OVER-THE-HORIZON RADIO SYSTEMS
2-GHZ OVER-THE-HORIZON RADIO SYSTEM
ITTL NUS 3653-8 10-KW POWER AMPLIFIER
TEST AND ALIGNMENT

This section contains test and alignment procedures for all operational components of the ITTL 10-kW power amplifier used in the 2-GHz Over-the-Horizon Radio System.

The safety precautions contained in Section 010-110-001 apply to all charts in this section.

Warning: The power amplifier is equipped with mechanical and electrical interlock systems designed for personnel protection. Do not tamper with the interlocks.

CHART **PAGE**

APPARATUS:

1—Volt-Ohm-Milliammeter, KS-14510

1—DC Power Supply, Hewlett-Packard 6285A, equipped with alligator clip leads

1—Microwave Power Meter, Hewlett-Packard 430C

1—Thermistor Mount, Hewlett-Packard 477B

APPARATUS (CONT):

1—Directional Coupler, Hewlett-Packard 777D

1—Coaxial Short, Hewlett-Packard 11511

1—RF Attenuator, 10 dB, Microlab AE1ON

1—RF Attenuator, 20 dB, Microlab AE2ON

1—Coaxial Resistor, 80A, Bird Termaline

1—Water Load, ITTL NUS 4961

1—Crystal Detector, Hewlett-Packard 420A

1—Low-Pass Filter, Microlab LA3ON

1—Oscilloscope, Tektronix 545B, equipped with dual trace unit 1A1

1—Test Cord, terminated

1—Test Load, 1000 ohms

1—Detector, EO8CN

1—Sweep Oscillator, Hewlett-Packard 8690A, equipped with power leveler 8692B

1—UHF Signal Generator, Hewlett-Packard 616A

2—Coaxial Tees

1—Pad Microlab AF10

1—Pad, Microlab AF3

CHART 1

PRELIMINARY

This procedure should normally be completed before any subsequent tests are attempted.

STEP	PROCEDURE
1	Complete the amplifier shutdown procedures contained in Section 403-405-300. Gain access to the interior by sequentially operating the key interlock system (Fig. 1).

CHART 1 (Cont)

STEP	PROCEDURE

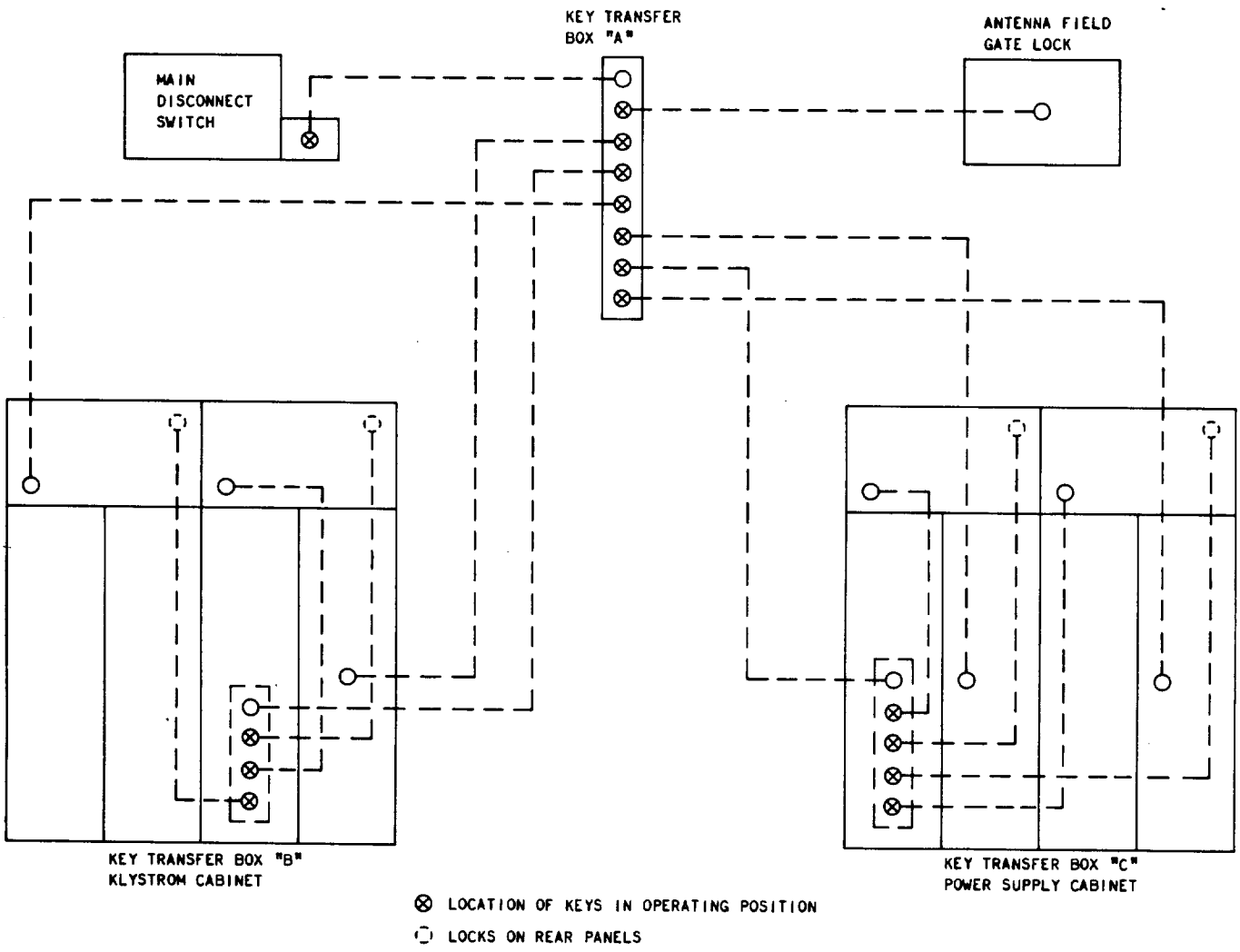


Fig. 1—Key Interlock System

2 Short the terminals of all filter capacitors to ground using the insulated grounding probe contained in each bay.

3 Inspect the power amplifier components in accordance with the following check list:

CHART 1 (Cont)

STEP	PROCEDURE

ITEM	CHECK FOR
High-Voltage Grounding Switches	Loose connections, binding
Wiring	Damaged insulation, loose lacing, missing identification tags
Coaxial and X-ray Cables	Loose connections, damaged or worn connectors, broken sheath connections, defective cables
Meter Switches	Binding, loose knobs
Lamps	Defective lamps, broken jewels or sockets
Transformers	Oil leaks, loose connections
Terminal Strips	Loose connections
Coolant Plumbing	Leaks, damaged or worn hoses, leaky quick-disconnect fittings
Cabinets	Doorlock operation, misplaced tools or parts, dirt, general appearance
Ancillary Components	Loose power plugs, missing hardware, damaged or worn controls

Requirement: All components should appear to be in good operating order.

