

YAESU

INSTRUCTION MANUAL

FT-224

2 METER FM TRANSCEIVER



YAESU MUSEN CO., LTD.
TOKYO JAPAN

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FT-224

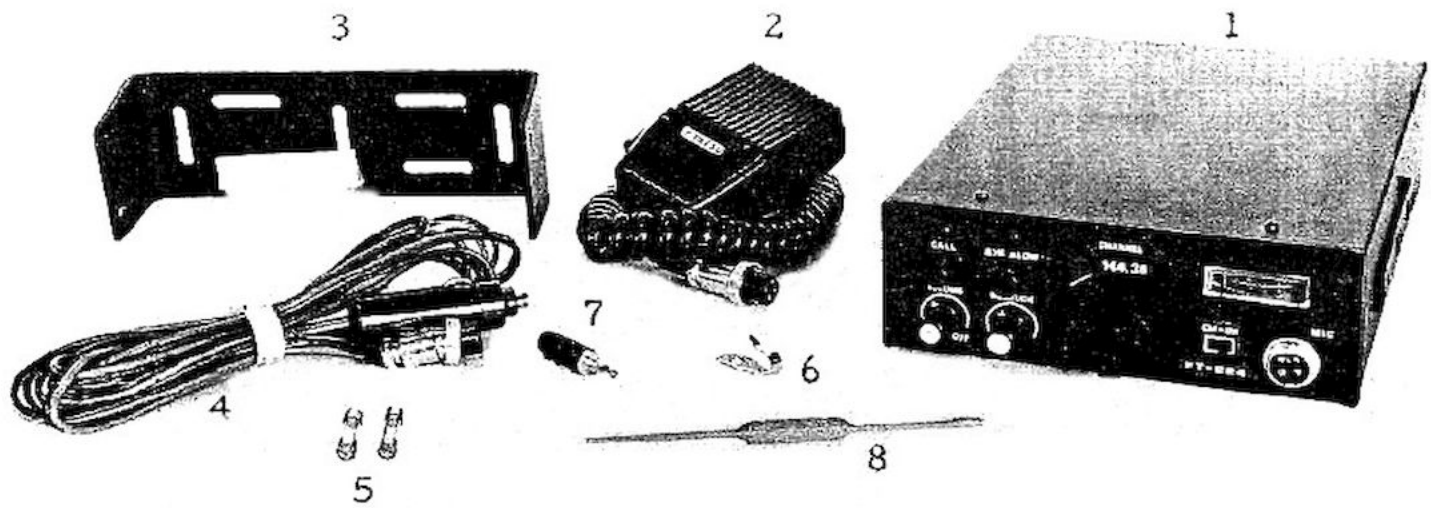
2 METER FM TRANSCEIVER



GENERAL

The model FT-224 is specifically designed to provide a high performance, compact transceiver for amateur VHF/FM service. The transceiver is completely solid-state with provision for operation on up to 24 crystal controlled channels between 144 and 148 MHz. Advanced circuit design features prevent damage to the transistors in case of high antenna VSWR, or reversed power supply polarity, while an adjustable "tone-burst" generator is included for repeater actuation. The heavy gauge metal case provides an extremely rugged package, light in weight, yet virtually immune to the effects of shock and vibration.

The FT-224 VHF/FM transceiver is supplied complete with all mounting hardware, cables, connectors and accessories required for a mobile installation, as shown in Figure 1.



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Figure 1

1. Transceiver with built-in 2-inch speaker (3 channels factory installed).
2. Dynamic push-to-talk microphone with retractable coiled cord.
3. Universal mounting bracket (with screws, washers and nuts).
4. Power cable (with cigar lighter adapter).
5. Spare fuses.
6. Self-adhering microphone hanger.
7. Miniature phone plug for external speaker.
8. Alignment tool.
9. Rub-on transfer type for adding frequencies to channel indicator.

The compact FT-224 is ideal for mobile installations, operating directly from the vehicle's 12 volt battery. For base station use, the accessory model, FP-2 Two-Way Power Supply, provides operating voltage plus a large external speaker. An optional extra feature of the FP-2 is an internal battery supply, rechargeable during normal AC operation. The battery will provide up to eight hours of dependable communications for use during portable or emergency operations, with provision for automatic "switchover" in case of AC power failure.

SPECIFICATIONS

GENERAL

Frequency Coverage - - - - -	144 to 148 MHz
Number of Channels - - - - -	24 (3 channels supplied)
Speaker - - - - -	Internal 2-inch dynamic with provision for connecting external 4-ohm dynamic speaker
Microphone - - - - -	Dynamic push-to-talk microphone with retractable coiled cord
Power Requirement - - - - -	13.5 Volts DC, $\pm 10\%$
Current Consumption - - - - -	0.45 Amp receive 0.7 Amp transmit (LOW) 2.6 Amp transmit (HI)
Metering - - - - -	Illuminated front panel meter indicates relative received signal strength, transmitter power output and discriminator output.
Dimensions - - - - -	165(W) x 60(H) x 225(D) mm.
Weight - - - - -	2.5 Kg.

TRANSMITTER

RF Output - - - - -	10 Watts (HI) or 1 Watt (LOW) into 50-ohm load at 13.5 Volts DC
Frequency Stability - - - - -	$\pm 0.001\%$

Crystal Multiplication - - - -	8 times
Modulation - - - - - - - - - -	F3 (phase modulation)
Deviation - - - - - - - - - -	Up to <u>+15</u> KHz (factory adjusted at <u>+5</u> KHz)
Audio Response - - - - - - - -	+1, -3 dB of 6 dB/Octave pre-emphasis characteristic from 300 to 2500 Hz
Spurious Emissions - - - - -	60 dB below carrier minimum
Tone Burst - - - - - - - - - -	Nominally one second at 1800 Hz (adjustable between 1300 and 3000 Hz)

RECEIVER

Type - - - - - - - - - - - - -	Double conversion superheterodyne (crystal controlled)
Intermediate Frequency - - -	10.7 MHz first IF; 455 KHz second IF
Sensitivity - - - - - - - - - -	0.3 uV for 20 dB S+N/N ratio
Selectivity - - - - - - - - - -	<u>+15</u> KHz at 6 dB; <u>+25</u> KHz at 50 dB
Audio Output - - - - - - - - - -	2 Watts

INSTALLATION

GENERAL

The model FT-224 transceiver is designed primarily for mobile service, requiring only an antenna and a 13.5 volt DC power source for operation. However, when operated in conjunction with a model FP-2 Two-Way Power Supply, the transceiver provides an efficient compact base station. The FP-2 power supply provides 13.5 volts DC to operate the transceiver from an AC power source, or optionally from a rechargeable battery. The transceiver has been factory pre-tuned and requires no adjustments for normal operation into a 50-ohm load.

The antenna location is the most important consideration in either a base or mobile installation, with effective communication range directly related to antenna height. The antenna should always be as high and in the clear as possible, however, a minimum distance of 5 feet

should be maintained between the VHF and other antennas. Also, in mobile installations it is advisable to locate the antenna as far from the engine as practical to minimize ignition noise pickup. In all installations ensure that the antenna VSWR is less than 1.5:1.

For a mobile installation the most popular antenna types are either a 1/4-wave whip with unity gain, or a 5/8-wave affording approximately 3.5 dB gain. Mobile antennas are available from most dealers in two-way mobile radio equipment, or other local electronic suppliers.

To minimize losses in the antenna system use the shortest length of coaxial cable that is practical, avoiding any sharp angles or kinks. Use type RG-8/U cable if the transmission line length exceeds 25 feet, while RG-58/U is suitable for shorter lengths. For all bends form the cable into a radius not less than 10 times its diameter.

MOBILE INSTALLATION

In mobile service the FT-224 should be installed where the controls, indicators, and microphone are easily visible and accessible for operation. The unit may be mounted in any position without degrading performance. Suitable locations are under the dash, atop the transmission tunnel, etc. A universal mounting bracket is supplied with the transceiver for this purpose. Install the FT-224 as follows (refer to Figure 2):

1. Use the universal mounting bracket as a template to locate the mounting holes. Use a 3/16-inch diameter drill for these holes and allow clearance for the transceiver, its controls and the connecting cables. Secure the mounting bracket with the screws, washers and nuts supplied as shown in "A".

