FIELD INTENSITY METER
MODEL FIM-71
OPERATING INSTRUCTIONS

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SECTION 3
FIM-71 OPERATING INSTRUCTIONS

3.1 CONTROLS, INPUTS & OUTPUTS, PANEL METER FUNCTIONS

The following paragraphs describe the controls, indicators, and connectors for the FIM-71. Refer to figure 3-1.

POWER Switch: In the OFF (center) position, the battery and external power source are disconnected; also, a conductor is switched across the panel meter terminals for maximum damping during transportation.

If the Rechargeable Battery kit is connected to the AC line, the charging circuit remains energized with the POWER switch OFF.

In the TEST position, the panel meter indicates the battery voltage, or the external voltage when the external power plug is inserted. The FIM-71 will not function properly if the TEST indication is below the (green) BATTERY/EXTernal bracket; also, the instrument can be permanently damaged if the external voltage exceeds the EXT bracket.

In the ON (and TEST) position, battery or external power is applied to the unit.

DEMODulator Switch: Selects the AM (amplitude or pulse modulation) or FM (frequency modulation) demodulator. The output of the selected demodulator is applied through the AUDIO control and demodulator output amplifier, to the loudspeaker and PHONES jack.

AUDIO Control: Adjusts the output level of the selected AM or FM DEMODulator at the loudspeaker or PHONES jack. With the AUDIO control set to the 0 mark, power is removed from the FM discriminator and the output amplifier to conserve battery energy.

DETector Switch: In the PEAK position, the panel meter indicates the RMS value of the carrier amplitude during pulse (on) modulation. Detector time constants are optimized for measuring the amplitude of TV sync pulses, and the PEAK detector is usually used with the TV (wide) IF bandwidth.

In the AVeraGe position, the panel meter indicates the RMS value of the carrier amplitude averaged over the modulation cycle, and is usually used with the FM/AM (narrow) IF bandwidth.

IF Bandwidth Switch: Selects the TV (wide) or FM/AM (narrow) bandwidth. The wide bandwidth is usually used when measuring the amplitude of TV sync pulses, or to obtain the widest demodulator bandwidth. The narrow bandwidth is usually used when measuring aurally modulated AM or FM signals, or to obtain the best demodulator selectivity and signal-to-noise ratio.

MeTeR Switch: In the LINear position, the receiver operates with constant gain, and the panel meter indicates input voltage over a range of 1-to-10, or 20 dB. The meter angular deflection is proportional to the logarithm of the input, so voltage can be read with constant percent accuracy, or in equal decibel increments. Also the RECORD output voltage or current is linearly proportional to the measured signal amplitude.

In the LOGarithmic position, DC feedback is applied to the receiver to obtain a measurement range of 1-to-1000 or 60 dB, and the panel meter deflection (green scale) is in equal decibel increments. Also the RECORD output is proportional to the logarithm of the measured signal, allowing a true dB plot on standard (linear) recording grid.

The LINear mode provides better measurement accuracy and lower AM demodulator distortion; the LOGarithmic mode provides greater measurement range, and better demodulator signal-to-noise ratio.

FULL SCALE Switch: 7-position rotary attenuator provides RF and IF attenuation to set the full scale meter sensitivity in both the LINear and LOGarithmic modes.

FREQuency Control and MHz Dial: The FREQuency control adjusts the frequency of both the receiver and the calibrating oscillator over the entire frequency range without bandswitching. The tuned frequency is indicated on the 6-turn spiral MHz dial under the hairline cursor and to the left of the RED pointer. The calibrating oscillator frequency is maintained at the center of the IF passband with automatic frequency control, for any on-scale panel meter indication.

CURSOR Control: Adjusts the angular position of the hairline cursor to calibrate the MHz dial on a known frequency near the desired frequency.

OSCillator Switch: In the OFF position, the calibration oscillator is off, and the receiver functions normally. In the CAL position, the Cal-Osc is on, and the 100 mV calibration signal is internally switched to the input of the RF attenuator; also the RF INPUT (BNC connector on side of unit) is internally disconnected and bypassed to ground. In the OUT position, the Cal-Osc is on, and the calibration signal is switched to the OSC OUT/100 mV output (BNC connector on side of unit); also the RF INPUT is internally switched to the input of the RF attenuator, and the receiver functions normally.

GAIN Control: Adjusts the overall gain of the receiver. Usually used in conjunction with the 100 mV calibration oscillator to compensate for variations in receiver gain, or to compensate for external losses such as antenna cable attenuation.

PHONES Jack: 75 ohms (source) wideband output from the selected AM or FM demodulator. Variable with AUDIO control up to approximately 5 V peak-to-peak into 75 ohms, 30 Hz to 100 KHz, no deemphasis. ¼ inch diameter phone plug disconnects speaker.

RECORD Jack: Provides two outputs: Tip contact on standard 2-conductor or 3-conductor ¼ inch diameter plug provides DC voltage proportional to panel meter indication, approximately 0.8 V to 8.0 V, 2000 ohms source resistance. Ring contact on 3-conductor plug provides calibration oscillator AFC voltage, 5.5 V ± 3.5 V, 10,000 ohms source resistance.

EXTernal PoWeR Jack: Located on rear of instrument, accepts input from external power source such as the PI AC Power Supply. Requires (–) 11.5 V to (–) 19.0 V DC with (+) ground. Mates with Switchcraft plug #760; insertion of plug disconnects battery.

RF INPUT/10 V MAX Connector: BNC, located on right side of instrument. 50 ohms input to receiver through RF attenuator section of FULL SCALE switch.

OSCillator OUTput/100 mV Connector: BNC, located on right side of instrument. 50 ohms calibration oscillator output with OSC switch in OUT position, 100 mV into 50 ohms. When fraction of Cal-Osc signal is applied to receiver for on-scale reading of at least 5 μV, Cal-Osc frequency "AFC'd" to receiver frequency, otherwise Cal-Osc sweeps approximately ± 1 MHz.

3.2 CALIBRATION AND RF VOLTAGE MEASUREMENTS

The following steps (1 through 11) describe the procedure to be followed when performing an RF voltage measurement. Step 8, with substeps (a) through (e), describe the procedure for calibrating the FIM-71. Paragraph 3.3 describes the Peak Detector Correction Procedure, and paragraphs 3.4 through 3.6 describe special measurement procedures.

1. Set the following controls to the positions appropriate for the intended measurement (see paragraph 3.1 on control functions).

DETector:	PEAK (TV sync or other pulse modulated signals) AVeraGe (CW, FM, AM signals)
IF Bandwidth:	TV (wide) FM/AM (narrow)
METER:	LINear (read black scale, 1 to 10 volts or –20 to 0 dB) LOGarithmic (read green scale, –20 to +40 dB)

