SECTION 6

ADJUSTMENTS & CALIBRATION

6-1. GENERAL

6-2. This section describes the procedures to be followed in order to correctly adjust the 350D/351D Autohet Counter. In general, adjustments should be made only if the instrument is not operating within specifications, or following replacement of components. Test equipment required is specified in Table 5-1. If adjustments do not result in specified performance, refer to Section 5.

IMPORTANT

Many adjustments are dependent upon previous ones. It is essential that care be taken to perform adjustments in exactly the order presented below. Adjustment locations are shown in Figure 6-1.

6-3. POWER SUPPLY ADJUSTMENT

6-4. Prior to any power supply adjustments, the instrument should be allowed to warm-up for at least 20 minutes. All voltages are measured on Counter Interconnect Board A113. Adjustments are made according to the following procedure:

a. Connect DVM to GND on A113.

b. Measure +12 V output. Adjust A107R7 until output is +12.000 ± .010 V.

c. Measure +5 V output. Adjust A107R15 until output is +5.000 ± .010 V.

d. Measure -12 V output. Adjust A107R21 until output is -12.000 ± .010 V.

e. Measure -5.2 V output. Adjust A107R31 until output is -5.200 ± .010 V.

6-5. BAND I ADJUSTMENTS (20 Hz to 300 MHz)

No Band I adjustments are required.

6-6. BAND II ADJUSTMENTS (100 MHz to 850 MHz)

a. Threshold:

(1) Set BAND SELECT switch to the 100 MHz - 850 MHz position.

(2) Connect a 100 MHz, -20 dBm CW signal to the Band II input connector. Set A109R41 (on Prescaler) to maximum sensitivity.

(3) Reduce signal level until counter just begins to miscount.

(4) Adjust A109R41 until the reading just drops to all zeros.

6-7. BAND III ADJUSTMENTS (825 MHz to 12.4/18 GHz)

a. For all the following tests, BAND SELECT switch should be set to the 825 MHz - 12.4/18 GHz position.

b. Video Detector Gain (see also Paragraph 6-7g.):

(1) Disconnect cable from output of Video Amplifier (A204J2).

(2) Connect a 150 MHz CW signal at -6 dBm to Cable A203P2 (W21).

(3) Connect DVM to Converter Control 1 Test Point A203TP6.

(4) Adjust A203R41 for 340 ± 20 millivolts.

