

iCOM

INSTRUCTION MANUAL



**HF AUTOMATIC
ANTENNA TUNER
AT-120**



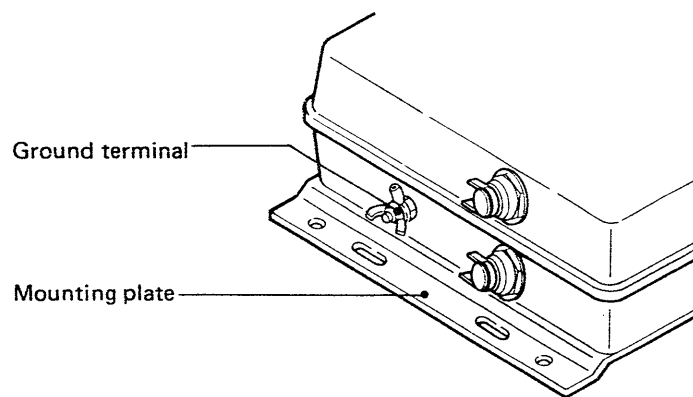
Icom Inc.

FOREWORD

Thank you for choosing this ICOM product.

The AT-120 HF Automatic Antenna Tuner was developed using both current commercial communications technology and ICOM's own advanced, state-of-the-art computer technology. It was designed, primarily, to be used with our IC-M700 HF SSB Radiotelephone.

Please read this INSTRUCTION MANUAL carefully to attain a thorough understanding of the tuner before using it. This will ensure long and reliable operation of your AT-120.



NEVER USE THIS TUNER WHEN IT IS UNGROUNDED. ALWAYS GROUND THE TUNER THROUGH THE GROUND TERMINAL BEFORE OPERATING. DO NOT use the mounting plates as ground.

NEVER TRANSMIT OR TUNE WITHOUT AN ANTENNA. Failure to use an antenna will damage the tuner.

HIGH VOLTAGE! NEVER TOUCH THE ANTENNA WHILE TRANSMITTING OR TUNING. Place the antenna in a position where you are sure it will not be touched.

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SECTION 1 GENERAL DESCRIPTION

The AT-120 HF Automatic Antenna Tuner provides a method of comfortably and easily matching the IC-M700 HF SSB Radiotelephone to an antenna system.

MATCHES VARIOUS ANTENNAS

The AT-120 matches a wide range of antenna impedances. For example, the tuner will match a 23 foot long-wire antenna across the frequency range of 2 to 24MHz.

QUICK TUNE-UP

Pushing the TUNE button on the front panel of the IC-M700 accomplishes complete matching of the radio and antenna.

EIGHT MEMORIES AVAILABLE

The AT-120 has eight convenient memories to store tuning information. The tuner "remembers" the settings of individual coils and capacitors after tune-up. Retuning for a previously tuned frequency takes about one-half second. The tuning information for eight different frequencies may be stored.

LOW POWER TUNE-UP

Output power from the AT-120 in the tune-up mode is only 300 milliwatts approximately. This low power eliminates the possibility of causing interference.

WEATHER-PROOF

Weather-proof construction completely protects the electronics of the AT-120. The cover is made from durable acrylic while all mounting hardware is stainless steel. This permits complete flexibility for interior or exterior installation.

SECTION 2 SPECIFICATIONS

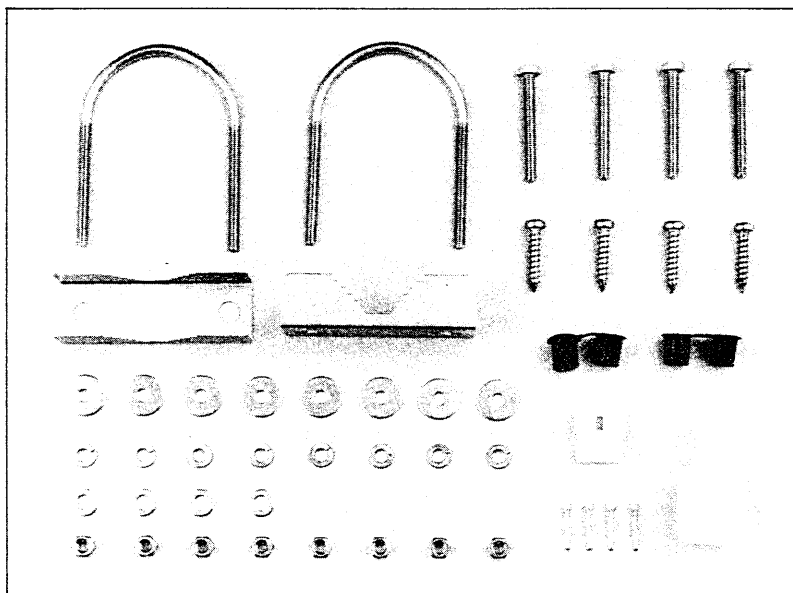
| | | | |
|--------------------------|---|---|-------------------|
| Number of Semiconductors | : | Transistors | 13 |
| | | ICs | 19 (CPU included) |
| | | Diodes | 39 |
| Frequency Range | : | 2 to 24MHz | |
| Power Capability | : | 150W PEP 100W continuous | |
| Input Impedance | : | 50 ohms | |
| Tune-up Power | : | 5 to 15W | |
| Tune-up Time | : | Typically 2 to 3 seconds | |
| Matching Accuracy (VSWR) | : | Less than 2.0 | |
| Antenna Required | : | Marconi type with suitable RF ground (More than 23 feet suggested) | |
| Power Supply Required | : | 13.6V DC (negative ground) 2A maximum (supplied by the IC-M700) | |
| Usable Temperature Range | : | −30°C to +60°C | |
| Dimensions | : | 230mm x 340mm x 80mm | |
| Case Construction | : | Weather-proof | |
| Weight | : | 2.4kg | |
| Control Cable | : | AWG 14 x 4 conductors | |

All stated specifications are subject to change without notice or obligation.

