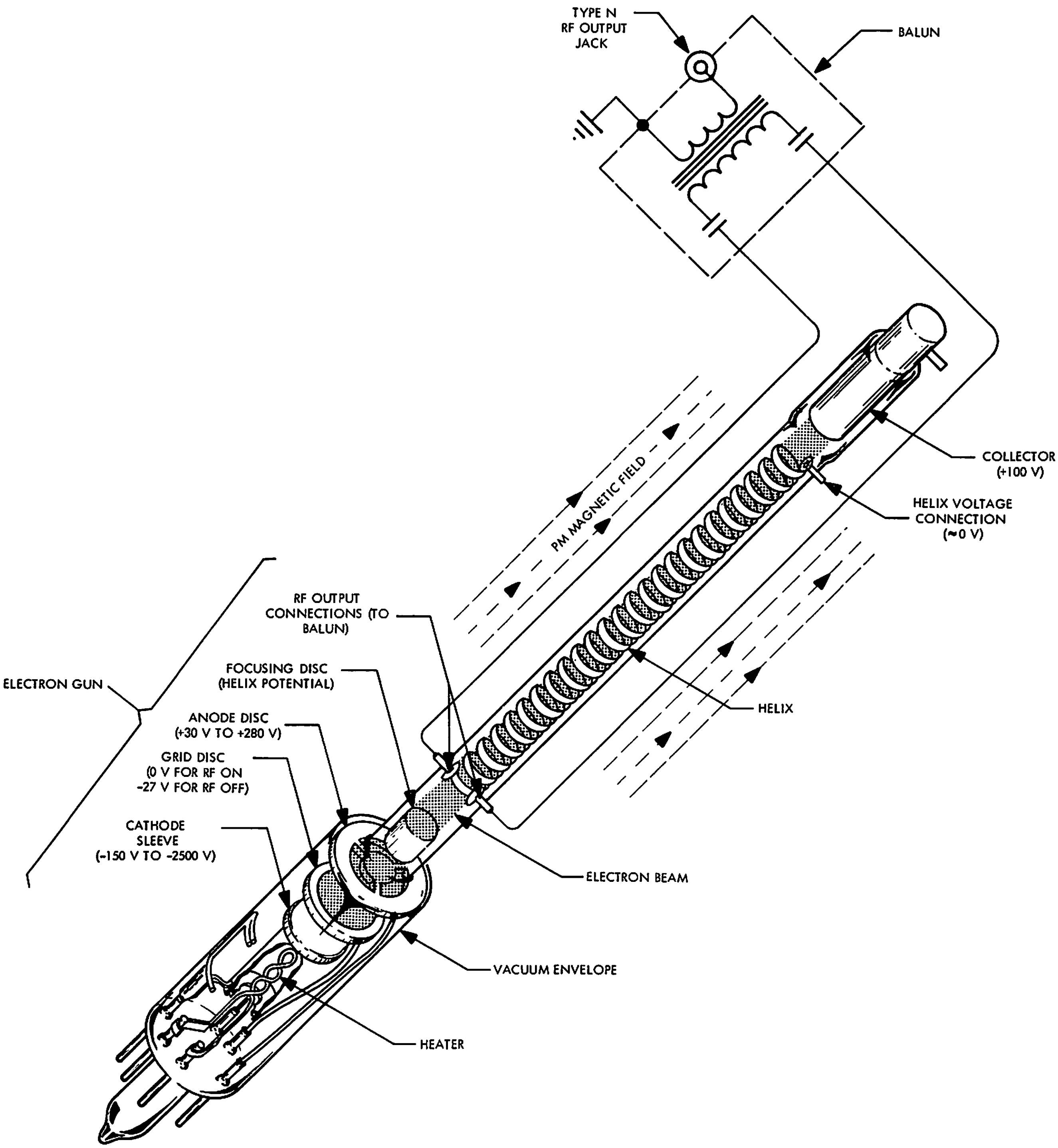
In a helix backward wave oscillator, it is desirable to have a hollow cylindrical electron beam since only the electrons that pass adjacent to the helix are fully effective in delivering energy to the wave. Electrons near the middle of the beam consume anode power but contribute little or nothing to the energy interchange that produces the backward wave oscillations. The electron gun elements are arranged to generate a hollow, circular electron beam. The magnetic field, which restricts the electrons to axial movement, then maintains the same geometry to achieve a hollow cylindrical beam throughout the length of the slow-wave structure.

The Stewart tube uses a sleeve-type cathode. In the Varian tube, the emitting portion of the cathode is a hollow cylinder having an L-shaped cross section to absorb the full radiant output of the heater and emit a thin, hollow, cylindrical electron beam having a diameter slightly less than that of the helix. The cold cathode, with a T-shaped cross-section, is fabricated from a non-emitting material and fills the remaining end surface of the cathode cylinder. The grid control field is developed between the cathode and grid disc, just outside the hot cathode ring. This provides effective control of the electron beam right at the emitting surface. The anode_1 voltage is maintained at a fixed positive level with respect to the cathode supply, so that the beam emitted from the electron gun does not change appreciably as the cathode voltage is changed to shift the operating frequency. (Since the anodes are of an intercepting type, care must be exercised not to apply too high a voltage or to permit too high a current.)

The helix is a slow-wave structure equal in length to several wavelengths of the lowest output frequency. Thus, the operating frequency range of a particular backward wave oscillator tube is primarily determined by the dimensions of the helix.

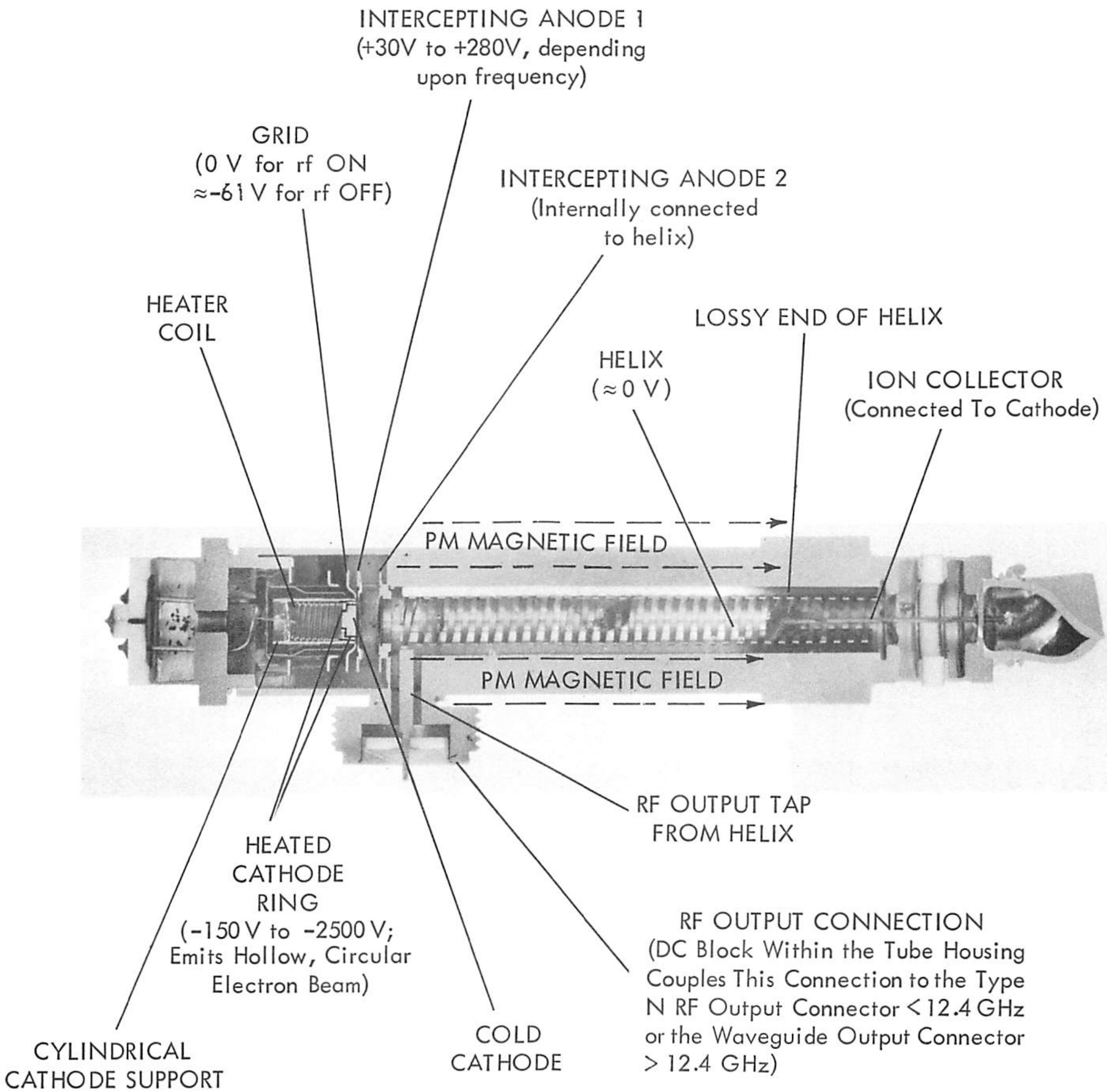
It is well known that a slow wave structure will propagate a particular range of frequencies at constant axial velocity (the non-dispersive region) and above that range, the axial velocity of propagation increases with frequency (the dispersive region). The backward wave oscillator operates in the dispersive region and it will oscillate at the frequency for which the electron beam velocity is very nearly equal to the axial velocity of propagation of the microwave signal on the helix. Figure 4-2A shows the variation of propagation velocity with frequency for a particular helix while Figure 4-2B shows how the beam velocity varies with the helix-to-cathode voltage.

From these figures it can be seen why the backward wave oscillator can be voltage tuned. By changing the helix-to-cathode voltage, the electron beam velocity changes, thereby changing the frequency for which the velocity of propagation on the helix and the velocity of the beam are in synchronism. The helix dimensions, primarily diameter and pitch,



A. STEWART BWO TUBE

FIGURE 4-1. BACKWARD WAVE OSCILLATOR TUBE



B. VARIAN BWO TUBE

FIGURE 4-1. BACKWARD WAVE OSCILLATOR TUBE

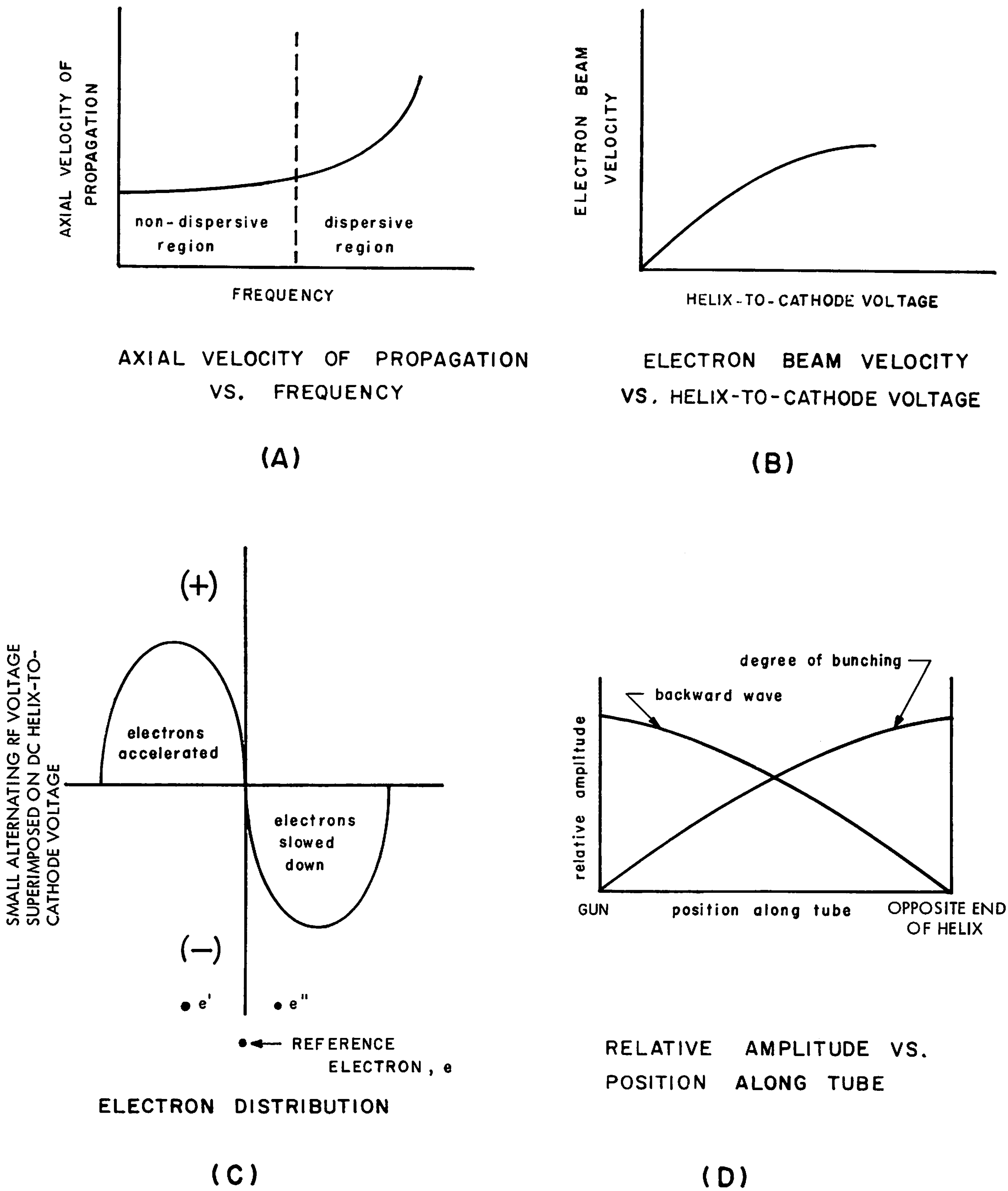


FIGURE 4-2. OPERATING CHARACTERISTICS OF BWO TUBE

are chosen so that the tuning voltages required for a particular frequency range are reasonable (usually about 200 to 2000 volts).

The oscillations, and hence the rf wave, begin in the backward wave oscillator in much the same manner as they begin in other oscillators. Noise waves are established on the helix from the shot noise coupled from the electron beam and from thermal energy developed at the input end of the tube. Rf waves are produced which travel in both directions in the helix i.e., from gun to collector and from collector to gun. Since the desired wave in a backward wave oscillator must travel from the collector to the gun end, attenuators are placed in the tube which eliminate the forward-moving waves. Amplification of the rf wave is produced by the interaction of the electrons in the beam and the electromagnetic field of the wave.

To obtain this interaction, the electron beam must be at some critical velocity which is achieved by applying a dc voltage to the helix. Because the rf electromagnetic field is alternating, electrons in the beam are subjected to either an accelerating or decelerating field. Thus, the beam electrons passing axially near the helix experience velocity modulation, with a tendency for bunches of electrons to be formed as the beam moves through the helix. The critical areas of interaction are adjacent to the spaces between the helix turns because the axial electric field is strong between helix turns and weak under the turns.

To explain the bunching process let us examine a group of electrons as they travel from the gun to the opposite end of the tube. Within this group there will be one electron, e, which corresponds to the zero point of the alternating axial field and is therefore unaffected by the signal on the helix. See Figure 4-2C. This electron experiences no acceleration from the electromagnetic field. However, electron e', just to the left of e, encounters a positive axial field and is accelerated, thus tending to catch up with e. Similarly, electron e", which is just to the right of e, encounters a negative or decelerating field and so slows down and tends to be overtaken by electron e.

The electrons centered about e are thus velocity modulated. This situation is repeated over and over again as the electrons centered about the reference electron pass one space after another enroute from the gun to the lossy end of the helix.

If the helix-to-cathode voltage is set to achieve a beam velocity such that at the collector end of the tube the phase difference between the wave and bunches in the beam is approximately one half cycle, the electron bunches will encounter relatively strong decelerating fields as they cross the spaces. Thus, the kinetic energy of the electrons is transferred to the backward wave. The amplitude of the backward wave builds up as it progresses toward the gun end of the tube because it passes more and more bunches from which it receives energy. At the same time, the alternating component of the beam current, i.e., the bunching, becomes greater as the electrons progress through the tube, because of the continuing velocity-modulation interaction between the beam and the established backward wave. See Figure 4-2D.

In the Stewart tube, the rf output signal generated on the helix is coupled off the helix at the gun end on two insulated wires which terminate in an external balun. The balun contains capacitors which block the dc operating potential and allow the output type N connector to operate at chassis ground.

These two wires are connected to the end loop of the helix at points 180° apart, to provide balanced output.

In the Varian tube, the rf output signal generated on the helix is coupled off through a dc-blocking capacitor at the gun end, and drives a properly-matched type N or waveguide output connection which operates at chassis ground.

The required cathode-to-helix operating potential is obtained by operating the helix near chassis ground and the cathode below ground. To shift the operating frequency from the low to high band limits, an exponential change of cathode supply voltage over a range of about 7:1 is required. The diode shaper board A13 is factory-set to provide the proper tuning voltage range for each tube, within the supply limits of -150 V to -2500 V.

The anode is operated at a positive potential with respect to the cathode, and the elevated supply board A12 is factory-set to provide feedback that develops the required output within the supply limits of +30 V to +280 V. The grid is operated at cathode potential for full rf output power, and at -27 V (Stewart tubes) or -61 V (Varian tubes) to cut off the electron beam, thereby turning off the rf output completely. This grid control is used for on-off modulation.

Typical cathode current is less than 30 milliamperes, and in Stewart tubes it divides between the helix and collector. In Varian tubes, it divides between the anode and helix, and all beam current not intercepted by the anode flows through the helix lead. In Stewart tubes, the collector is operated at above-ground potential through a resistor from the +100 V supply, and thus is 100 V positive with respect to the helix.

Helix, collector and anode operating currents are critical operating parameters and must not exceed the power dissipating capability of the tube elements. Proper operating current for these electrodes on the particular tube installed in each plug-in unit are indicated on Addendum A enclosed in the envelope bound into the rear of this manual. Because of variations in optimum operating currents and distribution of currents between electrodes in BWO tubes of the same type, the rf power output characteristics should be used as the principal indicator of tube performance.

The rf power output is proportional to the beam current. Beam current is controlled by both grid bias and anode voltage, and maximum beam current is limited by the power dissipating capacity of the helix and anode. Since variations in anode voltage also affect the frequency of oscillation, the sweep oscillator operates with constant anode voltage, and grid bias is used for on-off control of power output. The use of PIN diode leveling for analog power control eliminates the frequency-pulling effect that would be obtained by use of grid modulation to vary the output level. The use of grid control only for on-off control does not cause frequency pulling since the output is cut completely "off" whenever such grid voltage is applied.

In the "standby" mode when the FREQUENCY Mode Selector switch is turned OFF, the heater, cathode, anode, collector, and helix voltages are maintained, and the grid is biased to cut off the beam. With the other voltages applied, the tube is continuously being outgassed, and it has been found that through this technique, tube life is extended by more than 10%.

4.3 TUBE PERFORMANCE MONITORING. Cathode, heater, and anode supply voltages are monitored by means of TP6 through TP9 on the Model 650 chassis, which connect to the supply outputs in that unit. Grid voltage, which is developed in the active stage of the elevated supply PC Board A12 in the plug-in unit, is monitored by TP23 on the left side of the plug-in unit.

Helix current is coupled to terminal 19 of the elevated supply, through the normally-closed contact of FREQ STABILIZING INPUT connector J5. In units having Stewart tubes, this current is shunted to ground through A12R2, a factory selected resistor (nominal value 12.5 - 20 ohms) in the elevated supply in parallel with A7R14, a 49.9-ohm resistor in the helix overcurrent protection circuit (see Figure 4-10 of the Model 650 Instruction Manual). The helix current divides between the two resistors in a suitable ratio, so that a total of between 3.5 and 5 ma helix current, depending upon the tube, is required to produce 1 ma across A7R14 which trips the helix overcurrent relay. The voltage produced by the helix current flow through these resistors and through series resistor A12R15 is monitored at TP22. The monitored voltage will be 100 mv/helix ma, and will be less than 350 - 500 mv, which corresponds to the tripout level. In units having Varian tubes, the helix current is shunted to ground through A12R2 in the elevated supply, in parallel with A7R14, a 49.9-ohm resistor in the helix overcurrent protection circuit (see Figure 4-10 of the Model 650 Instruction Manual). A12R2 is a factory-selected resistor with a nominal value of 1.5-5 ohms. The helix current thus divides between the two resistors, so that a total of between 11 and 34 ma helix current, depending upon the tube, is required to produce sufficient current (about 1 ma) across A7R14 to trip the helix overcurrent relay, which also removes the anode voltage. The voltage produced by the helix current flow through these resistors and through series resistor A12R15 is monitored at TP22. The series resistor is also factory-selected, so that the monitored voltage will be 10 mv/helix ma.

Collector current is coupled to the +100 V supply through a 10-ohm resistor. TP21 is tied directly to the collector, so that the voltage developed by the collector current passing through the resistor will cause the voltage at TP21 to drop from +100 V (TP1) by 10 mv/collector ma.

The +100 V supply input to the elevated supply is not used with Varian tubes. TP21 is non-functional in units with Varian tubes.

4.4 FREQUENCY STABILIZING INPUT.

The FREQUENCY STABILIZING INPUT jack J5 provides a means of applying feedback to the helix to alter the instantaneous helix-to-cathode voltage in single-frequency operation. When generated by a suitable discriminator, such feedback can stabilize the rf single-frequency output to an accuracy approaching that of the best cavity-tuned microwave oscillators. When a mating connector is inserted in J5, it opens the normally-closed contacts shunting R6, so that the applied stabilizing feedback voltage is developed across R6, in series with the helix-to-ground voltage produced by the helix current flow through A12R2 and A7R14. When external stabilization is used, the discriminator voltage applied across R6 ranges between 0 and ±50 V. A positive voltage tends to increase the axial velocity of propagation of the electron beam by increasing the voltage differential between the cathode and helix. This tends to increase the oscillation frequency, in accordance with Figure 4-2A. Conversely, a negative voltage tends to decrease the beam velocity and output frequency. The response characteristics are mainly determined by the external feedback discriminator used to generate the stabilizing signal. The discriminator must have a low output impedance in order to supply the required helix current without affecting the voltage stabilization action.