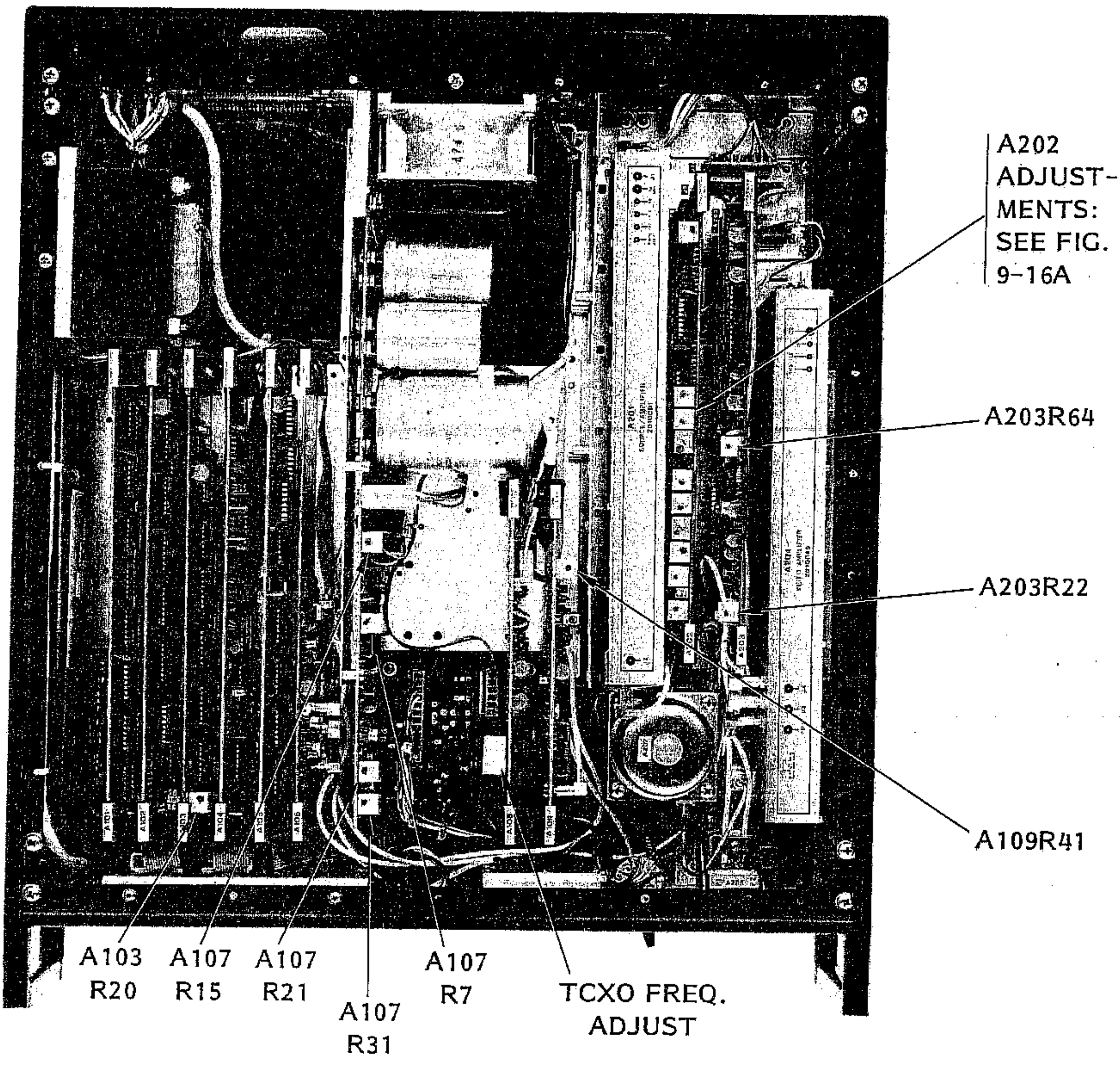
(5) Reconnect cable to A204J2.

c. In-Band Detector switching point:

(1) Disconnect cable from A204J2.

(2) Connect sweep generator to A203P2. Set controls as follows:

Sweep	265 MHz downward to 235 MHz
Level	0 dBm
Markers	Every 10 MHz


A202 ADJUSTMENTS: SEE FIG. 9-16A
A203R64
A203R22
A109R41
A103 R20
A107 R15
A107 R21
A107 R31
A107 R7
TCXO FREQ. ADJUST

(3) Adjust A203R64 so the switching spike is coincident with the 250 MHz marker as shown in Figure 6-2.

(4) Reconnect cable to A204J2.

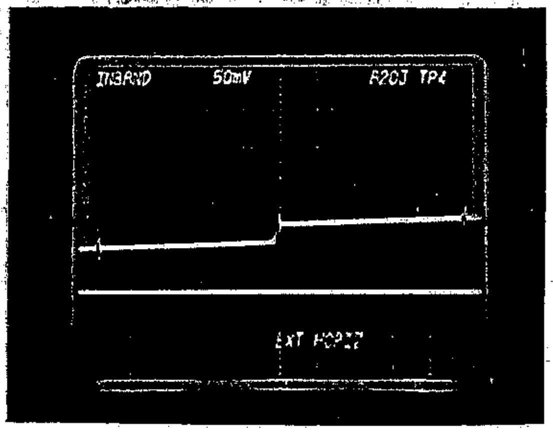


FIGURE 6-2
IN-BAND DETECTOR SWITCHING POINT

d. PIN Level Control Threshold:

(1) Unplug Source/Amplifier power plug A208J1.

(2) Connect a 3 dB pad to the Band III input connector. Apply a +3 dBm, 1.0 GHz, square-wave modulated signal to the pad.

(3) Observe the square-wave signal at A204TP1.

(4) Adjust A204R61 until the square-wave at TP1 is 90 to 100 mV in amplitude.

(5) Reconnect Source/Amplifier power plug.

e. YIG Driver Offset and Slope:

NOTE: For this adjustment a Summing Amplifier capable of providing a variable DC offset is recommended. One can be constructed as shown in Figure 5-1, or a dual trace oscilloscope with differential inputs (such as HP1200A) may be used if the signal is applied to one side of the differential input, and a variable DC power supply to the other input.