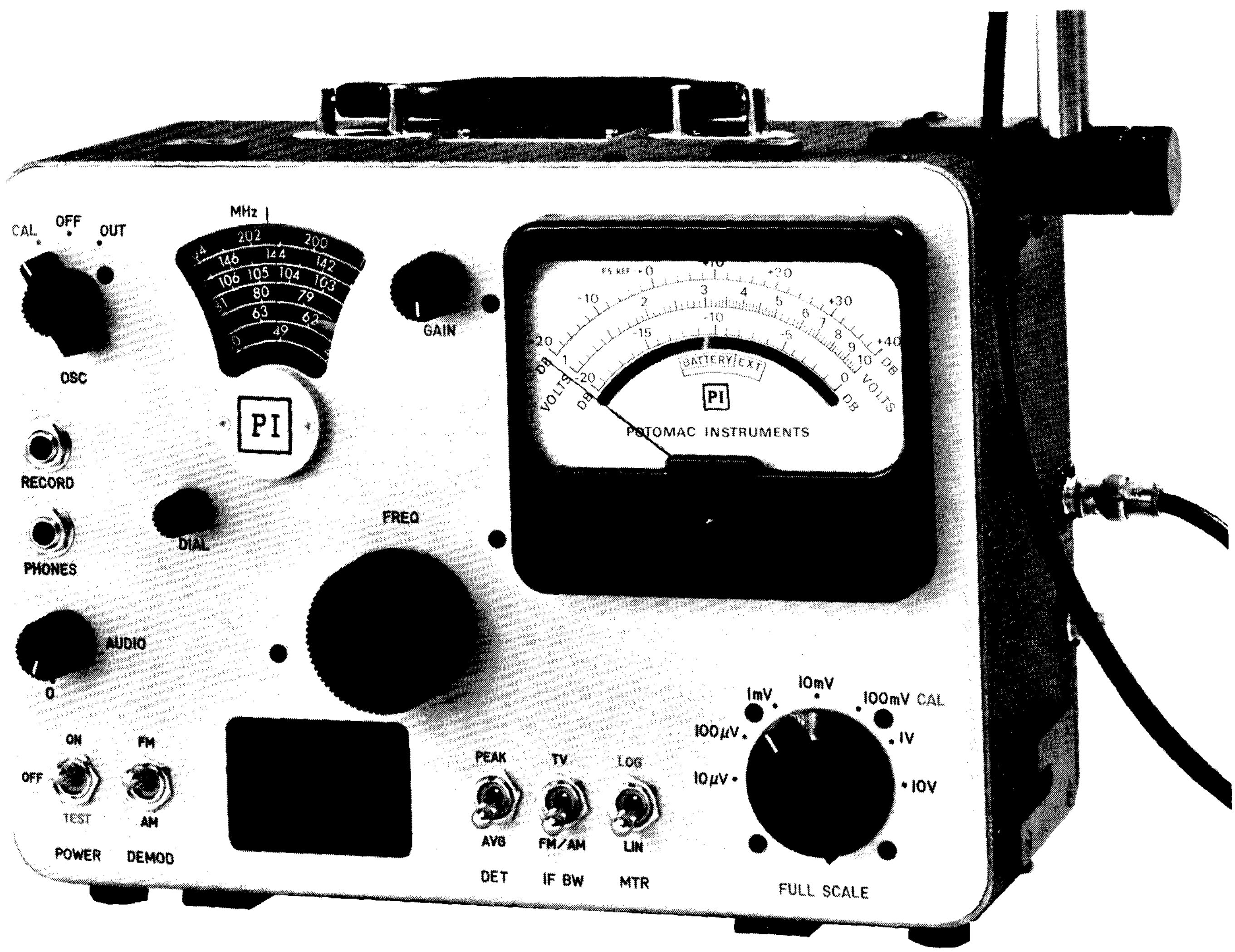


Figure 3-1. FIM-71 Operating Controls and Indicators

2. To check batteries or external power source, press the POWER switch to TEST – panel meter indication must be within the lower and upper limits of the green BATTERY/EXT bracket.

3. Set the POWER switch to ON. The FIM-71 requires approximately 90 seconds "warm up" to obtain best accuracy.

4. Set the FULL SCALE attenuator switch to the position corresponding to the maximum expected input voltage.

CAUTION

The RMS value of the input signal voltage (RMS sum of all RF, AC and DC components) must not exceed 10 VOLTS RMS under any condition, and must not exceed 1.0 VOLTS RMS with the FULL SCALE attenuator set to the 10 μV position.

5. Connect the signal source to be measured to the RF INPUT (BNC connector on right side of instrument).

CAUTION

The FREQuency control is designed to slip at the end of the range of the MHz dial without changing the frequency calibration. However, repeated forcing of the dial against the end stops will cause excessive strain and wear on the mechanism, and should be avoided.

6. Using the FREQuency control, set the MHz dial to the frequency of the signal to be measured, as indicated by the hairline cursor and red pointer. (Also see following note and paragraph 7.) Adjusting the FULL SCALE switch as necessary for an on-scale reading, tune in the signal for a maximum indication on the panel meter.

NOTE

The MHz dial is accurate to within 0.5% of the indicated frequency with the hairline cursor set to the MHz mark (above the dial window). Greater accuracy can be obtained by tuning to a signal of known frequency within approximately 7% of the desired frequency and adjusting the hairline cursor to the known frequency on the MHz dial.

7. The FIM-71 demodulators can be used as an aid in identifying a signal when when tuning the instrument. Set the DEMODulator switch to AM or FM as appropriate for the signal to be measured, and rotate the AUDIO control clockwise for the desired sound level at the phones or loudspeaker.

8. Calibration (Steps a through e)

NOTE

Measured signal voltages in excess of 1 V RMS may cause a small error when calibrating the instrument. Also, with the OSC switch in the CAL position, the RF Input is bypassed to ground with a .001 microfarad capacitor. For these reasons, the signal source should be disconnected from the RF INPUT for calibration steps a through d in the following cases: (1) Measured voltage exceeds 1 volt RMS; (2) Signal source will be damaged by low impedance load; and (3) Signal source can generate more than 0.5 watt across low impedance load, taking into account impedance transforming properties of transmission lines.

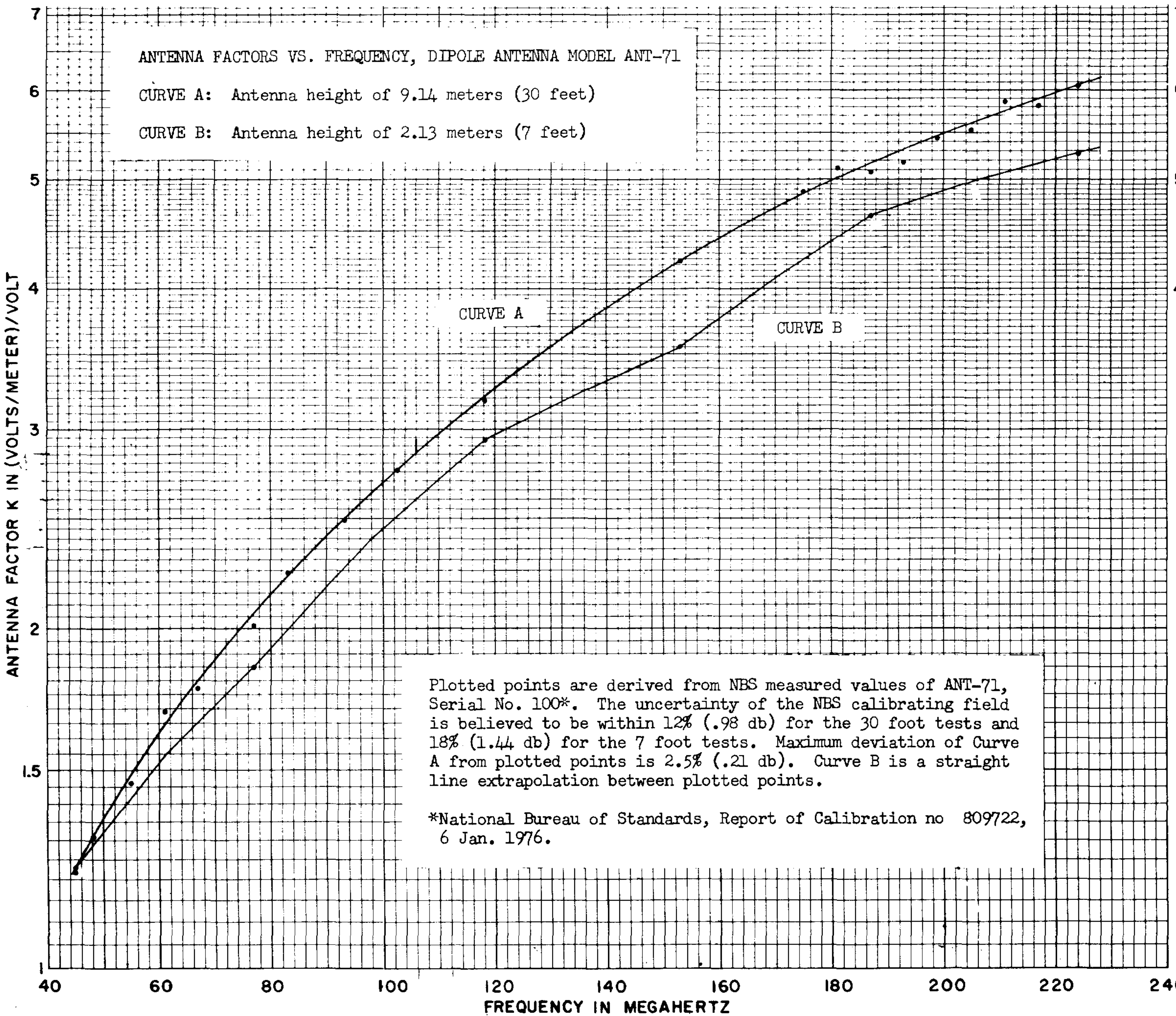


Figure 3-2. Antenna Factors, Curves A and B.

a. Set the FULL SCALE switch to the 100 MV CAL position.

b. Set the OSCillator switch to CALibration – after a slight hesitation, the panel meter should indicate up scale.

c. Rotate the 10-turn GAIN control for a reading of exactly 0 dB on the meter scale corresponding to the METER switch position (full scale for LIN, FS REF on green scale for LOG).

d. Return the OSC switch to OFF. The instrument is now calibrated for reading RF voltage.

e. (If applicable) reconnect signal source to RF INPUT.