4.5 DIODE SHAPER BOARD (see Figure 4-3).

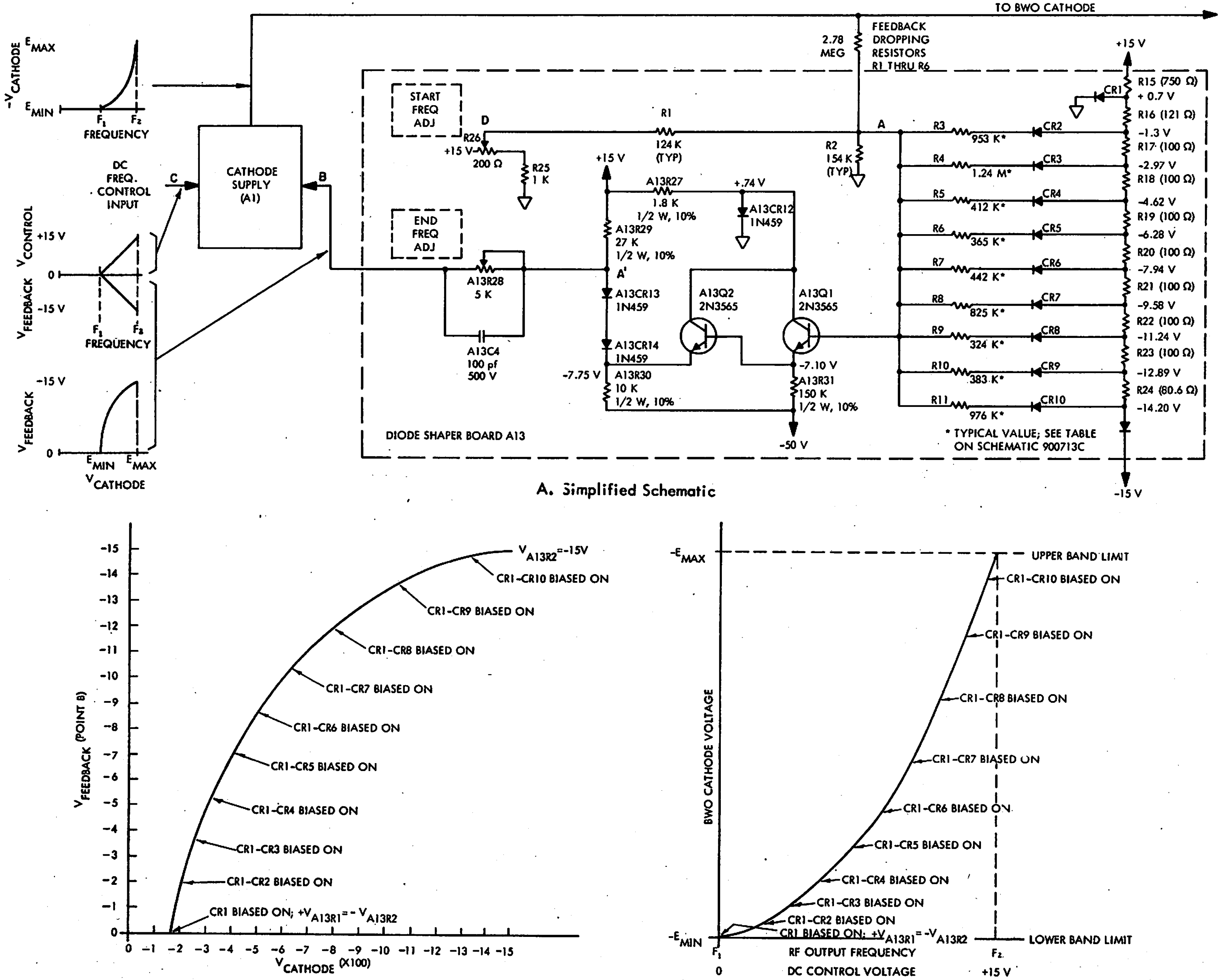
The diode shaper board plugs in to a PC connector in the lower rear compartment of the chassis, accessible from the opening in the left side of the chassis. The diode shaper board provides non-linear feedback as required to produce a tube electron beam velocity which yields frequency output that is linear with sweep time or control voltage. The non-linear relationship of frequency to propagation velocity or electron beam velocity, and the resultant requirement for non-linear helix-to-cathode voltage is evident from Figure 4-2A and B. Since the control voltage is linear with sweep time or sweep frequency, the cancelling feedback must be developed in non-linear fashion, so that a non-linear cathode voltage-vs-frequency curve will result when the feedback is used to balance out a linear control voltage.

The diode shaper board provides this non-linear feedback by shunting away an increasing portion of the feedback current through a biased-diode ladder shunt network as the output level increases. This network is biased by a resistor string connected between + and -15 V, such that only one diode is conducting at the lowest supply voltage, and all diodes are conducting at the highest supply voltage, with a non-linear turn-on curve in between. Thus, an increase in the cathode supply voltage produces a feedback voltage increase at a slower rate (negative slope derivative) as shown in Figure 4-3B. Since the cathode supply circuit increases its voltage output until the control and feedback signals applied to its summing junction cancel, this means that a linear increase in control voltage drives the cathode supply output in non-linear fashion with a positive slope derivative, as shown in Figure 4-3C, to produce feedback cancellation.

The resultant cathode supply voltage vs. frequency curve produces a linear frequency vs. control voltage performance curve. Mathematically, the curve of required cathode supply voltage vs. frequency (Figure 4-3C) approximates a third-order exponential function. By establishing a feedback curve that corresponds to the second derivative of that curve, a linear feedback voltage-vs.-frequency curve is obtained at point B, since the second derivative of a third-order function is linear.

The feedback current supplied to the low-voltage diode shaper board at point A, after passing through dropping resistors R1 through R6, is a fixed fraction of the negative cathode supply output. The feedback voltage developed between point A and ground is produced by the feedback current through A13R2. The ladder network, composed of diodes A13CR1 through A13CR10 and resistors A13R1 through A13R11, achieves the feedback slope shown in Figure 4-3B by progressively shunting a greater percent of feedback current away from A13R2 as the feedback level exceeds the "turn-on" voltage of each biased diode.

Amplifier stages A13Q1 and A13Q2 are emitter-follower stages that serve as an impedance converter amplifier to provide a low-impedance output at point B with the same voltage as the feedback level at point A. The point B output then serves as a suitable low-impedance source for summing junction feedback current through summing resistors A1R6 and A1R38 in the cathode supply.



B. Typical Diode Shaper Feedback Characteristic

C. Typical Overall Voltage vs. Frequency Characteristic for the Feedback-Controlled Cathode Supply

FIGURE 4-3. SIMPLIFIED SCHEMATIC AND OPERATING CHARACTERISTICS OF DIODE SHAPER BOARD

Resistors A13R15 through A13R24 and diode A13CR11 establish the bias on the diode string, and are the same value in all shaper boards. Diode A13CR1 stabilizes the voltage at the junction of A13R15 and A13R16 as the current load changes during feedback shunting conditions. Resistor A13R1 through A13R11 are different for each plug-in unit model, and are selected to obtain the desired curve by shunting away a greater percent of the increasing feedback current as the feedback voltage level reaches the forward-biasing point for each diode. The overall effect is that the feedback voltage developed at point A rises as cathode voltage increases, but at a slower rate, because resistors A13R3 through A13R11 shunt away part of the current that would otherwise pass through A13R2 to develop feedback voltage between point A and ground.

The resultant feedback voltage curve (Figure 4-3B) is a smooth-curve approximation with nine (9) gradual slope changes as the feedback level reaches the turn-on points of A13CR2 through A13CR10. The decrease in slope at each turn-on point is related to the additional shunting effect of the individual resistance values of A13R3 through A13R11 and the net difference between the level at point A and the return voltage of each diode.

At the low band-edge output frequency, the cathode supply output voltage must have a negative value corresponding to the minimum bias requirement of the tube, while the control voltage is zero. Thus, a zero feedback voltage must be developed at a finite supply output level, as shown by the X-axis intercept of the curve in Figure 4-3B. This is accomplished by selecting the value of A13R1 and setting its return voltage (point D) at a positive level between 12.5 and 15 V by means of Start Frequency Adjust resistor A13R26. This positive offset circuit then biases point A positively until the cathode supply voltage increases to the point where the cathode supply feedback voltage supplied to point A equals the positive offset voltage. This establishes a 0-volt null at point A, as required for zero feedback voltage. As the control voltage is subsequently increased above 0 to +15 V, the feedback developed at point A increases non-linearly from 0 to -15 V.

The dc impedance converter amplifier (A13Q1 and A13Q2) consists of two cascaded emitter follower stages with the collectors held close to ground level by A13CR12. Diodes A13CR13 and A13CR14 compensate for the sum of the emitter-base drops in A13Q1 and A13Q2 when these transistors are biased to heavy conduction by a 0-level feedback signal at point A, thus developing a 0-level signal at point A'. As the feedback signal increases to the -15 V level, the conduction of A13Q1 and A13Q2 decreases so that the voltage at A' tracks that at point A, but has a higher source impedance to drive the summing junction.

The End Frequency Adjust resistor A13R28 provides an adjustment for the feedback current supplied from the diode shaper board to summing resistor A1R6 in the cathode supply. It can be used to adjust the overall slope of the diode shaper board curve by establishing the feedback level required to generate 1 ma feedback current to the summing junction at the upper band limit. This then sets the maximum cathode supply voltage limit corresponding to that required by the BWO tube for the upper band-limiting frequency. When the BWO tube is replaced, adjustment of A13R1 and A13R28 permits the feedback of the diode shaper board to be tailored to the characteristic of the new tube without requiring replacement of fixed resistors on the diode shaper board.

4.6 LEVELER AMPLIFIER. (See Figure 4-0 and Foldout Schematic D900933.)

4.6.1 GENERAL.

The leveler-amplifier is located in the upper compartment of the plug-in unit chassis, near the front. It operates as a closed-loop differential error signal amplifier, driving the PIN diode attenuator assembly to correct for differences between the control and sampler signal levels applied to the differential input stage through A11-6 and A11-7. The output signal is applied to the PIN diode attenuator driver from A11-15, to control both the leveling and matching diodes.

The main leveling loop consists of A11Q1-Q5, A11Q7-Q9, and A11Q11. A11Q1 serves as a differential summing junction, and receives the reference voltage, e_r , from the POWER LEVEL control, and the rf sampler detector output signal, e_s. It develops an error output signal, ϵ_1 , which is amplified by differential stage A11Q3/Q4 and single-ended stage A11Q5. The output, e_1 , from A11Q5 is combined with e_2 at A11Q7/Q8, which serves as another differential summing junction. The final error signal, ϵ_2, developed by A11Q7/Q8 is amplified by single-ended stage A11Q11 which supplies the control voltage to the leveler driver.

Within the self-balancing leveling system, the PIN diode attenuator can be thought of as a variable-gain attenuator which offers the greatest attenuation in response to the highest sample voltage and the least attenuation in response to the lowest sample voltage, thereby tending to maintain the power output constant at the desired level which corresponds to the POWER LEVEL control setting. The gain equalizing loop functions to improve the performance of the variable-gain leveler attenuator by attempting to hold the amplification from e_1 to e_s constant, regardless of the power level at which the error occurs. It thereby compensates for the sampler crystal sensitivity variations and the natural gain-bandwidth variation of the amplifier in responding to error signals. Over the full-control range of the leveler (which is variable attenuation range >15 db, the gain equalizing loop attempts to maintain a constant effective gain from e_1 to e_s of -20 db, so that e_s tends to be 20 db below e_1 regardless of the absolute level of e_s.

4.6.2 OPERATION OF MAIN LEVELING LOOP AND GAIN-EQUALIZING LOOP IN LEVELED MODE.

Detailed operation of the main loop and gain-equalizing loop is as follows: If the rf output tends to increase to a greater level than that corresponding to the setting of the POWER LEVEL control, the (-) voltage applied to A11-7 from the sampler detector will exceed the reference level applied to A11-6. A11Q1 will become unbalanced, so that the conduction of its right-hand side will be diminished, and the left-hand side will tend to conduct heavily and take control of the stage. The heavier conduction through A11R1, compared with A11R2, will provide greater forward bias to A11Q4, compared to A11Q3, so that A11Q4 conducts more heavily and takes control of the A11Q3/Q4 differential stage. The output from this stage, obtained from the collector of A11Q3, goes negative due to the diminished conduction of A11Q3. This negative-going output tends to reduce the conduction of A11Q5, so that its single-ended output is positive-going. This positive-going signal is applied to the base of A11Q7.

This positive-going voltage change reduces the conduction of A11Q7, producing a negative-going change at the base of A11Q11. The conduction of A11Q11 is thereby increased, drawing more current through A11R37, to drop the leveler control voltage at A11-15. The PIN diode leveler increases its attenuation in response to a drop in control voltage, thus tending to correct for the increase in output power that produced the error signal. Conversely, if the rf output tends to decrease to a level below the setting of the POWER LEVEL control, error signal polarities will be reversed, and the conduction of A11Q11 will be reduced, so that the leveler control voltage becomes less negative, thereby reducing the attenuation. The control signal range at A11-15 is -2 V (maximum attenuation) to -0.5 V (minimum attenuation).

The control signal magnitude produced by the error signal applied to A11Q7 is altered by A11Q8, the other half of the differential stage, which is controlled by the gain equalizing loop amplifier. The negative-polarity sampler signal at A11-7 is applied to the left-hand base of A11Q6 in the gain equalizing amplifier, to provide this control. The sampler signal tends to reduce the conduction of that side of the differential stage by an amount proportional to its magnitude. Since the right-hand base of A11Q6 is connected to ground, this side will always conduct more heavily, but the amount of excess conduction will be proportional to the sampler signal level, i.e. a low-level sampler signal will allow both sides of A11Q6 to conduct almost equally, while a high-level signal will reduce the conduction of the left-hand side, so that the righthand side conducts more heavily. As conduction of A11Q6(R) increases, increased forward bias is applied to A11Q8, causing it to rob current from A11Q7. This reduces the error signal amplification of A11Q7 at high power levels where crystal sensitivity (in terms of Δ db/mv) is greater, and increases it at low power levels where crystal sensitivity is lower. Thus, the gain from e_1 to e_s tends to remain constant.

4.6.3 OPERATION OF PIN DIODE ATTENUATOR AND DRIVER CIRCUIT.

The PIN diode attenuator consists of a pi-network of four shunt diodes and two series diodes connected to form a variable-attenuation transmission line with input and output matching at all attenuation levels. PIN diodes act as electically variable resistors at microwave frequencies, with resistance inversely related to forward bias current in a non-linear manner. Each diode can be varied in resistance over a range of about 10,000 ohms to less than 25 ohms as the applied dc bias current varies from reverse-bias conditions to a maximum forward bias of about 30 ma.

The overall attenuation of the attenuator module ranges from a minimum of ≈ 5 db (max. insertion loss of the structure with the series diodes biased "on" and the shunt diodes biased "off") to a maximum of ≈ 33 db (max. attenuation with the series diodes biased "off" and the shunt diodes biased "on"). In operation the attenuation is controlled over this range by individual signals supplied to each series and shunt diode by the leveler driver circuit, in response to the single control signal developed at A11-15. Thus, a control signal ranging from -0.5 V to -2.0 V from A11 provides full attenuation control from minimum to maximum, respectively.

The attenuator driver circuit and PIN attenuator are factory-adjusted to operate as a single, non-repairable module. The driver circuit includes a control function shaping circuit and separate, factory-adjusted current driver amplifiers for each series and shunt diode. The module has ample design margins in each circuit to assure long life and trouble-free performance. No re-adjustment should be required for the life of the module.

4.6.4 OPERATION IN UNLEVELED MODE.

In the leveled mode, the leveler circuits operate as a closed loop rf level control system with rf sensing and feedback. In the unleveled mode, the system operates as an open-loop rf level control system, and electronic feedback is developed within A11 to close the control signal loop without rf sensing. In the unleveled mode, S2 (C) grounds the sampler signal input so that e_s is zero. This disables the gain equalizing loop and converts the main leveling loop to single-ended rather than differential amplifier operation. To permit stable control of the power level of the unleveled signal using the POWER LEVEL control R9, amplifier A11Q10 develops a negative feedback signal proportional to the control signal amplitude. This feedback current, combined with the POWER LEVEL control signal current at A11-6, reduces the open-loop gain of the main leveling loop and causes it to operate as a stable dc operational amplifier having gain set by the ratio of A11R31 to R8 (6.67:1). (A11Q10 and A11Q11 are unity-gain emitter followers which provide output isolation and low impedance drive for the feedback and attenuator control outputs.)

In the unleveled mode R9 is driven by a -275 mv signal developed by R3 and R2 from the -15 V supply. The leveler amplifier, operating as a dc operational amplifier, converts the ≈30-275 mv output range of the POWER LEVEL pot R9 into a -2.1 V to -0.4 V attenuator control range, to provide control from maximum to minimum attenuation respectively.

4.6.5 DEVELOPMENT OF REFERENCE LEVEL INPUT SUPPLIED TO A11-6.

4.6.5.1 Leveled Operating Mode. The reference level supplied to A11-6 in the leveled operating mode is the sum of the control signal tapped from the POWER LEVEL potentiometer, R9, and the control voltage "maximum limit" feedback signal developed at A11-17 through A11CR2. Within PC board A11, there is another feedback loop consisting of A11CR1 which supplies the control voltage "minimum limit" feedback signal to the common junction of A11-6 and the left-hand base of A11Q1.

In the leveled mode, the POWER LEVEL pot is driven by the leveler reference output from the modulator (A5-R via P6-8). This signal has a maximum amplitude of about -300 mv corresponding to unmodulated output, and an amplitude of 0 V corresponding to "full off" modulation. Thus, during square-wave or other "on-off" modulation, the leveler reference signal at A11-6 is reduced to 0 V at the same time the rf output drops to 0 (which causes the sampler input at A11-7 to drop to 0), so that the leveler can remain in balance rather than being driven to saturation. With unmodulated output, the variable level applied to A11-6 by adjusting the POWER LEVEL control R9 ranges between 300 mv and a minimum level set by A11R5, which is connected between R9 and ground. Adjustment of A11R5 sets the minimum level of the output provided by R9 between -60 mv and 0 mv, and the normal setting is selected to provide a power control range of 10 db below the power level at which full-band leveling occurs.

The voltages at A11-6 and A11-7 are near zero during the "rf off" time for retrace between sweeps or square wave modulation. In this condition the difference in values of A11R1 and A11R2 causes the A11-15 quiescent control voltage to go negative. The control voltage "maximum limit" feedback applied to A11-6 through A11-17 keeps the A11-15 control voltage from going more negative than a value (set by A11R42) corresponding to about 11 db below full band leveling (≈ -2 V). This gives a faster response time when the rf turns on than would occur if the control voltage was allowed to go more negative.

The control voltage "minimum limit" feedback applied through A11CR1 to the common junction of A11-6 and the left-hand base of A11Q1 provides feedback when the output level is set above the maximum which allows full-band leveling. This feedback limits the excess error voltage developed during the low power portions of each sweep, to prevent A11Q7 from being saturated in an attempt to reduce the A11-15 output below the level at which minimum signal attenuation is achieved. It sets the minimum output of A11-15 to about -0.4 V. By preventing saturation in the amplifier, this feedback provides faster response and a smooth transition between leveled and unleveled portions of a sweep at high power levels where only partial-band leveling is possible.

4.6.5.2 Unleveled Operating Mode. When S2 is in the UNLEVELED position, it removes the "maximum limit" feedback supplied by A11CR2 and applies control feedback from A11Q10 to A11-6 as described in paragraph 4.6.4 above. The POWER LEVEL control is driven by a fixed level of about 270 mv supplied by R3 and R2.

4.6.6 UNLEVELED LIGHT OPERATION.

The UNLEVELED WHEN LIT light is connected to +100 V through R4, and glows continually in the unleveled mode, when amplifier A4 is disconnected from the light by S2 (D). In leveled operation S2-D connects the output of amplifier A4 to shunt the lamp-energizing current to ground when leveled operation occurs.

The unleveled light driver amplifier A4 operates as follows: The input stage A11Q12 receives the unleveled sensing signal from A11-20. When operation is continuously leveled over the band being swept, this sensing signal is continuously more negative than -3.75 V. This causes emitter follower A11Q12 to either be biased to cutoff (emitter output = 0 V), or to conduct so slightly that its output is less than +0.6 V. In either case, A11Q13 remains cut off because its base does not receive sufficient bias to produce conduction. With A11Q13 cut off, the A11Q14 base is driven by +15 V through A11R47. A11Q14 then conducts heavily and shunts A11-22 to ground, to extinguish the UNLEVELED light.

When operation is not leveled over the full band being swept, the unleveled sensing signal at A11-20 becomes less negative than -3.75 V over some or all of each sweep interval. These voltage excursions produce sufficient conduction in A11Q12 to base bias of A11Q14 to ground level, cutting it off and discharging capacitor A11C10. A11-20 is then no longer shunted to ground, and the UNLEVELED light is turned on. The time constant of A11R47/C10 prevents A11Q14 from conducting if operation is unleveled over any portion of the cycle. Only when the A11-20 signal is continuously more negative than -3.75 V over the full sweep (indicating leveled operation) will the UNLEVELED light stay extinguished.

4.6.7 ADDITIONAL CIRCUIT DETAILS.

4.6.7.1 Constant-current Operation of Differential Error Detector/Amplifier Stages. Differential stages A11Q1 and A11Q7/Q8 operate in the common-emitter configuration and in a constant-current mode, driven by A11Q2 and A11Q9, respectively. Constant-current operation is required to provide excellent common-mode rejection, so that 0 V differential output occurs with 0 V differential input.