SECTION 3 INSTALLATION

3-1 UNPACKING

Carefully remove your tuner from the packing carton and examine it for signs of shipping damage. Notify the delivering carrier or dealer immediately, stating full details, should any damage be apparent. We recommend you keep the shipping carton for storing, moving or reshipping the tuner if necessary. Accessory hardware, cables, etc. are packed with the tuner. Make sure you have removed all equipment and parts before discarding the packing material.



| | | | |
|--|---|---|---|
| 1. U-clamp. | 2 | 8. Installation screws (hex head) | 4 |
| 2. U-clip plate. | 2 | 9. Weather-proof cap. | 1 |
| 3. Installation nuts (M6). | 8 | 10. Plastic grommet (attached to cable retainer) | 2 |
| 4. Spring washers (M6). | 8 | 11. Four pin plastic connector | 1 |
| 5. Flat washers (M6) | 4 | 12. Connector pins | 4 |
| 6. Flat washers (M6, large size) | 8 | | |
| 7. Installation screws (self-tapping). | 4 | | |

3-2 PLANNING

Select a location for the AT-120 where it will not be disturbed. Avoid long cable runs to the antenna and power source. Also, keep the cables as far from electrical pumps and other electrical apparatus as possible. In particular, do not run the cables in the vicinity of magnetic compasses or near electronic instruments.

3-3 TUNER INSTALLATION

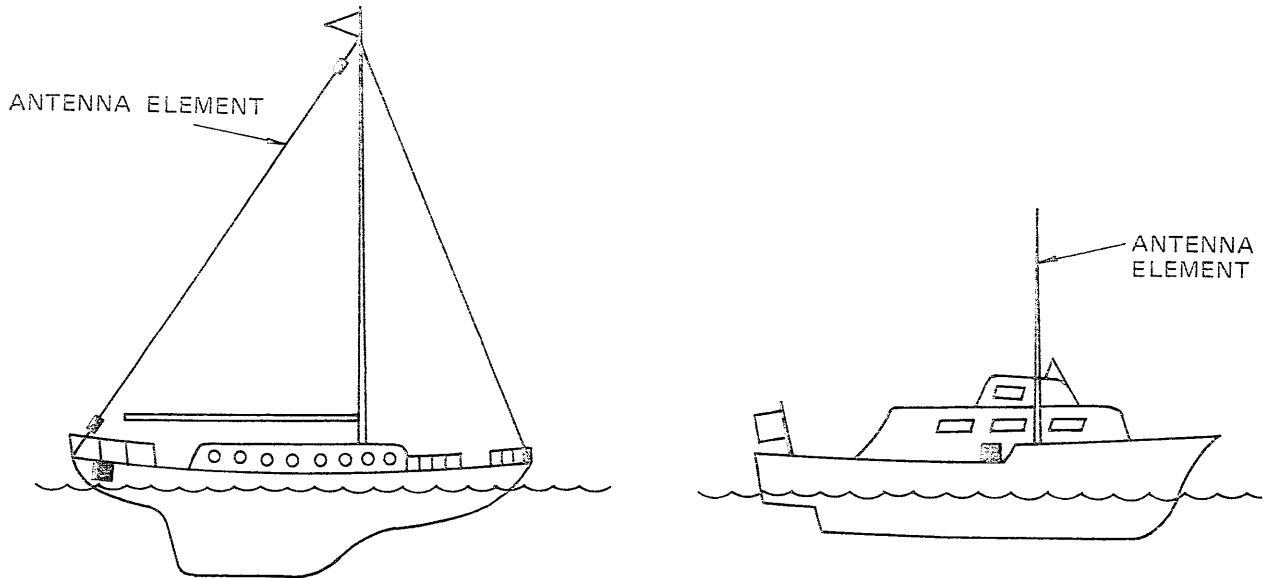
Three kinds of installation are available for any type of ship.

- (1) Installation by U-clamps
- (2) Installation by self-tapping screws
- (3) Installation by hex head screws

3-3-1 INSTALLATION RECOMMENDATIONS

- (1) Install the AT-120 on the deck or in the cabin near the antenna element base as in the figure. Try to install the tuner as close to an electrical ground as possible.

(Example installation)



■ ANTENNA TUNER

- (2) Attach the AT-120 either horizontally or vertically with one of the water drain screws downward. (NOTE: See page 12 for "water drain screw".)
- (3) Remove the downward-facing drain screw to provide an escape path for trapped moisture.
- (4) Clamp the coaxial cable between the tuner and your radiotelephone to the antenna mast to prevent the weight of the cable from pulling on the AT-120.
- (5) The antenna element length should be more than 7 meters (23 feet) to achieve full performance from the IC-M700/AT-120 system. Certain lengths should be avoided since they are difficult for the system to tune. Final SWR, in these cases, may be too high for efficient operation; and tuning may take longer. Note the formula below:

L: Element length to be avoided

$$L \text{ (meters)} = \frac{300}{\text{Operating frequency (MHz)}} \times \frac{1}{2} \times \text{Integer (1, 2, \dots)}$$

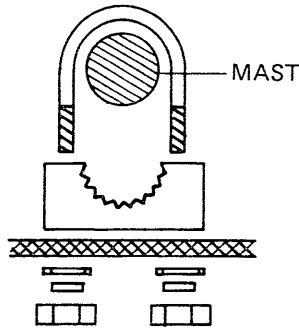
(Example)

Operating frequency: 2.182MHz (2182KHz)

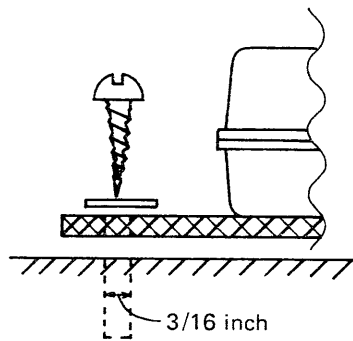
$$\begin{aligned} L &= \frac{300}{2.182} \times \frac{1}{2} \times 1 \\ &= 68.7 \text{ meters} \end{aligned}$$

3-3-2 INSTALLATION

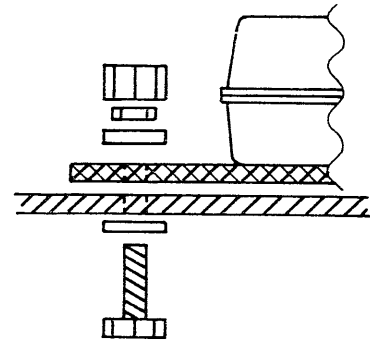
- (1) Test the AT-120 to ensure it is operational before attempting to mount it permanently.
- (2) Attach the AT-120 to its mounting structure using the supplied hardware. Use the correct hardware for your installation location. See the figure below.