NOTE

The above calibration, steps a through e, does not have to be repeated before every reading, particularly when only relative readings are required. Receiver gain may change with frequency, with the position of the IF, BW, and MTR switches, and with environmental conditions. Calibration routine should be based on experience with the instrument, and the measurement conditions.

9. After calibration, set the FULL SCALE switch for an on-scale reading and carefully retune for a maximum panel meter indication.

10. With the METER switch in the LINear position, the input voltage can be read directly on the VOLTS scale by noting the position of the FULL SCALE switch and interpreting the VOLTS graduations as either 0.1 to 1.0 or 1.0 to 10, depending on the FULL SCALE multiplier. In this mode, input voltage can also be read in decibels from −20 dB to 0 dB with respect to the FULL SCALE multiplier.

11. With the METER switch in the LOGarithmic position, an input voltage numerically equal to the FULL SCALE switch setting will be indicated on the green dB scale at the FS REF (full scale reference) index at 0 dB. In this mode, input voltage is read in decibels from −20 dB to +40 dB with respect to the FULL SCALE multiplier.

3.3 PEAK DETECTOR CORRECTION

The peak detector is less linear than the average detector; also, for signals less than 10 microvolts, internally generated noise causes a positive error which increases rapidly as the input voltage is reduced.

The peak detector characteristics are shown graphically in figure 3-4 for different settings of the FULL SCALE switch. A minor change affecting the peak detector was incorporated in the FIM-71 design, starting with serial number 141; the dashed curves apply to instruments with serial number less than 141.

The left hand ordinate of figure 3-4 shows the ratio of the peak detector reading to the actual peak value of the measured pulse, corresponding to the meter indication; the right-hand ordinate shows the same ratio in decibels. "Actual Peak Value" refers to the RMS value of the signal during the carrier-on interval, and is equal to the average detector reading of a CW signal precisely set to the pulse amplitude. These curves are based on measurements utilizing a 4.8 microsecond pulse at a repetition rate of 15750 Hz; the pulse amplitude was set 6 dB above a CW level simulating an "average" grey TV picture. The curves are typical, being derived from many measurements; the unit-to-unit spread in the data is believed to be less

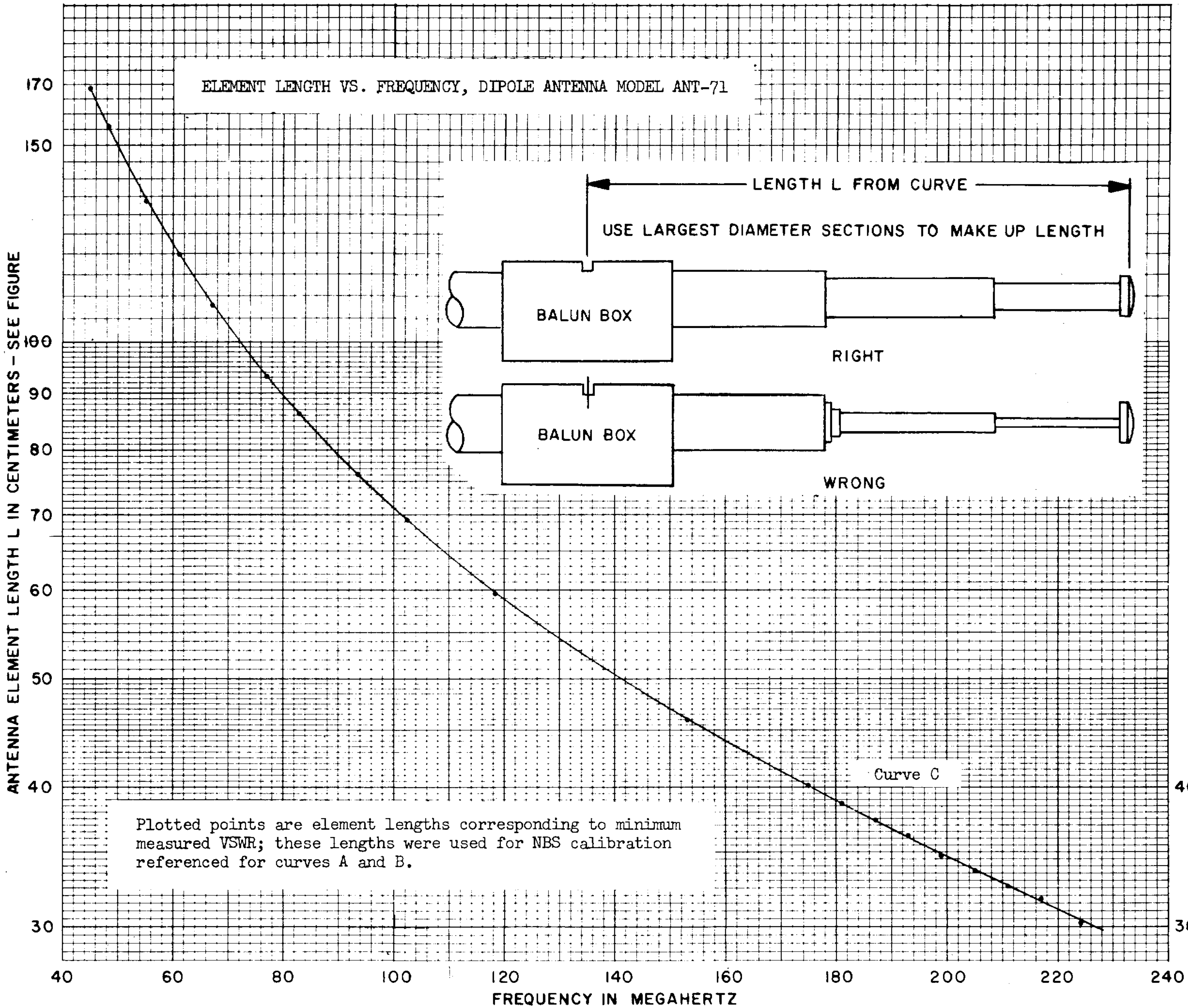


Figure 3-3. Antenna Factors, Curve C

than ± 0.2 dB. The average detector accuracy limits must be included in estimates of peak measurement uncertainty.

To correct the peak detector measurements, divide the volts reading by the left-hand ordinate value corresponding to the scale indication and FULL SCALE setting; alternatively, algebraically subtract the right hand dB values from the −20 to 0 dB scale indication. The peak detector correction curves only apply to the LIN (linear) mode and the TV (wide) IF bandwidths. Also, never use the peak detector to measure CW signals or "long" pulses with amplitude less than 1 mV.

Note that the correction curves cannot account for peak detector errors due to external interference, such as automative ignition noise. The FIM-71 peak detector response is reduced by at least 15 dB for impulse-like pulses with a repetition rate of 200 Hz or less. (Equivalent to an 8-cylinder engine running at 3,000 RPM.)

3.4 FIELD STRENGTH MEASUREMENTS WITH THE ANT-71

3.4.1 Mechanical Features

For storage and transportation, and for near ground measurements, the ANT-71 dipole antenna is normally attached to a telescoping mast which is supported by a swivel mounted on the right side of the FIM-71 (see figure 3-5). The mast swivel locks in three positions: vertically upward, at an angle of 60 degrees with respect to the front panel, and vertically downward (for storage).

The telescoping antenna elements screw into smaller swivel joints (contacts) which also lock in three positions: vertically up, horizontal (with a 2.5° uplift), and vertically down.

To reposition either the mast or the antenna element swivels, loosen the appropriate knurled locking knob, and pull the body of the joint toward the knob to release the detent pins; rotate the swivel until the detent pins snap into the desired position and tighten the locking knob. *Never* tighten a swivel knob unless the detent pins are engaged.

To store the antenna, the mast and antenna elements are fully collapsed, the antenna elements are positioned vertically downward, and the antenna mast is then rotated to an upside-down position so the small "button" on the side of the antenna balun housing can engage the support groove on the lower right side of the FIM-71. All locking knobs should be tightened (see figure 3-5).

3.4.2 Antenna Accessories Supplied

Identify the following accessories which are stored in the FIM-71 cover.

1. 3-3/4-foot coaxial cable
2. 34-foot coaxial cable
3. 2 meter tape scale
4. leather neck strap

3.4.3 Antenna Element Lengths

Rotate the antenna element swivels to the horizontal position and tighten the locking knobs. Using CURVE C of figure 3-3, determine the antenna element length L corresponding to the frequency of the signal to be measured. Measuring from the center slot on the top of the balun housing with the tape scale provided, carefully adjust the antenna elements to length L; be sure to utilize the largest diameter element sections to make up the length, as shown in the figure 3-3.

