SECTION 3
THEORY OF OPERATION

INTRODUCTION

3.01 The Theory of Operation is divided into three sub-sections. The first sub-section is a description of the Circuit Reference Series which is used for circuit and component identification. The following sub-section describes the overall functioning of the instrument from a block diagram viewpoint. The final sub-section is a description of the operation of the individual circuit boards.

CIRCUIT REFERENCE SERIES

General Description

3.02 The Circuit Reference Series is a series of numbers assigned to the circuits of the instrument to make it possible to relate the actual circuit board or assembly to the schematic diagrams, the parts lists and the text of the manual with a minimum of effort.

3.03 The series of numbers assigned to the CE-15 are as follows:

Front Panel 1000-1300

RF Casting 2000-2700

Main Chassis 3000-3800

Rear Panel 4000

The Front Panel itself is 1000 and 1100 is an assembly attached to the front panel containing circuits 1200 and 1300. The RF Casting is 2000 with the circuits 2100-2400 mounted inside the casting. Circuits 2500-2700 are mounted outside the casting but closely associated with it. The Main Chassis is 3000 and the circuits 3100-3700 are plugged into it. 3800 is the CRT assembly. 4000 is the Rear Panel.

Component Numbering

3.04 In each circuit the components are individually numbered with a separate series for each type of component. The complete identification for a component consists of the type designation letter, the circuit reference series number for that circuit and the component number. For example, the first resistor in the Log Converter will be R3301, the fourth capacitor C3304, etc.

3.05 When the individual circuits are described in the Circuit Description the component references will be abbreviated for convenience. Thus R1 will refer to a resistor on the board under consideration only. If reference is made to a component outside that board or when more than one circuit is being described the full reference designation will be used.

Cross Reference

3.06 In order to identify each board a cross reference list is given at the beginning of section 5 listing the basic board number, which is etched on each board, and the title, assembly number, circuit reference number and the figure and page number of the schematic diagram. The basic board number is in the 1780-xxxx series. However, in some cases the board is so small that sufficient room was not available to etch the full number. In these cases only the last four digits are etched with the 1780 to be understood. The 1780-xxxx number appears also in the parts lists along with the assembly number and the circuit reference number.

FUNCTIONAL DESCRIPTION

3.07 The CE-15 functions as a triple conversion superheterodyne receiver. Levels throughout the instrument are carefully controlled so that an accurately calibrated oscilloscope display is obtained as the output. Refer to Figure 3-1.

3.08 The first Local Oscillator (L.O.) is a YIG oscillator. The 2.1-3.1 GHz frequency is adjusted by the front panel COARSE and FINE controls. The 2100 MHz first IF is mixed with the 1900 MHz VCO second LO in the second converter to provide a second IF of 200 MHz. A feedback loop from the third IF output controls the 1900 MHz VCO to provide frequency stability in the Monitor mode. The third LO is a 189.3 MHz crystal controlled oscillator. This produces the 10.7 MHz third IF. An output from this oscillator is also brought to the front panel for use as the calibrating signal for the instrument.

3.09 The 10.7 MHz output from the third IF goes to the Log Converter and to the FM Demodulator. The FM Demodulator output is used to complete the AFC feedback loop to the 1900 MHz VCO second LO. It also is amplified and appears as the audio output through the built-in speaker. The Log Converter changes the linear amplitude signals to a logarithmic output which is detected, and then appears as the vertical display on the CRT screen. This detected output is also applied to the audio amplifier and appears as the detected AM audio signal on the speaker.

3.10 The horizontal display comes from a ramp generator. The ramp generator output also controls the YIG oscillator to sweep the frequency at the ramp generator rate to provide the swept display of the frequency spectrum being observed.

CIRCUIT DESCRIPTION

RF Attenuator. 2100

3.11 Input to the CE-15 is through the RF Attenuator which is adjustable for three attenuation levels, 0 dB, 20 dB and 40 dB. See Figure 5-5. The 20 dB attenuator is made up of C2, C5, R3, R5-R8, and the 40 dB attenuator is C7, C10, R9, R11-R14. Switching diodes, CR1-CR8, which are controlled by the RF ATTENUATOR wafer on the REFERENCE LEVEL switch, either switch in the proper attenuator or bypass the signal around the attenuators according to the setting of the switch. The diode switches are turned on by applying a positive voltage to the selected diode pair. Isolating RF chokes, L1, L3, L5, provide the ground return for the switching current. L2, L4 isolate input-output diodes.

3.12 Signal input from the RF INPUT connector comes in through terminal 5 and C1 to the attenuator. The signal from the FREQ CAL IN connector comes to terminal 6 and is connected to the input RF Attenuator through 20dB attenuator R1, R2. Output from the RF Attenuator passes to the First Converter through a 1 GHz low pass filter.

First Converter. 2200

3.13 The 0.5-1000 MHz signal from the RF Attenuator enters through terminal 1 and goes to the VHF diode mixer, Z1. Refer to Figure 5-6. The 2100-3100 MHz L.O. comes in through terminal 2, through a high pass filter made up of C2 and the printed circuit inductor, to the mixer through matching transformer, T1. The 2100 MHz output from the mixer passes through a high pass filter, C4, C5 and the printed circuit inductor to the first IF amplifier, Q1, Q2. Printed circuit components provide RF chokes and coupling inductors. Output from the first IF amplifier passes out through terminal 4 to a cavity type 2100 MHz band pass filter, 2600 board, before going to the second converter.

