SERVICE NOTE

CESIUM BEAM TUBE REPLACEMENT PROCEDURE

SUPERSEDES

This service note describes the procedure for replacement of the Cesium Beam Tube (05060-6090) in the Hewlett-Packard Model 5060A. The procedure consists of three parts: (1) removal of the old Cesium Beam Tube; (2) installation of the new tube; and (3) realignment of the instrument to obtain optimum performance with the new tube. Parts of Section III may also be used as an alignment procedure to aid in troubleshooting.

SECTION I. CESIUM BEAM TUBE REMOVAL

a. Disconnect power from the Model 5060A and remove instrument top and bottom covers.

b. Unsolder both heavy white wires from high voltage power supplies A18 and A19 at the bottom rear left of the instrument. Note the positioning of these wires for installing the new tube. Remove and save the rubber insulating boots.

c. Remove the three miniature plugs A4P1, P2, and P3 from the bottom of harmonic generator assembly A4.

d. Disconnect white-red and blue wires from harmonic generator assembly.

e. Release snap-locks on both cable plugs (P16 and P17) by moving the bar at the bottom of the plug toward the front panel. Disconnect these plugs.

f. Remove four screws in the beam tube hold-down straps.

g. Rotate beam tube 45° to allow removal of harmonic generator assembly. If beam tube is stuck in place, carefully loosen one end at a time.

h. Disconnect harmonic generator assembly by removing four screws from flange attached to beam tube. Lay the assembly aside; it will be mounted on the new beam tube.

i. Carefully lift out beam tube.

SECTION II. BEAM TUBE REPLACEMENT

a. Install new beam tube in the instrument with the label facing up. Rotate the tube so that harmonic generator may be installed.

b. Attach harmonic generator assembly A4 to new beam tube. Refer to Figure 5-7 in the Model 5060A Operating and Service Manual for orientation in the instrument. Be sure to tighten the four mounting screws securely to insure a good electrical connection.

c. Place the two plastic straps and the two metal hold-down straps over the beam tube. Position the beam tube to provide top cover clearance and permit connections to the harmonic generator assembly. Insert the four screws in the hold-down straps and tighten.

d. Insert the two beam tube cable plugs in their jacks on the instrument chassis. Slide snap-locks in place.

e. Insert the two heavy white & red wires through chassis hole and slide on rubber insulating covers. Locate the white wire marked "EM" and connect this white wire to pin 3 of -2500 vdc assembly A19 (05060-6092). Slip rubber cover over soldered connection. Use the syringe supplied and fill inside of rubber cover with silicone grease.

f. Connect heavy red wire marked "ION" to pin 5 of -3500 vdc assembly A18 (05060-6093). Slide rubber cover over the soldered connection and fill with silicone grease.

g. Observe identification markings on the harmonic generator assembly and connect the white-red and blue wires.

h. Connect the three miniature plugs to the bottom of the harmonic generator. Leave instrument top and bottom covers off since several adjustments are required.

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SECTION III. ADJUSTMENT PROCEDURE.

Several adjustments are required when the beam tube is replaced. Since some of the adjustments must be performed with power applied and covers removed, observe the following precautions: 1) never remove the A15 assembly on A15R1 with power applied, and 2) avoid contact with exposed voltage terminals. During the adjustment procedure, a 100 microampere meter (HP Part No. 1120-0083) or HP Model 412A VTVM may be substituted for the CIRCUIT CHECK 2 meter by using the plug supplied to connect to the EXT METER jack on the front panel.

a. Cesium Oven Controller. Refer to Cesium Oven Controller A20 schematic diagram and photo (Figure 5-26) in 5060A Operating and Service Manual to identify components referred to in the following steps:

1) With AC Power disconnected from the instrument, remove cesium oven controller assembly A20 as follows:

   a) Release the snap-lock on the plug at rear of assembly and disconnect this plug.

   b) Remove the mounting screw at each end of assembly and lift out.

   c) Remove six cover screws on top and six cover screws on bottom. Remove assembly cover and preserve shielding braid. Components are now exposed.