Note: If the requirement is not met, perform the indicated corrective maintenance.

CHART 2

AIR FLOW SWITCHES

An air flow switch should open when either of the two blowers in the power amplifier cabinet stops. The air flow switch operation can be checked with the KS-14510 ohmmeter.

STEP	PROCEDURE
1	Complete the procedures in Chart 1.
2	Set the selector switch on the KS-14510 meter to OHMS X1. Connect the meter leads to the terminals of air flow switches S1 and S2, located on the housing of blowers B1 and B2, respectively, and measure for an open or closed state. See Fig. 2. ***Requirement:*** Both switches should be in an open state. ***Note:*** If the requirement is not met, replace the defective switch.

CHART 3

LIQUID COOLANT FLOW METERS AND SWITCHES

The klystron assembly requires a liquid coolant flow of approximately 8 gallons per minute. This chart describes the procedures required to calibrate the flow meters, check the flow switches for correct operation, and to adjust flow switches in meters removed from service.

STEP	PROCEDURE
1	Complete the procedures of Chart 1.

CHART 3 (Cont)

STEP	PROCEDURE

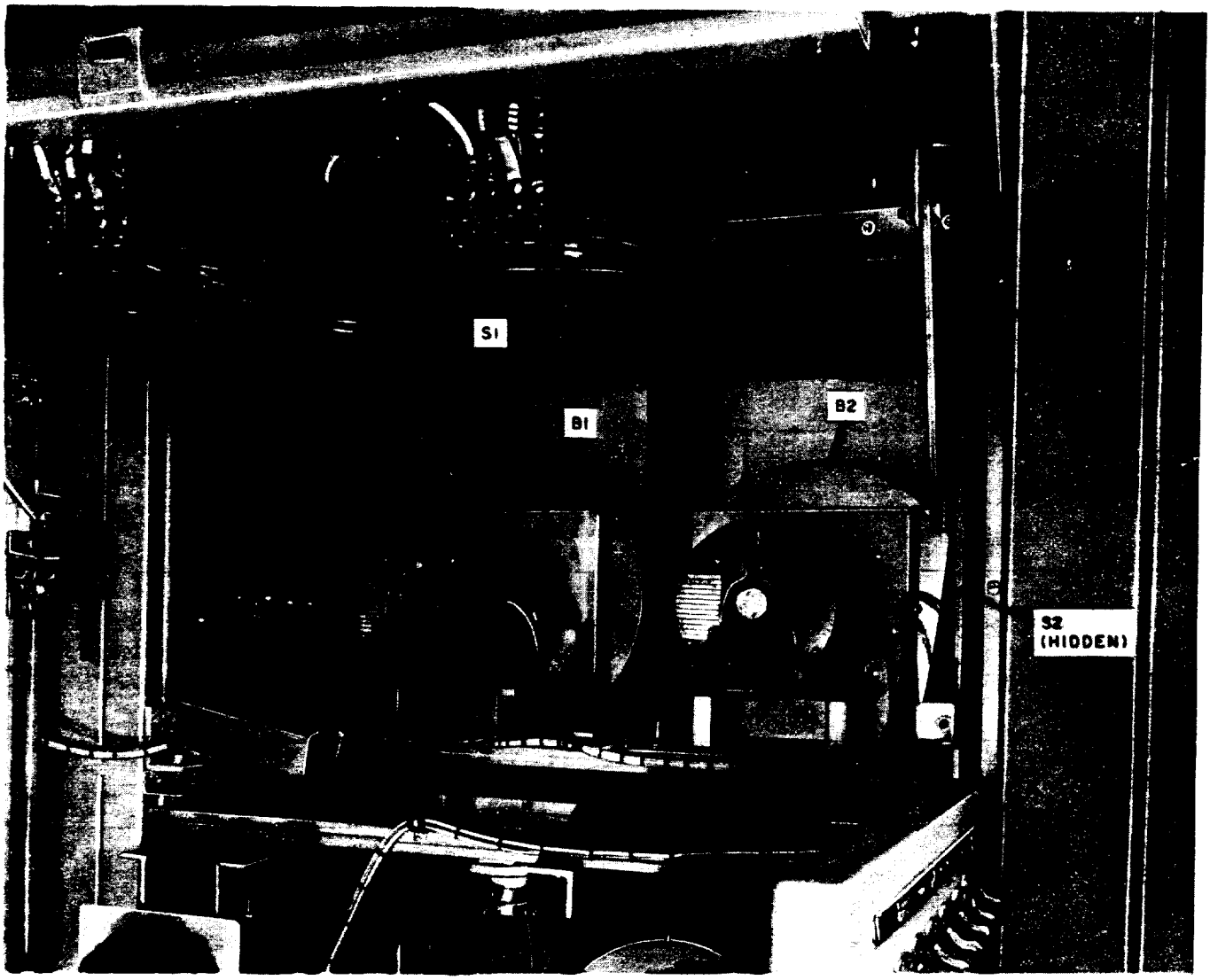


Fig. 2—Airflow Switches and Blower Locations

CHART 3 (Cont)

STEP	PROCEDURE
2	Note the indications on the COLLECTOR FLOW and BODY FLOW meters. ***Requirement:*** The meters should indicate zero. ***Note:*** If the requirement is not met, but the meter indications are near zero, a minor adjustment may be made to zero the indicators. The adjusting screw is located under the screw cap near the top front of each meter case.
3	Close and lock all equipment doors. Operate the MAIN DISCONNECT switch, the MASTER switch, and the CONTROL circuit breaker to the ON position.
4	Observing the condition of the COOLANT indicating lamp, the COLLECTOR FLOW meter, and the BODY FLOW meter, operate the HEAT EXCHANGER circuit breaker to the ON position. ***Requirement:*** The COLLECTOR FLOW and BODY FLOW meter indications should rise to greater than 7 GPM and 0.6 GPM, respectively, at which point the COOLANT indicating lamp should light. ***Note:*** If the requirement is not met, adjust the heat exchanger operating pressure to increase both meter indications, or adjust valves V5 and V6 in the klystron bay to correct an unbalanced condition.
5	Temporarily disconnect the coolant hose from the klystron body. ***Requirement:*** The COOLANT lamp should extinguish when the coolant hose is disconnected from the klystron. ***Note:*** If the requirement is not met, a faulty flow switch in the BODY FLOW meter is indicated. Replace the meter.
6	Reconnect the coolant hose to the klystron body.
7	Partially close valve V9 to reduce the COLLECTOR FLOW meter indication to 5 GPM. ***Requirement:*** The COOLANT lamp should extinguish when the collector flow is reduced to 5 GPM. ***Note:*** Failure to meet the requirement indicates a faulty flow switch in the COLLECTOR FLOW meter. Replace the meter.
8	Open valve V9.