Installation by U-clamps



Installation by self-tapping screws

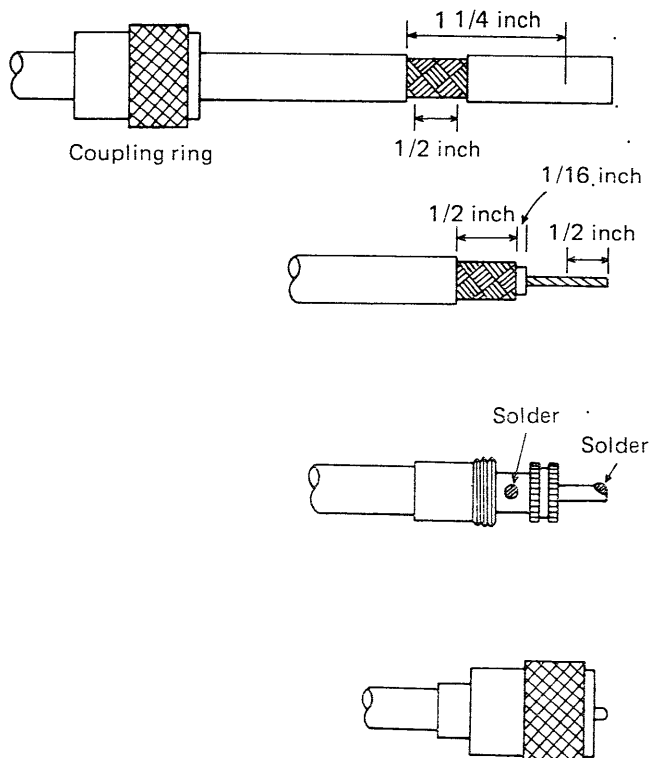


Installation by hex head screws

- (3) The U-clamp mounting hardware fits 30 to 60mm (1 1/4 to 2 1/2 inch) tubing. Antenna mast diameters outside this range require different hardware. This hardware is not supplied with the AT-120.
- (4) PL-259 coaxial connectors are not supplied with the AT-120. Obtain the correct connectors for the type of cable you are using in your installation. The following procedure illustrates the proper method for attaching the connectors.

NOTE: Read Section 3-3-3 before attaching the connectors.

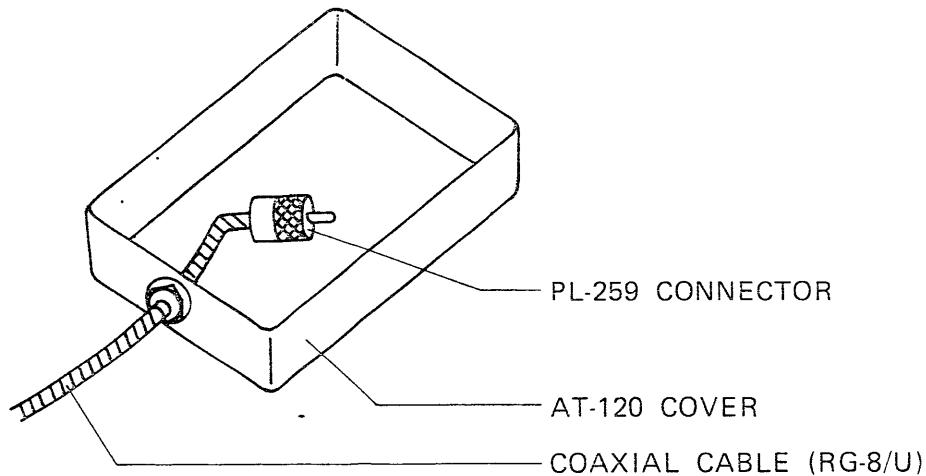
■ SOLDERING PL-259



1. Slide the coupling ring over the coaxial cable.
2. Strip the cable as in the figure, and tin about one-half inch of the shield conductor.
3. Remove the outer plastic casing and strip the center conductor insulation as in the figure. Tin the center conductor.
4. Slide the connector body onto the cable end and solder.
5. Screw the coupling ring onto the connector body.

3 - 3 - 3 COAXIAL CABLE CONNECTION

- (1) Prepare the coaxial cable and the two PL-259 connectors you intend to use.
Recommended coaxial cable: RG-8/U
- (2) Insert one end of the coaxial cable through the hole with the plastic grommet located on one end of the AT-120 cover. Install the two connectors on the ends of the cable.
- (3) Tighten the screw on the outside of the grommet to prevent water from entering the unit. This also acts as a strain relief for the cable.

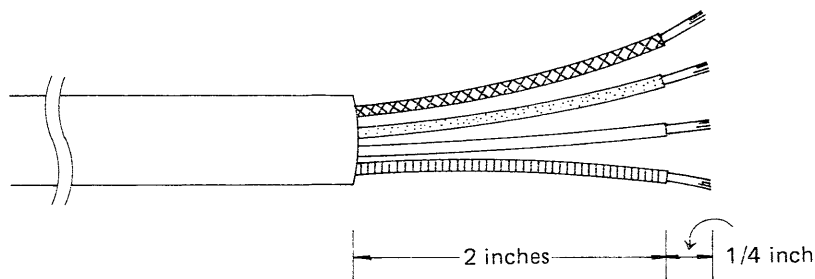


3 - 3 - 4 CONTROL CABLE CONNECTION

- (1) Prepare the control cable and the four pin connector that joins the AT-120 to the IC-M700 HF SSB Radiotelephone.