3.4.4 Near-Ground Measurements

For near-ground (7-foot) measurements, the antenna is normally supported on the telescoping mast attached to the receiver. If an UNIPOD (optional accessory) is used to support the FIM-71, the antenna mast is locked in the upright position, the mast is fully extended and the UNIPOD length is adjusted so

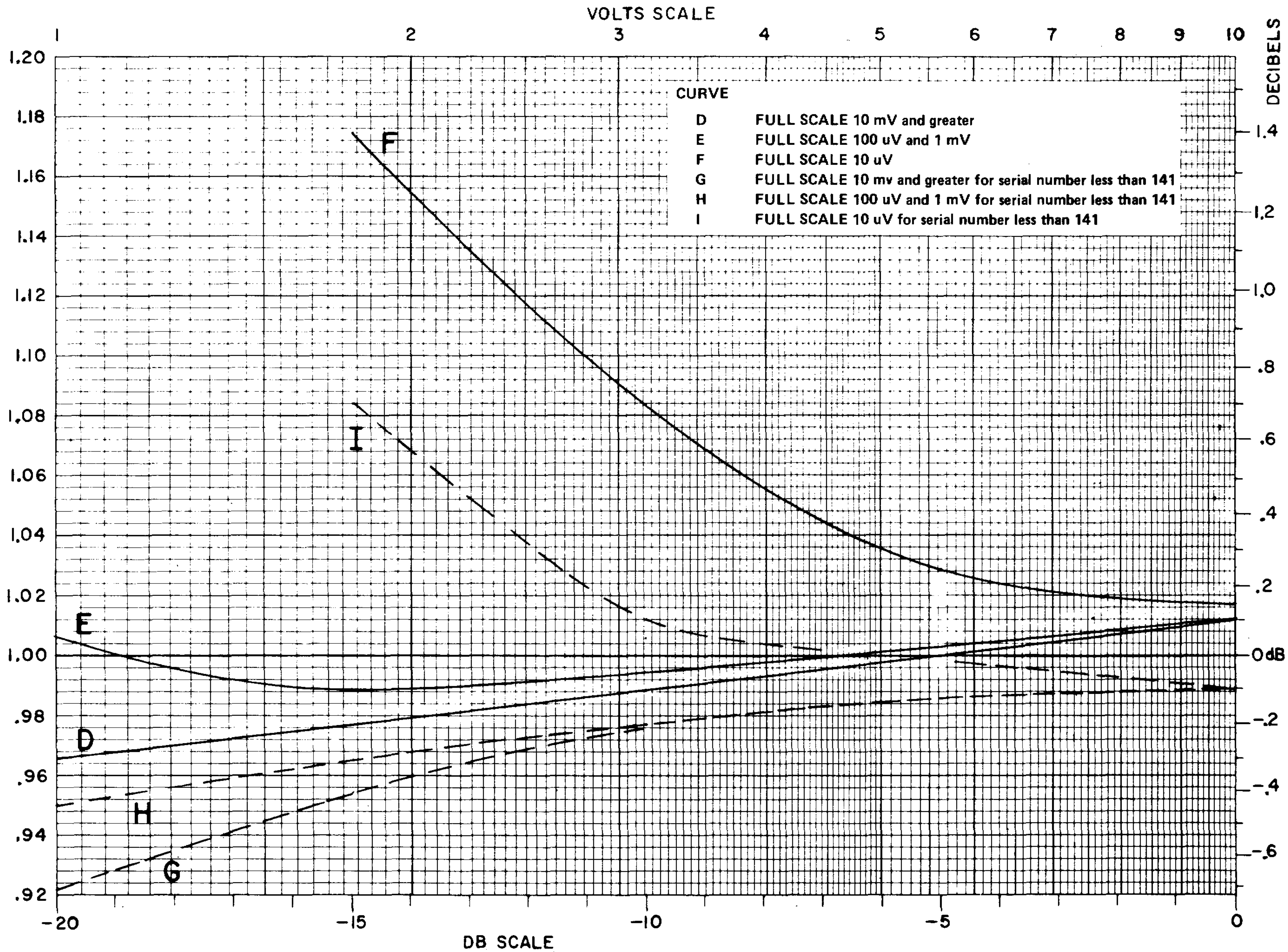
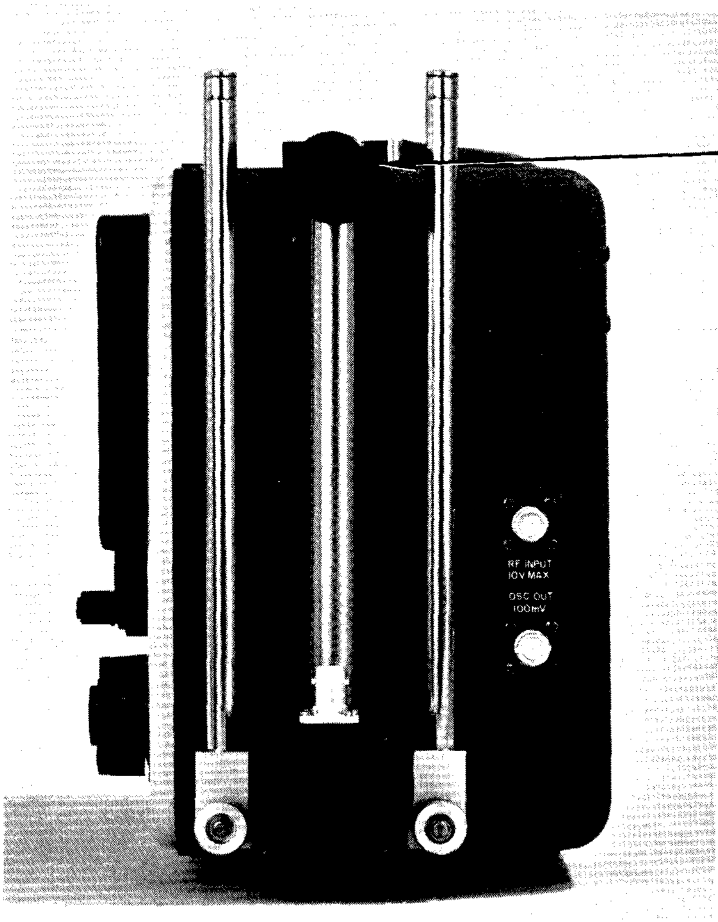
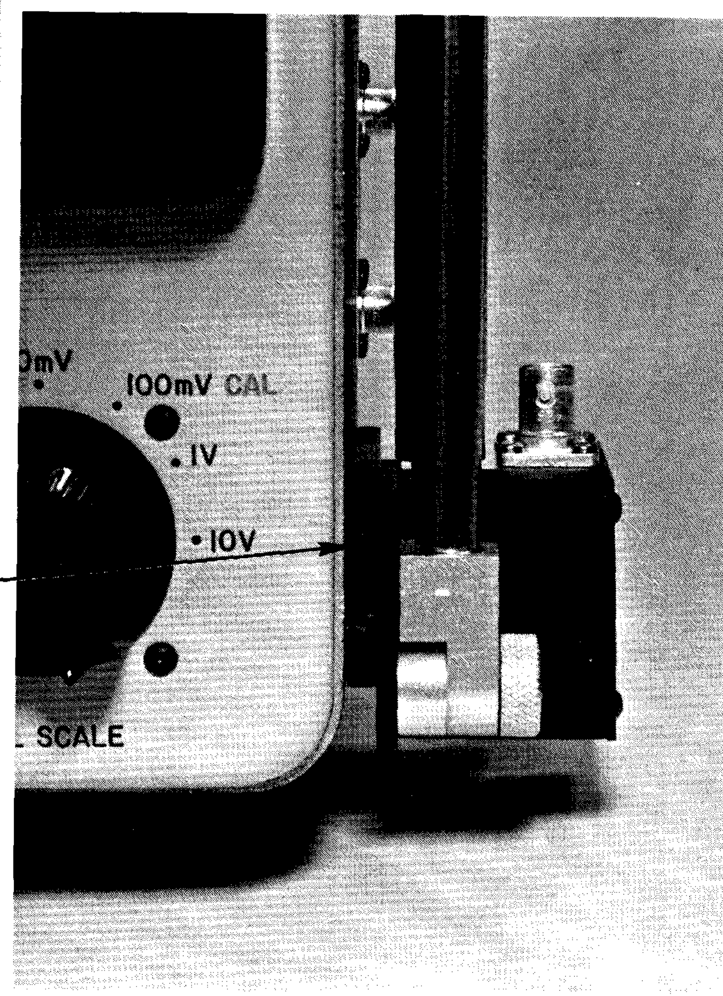


Figure 3-4. Indicated Peak of Sync/Actual Peak of Sync vs. Linear Scale Indication