4.6.7.2 Response Shaping. In the Gain Equalizing Loop, networks A11C6/A11R21, A11C7/A11R27, and A11C8/A11R26 provide proper response shaping to provide stable operation. In the Main Leveling Loop, A11C3 provides the basic 6 db/octave response roll-off. The networks A11C4/A11R9 and A11C5/A11R14 provide main loop compensation for the frequency characteristics of the Gain Equalizing Loop.

4.7 PIN DIODE ATTENUATOR POWER SUPPLY. (See Figure 4-0 and Schematic B900930.)

This supply receives 115 Vac from P6 on the plug-in unit chassis. The regulator components are contained on PC board 951087 located in the lower rear compartment of the chassis, just inside and above the opening in the left side of the plug-in unit. The transformer A14T1 and filter capacitor A14C1 are located on the chassis adjacent to the PC board. The 12.6 V output of A14T1 is full-wave rectified by A14CR1 and filtered by A14C1. A14Q1 regulates the output voltage to -12 V, controlled by closed-loop regulator-amplifier A14Q2/A14Q3. The output voltage is sampled by the wiper of A14R6 and applied to the base of A14Q3. The emitter of A14Q3 is held at -4.3 V by zener diode A14CR2. The V_{be} difference voltage thus establishes a low level of conduction in A14Q3. This conduction increases as the output voltage tends to become less negative than -12V. It decreases as the output voltage tends to increase to more than -12 V.

In operation, increased conduction of A14Q3 produces a voltage drop across A14R5 that increases the forward bias of A14Q2. Increased conduction of A14Q2 provides increased forward drive to regulate transistor A14Q1, causing it to conduct more heavily. This produces a negative-going change in the output voltage, to correct for the voltage decrease that caused the increased conduction of A14Q3. A14R1 and A14R3 establish basic working bias conditions for A14Q1. A14C2 filters the regulated output. The + output lead is connected to chassis ground, and the -12 V is used to supply operating power to the PIN diode attenuator.

4.8 ELEVATED SUPPLY.

The elevated supply is located on the front side of the deck that separates the upper front compartment of the chassis from the rear compartment. The passive circuits of the elevated supply PC Board A12 are illustrated and discussed individually in the paragraphs covering related circuits in the main chassis, in Section 4 of the Model 650 Instruction Manual.

The grid modulator A12Q1 is the only active stage in the elevated supply. Operating in the common-base configuration, it acts as an impedance converter and isolator for the output drive current developed by the transfer oscillator driver stage A9Q4.

After passing through A12Q1 the drive current develops the necessary grid bias across A12R5 to operate the grid at a voltage negative with respect to the cathode (0 line). For tube cut-off, a maximum driver/modulator current of 35 ma across A12R5 produces the necessary cut-off bias of -27 V for Stewart tubes at A12-13, and the added drop across A12R4 produces the necessary cut-off bias of -61 V for Varian tubes at A12-14. If a particular Varian tube requires much lower drive voltage, this is achieved by connecting the grid to A12-13 (for -27 V drive) or by interchanging A12R4 and A12R5 and connecting the grid to A12-13 (for -37 V drive). Such changes, when made, are noted on the Addendum A sheet. Diode A12CR7 provides a fixed base bias to A12Q1. In instruments below S/N 1481, where A12Q1 is a 2N699, zener diodes A12CR5 and A12CR6 are connected in series with its emitter to provide a drop of 30 V as necessary to protect A12Q1. Diode A12CR1 prevents the grid from ever being driven positive with respect to the cathode. Diode A12CR3 prevents the grid from ever being driven more negative than -100 V from cathode.

4.9 ANODE PROTECTION FUSE.

Varian BWO tubes contain a mesh-type intercepting anode (see Figure 4-1B). The power dissipation of this delicate anode electrode must not be allowed to exceed specified ratings. To protect against excess dissipation, an anode protection fuse is installed in plug-in units containing Varian tubes. The anode protection fuse is located in the upper rear compartment of the chassis, above TP21, 22, and 23. It is a 10 ma fuse on all units unless otherwise noted on Addendum A in the envelope at the rear of this manual. This fuse is connected as shown in overall schematic D907053. It completes the connection between A12-4 and A12-5 to couple the anode supply voltage from P7-1 through to the BWO anode. (Plug-in units not containing the anode protection circuit have a shunt wire connecting A12-4 and A12-5 in the elevated supply.)

Blow-out of the fuse will be indicated by disappearance of rf output with power applied.

4.10 LOW PASS FILTER. (Units with Internal Sampling.)

Most plug-in unit models with an internal sampler contain a low-pass filter as the first element in the rf output line from the BWO tube. This filter is a transmission-type resonant structure which attenuates rf harmonics generated by the BWO tube. Plug-in units without an internal sampler (i.e. without the "K" model number suffix) do not contain a low pass filter unless they contain a Varian tube model having an internal filter (see Table 1-1). When external leveling is desired on instruments not having a filter, it may be necessary to add a low-pass filter externally between the RF OUTPUT jack and the external sampler to improve leveling performance. Harmonic output without the filter will be at least 20 db down, but still may generate enough "noise" voltage at the crystal detector to degrade leveling performance at the upper end of some frequency bands.

SECTION 5 - MAINTENANCE

NOTE: Main paragraph topics in this section are numbered to agree with similar paragraphs in the Model 650 Instruction Manual. The material in this section should be used in conjunction with the Maintenance Section (Section 5) of the Model 650 Instruction Manual, which contains material pertinent to all plug-in units. This manual contains supplementary material pertinent to the plug-in "family" covered by this manual.

5.1 PERIODIC MAINTENANCE.

Refer to Model 650 Instruction Manual.

5.2 VOLTAGE AND CURRENT MEASUREMENTS AT CHASSIS TEST POINTS.

WARNING

The voltages and current pickoffs pertaining to the plug-in unit, available at test points on the left side of the Model 650 chassis and the plug-in unit, are at high-voltage levels. Suitable high-voltage measurement techniques and precautions must be used. The cathode supply output (TP6) is measured with respect to chassis ground, and a high-voltage voltmeter or a high-voltage probe must be used. For all other high voltage measurements, the "0 line" (TP10) which is at or near cathode potential is the reference rather than chassis ground, and a floating voltmeter with at least 3000 volts insulation must be used. The heater supply output between TP7 and TP8 may be measured with high voltage off, using a standard meter. The lowest cathode supply output voltage, which in some plug-in units is low enough for measurement without an insulated meter, is obtained with a single frequency setting at the low end of the band. Other high voltage measurements should be made at this setting of the cathode supply to keep the "0 line" voltage as low as possible for safety reasons.

a. Cathode Supply Voltage. [TP6 (-) to chassis ground (+)]. The proper cathode supply output voltages for the lower and upper band limit frequencies, corresponding to single-frequency settings of 0 and 100 on the logging scale, are given in Addendum A in the envelope at the rear of this manual. When a replacement BWO tube has been installed, refer instead to the manufacturer's data sheet for the tube, which should be in the same envelope. Make the dc voltage measurement with a high voltage digital meter or a suitable voltage-divider probe. Refer to Paragraph 5.3.4 of this manual for measurement of ripple effects.

b. Heater Voltage. [TP7 (+) to TP8 (-)]. All the BWO tubes utilize less than 1.5 amperes heater current, so that the proper heater voltage with one of these plug-in units loading the supply is 6.3 V ±0.1 V. It is recommended that this voltage be measured with the high voltage turned off by removing the top or rear panel to defeat the interlock switch. If the measurement is made with high voltage on, the heater will be at cathode potential, and a floating insulated voltmeter must be used.

c. -100 V Supply. [TP10 (+) to TP11 (-)]. Voltage should be 100 ± 0.1 V. For this measurement, the instrument must be operating with the FREQUENCY Mode Selector switch set to SINGLE, and with no modulation applied. The measurement must be made using a floating, insulated voltmeter.

d. Anode Supply. [TP9 (+) to TP10 (-)]. The proper anode supply voltage output setting is given in Addendum A in the envelope at the rear of this manual. When a replacement BWO tube has been installed, refer instead to the manufacturer's data sheet for the tube, which should be in the same envelope. The measurement must be made using a floating, insulated voltmeter.

e. Grid Voltage. [TP10 (+) to TP23 (-)]. Voltage should be ≈0 V with controls set for RF ON (unmodulated); and 61 ± 10 V (for Varian BWO tubes; less if noted on Addendum A) or 27 ± 2 V (for Stewart or WJ BWO tubes) with the FREQUENCY Mode Selector switch in the OFF position. The measurement must be made using a floating, insulated voltmeter.

f. Collector Current.

Instruments Having Varian BWO tubes: Collector current cannot be measured on Varian BWO tubes. All beam current is intercepted by the helix. The "Collector Current" test point (TP21) on these plug-in units should not be used.

Instruments Having Stewart (W-J) BWO tubes: [TP1 (+) to TP21 (-)]. The proper collector currents in ma for the lower and upper band limit frequencies, corresponding to single-frequency settings of 0, 50, and 100 on the logging scale, are given in Addendum A in the envelope at the rear of this manual. When a replacement BWO tube has been installed, refer instead to the manufacturer's data sheet for the tube, which should be in the same envelope.

To measure the collector current, measure the voltage drop between TP1 (+) and TP21 (-). This is the voltage drop produced across a 10-ohm resistor by the collector current. Hence, the voltage measured in millivolts must be divided by 10 to obtain the current in milliamperes.

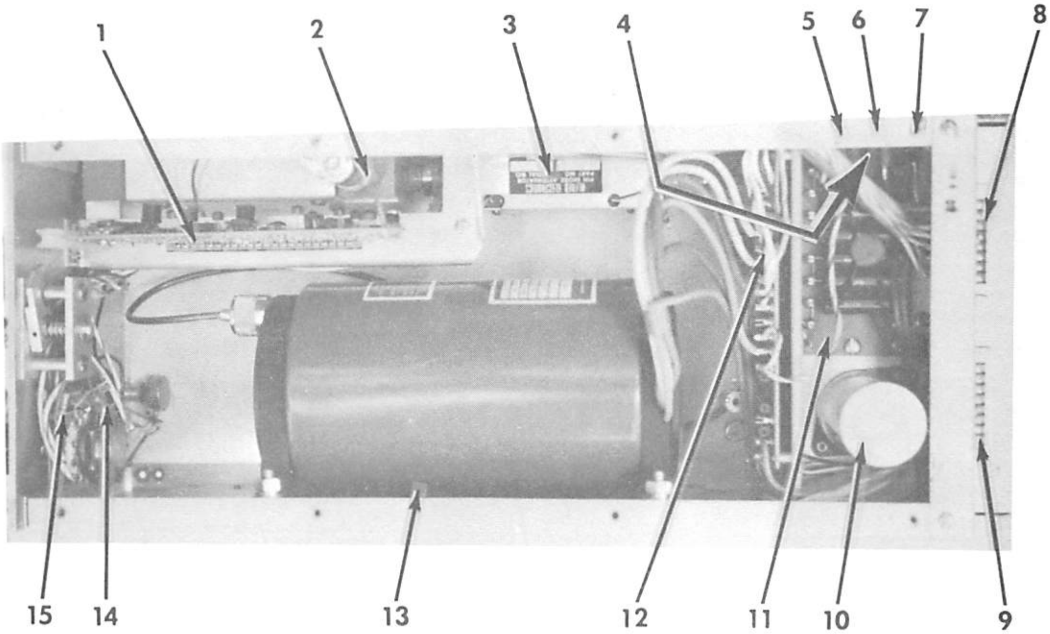
CAUTION

This voltage measurement is at the level of +100 V, since TP1 is the +100 V test point. Thus, the voltmeter used must be floating, but need not be a high-voltage unit.

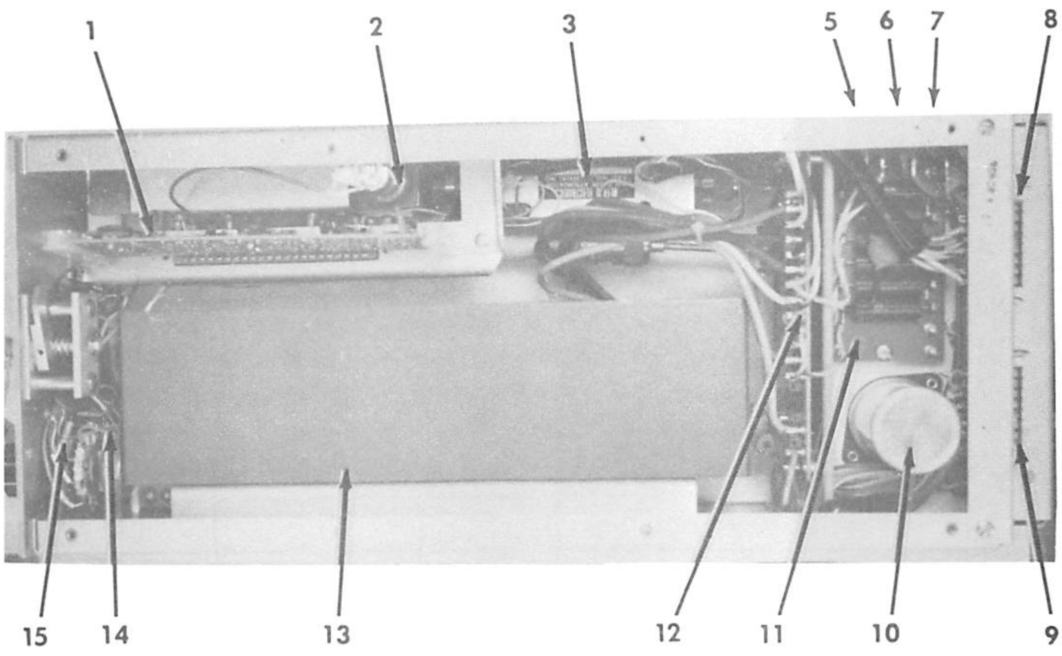
g. Helix Current. [TP22 (-), TP3 or chassis ground (+)]. The proper helix currents in ma for the lower and upper band limit frequencies, corresponding to single-frequency settings of 0 and 100 on the logging scale, are given in Addendum A in the envelope at the rear of this manual. When a replacement tube has been installed, refer instead to the data sheet for the new tube, which should be in the same envelope.

NOTE: The helix overcurrent trip-out level is listed in Addendum A.

Instruments Having Varian BWO tubes: To measure the helix current, measure the voltage drop between TP22 and TP3 (or chassis ground) with the controls set for



A. Plug-in unit having Varian BWO Tube

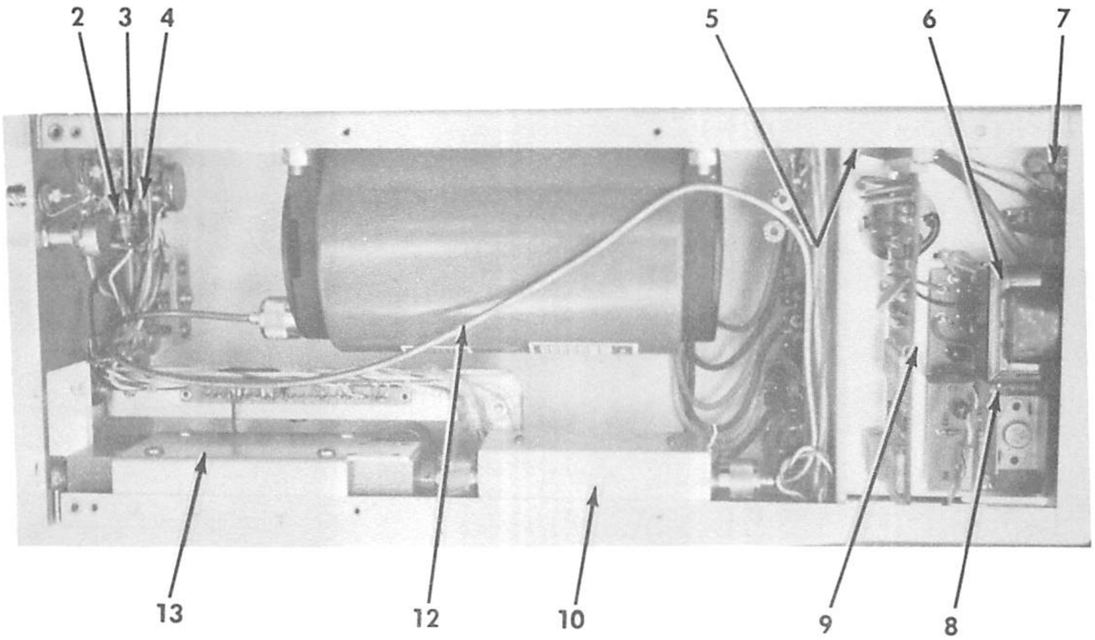


B. Plug-in unit having Stewart or WJ BWO Tube

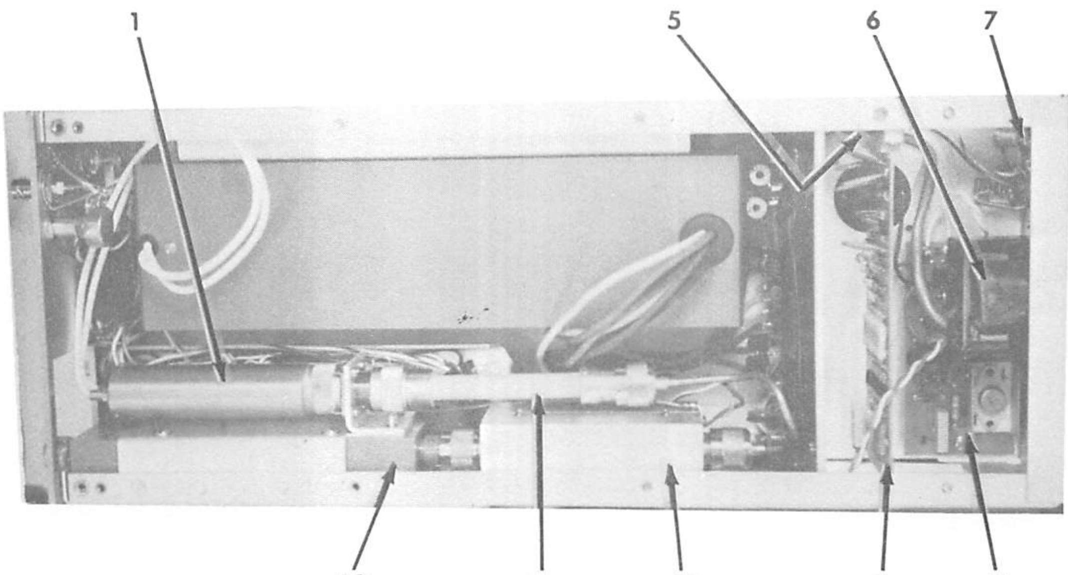
LEGEND FOR FIGURE 5-1

1. LEVELER-AMPLIFIER PC BOARD A11
2. INTERNAL SAMPLER (Consists of directional coupler + crystal detector; provided in plug-in units having K suffix only)
3. PIN DIODE ATTENUATOR MODULE (Assembly of PIN Diode Attenuator and PIN Diode Driver, which is non-adjustable and non-repairable in the field)
4. ANODE PROTECTION FUSE (Used with Varian BWO tubes - which have intercepting type anode-only; 10 ma unless otherwise noted.
5. TP23 (GRID)
6. TP22 (HELIX)
7. TP21 (COLLECTOR) (Non-functional or grounded in units having VARIAN BWO tubes)
8. P7
9. P6
10. A14C1
11. HIGH VOLTAGE FEEDBACK BOARD A25
12. ELEVATED SUPPLY PC BOARD A12
13. BWO TUBE
14. R8
15. R4

Figure 5-1. Top View of Plug-in Unit



A. Plug-in unit having Varian BWO Tube



B. Plug-in unit having Stewart or WJ BWO Tube

LEGEND FOR FIGURE 5-2

1. BWO TUBE OUTPUT BALUN (Part of Stewart/WJ BWO tube assy; serves as tube RF output connection; not used on Varian tubes.)
2. R2 }
3. R3 } Same location in both plug-in units; visible here only on photo of unit containing Varian BWO
4. R1 }
5. TIME METER M1 (Optional; no longer used on instruments having 1-year BWO tube warranty)
6. A14T1
7. R6
8. PIN DIODE ATTENUATOR POWER SUPPLY A14
9. DIODE SHAPER PC BOARD A13
10. PIN DIODE ATTENUATOR MODULE (Assembly of PIN Diode Attenuator and PIN Diode Driver, which is non-adjustable and non-repairable in the field)
11. OUTPUT LOW-PASS FILTER (Used only in Plug-in units having an internal sampler when the BWO tube structure does not contain an internal low pass filter)
12. BWO-TO-PIN ATTENUATOR MINIATURE COAX CONNECTION (Varian BWO tube shown contains an internal low-pass filter; when the tube does not contain an internal filter, an external filter is installed at this point in the rf circuit on plug-in units having internal sampling)
13. INTERNAL SAMPLER (Consists of directional coupler + crystal detector; provided in plug-in units having K suffix only)

Revised 12/15/69

Figure 5-2. Bottom View of Plug-in Unit

RF ON (unmodulated). This is the voltage drop produced across a 10-ohm resistance by the helix current. Hence, the voltages measured in millivolts must be divided by 10 to obtain the current in milliamperes. This voltage measurement is at ground level so that a floating or high voltage voltmeter need not be used.

Instruments Having Stewart (WJ) BWO Tubes. To measure the helix current, measure the voltage drop between TP22 and TP3 (or chassis ground). This is the voltage drop produced across a 100 Ω resistance by the helix current. Hence, the voltage measured in millivolts must be divided by 100 to obtain the current in milliamperes. This voltage measurement is at ground level so that a floating or higher-voltage voltmeter need not be used.

h. Anode Current. (To be measured only on instruments having Varian BWO Tubes.) The maximum allowable anode current and voltage are listed in Addendum A. On units having an anode protection circuit, the current trip-out level is indicated on Addendum A. Operating current level is typically well below the maximum value. To measure the anode current, use a clip-on milliammeter to monitor current in the red lead which connects to terminal 5 of the Elevated Supply PC Board A12.