The connector and pins are supplied with the IC-M700.

- (2) Strip both ends of the cable as shown in the figure.

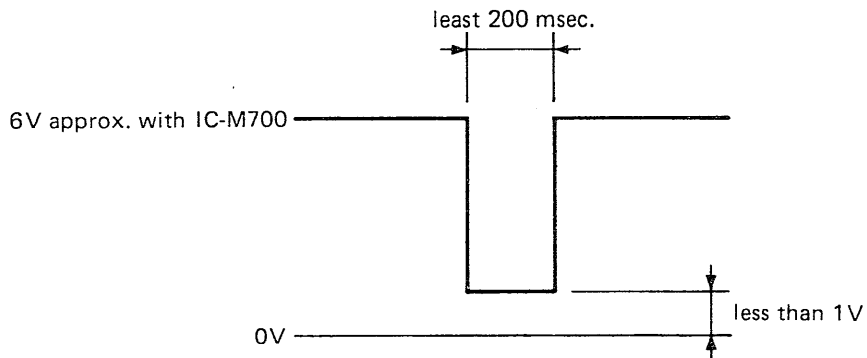


Control Cable: AWG 14 x 4 conductors

- (3) Solder or crimp the pins onto each wire. Insert the pins into the plastic connector. Feed the other end of the cable through the hole on the end of the main body of the AT-120 with the plastic grommet as shown.
- (4) Be certain the wires do not touch any adjacent parts or metal objects.

■ **TERMINAL DESCRIPTIONS**

START: The voltage on this line must be less than +1 volt for more than 200 milliseconds when starting the AT-120 tuner. The line impedance is 47 kilohms.

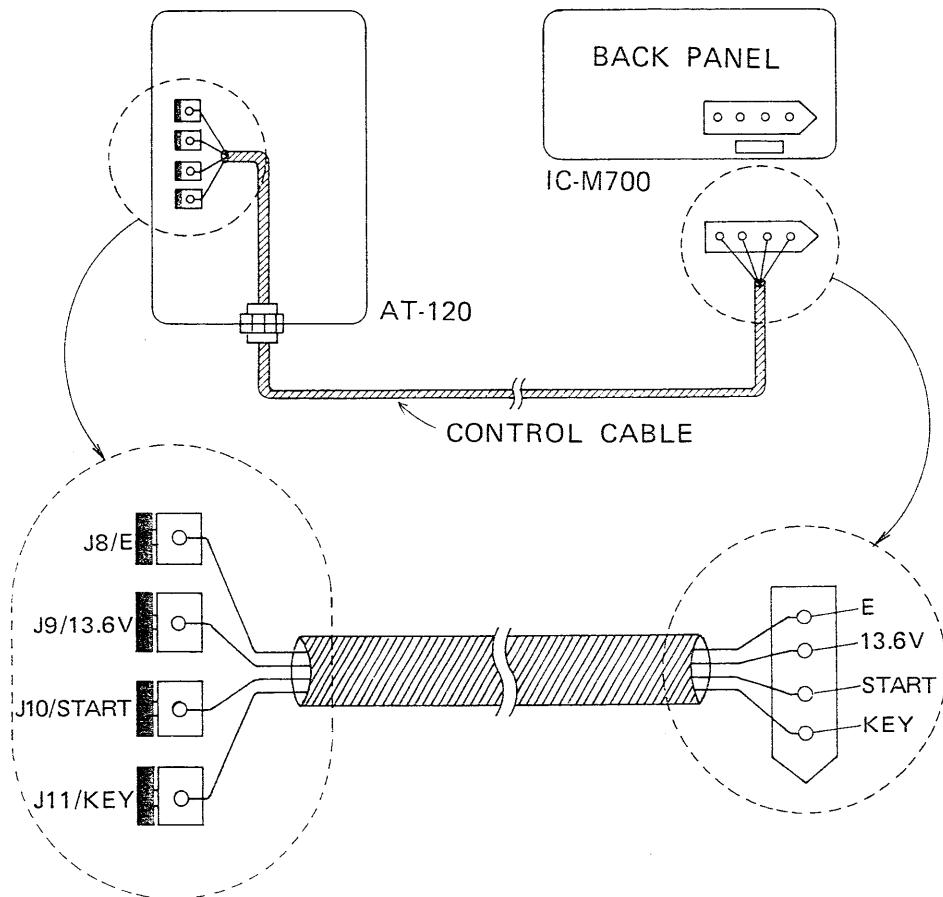


KEY: This line attaches to an open collector NPN transistor with 100 milliampere current capability to ground. The line is LOW level during tuning which switches the RF output power from the transmitter to 10 watts. The line impedance is 10 kilohms. **No special consideration is necessary when using the IC-M700.**

13.6V: 13.6 volts DC, 2 amperes maximum.