1. LOOSEN THIS KNOB AND PULL THE BODY OF THE ANTENNA TOWARDS THE KNOB.



2. MAKE CERTAIN THE "BUTTON" ON THE BALUN HOUSING CLEARS THE SUPPORT GROOVE.

Figure 3-5. Antenna Deployment, Sheet 1

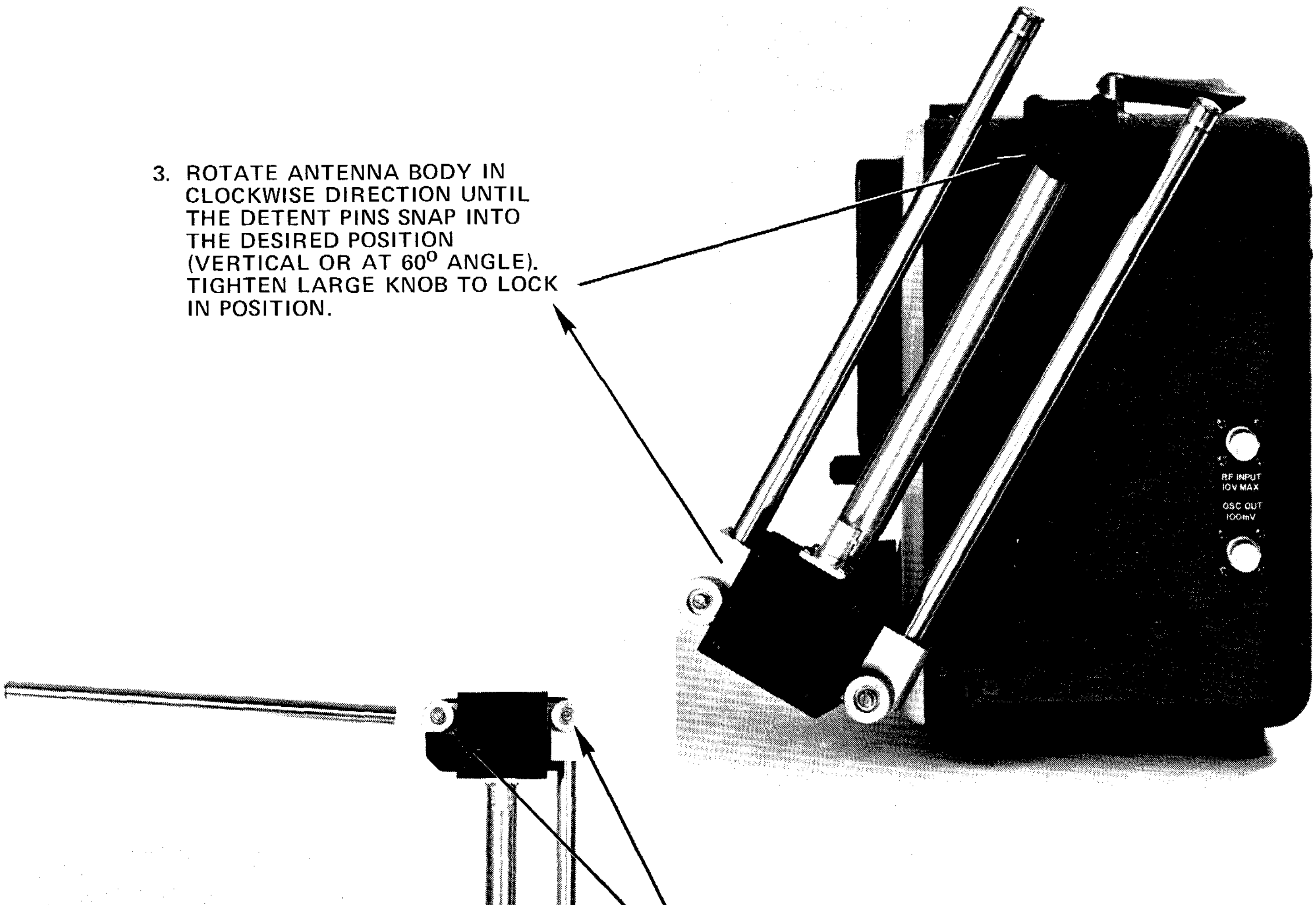
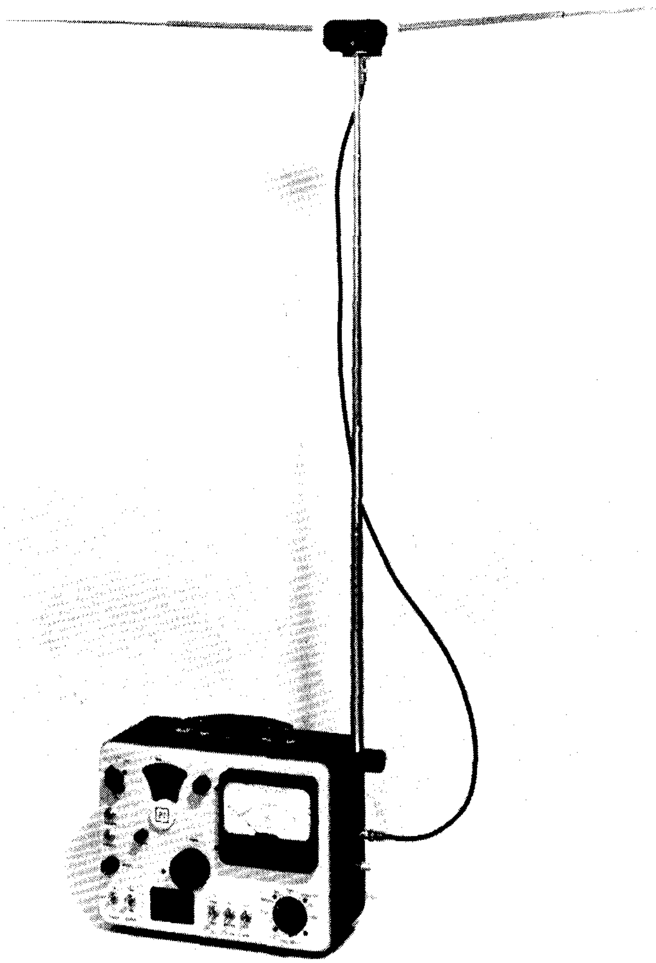


Figure 3-5. Antenna Deployment, Sheet 2



5. ADJUST ELEMENT LENGTH AND MAST HEIGHT AS REQUIRED. REVERSE THE SEQUENCE SHOWN IN STEPS 1 THROUGH 4 TO RETURN THE ANTENNA TO THE STORAGE POSITION.

Figure 3-5. Antenna Deployment, Sheet 3

the antenna elements are positioned 7 feet above the ground.

To hand hold the instrument, lock the antenna mast in the 60 degree position, so the receiver front panel slopes away from the operator when the mast is vertical. Attach the neck strap to the black kleats on the sides of the instrument; use the strap holes which comfortably position the antenna elements approximately 7 feet above the ground with the mast fully extended.

Connect the short coaxial cable from the antenna output connector on the bottom of the black balun housing to the RF INPUT on the receiver.

3.4.5 Elevated Measurements

For higher measurements, such as the F.C.C. approved 30-foot TASO tests, the antenna is removed from the telescoping mast by unscrewing the ¼-20 stud from the support bushing on the bottom of the antenna balun housing; a 7/16 inch wrench is required. The antenna can be attached to any mast fitted with a ¼-20 screw (not more than 7/16 inch long); the balun support bushing contains a self-locking insert.

Connect the 34-foot coaxial cable from the antenna to the RF INPUT on the receiver. Calibrate the cable as described in paragraph 3.4.6. Tape or otherwise attach the cable to the mast to relieve the stress on the cable connector, and to maintain the electrical symmetry of the antenna.

3.4.6 Cable Attenuation

NOTE

The ANT-71 ANTENNA FACTORS given in CURVES A and B relate the field strength to the antenna output voltage *at the balun output connector* terminated with 50 ohms. The following procedure provides a means of measuring and compensating for the losses of the cable connecting the antenna to the receiver. This procedure insures that the accuracy of field strength measurements are independent of the particular cable in use, and will also quickly show up a defective cable.

1. Connect one end of the antenna cable to the RF INPUT connector and the other end to the OSC OUT/100 mV connector.
2. Set the following switches to the positions indicated:

POWER:	ON
MeTeR:	LINear
FULL SCALE:	100 mV CAL
OSCillator:	CALibrate

3. Set the MHz dial to the frequency of the signal to be measured. For this step, the dial accuracy is sufficient, so it is not necessary to tune-in the signal.
4. After about 90 seconds warm-up, adjust the GAIN control for a meter reading of exactly 0 dB (full scale).
5. Set the OSC switch to OUT. The reduced meter reading shows the cable loss, which can be read directly either in decibels, on the dB scale, or as a fractional ratio on the VOLTS scale.