YIG Driver. 3100

3.14 The first L.O. is a YIG (Yittrium, Iron Garnet) oscillator. The YIG resonant frequency is determined by the strength of the magnetic field in which it operates. This makes it possible to smoothly control the oscillator frequency by varying the strength of the magnetic field. The YIG Driver, Figure 5-11, performs this function for the YIG oscillator, which is contained in the 2500 assembly.

3.15 The control inputs to the YIG Driver circuit are from the COARSE and FINE front panel frequency controls, a ramp generator input for sweeping the frequency and control from the SCAN WIDTH switch to adjust the sweep width. Outputs are current to the main coil and the Tickler (FM) coil of the YIG oscillator and a voltage, adjusted by the FREQ CAL control, to the Digital Panel Meter display circuit to indicate the frequency to which the instrument is tuned.

3.16 The COARSE and FINE controls apply a DC voltage to the non-inverting input of U1 through board pin 6. Current amplifier Q1, Q3 drives the Main Coil of the YIG to adjust the L.O. frequency. Coil current through R25 produces a voltage at the current junction (R24-R25) and is applied to the inverting input of U2 to drive the A/D Converter and Frequency display through the level adjusting buffer Q4. Q2 is a switch which shunts C10 across the Main Coil in all but the 10 MHz/cm mode to prevent any ripple appearing on the Main Coil.

3.17 Input from the Ramp Generator comes in through board pin 13 to the inverting input of U3 and to Q8. Q8 is switched off except in the 10 MHz/cm mode. The output of U3 controls the current amplifier, Q12, Q13 which drives the Tickler (FM) coil of the YIG. Gain of U3 is controlled by a switchable feedback loop. In the 10 kHz/cm mode Q10 switches in R17 as the feedback resistor. For 100 kHz/cm R19 is switched in by Q11, and for 1 MHz/cm all but R48 are switched out. The switches are activated by a ground closure at the SCAN WIDTH switch.

3.18 In the 10 MHz/cm mode Q9 is turned on to short out all feedback resistors reducing the gain of U3 to zero, setting the current through the Tickler coil at a constant level. At the same time Q5 and Q8 are also turned on, which then turn on Q6, Q7. Q5 also turns off Q2, taking C10 out of the circuit. The ramp is now applied to the summing junction R24-R25 through Q8, Q6, to sweep the Main Coil for the 10 MHz/cm mode. The output of Q6 is also applied to U2 inverting input to sweep the Frequency display.

3.19 In the MON AM mode Q9 is turned on to short the feedback loop around U3 to turn off the sweep so that AM audio may be heard on the speaker. The front panel FREQ CAL control adjusts a voltage at the non-inverting input of U2 while the internal calibration adjustment is made with R3 to calibrate the Frequency display. The overall display is centered with R41 and the 10 MHz/cm sweep by R37. Calibration of the narrow band sweep widths is with R43 and the wide band with R14.

Second Converter. 2300

3.20 Output from the First Converter passes through a 2100 MHz band pass filter through terminal 2 on the Second Converter to the Mixer, CR1, CR2. See Figure 5-7. The 1900 MHz Second L.O. comes in through terminal 1, through high pass filter C1, C2 and the printed circuit inductive elements, then through T1 to the mixer. 200 MHz output is amplified by Q1 and then passes through the 200 MHz band pass filter L4-L6, C9, C11-C15 to the output terminal 3.

1900 MHz Oscillator. 2700

3.21 This oscillator is made up of common base connected Q1 and printed circuit reactive elements. See Figure 5-9. CR1, CR2 are part of a voltage divider that sets the bias on the base of Q1. This bias is varied, however by the AFC voltage which comes in from board 3500 through C3, R4, R7. Oscillator output from terminal 3 goes through a variable pickup loop.

Third Converter. 2400

3.22 200 MHz input to the Third Converter comes in through terminal 2 to T4 of the Third Mixer which is made up of T1-T4, CR1-CR4. See Figure 5-8. Input from the 189.3 MHz Third L.O. comes to T1 and the 10.7 MHz output goes out through terminal 3.

3.23 The 189.3 MHz oscillator, Q1, Y1, is mounted on the same board as the Third Mixer. C5 provides fine adjustment of the oscillator frequency. Output is through a 3dB pad, R4-R7. R6 is made variable to tap off an output to be used as the front panel CAL OUT source.

IF Switchable Gain and Bandwidth. 3200

3.24 10.7 MHz input through board pin 3 goes to the switchable 20dB amplifier, Q1, through buffer Q3 to switchable 10dB amplifier, Q4 and through buffer, Q5 to the switchable bandpass filters, through buffer Q9 to the 30dB amplifier, Q7, Q8 and out through board pin 18. Refer to Figure 5-12.

3.25 The switches Q2 and Q6 are controlled by the front panel RF ATTENUATOR switch to switch the amplifiers to either 20dB, 10dB or 0dB gain. The bandpass filters are selected by the SCAN WIDTH switch. The 10 kHz bandpass filter is controlled through diodes CR1, CR2, the 100 kHz BPF by CR3, CR4 and the 2 kHz BPF by CR5, CR6. Equal levels through the BP Filters are adjusted by R21 in the 10 kHz filter and R26 in the 100 kHz filter. Level through the 2 kHz filter is the reference for this adjustment.