CHART 3 (Cont)

STEP	PROCEDURE
	Adjustment Procedure
	Note: The key interlock system prevents adjustment of flow switches while the power amplifier is being operated. Switches in spare meters and meters that have been removed from the power amplifier can be adjusted as follows.
9	Remove the meter case and carefully operate the meter bellows by hand to obtain the specified meter indications while adjusting the switch adjusting screw. Use an ohmmeter to sense the operation of the switch.
	Requirement:

METER INDICATION	SWITCH CONDITION
BODY FLOW	
0.5 GPM	Open
0.6 GPM	Closed
COLLECTOR FLOW	
6.5 GPM	Open
7.0 GPM	Closed

CHART 4

RF INPUT METERING CIRCUIT

This chart describes the procedure for calibrating the radio-frequency input metering circuits. The test equipment arrangement is shown in Fig. 3.

STEP	PROCEDURE
1	Complete the procedures in Chart 1 and disable the power amplifier.
2	Disable the Farinon SS2000W driver.

CHART 4 (Cont)

STEP	PROCEDURE

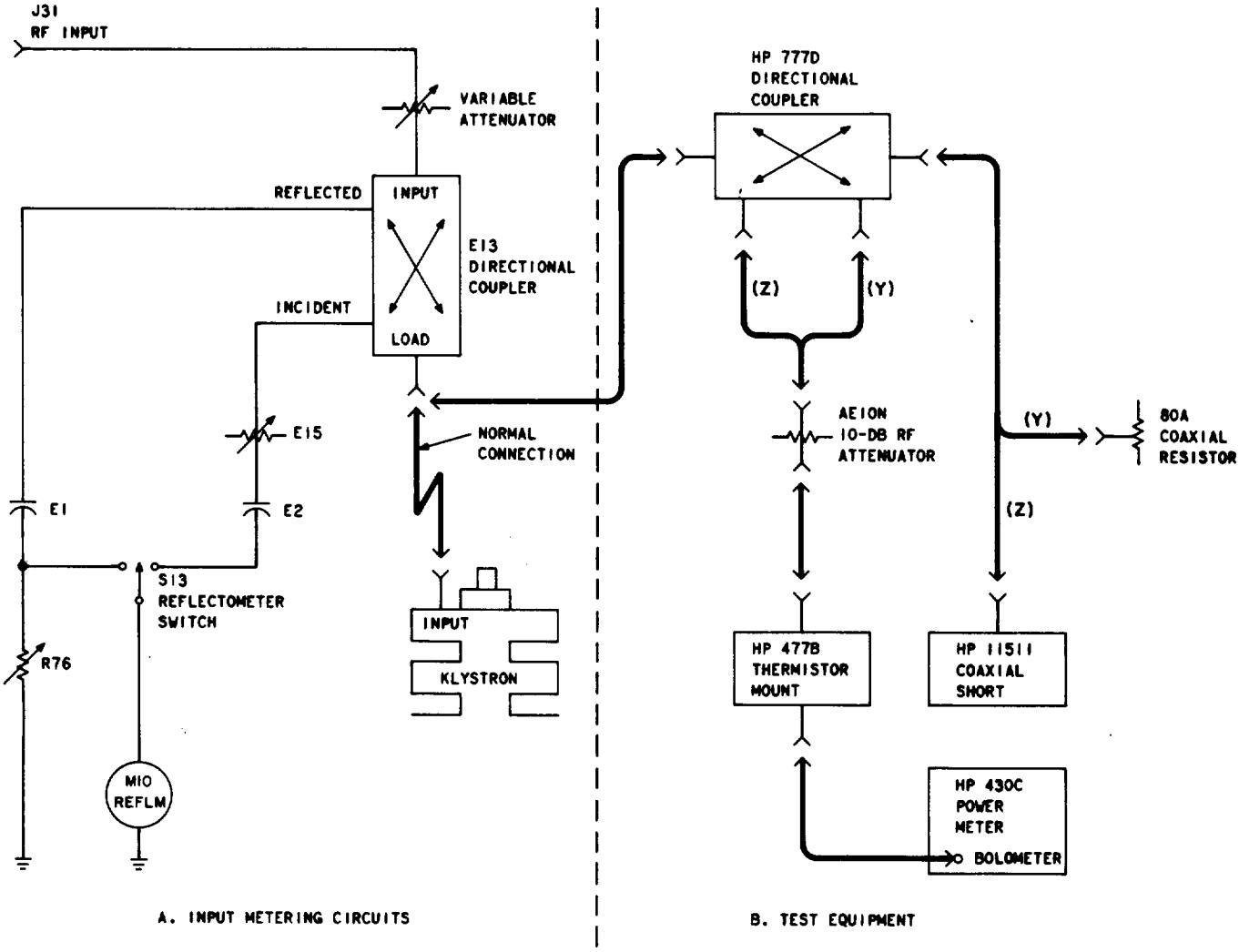


Fig. 3—RF Input Metering Circuits—Schematic Diagram and Test Arrangement

CHART 4 (Cont)

STEP	PROCEDURE
3	Disconnect the cable normally used between the LOAD jack of the input directional coupler, E13, and the klystron tube. Mount the HP 777D directional coupler on the E13 directional coupler LOAD jack and arrange the test equipment as shown in option Y of Fig. 3.
4	Adjust the controls of the 430C power meter as follows:

CONTROL	POSITION
BIAS CURRENT	OFF
POWER	ON
COEF	NEG
POWER RANGE	1 MW
ZERO SET COURSE	Maximum clockwise
ZERO SET FINE	Midrange

5	Rotate the BIAS CURRENT switch on the HP 430C power meter clockwise, one step at a time, until a positive power meter indication is obtained. Adjust the ZERO SET COURSE and ZERO SET FINE controls until the power meter indicates 0 milliwatt.
6	Record the setting of the variable attenuator at the input to directional coupler E13.
7	Enable the Farinon SS2000W driver.
8	Adjust the variable attenuator at the input to directional coupler E13 until the 430C power meter indicates 0.3 milliwatt. ***Note:*** This represents a power amplifier input level of 0.3 watt reduced by the 30-dB attenuator in the test circuit.
9	Operate the power amplifier REFLECTOMETER switch to the INPUT INCIDENT position.
10	Adjust the input power metering circuit attenuator E15 to obtain numerical agreement between the power meter indication and the REFLECTOMETER indication. Ignore the power terms.
11	Change the test equipment arrangement to that shown in Fig. 3, option Z.
12	Operate the power amplifier REFLECTOMETER switch to the INPUT REFLECTED position.

CHART 4 (Cont)

STEP	PROCEDURE
13	Adjust the INPUT REFLECTED ADJ control on the control bay door to obtain numerical agreement between the power meter indication and the amplifier REFLECTOMETER meter indication. Ignore the power terms.
14	Disconnect the test equipment and restore the normal connections.
15	Set the variable attenuator at the input to directional coupler E13 to the position recorded in Step 6.