2) Locate A20T1 (9100-0335) at the front of the assembly. Look on the new beam tube decal and note the hot wire ionizer taps called out.

   Refer to the table below and note the proper strapping required for these output taps.

output taps called out on Beam tube decal	strap T1 transformer taps
15, 17	14 & 16
16, 17	------
14, 17	15, 16

   Make those connections on T1 indicated by the beam tube decal and the above table.

3) Locate A20T2 (9100-0333) near the plug. Look on the new beam tube decal and note the transformer taps called out. Connect A20T2 as indicated on the new beam tube decal.

4) Locate A20T4 (9100-0334). Note taps called out for T4 on the beam tube decal and make the appropriate connections.

5) Install the resistors supplied for R24A, B, and R21.

6) Position the shielding braid on A20 assembly and replace cover with 12 screws.

7) Replace assembly in instrument and tighten the two mounting screws.

8) Connect plug to assembly and fasten snap-lock. This completes the Cesium Oven Controller adjustments.

b. Electron Multiplier Voltage Adjust (A15R1).

1) With instrument disconnected, connect a high-voltage meter (HP Model 410B with 11044A Probe, or equivalent) to terminal 3 of -2500 volt assembly A19. Note electron multiplier voltage given on new beam tube decal.

2) Locate A15 electron multiplier regulator assembly at top front center of instrument deck. Unplug this printed circuit board, install extender board, and plug A15 assembly into extender board socket (orient A15 same as originally installed).

3) Locate A15R1 on assembly A15. Install a 250K, ±1% resistor for A15R1.

4) Set MODE switch to LOOP OPEN/CS ON.

5) With meter connected to monitor the -2500 volt supply, connect power to the Model 5060A.

6) Set CIRCUIT CHECK 2 switch to ION PUMP I and observe current indication. Meter may indicate full scale and then decrease. After indication decreases below about 4, the -2500 volt supply will be enabled. If ION PUMP I does not decrease, see Paragraph 2-23 in the Model 5060A Operating and Service Manual.

7) Note the electron multiplier voltage called out on the new beam tube decal. The high-voltage meter should indicate within 5% of this value. If the measured voltage is too low, disconnect power from the instrument and reduce the value of the resistor in parallel with A15R1. If the voltage is too high, raise the value of this padding resistor. Connect power, wait for -2500 volt supply to be enabled and observe the voltage. Adjust A15R1 resistance until the electron multiplier voltage is at the value specified for the new beam tube.

8) Disconnect power from instrument, remove A15 assembly and extender board, and install A15 assembly in its socket.

9) Reconnect power to instrument. This completes the electron multiplier voltage adjustment.

c. Harmonic Generator Assembly A4 Adjustments. The harmonic generator assembly removed from the old beam tube should require only slight adjustment to operate with the new beam tube. RF level in the beam tube cavity is adjusted by first optimizing the Harmonic Generator for maximum 9192.63 MHz signal then adjusting this level into the beam tube to obatin maximum beam current. During adjustment of the harmonic generator assembly, beam current is most easily measured by connecting directly to the beam tube output. To do this, disconnect the cable from A7J5. Using the micon-to-male adapter and the micon to BNC cable provided with the 5060A, connect this cable to a pico-Ammeter or a high