Log Converter. 3300

3.26 The 10.7 MHz IF signal comes in through board pin 21 to the ±6dB variable gain amplifier, Q11, Q12. See Figure 5-13. Q10 controls this gain according to the setting of the front panel CAL LEVEL control. Q12 is a common base amplifier. Filtering is provided by the 10.7 MHz parallel resonant circuit, L10, C43.

3.27 The 15dB IF Amplifier/Limiter Q13-Q17 raises the level to a 0dB reference which is required at U1-9, and limits the output to 5 volts P-P to prevent overloading U1. A 15dB attenuator, R55, R56, at the input to the 15dB Amplifier/Limiter provides the -30dB input required at U1-7 and the 30dB attenuator, R23, R24 adjusts the level to -60dB at U1-4. From the 0dB output of the 15dB Amplifier/Limiter, two 15dB amplifiers in series, Q1-Q7 raise the level to the +30dB required at U1-12. The gain of these amplifiers is adjusted by R1. The break points on the logarithmic curve of the Log Converter U1 are adjusted by R27, R28, R29.

3.28 Voltage output from the Log Converter is amplified in the Voltage/Current Detector Driver, Q8, Q9, which drives the detector CR2, CR3. The recovered modulation is amplified by U2 and passes to the vertical deflection amplifier through board pin 13. R69 calibrates the gain and R66 sets the no-signal zero reference trace on the CRT display. The output of U2 is also taken through R70 to board pin 14 and from there to the Audio/+10 volt supply board.

Audio/+10V Supply. 3500

3.29 AC input from the rear panel mounted power transformer comes in through board pins 21, 22, to the bridge rectifier Z1. See Figure 5-15. One output from the rectifier passes through a current source Q1, Q2, Q4, to supply the Logic board. The +10 volt supply is regulated by Q3, Q5, Q6, Q7, U1. Q7 is the series voltage regulator driver for the series pass transistor mounted on the rear panel. Q3, Q5 form a starter circuit to turn on Q7 when power is first applied. U1, Q6 form the error amplifier and CR8 is the voltage reference. The +10V regulated current goes out through board pin 11 to the main +10V distribution terminal. A connection from this terminal comes back through board pin 12 as the regulator sense voltage. Regulator output voltage is adjusted by R14.

3.30 A 10.7 MHz output from the IF Switchable Gain and Bandwidth board comes in through board pin 2 to the FM Demodulator U2, Y1. Demodulated FM from U2-6 is applied to audio buffer amplifier, Q9, through switch, CR9, which is on in the FM mode. Audio output goes to the rear panel connector through board pin 14 and to the VOL control through board pin 16. The attenuated audio comes back in through board pin 15 to the speaker amplifier U4, Q14, Q15. In the AM mode the demodulated AM comes in through board pin 13, through switch CR10, which is turned on in the AM mode, to the audio buffer amplifier Q9.

3.31 An Automatic Frequency Control voltage from U2-7 passes through buffer, Q10, and switch, Q11, to the AFC amplifier, U3, and out through board pin 9 to control the 1900 MHz VCO on the 2700 board. When there is sufficient signal present to cause a squelch voltage to appear at U2-13, to turn on squelch threshold switch Q8, and at the same time the SCAN WIDTH switch is in either MON FM or AM, AND gate CR13, CR14 will be open, turning off Q12 and turning on Q11 to pass the AFC to the 1900 MHz VCO. When SCAN WIDTH is not in MON FM or AM the AND gate conducts, turning on Q12 and turning off Q11 to turn off the AFC and set it to a constant +5V. At the same time Q12 also turns on Q13 which turns off the audio buffer, Q9, to quiet the speaker output.

Ramp Generator/Deflection Amplifier. 3600

3.32 This board contains the power supply for the Astigmatism adjustment, the Vertical Amplifier, the Ramp Generator and the horizontal amplifier. Refer to Figure 5-16. A. C. from the power transformer through board pins 20, 21 is connected to the rectifier, Z1. Rectifier output is regulated by Q4, Q5 to approximately 250V across the astigmatism voltage divider, R20-R22.

3.33 Output from the Log Detector Amplifier on the Log Converter board is brought in through board pin 12 to cascode amplifier Q14, Q15, Q17, Q18. Q16 is a current source for the amplifier. R55 adjusts vertical centering and R49 adjusts vertical gain. Output to the CRT vertical deflection plates is through board pins 13 and 15. Q10, Q12 switch in C14 as a smoothing filter when the SCAN WIDTH switch is in the 10K (FLTR) position.

3.34 In the Ramp Generator Q1 is a switch which turns on to charge timing capacitor, C3, during retrace. Q2, Q3 are switches operated by the SCAN WIDTH control on the front panel to select the proper timing discharge resistor R6 or R9 to determine the ramp rate. U1 is the integrator and U2, U3 are comparators which control the Ramp. U2 stops the ramp at approximately +7 volts and starts the retrace by turning on Q1 to charge C3. U3 stops the retrace at approximately +3V by switching U2, to turn off Q1, allowing the ramp to start again.

3.35 Ramp output from U1-6 goes through push-pull amplifier Q9, Q13 to the horizontal deflection plates through board pins 6, 8. R45 adjusts horizontal centering and R31 adjusts horizontal gain. Q7 is a common base amplifier which buffers the retrace blanking pulse to the High Voltage Supply circuit. Ramp output through board pin 4 goes to the YIG Driver to generate the sweep of the First Local Oscillator.