WARNING

It will be necessary to remove the instrument top cover and "cheat" the interlock switch to operate the unit with access to the anode lead. Avoid touching the exposed live circuits.

5.3 INTERNAL ADJUSTMENTS.

5.3.1 AVAILABLE ADJUSTMENTS. There are six field-adjustable internal adjustments in each plug-in unit. The instrument is designed for long-term operation with a minimum of adjustment. The main purpose of the adjustments provided is to simplify the recalibration of the plug-in unit after installation of a new BWO tube or other components. These adjustments can also be used for periodic recalibration at six-month intervals or as required. The adjustments and a recommended adjustment procedure for each, are described in the paragraph below. These procedures permit the plug-in unit to be calibrated to meet published specifications, when operating in a Model 650 main chassis which has been factory calibrated or field-calibrated with a Sweep Oscillator Calibration Plug-in unit, Model 650T.

A factory calibration service is available at nominal cost by returning the instrument to ALFRED. Contact your nearest representative or our sales department.

NOTE: Refer to the Model 650 Instruction Manual for adjustment procedures for the heater supply voltage (A6R21 HEATER ADJ., Paragraph 5.3.3), the -100 V supply voltage (A6R5 -100 V ADJ., Paragraph 5.3.3). These adjustments are accessible from the top of the Model 650 chassis, as shown in Figure 5-1 of the Model 650 Instruction Manual.

5.3.2 ADJUSTMENT PROCEDURES. (The adjustments are shown in Figure 5-2 of the Model 650 Instruction Manual and Figure 5-1 of this manual.)

CAUTION

Use a non-metallic screwdriver in making these adjustments. Use of a metallic screwdriver can

(1) Damage magnetic focus of microwave tube
(2) Cause circuit-damaging shorts in the area between the access opening and the adjustment screw.

1. A12R9 ANODE ADJUST Adjustment. This control is used for fine adjustment of the anode voltage supplied to the BWO tube, after installation of the proper-value resistor in the A12R14 circuit position. Re-adjustment will usually be required when the BWO tube is replaced, and may also be useful to restore the power output level of an aging BWO tube. The final criterion of a proper anode voltage adjustment (assuming other voltages are correct) is that rated power output is obtained. Thus, the final adjustment of anode voltage should be made in terms of output power, in accordance with the procedure of Par. 5.3.5, rather than setting the voltage to a specific value. For a newly installed BWO, a preliminary adjustment of anode voltage to the operating value specified by the manufacturer can be made using the following procedure. To check anode voltage in older tubes, use the procedure of paragraph 5.3.5.

a. Determine the operating value for anode voltage specified in Addendum A (located in the envelope at the rear of this manual). Use this voltage value and the graph given in Figure 5-8 of the Model 650 Instruction Manual to determine the correct value for feedback resistor A12R14 at the top of the elevated supply PC board in the plug-in unit.

b. If the value of A12R14 determined in Step a differs from the resistor actually installed in the unit, change A12R14 to the proper value.

c. Measure the anode voltage between TP9 (+) and TP10 (-), and adjust it to the value determined in Step a, by using A12R9 ANODE ADJ.

WARNING

This is a high-voltage measurement. Use a floating, insulated voltmeter.

d. Refer to Paragraph 5.3.5 for a final adjustment of anode voltage in terms of output power.

2.,3. A13R26 START FREQ and A13R28 END FREQ. Adjustments. These controls are used to set the cathode supply feedback limits to obtain the proper cathode supply output voltage limits for the BWO tube, corresponding to the lower and upper frequency limits of the plug-in unit. The proper voltages for these band limits can be checked as described in Paragraph 5.2 a above.

Adjustment of these voltages to the prescribed values is the first step in frequency calibration of the plug-in unit. Final frequency calibration involves a further adjustment of A13R26 and A13R28 to obtain calibrated frequency performance. Once final frequency calibration of the plug-in unit has been carried out using the procedure given in Paragraph 5.3.3, these voltages should not be re-adjusted.

Refer to Paragraph 5.3.3 for the proper adjustment procedure.

4. A11R17 INTERNAL SAMPLER SENSITIVITY Adjustment (functional on instrument models with K-suffix numbers only). This control is used to set the signal level applied to the leveler-amplifier from the internal rf sampler. The proper adjustment for standard applications is one that places the full-band leveling point at about the center of the adjustment

range of the red POWER LEVEL control, and provides unleveled output with the POWER LEVEL control turned fully CW. This allows the POWER LEVEL control to be set above the full-band-leveled position for higher-level, partial-band leveling, and also provides an adjustment range of at least 10 db below full-band-leveled power when the POWER LEVEL control is turned fully CCW. Note that this control affects only operation with the internal rf sampler. When an external sampler is used, the front panel RF SAMPLER SENS. control provides a similar adjustment function. To achieve the maximum available amount of controlled reduction below the full-band-leveled point, a readjustment of the MINIMUM POWER LIMIT control A11R5 may also be required.

The adjustment procedure is as follows:

a. Connect the RF OUTPUT jack through a suitable attenuator to a crystal detector, and connect the detector output to the vertical channel of an oscilloscope. Use the OUTPUT SWEEP signal to drive the horizontal channel of the oscilloscope.

b. Make the following control settings:

   RF OUTPUT to LEVELED
   RF SAMPLER to INT
   FREQUENCY Mode Selector to SWEEP $F_1 \rightarrow F_2$
   MARKER AMPLITUDE to OFF
   MODULATION to AM OFF
   SWEEP TIME to .01
   SWEEP TRIGGER to FREE RUN
   F_1 to 0 on the logging scale
   F_2 to 100 on the logging scale
   Red POWER LEVEL fully CW.

c. Adjust the INTERNAL SAMPLER SENS adjustment until the maximum-power excursion of the unleveled CRT presentation appears flattened, indicating the start of leveled response. Then back off the adjustment so that the unleveled trace remains unaffected with the red POWER LEVEL control remaining fully CW.

d. Turn the red POWER LEVEL control CCW slowly and observe the onset of leveled performance across the band. Full-band leveling should be achieved at a mid-range setting of the POWER LEVEL control.

e. With the red POWER LEVEL control set at the maximum power level that allows full-band-leveling, adjust the oscilloscope vertical amplification to obtain a full-height presentation on the CRT.

f. Turn the red POWER LEVEL control fully CCW. With the oscilloscope amplification set as above, and the input to the crystal detector attenuated sufficiently that square-law operation is assured, the presentation on the CRT should be reduced to less than 1/10 of the amplitude observed in Step e. If not, adjust the MINIMUM POWER LIMIT adjustment A11R5 to achieve such a reduction in level. If the adjustment of A11R5 seems to "bottom out" with insufficient range, turn the CONTROL VOLTAGE LIMIT adjustment A11R42 fully CW to permit adjustment of the MINIMUM POWER LIMIT. Then refer to item 6 below to properly adjust the CONTROL VOLTAGE LIMIT.

5. A11R5 MINIMUM POWER LIMIT Adjustment. This control is used to set the range of the red POWER LEVEL control by adjusting its lower limit. It does not affect the upper limit of the control range.

The adjustment procedure for units with internal sampling is included as the final step in the INTERNAL SAMPLER SENS adjustment procedure, item 4 above. For units without internal sampling, use the following procedure:

a. Connect a suitable external sampler loop, consisting of a sampler or a directional coupler and detector, to the RF OUTPUT jack, and use the sampler output to drive the RF SAMPLER INPUT jack (see Figure 5-3). Terminate the rf loop with a suitable attenuator and crystal detector, and connect the detector output to the vertical channel of an oscilloscope. Use the OUTPUT SWEEP signal to drive the horizontal channel of the oscilloscope.

b. Make the following control settings:
   RF OUTPUT to LEVELED
   RF SAMPLER to EXT
   FREQUENCY Mode Selector to SWEEP $F_1 \rightarrow F_2$
   MARKER AMPLITUDE to OFF
   MODULATION to AM OFF
   SWEEP TIME to .01
   F_1 to 0 on the logging scale
   F_2 to 100 on the logging scale
   Red POWER LEVEL fully CW

c. Adjust the front panel RF SAMPLER SENS control until the maximum-power excursion of the unleveled CRT presentation appears flattened, indicating the start of leveled response. Then back off the adjustment so that the unleveled trace remains unaffected with the red POWER LEVEL control remaining fully CW.

d. Turn the red POWER LEVEL control CCW slowly and observe the onset of leveled performance across the band. Full-band leveling should be achieved at a mid-range setting of the red POWER LEVEL control.

e. With the red POWER LEVEL control set at the maximum power level that allows full-band-leveling, adjust the oscilloscope vertical amplification to obtain a full-height presentation on the CRT.

f. Turn the red POWER LEVEL control fully CCW. With the oscilloscope amplification set as above, and the input to the crystal detector attenuated sufficiently that square-law operation is assured, the presentation on the CRT should be reduced to less than 1/10 of the amplitude observed in Step e. If not, adjust the MINIMUM POWER LIMIT adjustment A11R5 to achieve such a reduction in level.

   If the adjustment of A11R5 seems to "bottom out" with insufficient range, turn the CONTROL VOLTAGE LIMIT adjustment A11R42 fully CW to pemit adjustment of the MINIMUM POWER LIMIT. Then refer to item 6 below to properly adjust the CONTROL VOLTAGE LIMIT.

6. A11R42 CONTROL VOLTAGE LIMIT Adjustment. This adjustment is used to set the quiescent leveler attenuation whenever rf output is modulated off, by setting the limiting amount of controlling feedback supplied in the absence of rf signal. The operating characteristics do not change with age. Unless the factory adjustment is altered improperly, readjustment should not be required unless the PIN attenuator or A11Q1 are replaced. At that time, A11R42 should be carefully set to provide a proper balance between the extremes of (1) producing excess overshoot in square wave modulation, and (2) interfering with smooth leveling at low power levels.

To adjust the CONTROL VOLTAGE LIMIT, proceed as follows after having set the MINIMUM POWER LIMIT in accordance with item 5 above:

a. With the plug-in unit installed in a Model 650, make the following control settings:

RF OUTPUT to LEVELED
FREQUENCY Mode Selector to SWEEP $F_1 \rightarrow F_2$
MARKER AMPLITUDE to OFF
MODULATION to AM OFF
SWEEP TIME to .1
SWEEP TRIGGER to FREE RUN
F_1 to 0 on the logging scale
F_2 to 100 on the logging scale
POWER LEVEL (red) fully CCW.

b. If the unit has internal sampling, switch the RF SAMPLER INT-EXT switch to INT. For units without internal sampling, obtain leveled operation with an external sampler as described in item 5a above.

c. Connect the RF OUTPUT jack through a suitable attenuator to a crystal detector, and connect the detector output to the vertical channel of an oscilloscope. Use the OUTPUT SWEEP signal to drive the horizontal channel of the oscilloscope.

d. Rotate the POWER LEVEL control slightly away from the CCW position and then back to the CCW position, and observe the oscilloscope trace level which should move up and down to indicate that the output level is tracking the setting of the POWER LEVEL control. (If this response is not obtained, turn the CONTROL VOLTAGE LIMIT adjustment A11R42 in the CW direction to permit such response).

e. While continuing to rotate the POWER LEVEL control as in step d, turn the CONTROL VOLTAGE LIMIT adjustment A11R42 CCW slowly until it interferes with smooth tracking, by the oscilloscope trace, of the POWER LEVEL control. When the point of interference is reached, back off the CONTROL VOLTAGE LIMIT adjustment in the CW direction about 3 degrees.

f. Turn the MODULATION Mode Selector to SQ WAVE.

g. Observe the character of the square wave pulses and make a slight "touch-up" adjustment of the CONTROL VOLTAGE LIMIT adjustment A11R42 over a range of ±3° to improve pulse rise time [ccw adjustment] and limit overshoot [cw adjustment] if necessary.

5.3.3 FREQUENCY CALIBRATION ADJUSTMENT. (See Figure 5-3.)

The following procedure should be used for periodic frequency calibration of the plug-in unit.

CAUTION

Check all supply voltages except the cathode supply output before performing this calibration adjustment. (See Paragraph 5.2.)

a. Let the instrument warm up and stabilize for about 1/2 hour.

b. Make the following control settings:

RF OUTPUT to UNLEVELED
FREQUENCY Mode Selector to SINGLE
SINGLE Frequency Selector to F_0
MARKER AMPLITUDE to OFF
MODULATION to AM OFF
SWEEP TIME to .01
SWEEP TRIGGER to FREE RUN

c. With the instrument operating unmodulated in single-frequency mode, measure the cathode supply voltage output at the lower and upper band limit frequencies as directed in Paragraph 5.2 a.

d. If either voltage measured in Step c is incorrect, adjust it to the proper value using the START FREQ or END FREQ adjustment controls. (The START FREQ adjustment sets the voltage at the low band-edge frequency, and the END FREQ adjustment sets the high band-edge frequency.)

e. Connect an rf test loop consisting of a variable attenuator, wavemeter, and crystal detector to the RF OUTPUT jack, and connect the crystal detector output to the vertical channel input of an oscilloscope. Use the OUTPUT SWEEP signal to drive the horizontal channel of the oscilloscope.

f. Make the following changes in control settings:

FREQUENCY Mode Selector to SWEEP $F_0 \pm \Delta F$
RETRACE to OFF
Δ F AMPLITUDE fully CW
SWEEP TIME to .01
SWEEP TRIGGER to FREE RUN
F_0 to 0 on the logging scale (the low band-edge frequency).

g. Adjust the wavemeter to the low band-edge dial frequency.

h. Observe the CRT presentation. The wavemeter pip should appear exactly in the center of the trace. If it is obviously off-center, adjust the A13R26 START FREQ control to move the pip to the center of the trace.

i. When the pip appears centered in Step h above, turn the Δ F AMPLITUDE control CCW slowly, continuing to the CCW rotation limit (labeled 0) unless the pip appears off center as the control is turned. If necessary, stop turning the Δ F AMPLITUDE control, and adjust the START FREQ control again to restore the pip to the center of the trace. Continue this procedure until the Δ F AMPLITUDE control is fully CCW and the wavemeter pip remains in the center of the trace.

k. Adjust the F_0 FREQUENCY control to 100 on the logging scale, and turn the Δ F AMPLITUDE control fully CW.

l. Observe the CRT presentation. The wavemeter pip should appear exactly in the center of the trace. If it is obviously off-center, adjust the A13R28 END FREQ control to move the pip to the center of the trace.

m. When the pip appears centered in Step l above, turn the Δ F AMPLITUDE control CCW slowly, continuing to the CCW rotation limit (labeled 0) unless the pip appears off center as the control is turned. If necessary, stop turning the Δ F AMPLITUDE control, and adjust the END FREQ control again, to restore the pip to the center of the trace. Continue this procedure until the Δ F AMPLITUDE control is fully CCW and the wavemeter pip remains in the center of the trace.

n. Adjust the F_0 FREQUENCY control to 0 on the logging scale and turn the Δ F AMPLITUDE control fully CW.

o. Repeat Steps g through m .

p. Repeat Steps n and o one additional time. Repeating the steps is necessary because of the interaction of the START FREQ adjustment A13R26 and END FREQ adjustment A13R28.

q. Check the frequency tracking across the dial at several points by turning the Δ F AMPLITUDE control to 100% and setting both the F_0 control and the wavemeter to identical frequencies. Frequency accuracy should be ± 1.0% or better across the band. If necessary, Steps n through p above may be repeated to offset the end frequencies slightly in order to reduce mid-band inaccuracies.

r. If it is desired to check residual FM and AM, retain the test set-up and follow the procedures of Paragraph 5.3.4.

5.3.4 CHECKOUT PROCEDURE FOR RESIDUAL FM AND AM. (See Figure 5-3.)

The following procedure may be used for periodic verification that residual FM and AM are within specification limits. It should be performed as a continuation of the frequency calibration adjustment procedure given in Paragraph 5.3.3 above. The FM procedure should be performed at the low-frequency end of the band, because residual FM effects are greatest at that point; and the AM procedure should be performed at the high-frequency end of the band.

a. The instrument should be operating with an rf test loop equivalent to Step e of Paragraph 5.3.3. To permit the high sensitivity readings required later in the procedure, the oscilloscope should be set for AC coupling.

b. Make control settings as in Step f of Paragraph 5.3.3, except turn the RETRACE control to ON. Also set the RF OUTPUT control to UNLEVELED and turn the MARKER AMPLITUDE and MODULATION both off.

c. Adjust the wavemeter to center its pip on the CRT display.

d. Slowly turn the Δ F AMPLITUDE control CCW, while adjusting the wavemeter slightly, as necessary to keep the wavemeter pip centered on the CRT trace. Continue this procedure until the Δ F AMPLITUDE control is fully CCW.

e. Set the wavemeter to place one-half of its pip at the left edge of the trace.

f. Adjust the oscilloscope horizontal sensitivity to yield a full-graticule sweep width while being driven by the OUTPUT SWEEP signal of the Model 650.

g. Adjust the oscilloscope for maximum vertical sensitivity, and set the vertical position so that the CRT presentation shows a sloping line which represents one half of the magnified wavemeter pip at the left edge.

h. Adjust the wavemeter enough to move the sloping line (pip) from one edge of the CRT presentation to the other. The difference between the wavemeter settings at each edge of the CRT will calibrate the horizontal scale (typical value = 20 MHz).

NOTE: Since the rf output is being left on during retrace, there will be two parallel lines visible on the CRT. Use the brighter line for the residual FM check (the dim line is the retrace indication).

i. Adjust the wavemeter slightly to move the sloping line to a convenient point on the graticule.

j. Observe the horizontal jitter in the line while the Δ F AMPLITUDE control remains fully CCW. The horizontal scale calibration made in Step h above will permit evaluating the frequency deviation of the jitter.

This deviation should be less than ± the KHz value indicated for "Maximum Residual FM" in Table 1-1. If excess residual FM is present, check the ripple voltage on the cathode supply [TP6 (-), TP3 (+; chassis ground)] . Use an oscilloscope with a 10:1 divider probe and operate the vertical channel with ac coupling. The ripple voltage should not exceed ± 0.01% of the cathode supply output voltage at any point. Refer to the trouble-shooting procedures for the cathode supply in the Model 650 Instruction Manual if excess ripple is present. If excess power supply ripple is not present, the excess residual FM may be due to arcing or other breakdown in the BWO tube, which requires replacement of the tube.

NOTE: If desired, the above residual FM checkout procedure may be repeated at other frequencies in the frequency range of the plug-in unit. Since arcing or other breakdown effects in a BWO tube often show up initially as excess residual FM, this procedure can be useful in evaluating performance of aging BWO tubes.

k. Make the following changes in control setting, in preparation for the residual AM test.

FREQUENCY Mode Selector to SINGLE
SINGLE Frequency Control to F_0
F_0 control set at high end of band
MODULATION to SQUARE WAVE

l. Adjust the wavemeter away from the frequency of interest, or remove it from the circuit completely, as desired. Make sure that sufficient attenuation is provided in the rf test loop to allow the crystal detector to operate in its square-law range.

m. Adjust the oscilloscope for a free-running horizontal sweep independent of the Model 650. Leave the oscilloscope vertical input ac-coupled. Adjust the oscilloscope vertical sensitivity to obtain a square-wave height of 5 scale divisions (5 cm) on the graticule.

n. Turn the MODULATION switch to AM OFF.

o. Without changing the vertical sensitivity vernier adjustment of the oscilloscope from the setting used to obtain a full-height display in Step m, set the oscilloscope vertical sensitivity switch to step-increase vertical amplification by a factor of 10 (so that the full-height square-wave presentation would now be 50 scale divisions). Adjust the zero position control as necessary to place the unmodulated power-on straight line trace at a convenient line on the graticule.

p. Observe the vertical ripple on the CRT trace. It must not exceed 1 scale division (i.e. less than 1/50 or 2% of the output amplitude). If excess residual AM is present, refer to the trouble-shooting procedures for the anode and -100 V supplies in the Model 650 Instruction Manual.

5.3.5 POWER CALIBRATION ADJUSTMENT. (See Figure 5-4.)

The following adjustment procedure can be used to check and adjust the power output level of the plug-in unit.

a. For newly installed BWO tubes, check and adjust the anode voltage to the specified level using the ANODE ADJ control as directed in Paragraph 5.3.2. For adjustment of older tubes, proceed as follows:

b. Connect an rf test loop consisting of a suitable attenuator pad, a thermistor mount, and a power meter to the RF OUTPUT jack to measure absolute power. Be sure to use a large enough attenuator to avoid exceeding the thermistor power rating. Alternately, an ALFRED 8000/7051 Oscilloscope/Sweep Network Analyzer system can be used for making direct absolute power measurements with a crystal detector.

c. Make the following control settings:

RF OUTPUT to UNLEVELED
FREQUENCY Mode Selector to SWEEP $F_1 \rightarrow F_2$
MARKER AMPLITUDE to OFF
MODULATION to AM OFF
SWEEP TIME to 10
SWEEP TRIGGER to FREE RUN
F_1 to 0 on the logging scale
F_2 to 100 on the logging scale

d. Observe the unleveled power output characteristic. If power at any point in the sweep is below the level specified in Table 1-1, increase the anode voltage slightly using the ANODE ADJ control.

NOTE: The ANODE ADJ. control permits an adjustment range of about ± 10 V. To provide a greater adjustment, particularly to restore the tube power output level after long service, it may be necessary to raise the anode voltage by more than the amount available from the ANODE ADJ. control. To do this, substitute a slightly higher resistance value for A12R14 (see Figure 5-8 in the Model 650 Instruction Manual), and then set the ANODE ADJ. control.

WARNING

Turn power off when changing A12R14.

CAUTION

Do not increase the anode supply voltage more than necessary to bring the minimum power point up to specifications. If rated power output cannot be obtained with a reasonable anode voltage, and other tube operating voltages are correct, the BWO tube must be replaced. Also helix current must not be allowed to exceed the specified maximum (trip out) level. Any increase in anode voltage over the factory setting shown in Addendum A will reduce the operating life of the BWO tube.