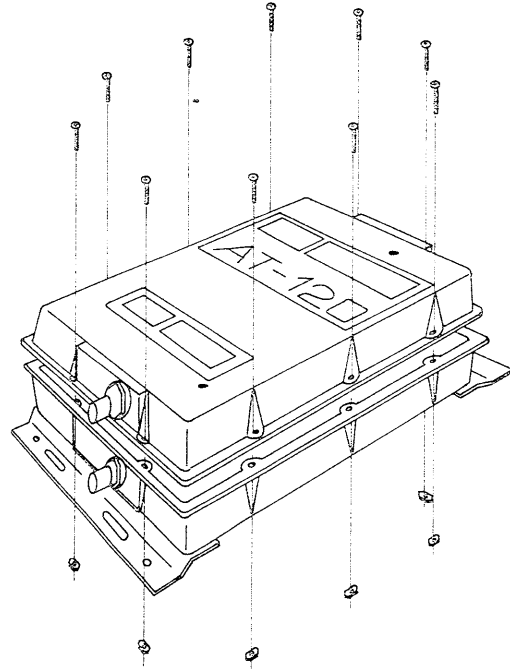
E: Ground

■ **CONNECTIONS**



3 - 3 - 5 COVERING

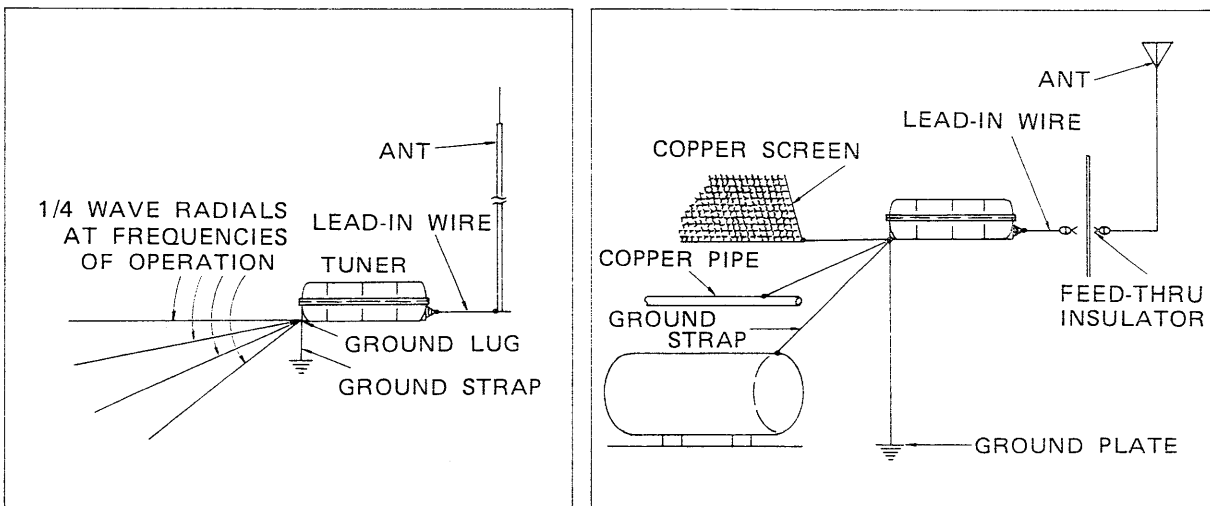
- (1) After making all other connections, connect the PL-259 plug to the SO-239 jack on the TUNER unit.
- (2) Confirm that the cover gasket makes good contact with the body and the cover for a water-tight seal.
- (3) Fit the cover onto the base and fasten them together with 10 screws as illustrated in the figure.
- (4) Tighten the screws on the cable retainers.
- (5) The AT-120 is now ready for final installation aboard your vessel.



3 - 3 - 6 -GROUND SYSTEM

- (1) The AT-120 must be connected to a good electrical ground. A good ground prevents shocks, interference and numerous other problems. One example of a good ground is the nearest metal member on a metal vessel. For best results, use the heaviest gauge wire or metal strap available. Make the length of wire as short as possible.
- (2) Good ground systems on wood or fiberglass boats are more difficult to install. For best results, use a heavy gauge wire or strap connected to the engine block and/or other large metal objects. This may be adequate for operation on frequencies in the 2 to 4MHz range.

Install a counterpoise for each band of frequencies used above 4MHz, as shown in the figure.



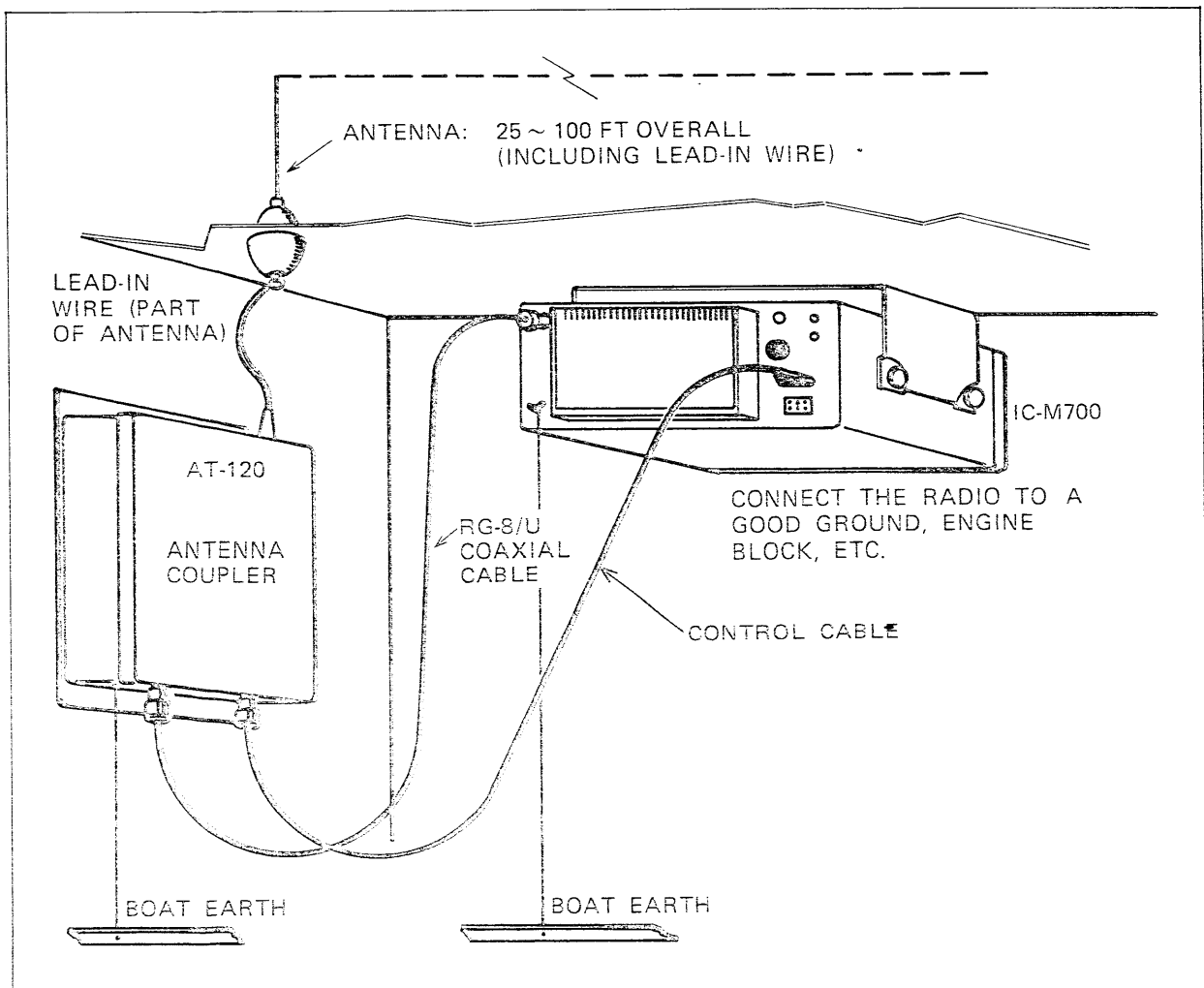
NOTE 1: Insulate the ends of each counterpoise from other metal objects.