High Voltage Supply. 3700

3.36 A. C. at 960 VRMS (1353 P-P) is brought in through terminals 4, 5 to the voltage doubler circuit CR1, CR2, C1, C2 to provide an output of approximately -2500V DC. See Figure 5-17. Q2-Q5 is a voltage controlled variable resistor, controlled by U1, an optical isolator amplifier. Output at about -2000V is applied to the voltage divider, R10-R13, R17-R21, R27. The positive end of the divider is tied to the +10V regulated voltage.

3.37 U2 is the high voltage regulator error amplifier. It is referenced to the voltage at the wiper of R14, which is the high voltage set adjustment. The regulated point is the junction of R21, R27, which is about +4V DC. Diodes CR4-CR6 prevent the U2 output from falling below +3V DC.

3.38 The CRT cathode potential is taken from the junction of R12, R17. It is approximately -1875V and is connected to the CRT through terminal 2. The wiper arm of the Intensity control, R11, is connected to the CRT through terminal 3, and the Focus control, R13, wiper arm is connected to the CRT through terminal 1. The retrace blanking pulse from the Ramp Generator comes in through board pin 1 to the optical isolator amplifier, U3, which controls switch, Q6. During retrace Q6 is turned on to bring the CRT intensity level down to a voltage below the CRT cut off point which turns off the CRT beam. Q1 is effectively a variable resistance in the rotation coil around the CRT, controlled by R2 to adjust the inclination of the horizontal trace.

A/D Converter. 1300

3.39 This circuit board contains both the A/D converter and a logic power supply regulator. Refer to Figure 5-3. Current from a current source on the Audio/+10V supply board, 3500, comes in through board pin 4 to an isolation stage, Q1, Q2. The function of this stage is to isolate the rest of the instrument from the logic noise generated in board circuits 1200 and 1300. The regulator consists of the error amplifier, U3, and shunt regulator, Q3. The reference voltage for the error amplifier is the regulated +10 volts brought in through board pin 5. See Figure 5-3. The output is +5V regulated to the logic boards 1200 and 1300.

3.40 A variable voltage proportional to the YIG oscillator frequency is brought in from the YIG Driver board, 3100, through board pin 3. This voltage is applied to the A/D system U1, U2. The output of U2 is a BCD form of the three decimal numbers to be displayed on the 1200 board display readout. Output passes through terminals 7, 8, 9, 10. These BCD numbers are multiplexed by the U2 outputs through terminals 3, 4, 6, to the anode drivers of the display units to turn on each unit in the proper sequence. Another output from U2 through terminal 2 goes to the OVERFLOW light driver to indicate that the frequency has been set out of range.

Display. 1200

3.41 The BCD output from the A/D converter through terminals 7, 8, 9, 10, is applied to the BCD to 7 segment decoder, U1, to generate the seven segment display in LED1-LED3. The anode drivers Q2-Q4 multiplex the display according to the sequence generated in U1302 and brought in through terminals 3, 5, 6. The OVERFLOW light driver, Q1, is controlled by an output from U1302 through terminal 2.

12V DC Inverter. 3400

3.42 The 12V DC Inverter is a modification, M1, which is available on factory order. The function of the inverter is to provide an A. C. source to operate the instrument transformer to provide the required 6.3V, 250V, 960V AC outputs. It also provides regulation for the AC output. Refer to Figure 5-14.

3.43 The instrument +10V supply is obtained from the 12V DC input which is regulated through the series regulator Q4001. See the M1 Rear Panel Interconnection Diagram, Figure 5-19. The 10V DC for the Inverter is reduced from the 12V input by zener regulator CR3402. The AC is generated by RC oscillator U2 which operates at about 400 Hz. The signal is squared up by U1-1, 5, to operate the flip-flop divider U1-11, 8, 9 to produce a 200 Hz (approximately) output to the switch drivers Q3401, Q3402.

3.44 The Relay K4001 automatically connects the switching transistors Q4003, Q4004 to the Inverter winding of the transformer, T4001-9, 11 and to series regulator Q4002 whenever 12V DC is connected to the DC input terminals.

3.45 Positive 12V is regulated to +10V through Q4002, passes through polarity reversal preventing diode, CR4002, to the center tap of transformer, T4001-10. Current through the transformer is switched alternately through each winding by Q4003, Q4004. The reference voltage for Q4003 is provided by R3401, CR3401. CR4001 is also a polarity reversal preventing diode causing fuse F4002 to blow in case polarity is reversed.

SECTION 4
MAINTENANCE

GENERAL

4.01 This section of the manual contains the information necessary to check the performance of the Model CE-15. It also contains the procedures for adjustment and calibration recommended for field maintenance.

4.02 The Performance Checks are to be used to verify proper operation and may be used for incoming inspection. Adjustment and calibration procedures should be carried out only if out-of-tolerance operation is observed.

4.03 If the Adjustment procedures fail to correct the difficulty, and the cause of the trouble is not readily apparent or repairs cannot conveniently be made, it is recommended that the instrument be returned to the factory or sent to a service center for repair. Always contact Cushman Electronics Customer Service Department before returning equipment or shipping to a service center. See paragraph 2.11.

4.04 The Model CE-15 should be turned on and warmed up for two hours before beginning the Performance Check or the Calibration and Adjustment procedures.