(1) Connect dual trace oscilloscope as follows:

Ch. A	A203TP6 (Video Detector Output)
Ch. B	A202J3 pin 1 (Ramp) via Summing Amplifier
Ext. Trig.	A203TP5 (CONVERTER RESET)

(2) Ground A203TP1.

(3) Apply a signal of approximately 1.1 GHz at -15 dBm to Band III input.

(4) Depress RESET switch.

(5) With no DC offset applied, adjust Channel B vertical sensitivity so each ramp step is two vertical divisions (approximately 10 mV/div). Set Channel A to 20 mV/div. Set time base to 5 ms/cm and set time base multiplier to X10. Oscilloscope display should appear as shown in Figure 6-3.

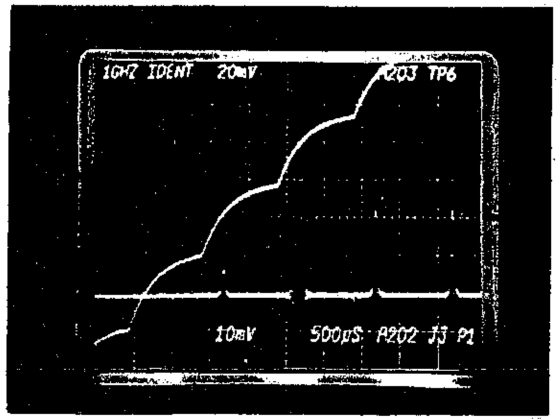


FIGURE 6-3
1 GHz COMB LINE IDENTIFICATION

(6) Reduce the input frequency to 1.0 GHz. When the input frequency is exactly 1 GHz, the center line of the three comb lines on Channel A should null. This identifies the 1 GHz comb line. The 800 MHz comb line is the line preceeding the 1 GHz line.

(7) Remove the ground from A203TP1 and place it on A203TP2. Depress the RESET switch.

(8) Adjust YIG Offset A202R49 so the ramp resets at 50% (1 div) of the fourth ramp step (See Figure 6-4).

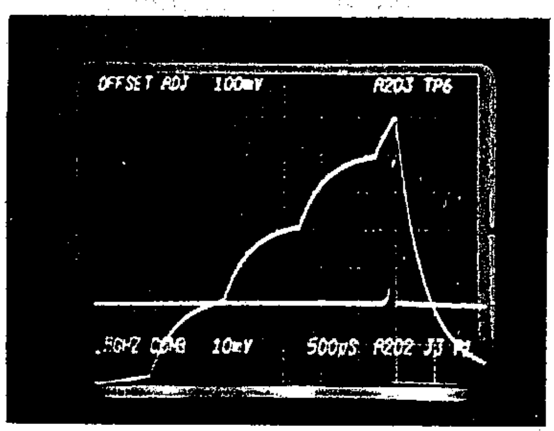


FIGURE 6-4
YIG DRIVER OFFSET ADJUSTMENT

(9) Tune slowly from 1 GHz to 18 GHz. As the frequency is changed, adjust the DC offset and the horizontal position control of the oscilloscope to maintain the upper portion of the ramp on the display. Above 10 GHz, the time base will need to be increased to 10 msec/div.

As the frequency is changed, adjust YIG slope with A202R53 so the ramp reset occurs in the range of 40 to 60% of the full step amplitude. At 18 GHz, adjust R53 so reset occurs at 60% of the step amplitude.

(10) Recheck YIG Offset A202R49 and readjust at 1 GHz if necessary. If A202R49 is readjusted, it will be necessary to reset YIG Slope A202R53 at 18 GHz.

f. YIG Delay Correction

(1) With connections as in paragraph 6-7e, set input frequency to 1 GHz at -15 dBm, and oscilloscope time base control to 10 ms/div, unexpanded.

(2) Adjust YIG Delay Correction A202R16 so display appears approximately as shown in Figure 6-5.