CHART 5

BEAM CURRENT AND BODY CURRENT METERING AND OVERLOAD PROTECTION CIRCUITS

This chart provides the procedure for calibrating the meters in the klystron beam and body circuits. Procedures are also included for adjusting the meter protection devices and checking the operation of the beam and body current overload protection relays.

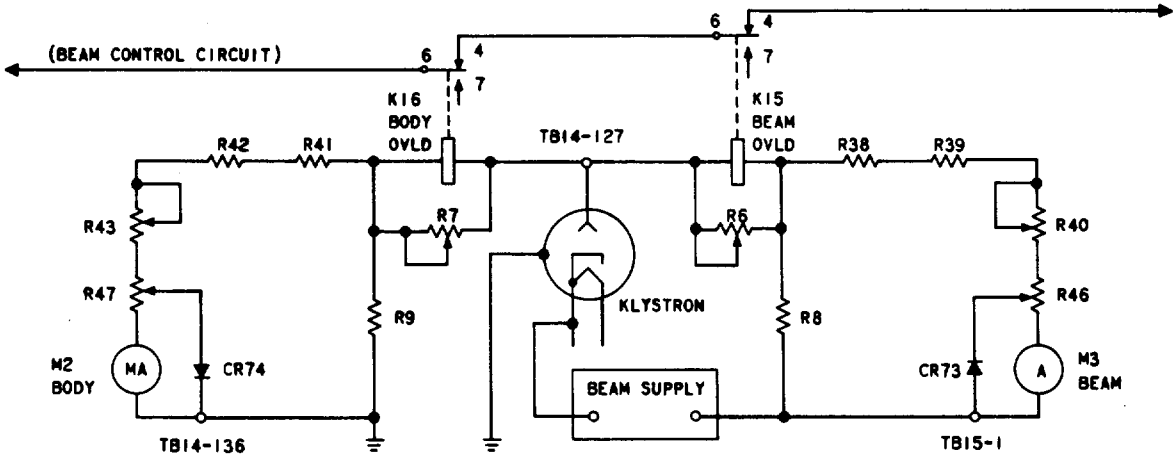
STEP	PROCEDURE
1	Complete the requirements of Chart 1, disabling the power amplifier.
2	Arrange the test equipment as shown in Fig. 4C.
3	On the HP 6285A dc power supply, make the following control adjustments:

CONTROL	POSITION
VOLTAGE	Fully clockwise
CURRENT	Fully counterclockwise
METER	6A

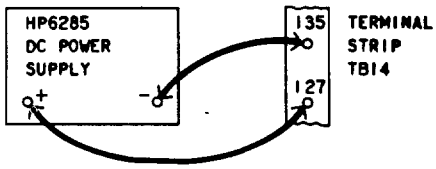
4	Adjust BEAM DIODE ADJ potentiometer R46 in the klystron enclosure fully counterclockwise.
5	On the dc power supply, set the LINE switch to ON and adjust the CURRENT control until the power supply meter indicates 3.0 amperes.

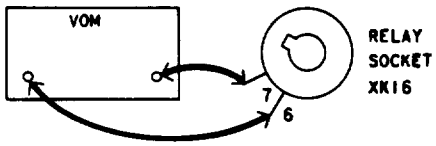
CHART 5 (Cont)

STEP	PROCEDURE

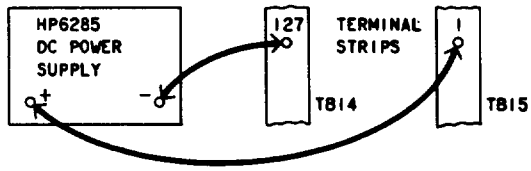


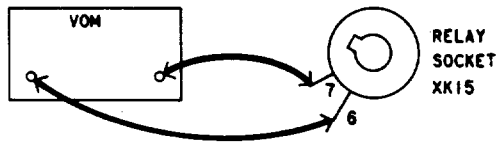
A. BODY AND BEAM CURRENT METERING AND PROTECTION CIRCUITS





B. TEST ARRANGEMENT BODY CIRCUITS





C. TEST ARRANGEMENT-BEAM CIRCUITS

Fig. 4—Body Current and Beam Current Metering and Protection Circuits—Schematic Diagram and Test Equipment Hook-Up

CHART 5 (Cont)

STEP	PROCEDURE
6	Adjust the BEAM METER CAL control R40 in the klystron enclosure until the BEAM CURRENT meter on the power amplifier indicates 3.0 amperes.
7	Adjust BEAM DIODE ADJ control R46 to obtain a decrease of one minor division of the BEAM CURRENT meter indication.
8	Rotate the dc power supply CURRENT control fully counterclockwise.
9	Set the volt-ohm-milliammeter range switch to OHMS X1.
10	While observing the volt-ohm-milliammeter for a continuity indication, slowly adjust the dc power supply CURRENT control clockwise until the ohmmeter indicates that beam overload relay K15 has operated. ***Requirement:*** The dc power supply meter indication should be 2.25 $\pm$0.1 amperes upon operation of relay K15. ***Note:*** If the requirement is not met, adjust BEAM OVERLOAD ADJUST control R6 located on the control bay door so that the relay operates within the specified limits.
11	Connect the test equipment as shown in Fig. 4B.
12	On the dc power supply, adjust the controls as follows:

CONTROL	POSITION
VOLTAGE	Fully clockwise
CURRENT	Fully counterclockwise
METER	0.6A

13	In the klystron enclosure, adjust BODY DIODE ADJ potentiometer R47 fully counterclockwise.
14	On the dc power supply, operate the LINE switch to ON and adjust the CURRENT control until the power supply meter indicates 0.3 ampere.
15	Adjust BODY DIODE ADJ control R47 to obtain a decrease of one-half a minor division in the BODY CURRENT meter indication.
16	On the dc power supply, operate the CURRENT control fully counterclockwise.
17	On the volt-ohm-milliammeter, set the range switch to the OHM X1 position.

CHART 5 (Cont)

STEP	PROCEDURE
18	On the dc power supply, slowly adjust the CURRENT control clockwise until the volt-ohm-milliammeter indicates the operation of body overload relay K16. ***Requirement:*** The dc power supply meter should indicate 0.125 ampere upon operation of relay K16. ***Note:*** If the requirement is not met, adjust BODY OVERLOAD ADJUST control R7 located on the control bay door to bring the relay within specified limits.
19	Disconnect the test equipment.