PERFORMANCE CHECK

Test Equipment Required

4.05 Any equivalent instrument may be used:

Signal Generator	HP8640B
Power Meter	HP435A/8481A
Precision Step Attenuator	HP355C/D
Oscilloscope	HP180/1801/1820

4.06 Set up the controls and make front panel connections as follows:

PWR/VOL	On (just out of detent)
SCAN WIDTH	1 MHz/DIV
REFERENCE LEVEL	0 dBm
RF ATTENUATOR	20dB (red dot)
CENTER FREQUENCY	189 MHz

4.07 Connect CAL OUT to RF INPUT with a short BNC connector coaxial cable. Adjust INTENSITY for desired display brightness. Adjust FOCUS for a sharp trace.

4.08 Adjust COARSE TUNE until the displayed trace is centered on the F_0 line of the graticule. Adjust CAL LEVEL until the top of the trace just reaches to -30dB line on the graticule. Disconnect the CAL OUT/RF INPUT cable.

Level Accuracy

4.09 Set the Signal Generator to an accurate +20 dBm reference level at 189 MHz, with the Power Meter as follows:

a. Set the Precision Attenuator to 30dB attenuation and connect to the Signal Generator output. Set Signal Generator to 189 MHz.

b. Set the Power Meter to -10 dBm and connect to the output of the Attenuator. Connecting cables should be as short as possible.

c. Set the Signal Generator output for +20 dBm and adjust for a Power Meter reading of exactly -10 dBm. Disconnect the power meter from the Attenuator and connect the Attenuator output to the CE-15 RF INPUT. Tune CE-15 for the signal at F_0.

d. Check the level accuracy of the REFERENCE LEVEL control in 10dB steps using the Precision Attenuator to set the signal input levels. Level error should not exceed ± 2 dB.

e. Check each graticule division for level accuracy using Precision Attenuator to set levels. Error should not exceed ± 3 dB.

Frequency Response

4.10 With the Signal Generator and Precision Attenuator connected as in the previous steps, check the frequency response as follows:

a. Set the Precision Attenuator for 50dB attenuation. Set the CE-15 REFERENCE LEVEL to -30 dBm and RF ATTENUATION to 0dB. Check that trace is at the 0dB REFERENCE LEVEL graticule division.

b. Set the Signal Generator and the CE-15 to 1 MHz, 400 MHz and 1000 MHz. Tune the CE-15 for a response at F_0 for each frequency.

c. Check the level and frequency accuracy at each frequency. Level should not vary more than ± 3 dB. Frequency should be within ± 5 MHz at 400 MHz and 1000 MHz.

Scan Width Functions

4.11 With the Signal Generator and Precision Attenuator connected as in previous steps check the Scan Width functions as follows:

a. Set the CE-15 to -30 dBm and RF Attenuator to 0dB. Set Precision Attenuator to put top of trace on the 0dB Reference Level graticule line. Tune trace to F_0 line with COARSE and FINE controls.

b. Set SCAN WIDTH control to each Scan Width mode from 10M to 10K (FLTR). Recenter trace to F_0 line at each step. Jump in horizontal position of trace between SCAN WIDTH positions should not exceed ± 2 divisions. The level displayed should not change more than 3dB P-P through all positions.

FM Demodulation

4.12 With the Signal Generator and Precision Attenuator set up as in previous steps check FM Demodulation as follows:

a. Set the CE-15 to +20 dBm and RF Attenuator to 40dB.

b. Set the output of the Precision Attenuator to -10 dBm (30dB attenuation). Trace should now be on -30dB graticule line. Set SCAN WIDTH control to 10K and center trace on F_0 line.

c. Set the Signal Generator modulation to Internal FM, 1 kHz rate and 3 kHz peak deviation.

d. Set SCAN WIDTH control to MON FM. Adjust VOL control for audible 1 kHz tone on internal speaker. Connect oscilloscope to DEMOD OUTPUT (Rear Panel) and check for sine wave output .15V ± .05V P-P at 1 kHz.

AM Demodulation

4.13 With setup the same as in the previous step check AM Demodulation as follows:

a. Set Signal Generator for Internal 50% AM at 1 kHz rate.

b. Set SCAN WIDTH control to MON AM. Check for audible 1 kHz tone on internal speaker. Check that DEMOD OUTPUT on oscilloscope is a 0.11V ± .02V P-P, 1 kHz sine wave.

ADJUSTMENTS

General

4.14 The Model CE-15 should be turned on and warmed up for two hours before beginning the Adjustment procedures. The following procedures should be carried out only if out-of-tolerance operation is observed while making the performance checks given above.

4.15 The AC power source should be checked for a voltage of 115V AC. If necessary use a voltage variable transformer (Variac or Powerstat) to supply 115V AC to the CE-15 during calibration procedures. After making calibration adjustments they should remain stable over a range of 105.5V to 126.5V AC.

NOTE

Circuit boards are not normally interchangeable between instruments without full recalibration.

Equipment Required

4.16 Any equivalent instruments may be used.

DVM	Dana 4300
High Voltage Probe	Dana 82
DC Power Supply	Power Designs 6050
Oscilloscope	HP180/1801/1820
Frequency Counter	Dana 8020B
Signal Generator	HP8640B
Test Oscillator	HP652A

NOTE

A less accurate Signal Generator, set to frequency with a Frequency Counter, may be substituted for the HP8640B.