NOTE 2: Lay out the wires horizontally and as straight as possible.

3-3-7 CABLE CONNECTIONS

- (1) Connect the control cable to the ANTENNA TUNER CONNECTOR on the back panel of the IC-M700 as shown in the figure.
- (2) Connect the antenna coaxial cable to the ANTENNA CONNECTOR.
- (3) Route the cables as planned earlier.
- (4) The antenna element or wire from the RF output terminal on the radio must be insulated from other metal objects.
- (5) The IC-M700 provides the necessary connector to output and/or input control signals to an automatic antenna tuner. Internal switches select the control signal levels; therefore, most existing antenna tuners may be used.

CAUTION: Avoid long cable runs to the antenna and power source. Also, keep the cables as far from electrical pumps and other electrical apparatus as possible. In particular, do not run the cables in the vicinity of magnetic compasses or near electronic instruments.



SECTION 4 OPERATION

Carefully confirm the connections between the AT-120 and IC-M700, as well as the antenna and ground installations, conform with the procedure given in the CABLE CONNECTIONS section on Page 9.

4 - 1 OPERATION WITH THE ICOM IC-M700

- (1) Set the operating frequency. This is easily done with the numerical key pad on the IC-M700.
- (2) Push the "TUNE" button to begin the automatic tuning operation.
- (3) The yellow lamp on the front panel of the IC-M700 lights while the AT-120 tunes.
- (4) The lamp goes out when the tuning finishes. Tuning time is typically 2 to 3 seconds.

NOTE: The tuner may take up to 15 seconds when operating in the 2 to 4MHz range.

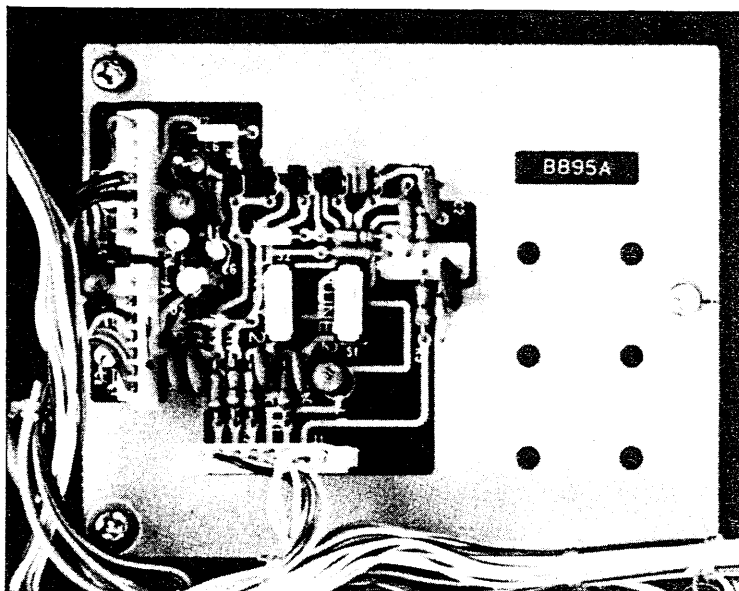
The LOGIC unit memorizes the settings of the coils and capacitors once tuning on a particular frequency is complete. Tuning at a later time on this same frequency will take 1 second or less. The LOGIC unit has eight memories able to store information for eight different frequencies.

- (5) Both switches S1/TUNE and S2/KEY must be in the "2" position as shown in the picture when operating the IC-M700 with the AT-120.

WARNING: IC-M700 radios with serial numbers 2501 and above have both switches in the "2" position already.

IC-M700 radios with serial numbers 2500 and below require the user to change the S1/TUNE switch from the "1" to the "2" position.

The IC-M700 INSTRUCTION MANUAL gives a detailed description of the switches on Page 9, Section 5 - 4.



4 - 2 OPERATION WITH OTHER TRANSMITTERS

- (1) When using radiotelephones other than the IC-M700, the four wires in the control cable must be correctly connected to the radio for proper operation of the AT-120.

See Page 6, Section 3 - 3 - 4 CONTROL CABLE CONNECTION for wiring details.

- (2) If the "KEY" line voltage, which controls the radiotelephone output power, is more than 8 volts at the radiotelephone end; place switch S1 in the position nearest the shielding can of the adjacent LOGIC unit. S1 is located near the control cable terminals as shown in the figure.
- (3) Adjust the output power at the radiotelephone end for 10 watts by grounding the "KEY" line to place the AT-120 in the tune mode.

CAUTION: Never transmit alarm signals except when your ship is in distress.