In addition, for instruments having Varian tubes, the anode supply voltage should never be adjusted so that this voltage, monitored as described in Paragraph 5.2d, exceeds the maximum operating level shown in Addendum A or the tube data sheet. Anode current in Varian tubes (monitored as described in Paragraph 5.2h) must not be allowed to exceed 10 ma (or the maximum current rating specified in Addendum A for instruments without the 10 ma anode protection fuse). Exceeding the voltage or current limits for the anode voids the warranty!

e. For units with internal sampling, set the RF OUTPUT control to LEVELED and the RF SAMPLER switch to INT. Then check the leveled power characteristic across the band, and also check leveler response to the POWER LEVEL control. The maximum power output obtainable with full-band leveling should occur at a mid-range setting of the POWER LEVEL control, and should equal or exceed the level specified in Table 1-1. Also check the leveled power variation across the band. The variation across the entire band should not exceed the amount specified in Table 1-1. If the unit does not meet leveled output specifications, check the INTERNAL SAMPLER SENSITIVITY and CONTROL VOLTAGE LIMIT adjustments as directed in Paragraph 5.3.2.

f. For units which require external sampling, set the RF OUTPUT control to LEVELED. Connect a suitable external rf sampler loop to drive the RF SAMPLER INPUT jack, as shown in Figure 5-3, by inserting a sampler or a coupler and detector between the RF OUTPUT jack and the attenuator pad. With a suitable sampler and a proper adjustment of the RF SAMPLER SENS. panel control, it should be possible to obtain full-band leveling with a mid-range setting of the POWER LEVEL control; and response to adjustment of the POWER LEVEL control above and below the full-band leveling point should be as described in the Model 650 Instruction Manual. The maximum power output obtainable with full-band leveling should approximately equal the level specified in Table 1-1. (An optimum external sampler loop using flat components can achieve the minimum variation specifications given in Table 1-1.) If leveler performance is unsatisfactory and the external sampler loop is known to be adequate, check the CONTROL VOLTAGE LIMIT adjustment as directed in Paragraph 5.3.2.

5.4 TROUBLE SHOOTING.

NOTE: Refer to Paragraph 5.4 of the Model 650 Instruction Manual. The following material is supplementary to that manual.

5.4.1 BWO TUBE AGING AND FAILURE.

There are three general indications of BWO tube aging: (1) reduced rf output throughout the operating band; (2) complete loss of rf output at one or more frequencies in the operating band; (3) repeated tripout of the helix overcurrent protection relay when operating unleveled with full output power, particularly in the upper portion of the operating band. Indications (1) and (2) above are usually caused by reduced cathode emission, while gas ionization in the BWO tube causes indication (3). Indication (2) at either band limit can be caused by a defective cathode supply or a defective or mis-adjusted diode shaper board that produces cathode voltage outside the proper tuning range. Normal aging of the BWO tube does not produce frequency calibration error; but internal arcing or other breakdown can produce excess residual fm.

To localize trouble to the BWO tube when indications of the above type are present, check all tube voltages and currents in accordance with Paragraph 5.2 above, and make adjustments as necessary following the procedures of Paragraph 5.3. If proper operation is not restored with proper voltages applied, refer to paragraph 5.3.5 and try increasing the anode voltage above the normal level (but never above the Maximum Anode Voltage level shown for Varian tubes in Addendum A or the tube data sheet) to restore power output. If proper operation is still not restored and the BWO tube is still in warranty, read the Tube Warranty and Replacement Procedure at the rear of this manual and follow the specified return procedure. If the tube warranty has expired, refer to the procedure of Paragraph 5.3.5 and try increasing the anode voltage above the normal level to restore power output, before discarding the tube.

NOTE: Where failure is due to gas ionization, no adjustment of voltages will restore normal, full-band operation. If desired, the tube can still be used within a restricted tuning range, at frequencies below the point where excessive helix current occurs.

5.4.2 ELEVATED SUPPLY FAILURE. When failure is suspected in the Elevated Supply PC Board A12, all the passive components can be checked with power turned off. If the passive components are satisfactory, and the correct grid voltage is not produced with suitable drive from the modulator, check the performance of A12Q1 by substitution.

5.4.3 DIODE SHAPER BOARD FAILURE. If the proper voltages cannot be obtained when adjusting the START FREQ and END FREQ adjustment controls, and voltage measurements on the cathode supply feedback amplifier indicate that it is operating properly, check the performance of the diode shaper board. Typical operating voltages on the resistor biasing string are indicated in Figure 4-3. Performance of the diodes can be checked with power off by using an ohmmeter to measure forward and reverse resistance. To avoid overloads, do not use any range where open-circuit voltage exceeds 1.5 V, or short-circuit current exceeds 3 ma. In-circuit voltage checks may also be used to check A13Q1, A13Q2, A13CR13 and A13CR14.

5.4.4 INTERNAL SAMPLER FAILURE. If the instrument operates properly with an external sampler known to be in good condition, but performance with internal sampling is unsatisfactory, check the adjustment of the INTERNAL SAMPLER SENSITIVITY control following the procedure of paragraph 5.3.2. Also check the crystal detector on the internal sampler by substitution. If the internal sampler or its crystal detector are replaced, reset the INTERNAL SAMPLER SENSITIVITY adjustment following the procedure of Paragraph 5.3.2.

5.4.5 LEVELER-AMPLIFIER IMBALANCE or FAILURE. When the CONTROL VOLTAGE LIMIT adjustment is not set properly, it can interfere with the normal smooth leveler response by unbalancing the feedback loop. When response does not seem consistent across the full swept band or at low and high power levels, re-adjust the CONTROL VOLTAGE LIMIT as directed in paragraph 5.3.2. If the CONTROL VOLTAGE LIMIT adjustment cannot restore proper operation, make voltage measurements in the leveler-amplifier under various operating conditions, in accordance with the table shown on schematic D900933. These measurements should localize the trouble to the defective component or stage - or to the PIN diode attenuator module itself.

5.4.6 PIN ATTENUATOR MODULE FAILURE. If the output is not leveled, and does not change in response to adjustment of the POWER LEVEL control, and if voltage checks on the leveler-amplifier (paragraph 5.4.5) indicate that a proper drive is being supplied at terminal A11-15, the PIN attenuator may be defective. To check the PIN attenuator, perform the following procedure:

a. First check that proper -12 V power is being supplied to the leveler from the PIN attenuator power supply A14. Measure this voltage between pin 1 of the PIN attenuator module (-) and the module body (+,ground) with a digital voltmeter. This can be done most easily by removing the plug-in unit from the Model 650 and applying 115 Vac across terminal 4 and 5 of A14 to drive the supply.

CAUTION

Double-check that the correct terminals are being used for this application of voltage. Otherwise costly damage to the instrument may occur.

b. If the voltage monitored in step a is not within the specification range of -12 ± 0.1 V, adjust it using A14R6.

c. Monitor the supply ripple by connecting an oscilloscope to the same terminals [pin 1 of the leveler module (-) and the module body (+, ground)]. Ripple should be < 5 mv.

d. If the voltage cannot be properly adjusted or has excessive ripple, check the power supply components for failure and replace as necessary. Then check and adjust the voltage in accordance with steps a and b above.

e. To check the PIN attenuator disconnect the temporary 115 Vac leads from terminals 4 and 5 of A14, and replace the Plug-in unit into the Model 650 main frame. The 0.5 V to -2.0 V control range provided at A11-15 in the unleveled mode (as verified by the measurements of paragraph 5.4.5) will be used to provide full-range drive to the leveler module for this test.

f. Make control settings as follows:

RF OUTPUT to UNLEVELED
FREQUENCY Mode Selector to SINGLE
SINGLE Mode Selector to F_0
F_0 control to band center
RETRACE to OFF
MARKER AMPLITUDE to OFF

g. Connect the RF OUTPUT connector to an rf power measurement loop such as shown in Figure 5-4.

h. Monitor the power output range provided when the POWER LEVEL control is adjusted over its full range from the CCW limit to the CW limit. The difference between minimum and maximum output should be as follows:

FREQ. RANGE OF INSTRUMENT (GHz)	PIN ATTENUATOR PART NO.	MINIMUM DIFFERENCE BETWEEN MIN. & MAX. OUTPUT (Unleveled Mode)
1 - 2	951041-02	25.5 db
≦1.7 - 4.2	951041-02 or -03	30.5 db
≦3.5 - 8.3	951041-04	26.5 db
≦ 7 - 12.4	951041-05	22 db

i. Adjust the F_0 control to each band limit and repeat the power control range test of step h. If adequate control range is provided across the band, the PIN attenuator module is probably operating properly. If no or insufficient control range is provided, the PIN attenuator module is probably defective and must be returned to the factory for repair.

CAUTION

The PIN diode attenuator module is not field repairable or field adjustable. Do not attempt to adjust or disassemble the attenuator or driver circuits in the field.

j. A final check of PIN attenuator performance can be made by removing the PIN attenuator module from the plug-in unit. Label the wires attached to pins 1, 7, 8, and the body, and then unsolder them. Then remove the leveler attaching hardware and disconnect the rf lines.

k. To supply -12 V power to the PIN attenuator for external testing, connect jumpers as follows:

Pin 1 of the PIN attenuator power supply to the attenuator module body.
Pin 6 of the PIN attenuator power supply to pin 1 of the attenuator module.
Pins 4 and 5 of the PIN attenuator power supply to 115Vac.

l. Obtain a controlled, well regulated and filtered dc test source with an output in the range 0.5 - 2.0 Vdc.

m. Adjust the dc test source voltage to 0.5 V, and connect its + lead to the PIN attenuator module body (ground) and its - lead to pin 7 of the PIN attenuator module.

n. Connect the PIN diode attenuator into an rf power measurement loop such as shown in Figure 5-4, between the signal source attenuator and the detector. The source output and attenuator value should be selected to avoid applying more than 100 mw to the PIN attenuator.

o. Set the dc test source voltage (with polarity as specified in step m) first to 0.5 V and then to 2.0 V, and monitor the output level in each case. The leveler should provide minimum attenuation at a control voltage of 0.5 V, and maximum attenuation at a control voltage of 2.0 V. Attenuation provided in each case should be:

FREQ. RANGE OF PLUG-IN UNIT (GHz)	PIN ATTENUATOR PART No.	MIN. ATTENUATION	MAX. ATTENUATION
1 - 2	951041-02	≦2.5 db	≧28.0 db
≦1.7 - 4.2	951041-02 or -03	≦2.5 db	≧33.0 db
≦3.5 - 8.3	951041-04	≦3.5 db	≧30.0 db
≦ 7 - 12.4	951041-05	≦5.0 db	≧27.0 db

If attenuation is outside these limits, the attenuator must be returned to the factory for repair.

p. To measure PIN attenuator input matching, terminate the output connector in a 50 Ω load and connect a directional coupler to the input connector, oriented to pick up reflections from the PIN attenuator. Connect the detector

FREQ. RANGE OF PLUG-IN UNIT (GHz)	PIN ATTENUATOR PART No.	MIN. RETURN LOSS (EITHER END)
1 - 2	951041-02	8.0 db
≦1.7 - 4.2	951041-02 or -03	9.0 db
≦3.5 - 8.3	951041-04	7.5 db
≦ 7 - 12.4	951041-05	6.5 db

to the coupler arm to measure the return loss using reflectometry techniques. Return loss with leveler control voltage anywhere in the 0.5 - 2.0 V range should be more than the above minimum.

q. Interchange the rf test connections to the PIN attenuator input and output connectors and repeat the return loss measurement of step p above. If return loss is less than the minimum specified at either end, the PIN attenuator must be returned to the factory for repair.

5.4.7 BURNOUT OF ANODE PROTECTION FUSE. (Units with Varian Tubes Only.)

The 10 ma anode protection fuse is chosen to blow only when the maximum allowable anode current is exceeded. The factory-installed fuse value should never be changed. ALL replacement tubes of the same type require the same fuse amperage. If repeated blow-outs occur, check the anode voltage adjustment. If excessive anode current is drawn when the proper anode voltage is applied, the BWO tube must be replaced.

5.5 PARTS REPLACEMENT.

5.5.1 REPLACING THE BWO TUBE.

Refer to Paragraphs 5.7.1 and 5.7.2 of the Model 650 Instruction Manual. After the tube is replaced, replace the time meter and adjust operating voltages as directed in Paragraph 5.7.5 of the Model 650 Instruction Manual. Then perform final frequency calibration in accordance with Paragraph 5.3.3 of this manual.

NOTE: Always retain the data sheet supplied with the new tube for future reference, by placing it in the envelope at the rear of this manual.

5.5.2 REPLACING INDIVIDUAL CIRCUIT COMPONENTS.

Refer to Figures 5-1 and 5-2 of this manual for the locations of circuit board and major rf components. Parts on all PC boards are identified by silkscreened reference designators. These parts are also shown on the overall schematics in Section 7. The proper soldering techniques for parts replacement are given in Paragraph 5.8 of the Model 650 Instruction Manual.

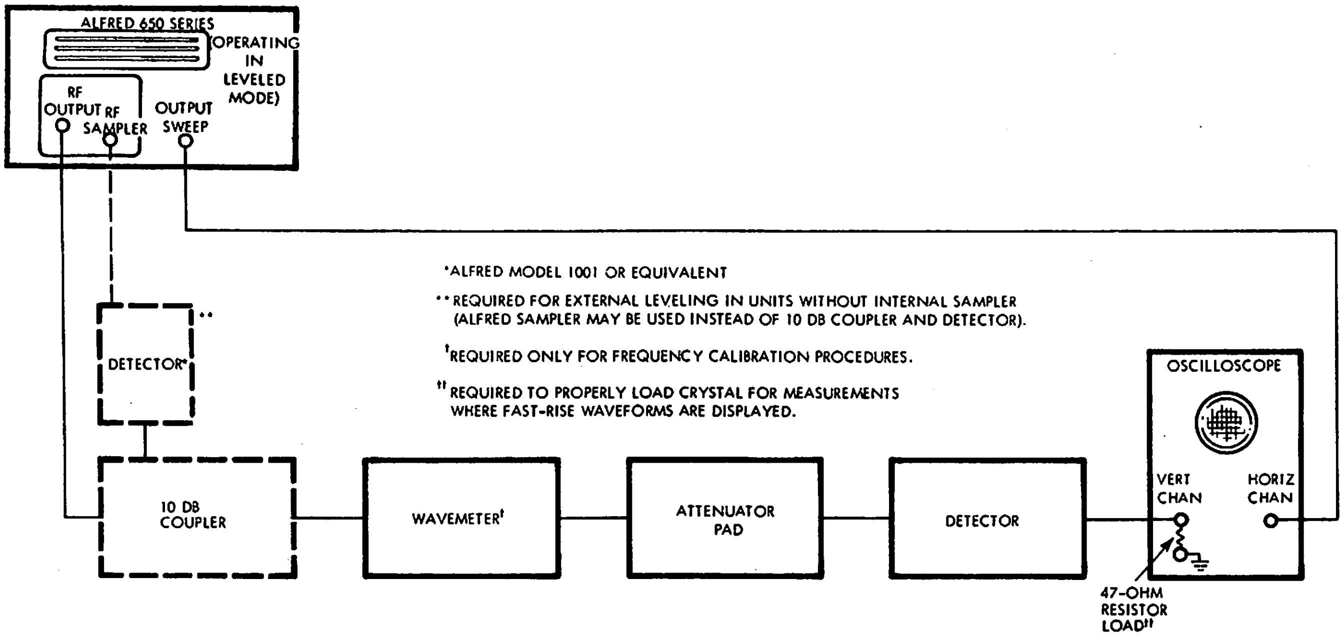


FIGURE 5-3. BASIC RF TEST SET-UP

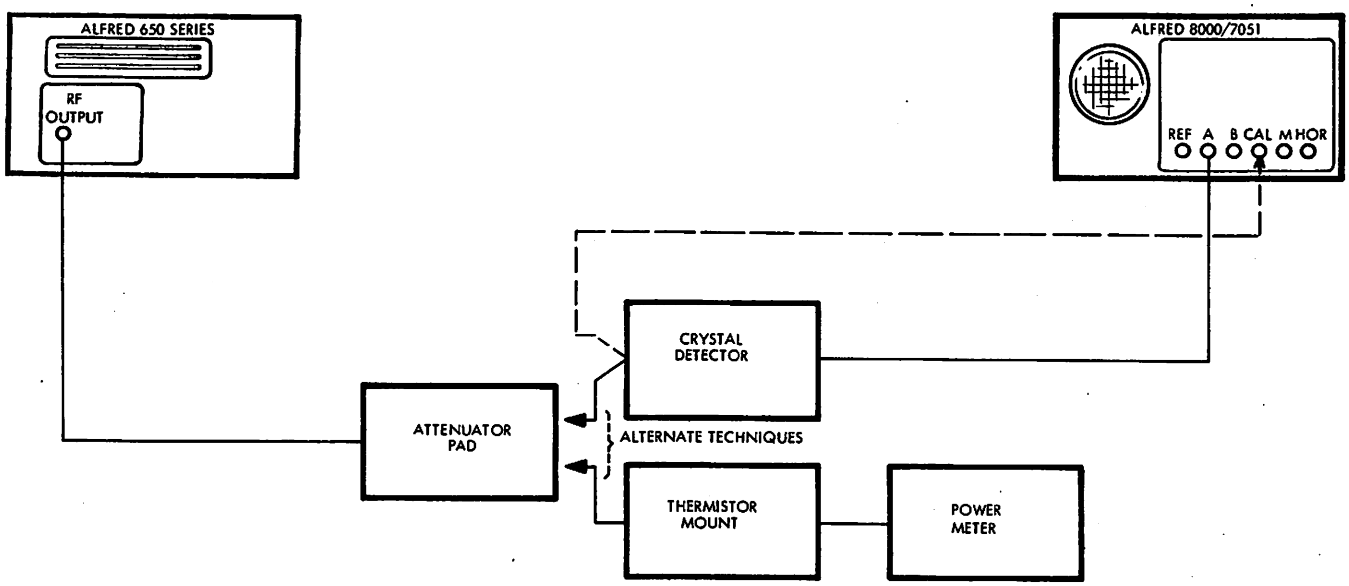


FIGURE 5-4. POWER CALIBRATION TEST SET-UP

SECTION 6

PARTS LIST

List of Assemblies for Model 650-C Plug-in

Reference Designation	Alfred Part No.	Description	Schematic
		650-C Plug-in Chassis	D907053
A11	951088	PIN Diode Leveler Amplifier PC Board A11	D900933
A12	901488 951917	Elevated Supply PC Board A12	C900869 (S/N 1480 & below) C907377 (S/N 1481 & above)
A13	†	Diode Shaper PC Board A13	C900713
A14	951087	-12 V Supply PC Board A14	B900930††
A25	950278	H.V. Feedback PC Board A25	†††

† See Table 1-1 for Part Nos.
†† On apron of D907053.
††† Included on D907053.

PIN DIODE PLUG-IN CHASSIS ASSEMBLY

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
		DIODES		
CR1	81-135	Diode, EH 400 (Varian Only)	83701	EH 400
		LAMPS		
DS1	126-11	Lamp, clear, 110 v	72765	116-303
		FUSES		
F1	121-27	Fuse, 1/100 A, 250 v (Varian Only)	75915	361.010
		CONNECTORS		
J1	133-62	Socket, P.C. Plug-in 10 pin min. #KZ 10S	81312	KZ 10S
J2	133-63	Socket, P.C. Plug-in 22 pin min. #KZ 22S	81312	KZ 22S
J3 and J4	131-UG 1094	Connectors, BNC-Panel, UG 1094U	94375	UG 1094/U
J5	133-77	Jack; Telephone	82389	13-B
		TIME METERS		
M1**	87-3	Elapsed time meter	03782	87-3
		RESISTORS		
R1	51-330 Ω	Resistor, fixed, dep. carb. 330 Ω, 1/2 w, 5%	73445	E-009-AB/B-330 Ω
R2	51-390 Ω	Resistor, fixed, dep. carb., 390 Ω, 1/2 w, 5%	73445	E-009-AB/B-390 Ω
R3	51-15K	Resistor, fixed, dep. carb., 15K, 1/2 w, 5%	73445	E-009-AB/B-15K
R4	51-56K	Resistor, fixed, dep. carb., 56K, 1/2 w, 5%	73445	E-009-AB/B-56K
R5**	56-69.8K	Resistor, fixed, MF, 69.8K, 1/2 w, 1%	19701	MF-7C-TO-69.8K
R6	62-1	Resistor, fixed WW, 10K, 10W, 5%	354434	C10-10K-TS
R7	71-133	Resistor, variable, 1.5K, .3w, 30%	03782	71-133
R8	51-1.5K	Resistor, fixed, dep. carb., 1.5K, 1/2 w, 5%	73445	E-009-AB/B-1.5K
R9	(102-134)	Resistor, variable, 1K (part of S2)	03782	(102-134)
		SWITCHES		
S1	102-136	Switch, slide, DPDT	76854	399278-278
S2	102--34	Switch, rotary with 1K pot (R9)	03782	102-134
		TEST POINTS		
TP21	133-29	Tip jack, black	74978	105-803
TP22 and TP23	133-28	Tip jack, red	74978	105-802
		HOLDERS		
XM1**	122-2	Time Meter holder (fuse holder)	75915	357001

**Not used in instruments having 1 year BWO warranty

A14 -12 V SUPPLY PC BOARD (ASSY. 951087)