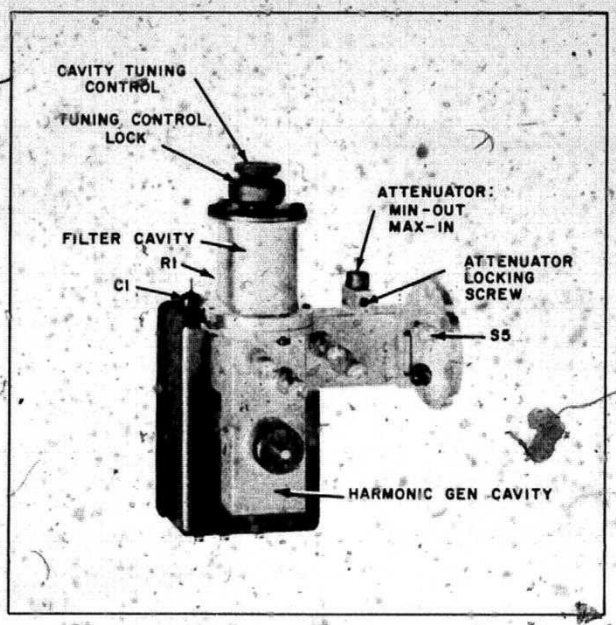

Figure 1. Harmonic Generator Assembly

impedance Voltmete: such as the HP Model 412A. If a Voltmeter other than a 412A is used, its input impedance and sensitivity should be capable of measuring a current of approximately 10^{-8}A.

Note

The following adjustments should be made only after the cesium tube and quartz crystal oven are at operating temperature. Refer to the Operating & Service Manual for turn-on procedure, Paragraph 3-8. Be sure the instrument is tuned to the central maximum of the cesium resonance.

IMPORTANT: Adjust only those controls on Assembly A4 which specifically referred to in the following procedure. The others are factory set and do not require adjustment.

1) Set 5060A controls as follows:

TIME CONSTANT (rear panel)	Short
MOD	OFF
MODE	LOOP OPEN/CS ON

2) Loosen microwave attenuator locking screw (Figure 1) on Harmonic Generator (near beam tube flange) and slide attenuator all the way out. This is minimum attenuation position.

3) To monitor beam current, remove the cable from A7J5 and connect this cable to a pico-ammeter or high impedance voltmeter such as the HP 412A.

4) Locate A20R27 on cesium oven controller A20 and adjust for maximum beam current. Tuning screw A4S5 (Figure 1) may require a slight adjustment at this time before a significant beam current can be measured while adjusting R27. CAUTION -- Less than 1/2 turn of A4S5 should be necessary.

IMPORTANT: The following adjustments (unless otherwise specified) must be made with less than optimum RF power available to saturate the beam tube. That is, when using the hyperfine atomic resonance as a tuning indicator, always be sure that the power level is small enough so that the atomic resonance is not saturated.

5) Locate A4R1 on the harmonic generator assembly (see Figure 1).

6) Adjust A4R1 fully counterclockwise and observe Beam Current indication. This current is the background level.

7) While observing beam current, slowly turn A4R1 clockwise to the first peak.

8) Loosen attenuator locking screw (Figure 1), and slide attenuator in until the beam current is half way between the maximum and background levels.

9) Adjust tuning screw A4S5 to obtain maximum beam current.

NOTE

It is necessary to adjust A4S5 locknut and A4S5 screw simultaneously.

10) Repeat Step 7 to insure that the atomic transition is not saturated.

11) Again adjust tuning screw A4S5 and locknut for maximum beam current.

12) Pull out the attenuator slightly. The beam current should increase by a corresponding amount. If the beam current remains the same or decreases, Cesium Beam tube is saturated and Steps 8 through 12 should be repeated.

13) Loosen knurled plunger lock on filter cavity.

14) Peak beam current by tuning the frequency tuning plunger. Be certain that the Cesium Beam tube is not saturated. Adjust attenuator if necessary.

15) Tighten knurled plunger lock filter cavity.

16) Adjust Oscillator COARSE control to insure that the Beam tube is tuned to the central peak of the atomic resonance.

17) Adjust A4R1 to its maximum counter clockwise position. Then slowly turn it clockwise to the first beam current maximum. Continue rotating A4R1 through its range to check for a second maximum. If second maximum appears, these two maxima indicate that there is enough rf power available to saturate the beam tube. Perform step 20.