Power Supply Adjustment

4.17 Make adjustments as follows: (Refer to Figure 4-1 for circuit board and assembly locations).

a. Connect the DVM between WT3001 (gnd) and WT3002 (+10V) turret terminals. Adjust R3514 for a reading of +10.000 volts.

b. Connect DVM across R3501 (board pin 4 and Q3501 emitter). Adjust R3505 for a reading of 1.53V DC.

c. Connect the High Voltage Probe to the DVM and touch probe to terminal 3702 (blue) on the High Voltage supply board. Adjust R3714 for a reading of -1875V DC.

Ramp Generator/Deflection Amplifier Adjustment

4.18 Make setup and adjustment as follows:

a. Use insulated clip leads to short board pins 3606 to 3608 and pin 3613 to 3615. NOTE: Pins are at 250V DC potential.

b. Set FOCUS for approximately a one

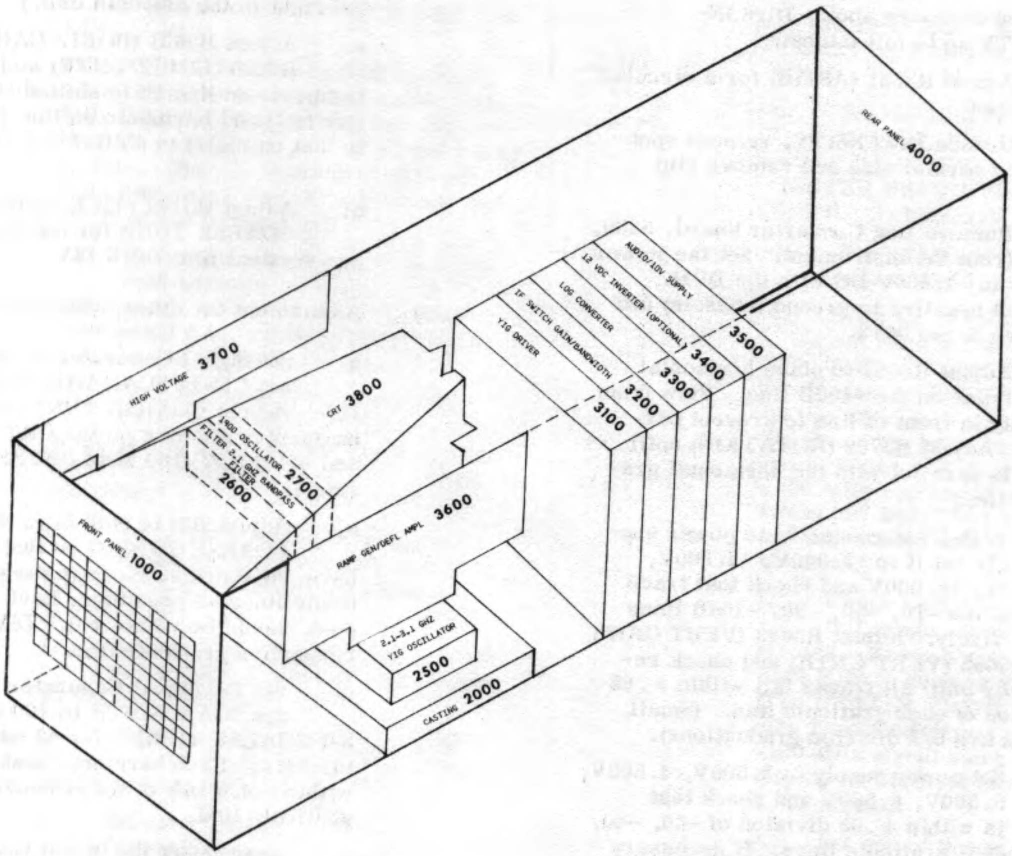

Figure 4-1. Circuit Board and Assembly Locations

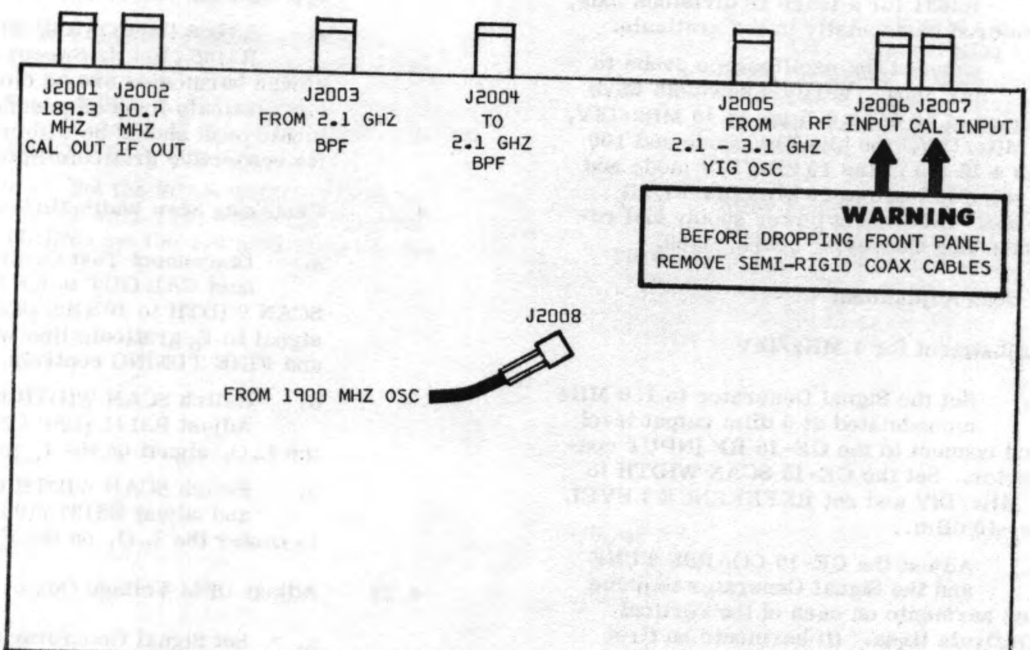

Figure 4-2. RF Casting Cable Connection Locations

division diameter spot. Turn INTENSITY up to full intensity.

c. Adjust R3621 (ASTIG) for a circular spot.

d. Reduce INTENSITY, refocus spot to normal size and remove clip leads.

e. Remove Log Converter board, 3300, from the instrument. Set the Power Supply to +4.500V DC with the DVM. Connect negative to ground (chassis) and positive to pin 3612.

f. Adjust R3655 to place horizontal trace on the -40dB line. View from directly in front of line to prevent parallax. Adjust R3702 (ROTATION) until trace is parallel with the horizontal graticule line.

g. With DVM connected to power supply set it to +3.000V, +4.000V, +5.000V, +6.000V and check that trace falls on the -70, -50, -30, -10dB lines respectively. Adjust R3649 (VERT GAIN) and R3655 (VERT CNTR) and check repeatedly until all traces fall within ± .05 division of each graticule line. (Small marks are 0.2 division graduations).

h. Set power supply to 3.500V, 4.500V, 5.500V, 6.500V and check that trace is within ± .05 division of -60, -40, -20, -0dB graticule lines. If necessary readjust R3649 and R3655 slightly. Repeat g. and h. until specifications are met at each graticule line.

i. Adjust R3645 (HORIZ CNTR) and R3631 for a trace 10 divisions long, centered horizontally in the graticule.

j. Connect the oscilloscope probe to pin 3604. Verify a sawtooth wave period of 50 ms ± 6.5 ms in 10 MHz/DIV, 1 MHz/DIV, 100 kHz/DIV mode and 100 ms ± 15 ms in the 10 kHz/DIV mode and 1 sec ± .15 sec in 10 kHz/DIV FLTR mode. Disconnect power supply and replace Log Converter board, 3300.