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
		CAPACITORS		
A14C1	13-72	Capacitor, fixed, elect., 1000 mf, 25 v	56289	TL 1218
A14C2	12-52	Capacitor, fixed, ceramic, 0.47 µf, 25 v	71982	5865-000-Y5UO-474Z
A14C3	13-49	Capacitor, fixed, elect., 50 µf, 25 v	56289	TE 1209
		DIODES		
A14CR1	81-178	Rectifier Bridge Assy., MDA-920A-2	04713	MDA 920A-2
A14CR2	81-123	Diode, Zener, 1N749A	04713	1N479A
		TRANSISTORS		
A14Q1	81-133	Transistor, 40372	07029	40372
A14Q2	81-114	Transistor, 2N3638A	07263	2N3638A
A14Q3	81-169	Transistor, 2N3569	07263	2N3569
		RESISTORS		
A14R1	51-10K	Resistor, fixed, dep. carb., 10K, 1/2 w, 5%	73445	E-009-AB/B-10K
A14R2	51-1.5K	Resistor, fixed, dep. carb., 1.5K, 1/2 w, 5%	73445	E-009-AB/B-1.5K
A14R3	51-1.2K	Resistor, fixed, dep. carb., 1.2K, 1/2 w, 5%	73445	E-009-AB/B-1.2K
A14R4	51-390 Ω	Resistor, fixed, dep. carb., 390 Ω, 1/2 w, 5%	73445	E-009-AB/B-390 Ω
A14R5	51-680 Ω	Resistor, fixed, dep., carb., 680Ω 1/2 w, 5%	73445	E-009-AB/B-680 Ω
A14R6	71-95	Resistor, variable, 2K, 1 w, 10%, 20 turn	21030	79PR2K
		TRANSFORMERS		
A14T1	91-205	Transformer	14026	F119X

A25 H.V. FEEDBACK PC BOARD (Assy. 950278)

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
		CAPACITORS		
A25C1	12-30	Capacitor, fixed, ceramic, 1.5 pf 6 KV	56289	60-GA-V15
		RESISTORS		
A25R1 thru A25R6	52-464K	Resistor, fixed, MF, 464K, 1 w, 1%	19701	MFS-1-T2-464K

A11 PIN DIODE LEVELER AMPLIFIER PC BOARD (ASSY. 951088)

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
		CAPACITORS		
A11C1 and A11C2	14-37	Capacitor, fixed film, 0.1 µf, 10%, 80 v	56289	192P1049R8
A11C3*	14-40	Capacitor, fixed, mylar, .015 µf, 80 v	56289	192P1539R8
A11C4	11-36	Capacitor, fixed, dipped mica, 150 pf, 10%, 100 v	72136	DM-5-151-K
A11C5	11-25	Capacitor, fixed, dipped mica, 47 pf, 5%	00853	D15-47 pf
A11C6	11-37	Capacitor, fixed, dipped mica, 200 pf, 10%, 100 v	72136	DM-10-201-K
A11C7 and A11C8	11-28	Capacitor, fixed, dipped mica, 82 pf, 2%	00853	D153E820GO
A11C9		Same as A11C1		
A11C10	13-68	Capacitor, fixed, 3.3 µf, 15V, ±10%	22229	K3R3C15K
A11C11	12-2	Capacitor, fixed, 0.001 µf, 100 v	72982	851-X5R-102K
		DIODES		
A11CR1 thru A11CR3	81-132	Diode, 1N914	07263	1N914
		TRANSISTORS		
A11Q1	81-194	Transistor, Sprague TD100	56289	TD100
A11Q2	81-115	Transistor, 2N3565	07263	2N3565
A11Q3 and A11Q4	81-140	Transistor, 2N5087	04713	2N5087
A11Q5		Same as A11Q2		
A11Q6		Same as A11Q1		
A11Q7 thru A11Q11	81-189	Transistor, 2N4917	07263	2N4917
A11Q12 and A11Q13	81-169	Transistor, 2N3569	07263	2N3569
A11Q14	81-72	Transistor, NPN, 2N699	96214	2N699
		RESISTORS		
A11R1	59-26.7K	Resistor, fixed, MF, 26.7K, 1/4 w, 1%	19701	MF-5-CTO-26.7K
A11R2	59-26.1K	Resistor, fixed, MF, 26.1K, 1/4 w, 1%	19701	MF-5-CTO-26.1K
A11R3 and A11R4	59-1K	Resistor, fixed, MF, 1K, 1/4 w, 1%	19701	MF-5-CTO-1K
A11R5	71-136	Resistor, variable, comp., 250 Ω, 0.2 w, 30%	71450	U 201R251B
A11R6 and A11R7	34-10K	Resistor, fixed, comp., 10K, 1/4 w, 5%	01121	CS 1035
A11R8	34-4.7K	Resistor, fixed, comp., 4.7K, 1/4 w, 5%	01121	CS 4725
A11R9		Same as A11R6		
A11R10 and A11R11	34-560 Ω	Resistor, fixed, comp., 560 Ω, 1/4 w, 5%	01121	CS 5615
A11R12 and A11R13		Same as A11R6		
A11R14	34-5.6K	Resistor, fixed, comp., 5.6K, 1/4 w, 5%	01121	CS 5625
A11R15	34-4.3K	Resistor, fixed, comp., 4.3K, 1/4 w, 5%	01121	CS 4325
A11R16	34-1.8K	Resistor, fixed, comp., 1.8K, 1/4 w, 5%	01121	CS 1825
		RESISTORS (Con't)		
A11R17	71-135	Resistor, variable, comp., 1.5K 0.2 w, 30%	71450	U201R152B
A11R18		Same as A11R14		
A11R19 and A11R20	34-390 Ω	Resistor, fixed, comp., 390 Ω, 1/4 w, 5%	01121	CS 3915
A11R21		Same as A11R8		
A11R22	34-8.2K	Resistor, fixed, comp., 8.2K, 1/4 w, 5%	01121	CS 8225
A11R23	34-1K	Resistor, fixed, comp., 1K, 1/4 w, 5%	01121	CS 1025
A11R24		Same as A11R6		
A11R25	34-15K	Resistor, fixed, comp., 15K, 1/4 w, 5%	01121	CS 1535
A11R26	34-330 Ω	Resistor, fixed, comp., 330 Ω, 1/4 w, 5%	01121	CS 3315
A11R27		Same as A11R26		
A11R28 and A11R29	34-820 Ω	Resistor, fixed, comp., 820 Ω, 1/4 w, 5%	01121	CS 8215
A11R30		Same as A11R8		
A11R31		Same as A11R6		
A11R32	34-2.2K	Resistor, fixed, comp., 2.2K, 1/4 w, 5%	01121	CS 2225
A11R33	34-220 Ω	Resistor, fixed, comp., 220 Ω, 1/4 w. 5%	01121	CS 2215
A11R34		Same as A11R26		
A11R35		Same as A11R23		
A11R36		Same as A11R28		
A11R37 and A11R38		Same as A11R23		
A11R39	34-1.5K	Resistor, fixed, comp., 1.5K, 1/4 w, 5%	01121	CS 1525
A11R40 and A11R41		Same as A11R25		
A11R42	71-134	Resistor, variable, comp., 500 Ω, 2 w, 30%	71450	U201R501B
A11R43	34-33K	Resistor, fixed, comp., 33K, 1/4 w, 5%	01121	CS 3335
A11R44*	34-6.8K	Resistor, fixed, comp., 6.8K, 1/4 w, 5%	01121	CS 6825
A11R45 and A11R46		Same as A11R23		
A11R47	59-100K	Resistor, fixed, MF, 100K, 1/4 w, 1%	19701	MF-5C-TO-100K
A11R48	59-133K	Resistor, fixed, MF, 133K, 1/4 w, 1%	19701	MF-5C-TO-133K

*Factory Selected

ELEVATED SUPPLY PC BOARD A12

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
		Assy. 951917 (S/N 1481 & above) Assy 901488 (S/N 1480 & below)		
		CAPACITORS		
A12C1	12-28	Fixed, ceramic, .001 µf, 6Kv	71590	DD60-102
A12C2		Not used S/N 1481 & above)		
	11-2	Fixed, ceramic, 24 pf, 600v (S/N 1480 & below)	72136	CM-15E-240-J
A12C3 and A12C4		Not used (S/N 1481 & above)		
	12-3	Fixed, ceramic, .01 µf, 1Kv (S/N 1480 & below)	71590	DD-1032
		DIODES		
A12CR1	81-20	1N4385 (S/N 1133 & above)	76433	1N4385
	81-41	1N459 (S/N 1132 & below)**	07263	1N459
A12CR2		Not used (S/N 1481 & above)		
	81-41	1N459 (S/N 1480 & below)**	07263	1N459
A12CR3	81-20	1N4385 (S/N 1133 & above)	76433	1N4385
	81-41	1N459 (S/N 1132 & below)**		
A12CR4		Not used (S/N 1481 & above)		
	81-41	1N459 (S/N 1480 & below)**	76433	1N4385
A12CR5 and A12CR6		Not used (S/N 1481 & above)		
	81-156	Zener, MZ 1000-17 (S/N 1480 & below)	04713	MZ 1000-17
A12CR7	81-206	1N4737A (S/N 1481 & above)	04713	1N4737A
		Not used (S/N 1480 & below)		
		INDUCTORS		
A12L1	92-22	Choke, RF, 33µhy	71895	1537-52
		TRANSISTORS		
A12Q1	81-239	2N2405 (S/N 1481 & above)	07029	2N2405
		2N699 (S/N 1480 & below)	96214	2N699
		RESISTORS		
A12R1	51-150K	Fixed, dep. carb., 150K, 1/2 w 5%	73445	E-009-AB/B-150K
A12R2*		Factory Select (See Addendum A)		
A12R3		Not used (S/N 1481 & above)		
	46-1K	Fixed, met. film, 1K, 2 w, 5% (S/N 1480 & below)	01121	HB 1025
A12R4	50-820 Ω	Fixed, tin oxide, 820 Ω, 2 w, 2% (S/N 1481 & above)	16299	C42-1.1K
	35-1.1K	Fixed, met. film, 1.1K, 2 w, 5% (S/N 1481 & below)	16299	C42-1.1K
A12R5	50-820 Ω	Fixed, tin oxide, 820 Ω, 2 w, 2%	16299	C42S-820 Ω
A12R6		Not used (S/N 1481 & above)		
	51-7.5K	Fixed, dep. carb., 7.5K, 1/2 w, 5% (S/N 1480 & below)	73445	E-009-AB/B-7.5K
A12R7	44-10K	Fixed, comp., 10K, 2 w, 5% (S/N 1481 & above)	01121	HB 1035
	45-11K	Fixed, comp., 11K, 1 w, 5% (S/N 1480 & below)	01121	GB 1135
A12R8		Not used (S/N 1481 & above)		
	51-10 Ω	Fixed, dep. carb. 10 Ω, 1/2 w, 5% (S/N 1480 & below)	73445	E-009-AB/B-10 Ω
A12R9	71-106	Variable, 5K (S/N 1481 & above)	71450	201-5K
	71-103	Variable, 50K (S/N 1480 & below)	71450	201-50K
A12R10	56-23.7K	Fixed, met. film, 23.7K, 1/2 w, 1% (S/N 1481 & above)	19701	MF-7C-TO-23.7K
	56-237K	Fixed, met. film, 237K, 1/2 w, 1% (S/N 1480 & below)	19701	MF-7C-TO-237K
A12R11		Not used (S/N 1481 & above)		
	51-8.2K	Fixed, dep. carb., 8.2K, 1/2 w 5% (S/N 1480 & below)	73445	E-009-AB/B-8.2K
A12R12		Not used		
A12R13	56-10Ω	Fixed, met. film, 10 Ω, 1/2 w, 1%	19701	MF-7C-TO-10 Ω
A12R14* and A12R15*		Factory Select (See Addendum A)		
A12R16		Not used		
A12R17		Not used (S/N 1481 & above)		
	51-180K	Fixed, dep. carb., 180K, 1/2 w, 5% (S/N 1480 & below)	73445	E-009-AB/B-180K
A12R18		Not used (S/N 1481 & above)		
	51-27K	Fixed, dep. carb., 27K, 1/2 w, 2% (S/N 1480 & below)	73445	E-009-AB/B-27K
A12R19	50-820 Ω	Fixed, tin oxide, 820 Ω, 2 w, 2% (S/N 1481 & above)	16299	C42S-820 Ω
		Not used (S/N 1480 & below)		
		TEST POINTS		
A12TP1 thru A12TP3	133-85	Jack, probe insert	78947	119-437B

DIODE SHAPER PC BOARD (ASSEMBLY A13; See Table 1-1 for Part No.'s)

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
		CAPACITORS		
A13C1 thru A13C3	12-34	Capacitor, fixed, ceramic, 0.1 µf, 100 v	91418	BT 010
A13C4	12-22	Capacitor, fixed, ceramic, 100 pf, 500 v	71982	821-X5R-101K
A13C5 and A13C6		Same as A13C1		
		DIODES		
A13CR1, 3, 6, 8	81-260	Diode, 1N4148	07263	1N4148
A13CR1, 2, 4, 5, 7, 9 thru 14	81-41	Diode, 1N459	07263	1N459
		TRANSISTORS		
A13Q1 and A13Q2	81-115	Transistor, 2N3565	07263	2N3565
		RESISTORS		
A13R1 thru A13R11		See Table 7-1 on schematic 900713C		
A13R12 thru A13R14		Not used		
A13R15	56-750 Ω	Resistor, fixed, MF, 750 Ω, 1/2 w, 1%	19701	MF-7C-TO-750 Ω
A13R16	56-121 Ω	Resistor, fixed, MF, 121 Ω, 1/2w, 1%	19701	MF-7C-TO-121 Ω
A13R17 thru A13R23	56-100 Ω	Resistor, fixed, MF, 100 Ω, 1/2w, 1%	19701	MF-7C-TO-100 Ω
A13R24	56-80.6 Ω	Resistor, fixed, MF, 80.6 Ω, 1/2w, 1%	19701	MF-7C-TO-80.6 Ω
A13R25	56-1K	Resistor, fixed, MF, 1K, 1/2 w, 1%	19701	MF-7C-TO-1K
A13R26	71-90	Resistor, variable, WW, 200 Ω, 20 turns	21030	79PR200
A13R27	41-1.8K	Resistor, fixed, comp., 1.8K, 1/8 w, 10%	01121	EB 1821
A13R28	71-94	Resistor, variable, WW, 5K, 20 turns	21030	79PR5K
A13R29	41-27K	Resistor, fixed, comp., 27K, 1/2 w, 10%	01121	EB 2731
A13R30	41-10K	Resistor, fixed, comp., 10K, 1/2 w, 10%	01121	EB 1031
A13R31	41-150K	Resistor, fixed, comp., 150K, 1/2 w, 10%	01121	EB 1541

BWO TUBE (See Table 1-1)

PIN ATTENUATOR MODULE (See listing of assy. no. vs. frequency range of plug-in unit on page 5-9)

OUTPUT LOW-PASS FILTER AND INTERNAL SAMPLER (As applicable; see Table 1-1)

*Factory Selected

** Use 1N4385 for replacement.

FEDERAL SUPPLY CODE FOR TRUE MANUFACTURERS

FMC NO.	Full Name and Address of Vendor
00656	Aerovox Corporation, 740 Belleville Ave., New Bedford, Mass.
00686	Film Capacitors, Inc., 100 East 8th Street, Pabsaic, N.J.
00816	Hughes Aircraft Co., Vacuum Div., 500 Superior Ave., Newport Beach, Calif.
00853	Sangamo Electric Co., P.O. Box 128, Pickens, S.C.
00866	Goe Engineering Co., 219-21 S. Mednik Ave., Los Angeles, Calif.
01121	Allen Bradley Co., 136 W. Greenfield Ave., Milwaukee, Wisc.
01281	Pacific Semiconductor Co., 10451 W. Jefferson Blvd., Culver City, Calif.
01456	Microwave Development Laboratories, 87 Crescent Road, Needham Heights, Mass.
01963	Cherry Electrical Products Corp., Box 439, Highland Park, Ill.
02111	Spectrol Electric Corporation, 17070 E. Gale Ave., City of Industry, Calif. 91745
03508	G.E. Semiconductor, Electronics Park, Syracuse, N.Y., 13201
03565	Dayton Electronic Products Co., 117 E. Helena St., Dayton, Ohio
03782	Alfred Electronics, 3176 Porter Drive, Palo Alto, California 94304
04009	Arrow-Hart, & Hegeman Elec. Co., 113 Hawthorne St., Hartford, Conn.
04713	Motorola Semiconductor Products, Inc., P.O. Box 955, Phoenix, Arizona
05783	Stewart Engineering Co., 467 Bean Creek Rd., Santa Cruz, Calif.
05820	Wakefield Engineering Inc., 139-T Foundry St., Wakefield, Mass.
06049	Topaz, 3802 Houston, San Diego, California 92110
06555	Beede Electrical Instrument Co., Inc., Penacock, N.H.
06980	Varian, 611 Hansen Way, Palo Alto, Calif. (BWO)
02735	Radio Corp. of America, Electronic Components & Devices, 415 S. 5th St. Harrison, N.J.
07137	Transistor Electronics Corp., Box 6191, Minneapolis, Minn.
07263	Fairchild Semiconductor, 545 Whisman Rd., Box 880, Mountain View, Calif.
08806	General Electric Corp., Min. Lamp Dept., Nela Park, Cleveland, Ohio
09022	Cornell-Dubilier, 50 Paris St., Newark, N.J. (Mica Caps)
09023	Cornell-Dubilier, 50 Paris St., Newark, N.J. (Electrolytic Caps)
09297	CP Electronics Inc., Columbus, Ind.
11312	Microwave Electronics Div. of Teledyne, 3165 Porter Drive, Palo Alto, Calif.
12060	Diodes, Inc., 9261 Independence Ave., Chatsworth, Calif.
12122	Astrodyne, Inc., 2nd Ave., NW. Ind. Park, Burlington, Mass. 01803
12360	Albany Products, 351 Connecticut Ave., South Norwalk, Conn.
12697	Clarostat Mfg. Co., Washington St., Dover, N.H.
13664	Workman Elec. Prod. Inc., Packing House Rd., Sarasota, Florida 33578
13862	Alasco Rubber & Plastic Corp., 839 Malcom Rd., Burlingame, Calif.
14026	Spatron, Inc., 715 S. Raymond Ave., Alhambra, California 91803
14433	International Telephone & Telegraph, 3301 Electronic Way, W. Palm Beach, Florida
14482	Watkins-Johnson Co., 3333 Hillview, Palo Alto, California
15582	Bay City Screw & Bolt Co., 601 Industrial Way, San Carlos, Calif.
15818	Amelco, 1300 Terra Bella, Mt. View, Calif. 94042
16299	Corning Glass Works, Electronic Products Div., 3906 Electronics Dr., Raleigh, N.C.
16741	Triad Dist. Div. (Litton Ind.) 305 N. Briant St., Huntington, Ind.
17474	Tranex, Inc., 1599 Stierlin Rd., Mountain View, California
17545	Atlantic Semiconductors, Inc., 905 Mattison Ave., Asburg Park, N.J. 07712
17920	Warnecke Electron Tubes, 175 W. Oakton St., Des Plaines, Ill.
18489	Reliable Capacitors Co., 14716 Arminta St., Van Nuys, Calif.
18915	Birtcher Corp., The Industrial Div., 745 S. Monterey Pass Rd., Monterey Park, Calif.
19701	Electra Mfg. Co., 800 North 21, Independence, Kansas
20286	Daytron, Inc., 1269 Terra Bella, Mountain View, California
20649	Universal Metal Products, 5924 N. Western Ave., Chicago 45, Ill.
21030	Beckman Instrument, Inc., Helipot Div., 2500 Harbor Blvd., Fullerton, California
21743	Canseat Corp., 4164 Greenbush Ave., Sherman Oaks, Calif.
22229	Union Carbide, KEMET Elect. Div., Mountain View, California
23880	Standford Applied Engineering, 340 Marton Ave., Santa Clara, Calif.
24220	Gowanda, 179 Broadway Rd., Gowanda, N.Y.
24796	Parelco, Inc., 26181 Avenida Aevoprierto, San Juan Capistrano, California
27014	National Semi-Conductor Corp., 2950 San Ysidro Way, Santa Clara, Calif.
28480	Hewlett-Packard, Paeco Div., 3215 Porter Drive, Palo Alto, California
31918	International Electronics Exchange, 6529 Cambridge St., Minneapolis, Minn. 55426
33173	General Electric Corporation., Tube Dept., 316 E. Ninth St., Owenboro, Ky.
33293	Intersil Inc., Cupertino, Calif.
35434	Lectrohm, Inc., 5560 Northwest Hwy., Chicago, Ill.
37942	Mallory Capacitor Co., Div. P.R. Mallory & Co., Inc., 3029 E. Washington St., Indianapolis, Ind.
42190	The Muter Co., 1255 S. Michigan Ave., Chicago 5, Ill.
42498	National Radio Co., Melrose, Mass.
44655	Ohmite Mfg., Co., 3635 W. Howard St., Skokie, Ill.
46384	Penn Engineering, West State St., Doylestown, Penn.
56289	Sprague Electric Co., 91 Marshall St., N. Adams, Mass.
59730	Tyrap, C/O Thomas & Betts Co., 645 Phelps St., San Francisco, California