CHART 6

AMPLIFIER KLYSTRON

The power amplifier klystron requires complete alignment following replacement and a partial alignment to compensate for characteristic changes that may occur after operation. The chart provides procedures for the following:

A. Filament and Body Magnet Coil Adjustments

B. Preliminary (Synchronous) Tuning

C. Final (Broadband) Tuning.

STEP	PROCEDURE
	A. Filament and Body Magnet Coil Adjustments ***Note:*** This part applies primarily to replacement klystrons. After klystron replacement has been performed in accordance with Section 403-405-801, proceed as follows.
1	Complete the requirements of Charts 1 through 5.
2	Operate the power amplifier controls to the positions listed below:

CHART 6 (Cont)

STEP	PROCEDURE	
	CONTROL	POSITION
	KLYSTRON FILAMENT Variac	Fully Counterclockwise
	BEAM VOLTAGE Variac	Fully Clockwise
	BEAM Switch	OFF
	BOOST-BUCK Switch	BUCK
	MASTER Switch	OFF
	AMPLIFIER ALARM Switch	OFF
	REGULATOR MOTOR SUPPLY Switch	ON
	REGULATOR AUTOMATIC AND TEST Switch	AUTOMATIC
	CONTROL Circuit Breaker	ON
	RECTIFIER FILAMENT Circuit Breaker	ON
	KLYSTRON FILAMENT Circuit Breaker	ON
	MAGNETS-BODY 1 Circuit Breaker	ON
	MAGNETS-BODY 2 Circuit Breaker	ON
	MAGNETS-BODY 3 Circuit Breaker	ON
	CABINET COOLING Circuit Breaker	ON
	HEAT EXCHANGER Circuit Breaker	ON
	REGULATOR Circuit Breaker	ON

CHART 6 (Cont)

STEP	PROCEDURE
3	Disable the Farinon SS2000W driver associated with the power amplifier under test. ***Caution: Failure to disable the driver at this time can cause irrepairable klystron damage. The input cable must remain connected to the klystron under test.***
4	Verify that all compartments and doors are closed and all keys are installed in KEY TRANSFER BOX A.
5	Remove the top key from the key transfer box. Insert the key in the MAIN DISCONNECT switch and operate the MAIN DISCONNECT switch to ON.
6	Operate the MASTER switch to ON. When the COOLANT lamp lights, operate the COOLANT ALARM switch to ON.
7	Adjust the BODY MAGNET controls for the following initial indications: BODY 1 MAGNET 5.0 amperes BODY 2 MAGNET 4.0 amperes BODY 3 MAGNET 2.5 amperes
8	Adjust the KLYSTRON FILAMENT control clockwise in small increments until the KLYSTRON FILAMENT VOLT meter indicates 3.5 volts. Wait approximately five minutes before proceeding.
9	Check that the KLYSTRON FILAMENT CURRENT meter indicates ***15.0 amperes.*** If not, adjust the KLYSTRON FILAMENT control slightly until the correct current indication is obtained.
10	Operate the BEAM switch to ON. Adjust the BODY MAGNET controls to obtain a minimum indication on the BODY CURRENT meter. ***Note:*** High or fluctuating body current meter indications denote a gassy klystron condition. If this condition is observed, do not increase the beam voltage until a stabile body current indication of less than 75 milliamperes can be obtained by readjusting the body magnet controls.
11	Slowly increase the beam voltage as indicated on the BEAM VOLTAGE meter in 0.5-kilovolt increments by operating the BEAM VOLTAGE control counterclockwise. Adjust the three BODY MAGNET controls after each voltage change to maintain a minimum BODY CURRENT meter indication. When the counterclockwise limit of the BEAM VOLTAGE control is reached, operate the BOOST-BUCK switch to BOOST and rotate the BEAM VOLTAGE control clockwise until the BEAM VOLTAGE meter indicates 16.0 kilovolts.

CHART 6 (Cont)

STEP	PROCEDURE

12 Check that the BODY MAGNETS meter indications are within the following limits:

BODY 1 MAGNET	4.0-6.0 amperes
BODY 2 MAGNET	2.5-5.0 amperes
BODY 3 MAGNET	1.0-4.0 amperes.

If the required indications are obtained, record the body magnet meter indications. If the indications are out-of-limits, repeat Steps 10 through 12 until the final meter indications in Step 12 are obtained.

13 Reduce the beam voltage to the minimum obtainable through the operation of the BOOST-BUCK switch and the BEAM VOLTAGE control. Operate the BEAM switch to OFF.

B. Preliminary (Synchronous) Tuning

Note: Preliminary tuning is required only when the replacement klystron will be operated at the power amplifier frequency for the first time or if the cavity tuning controls have been disturbed.

14 Connect the ITTL NUS 4961 water load to the output of the directional coupler on the antenna side of the isolator-circulator. Connect the water load hoses to the water load coolant supply and drain connections located near the power amplifier. Adjust the water load coolant flow valve to obtain a flow of 4.0 gallons per minute through the water load.

15 Making certain that the power amplifier input attenuator is set for maximum attenuation, activate the Farinon SS2000W driver associated with the power amplifier being aligned.

16 Verify that the BOOST-BUCK switch is in the BUCK position and that the BEAM VOLTAGE control is at its clockwise limit.

17 Set the power amplifier REFLECTOMETER switch to INPUT INCIDENT. Adjust the input attenuator to obtain an input power indication of 0.05 watt on the REFLECTOMETER meter.

18 Set the REFLECTOMETER switch to INPUT REFLECTED.

19 Operate the BEAM switch to ON. Adjust the INPUT control on the cavity tuning control panel to obtain a minimum indication on the REFLECTOMETER meter.

20 Operate the REFLECTOMETER switch to INPUT INCIDENT.

CHART 6 (Cont)

STEP	PROCEDURE
21	Adjust the variable attenuator, mounted atop the input directional coupler located on the left wall of the klystron bay, to obtain a REFLECTOMETER meter indication between 0.075 and 0.1 watt.
22	Adjust the THIRD tuning control on the cavity tuning control panel to obtain a tuning control counter indication that is 400 less than the INPUT control counter indication.
23	Adjust the SECOND and OUTPUT tuning controls to obtain the same indications as those of the INPUT control counter.
24	Adjust the SECOND and OUTPUT tuning controls to obtain a maximum indication on the power amplifier RF POWER meter.
25	Adjust the BEAM VOLTAGE control to obtain a BEAM VOLTAGE meter indication of 15.0 kilovolts. ***Caution: Tuning the klystron third cavity to a frequency lower than the driver output frequency can result in irreparable klystron damage. When adjustments are made at the third cavity tuning control, an increase in counter turn numbers should always produce an increase in amplifier output. If the adjustment in the following step results in a reduction of output power, turn off the beam voltage and check the klystron installation.***
26	Adjust the THIRD tuning control in the direction of increasing turn numbers until the RF POWER meter indicates 10.0 kilowatts.
27	Adjust the SECOND tuning control in the direction of increasing turn counter numbers until the RF POWER meter indication is reduced to 5.0 kilowatts.
28	Adjust the THIRD tuning control in the direction of decreasing counter turn numbers until the RF POWER meter indication is reduced to 2.5 kilowatts.
29	Adjust the variable attenuator atop the input directional coupler to obtain a maximum indication on the power amplifier RF POWER meter. Limit the output power to 10 kilowatts by reducing the beam voltage as the 10-kilowatt level is approached.
30	Reduce the beam voltage to minimum through the operation of the BOOST-BUCK switch and the BEAM VOLTAGE control; then, operate the BEAM switch to OFF.
31	Perform the broadband alignment adjustment as described in Part C.