18) If no second maximum appears, gently pull the attenuator knob upward about 1/8 inch.

19) Again rotate A4R1 to check for two maxima. Pull attenuator knob upward and rotate A4R1 until two maxima appear. Repeat until two maxima result.

20) When two maxima are obtained, push attenuator knob down in small increments and adjust A4R1 after each increment. Repeat until only one maximum appears. Adjust A4R1 for maximum beam current. Carefully tighten attenuator lock screw.

Note

If there are still two maxima present with the attenuator set all the way in, set the attenuator 1/16 inch out and lock in this position. Starting at its maximum ccw position, adjust A4R1 clockwise to the first beam current maximum.

CAUTION

The attenuator shaft is nylon. If the locking screw is tightened excessively, this shaft will be damaged.

This completes adjustment of the harmonic generator assembly. Leave the meter connected to the beam tube and controls set for step d.

d. Beam Current Record.

1) Check to be sure the Model 5060A is set up as in steps c(1) and c(3).

2) Record the beam current with oscillator tuned to central maximum (use COARSE control). This is called the "peak signal."

3) Adjust the OSC. FREQ. ADJ. COURSE for a minimum (adjacent to the central maximum) beam current. Record this minimum value; it is called the "valley signal."

4) Adjust beam current to central maximum as in Step 1.

5) Remove +20V wire (R) from A3 Multiplier Assembly and record beam current. This remaining beam current is the background signal.

6) Reconnect +20V wire (R) to A3 Multiplier Assembly and cable to A7J5 of AC Amplifier Assembly.

7) The "peak", "valley", and "background" figures should be recorded and referred to, along with the beam tube serial number, should it be necessary to contact Hewlett-Packard. The quotient,

$$\frac{\text{Peak Signal} - \text{Valley Signal}}{\text{Background Signal}}$$

is a good indicator of the beam tube's performance. A value greater than 1 indicates that the beam tube is performing satisfactorily.

e. Phase Modulation Frequency

1) Connect a frequency counter to sweep output A8J2.

2) Adjust A8R10 for a reading of 137 Hz on the Counter.

3) Remove counter from A8J2.

f. Phase Detector Zero.

1) Check that MOD switch is off.

2) Set Circuit Check 2 meter to "90 Mc".

3) Disconnect +20-volt lead (white/red) from AC amplifier A7.

4) Observe DC voltage at phase detector test output A8J1. Adjust A8R39 for a voltage reading of less than 1 Mv.

g. Operational Amplifier Zero.

1) Locate the phase detector output cable at the rear of phase detector module A8. The center conductor and shield of this cable are connected to terminals located near the rear panel. Using a short clip lead or jumper, short the shield to the center conductor at these terminals. This shorts the input to the operational amplifier.

2) Connect a DC voltmeter to the BNC connector marked CONTROL on the rear panel.

3) Switch the MODE switch to LOOP OPEN and then to OPER. Observe the voltage on the 10 Mv range of the voltmeter. This voltage will probably be drifting since the operational amplifier integrates its internal zero offset. Adjust A9R28 to stop this drift. Switch MODE switch from OPER. to LOOP OPEN and back to OPER. This will discharge the integrating capacitor and permit using the voltmeter on a lower range for more precise zero setting. Again adjust A9R28 so that control voltage drift is less than 1.5 mV/minute.

4) Remove shorting jumper from the operational amplifier input.

5) Replace +20-volt lead (white/red) on AC amplifier assembly A7. This completes the operational Amplifier Zero set.

h. Phase Modulation Amplitude.

1) Set 5060A controls as follows:

MOD switch	ON
MODE switch	LOOP OPEN
FINE frequency control	0250
CIRCUIT CHECK 2 switch	BEAM I

2) Observe BEAM I meter indication and adjust oscillator COARSE tuning to the central peak of the atomic resonance.