NOTE

Depending on the measurement conditions, two alternate procedures are given for compensating for the antenna cable attenuation. When it is inconvenient to periodically disconnect the antenna cable from the antenna, step 6 can be used. Alternatively, if both ends of the antenna cable are accessible, step 7 (ALTER-

NATE) eliminates the need for calculated corrections.

6. Record the cable attenuation obtained in step 5 above. When measuring antenna output voltage according to paragraph 3.2, all readings must be mathematically corrected to account for the cable loss.

   When using the short antenna cable, the cable loss may be negligible, particularly at the lower frequencies.

7. (ALTERNATE TO STEP 6) With the OSCillator switch in the OUT position, adjust the GAIN control for a meter reading of 0 dB. This procedure increases the gain of the receiver to compensate for the loss in the antenna cable, and can be used in either the LINear or LOGarithmic modes as long as the cable attenuation does not exceed the range of the GAIN control.

   When measuring antenna output voltage according to paragraph 3.2, the calibration procedures in step 8 should *not* be performed since the procedure given above effectively calibrates the receiver including the antenna cable, and the GAIN control must *not* be readjusted. The adjustments of steps 1 through 7 should be checked periodically.

NOTE

If the cable or measurement frequency is changed, the procedures described in paragraph 3.4.6 must be repeated.

3.4.7 Measurements and Antenna Factors

Note the large arrow on the top of the antenna balun housing. When measuring a signal, the antenna must be rotated (with the vertical mast as an axis) for the maximum reading. However, two slightly different "maximums" (usually with less than 0.5 dB difference) will be found 180° apart. Normally the higher maximum will be obtained with the balun arrow pointing (approximately) toward the source of the signal being measured, and this antenna orientation should always be used.

Treating the ANT-71 as any signal source, measure the antenna output voltage with the procedure given in paragraph 3.2. (Also review Paragraph 3.4.6 concerning cable attenuation.) Refer to CURVE A or CURVE B (7-foot measurement) of figure 3-2 and determine the appropriate ANTENNA FACTOR corresponding to the frequency being measured.

To obtain the field strength at the ANT-71 antenna, multiply the (corrected) antenna output voltage by the ANTENNA FACTOR.

FIELD STRENGTH (VOLTS/METER) = ANTENNA VOLTS X ANTENNA FACTOR

3.5 VERTICAL POLARIZATION MEASUREMENTS

The ANT-71 was not calibrated in a vertically polarized field. However, it is believed that the antenna factors obtained for horizontally polarized fields at a height of 30 feet are accurate for measurements of vertically polarized fields, provided that the asymmetry introduced by the antenna support and cable is minimized. The accuracy of near-ground measurements of vertically polarized fields is unknown.

To measure vertically polarized fields, the ANT-71 dipole elements are extended normally with respect to the balun housing, but the antenna assembly must be oriented so that one element points towards the sky, the other towards the ground. The antenna support and coaxial cable must extend horizontally (at right angle to the elements) for at least ½ wavelength to the main vertical support, thus forming a cantilever-like structure. At the vertical support the antenna cable can descend to the selective voltmeter. The less metal used in the antenna support the better, particularly in the upper section near the antenna.

The antenna element length and antenna factor are obtained from curves C and A respectively (see figures 3-3 and 3-2) for the frequency to be measured; curve B is not applicable for vertical polarization measurements.

For non-precise relative measurements near the ground, the ANT-71 can be set up to approximate a vertical ¼ wave "whip" antenna. With the arrow on top of the balun housing pointing *away* from the user, set the right hand element vertically downward and fully collapsed; set the left hand element vertically upward and extend to the length given in curve C for the frequency to be measured. Hand held readings can be made with the FIM-71 mast fully extended; if the neck strap is used, lock the mast into the 60 degree detent. Antenna factors are not provided for this configuration.

WARNING

BEWARE OF POWER LINES.

3.6 HARMONIC MEASUREMENTS, VOLTAGE AND FIELD STRENGTH

3.6.1 General

With certain restrictions, the FIM-71 can be used to accurately measure harmonic frequency signals which are more than 80 dB below a fundamental frequency signal.

Second and third harmonics can be measured for fundamental frequencies from 45 MHz to 75 MHz; second harmonics can be measured for fundamental frequencies up to 112.5 MHz, which includes the FM broadcast band.

The minimum measurable harmonic voltage is limited by the ultimate sensitivity of the voltmeter, and also by the amplitude of harmonics generated within the voltmeter due to the presence of the fundamental. For some measurements, a band-stop filter or trap may be required to attenuate the fundamental, when the voltmeter is tuned to the harmonic frequency.

Internally generated harmonics tend to increase rapidly as the fundamental voltage exceeds some "threshold" level which depends on many factors. Also, the internally generated harmonics and the measured harmonics add as vectors, so the error associated with a particular measurement depends on the relative amplitude *and* the phase of the two components, and partial cancellation of the measured harmonic is a practical possibility. For example, assuming that the detector is linear, if all internally generated harmonics are 20 dB below the measured harmonic, the maximum measurement error due to the internally generated components is limited to ± 1 dB.

Harmonics generated within the FIM-71 will be at least 100 dB below any fundamental voltage up to 50 mV, at any FULL SCALE position.

NOTE

> This statement is quite conservative. For example, with fundamental frequencies within the FM broadcast band, internally generated second harmonics are typically measured at more than 100 dB below a fundamental voltage of 316 mV.

When measuring the field strength of harmonic signals with the ANT-71 antenna, the antenna output voltage at the fundamental frequency will be reduced approximately 6 dB when the antenna elements are adjusted for the harmonic wavelength; in this case, internally generated harmonics will be at least 100 dB below a fundamental voltage up to 100 mV at any FULL SCALE position.

If the fundamental voltage is attenuated by at least 30 dB (the band-stop filter or trap attenuation at the harmonic frequency should not exceed 1.5 dB) when the voltmeter is tuned to the harmonic frequency, internally generated harmonics will be at least 120 dB below any measured fundamental voltage up to 10 V. If the fundamental voltage exceeds 1 V, harmonic measurement made on the 10 μV FULL SCALE range may be inaccurate.

For fundamental voltage of 50 mV or less, a fundamental band-stop filter or trap is normally not required. For fundamental voltage above 50 mV, the need for a filter depends on the fundamental frequency, the order of harmonics (2nd, 3rd, etc.), the harmonic to fundamental ratio, and the required measurement accuracy. Consequently, for the higher input levels, the necessity for fundamental attention is best determined experimentally. In general, if the change in harmonic reading with and without the device is less than the required accuracy, then the filter or trap is not necessary.

An inexpensive, easily constructed trap suitable for second harmonic measurements is described in paragraph 3.6.4 below.

3.6.2 Measuring the Harmonic Output of Voltage Sources

1. Using the procedure given in paragraph 3.2, calibrate the voltmeter, including the signal source-to-voltmeter cable. Measure and record the fundamental frequency voltage. Note that any band-stop filter or trap *must be removed* from the set up when the fundamental voltage is measured.
2. A band-stop filter or trap may be used to attenuate the fundamental voltage when the voltmeter is tuned to the harmonic frequency. Connect the filter to the RF INPUT of the voltmeter, and connect the source of voltage to the filter input.
3. Calibrate the voltmeter, including the source-to-voltmeter cable and, if applicable, the band-stop filter or trap, *at the harmonic frequency*. Measure and record the harmonic frequency voltage.
4. The ratio of the harmonic voltage V_h to the fundamental voltage V_f can be calculated and expressed in decibels as follows:

$$V_h/V_f \text{ (dB)} = 20 \text{ LOG}_{10} (V_h/V_f)$$

Alternatively, the ratio of V_h to V_f can be obtained directly in dB by reading either the LIN or the LOG dB scale on the panel meter, and subtracting 20 dB for each CCW step of the FULL SCALE switch going from V_f to V_h.

$$V_h/V_f \text{ (dB)} = V_h \text{ (dB)} \quad V_f \text{ (dB)} - 20 \text{ (FULL SCALE steps CCW from } V_f \text{ to } V_h)$$

Note that V_h (dB) and V_f (dB) must include the (±) sign obtained from the decibel scale readings.

3.6.3 Measuring the Harmonic Content of Radiated Signals

The procedure for measuring the field strength of fundamental and harmonic signals is similar to the procedure of paragraph 3.6.2, with the ANT-71 antenna providing the source of signal voltage. However, in this case, field strength and ratio calculations must include the antenna factors, which are different at the fundamental and harmonic frequencies. Antenna factors and antenna element lengths corresponding to the fundamental and harmonic frequencies are obtained from CURVES A, B, and C of figures 3-2 and 3-3.