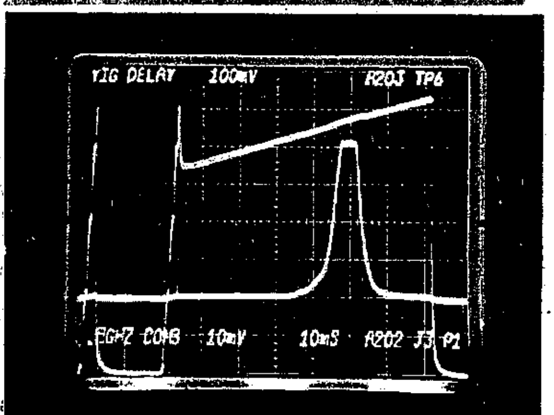


FIGURE 6-5
YIG DELAY CORRECTION 1

(3) Set time base to variable (approx. 5 ms/div) and externally trigger oscilloscope from A203P1 pin 12 (DAC 2 ENABLE). Adjust oscilloscope time base so DAC 2 ramp occupies the full screen.

(4) Adjust A202R16 so the 50% point of the leading edge of the video pulse occurs one division to the right of center of the DAC 2 ramp as shown in Figure 6-6. Note that the point marked "Ramp Start" is 3 ms after DAC 2 ENABLE and that the point marked "Ramp Center" is *not* the center of of the display.

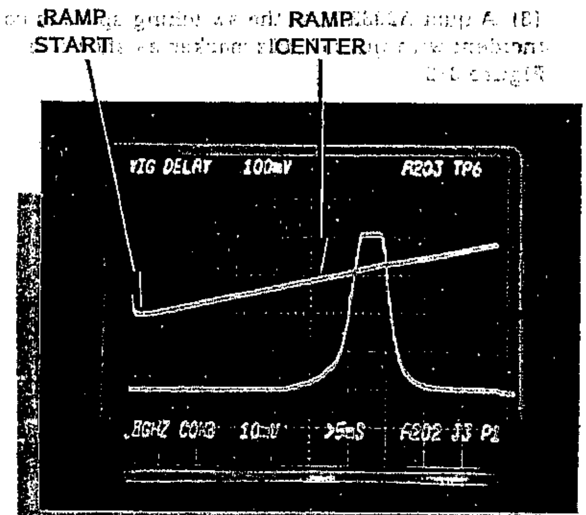


FIGURE 6-6
YIG DELAY CORRECTION 2

(5) Tune to 18 GHz (12.4 on 350D) and observe leading edge position with respect to DAC 2 "Ramp Center". This should be approximately one division to the left of "Ramp Center".

(6) If necessary, readjust A202R16 until the leading edge of the video pulse is the same distance to the right of "Ramp Center" at 1 GHz, as it is to the left of "Ramp Center" at 18 GHz (12.4 GHz on 350D).

g. Final Video Detector Gain Adjustment

NOTE: The procedure of paragraph 6-7b will not necessarily result in optimum performance. The following procedure sets the Video Detector gain to give maximum sensitivity without loss of instrument accuracy.

(1) Set stable source power level to -20 dBm, and frequency to 8 GHz (short term stability < 1 kHz). Connect source to the Band III input. Observe frequency indication on counter.

(2) Reduce input power slowly while frequently pressing RESET button. At some power level, the counter will lose lock.

(3) Increase power slightly so counter will just achieve lock and display a frequency.

(4) Displayed frequency should be correct (no reduction in indicated frequency). Increase Video Detector gain (adjust A203R22), and repeat steps (2) and (3) until an erroneous count is obtained.

(5) Once an erroneous count is obtained, begin decreasing Video Detector gain and repeat steps (2) and (3) until frequency indication is either correct, or zero (no LOCK), as power level is varied and counter is reset.

h. Comb Leveling/Bias:

NOTE: The most important function of comb leveling is to insure that spurious mixing products (due to doubling of the comb frequency within the Mixer), do not cause erroneous readings. Thus this leveling procedure insures that maximum output due to these mixing products are below the lock threshold.

(1) Connect oscilloscope as follows:

Ch. A	A203TP6 (Video Detector output)
Ext. Trig.	A202P1 pin 12 (CONV. RESET)
Time Base	2 ms/div

(2) Ground A203TP1.

(3) Apply a 1.5 GHz signal at +7 dBm; observe the Video Detector signal.

(4) Slowly tune the frequency upward. At some frequencies, a spurious output corresponding to approximately one half the input frequency will be visible.

(5) As the frequency is varied from 1.5 to 18 GHz, adjust A202R69 so no spurious signal has an amplitude in excess of 290 mV. Refer to Figure 6-7 for a typical display. (Vary scope time base as necessary to keep the display on the screen.)