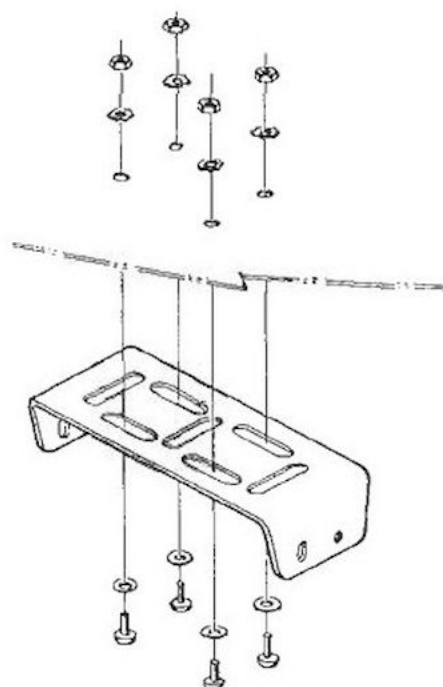


Figure 2A

2. Install the transceiver in the mounting bracket, securing with the four knurled head screws and washers as shown in "B".

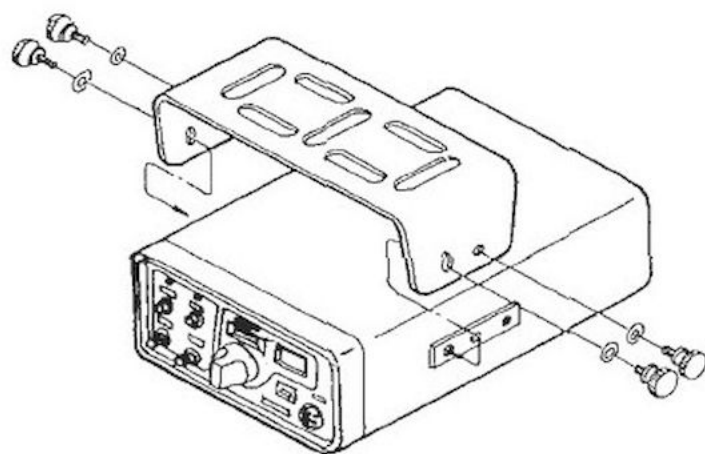


Figure 2B

3. Peel the protective backing from the self-adhering microphone hanger and affix the hanger to a convenient location as shown in "C". Press firmly on the hanger to assure a good contact is obtained.

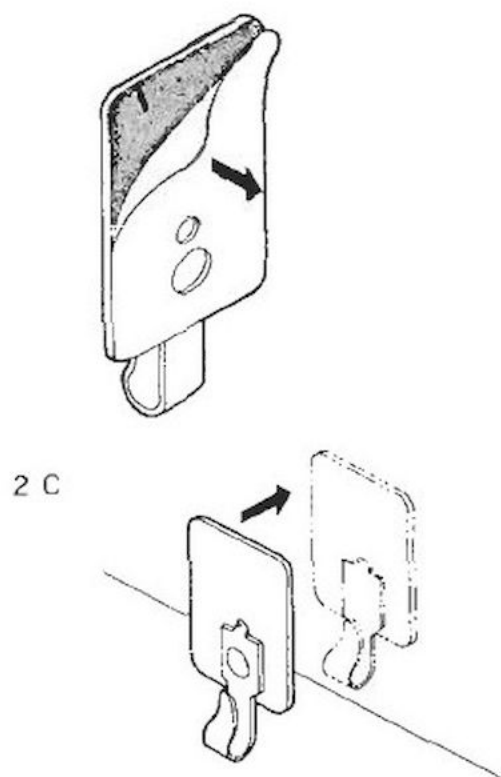


Figure 2C

4. The power cable supplied may be plugged directly into the vehicles cigar lighter receptacle for casual operation if desired. For a permanent installation the lighter plug may be removed and the leads routed directly to the battery (red positive, black negative or ground), or the nearest termination to the battery; i. e. ignition switch, fuse block, etc. If it is necessary to extend the power leads, use #16 AWG

insulated copper wire and do not extend the leads further than required to prevent excessive voltage drop.

CAUTION
=====

Before connecting the power cable to the transceiver, check the battery voltage with the engine running (battery charging). If the voltage exceeds 14 volts DC the regulator should be readjusted so the highest charging rate does not exceed 14 volts. Also be sure to observe proper polarity when making battery connections (reversed polarity will not damage the FT-224 due to the protective circuitry incorporated in the design, however, the equipment will not operate under this condition).

5. Connect the power cable to the POWER receptacle on the rear panel.
6. Connect the 50-ohm antenna cable to the ANT receptacle on the rear panel.
7. Connect the microphone cable to the 4-pin microphone receptacle on the front panel.
8. An external 4-ohm speaker may be connected at the SP receptacle on the rear panel if desired (this automatically disconnects the internal speaker). Use the external speaker plug supplied.

BASE STATION INSTALLATION

As a base station the FT-224 requires a source of 13.5 volts DC at 2.6 amperes. This may be obtained from the accessory FP-2 power supply, which also includes a speaker and provision for installation of an optional rechargeable battery pack. The power supply provides for automatic "switchover" to battery operation in case of an AC power failure. Assemble and connect the FT-224 and FP-2 as follows:

CAUTION
=====

The FP-2 power supply will operate from a 50/60 Hz source of 100, 110, 117, 200, 220 or 234 volts. Check that the transformer is properly wired for the source to be used prior to connecting the power supply to an AC source.

1. Install the battery in the power supply as follows:
 - (a) Remove the four screws on the bottom of the cabinet and slide the chassis backward an inch or so from the cabinet.
 - (b) Remove the four screws securing the blank panel covering the battery compartment. Slide the chassis back into the cabinet and replace the four screws from step (a).
 - (c) Insert the battery from the rear, securing the two knurled head screws.
 - (d) Connect the fused cable from the battery to the BATTERY receptacle on the rear panel.
2. Install the transceiver between the mounting bracket on top of the power supply, securing with the four knurled head screws and washers.
3. Connect the POWER-SP cable from the power supply to the transceiver; 2-pin connector to the POWER receptacle and speaker plug to SP receptacle on the rear panel of the transceiver.
4. Connect a good ground lead to the GND terminal on the power supply. This should be to a cold water pipe if possible.
5. Connect the AC power cord from the power supply to the AC source.
6. Connect the 50-ohm antenna cable to the ANT receptacle on the rear panel of the transceiver.
7. Connect the microphone cable to the 4-pin microphone receptacle on the front panel of the transceiver.

CONTROLS & SWITCHES

The FT-224 VHF/FM Transceiver and FP-2 Two-Way Power Supply have been designed for ease of operation. Be sure you thoroughly understand the function of each control and indicator before operating the equipment. The operating functions are as follows.