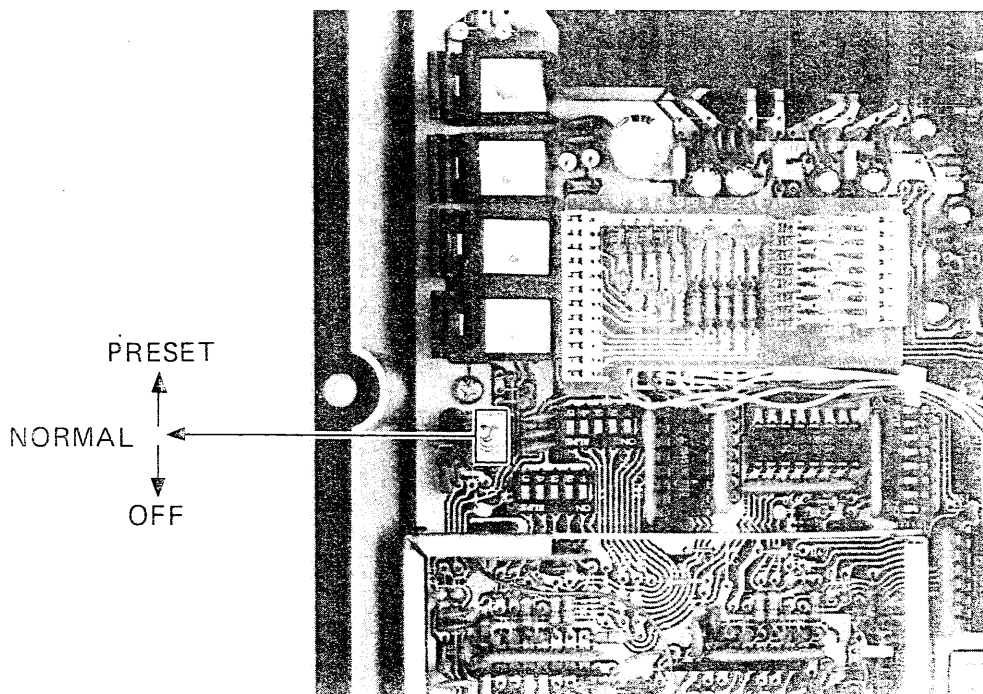
- (4) The AT-120 has a PRESET function which allows different combinations of coils and capacitors to be connected without reference to the antenna system. Dip switches determine exactly which coils and capacitors will be selected when the PRESET switch is placed in the "PRESET" position.

When using the PRESET function, remember that the automatic detector circuits are not operational; therefore, the antenna system will only perform efficiently over a narrow range of frequencies in this condition. That is, the AT-120 has no automatic tuning function when in the PRESET mode.

WARNING: Turn the PRESET switch to OFF for normal tuner operation if the KEY line voltage is greater than 8 volts when using a radio other than the ICOM IC-M700.

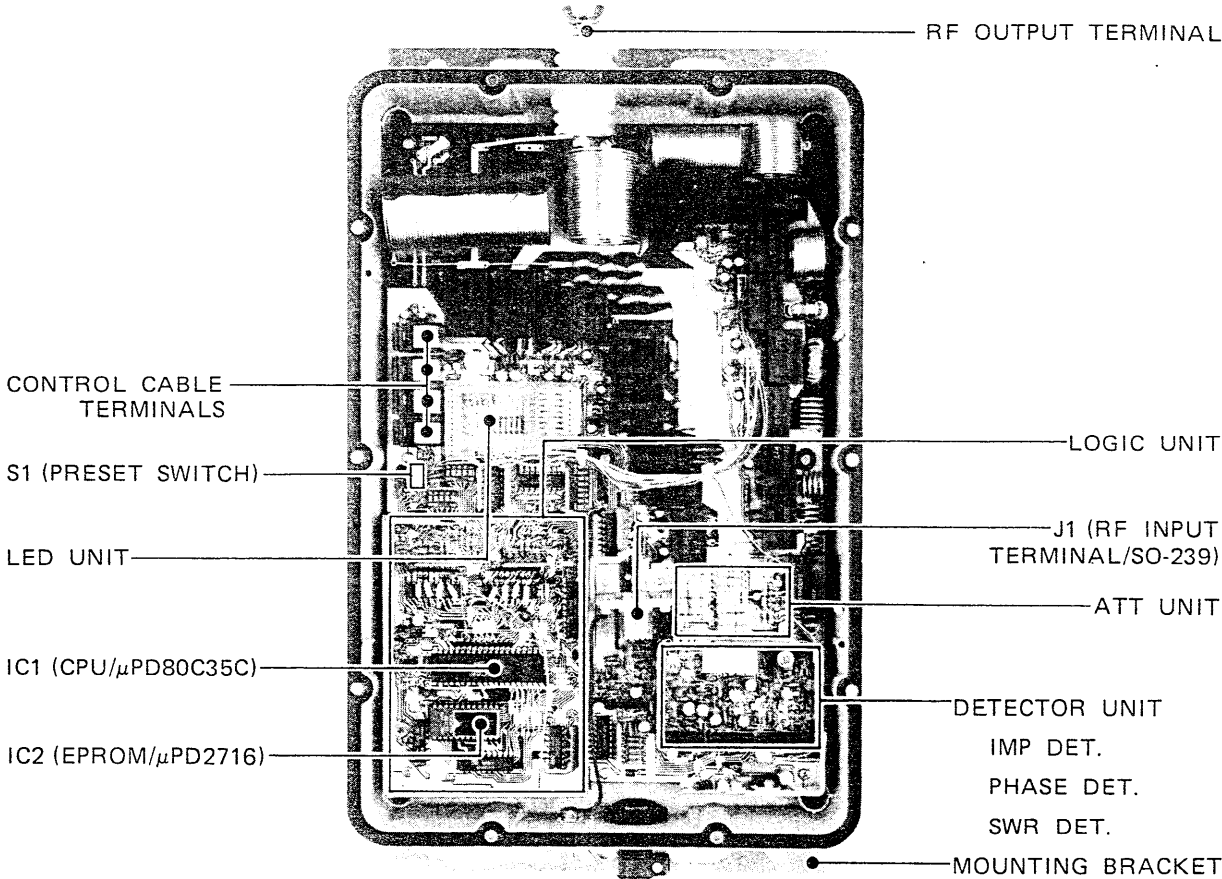
- (5) Verify that the PRESET switch is in the correct position.