Frequency Scan Adjustment

4.19 Adjustment for 1 MHz/DIV

a. Set the Signal Generator to 1.0 MHz unmodulated at 0 dBm output level and connect to the CE-15 RF INPUT connector. Set the CE-15 SCAN WIDTH to 1 MHz/DIV and set REFERENCE LEVEL to -40 dBm.

b. Adjust the CE-15 COARSE TUNE and the Signal Generator to place one harmonic on each of the vertical graticule lines. (If harmonic on first line of graticule does not line up disregard and line up the other ten.) (Line to far left is first line and last line to the right is the eleventh line.)

c. Adjust R3631 (HORIZ GAIN) and R3645 (HORIZ CNTR) so that the harmonic on line #3 is shifted to line #1 (far left) and harmonic on line #10 (next to last on right) is shifted 0.7 DIV to the right.

d. Adjust R3143 (TICK GAIN) and the COARSE TUNE for one harmonic per vertical line ± 0.5 DIV.

4.20 Adjustment for other Scan Rates

a. Set Signal Generator to 10 MHz and set CE-15 SCAN WIDTH to 10 MHz/DIV. Adjust COARSE TUNE for eleven harmonics showing on the CRT screen, and set R3137 (100 MHz OFFSET) to midrange.

b. Adjust R3114 (100 MHz SWEEP) and COARSE TUNING so that the eleven harmonics are as close to the eleven graticule lines as possible. Each harmonic peak should be within ± 0.5 DIV of its respective graticule line.

c. Set the Signal Generator to 100 kHz, set SCAN WIDTH to 100 kHz/DIV. Set COARSE TUNING for 11 harmonics on the CRT. Each harmonic peak should be within ± 0.5 DIV of its respective vertical graticule line.

d. Disconnect the Signal Generator and connect the Test Oscillator to the CE-15 RF INPUT connector. Set the Test Oscillator to 10 kHz at +20 dBm. (Use counter to set the Test Oscillator frequency). Set the CE-15 to 10 kHz/DIV.

e. Adjust the COARSE TUNING and R3155 (10 kHz Sweep) so that the eleven harmonics are as close to the eleven graticule lines as possible. Each harmonic peak should be within ± 0.5 DIV of its respective graticule line.

4.21 Centering Scan Width Modes

a. Disconnect Test Oscillator and connect CAL OUT to RF INPUT. Set SCAN WIDTH to 10 kHz/DIV and tune CAL signal to F_o graticule line with COARSE and FINE TUNING controls.

b. Switch SCAN WIDTH to 1 MHz/DIV. Adjust R3141 (DSP CNTR) to center the L.O. signal on the F_o graticule line.

c. Switch SCAN WIDTH to 10 MHz/DIV and adjust R3137 (100 MHz OFFSET) to center the L.O. on the F_o graticule line.