FT-224 VHF/FM TRANSCEIVER

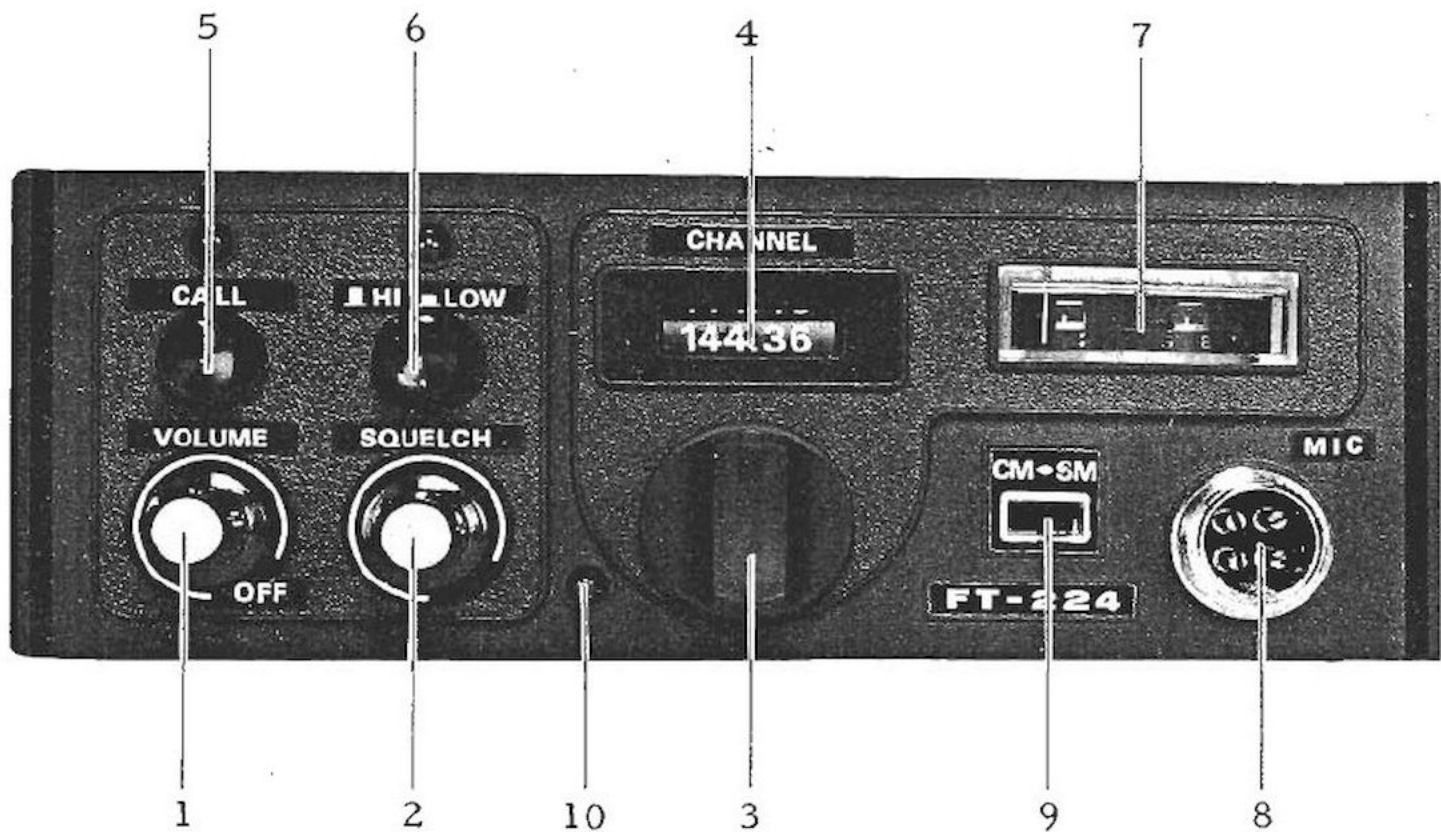


Figure 3

1. VOLUME Control
 - The VOLUME control adjusts the receiver audio output level (applies power when rotated clockwise past OFF position).
2. SQUELCH Control
 - The SQUELCH control adjusts the receiver squelch threshold sensitivity.
3. CHANNEL Selector
 - The 23 position CHANNEL selector switch selects the desired operating channel.

4. CHANNEL Indicator - The channel indicator shows the selected operating channel and frequency (illuminated when power applied).
5. CALL Switch - When depressed, the CALL switch selects a preset channel regardless of the CHANNEL selector switch position.
6. HI-LOW Switch - The HI-LOW switch selects the desired power output, 10 watts in HI position, or 1 watt in LOW position.
7. S/C Meter - The S/C meter indicates the relative signal strength and discriminator output.
8. Microphone Receptacle - Four-pin connector is used for microphone input and push-to-talk relay actuation.
9. CM/SM Switch - The CM/SM switch selects the meter indication, S-meter or discriminator output.
10. "Transmit" Indicator - The red "transmit" indicator is illuminated in the "transmit" mode.

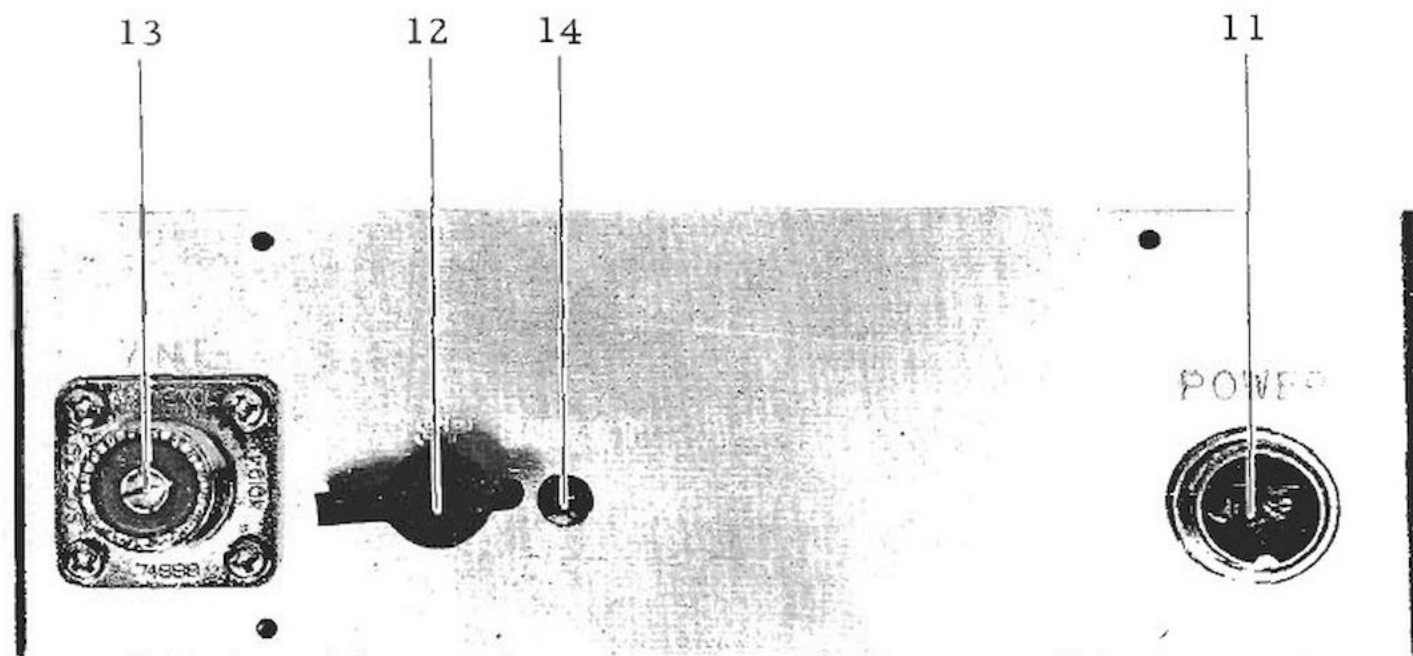


Figure 4

- | | |
|----------------------|--|
| 11. POWER Receptacle | - Two-pin connector is used for connection to 13.5 volt DC (negative ground) power source (vehicle battery or FP-2 power supply). |
| 12. SP Receptacle | - Audio output is provided at this receptacle for an external speaker (or speaker in FP-2 power supply). Output impedance is 4 ohms and the internal speaker will be disabled when a plug is inserted. |
| 13. ANT Receptacle | - UHF type coaxial receptacle for connection of antenna. |
| 14. BURST Switch | - The BURST switch applies a short "tone burst" to the carrier at the start of each transmission in the ON position. This is normally used only with "tone access" repeater operation. |

FP-2 TWO-WAY POWER SUPPLY



Figure 5

1. POWER Switch
 - The POWER switch applies AC power in the ON position. Also, actuates the battery charging circuit when an internal battery is installed in the power supply.
2. POWER Indicator
 - The red POWER indicator is illuminated when AC power is supplied.
3. CHARGE Switch
 - The CHARGE switch selects the desired charging rate when an internal battery is installed.
4. CHARGE Indicator
 - The green CHARGE indicator is illuminated when an internal battery is installed and AC power is applied.

OPERATION

OPERATING PROCEDURE

1. Rotate the VOLUME control clockwise from the OFF position to apply power: The channel indicator and meter will illuminate.

NOTE

When operating with the FP-2 power supply set the POWER switch on the FP-2 to the ON position. The red POWER and green CHARGE indicators will illuminate (the CHARGE indicator only illuminates if a battery is installed). The CHARGE switch should be left in the LOW position. A fully charged battery will provide approximately 8 hours operation. If the battery is completely discharged, charge in the HI position for four hours to restore full battery capability.

2. Set the CHANNEL selector to the desired channel, as shown in the channel indicator window. Ensure that the CALL switch is at OFF position. When the CALL switch is in depressed position, the preset channel is used regardless of the CHANNEL selector switch position. For the preset channel operation, just push down the CALL switch.
3. Rotate the SQUELCH control fully counter-clockwise.
4. Adjust the VOLUME control for a normal listening level (background noise or a station if one is transmitting).
5. When the channel is clear (background noise only), rotate the SQUELCH control clockwise until the receiver is silenced: Perform this step carefully, do not go beyond the silencing point or the receiver will not respond to weak signals.
6. Set the HI-LOW switch to the desired power output position.
7. If operating on a repeater channel requiring "tone access" set the BURST switch on the rear panel to the ON position: The "tone burst" will be applied to the carrier each time the push-to-talk lever on the microphone is depressed.