(PRESET SWITCH)

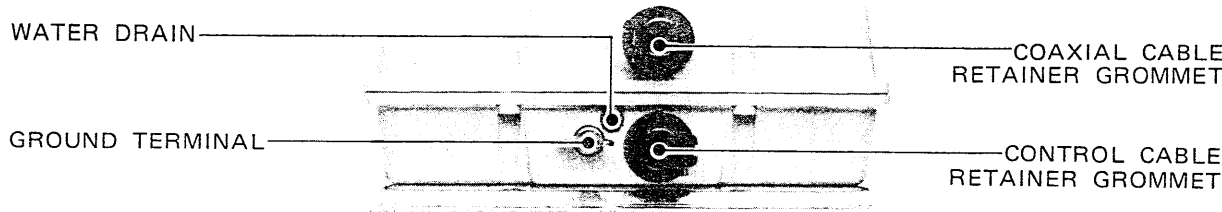


SECTION 5 INSIDE VIEW

5-1 TOP VIEW



5-2 SIDE VIEW



SECTION 6 THEORY OF OPERATION

6-1 GENERAL

An 8-bit microprocessor controls the ICOM AT-120. The tuner matches the antenna system to the radio by using four kinds of detector circuits. These circuits are:

- (1) FORWARD POWER DETECTOR
- (2) SWR DETECTOR
- (3) PHASE DETECTOR
- (4) IMPEDANCE DETECTOR

Detailed descriptions of each circuit follows.

6-2 FORWARD (FWD) POWER DETECTOR CIRCUIT

This circuit ensures the input power from the radiotelephone is low enough to be handled by the attenuator within the tuner.

On the TUNER unit, L1 detects the RF input current. C1 and C2 divide the detected voltage and feed it to IC14a and IC14b through CP1.

If the input terminal receives an appropriate power (about 10 watts or less), the CP2 voltage is LOW and the CPU allows the tuning function.

If power that is too high appears at the input terminal (much greater than 10 watts), the CP2 voltage stays HIGH and the CPU does not respond.

6-3 SWR DETECTOR CIRCUIT

The reflected power from the antenna system provides a detection voltage.

The voltage doubler, consisting of D12 and D13, rectifies this voltage and passes it to comparators IC16a, IC16b and IC17b through the voltage divider formed by R69, R70 and R71.

These SWR data from the comparator chips feed into IC1, the CPU. The CPU controls the setting of the coils and capacitors in the matching network.

6-4 PHASE DETECTOR CIRCUIT

This circuit consists of L2, L3 and IC18. The phase detector's purpose is to detect reactance components and provide a pure resistance.

The output of IC18 is a reference voltage of approximately 4 volts when the load of L3 is a pure resistance with no reactance. An inductive load produces an output voltage from IC18 which is lower than reference; whereas, a capacitive load produces an output voltage higher than reference.

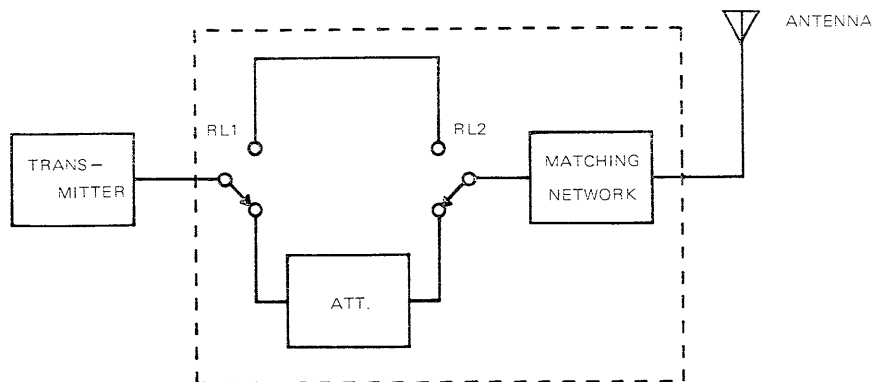
IC17a amplifies the output voltage and passes it to comparator IC15a.

The CP14 voltage is LOW level with an inductive load and HIGH level with a capacitive load.

6-5 IMPEDANCE DETECTOR CIRCUIT

The tuner uses an attenuator to reduce the transmit power to a very low level. The low power minimizes the risk of interference to other stations while matching an antenna to the transmitter.

The VSWR at the input terminal is usually close to 1:1 even with a large change of impedance at the attenuator output due to the 16dB of isolation between the input and the matching network.



The circuit uses the constant voltage at D8 and D9 on the TUNER unit as a reference. If the impedance of the attenuator output is higher than 50 ohms, the detected voltage by D10 and D11 is HIGH. If the impedance is lower than 50 ohms, the voltage is LOW. Both the reference and detected voltages feed to comparator IC15b.

The CP15 voltage is HIGH if the output impedance is lower than 50 ohms, and LOW if the impedance is higher than 50 ohms.

6-6 LOGIC CIRCUIT

IC1, the CPU, controls the antenna matching network.

The CPU receives +5 volts through Q1, Q2 and IC7 when DC power is applied to the tuner. This voltage initializes the CPU. The ALE signal from the CPU then transfers the program address from the CPU into IC3. The stored program in the Read Only Memory (ROM) IC2 sets each relay to the initial condition.

The tuning program begins only if the START line is LOW level. If so, RL1 and RL2 activate when RF power at the input antenna connector from the radiotelephone is present at an appropriate level (See Section 6 - 2).

The data from the previously described detectors (input RF power, reflected RF power, phase difference, impedance difference) feed into the CPU through buffer IC8. The coil data then passes to IC4, the capacitor data to IC5 and the control data to IC6 according to the tuning program.

The CPU halts when all of the above procedures are complete. The CPU oscillator also stops to avoid causing interference to the receiver.

6-7 LED UNIT

The LEDs display the status of the relays.

A LED lights whenever its associated relay turns ON. The activated relay connects a coil or capacitor into the tuning circuit.

The LED unit may be removed from the AT-120 to save power, if desired, since the display is for monitoring purposes only.

SECTION 7 BLOCK DIAGRAM