1. Using the procedure of paragraph 3.3, at the fundamental frequency, adjust the antenna element length and calibrate the voltmeter including the antenna-to-voltmeter cable. Measure the antenna output voltage and calculate and record the fundamental field strength; alternatively, (see step 3) record the voltmeter reading and the antenna factor.
2. At the harmonic frequency, readjust the antenna element length and calibrate the voltmeter including the antenna-to-voltmeter cable, and if applicable, the band-stop filter or trap.
3. The ratio of the harmonic field strength E_h to the fundamental field strength E_f can be expressed in decibels as follows:

$$E_h/E_f \text{ (dB)} = 20 \text{ LOG}_{10} (E_h/E_f)$$

Alternatively, to reduce the number of calculations, the ratio of E_h to E_f can be obtained directly in dB by recording the ratio of harmonic to fundamental voltage directly in dB as done in step 4 of paragraph 3.6.2 and then adding the ratio (expressed in dB) of the harmonic to fundamental antenna factors:

$$E_h/E_f\ (dB) = V_h/V_f\ (dB) + 20\ LOG\ (K_h/K_f)$$

$$= V_h\ (dB) - V_f\ (dB) - 20\ (\text{FULL SCALE steps CCW from } V_f \text{ to } V_h) + 20\ LOG\ (K_h/K_f)$$

where K_h and K_f = harmonic and fundamental antenna factors respectively.

3.6.4 A Fundamental Frequency Trap

A very simple, yet effective fundamental frequency trap can be constructed using a T connector and a length of coaxial cable experimentally cut to ¼ wavelength. This "quarter wave stub" can only be used when measuring even order (2nd, 4th, etc.) harmonics.

Since the trap functions by "shorting" the fundamental voltage, it will only be effective if the voltage source impedance matches (approximately) the impedance of the source-to-voltmeter cable. Also, if any of the conditions listed below are applicable, it may be necessary to partially isolate the voltage source from the voltmeter and trap; attenuators (pads), power dividers, directional couplers, sample probes, etc., are used for this purpose.

1. Voltage source will be damaged if shorted by trap.
2. Harmonic output of source increases significantly when fundamental is shorted by trap.
3. Excessive power will be dissipated.

The trap described (steps 1 through 8) below may be used with the ANT-71 antenna without additional isolation.

The maximum fundamental attenuation will be obtained when low loss cable such as RG-232/U is used; however, miniature cable such as RG-174/U is usually satisfactory and is very convenient.

1. Cut a coaxial cable to approximately 80% of the length L given on CURVE C (figure 3-3) corresponding the fundamental frequency. This length should be 3% to 10% too long depending on the type of cable and the frequency.
2. Install a BNC plug on one end of the cable. (Use UG-88C/U for RG-232/U cable or Amphenol #69475 for RG-174/U cable.)
3. Connect a BNC T adapter (UB-274B/U) directly to the RF-INPUT connector on the side of the FIM-71. Connect the quarter wave stub to one input of the T adapter; using a short 50 ohm cable, connect the other input of the T adapter to the OSC OUT connector.
4. Set the FIM-71 controls as follows:

POWER: ON	MTR: LOG	OSC: OUT
DET: AVG	FULL SCALE: 10 mV	

5. The panel meter should indicate up scale. Starting at the fundamental frequency, slowly tune the voltmeter in the direction of lower frequency to find the frequency corresponding to the minimum panel meter indication – the "notch" frequency. Decrease the setting of the FULL SCALE switch if necessary.
6. Using a sharp cable cutter or knife, cut a small piece off the end of the cable and tune the voltmeter to find the new notch frequency. Continue this process until the notch frequency is equal to the fundamental frequency. Set the MTR switch to LIN to obtain greater resolution as the notch frequency approaches the fundamental frequency, and be careful not to cut off too much cable. If the cable is to be coiled-up or otherwise contained, this should be done before the final cut.
7. To finish the trap, dip the end of the cable in an insulating varnish such as RED GLPT® (G.C. Electronics catalogue number 90-2); when dry, tape the end to prevent fraying. The trap should be labeled with the notch (fundamental) frequency.

8. To use the trap, connect the T adapter directly to the RF INPUT of the voltmeter; connect the voltage source (or antenna) to one input of the T adapter, and connect the quarter wave stub to the other input of the T adapter. When measuring the fundamental voltage, the trap must be removed; this is done by simply unplugging the quarter wave stub from the T adapter.

3.7 NOTES ON BATTERIES AND BATTERY LIFE

Assuming that it takes approximately three minutes to calibrate the instrument and perform a voltage or field strength measurement, the FIM-71 should obtain at least 1500 readings from a "standard" battery consisting of 10 carbon-zinc D size dry cells. (See List of Parts, Section 6.)

NOTE

The estimated battery life is based on operation at normal or elevated temperatures. Battery life is decreased at low temperatures.

The instrument will also operate continuously for at least 24 hours on a standard battery, although continuous battery operation becomes somewhat expensive. Continuous operation is more practical using an external AC powered DC supply. Any power source providing between (–) 11.5 V and (–)19.0 V DC at not less than 150 mA can be plugged into the EXT PWR jack on the rear of the FIM-71. (Use Switchcraft #760 plug.) Plugging-in an external power supply disconnects the internal battery.

Potomac Instruments provides an inexpensive and very convenient AC power supply for this purpose. (See Optional Accessories in Section 1.)

Extended readings can also be made using a 12.6 V automotive battery.

CAUTION

The (+) terminal of the external supply must be connected to the FIM-71 case (Ground). *Severe damage can occur if the instrument is powered from an automotive electrical system with a negative ground.*

The instrument will also operate continuously for approximately 20 hours on the Potomac Instruments Rechargeable Battery Kit, which can be recharged in approximately 8 hours (See Optional Accessories in Section 1).

If the instrument is to be frequently operated for periods of 30 minutes or more, or if readings are to be made at low temperatures, then the alkaline (manganese dioxide) cells privide a significantly longer battery life. (See List of Parts, Section 6.) However, if typical operation is for short periods at normal or elevated temperatures, the standard carbon-zinc cells will provide nearly the same life at a much lower cost.

The minimum battery current of approximately 60 mA is obtained with the FIM-71 controls set as follows:

AUDIO: MAX CCW AT 0 DEMOD: AM OSC: OFF

A slight CW rotation of the AUDIO control switches DC power to the demodulator output amplifier, which drives the loudspeaker and PHONES jack. Depending on the speaker loudness, the battery current will increase to a value of 1.1 to 1.6 times the minimum current. If a low impedance load (i.e. 75 ohms) is connected to the PHONES jack, a similar increase in battery current is obtained, again depending on the output level. The battery current increase is negligible if high impedance (2000 ohms or higher) phones are used. Setting the DEMOD control to FM applies DC power to the FM discriminator, and increases the battery current to approximately 1.4 times the minimum current. Setting the OSC control to CAL or OUT switches DC power to both the FM discriminator and the calibration oscillator, and increases the battery current to approximately 1.5 times the minimum current. Using the loudspeaker with the FM demodulator and/or the Cal-Osc can increase the battery current up to approximately 2 times the minimum current.

The FIM-71 is not recommended as a battery-powered "FM radio."

3.8 INSTALLING AND REPLACING BATTERIES

NOTE

Replacement of the battery compartment cover requires considerable force to compress the spring contacts so the cover fasteners can be engaged. To facilitate battery installation, it is strongly recommended that the front panel cover be temporarily installed so the instrument can be supported on the cover with the rear of the unit facing upward. Never support the instrument directly on the front panel without providing protection for the meter and controls.

1. To remove the battery compartment cover, use a large blade screwdriver or a coin, and rotate the six (6) black fasteners on the cover ½ turn counter clockwise.
2. The FIM-71 requires ten (10) "D" size cells. When installing the cells, the positive (+) terminal of 5 cells must be carefully placed into the 5 RED cups on the bottom contact assembly. The remaining 5 cells are installed with the (+) terminal toward the cover contact assembly.
3. To replace the battery compartment cover, force the cover into position against the batteries, and rotate the six (6) fasteners ½ turn clockwise.
4. Always remove batteries when the instument is to be stored for an extended period.

3.9 INSTALLATION AND OPERATING INSTRUCTIONS, RECHARGEABLE BATTERY KIT

NOTE

The Rechargeable Battery Kit is made up of the BC-71 Battery Charger and the BP-71 Battery Pack. Both units are connected together electrically and installed into the FIM-71 battery compartment.