N O T E

Refer to the Tone Adjustments paragraph to change the tone frequency or duration (factory set for 1800 Hz and one second).

8. When ready to transmit hold the microphone close to your lips, depress the push-to-talk lever and speak distinctly at a normal conversational level: Check that the red "transmit" indicator illuminates and the meter indicates upward.

N O T E

The MONITOR switch located in the case is set to OFF position at factory. When the MONITOR switch is in the ON position, the changeover relay is disabled. Therefore, ensure that the MONITOR switch is in the OFF position before installing the case after inside work is completed.

THEORY OF OPERATION

GENERAL

Functional operation of the model FT-224 VHF/FM Transceiver is illustrated in the Block Diagram, Figure 9 on page 29. Refer to the schematic diagram for the circuit description. The transceiver consists of a crystal controlled transmitter and receiver, operating on any of 24 channels within the frequency range of 144 to 148 MHz. In addition to 23 channels which are selected by the CHANNEL selector switch, one most-often-used channel may be preset for the ease of operation. Solid-state circuitry is employed throughout, and the transceiver is designed to operate from a 13.5 volt $\pm 10\%$ DC negative ground power source.

TRANSMITTER SECTION

The transmitter section produces an FM (phase modulation method) output signal.

The audio signal from the microphone is amplified by an integrated circuit Q3 (LD3150) on MOD board, and applied to an IDC

(Instantaneous Deviation Control) circuit. The IDC circuit, diodes D3 and D4, clip both positive and negative peaks when they exceed a pre-determined level to limit the maximum deviation of the transmitter. The IDC control, VR2, permits the deviation to be adjusted, and is nominally factory set for a deviation of ± 5 KHz. When wide-band transmission is desired, VR2 must be readjusted to provide a maximum deviation of ± 15 KHz.

The limited audio signal is applied through a low-pass filter to Q4, where it is amplified and applied to the phase modulator, varactor diode D1 (1S1658). The low-pass filter limits the transmitter modulation spectrum by attenuating frequencies above the speech range.

The oscillator, Q1 (2SC372Y), operates on the crystal frequency to generate the initial RF signal. The crystal frequency is in the 18 MHz range, and is determined as follows:

$$\text{Crystal Frequency (MHz)} = \frac{\text{Output Frequency (MHz)}}{8}$$

Trimmer capacitors TC1 through TC24 permit each of the 24 crystals to be individually set to frequency. Output from Q1 is amplified by Q2 (2SC372Y), and applied across transformer L501.

The audio signal from Q4 varies the bias applied to D1, in turn causing the capacity of the diode to vary in accordance with the audio voltage. As D4 and L503 are in series across the secondary of L501 the capacity change in the diode effectively changes the resonant frequency to produce a phase shift at an audio rate in the input of Q1 (2SC373) in the exciter stage.

The angular phase shift from the modulator is relatively small, therefore the crystal frequency is multiplied eight times to obtain the desired deviation at the output frequency of 144 to 148 MHz. Three doubler stages, Q1 (2SC373) through Q3 (2SC388A) on the exciter board, provide the necessary frequency multiplication and the 144 to 148 MHz signal is amplified by Q4 (2SC741) and applied to the driver Q5 (2SC730)

The phase modulated 144 to 148 MHz signal is amplified by Q1 (2SC1011) and the power amplifier, Q2 (2SC1177) on booster board, and applied through a three section pi-network to the antenna relay. The pi-network matches the output impedance of Q2 to the 50-ohm antenna. When the HI-LOW switch is set to the LOW position, Q5 (2SD313) is placed in series with the +13.5 volts DC applied to Q1 and Q2, reducing the power output to one watt.

If the transmitter is keyed without an antenna connected, or if a high VSWR exists in the antenna system, the DC voltage rectified by D2 (1S188FM) triggers D2 (CW01) on PB-1377 into conduction. This decreases the base voltage of Q6 (2SC372Y), and Q7 (2SA496) decreases collector current causing the voltage drop across Q5 (2SD313) to protect the driver and final transistors.

The AFP (Automatic Final Protector) control, VR4, permits adjusting the level at which D2 triggers. This circuit is also used to switch the power output down to 1 watt when the HI-LOW switch is set to LOW position. The amount of the power reduction may be adjusted by VR3. Diodes, D1 and D3 (1S188FM), rectify a small portion of the RF output and apply the resulting DC level to the meter, M1, where it provides an indication of relative power output from the transmitter. The PO control, VR2, permits the sensitivity of the output metering circuit to be adjusted. The RF voltage rectified by the S-meter diodes is amplified by Q3 and Q4 (2SC372Y) to light on air lamp PL3 (SL103) while the RF power is present in antenna circuit.

RECEIVER SECTION

The 144 to 148 MHz input signal from the antenna relay is amplified by FET Q1 (3SK40K) on RF board, and applied through five hi-Q slot-coupled resonators to the first mixer, Q2 (2SK19GR). The use of a FET RF amplifier, together with the slot-coupled resonators combine to minimize effects of cross modulation and other spurious responses, while providing a low noise figure for the receiver front end.

The 144 to 148 MHz signal is heterodyned with the output of the first local oscillator by Q2 and produces the first IF, 10.7 MHz. The first local oscillator injection frequency is 10.7 MHz below the input signal frequency in all cases. The fundamental crystal frequency is multiplied nine times to obtain the injection frequency. The crystal frequency is in the 15 MHz range, and is determined as follows:

$$\text{Crystal Frequency (MHz)} = \frac{\text{Signal Frequency (MHz)} - 10.7}{9}$$

The first local oscillator consists of a crystal oscillator, Q1 (2SC372Y) and triplers, Q2 and Q3 (2SC784R) on local board. The 10.7 MHz output from Q2 is applied through a crystal filter, MF1, to the first IF amplifier, Q1 (2SC372Y) on IF board. The amplified first IF signal is applied to the second mixer Q2 (2SK19GR) through additional ceramic filter which further reduces spurious responses. The 10.7 MHz

signal is heterodyned with the 11.155 MHz output of the second local oscillator, Q3 (2SC372Y), to produce the second IF, 455 KHz, at the output of Q2.

The 455 KHz IF circuit consists of Q4, Q5 (2SC372Y) and amplified and limited by IC Q6. The ceramic filter, CF2, provides the narrow band selectivity for the receiver, and the limiting action of Q6 removes any amplitude variations in the signal applied to the discriminator, D3 and D4 (1S188FM).

The discriminator produces an audio output in response to a corresponding frequency (or phase) shift in the 455 KHz IF signal. The discriminator output is applied across the VOLUME control, VR1, to the input of the IC audio amplifier Q5 (AN214), and also to the squelch circuit. The output from Q5 is applied to the internal speaker, SP1, and also the SP receptacle where an external 4-ohm speaker may be connected if desired.

The squelch circuit consists of Q1 through Q3 (2SC372Y) on AF board. When no carrier is present in the 455 KHz IF, the "noise" at the discriminator output is amplified by Q1 and Q2, and detected by D1 and D2 (1S188FM) to produce a DC voltage. This DC voltage is applied to turn Q3 "on". With Q3 "on" the voltage drop appears at the input of Q6 to quiet the audio amplifier. When a carrier is present in the 455 KHz IF the quieting action of the receiver removes the noise at the discriminator output and Q3 is turned "off", permitting normal operation of Q6. The SQUELCH control, VR2, permits the squelch threshold sensitivity to be adjusted by setting the level at the input of Q2.

The 455 KHz output from Q5 (2SC372Y) on IF board is also applied to the S-meter rectifiers, D1 and D2 (1S188FM). The diodes rectify the signal and the resulting DC voltage is applied through the SM/CM switch to the meter, M1, where it provides an indication of relative signal strength. The S-meter control, VR1, permits the meter circuit sensitivity to be adjusted. A DC level at the discriminator output is applied to a differential amplifier Q4 and Q5 (2SK19GR) on local board. When the frequency of received signal is shifted from the discriminator center, the resulting DC level causes either of Q4 and Q5 to conduct indicating the amount of shift on the meter with the SM/CM switch at CM position. The VR1 balances a differential amplifier and VR2 calibrates the sensitivity of the meter.

tone burst circuit

The tone burst circuit consists of a timing generator and a gated multivibrator. When the BURST switch is set to the ON position and the transmitter "keyed" +13.5 volts DC is applied to trigger the 4-gate NAND logic timing generator, Q601 (SN7400N). The timing generator produces an output pulse applied to Q602 (2SC712D). Transistor Q602 gates Q603 and Q604 (2SC712D) to produce a tone output that is applied to the microphone input of the transmitter section. The tone frequency is adjustable between 1300 and 3000 Hz by VR602, while the output level (deviation) is adjustable by VR603, and the burst duration by VR601.