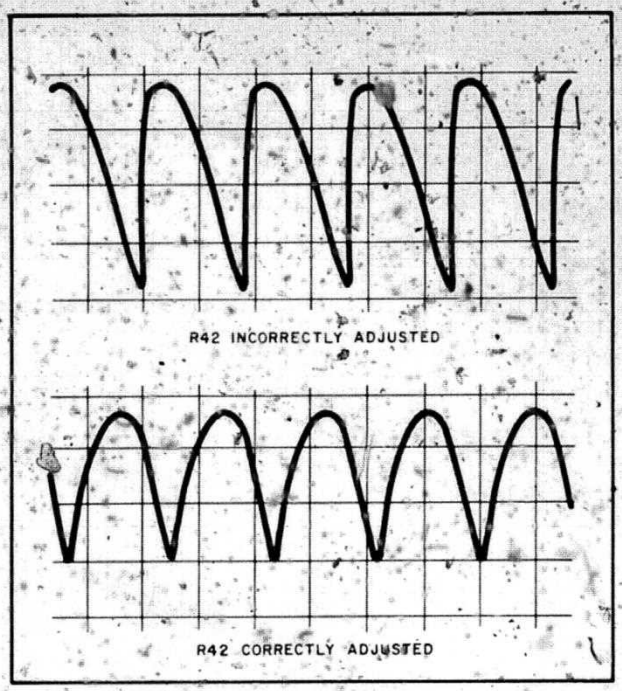

Figure 2. A8R42 Adjustment

3) Adjust the FINE frequency control to 0100. The quartz oscillator is now offset by -150 parts in 10^{10}.

4) Using the Micon to BNC cable supplied with the instrument, connect an oscilloscope to test output A7J2.

Note

This waveform should be a sine wave. If there is clipping or distortion of this waveform, the AC Gain should be reduced by adjusting A7R18. This control will be properly reset later.

5) Adjust phase modulation level control A3R20 for a maximum voltage indication on the oscilloscope.

This completes the adjustment. Remove the oscilloscope connection from A7J2.

i. Phase Modulation Phase Adjust.

1) Check to see that the instrument is set up as follows:

MOD switch	ON
Mode	Loop OPEN
Fine Frequency control	0100
CIRCUIT Check 2 switch	Beam I

2) Using the Micon to BNC Connector provided, connect an oscilloscope to A8J1.

3) Adjust A8R42 for the correct waveform as shown in Figure 2.

Note

If A8R42 has insufficient adjustment range, reverse the positions of A8R34, located inside the module, so that the emitter of A8Q8 is connected to A8R42 and the emitter of A8Q9 is connected to A8C20.

4) Reset the FINE frequency control to 0250. This completes the phase modulation phase adjustment.

j. AC Gain Adjust.

1) Check that instrument is set up as follows:

MOD switch	ON
MODE switch	Loop Open
FINE frequency control	0250

2) Connect a DC Voltmeter to A8J1.

3) Adjust oscillator COARSE control for a zero reading on the voltmeter (there will be some noise present but adjust for minimum output).

4) Set Oscillator FINE control to 0200.

5) Adjust AC Gain Control A7R18 for a reading of +1.6V on the voltmeter. This reading will be somewhat noisy.

6) Set MODE switch to OPER. The DC voltage should fall to zero. This verifies proper operation of the atomic phase lock loop.

7) Remove voltmeter and cable from A8J1 and adjust oscillator FINE control to 0250. This completes the AC Gain Adjustment.

k. Logic Circuit Adjustment.

1) Set CIRCUIT CHECK 1 switch to CONTROL. Adjust COARSE OSC. FREQ. ADJ. for zero CONTROL indication. This insures that the quartz oscillator is tuned to the central peak of the cesium resonance.

2) Set MODE switch to LOOP OPEN, CS ON and MOD switch to ON.

3) Adjust mass spectrometer potentiometer A20R27 to reduce CIRCUIT CHECK 2 meter BEAM I indication to 1/3 of its initial value.