IMPORTANT: Do not attenuate comb lines more than absolutely necessary to maintain maximum spurious outputs of 290 mV. Comb line power relates directly to sensitivity.

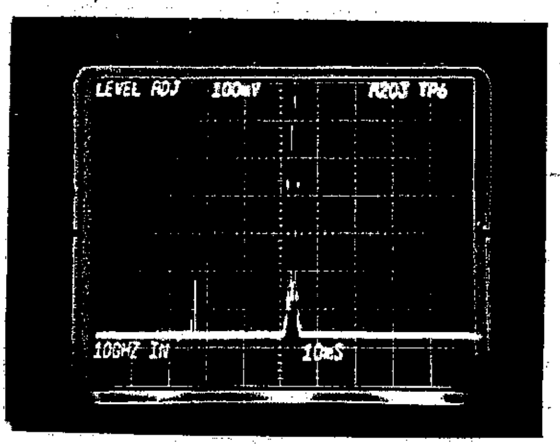


FIGURE 6-7
COMB FREQUENCY HARMONIC GENERATION

6-8. TIME BASE CALIBRATION

IMPORTANT

The precision of time base calibration directly affects overall counter accuracy. Reasons for recalibration, and procedures to be used, should be thoroughly understood before attempting any readjustment.

6-9. The fractional frequency error in the frequency indicated by the counter, is equal to the negative of the fractional frequency error of the Time Base Oscillator with respect to its true value. That is:

$$\frac{\Delta f_s}{f_s} = -\frac{\Delta f_t}{f_t}$$

where f_s is the true frequency of the measured signal, and f_t is the true frequency of the Time Base Oscillator. Thus the inaccuracy associated with a frequency measurement, is directly related to the quality of the Time Base Oscillator, and a measure of the precision with which it was originally adjusted.

6-10. TCXO CALIBRATION

6-11. The standard time base oscillator used in the counter is a temperature-compensated crystal oscillator: a TCXO (A116). The highest and lowest actual measured frequencies of this oscillator will differ by no more than 2 parts in 10^6 if the temperature is varied slowly from 0° to +50°C. Therefore, an indicated measurement will exhibit the same fluctuation even though the signal being measured is not changing. To center this fluctuation on the true value of the measured signal, each TCXO has imprinted on its side, the frequency to which it must be set at +25°C. The calibration procedure for this adjustment is described in Paragraphs 6-15 through 6-17.

6-12. At approximate room temperature (+25°C.), the slope of the frequency vs. temperature curve, is normally no worse than -1×10^{-7} parts per °C. Therefore, if the counter is used in an ordinary laboratory environment, the TCXO may be set as close to 10 000 000 Hz as desired. In this environment, a peak-to-peak temperature variation of 5°C. will result in a measured signal error due to oscillator temperature characteristics of no more than $\pm 2.5 \times 10^{-7}$ parts. Refer to Paragraphs 6-23 through 6-26 for a recommended adjustment procedure.

6-13. Another source of inaccuracy in the measured signal due to the Time Base Oscillator originates in the natural aging characteristic of the crystal. Aging refers to the long term, irreversible change in frequency, generally in the positive direction, which all quartz oscillators experience. The magnitude of this frequency fluctuation in the TCXO is specified to be less than 3×10^{-7} parts per month. This may be expected to improve in time to be no worse than 1×10^{-6} parts per year in continuous service.

6-14. Error due to aging adds directly to error due to temperature perturbations. Thus the frequency of recalibration is dependent upon the overall accuracy requirement of the counter and its environment. For example: If the counter is subjected to the full operating temperature range, and initially adjusted properly, then one month later, the inaccuracy over temperature could be expected to vary from $+1.3 \times 10^{-6}$ parts, to -0.7×10^{-6} parts.

6-15. TCXO CALIBRATION PROCEDURE

NOTICE

For both TCXO recalibration methods: Remove top cover of counter. Connect counter to reliable power source. Note ambient temperature.

6-16. METHOD 1:

a. Measure the frequency of the TCXO at the rear panel 10 MHz IN/OUT connector, with a second counter of known calibration accuracy:

b. Adjust the TCXO if necessary, by turning the calibration screw on the TCXO case until the measured frequency is the same as that shown on the TCXO calibration label.