MAINTENANCE

GENERAL

Your model FT-224 VHF/FM Transceiver has been carefully aligned and tested prior to shipment from the factory. The reliability of the solid-state devices used in the FT-224 should provide years of trouble free service if the transceiver is not abused and normal routine maintenance carried out.

The following precautions should be observed to prevent damaging the transceiver:

1. Do not exceed 14 volts DC at the POWER receptacle. When operating mobile check the battery voltage under load (transmitter "keyed") with the engine running fast enough so the ammeter shows "charge". Also, do not operate the FT-224 if the supply voltage is below 12 volts DC.
2. Do not apply any DC potentials at the ANT receptacle.
3. Avoid direct exposure to water.

ROUTINE MAINTENANCE

Routine maintenance should be limited to keeping the transceiver clean, and periodic performance checks of the transmitter RF output and receiver 20 dB quieting sensitivity.

Cleaning: When the transceiver is used in dusty or sandy areas the interior should be periodically cleaned. A vacuum cleaner, or low pressure air source should be used, while accumulated dirt may be removed with a soft brush and alcohol. Check that the interior is thoroughly dry before replacing the case and/or operating the equipment. Wipe the exterior with a damp cloth whenever required.

Performance Checks:

N O T E

Make all performance checks at 13.5 volts DC (under load). Use a battery of adequate capacity, or the Model FP-2 power supply. Do not use a battery charger to power the FT-224.

1. Check the transmitter RF output as follows:
 - (a) Connect a suitable 50-ohm dummy load/RF wattmeter to the ANT receptacle.
 - (b) "Key" the transmitter in both HI and LOW positions and check the power output: The power should be approximately 10 and 1 watt respectively, and the "S" meter should read between 6 and 7 in the HI position.
 - (c) Repeat step (b) for each channel.
2. Check the receiver 20 dB quieting sensitivity as follows:
 - (a) Connect an AC VTVM to the SP receptacle and adjust the SQUELCH control fully counter-clockwise.
 - (b) Connect the RF output of a precision VHF signal generator to the ANT receptacle and with no signal input note the voltage reading on the VTVM: Adjust the VOLUME control and VTVM range as required to obtain an approximate full scale reading (do not change the VOLUME setting after this adjustment is made).
 - (c) Set the signal generator to the proper input frequency for the CHANNEL selector position and adjust the output amplitude until the VTVM reads 1/10th (20 dB decrease) of the reading in step (b). The signal generator output amplitude at this point is the 20 dB quieting sensitivity, and should be approximately 0.3 microvolt.

- (d) Repeat steps (b) and (c) for each channel.

If the above performance checks indicate a need for realignment it is recommended that the transceiver be returned to the dealer for alignment. The alignment procedures require special test equipment and techniques not normally available to the average owner. Attempt to realign the tuned circuits without proper test equipment will result in degraded performance.

ADJUSTMENTS

Internal adjustments should be limited to those described in the following paragraphs. Remove the 4 screws on the rear panel, and 4 screws on the top and bottom of the case, and slide the transceiver out of the case to obtain access to the interior.

1. Discriminator Crossover Adjustment: Adjust the discriminator crossover point as follows:
 - (a) Connect a 25-0-25 uA DC meter between CM out terminal on IF board and ground.
 - (b) Adjust the FT-224 for normal operation without the antenna connected.
 - (c) Connect the RF output of a precision signal generator through a 0.01 uf capacitor to the base of Q2 on IF board: Monitor the signal generator output with a frequency counter if possible.
 - (d) Adjust the signal generator for a 100 microvolt output at exactly 455 KHz (± 100 Hz or less).
 - (e) Using the alignment tool, carefully adjust the cores in primary and secondary of L304 and L116 to obtain a "zero" indication on the meter.
2. Crystal Trimmer Adjustment: Adjust the receiver and transmitter crystal trimmers as follows:
 - (a) Connect a 25-0-25 uA DC meter between CM out terminal and ground.
 - (b) Adjust the FT-224 for normal operation.

- (c) Connect the output of a precision VHF frequency meter (0.0001% minimum tolerance) to the ANT receptacle.
- (d) Set the CHANNEL selector to the desired channel and adjust the frequency meter to provide a signal at the exact input frequency.
- (e) Using a non-metallic alignment tool adjust the appropriate trimmer capacitor, TC1 through TC24 on RX crystal board, to obtain a "zero" indication on the meter.
- (f) Repeat steps (d) and (e) for each channel.
- (g) Disconnect the frequency meter from the ANT receptacle and connect a 50-ohm dummy load in its place.
- (h) Adjust the frequency meter to indicate the exact frequency of the channel to be adjusted.
- (i) Key the transmitter and using the alignment tool adjust the appropriate trimmer capacitor, TC1 through TC24 on TX crystal board, until the correct frequency is indicated on the frequency meter.
- (j) Repeat steps (h) and (i) for each channel.

N O T E

When the discriminator and center meter is accurately adjusted, the receiver crystal trimmers may be adjusted by receiving accurate frequency signal. With the meter switch at CM position, adjust trimmers for zero (center) meter indication receiving accurate frequency signal against the receiving channel.

After the receiver crystal trimmer adjustment is accomplished, set the MONITOR switch in the case to ON position. Adjust transmitter crystal trimmers for zero (center) meter reading pressing the PTT switch down.

3. Tone Adjustments: Adjust the tone burst generator as follows:

- (a) Connect a 50-ohm dummy load to the ANT receptacle.

- (b) Disconnect the microphone to prevent accidentally voice modulating the transmitter.
 - (c) Temporarily ground the collector of Q602.
 - (d) Adjust the FT-224 for normal operation and set the BURST switch to the ON position.
 - (e) If a frequency counter is available, connect the input between pins 2 (hot) and 1 (ground) of the microphone receptacle. Key the transmitter by grounding pin 3 (push-to-talk) of the microphone receptacle and adjust potentiometer VR602 until the counter indicates the exact tone frequency desired.
 - (f) Remove the ground at the collector of Q602.
 - (g) Key the transmitter and adjust potentiometer VR601 until the tone burst duration (as monitored in step (e) or (f)) is the desired length (one second maximum).
 - (h) Adjust an FM deviation meter to display the transmitter deviation. Key the transmitter and check that the deviation does not exceed +5.0 KHz; If the deviation exceeds +5.0 KHz adjust potentiometer VR603 as required.
4. Deviation Adjustment: Adjust the transmitter deviation as follows:
- (a) Connect a 50-ohm dummy load to the ANT receptacle.
 - (b) Disconnect the microphone to prevent accidentally voice modulating the transmitter.
 - (c) Adjust the FT-224 for normal HI power operation (BURST switch OFF).
 - (d) Connect the output of an audio oscillator between pins 2 (hot) and 1 (ground) of the microphone receptacle. Adjust the oscillator for a 80 millivolt output at 2500 Hz.
 - (e) Adjust an FM deviation meter to display the transmitter deviation. Key the transmitter by grounding pin 3 of the microphone receptacle and adjust the IDC potentiometer, VR2, for a deviation of +5.0 KHz.

N O T E

If wide band operation only is desired, set VR2 for ± 15 KHz, while if narrow band only is desired adjust it for ± 5 KHz.

- (f) Adjust the audio oscillator for a 2.5 millivolt output at 1 KHz and key the transmitter. Adjust potentiometer VR1 for a deviation of ± 3.5 KHz.
 - (g) Disconnect the audio oscillator and set the BURST switch to the ON position. Key the transmitter and check that the tone burst deviation does not exceed the maximum of step (e). If it does, readjust potentiometer VR603 (step (h), paragraph 3) as required.
5. Output Meter and Automatic Final Protection Adjustments: Adjust the output meter and automatic final protection circuits as follows:
- (a) Connect a 50-ohm dummy load/RF wattmeter to the ANT receptacle.
 - (b) Adjust the FT-224 for normal HI power operation.
 - (c) Key the transmitter and check that the S-meter reads between 6 and 7 with approximately 10 watts shown on the RF wattmeter.
 - (d) If the S-meter reading is below 6 or above 7 in step (c), adjust potentiometer VR2 on booster board as required.
 - (e) Disconnect the 50-ohm load/RF wattmeter from the ANT receptacle and momentarily key the transmitter: Check that the S-meter reads zero.
 - (f) If the S-meter reading is above 2 in step (e), adjust potentiometer VR1 on booster board as required.
6. S-Meter Adjustments: Adjust the S-meter circuit as follows:
- (a) Connect the RF output of a precision VHF signal generator to the ANT receptacle.
 - (b) Set the signal generator to the proper input frequency for the CHANNEL selector position and adjust the output amplitude to 30 microvolts: Check that the S-meter reads 10.