C. Final (Broadband) Tuning

Note: This procedure adjusts the bandwidth of the klystron amplifier for the required maximum bandwidth of 5 MHz at 1-dB points ($\pm$2.5 MHz from the nominal output frequency). A new klystron, or one that was last operated at a frequency different from the present

CHART 6 (Cont)

STEP	PROCEDURE
	power amplifier frequency, must first be prepared for the broadband alignment as directed in Part B. A klystron that was last operated at the present power amplifier frequency should be in a suitable condition for starting the final alignment procedure if the klystron tuning controls have not been disturbed.
32	Obtain the release of the transmitter from service.
33	Switch the BUCK-BOOST switch to BUCK. Set the BEAM VOLTAGE control fully clockwise. Set the BEAM and ALARM switches to OFF.
34	Remove the output section of the waveguide and install a NUS 4961 10-kW water load. Connect the water hoses; then open the valves to obtain a flow of 4 gallons per minute.
35	Disconnect the driver output from the input reflectometer.
36	Make test connections in accordance with Fig. 5. Set the controls on the test equipment to the following preliminary positions:

CHART 6 (Cont)

STEP	PROCEDURE	
UNIT	CONTROL	SETTING
UHF Signal Generator	POWER	ON
	Switch	CW
	SIGNAL SELECTOR	Adjust to station frequency
Sweep Oscillator	SWEEP SELECTOR	AUTO
	SWEEP TIME	1-.01
	START FREQ	Station frequency -3 MHz
	STOP FREQ	Station frequency +3 MHz
	STOP-START	START
	ALC	Depress
Oscilloscope	TIME BASE	A
	STABILITY	PRESET
	TRIGGER LEVEL	0
	TRIGGER MODE	AC
	TRIGGER SLOPE	EXT +
Horizontal Display A	5x MAGNIFIER	OFF
	HORIZONTAL POSITION	To center trace
Counter	FUNCTION	FREQUENCY

CHART 6 (Cont)

STEP	PROCEDURE
37	Adjust the input reflectometer for a minimum indication.
38	Set the BEAM switch to ON. Set the ALARM switch to ON.
39	Adjust the BEAM VOLTAGE control until the BEAM VOLTAGE meter indicates 13 kV. Set the BUCK-BOOST switch to BOOST.
40	Gradually, increase the beam voltage to the desired operating voltage with the BEAM VOLTAGE control.
41	Adjust the sweep output for a presentation of 1 MHz per division on the oscilloscope.
42	Adjust the CAVITY TUNING controls on the power amplifier for the flattest indication. ***Requirement:*** The output shall be flat within 1 dB between the −2.5 and +2.5 MHz points.
43	When the requirement is met, set the BEAM switch to OFF, close the water load valves, remove the dummy load, and restore the waveguide to its normal configuration.
44	Reconnect the driver output to the input reflectometer.
45	Energize the power amplifier; then set the drive to the input reflectometer.

CHART 7

RF OUTPUT METERING AND PROTECTION CIRCUITS

Calibration of the RF output metering and protection circuits should normally follow the completion of Chart 6, while the water load is still connected to the output waveguide transmission line. If the water load is not connected, the amplifier shutdown procedure in Chart 1 must be completed so that the water load can be connected.

STEP	PROCEDURE
1	Verify that the water load is connected to the amplifier output waveguide transmission line and that the water load hoses are connected to the coolant supply and drain ports.
2	Adjust the water load coolant flow valve to obtain a flowmeter indication of 3.8 gallons per minute.

CHART 7 (Cont)

STEP	PROCEDURE

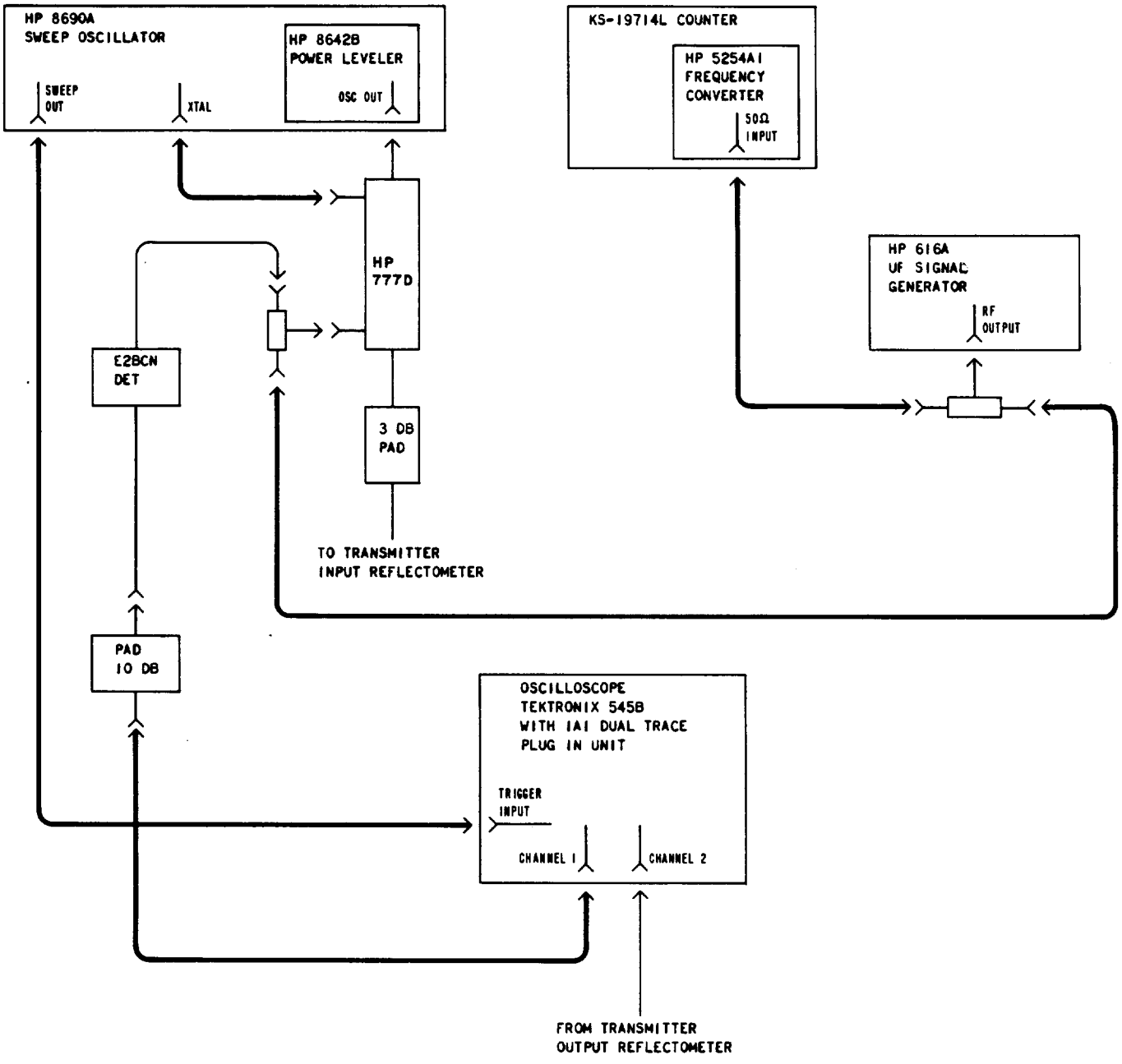


Fig. 5—Broadband Test Arrangement

CHART 7 (Cont)