FMC NO.	Full Name and Address of Vendor
70309	Allied Control Co., Inc., 2 East End Ave., New York, New York
70563	Amperite Co., Inc., 600 Palisade Ave., New Jersey
70903	Belden Mfg. Co., Box 5070-A, Chicago, Ill. 60644
71436	Chicago Condenser Corporation, 3253 Armitage Ave., Chicago, Ill. 60647
71450	CTS Corp., 1172 W. Beardsley, Elkhart, Ind.
71590	Centralab, Electronics Div., Globe Union, 934 Keefe Ave., Milwaukee, Wisconsin
71785	Cinch Mfg. Co., 1026 S. Homan Ave., Chicago 24, Ill.
71895	Delavan Mfg. Co., Electro-Sonics Div., West Des Moines, Iowa
72982	Erie Technological Products, Inc., 644 W. 12th St., Erie, Penn.
72012	M. Ducommun Mfg. Co., 580 Fifth Ave., New York , New York 90036
72136	Electro Motive Mfg. Co., Inc., S. Park & John Streets, Williamantic, Conn.
72765	Drake Mfg. Co., 4626 N. Olcott Avenue, Harwood Heights, N.Y. 60656
72983	Stancor Electronics (Essex Wire Corp.) 3501 W. Addison St., Chicago, Ill.
73293	Hughes Aircraft Co., Elec. Comp., Div., 500 Superior Ave., Newport Beach, Calif.
73445	Amperex Electronic Corporation, Box 418, 230 Duffy Ave., Hicksville, N.Y.
73899	JFD Elect. Co., Comp. Div., 15th Ave., at 62nd St., Brooklyn, N.Y.
74542	Hoyt Electrical Inst. Works, Inc., 42 Carleston St., Cambridge, Mass.
74868	Amphenol Corp., Connector Div., 1830 S. 54th Ave., Chicago, Ill.
74970	The E.F. Johnson Co., 1923 10th Ave., S.W. Waseca, Minn.
75376	Kurz Kasch, 1417 S. Broadway, Dayton, Ohio
75382	Kulka Electric Corp., 520 S. Fulton Ave., Mt. Vernon, N.Y.
75042	IRC, Inc., 401 N. Broad St., Philadelphia, Penn.
75497	Lamson & Sessions, 5002 Tiedeman Rd., Cleveland, Ohio
75915	Littlefuse, Inc., 800 E. Northwest Hwy., Des Plaines, Ill.
76433	General Instrument Corp., 65 Gouverneur, Newark, N.J.
76487	James Millen Mfg. Co., Inc., 150 Exchange St., Malden, Mass.
76854	Oak Mfg. Co., Crystal Lake, Ill.
77342	Potter & Brumfield, Div., American Machine & Foundry Co., 1200 E. Broadway, Princeton, Ind.
77557	Reliable Spring & Wire Forms Co., 3167 Fulton Rd., Cleveland, Ohio
78553	Tinnerman Co., Dept. 16-T, P.O. Box 6688, Cleveland, Ohio
78947	Ucinite Corporation, 459 Watertown St., Newtonville, Mass. 02160
79493	J.W. Miller Co., 5915 S. Main St., Los Angeles, Calif. 90003
80294	Bourns, Inc., 1200 Columbia Ave., Riverside, California 92507
81073	Grayhill, Inc., 569 Hillgrove Ave., La Grange, Ill.
81312	Winchester Electronics, Inc., Div. Litton Industries, 19 Willard Rd., Norwalk, Conn.
82389	Switchcraft, Inc., 5555 N. Elston Ave., Chicago 30, Ill.
83186	Victory Engineering, 128 Springfield Ave., Springfield, New Jersey
83701	Electronic Devices, Inc., 21 Grey Oaks Ave., Yonkers, N.Y.
88245	USECO, Div. of Litton Industries, 13536 Saticoy St., Van Nuys, Calif.
89536	John Fluke Mfg. Co., Inc., P.O. Box 7428, Seattle, Wash.
91278	Stoesser Tool & Die, 3366 Fayette Dr., Mountain View, California
91418	Radio Materials Co., 4242 W. Bryn Mawr Ave., Chicago 46, Ill.
91637	Dale Electronics, Inc., (Subs. Lionel Corp.), Box 609, 1342 - 28th St., Columbus, Nebr.
91737	Gremar Mfg. Co., Wakefield, Mass.
91755	Harrison & Bonini, 1122 Harrison St., San Francisco, California
91827	K & F Tool Die & Mfg. , Inc., 1203 Dell Ave., Campbell, California
93332	Sylvania Electric Products, Inc., Semiconductor Div., 100 Sylvan Rd., Woburn, Mass.
93389	Proto Stamping, Washington & Santa Fe, Los Angeles 54, Calif.
94144	Raytheon, 465 Centre St., Quincy, Mass. 02164
94375	Automatic Metal Products Corp., 323 Berry St., Brooklyn 11, N.Y.
95263	Leecraft Mfg. Co., Inc., 44-35 - 21st St., Dept. E., Long Island City, N.Y.
95354	Methode Electronics, Inc., 7447 W. Wilson Ave., Chicago, Ill.
95987	Weckesser Co., Inc., 4444 W. Irving Park, Chicago, Ill.
96214	Texas Instruments, Inc., Semiconductor -Components Div., Box 5012, Dallas, Texas
96791	Borg Electronics, Div., Amphenol-Borg Electronics Corp., 120 S. Main St., Janesville, Wisc.
97464	Industrial Retaining Ring Co., 57 Cordier St., Irvington, N.J.
99120	Plastic Capacitors, Inc., 2620 N. Clybourn Ave., Chicago, Ill.
99313	Varian, 611 Hansen Way, Palo Alto, California (BWO)
99942	Hoffman Electronics Corp., Semiconductor Div., Box 471, El Monte, California

ADDITIONAL NUMBERS

FMC NO.	Full Name and Address of Vendor
00929	Microlab/FXR, 10 Micralab Rd., Livingston, N.J.
02114	Ferroxcube Corp. of America, Mt. Marion Rd., Saugerties, N.Y. 12477
02116	Wheelock Signals Inc., 273 Branchport Ave., Long Branch, N.J. 07440
02735	RCA Corp. Solid State & Tube Div., Route 202, Somerville, N.J.
04773	Automatic Electric Co., Wolf Rd. Northlake, Ill. 60164
11870	Melabs, Inc., 3300 Hillview, Palo Alto, Calif. 94304
12598	RLC Electronics, Inc., 25 Martin Pl., Port Chester, N.Y. 10573
13175	Electro-Mechanical Corp., 701 S. Elmer Ave., Sayre, Pa. 18840
18741	High Vacuum Electronics, Inc., 538 Mission St., So. Pasadena, Calif. 91030
23095	Aztec Electronics, Inc., 163 Liberty Ave., Anaheim, Calif. 92801
24931	Spec. Connector Co., 3560 Madison Ave., Indianapolis, Ind. 46227
26851	Compac Eng. Co., 810 East St., Hollister, Calif. 95023
70318	Allmetal Screw Products Co. Inc., 821 Stewart Ave., Garden City, N.Y.
71707	Cato Coil Co. Inc., Box B, Edgewood Station, Providence, R.I.
73559	Carling Electric Inc., 505 New Park Ave., West Hartford, Conn. 06110
82219	Sylvania Electric Prod., Revg Tube Div., Emporium, Pa.
84411	TRW Capacitor Div., 112 W. 1st St., Ogallala, Nebr.
89110	AMP, Inc., 155 Park St., Elizabethtown, Pa.
92219	Waldom Electronics Inc., 4625 W. 53rd St., Chicago, see 60632.
94696	Magnecraft Electric Co., 5579 N. Lynch Rd., Chicago, Ill. 60630
95348	Gordos Corp., 250 Glenwood Ave., Bloomfield, N.J. 07003
95712	Dage, Franklin, Ind.
98003	Neilson Hdwr. Corp., 770 Weathersfield Ave., Hartford, Conn.
99779	Barnes Dev. Co., 213 W. Baltimore Pike, Lansdowne, Pa. 19050

SECTION 7

SCHEMATIC DIAGRAMS

Schematics are included in the following order:

TABLE OF VOLTAGE MEASUREMENTS ON LEVELER-AMPLIFIER A11 PC BOARD

TEST POINT	LOCATION		MEASUREMENT CONDITION (Operating Mode)* & MEASURED VOLTAGES (All Measurements in Volts)			
			LEVELED		UNLEVELED	
			a*	b*	c*	d*
A	Q1A	Base	- .073	- .018	- .011	- .011
B	Q1B	Base	- .062	- .008	0	0
C	Q3	Base	+ 2.33	+ 2.35	+2.34	+2.34
D	Q4	Base	+ 2.40	+ 2.39	+2.39	+2.39
E	Q5	Base	- 8.57	- 8.66	-8.63	-8.72
F	Q7	Base	+ 3.92	+ 4.56	+4.32	+4.95
G	Q8B	Base	+ 0.16	+ 4.68	+4.76	+4.76
H	Q10 and Q11	Base Base	- 1.57	- 1.89	-1.09	-2.75
J	Q11	Emitter	- 0.91	- 1.23	-0.43	-2.07
K	CR2	Cathode	+ 0.56	+ 0.29	+1.00	-0.49
L	PIN 18		- 0.52	- 0.53	+1.00	-0.48
M	Q12	Base	- 3.72	- 4.39	-3.43	-3.79
N	Q12	Emitter	- 1.08	- 0.80	+0.08	+0.10
O	Q14	Base	- 0.46	- 0.19	+0.01	+0.52
P	Q14	Collector	+21.5	+21.6	0	+0.05

* DC VOLTAGES SHOWN ARE TYPICAL, MEASURED WITH RESPECT TO CHASSIS GROUND DURING SINGLE-FREQUENCY OPERATION, USING A HIGH-IMPEDANCE DIGITAL METER. AN ATTENUATOR OR OTHER SUITABLE LOAD SHOULD BE CONNECTED TO THE RF OUTPUT JACK.

a. Measured in LEVELED mode with POWER LEVEL control set at the mid-band point which provides maximum power with full-band leveling. (this point can be found by adjusting the POWER LEVEL control to the point where the UNLEVELED light is turned off during full-band sweep before switching to single-frequency operation for measurements.)

b. Measured in LEVELED mode with POWER LEVEL control fully CCW (minimum power).

c. Measured in UNLEVELED mode with POWER LEVEL control fully CW (maximum power).

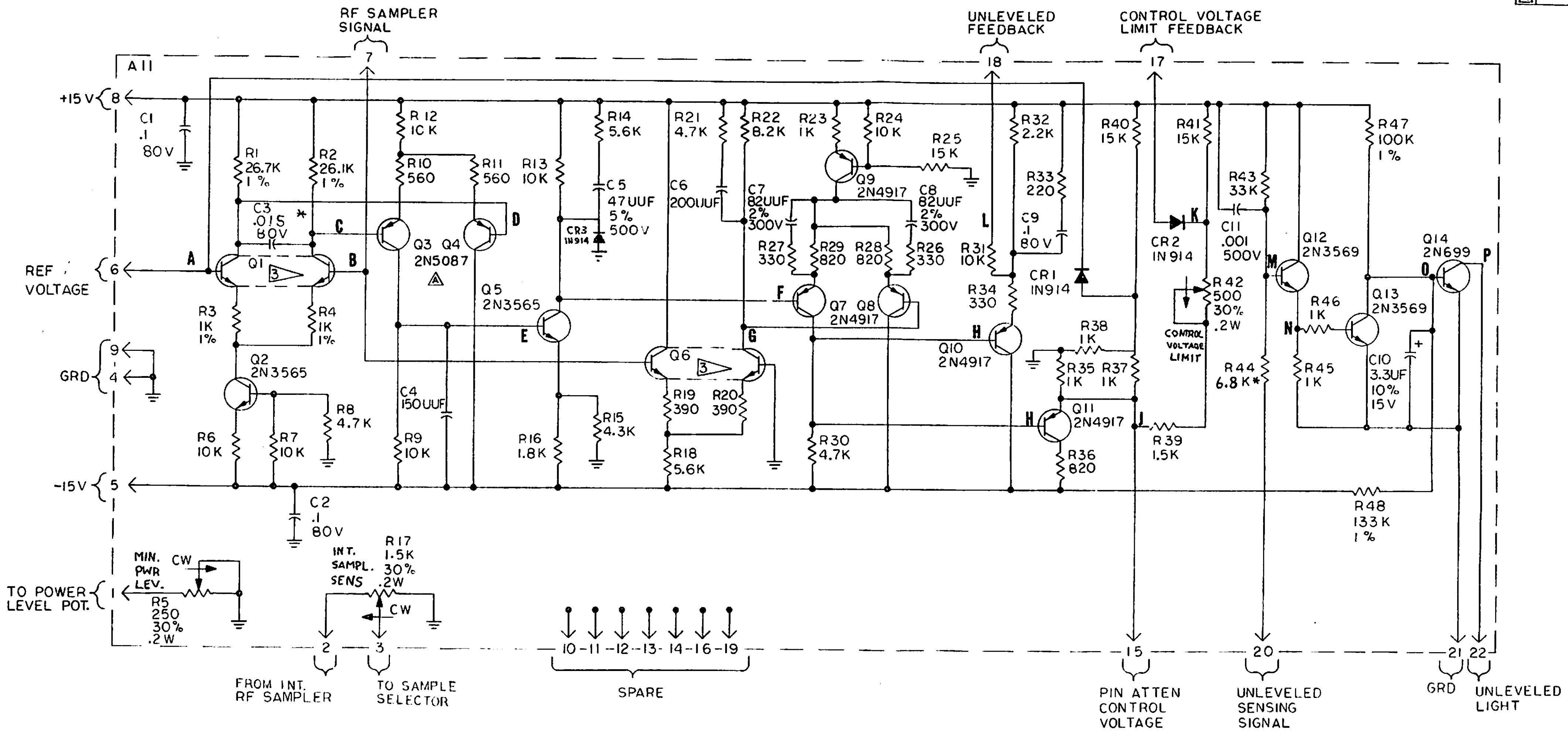
d. Measured in UNLEVELED mode with POWER LEVEL control fully CCW (minimum power).

d*
.011
0
2.34
2.39
8.72
4.95
4.76
2.75
2.07
0.49
0.48
3.79
0.10
0.52
0.05

NG SINGLE-
OR OTHER

les maximum
l to the
le-frequency

SYM	DESCRIPTION	NO	DATE	BY
–	PROD. RELEASE		2-6-68	
3		13707	7-25-68	



NOTES:

1 UNLESS OTHERWISE SPECIFIED:
ALL RESISTOR VALUES IN OHMS, ±5%, 1/4 W
ALL CAPACITOR VALUES IN MICROFARADS, ±10%, 100 V

2 PREFIX REF DESIGNATOR WITH "A11"

3 FOR FIELDS SERVICE SUBSTITIONS USE (1D-100 SPRAGUE) IN PLACE OF ALFRED NO. 81-191

*FACTORY-SELECTED

1/10/70

951088	6400
951088	650
NEXT ASSY	USED ON

ITEM	REQD	PART NO	DESCRIPTION
		LIST OF MATERIAL	

MATERIAL
MATERIAL STOCK NO
FINISH OR TREATMENT

DRAWN R. Ma... 20 DEC 67
CHECK
ENG T. J. Russell 2-5-68
PROD. ... 2-6-68
SCALE NONE

SCHEMATIC DIAGRAM LEVELER AMPLIFIER (PIN MODULATOR) A11

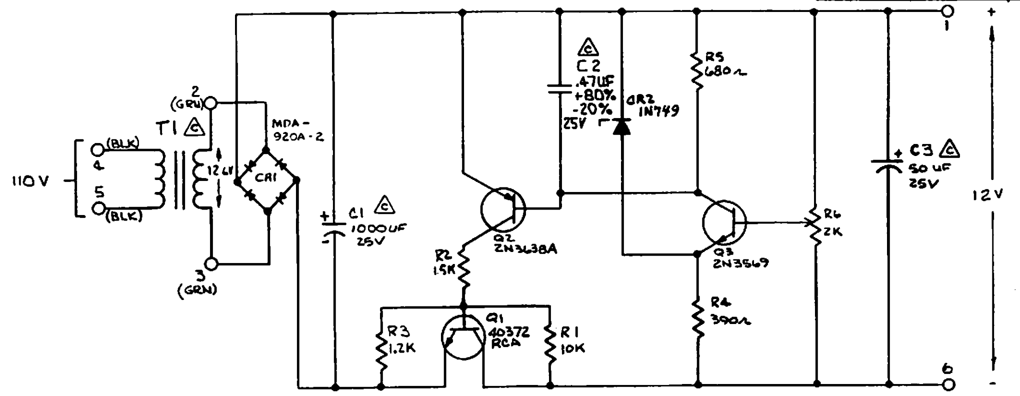
DIMENSIONS ARE IN INCHES TOL .XX ± .015 .XXX ± .005 ANGLE ± ½ UNLESS INDICATED OTHERWISE

ALFRED ELECTRONICS
PALO ALTO CALIFORNIA

SIZE D 900933 REV. E

SHEET 1 OF 1

SYM	DESCRIPTION	NO	DATE	BY
–	PRODUCTION RELEASE		11-28-67	
A	CHANGED R1 & R3, ADDED NOTE 1	13422	22 FEB 68	
B	REVISED PER ECO	13509	10	
C	REVISED PER ECO			



NOTES

1. ALL RESISTANCE VALUES IN OHMS, ±5%, 1/2W.
2. CIRCLES INDICATE TERMINALS ON PW BOARD.

ITEM	REQD	PART NO	DESCRIPTION

LIST OF MATERIAL

NEXT ASSY	USED ON
951087	6400
951087	650 PLUG-IN

MATERIAL

MATERIAL STOCK NO.

FINISH OR TREATMENT

DRAWN: Watson — DATE: 4.28.67
ENG: T. Russell — 11-29-67
APPD: — 11-29-67

SCALE

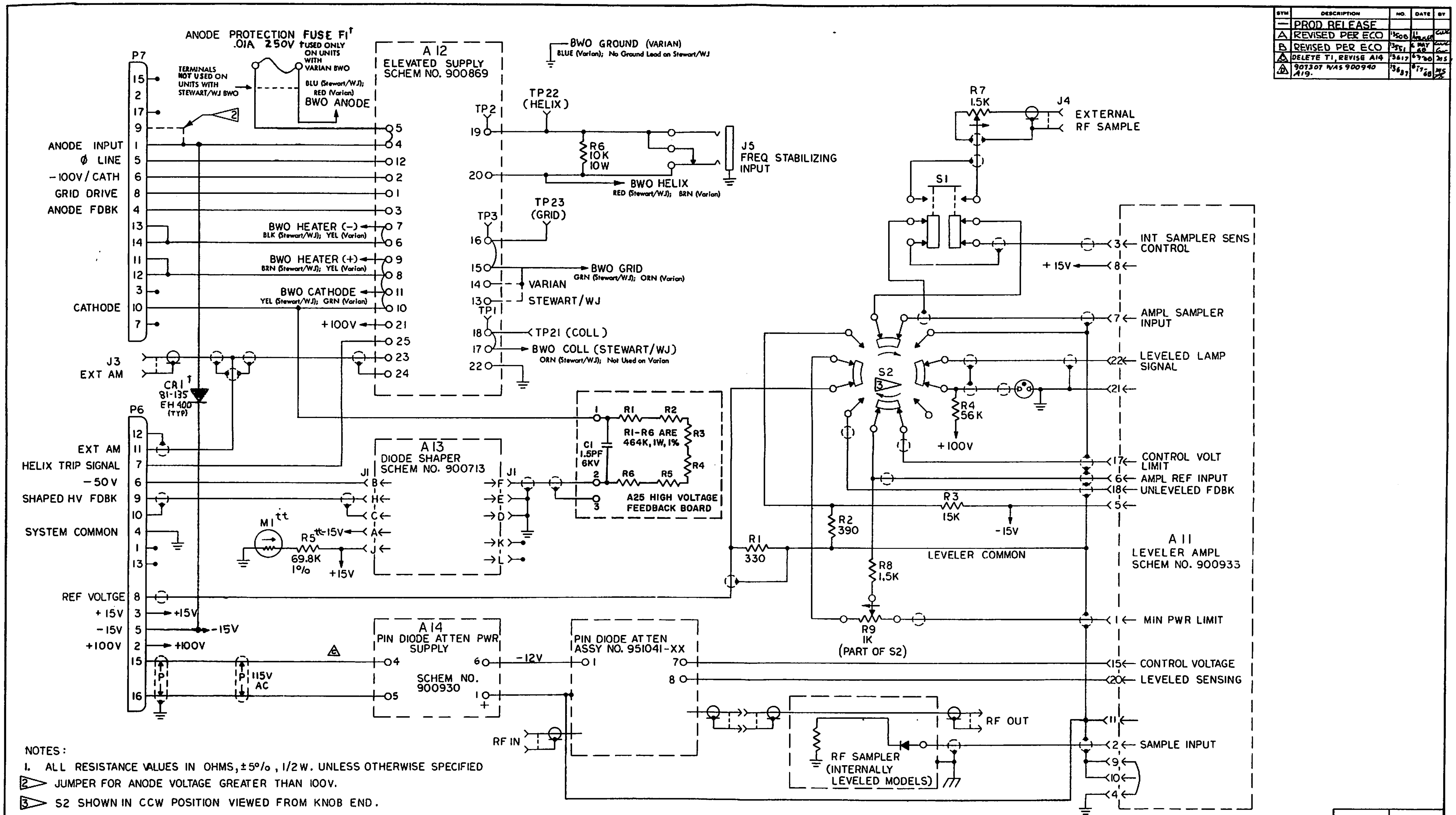
12V SUPPLY

DIMENSIONS ARE IN INCHES
TOL XX ± .015 XXX ± .005 ANGLE ± 1/2°
UNLESS INDICATED OTHERWISE

ALFRED ELECTRONICS
PALO ALTO, CALIFORNIA

SIZE: B — 900930 — REV: C

SHEET 1 OF 1



NOTES:

1. ALL RESISTANCE VALUES IN OHMS, ±5%, 1/2W. UNLESS OTHERWISE SPECIFIED

2 JUMPER FOR ANODE VOLTAGE GREATER THAN 100V.

3 S2 SHOWN IN CCW POSITION VIEWED FROM KNOB END.

†† NOT USED WITH 1-YR-WARRANTY BWO TUBES

SYM	DESCRIPTION	NO.	DATE	BY
—	PROD RELEASE			
A	REVISED PER ECO			
B	REVISED PER ECO			
C	DELETE T1, REVISE A14			
D	907307 WAS 900940 A19.			