4.22 Adjust DPM Voltage Output

a. Set Signal Generator to 100 MHz at +10 dBm and connect to CE-15 RF INPUT. Set CE-15 REFERENCE LEVEL to -40 dBm and SCAN WIDTH to 10 MHz/DIV.

b. Clear YIG by adjusting COARSE TUNING control fully CCW, then fully CW, then fully CCW, then tune to the 10th harmonic of 100 MHz and set to F_0 line. (Reduce input until only 100 MHz line seen, then increase input and count up ten harmonics).

c. Carefully zero the DVM and connect between 3100 board pin 10 and ground, on 3100 board. Adjust front panel CAL FREQ adjustment for a reading of +1.000V DC on DVM.

d. Adjust COARSE TUNING fully CCW, then set 100 MHz signal to F_0 graticule line. Adjust R3103 (DVM GAIN) for a reading of +0.100V DC on the DVM.

e. Reset 10th harmonic of 100 MHz to the F_0 line and readjust CAL FREQ control for a DVM reading of 1.000V DC.

f. Repeat d. and e. until there is no more than ±.001V DC difference in the two readings.

g. Turn COARSE TUNING control fully CCW and verify a DVM reading of 5mV ± 5mV.

h. Adjust COARSE TUNING for a frequency display from 999 to (1)000 plus OVERLOAD. If the display jumps 3 or more digits adjust R3505 slightly clockwise until reading is stable.

Digital Panel Meter Adjustment

4.23 Turn COARSE TUNING control fully CCW, then fully CW, then fully CCW.

a. Adjust R1303 (ZERO ADJ) for a reading of 005 MHz on the CENTER FREQUENCY display.

b. Set the SCAN WIDTH switch to 1 MHz/DIV. With the COARSE TUNING set the 100 MHz signal to the F_0 graticule line. Adjust FREQ CAL for a CENTER FREQUENCY reading of 100 MHz.

c. Set the 10th harmonic (1000 MHz) to the F_0 line (see para. 4.22b). Adjust R1301 (FULL SCALE CAL) for a CENTER FREQUENCY reading of (1)000 with the OVERFLOW light on.

d. Repeat b. and c. until no further adjustment is required.

e. With the COARSE TUNING control, set each harmonic in order (100, 200, 300, ..., 1000 MHz) to the F_0 graticule line. CENTER FREQUENCY should be the same as the harmonic ± 5 MHz. To obtain the best linearity over the full range R1301 may be adjusted to set the 1000 MHz reading at some number between 997 and (1)003 MHz. Repeat check and adjustment until best linearity is obtained.

f. Check COARSE TUNING over the full range, using the 100 MHz harmonics. Range should be from less than -100 MHz to greater than 1100 MHz. (The CENTER FREQUENCY display will only read a minimum of 005 MHz but the -100 MHz signal can be seen on the CRT display as the first harmonic below the L.O. signal).

g. Set one of the harmonic signals to the F_0 graticule line. Adjust the FINE TUNING control from the fully CCW to fully CW position and note how far the signal display on the CRT moves. Range should be 1.5 MHz ±.5 MHz.

h. Note reading of CENTER FREQUENCY. Adjust FREQ CAL control from maximum to minimum. There should be a range greater than 30 MHz on each side of the calibrated setting of the control.

4.24 After completing the Adjustment procedures the Performance Check procedures, paragraphs 4.05-4.13 should be carried out.

Table 4-1. Troubleshooting Chart

Indication	Possible Cause	Check
1. Does not operate when switched on	1. Main fuse open 2. AC cord loose 3. No AC at source 4. Line switch wrong position	1. Replace 1/2A fuse (F4001) 2. AC cord - both ends 3. AC source 4. Line switch rear panel
2. Does not work when 12V applied	1. Inverter board not plugged in. 2. 3A fuse open	1. Check 3400 M1 board 2. Replace 3A fuse (F4003)
3. CRT spot but no deflection	1. +10V supply fuse open 2. Component in +10V supply	1. Replace 2A fuse (F4002) 2. 3500 board
4. Frequency read-out ok but no CRT trace	No high voltage or filament current to CRT	CRT socket, 3700 board
5. CRT trace dim, not sharp	1. Low output from high voltage 2. Defective CRT	1. 3700 board 2. V3801
6. Trace not horizontal	Rotation control out of adjustment. Defective transistor	R3702, Q3701
7. Coarse and fine do not tune	Fuse to YIG oscillator open	Replace F3001
8. Large signal variations with frequency	Components in microwave casting	Check output level from microwave casting
9. No 189.3 MHz cal signal	Bad connection at microwave casting	Check microwave casting connections
10. Spurious responses	Component failure in microwave casting	Check microwave casting
11. Decreased sensitivity	1. RF fuse bad 2. Bad connections to microwave casting 3. Low 1st or 2nd L.O. levels 4. Possible component failure in microwave casting 5. 2nd L.O. not on frequency 6. 2.1 GHz filter not operating properly	1. Check RF fuse (F1001) 2. Check connections on microwave casting 3. Check for L.O. levels 4. Check microwave casting 5. Check 2nd L.O. frequency 6. Check 2.1 GHz filter insertion loss
12. Unable to calibrate with 189.3 MHz internal osc.	1. Microwave casting output not set properly 2. Front panel pot not operating properly 3. Microwave casting not tuned up properly	1. Check the 189.3 MHz output from casting 2. Check the level set control 3. Check casting output levels