STEP	PROCEDURE
3	Place the Farinon SS2000W driver associated with the power amplifier into service.
4	Fill the wells at the bottom of the two water load thermometers with water.
5	Verify that the power amplifier BOOST-BUCK switch is in the BUCK position and that the BEAM VOLTAGE control is at its clockwise limit.
6	Operate the BEAM switch to ON. Adjust the BEAM VOLTAGE control to obtain a BEAM VOLTAGE meter indication of 14.0 kilovolts.
7	Note the temperature difference between the input and output water load thermometers. Adjust the BEAM VOLTAGE control to obtain an indicated difference of 10 degrees.
8	On the output directional coupler, adjust the variable attenuator at the INC port to obtain an indication of 10 kilowatts on the power amplifier RF POWER meter.
9	Operate the REFLECTOMETER switch to the INPUT INCIDENT position and record the REFLECTOMETER indication.
10	Adjust the BEAM VOLTAGE control on the power amplifier to obtain a temperature difference of 1 degree between the two water load thermometers. If this temperature difference cannot be attained by operation of the BEAM VOLTAGE control, reduce the setting of the variable attenuator atop the input directional coupler (located on the left wall of the klystron bay) until the 1-degree thermometer difference can be attained through adjustment of the beam voltage.
11	Disconnect the coaxial components normally used at the INC- (low RF) jack on the output waveguide directional coupler.
12	Move the coaxial components and cable connection normally used at the REFL_ (antenna reflected) jack to the INC_ (low RF) jack.
13	On the power amplifier control panel, set the REFLECTOMETER switch to ANTENNA REFLECTED X 1000.
14	Adjust the relocated attenuator associated with the antenna reflected components to obtain a full-scale REFLECTOMETER indication. Secure the attenuator in this position.
15	Adjust the BEAM VOLTAGE control, and the attenuator atop the input directional coupler, if necessary, to obtain a REFLECTOMETER indication of 0.4.
16	Move the coaxial components from the INC_ (low RF) jack to their normal position at the REFL_ (antenna reflected) jack on the output directional coupler.

CHART 7 (Cont)

STEP	PROCEDURE
17	At the REFL_ (antenna mismatch) jack, remove the coaxial cable from the crystal detector assembly. Move the coaxial components normally used at this jack to the INC_ (low RF) jack.
18	Connect the 1000-ohm test load to the crystal detector assembly now located at the INC_ (low RF) jack. Operate the volt-ohm-milliammeter to the 3DC VOLTS range and connect the meter test leads to the test load pin jacks.
19	Adjust the antenna mismatch attenuator, now located at the INC_ (low RF) jack, to obtain a voltmeter indication of 1.0 volt. Secure the attenuator in this position.
20	Operate the REFLECTOMETER switch to the INPUT INCIDENT position and increase the setting of the attenuator atop the input directional coupler to obtain the REFLECTOMETER indication recorded in Step 9.
21	Operate the BEAM switch to OFF.
22	Temporarily remove the arc sensors, one at a time, from the waveguide section adjacent to the klystron and from the directional coupler. ***Requirement:*** Exposure of the arc sensor tip to room light should cause the OUTPUT LINE ARC indicator lamp to extinguish. ***Note:*** If the requirement is not met, replace the defective sensor.
23	Dismantle the test arrangement. Move the coaxial components from the INC_ (low RF) jack to their normal position at the REFL_ (antenna mismatch) jack. Reconnect the cable normally used at the detector assembly. Reconnect the coaxial components normally used at the INC_ (low RF) jack.
24	Disconnect the water load from the waveguide and restore the waveguide transmission line to its normal arrangement.

CHART 8

PRIMARY VOLTAGE REGULATOR

The primary voltage regulator is a motor-driven 3-phase variable autotransformer. The regulator control is mounted on the front panel of the regulator bay and includes a voltage-sensitive regulating relay which automatically adjusts the variable autotransformer to compensate for the line voltage fluctuations.

The chart describes the procedures for testing and aligning the regulating relay.

CHART 8 (Cont)

STEP	PROCEDURE

1 Complete the requirements of Chart 1.

2 Adjust the power amplifier controls as follows:

CONTROL	POSITION
KLYSTRON FILAMENT Variac	Fully Counterclockwise
BEAM VOLTAGE Variac	Fully Clockwise
BEAM Switch	OFF
BOOST-BUCK Switch	BUCK
MASTER Switch	OFF
AMPLIFIER ALARM Switch	OFF
REGULATOR MOTOR SUPPLY Switch	ON
REGULATOR AUTOMATIC & TEST Switch	AUTOMATIC
CONTROL Circuit Breaker	ON
RECTIFIER FILAMENT Circuit Breaker	ON
KLYSTRON FILAMENT Circuit Breaker	ON
MAGNETS BODY 1 Circuit Breaker	ON
MAGNETS BODY 2 Circuit Breaker	ON
MAGNETS BODY 3 Circuit Breaker	ON
CABINET COOLING Circuit Breaker	ON
HEAT EXCHANGER Circuit Breaker	ON
REGULATOR Circuit Breaker	ON

CHART 8 (Cont)