- (c) If the S-meter reading is not 10 in step (b), adjust potentiometer VR1 on IF board as required.
7. CM (Center Meter) Adjustments: Adjust the GM as follows:
- (a) Disconnect the antenna and set the CM/SM switch to CM position.
 - (b) Set the VR2 on local board to fully counter-clockwise position.
 - (c) Adjust the VR1 on local board until the meter indication shows 5 (center).
 - (d) Advance the VR2 to half way of its full travel. Observe the meter indication. If the meter moves to either side from the center adjust L303 on IF board.
 - (e) Connect the signal generator to the ANT receptacle. Set the frequency of the signal generator to the channel frequency exactly, and output level to 10 microvolt.
 - (f) Shift the frequency of the signal generator 15 KHz higher. Adjust the VR2 for 10 (full scale) reading of the meter.

EXPANDING CHANNEL CAPABILITIES

Your FT-224 transceiver is supplied with crystals installed for three channels. You may add up to 21 more sets of crystals to provide for operation on the frequencies used in your area.

1. Ordering Crystals: The crystals used in your FT-224 are manufactured to extremely close tolerance to match the electrical characteristics of the oscillator circuits. It is recommended that whenever additional crystals are installed in the transceiver these be obtained from your dealer to assure proper functioning of the circuitry under varying environmental conditions.
2. Installing Additional Channels: To install additional channels in your FT-224 proceed as follows:
 - (a) Remove the 8 screws on the rear panel and the side, and slide the transceiver out of the case.

- (b) Install the new crystals in their appropriate sockets on the transmitter and receiver circuit boards.

N O T E

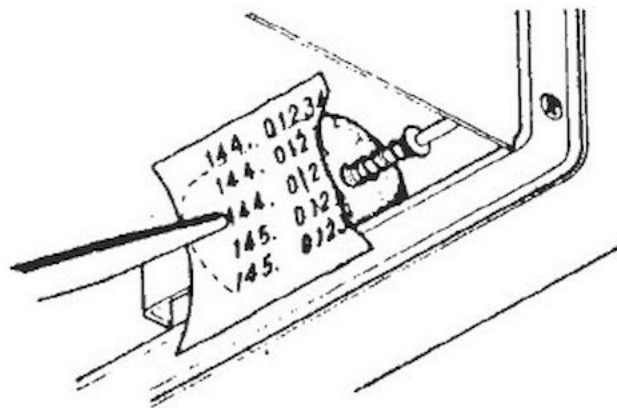
The channel indicator drum is labeled A through W. The crystal sockets are located from left to right corresponding to the channel indicator designation starting from "A". The 24th socket is for "CALL" channel.

- (c) Adjust the new crystals to frequency as described in paragraph 2, ADJUSTMENTS.
- (d) Carry out the transmitter and receiver performance checks to ensure proper operation on each new channel installed.
- (e) Apply the frequencies to the channel indicator drum as follows (see Figure 6):
- Adjust the CHANNEL selector until the drum position for the particular channel is accessible.
 - Remove the backing sheet and lay the sheet of rub-on transfer type supplied against the drum in the proper position.
 - Rub over the numerals with a pencil point or ball-point pen to transfer them to the drum. Transfer the 146 or 147 designation first, then gently lift the sheet from the drum and reposition as required to obtain the decimal designations.

N O T E

Rub vigorously to transfer the numerals, but be careful not to gouge the surface of the sheet.

Figure 6



TROUBLESHOOTING

Solid-state devices as used in your FT-224 exhibit extreme reliability in operation. However, unlike vacuum tubes any failure within a solid-state device (diode, integrated circuit, or transistor) is usually catastrophic. The device will either function, or not, therefore troubleshooting can be conducted easily by the signal tracing method to localize the trouble to a particular circuit. A signal generator and oscilloscope provide the most convenient means of such signal tracing. The voltage and resistance measurements tabulated for the transistors and integrated circuits may be used to verify a suspected failure, or improper level in the transceiver.