4) Set CIRCUIT CHECK 1 meter to 2ND HARMONIC.

5) Locate A14R11 on plug-in logic assembly A14 at bottom of instrument. Turn this control to its maximum counterclockwise position. The 2ND HARMONIC light should come on.

6) In small increments, adjust A14R11 clockwise (wait a few seconds after each increment) until the 2ND HARMONIC light just turns off. The CIRCUIT CHECK 1 meter will read about +20 when this adjustment is properly made.

7) Readjust mass spectrometer potentiometer A20R27 for BEAM I maximum on CIRCUIT CHECK 2 meter.

8) Set MODE switch to OPER CS ON and MOD switch ON. Push LOGIC RESET button. CONTINUOUS OPERATION light should come on and remain on. This completes the logic circuit adjustment.

l. BEAM I METER Adjustment.

1) With instrument operating and CONTINUOUS OPERATION light on, set CIRCUIT CHECK 1 switch to CONTROL. Adjust COARSE OSC. FREQ. ADJ. for zero CONTROL indication.

2) Set MODE switch to LOOP OPEN CS ON and MOD switch to OFF.

3) Locate cesium oven controller assembly near bottom right of instrument. Turn mass spectrometer control A20R27 maximum counter-clockwise.

4) Locate meter resistor board assembly (A17) near bottom center below harmonic generator assembly. Set CIRCUIT CHECK 2 switch to BEAM I and adjust A17R14 for zero BEAM I indication.

5) Observe BEAM I indication and adjust A20R27 Mass Spectrometer Control, for maximum BEAM I.

6) If maximum BEAM I indication is not approximately mid-scale (around 5), locate resistor A17R8 on assembly A17. (See Figure 5-23 in the Operating & Service Manual.) Select a value for this resistor that will give a maximum BEAM I reading of approximately 5.

Note

When soldering resistor on Meter Board A17, avoid damage to the circuit check meter by setting circuit check switch to a setting other than circuit being adjusted.

m. C Field Adjustment.

1) Set CIRCUIT CHECK 1 switch to CONTROL and CIRCUIT CHECK 2 switch to BEAM I. Adjust oscillator COARSE control for a zero CONTROL indication.

2) Set MODE switch to LOOP OPEN and MOD switch to OFF.

3) Connect an HP Model 200CD (or equivalent) audio oscillator in parallel with an HP 5512A (or equivalent) frequency counter to the ZEEMAN MOD INPUT of the Model 5060A. Set audio oscillator output to approximately 1V rms.

4) Using the counter, set the audio oscillator to the appropriate frequency corresponding to the time scale of the Model 5060A under test (see Table 5-5 in the 5060A Operating and Service Manual).

Note

An error of 1% in the Zeeman frequency will cause an error of 3.6 parts in 10^{12} in the 5 Mc output frequency.

5) Adjust C FIELD control and audio oscillator amplitude to obtain a maximum indication on the BEAM I meter. (If BEAM I meter goes off scale during this adjustment, the value of A17R8 should be increased so that the meter reading is on-scale.) As you rotate the C Field Control, the beam current will have a central peak with a slightly smaller subsidiary peak on either side. Adjust the C Field Control to the central peak and then adjust the Audio Oscillator amplitude for maximum beam current. Again, adjust the C Field Control as close as possible to the center of the resonance.

6) Disconnect the counter and audio oscillator from the Model 5060A.

7) Set MOD switch ON and MODE switch to OPER CS ON. Wait 30 seconds and press LOGIC RESET button. Continuous operation light should come on and stay on.

Note

The Cesium Beam tube is slightly sensitive to changes in both the earth's magnetic field and local magnetic fields. Therefore, the C field should be readjusted if the instrument is moved to a different location or if its orientation with respect to the earth's magnetic field is changed.

8) Replace top and bottom covers. This completes the Cesium Beam tube replacement procedure.