LIST OF MATERIAL

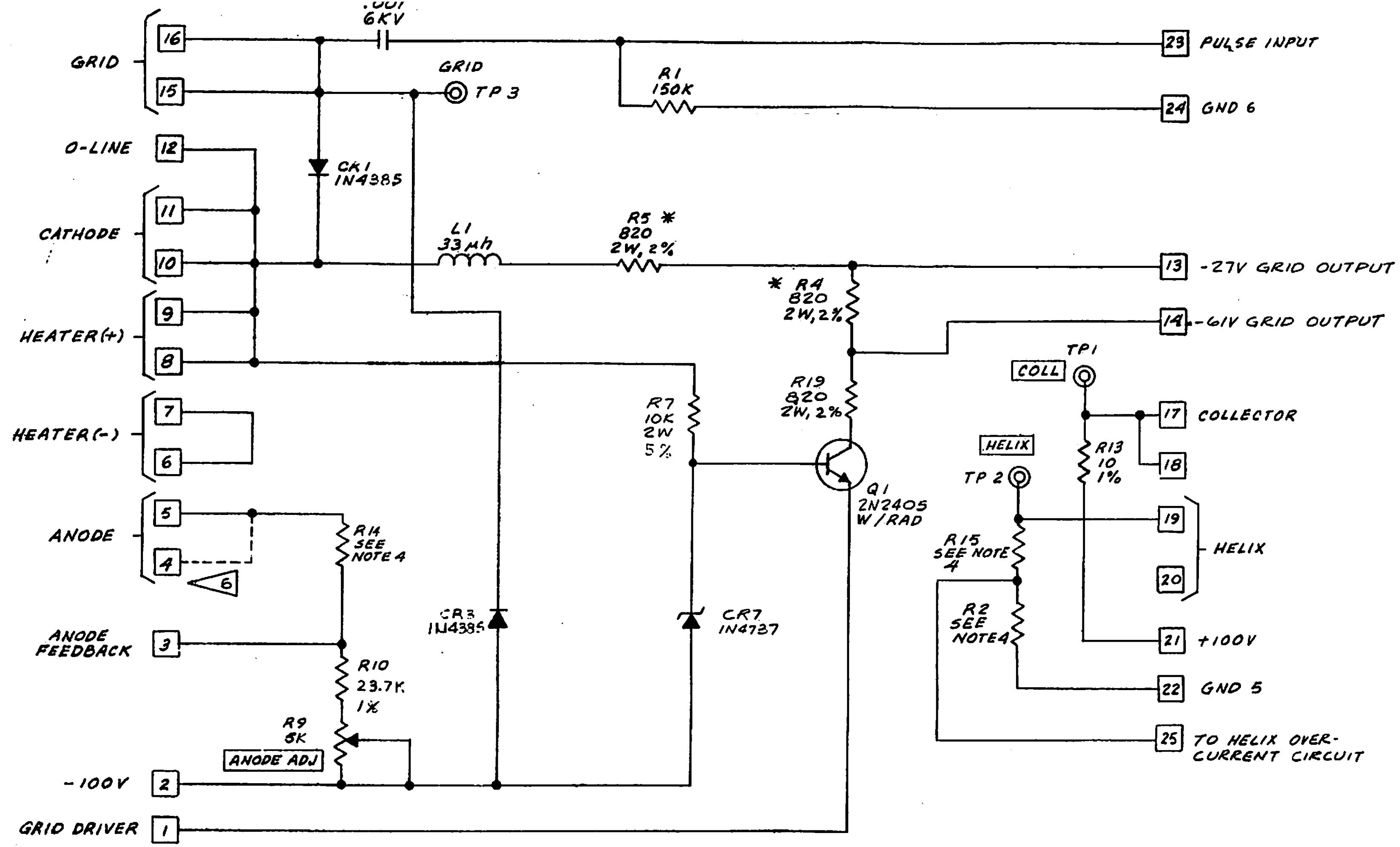
SCHEMATIC
650 PLUG-IN
PIN DIODE LEVELED

PLUG-IN 650

ALFRED ELECTRONICS
PALO ALTO, CALIFORNIA

D 907053 REV. H

SHEET 1 OF 1



REFERENCE DESIGNATIONS		
FIRST	LAST	NOT USED
C1	C1	
CR1	CR7	CR2,4,5,6
L1	L1	
Q1	Q1	
R1	R18	R3,R12,R16 R6,R8,R17 R18 R11

NOTES:

UNLESS OTHERWISE SPECIFIED:

2 SQUARES (□) DESIGNATE TERMINAL CONNECTIONS ON ASSY "A12" ASSEMBLY NO. 951917

3 PREFIX REFERENCE DESIGNATORS BY "A12" (I.E.: A12R1, A12Q1)

4 REFER TO INSTRUCTION MANUAL. (R14 IN K OHMS = $\frac{\text{ANODE VOLTAGE}+5}{3.9}$)

5 ASSY P.C. BD. NUMBER IS 944286

6 ON INSTRUMENTS USING THE ANODE PROTECTION CIRCUIT 951155, THE CONNECTION BETWEEN A12-4 & A12-5 IS BROKEN.

* FACTORY SELECT

1481 & UP	550-6
S/N 776 & UP <12.4 GHz	650-3
S/N 371 & UP >12.4 GHz	-1, 3, 5
S/N 1011 & UP <12.4 GHz	650-1
951917	650 PLUG-IN
NEXT ASSY	USED ON

ITEM	REQD	PART NO.	DESCRIPTION

LIST OF MATERIAL

MATERIAL

MATERIAL STOCK NO.

FINISH OR TREATMENT

DRAWN K. BURNS DATE 11/14/67

ENG.

PROD

SCALE NONE

SCHEMATIC ELEVATED SUPPLY

DIMENSIONS ARE IN INCHES
TOL: .XX ± .015, .XXX ± .005, ANGLE ± ½°
UNLESS INDICATED OTHERWISE

ALFRED ELECTRONICS
PALO ALTO, CALIFORNIA

SIZE C | 907377 | REV.

SHEET 1 OF 1

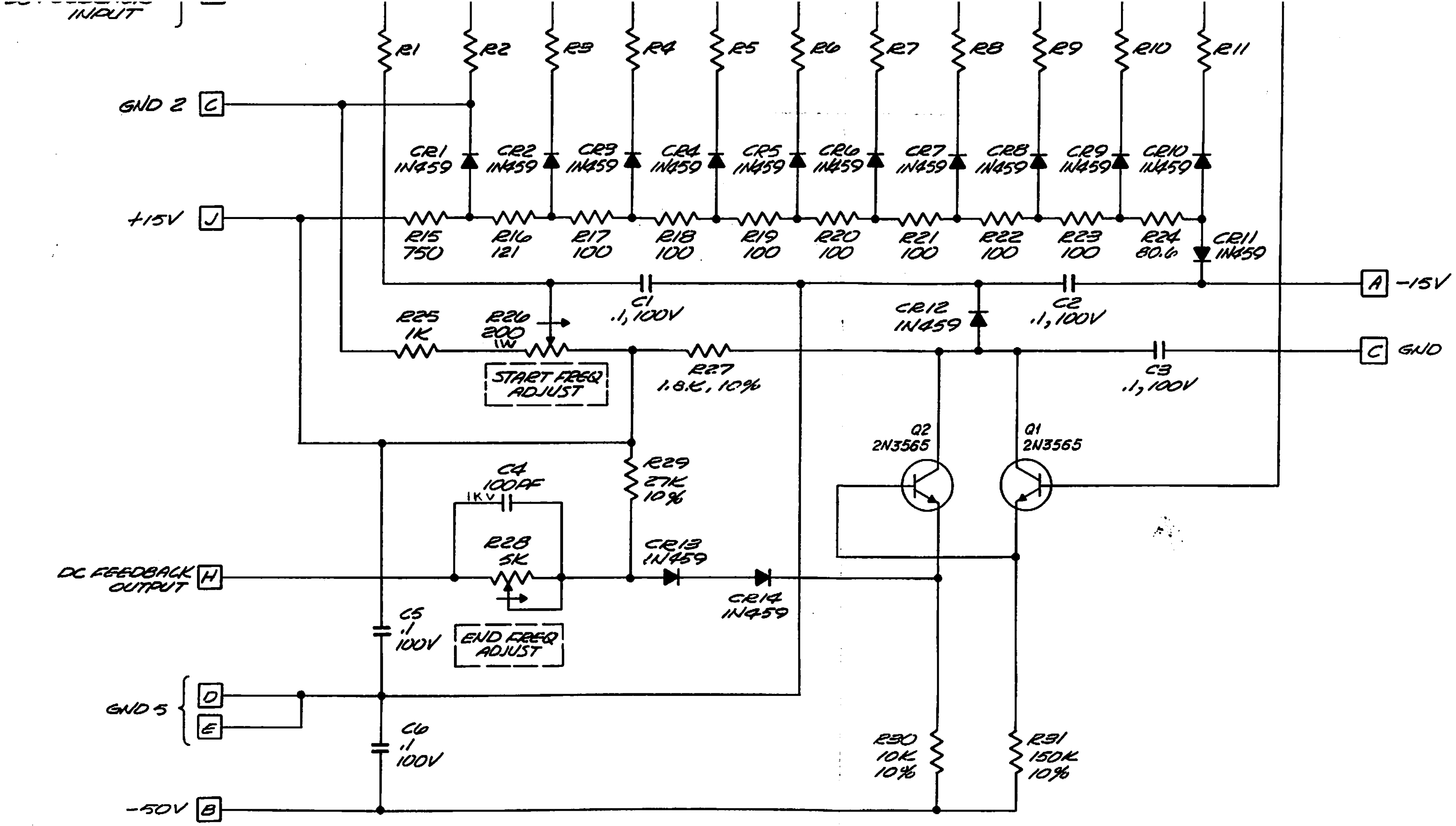
Table of Resistor Values for the Diode Shaper Assembly

Frequency GHz.	6400 Model No.	650 Model No.	Tube Manufacturer	Alfred Tube No.	Diode Shaper PC Board	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11
1 to 2	6410 thru 6415	651 651C 651K 651CK	Stewart	112-029	950636	124K	165K	499K	475K	357K	562K	432K	422K	866K	261K	576K
1.4 to 2.5	6410-1 thru 6415-1	651-S1 651C-S1 651K-S1 651CK-S1	Stewart	112-034	950637	107K	340K	442K	576K	887K	412K	464K	1.15M	374K	412K	1.15M
1.7 to 4.2	6420-1 thru 6423-1	652-S5 652C-S5 652K-S5 652CK-S5	Stewart	112-033	950858	178K	102K	280K	261K	205K	187K	210K	154K	147K	137K	162K
2 to 4	6420 thru 6425	652 652C 652K 652CK	Watkins-Johnson	112-095	951877	107K	121K	750K	309K	422K	348K	287K	536K	267K	392K	383K
			Varian	112-015	951601	215K	274K	953K	887K	536K	604K	619K	634K	562K	487K	634K
			Stewart	112-031	950638	133K	124K	383K	332K	340K	280K	301K	267K	232K	221K	232K
3.5 to 6.75	6430-1 thru 6435-1	653-S1 653C-S1 653K-S1 653CK-S1	Stewart	112-035	950640	100K	121K	402K	383K	243K	301K	237K	374K	130K	340K	174K
			Varian	112-016	951602	226K	340K	768K	909K	866K	649K	576K	649K	562K	562K	453K
3.7 to 8.3	6430-2 thru 6433-2	653-S2 653C-S2 653K-S2 653CK-S2	Stewart	112-028	950965	158K	110K	316K	261K	226K	221K	178K	165K	154K	124K	110K
			Varian	112-017	951610	205K	147K	402K	374K	324K	294K	267K	237K	165K	412K	140K
4 - 8	6430 thru 6435	653 653C 653K 653CK	Stewart	112-027	950639	133K	133K	392K	340K	294K	274K	243K	215K	200K	187K	154K
			Varian	112-006	950932	215K	196K	499K	357K	324K	287K	261K	215K	178K	143K	143K
			Watkins-Johnson	112-105	951909	130K	133K	374K	357K	287K	287K	200K	255K	182K	187K	133K
7 to 11	6440 thru 6443	654 654C 654K 654CK	Varian	112-012	950641	187K	866K	976K	1.15M	1.02M	953K	649K	698K	634K	576K	499K
			Watkins-Johnson	112-039	951699	86.6K	576K	806K	549K	866K	442K	665K	523K	324K	619K	422K
7 to 12.4	6440-1 thru 6443-1	654-S1 654C-S1 654K-S1 654CK-S1	Varian	112-012	950647	191K	274K	619K	536K	475K	402K	365K	316K	249K	249K	169K
			Watkins-Johnson	112-039	951603	82.5K	154K	357K	357K	301K	301K	255K	243K	215K	200K	182K
8 to 12.4	6450 thru 6453	655 655C 655K 655CK	Varian	112-013	950642	133K	465K	715K	649K	549K	536K	475K	392K	357K	294K	280K
			Watkins-Johnson	112-038	951604	634K	340K	453K	464K	442K	365K	324K	442K	267K	324K	243K
10 to 15.5	6460	656	Varian	112-014	950643	137K	549K	750K	715K	487K	536K	619K	453K	499K	549K	249K
12.4 to 18	6470 6471	657 657K	Watkins-Johnson	112-109	951910	69.8K	464K	649K	348K	499K	280K	383K	255K	215K	280K	221K
			Varian	112-009	950644	133K	—	1.40M	768K	1.40M	604K	866K	536K	590K	715K	604K
18 to 26.5	6480	658	Watkins-Johnson	112-110	951911	69.8K	464K	643K	475K	422K	332K	309K	332K	226K	237K	191K
			Varian	112-010	950645	150K	1.40M	1.24M	953K	909K	750K	825K	634K	649K	442K	324K
26.5 to 40	6490	659	Watkins-Johnson	112-111	951912	75K	301K	442K	340K	442K	324K	316K	287K	191K	280K	154K
			Varian	112-011	950646	110K	464K	634K	619K	549K	475K	442K	392K	294K	357K	243K

499K	475K	357K	562K	432K	422K	866K	261K	576K
715K	698K	665K	634K	619K	590K	562K	549K	511K
442K	576K	887K	412K	464K	1.15M	374K	412K	1.15M
280K	261K	205K	187K	210K	154K	147K	137K	162K
383K	332K	340K	280K	301K	267K	232K	221K	232K
953K	887K	536K	604K	619K	634K	562K	487K	634K
402K	383K	243K	301K	237K	374K	130K	340K	174K
768K	909K	866K	649K	576K	649K	562K	562K	453K
316K	261K	226K	221K	178K	165K	154K	124K	110K
402K	374K	324K	294K	267K	237K	165K	412K	140K
392K	340K	294K	274K	243K	215K	200K	187K	154K
499K	357K	324K	287K	261K	215K	178K	143K	143K
976K	1.15M	1.02M	953K	649K	698K	634K	576K	499K
806K	549K	866K	442K	665K	523K	324K	619K	422K
619K	536K	475K	402K	365K	316K	249K	249K	169K
357K	357K	301K	301K	255K	243K	215K	200K	182K
715K	649K	549K	536K	475K	392K	357K	294K	280K
453K	464K	442K	365K	324K	442K	267K	324K	243K
750K	715K	487K	536K	619K	453K	499K	549K	249K
1.40M	768K	1.40M	604K	866K	536K	590K	715K	604K
1.24M	953K	909K	750K	825K	634K	649K	442K	324K
634K	619K	549K	475K	442K	392K	294K	357K	243K

cuits.

l sampler for leveling.



NOTES:

1. UNLESS OTHERWISE SPECIFIED:
   1A. ALL RESISTORS IN OHMS, 1/2W, 1% METAL FILM
   1B. ALL CAPACITORS IN MICROFARADS
2. REFER TO INSTRUCTION MANUAL FOR SPECIFIC VALUE OF R1 THRU R11 FOR THE PARTICULAR MODEL INVOLVED
3. SQUARES (□) DESIGNATE PRINTED CIRCUIT CONNECTION ON ASSY NO. 950---
4. PREFIX REFERENCE DESIGNATORS BY "A13" (I.E: A13R1, A13Q2)

ITEM	REQD	PART NO.	DESCRIPTION
LIST OF MATERIAL			

S/N 11-UP | 650
NEXT ASSY | USED ON

MATERIAL

MATERIAL STOCK NO.

FINISH OR TREATMENT

DRAWN D. Stev — DATE 1-16-64
ENG — 1-4-65
PROD H. Kelm — 1-11-65

SCALE

SCHEMATIC DIODE SHAPER

DIMENSIONS ARE IN INCHES
TOL: .XX ± .015, .XXX ± .005, ANGLE ± ½°
UNLESS INDICATED OTHERWISE

ALFRED ELECTRONICS
PALO ALTO, CALIFORNIA

900713C

SHEET 1 OF 1

ALFRED

Tube Warranty and Replacement Procedure

TUBE REPLACEMENT

All TWT and BWO tubes furnished in ALFRED instruments are available from ALFRED ELECTRONICS for either warranty or out-of-warranty replacements. Current prices are given on the Replacement Tube Price List.

TUBE WARRANTY

The following warranties are applicable to tubes used in catalog instruments only. For the warranty applicable to tubes used or for use in special or modified instruments, please check with the factory. All tube warranties are from date of shipment by ALFRED.

WARRANTY FOR TWT AND VTM

Tubes are warranted unconditionally against defects in workmanship, materials, and construction within the period shown in Column A and the number of heater hours shown in Column B. To supplement the unconditional warranty, the tubes are warranted on a pro-rata basis for the rated number of heater hours shown in Column C or for one year, both computed from the date of original shipment by ALFRED, whichever expires first. The pro-rated adjustment will be based on the current list price of the tube and the unused percentage of heater hours (Column C) or one-year time period, whichever results in lesser credit.

Warranty Condition*	Tube Type	Applicable Tube Group or Alfred Tube Part No. Series	A Mo.	B Hours	C Hours
WC2	VTM	112-001 and 112-003	2	100	1000
WC3	TWT	10 and 20 mw output except WC4 tubes	12	500	2000
WC4	TWT	112-040 and 112-047	12	2000	-
WC5	TWT	1 watt output except WC6 and WC7 tubes	12	1500	-
WC6	TWT	112-046, 112-065, & 112-072	12	1000	-
WC7	TWT	112-057, 112-080, & 112-081	12	250	1000
WC8	TWT	2 to 10 watt output except WC9 tubes	12	75	500
WC9	TWT	112-055	2	50	500

* WC# denotes the corresponding warranty period(s) shown in the right-hand column(s) and is used for cross-reference to this warranty statement from other documents.

WARRANTY FOR ALL BWO TUBES

Tubes are warranted unconditionally against defects in workmanship, materials, and construction within the period shown below, without regard to the number of heater hours used.

Warranty Condition*	Tube Type	Warranty
WC10	BWO	Warranted unconditionally for one (1) year.

WARRANTY CONDITIONS APPLY ONLY TO TUBES LISTED ABOVE WHICH ARE USED IN ALFRED CATALOG INSTRUMENTS.

This warranty applies only to tubes sold after July 1, 1969.

TUBE SERVICE REPORT

TO OBTAIN WARRANTY CREDIT THE TUBE SERVICE REPORT MUST BE COMPLETED AND RETURNED WITH THE TUBE.

RETURN PROCEDURE

In case a tube or instrument fails, please contact the factory or your local sales representative for advice or authorization to return either the tube or the instrument to the factory. NO TUBE OR INSTRUMENT WILL BE ACCEPTED FOR REPAIR OR CREDIT ADJUSTMENT WITHOUT WRITTEN AUTHORIZATION AND ACCOMPANYING SERVICE REPORT.

When the authorization is received, pack the tube in a rigid container (use original carton if available) at least 4" larger than the tube in each dimension. Wrap the tube with 1/4" of soft padding material and heavy kraft paper before placing in container. Pack at least 2" of resilient dunnage such as rubberized hair, foam, or similar shock absorbing material completely around the tube. Mark the container "FRAGILE" and ship PREPAID via air freight, air express or rail 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 via these methods.

Use similar wrapping, packing and shipping provisions for an instrument. At least 6" of rubberized hair (or equivalent shock absorbing material) is required for an instrument.

IN-WARRANTY FAILURE - BWO AND VTM TUBES

BWO and VTM tubes which fail in warranty will be replaced with a new tube. In case a tube fails, please issue a purchase order for a new tube at the tube list price and return the defective tube. Warranty credit will be issued and deducted from the price, subject to tube manufacturer's verification that failure was caused by tube malfunction. To qualify for maximum credit, it is essential that the defective tube be properly packed and returned within 30 days after failure.

REPAIRABLE OR IN-WARRANTY FAILURE - TW TUBES

If the returned tube is found to be repairable, the user will be asked to issue a purchase order for repair charges determined by the original tube manufacturer. In general, the repair will be at no cost if the tube is in warranty and there is no evidence of misuse or abnormal conditions of operation.

WARRANTY CREDIT

Any applicable credit allowed under the terms of this warranty applies only toward the purchase of a replacement tube from ALFRED ELECTRONICS. Cash settlements will not be made. In terms of this warranty, a replacement tube must be the same type as that on which credit is allowed. Credit for one tube only may be applied toward the purchase of a single replacement tube. Warranty credit remains in effect for a maximum of six (6) months from date ALFRED ELECTRONICS notifies the customer. All credits will be based on the purchase price of the tube which prevails at the time the order for a replacement tube is received by ALFRED ELECTRONICS.

BWO RF CABLES

RF OUTPUT CABLE MUST ACCOMPANY BWO TUBES returned for warranty credit, repair or replacement. If rf output cable is NOT returned, the cable price is added to the normal BWO repair or replacement charge. For prices see Replacement Tube Price List.

SPECIAL CONDITIONS

If a returned tube or instrument proves not to be defective after test and evaluation at ALFRED ELECTRONICS, the tube or instrument will be returned at the customer's expense.

The final determination as to whether the tube failed in normal operation thereby bringing it under the applicable warranty or whether the tube was misused thereby excluding it from application of the warranty provisions, lies solely with the tube manufacturer.

Data, warranty credit, and prices subject to change without notice.

8/1/69

ALFRED ELECTRONICS

Service Report

Instrument Model ____________ Serial No. ____________ Date Received ____________

TW/BWO Tube Type ____________ Serial No. ____________ Date Received ____________

Date First Tested ____________ Date Placed in Service ______ Date of Failure ____________

Total Number of Hours of TWT/BWO Heater Operation ____________________________

____

1. Was operation normal just prior to failure? Yes ________ No ________

2. If not, what was done to adjust it? ____________________________

____

____

3. Has proper cooling been maintained during tube operation? ____________

____

4. Did helix overcurrent tripout occur? ____________________________

____

5. Was environment normal? (specify) ____________________________

____

6. Symptoms – (describe failure) ____________________________

____

____

7. Operating conditions at time of failure (indicate any unusual conditions) ________

____

____

8. Name of person to contact regarding evaluation of failure ____________

Telephone No. ____________ Signature ____________

Title ____________

Date ____________