TOP VIEW

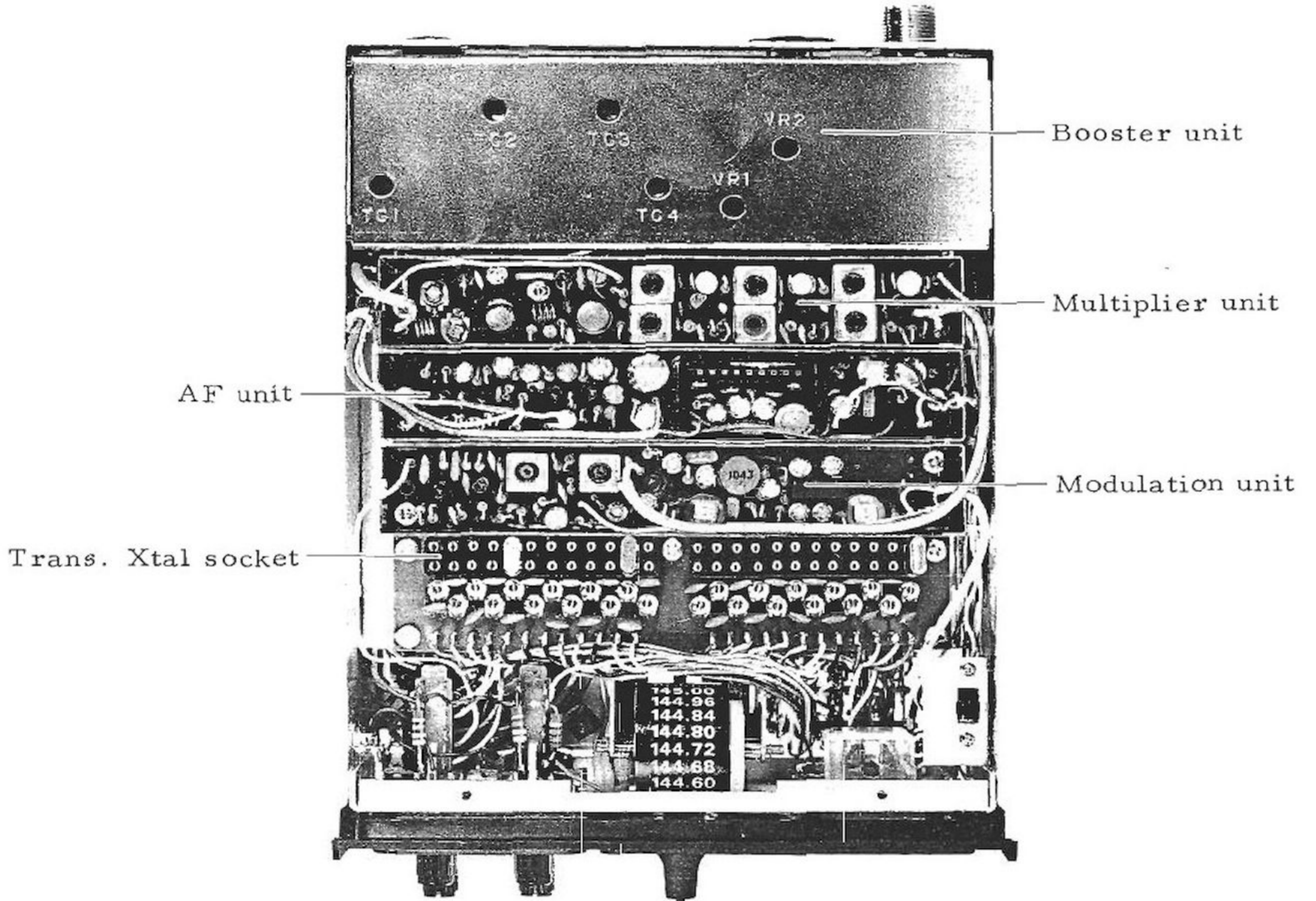


Figure 7

BOTTOM VIEW

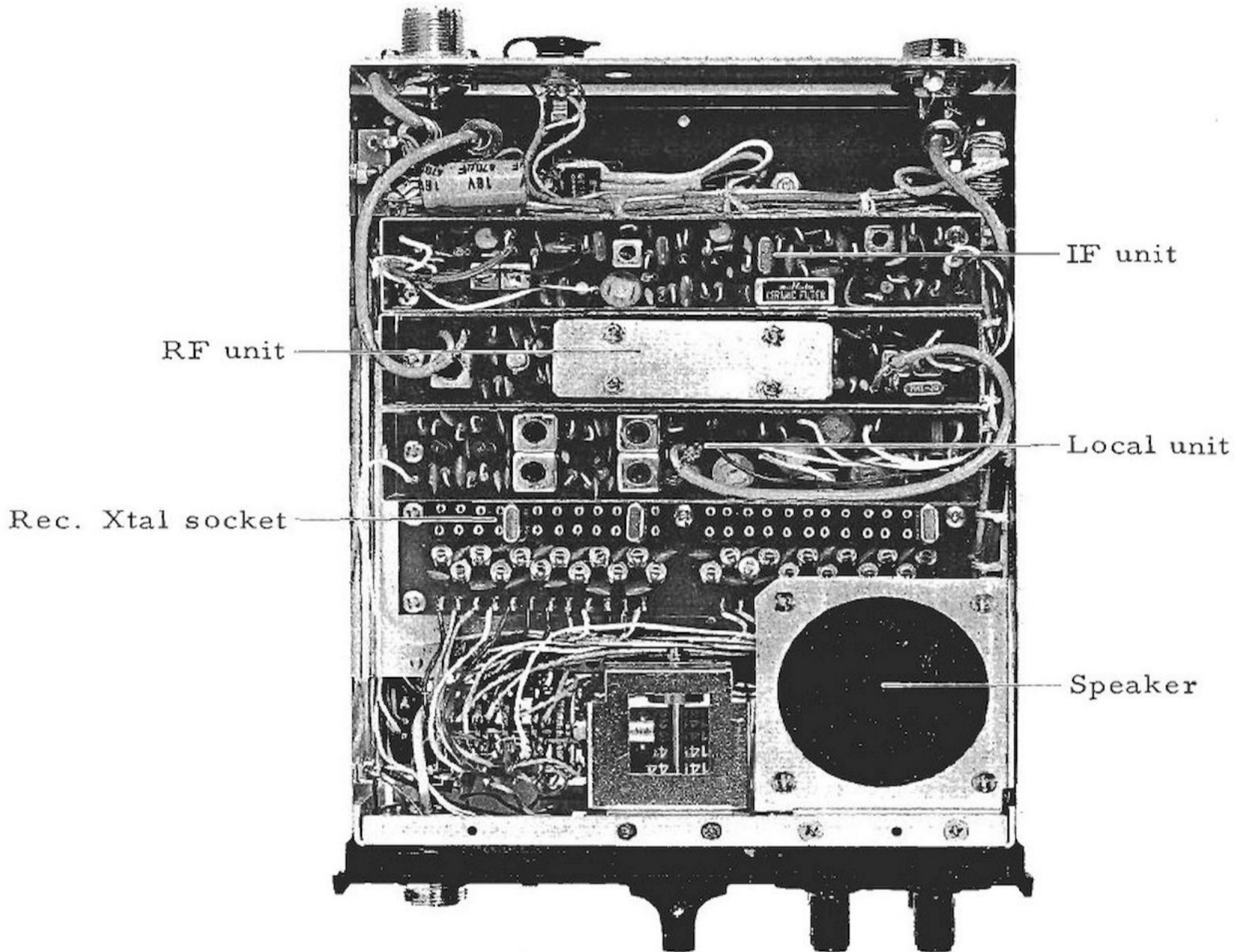


Figure 8

FT-224 BLOCK DIAGRAM

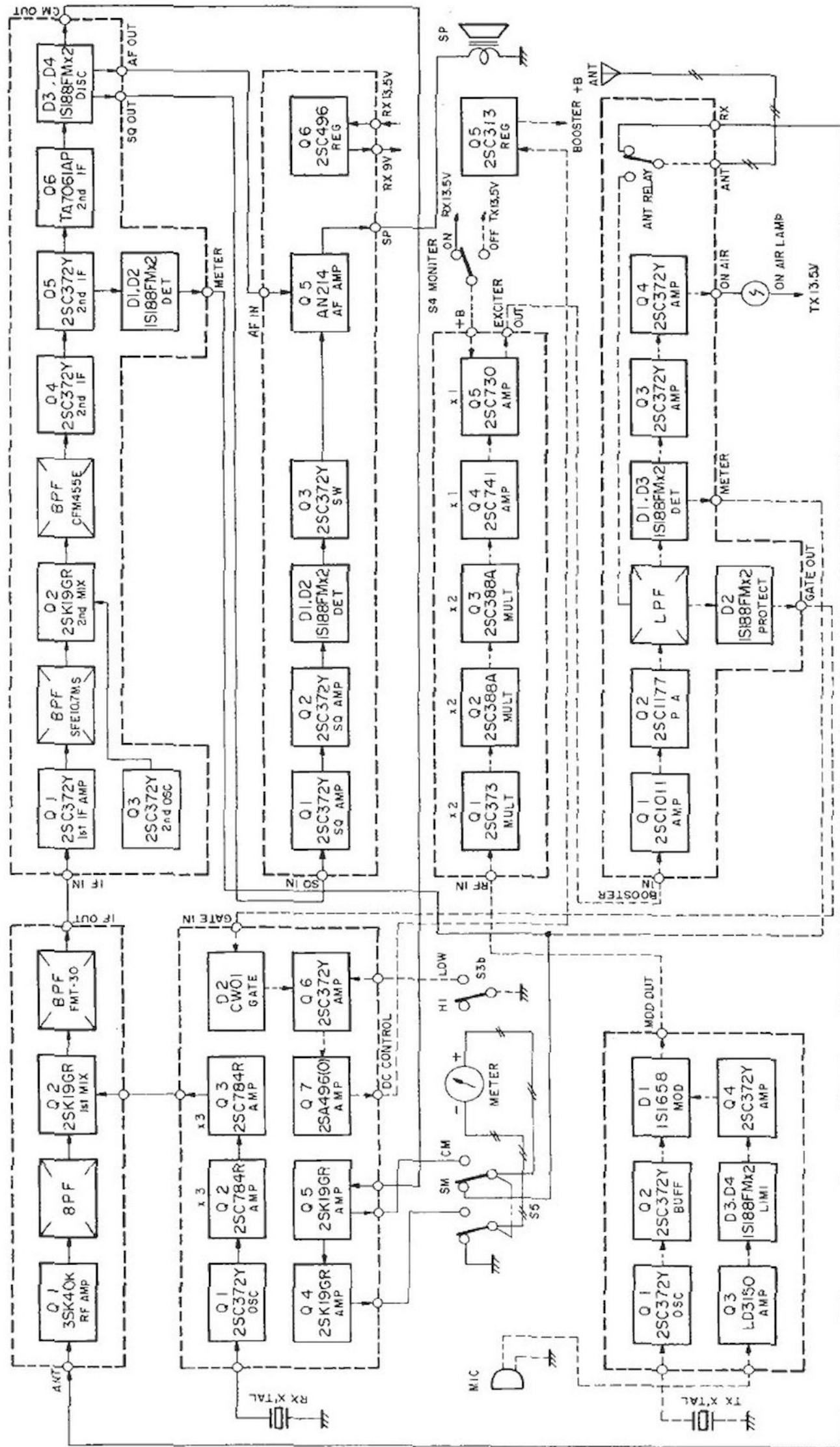


Figure 9

Resistance

RF & UNIT	BASE GATE	EMTR SOURCE	COLL DRAIN		BASE GATE	EMTR SOURCE	COLL DRAIN
Q ₁	100K	100	250	Q ₃	820	0	1.8K
Q ₂	1.5K	520	450	Q ₄	1.8K	1 K	1.8K
IF & UNIT				Q ₅	580	300	140
Q ₁	1.2K	560	560	MOD UNIT			
Q ₂	2.5K	1.2K	1.2K	Q ₁	1.6K	1 K	1.2K
Q ₃	1.3K	1 K	500	Q ₂	1.3K	470	1.6K
Q ₄	2.3K	1 K	1.8K	Q ₃	1.3K	470	2.3K
Q ₅	1.1K	4.7K	500	MUL UNIT			
Local UNIT				Q ₁	1.1K	220	850
Q ₁	1.3K	1 K	500	Q ₂	440	100	850
Q ₂	1.2K	330	330	Q ₃	440	47	850
Q ₃	1 K	220	300	Q ₄	300	22	850
Q ₄	1 K	230	300	Q ₅	47	0	850
Q ₅	0	210	300	Booster UNIT			
Q ₆	1.6K	470	∞	Q ₁	0	0	∞
Q ₇	∞	850	1.4K	Q ₂	0	0	∞
AF UNIT				Q ₃	5 K	850	∞
Q ₁	1.7K	1 K	3.8K	Q ₄	850	0	∞
Q ₂	1.5K	1 K	1.3K	Q ₅	1.4K	∞	850