STEP	PROCEDURE
3	Verify that all amplifier compartments and doors are closed and all keys are inserted in place in KEY TRANSFER BOX A.
4	Remove the top key from the key transfer box; insert the key in the MAIN DISCONNECT switch. Operate the MAIN DISCONNECT switch to ON.
5	Operate the MASTER switch to ON. When the COOLANT indicator lamp lights, set the COOLANT ALARM switch to ON.
6	Adjust the MAGNETS controls and KLYSTRON FILAMENT control to obtain the values established and recorded in the most recent klystron alignment.
7	Verify that the BEAM switch is OFF.
8	Operate the VOLTAGE regulator control AUTOMATIC & TEST switch to MANUAL.
9	On the power amplifier, operate the LINE VOLTAGE switch to UNREGULATED BC. Note the line voltage indication on the AC LINE VOLTAGE meter.
10	Operate the LINE VOLTAGE switch to REGULATED BC.
11	Operate the voltage regulator MANUAL OPERATING LEVERS to obtain the same AC LINE VOLTAGE meter indication as that obtained in Step 9.
12	Operate the LINE VOLTAGE switch alternately to UNREGULATED AB and REGULATED AB. Record the two AC LINE VOLTAGE meter indications.
13	Operate the LINE VOLTAGE switch alternately to UNREGULATED CA and REGULATED CA. Record the two AC LINE VOLTAGE meter indications. ***Requirement:*** The unregulated AB and regulated AB voltage indications shall be within 2 volts. The unregulated CA and regulated CA voltage indications shall be within 2 volts. ***Note:*** If the requirement is not met, misalignment of the motor-driven autotransformer is indicated. Refer to the General Electric Instruction Bulletin GEI-57801 contained in the ITTL instruction book for the power amplifier.
14	Operate the LINE VOLTAGE switch to REGULATED BC.
15	On the voltage regulator control, operate the AUTOMATIC & TEST switch to AUTOMATIC & TEST. Adjust the HOLDING EFFECT control to its clockwise limit.
16	Alternately operate the LOWER and RAISE MANUAL OPERATING LEVERS while observing the AC LINE VOLTAGE meter. Each lever operation should be sustained only until the vibration caused by operation of the motor control relay is sensed. Allow sufficient time between each lever operation to permit the voltmeter indication to stabilize. Adjust the

CHART 8 (Cont)

STEP	PROCEDURE
	HOLDING EFFECT control slowly counterclockwise until a point is reached where the voltmeter indication stabilizes at the same voltage following each lever operation.
17	Note the AC LINE VOLTAGE meter indication. ***Requirement:*** The regulated voltage across primary BC phase legs, indicated on the line voltmeter, should be 208 $\pm$1 volts. ***Note:*** If the requirement is not met, remove the regulating relay front cover and adjust the regulating relay compensating spring tension control to obtain a meter indication of 208 volts. The spring tension control is the smaller of the two knurled knobs at the inside top of the relay housing.
18	Alternately operate the LOWER and RAISE levers while observing the AC LINE VOLTAGE meter. Note the meter indications at the points where the vibration caused by operation of the motor control relay is sensed. Compute the regulator bandwidth which is the difference between the upper and lower value meter indications. ***Requirement:*** The regulator bandwidth should be between 2 and 4 volts. ***Note:*** If the requirement is not met, adjust the regulator stationary contact adjusting nut to obtain a regulator bandwidth of 3 volts. The stationary contact adjusting nut is the larger of the two knurled knobs on the top of the regulating relay.
19	Replace the regulating relay cover.

CHART 9

DIODE RECTIFIERS, HIGH-VOLTAGE RECTIFIER TUBES, HIGH-VOLTAGE BLEEDER RESISTORS, AND BEAM CURRENT LIMITING RESISTORS

This chart provides procedures for determining faulty components in the high-voltage power supply. High-voltage power supplies may use either diode rectifiers or vacuum tube rectifiers. These are interchangeable in sets in the rectifier circuit. Whenever possible, the diode rectifiers will be used. The vacuum tube rectifiers will be used only in emergency situations when diode rectifiers are not available. The following procedures should be used for checking the high-voltage components:

A. Checking Diode Rectifier Circuits

B. Identifying Faulty Rectifier Tubes

C. Checking Resistors in Beam Current Limiting String

CHART 9 (Cont)

D. Checking Resistors in the Bleeder Circuit.

STEP	PROCEDURE
	A. Checking Diode Rectifier Circuits
1	Looking through the window in the power supply door, while the power supply is in the normal operating state, check that all the neons on each diode rectifier stack are lighted. ***Requirement:*** All neon indicator lamps shall be lighted. If any neon lamp is extinguished, perform the amplifier shutdown procedures in Section 403-405-300.
2	Gain access to the interior of the power supply by sequentially operating the key interlocks shown in Fig. 1.
3	Remove the diode rectifier stack in which the neon lamp was extinguished.
4	Using an ohmmeter, measure the front-to-back resistance of each diode in the rectifier stack. ***Requirement:*** The forward resistance of each diode shall be approximately 5 ohms and the reverse indication, approximately infinity. Replace any diodes that do not meet the requirement.
5	Examine resistors and wiring for signs of deterioration or damage. Replace any damaged item.
	B. Identifying Faulty Rectifier Tubes
6	Complete the requirements of Chart 1.
7	Remove and visually inspect all rectifier tubes. Sometimes, defective tubes can be identified by evidence of damage, such as filament shivers or plate perforations. If these are not found, proceed with this test.
8	Install a clip lead between the plate lead connector and the gap bracket at the socket of rectifier V2.
9	Install a questionable rectifier tube in the socket of rectifier V5. Connect the plate lead to this tube and arrange all remaining plate leads in a manner to prevent grounding.

CHART 9 (Cont)

STEP	PROCEDURE
10	Verify that the power amplifier BOOST-BUCK switch is in the BUCK position and the BEAM VOLTAGE control is set at its clockwise limit. Perform the procedure for "Placing in Service Following Complete Shutdown" described in Section 403-405-300.
	Caution: Do not set the BEAM switch to the operate position before reading Step 11 completely. Step 11 must be performed rapidly.
11	While observing the amplifier BEAM VOLTAGE meter, operate the BEAM switch to ON. A zero or negative meter indication signifies a defective rectifier tube. Operate the BEAM switch to OFF. If the meter indicates approximately 14 kilovolts, quickly adjust the BEAM VOLTAGE control so that the BEAM CURRENT meter indicates 1 ampere. If the BEAM VOLTAGE meter indication is steady at this point, the tube under test is good. Switch the BEAM switch to OFF.
12	Complete the amplifier shutdown procedure described in Section 403-405-300. Repeat this test for each questionable rectifier tube.
	C. Checking Resistors in the Beam Current Limiting String
13	Complete the amplifier shutdown procedure. Observing the safety procedures and precautions in Section 010-110-001, remove the rear cabinet door from the left power supply compartment.
14	Using the KS-14510 volt-ohm-milliammeter in the OHM X1 range, measure the resistance of each of the four beam current limiting resistors, R17 through R20. Inspect the resistors for evidence of deterioration.
	Requirement: The resistance of each beam current limiting resistor should be 25 $\pm$5 ohms. There should be no evidence of deterioration.
	Note: Any resistor that fails to meet the requirement should be replaced.
	D. Checking Resistors in the Bleeder Circuit
15	Using the volt-ohm-milliammeter in the OHMS X 1000 range, measure the resistance of each of the seven bleeder resistors, R10 through R16. Inspect each resistor for evidence of deterioration.
	Requirement: Each bleeder resistor should measure 100,000 $\pm$20,000 ohms. There should be no evidence of deterioration.
	Note: Any resistor that fails to meet the requirement should be replaced.