6-17. METHOD 2:

a. Apply a 10 000 000 Hz signal from a frequency standard or other oscillator of suitable accuracy and stability to the Band I input of the counter. All RESOLUTION switches should be set to display all the digits including the 1 Hz digit.

b. Adjust the TCXO until the indicated reading on the counter is offset from 10 000 000 Hz by the negative of the frequency shown on the TCXO. For example: If the TCXO calibration label shows a frequency of 10 000 003 Hz, adjust the TCXO until the displayed reading shows 9 999 997 Hz.

6-18. OVEN STABILIZED OSCILLATOR CALIBRATION

6-19. If one of the Oven Stabilized Oscillator options is installed in the counter (see Section O), the effects of temperature perturbations and aging must still be considered, although the magnitude of these inaccuracies associated with each oscillator are greatly reduced.

6-20. Full benefit of the Oven Stabilized Oscillator characteristics can only be realized if the Oscillator is running continuously: that is, with the counter always connected to a source of AC power. Under these conditions, the perturbations in frequency will generally be in the positive direction for either an increase or decrease in temperature from +25°C. The aging characteristic is also generally in the positive direction.

6-21. The frequency of readjustment of the Oven Stabilized Oscillator is determined by the level of accuracy required. A method of adjusting the oscillator to an inaccuracy of less than 1×10^{-9} parts, relative to a standard, is given in Paragraphs 6-22 through 6-26.

6-22. OVEN STABILIZED OSCILLATOR TEST PROCEDURE

NOTE: This procedure is also usable with the TCXO under the conditions described in Paragraph 6-12.

6-23. TEST EQUIPMENT REQUIRED:

See Table 5-1.

6-24. Figure 6-8 shows the test set-up for determining the frequency of the Oven Stabilized Oscillator (A112). The frequency inaccuracy, relative to a standard, is determined by observing the drift of the oscilloscope pattern. The fractional frequency offset is computed from:

$$\frac{T_{\text{drift of zero crossing}}}{T_{\text{observation time of drift}}} = \frac{\Delta f}{f}$$

For example: If the pattern drifts at a rate of .01 microsecond every 10 seconds, the frequency is in error by 1 part in 10^9.

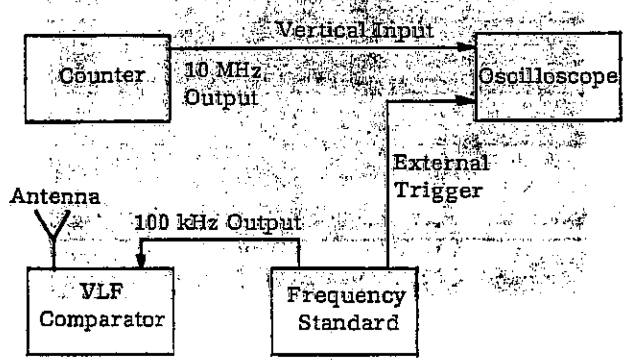


FIGURE 6-8
TIME BASE CALIBRATION

6-25. All frequency checks and adjustments should be made only after the Oven Stabilized Oscillator has been connected to its operating power supply for 24 hours. If the oscillator has been disconnected from its power source for more than 24 hours, it may require 72 hours of continuous operation to achieve the specified frequency aging rate (refer to paragraph 7-12).

6-26. TO MEASURE OSCILLATOR FREQUENCY:

a. Connect the counter's internal oscillator output signal from the 10 MHz IN/OUT connector (on the rear panel of the counter) to the vertical input of the oscilloscope.

b. Trigger oscilloscope externally with the frequency standard. The VLF Comparator is used to determine the absolute frequency of the standard.

c. Set oscilloscope sweep rate to 0.1 μ sec/cm and expand X10; this results in a sweep rate of .01 μ sec/cm.

d. Adjust oscilloscope vertical controls for maximum gain.

e. Determine the frequency difference (see para. 6-24).

f. Horizontal drift of oscilloscope display in μ sec/sec, is a measure of the difference between the frequency standard and the counter oscillator frequency. If the difference is excessive for the desired counter application, vary the TIME BASE ADJUST control on the rear panel of the counter until the pattern stops drifting. NOTE: For highest accuracy, the counter should be operated for 72 hours prior to adjustment.

6-27. LOCKBOX ADJUSTMENTS

No lockbox adjustments are required.

6-28. Instrument calibration is now complete.