IF UNIT	1	2	3	4	5	6	7	8	9
Q ₆	1.2K	840	750	0	500	1.2K	1.2K		
AF UNIT									
Q ₅	1 K	0	1 K	2.7K	1 K	0	1.7K	50K	130
MOD UNIT									
Q ₃	1 K	110	0	0	17K	2.3K	900	6 K	1.1K

Remarks: Unit is in OHM.
All: measurements made With VTVM

Voltage

RF UNIT	BASE GATE	EMTR SOURCE	COLL DRAIN		BASE GATE	EMTR SOURCE	COLL DRAIN
Q ₁ (R)	0.5	0.4	10	Q ₃ (R)	0	0	2.1
Q ₂ (R)	0	2.9	10	Q ₄ (R)	2.1	1.4	9.7
IF UNIT				Q ₅ (R)	11	11	13.5
Q ₁ (R)	22.6	1.6	9.6	MOD UNIT			
Q ₂ (R)	0	2.1	10	Q ₁ (T)	2.5	1.9	9.5
Q ₃ (R)	11.8	2.3	10	Q ₂ (T)	2.3	1.6	8.2
Q ₄ (R)	22.9	2.1	3.6	Q ₄ (T)	2.6	1.9	6.1
Q ₅ (R)	22.1	1.3	10	MUL UNIT			
Local UNIT				Q ₁ (T)	2.1	1.5	13.5
Q ₁ (R)	11.8	1.1	10	Q ₂ (T)	0.9	0.9	13.5
Q ₂ (R)	11.7	1.0	10	Q ₃ (T)	0.8	0.8	13.5
Q ₃ (R)	11.7	1.2	10	Q ₄ (T)	0.8	0.8	8
Q ₄ (R)	0	0.8	2.2	Q ₅ (T)	0	0	8
Q ₅ (R)	0	0.7	1.8	Booster UNIT			
Q ₆ (T)	11.4	10.7	13.3	Q ₁ (T)	0	0	13.0
Q ₇ (T)	13.0	13.5	13.3	Q ₂ (T)	0	0	13.0
AF UNIT				Q ₃ (T)	1.4	0.7	0.7
Q ₁ (R)	11.8	1.1	7.1	Q ₄ (T)	0.7	0	0.7
Q ₂ (R)	22.6	1.9	9.1	Q ₅ (T)	13.5	13.5	13.5

IF UNIT	1	2	3	4	5	6	7	8	9
Q ₆ (R)	2	2	10	0	8.9	2	2		
AF UNIT									
Q ₅ (R)	5.5	0	6.9	10.4	5.5	0	5.5	12	13.5
MOD UNIT									
Q ₃ (T)	0.6	0	0	0	7	1.5	9	4.8	0.9

Remarks: Unit is in VOLT.
(R) means RECENE and (T) means TRANSMIT.
All measurements made with VTVM.

PARTS LIST

RF-UNIT		4, 10	1/4 W	220 Ω	± 5 %
PB	PRINTED CIRCUIT BOARD	7, 18	1/4 W	470 Ω	± 5 %
PB1373(A~Z) RF		3	1/4 W	1 KΩ	± 5 %
C	CAPACITOR	8, 14, 15, 17	1/4 W	2.2KΩ	± 5 %
DIPPED MICA		1, 5, 19	1/4 W	4.7KΩ	± 5 %
1	50 WV 3PF ±0.5PF				
2, 7	50 WV 20PF ±10%	16	1/4 W	10 KΩ	± 5 %
CERAMIC DISC		2, 9	1/4 W	22 KΩ	± 5 %
8	50 WV 0.001μF +100% -0%	6	1/4 W	33 KΩ	± 5 %
3~6, 9, 10	50 WV 0.01 μF +80% -20%				
L INDUCTOR		VR VARIABLE RESISTOR			
101	ANT. TRANS.	1	SR19R-001	470 ΩB	
102, 106	R.F. RESONATOR A	3, 4	SR19R-001	4.7KΩB	
103~105	" B	2	SR19R-001	100KΩB	
107, 108	10.7MHz I.F.T				
MF CRYSTAL FILTER		IF UNIT			
1	FMT-30	PB	PRINTED CIRCUIT BOARD		
Q FET		PB-1378(A~Z)		IF	
1	3SK40	C	CAPACITOR		
2	2SK19(GR)	DIPPED MICA			
R RESISTOR		4	50 WV	1PF	±0.5P
CARBON FILM		6	50 WV	50PF	±10%
4	1/4 W 100 Ω ± 5 %	7, 8	50 WV	100PF	±10%
5, 8	1/4 W 220 Ω ± 5 %	CERAMIC DISC			
7	1/4 W 3.3KΩ ± 5 %	1, 3, 11, 13, 16	50 WV	0.001μF	±100% 0%
3	1/4 W 68 KΩ ± 5 %	2, 5, 9, 10, 17, 18, 24	50 WV	0.01 μF	±80% 20%
1, 2, 6	1/4 W 100 KΩ ± 5 %	PLASTIC FILM			
LOCAL UNIT		29	50 WV	0.0033μF	±20%
PB	PRINTED CIRCUIT BOARD	28, 30, 31	50 WV	0.022 μF	±20%
PB-1377(A~Z) LOCAL		12, 14, 15, 19, 21~23	50 WV	0.047 μF	±20%
C	CAPACITOR	STYROL FILM			
DIPPED MICA		25	50 WV	330PF	±10%
15	50 WV 1PF ±0.5PF	26	50 WV	1000PF	±10%
9	50 WV 3PF ±0.5PF	TANTALUM			
14, 16	50 WV 8PF ±0.5PF	20	50 WV	0.47μF	
8, 10	50 WV 30PF ±10%	ELECTROLYTIC			
4	50 WV 40PF ±10%	27	16WV	3.3 μF	±75% ±10%
1, 2	50 WV 100PF ±10%	CF FILTER			
CERAMIC DISC		CERAMIC FILTER			
11, 17	50 WV 0.001μF +100% -0%	1	SFE-10.7MS		
3, 5~7, 12, 13, 18	50 WV 0.01 μF +80% -20%	2	CFM-455E		
ELECTROLYTIC		D DIODE			
22, 23	16WV 1μF +75% -10%	GERMANIUM			
24, 25	16WV 10μF +75% -10%	1~4	1S188FM		
D DIODE & SCR		L INDUCTOR			
1	GERMANIUM 1S188FM	301	I.F.T	10.7MHz	
2	S.C.R CW01	302	CHOKE 1mH		
L INDUCTOR		303	I.F.T.	455kHz	
MULTIPLIER		304	DISCRIMINATOR A		
201, 202	42 MHz	305	" B		
203, 204	134 MHz	306	CHOKE 2 mH		
Q TRANSISTOR & FET		Q TRANSISTOR, FET, & I.C			
TRANSISTOR		TRANSISTOR			
1, 6	2SC372(Y)	1, 3~5	2SC372(Y)		
2, 3	2SC784(R)	2	FET 2SK19(GR)		
7	2SA496(O)	6	I.C TA7061AP		
4, 5	FET 2SK19(GR)	R RESISTOR			
R RESISTOR		CARBON FILM			
CARBON FILM		21	1/4 W	10 Ω	± 5 %
11, 20	1/4 W 10 Ω ± 5 %	10, 20, 22	1/4 W	220 Ω	± 5 %
		4	1/4 W	330 Ω	± 5 %
		18, 23	1/4 W	470 Ω	± 5 %
		3	1/4 W	560 Ω	± 5 %
		9, 14, 24, 25	1/4 W	1KΩ	± 5 %