3.9.1 Installation

1. Place the front panel cover on the FIM-71. Set the instrument front-down on a protective surface, and orient the case so the carrying handle is *away* from the user.
2. With a large screwdriver or coin, rotate the six slotted battery cover fasteners counter-clockwise, and remove the battery cover and ten "D" cells.
3. Identify the three small and the three large holes in the BP-71 Battery Pack printed circuit board. Install the BP-71 into the *right* side of the battery compartment so that the six right-most battery terminals in the bottom of the compartment fit into the holes in the Battery Pack PC board—the red (+) battery terminals fit into the large holes. The 4-conductor cable should be coming off the left side of the Battery Pack.
4. Identify the 4-conductor receptacle J701 mounted on the Battery Charger printed circuit board near the fuse holder. Also straighten out the leads with the yellow and green pin plugs, P701 and P702.
5. Holding the Battery Charger in one hand above the battery compartment, insert the yellow and green pin plugs P701 and P702 into the *same-colored* jacks on the battery compartment board. Bend the yellow and green leads down over the plugs. After the pin plugs are inserted, connect the 4-conductor Battery Pack Plug P801 to J701.

CAUTION

Short-circuiting the battery can cause damage to charger or battery. Do not allow P701 to touch P702 after P801 is connected. Also, reversal of P701 and P702 will reverse the battery polarity and severely damage the FIM-71. Also, some units have a third (blue) pin jack which is not used with the Rechargeable Battery Kit. If there is any question concerning the proper connection of P701 and P702, contact Potomac Instruments – *don't guess.*

6. Carefully lower the Battery Charger into the space to the left of the Battery Pack. Dress the Battery Pack cable into the gap between the charger and the battery. As the Battery Charger cover is lowered there will be some resistance when the foam backing presses against the battery; however, it should not be necessary to "force" the unit into place. Pressing the Battery Charger panel flush with the rear of the FIM-71, complete the installation by rotating the six slotted fasteners clockwise using a large screwdriver or coin.

3.9.2 Operation

WARNING

AC line voltage accessible under the BC-71 Battery Charger panel can be dangerous and even lethal, particularly when units are operated from 230 volts. NEVER connect the line cord to the charger unless the BC-71 is properly installed in the FIM-71 battery compartment, and the six fasteners are tight. NEVER remove the BC-71 before first disconnecting the line cord. NEVER remove or install the BC-71 fuse with the line cord connected. NEVER operate the BC-71 from an AC receptacle which does not properly ground the U-prong on the line cord plug.

1. With the Battery Pack and Battery Charger installed in the battery compartment, depress the FIM-71 POWER switch to TEST. The instrument panel meter should indicate within the green BATTERY bracket.
2. If no BATTERY indication is obtained, take a small diameter instrument (ball point pen, tooth pick, paper clip, etc.) and push-in the red plunger labeled LOW BATTERY BREAKER on the Battery Charger panel; the red plunger should latch approximately ¼ inch into the cylindrical guide.
3. With a fully charged battery, the POWER TEST indication should be somewhat above the first "T" in BATTERY. As the battery is discharged, the TEST indication will decrease; a reading near the lower limit of the BATTERY bracket indicates that the battery should be recharged.
4. If the battery is excessively discharged (indicated by a POWER TEST reading below the BATTERY bracket) battery damage will be prevented by the LOW BATTERY BREAKER, which will release (trip) and disconnect the battery from the FIM-71. A tripped battery breaker is indicated by the red plunger which "pops out" almost flush with the end of the cylindrical guide.

CAUTION

Holding the LOW BATTERY BREAKER plunger in when it will not latch will severely discharge the battery, and may cause damage to the battery, the charger, or the FIM-71 (see step 8).

NOTE

A sharp blow to the FIM-71 (such as dropping the instrument) may trip the magnetically latched LOW BATTERY BREAKER, even though the battery is fully charged. If this happens, simply reset the breaker by pushing-in the red plunger.

5. To recharge the battery, plug the female end of the line cord into the line connector J702 on the BC-71 panel. Plug the line cord into a 3-prong U-grounded receptacle with nominal AC voltage equal to the VOLTS AC engraved on the Battery Charger panel. The red BATTERY CHARGING light on the charger panel will be energized whenever AC voltage is applied. (See WARNING at start of this section.)
6. The FIM-71 can be switched off, or it can be operated while the battery is charging. Operating the instrument increases the recharge time by approximately 20 percent. As the battery is being charged, the POWER TEST indication should gradually rise to above the "E" in BATTERY. Also, when charging a deeply discharged battery, it is normal for the Battery Charger panel to run hot; the panel should cool to slightly above ambient temperature as the battery reaches full charge.
7. A discharged battery will be almost fully recharged in 8 hours. Because of the "tapered" characteristics of the charger current, it may take one or more days to fully charge a deeply discharged battery. The Battery Charger can be left connected to the AC line for more than a week with no degradation in battery service life. Continuously "float" charging the battery is safe, but may cause a reduction in service life. The Battery charging rate decreases at both the high and low temperature extremes. (See the BC-71/BP-71 specifications for additional information on charging and discharging.)
8. To protect the FIM-71, the battery breaker will also release if the charging voltage becomes excessive. If the breaker trips while charging the battery, check that the POWER TEST indication does not exceed the EXT bracket when the breaker plunger is pressed in with AC voltage applied. Excessive charging voltage, which can only occur if the charger circuit has failed, will quickly destroy the battery; a Battery Charger exhibiting this condition should be immediately removed from service for repair.
9. The small current required for the battery breaker circuit will discharge the battery in 18 to 24 months. If the FIM-71 is to be stored for a long time with the Rechargeable Battery Kit installed, the battery should be isolated from all loads by manually releasing the battery breaker. This is easily accomplished by inserting a thin conductor (such as the end of a paper clip) into the small hole labeled BREAKER TRIP on the BC-71 panel. The conductor must touch and ground the terminal inside the hole which will cause the breaker plunger to "pop out". The self-discharge rate of the isolated battery is greatly increased at elevated temperatures.
10. The BP-71 utilizes four lead-acid cells which are normally sealed. However, in the event the charger circuit fails, a small amount of hydrogen gas may be emitted from the battery. Four small vent holes have been provided in the battery cover for this contingency—these holes should not be obstructed.
11. The BC-71 and BP-71 may be installed in the FIM-71 indefinitely. After a number of years of service, the Battery Pack may not accept or hold a charge. In this event, the BP-71 can be purchased separately and replaced without readjusting the BC-71 Battery Charger.

INSTRUCTION MANUAL SUPPLEMENT, FIM-71 Sec. 3,4,1, FIM-72 Sec. 2.4.1

The short antenna mast mounted on the FIM case has been changed from a telescoping mast, whish is no longer available, to a mast made up of separate sections which must be screwed together. There are three sections, a short base section attached to the unit and two long sections which are supplied loose. The long sections can be stored in the bottom of Meter Carrying Case Type MCC-71.

The base section of the new mast is mounted to the case as the old mast was by a pivot assembly consisting of two cylindrical parts, an inner part to which the mast is attached, and an outer knob which clamps the inner part in place. The inner part has detent pins which allow it to be locked in three positions: straight down for storage, straight up for use with the meter panel vertical, and an intermediate position for hand-held measurements using the neck strap.

The base section of the mast has a rotating joint, clamped by a thumbscrew, which permits the antenna to be oriented as desired. This joint may be pulled apart when the thumbscrew is unscrewed is unscrewed two to three turns; do not completely remove the thumbscrew.

TO SET UP THE ANTENNA ON THE SHORT MAST:

1. Fully unscrew the outer knob of the pivot (approx. two turns).

2. Pull the inner part of the pivot away from the case to free its detent pins, and swing the mast and antenna forward and up until the pins fit into holes at the desired operating position.

3. Tighten the outer knob to lock the mast in position.

4. Unscrew the thumbscrew in the mast base section 2-3 turns and remove the antenna with the base section stub (the shorter part of the mast base section) attached.

5. Unscrew the base section stub from the antenna balun box. For the FIM-71, first swing the antenna elements up into their operating position , leaving them fully compressed.

6. Screw on of the long mast sections into the antenna balun box, screw the second long section into the first, and screw the base section into the second long section.

7. Install the antenna and mast on the FIM by reassembling the rotating joint in the base section of the mast. Orient the antenna assembly as desired and tighten the thumbscrew.

8. Connect the 45-inch RG-223 cable supplied in the FIM cover between the antenna connector and the FIM’s RF INPUT connector.

9. Adjust the antenna element length as required.

TO RETURN THE ANTENNA TO THE STORAGE POSITION:

Carry out the procedure above in reverse. At Step 4, when reassembling the antenna and stub to the base section, orient the antenna box with its long side parallel to the end of the case and tighten the thumbscrew.

Potomac Instruments, inc. Date of issue 8-1-90