



C O M P A N Y N A M E C H A N G E

In November of 1979, Swan Electronics changed its name and we have been phasing out the name "SWAN" since that time. The advanced technology which has gone into the production of your unit, combined with the new cosmetics, are your introduction to CUBIC COMMUNICATIONS, INC., a wholly-owned subsidiary of Cubic Corporation of San Diego, California.

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CUBIC COMMUNICATIONS, INC.

ADDENDUM

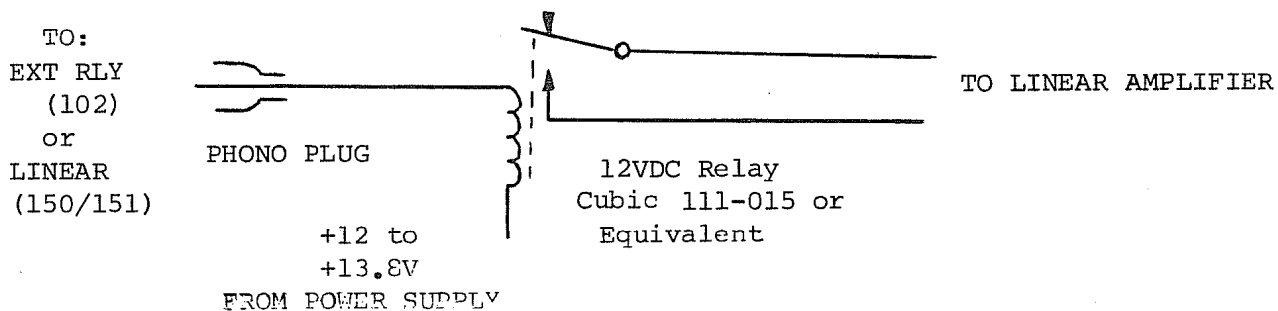
SUBJECT: Use of Cubic Transceivers with External Linear Amplifiers not Manufactured by Cubic

APPLICABLE TO: ASTRO-102BXA and ASTRO-150A/151A

DISCUSSION:

Keying circuitry is included with the Cubic Transceivers to control the operation of Cubic 1200Z and 1500ZA Linear Amplifiers. Linear amplifiers from other manufacturers can be controlled directly provided that the amplifier keyline provides a positive voltage of not more than 200 volts and requires not more than 200 milliamperes to actuate. Amplifiers requiring control of a negative voltage, voltages or currents higher than the above values, or metallic contact switching can be accommodated with an external relay between the Cubic Transceiver and the other make Linear Amplifier.

The external relay should have its coil connected between the transceiver power supply and the transceiver EXT RLY (102) or LINEAR (150/151) jacks. A relay with a nominal 12 volt coil is required such as the Cubic 111-015 or equivalent. A set of normally open contacts on the relay is then connected to the appropriate point on the linear amplifier. A schematic diagram of this connection is shown below:



The external relay will probably not be fast enough to operate in full break-in mode. Therefore, when operating CW the break-in switch should be set to the SEMI mode. VOX operation in SSB mode will be possible, although the DELAY control may be advanced slightly to insure that the linear amplifier does not drop out between syllables, thus cutting off the first part of the next syllable.

OWNER'S OPERATION MANUAL
FOR THE
ASTRO-150 SSB TRANSCEIVER

ISSUE 2

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Welcome to the ranks of ASTRO-150 owners!

This manual has been prepared to help you get the most pleasure from your transceiver. It contains information about operating procedures, technical specifications, theory of operation and instructions for calibration, service and repair. We urge you to read it from cover to cover before applying power to this transceiver.

WARNING NOTE

DO NOT APPLY POWER TO THIS TRANSCEIVER UNTIL THIS MANUAL IS READ AND UNDERSTOOD.

PROPRIETARY STATEMENT

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SCOPE OF WARRANTY - FREE PARTS AND LABOR

All of the Cubic Communications, Inc., Swan Division communications products are warranted against defects in material and workmanship. During the warranty period, Swan or an authorized Swan service station will provide to you free of charge both parts (except RF output transistors) and labor necessary to correct any defect in material or workmanship. Periodic checkups, voltage conversion are not covered by this warranty. All implied warranties, except to the extent prohibited by applicable law, shall have no greater duration than the warranty period set forth for this unit. No warranties whether express or implied, including warranties of merchantability or fitness, shall apply to this product after the warranty period has expired. Under no circumstances shall Swan be held liable for any loss or damage, direct or consequential, arising out of the use of, or inability to use, this product.

WARRANTY PERIOD

Swan communications products are warranted for ninety days from the date of the original purchase.

PURCHASER'S RESPONSIBILITIES

You, as the purchaser of a new Swan communications product, must do the following to qualify for warranty service.

1. Retain your sales slip or other proof of purchase or send in your warranty registration card to avoid unnecessary difficulties in determining your eligibility for warranty work.
2. Notify your nearest authorized Swan service center or Swan as soon as possible after discovery of a possible defect with the model, serial, and warranty registration (if any) numbers and a detailed description of the problem, including details on the electrical connection to associated equipment and the list of all such equipment.
3. Make your Swan product available to an authorized Swan service center for inspection and approved warranty service or ship your Swan product, in its original container or equivalent, fully insured and shipping charges prepaid, to Swan.

PROPER MAINTENANCE AND USE

This warranty will not apply to any failure that Swan determines is due to any of the following:

1. Improper maintenance or repair, including the installation of parts or accessories that do not conform to the quality and specification of the original parts.
2. Misuse, abuse, neglect, including improper installation.
3. Accidental or intentional damage.

TABLE OF CONTENTS

1.0	INTRODUCTION.....	1
2.0	SPECIFICATIONS.....	1
3.0	REQUIREMENTS FOR OPERATION.....	4
	A. AC Operation.....	4
	B. DC Operation - Cable Requirements.....	6
	C. Antenna - Fixed; Mobile.....	7
	D. Microphone.....	7
	E. Speaker/Head Phones	8
4.0	INSTALLATION.....	8
	A. Accessories Included.....	8
	B. Location; Ventilation	8
	C. Cabling; Ground.....	9
	D. Linear Amplifier Hookup.....	9
	E. Other Forms of Modulation.....	10
	F. CW Key.....	10
	G. Mobile.....	10
5.0	OPERATING CONTROLS, AND CONNECTORS.....	11
	A. Front Panel.....	11
	B. Rear Panel.....	12
6.0	OPERATING INSTRUCTIONS.....	15
	A. Receiver.....	15
	B. Transmitter Tuning (Detailed).....	18

7.0	THEORY OF OPERATION.....	19
	A. General Description.....	19
	B. Functional Description.....	24
	1. Receive Mode.....	24
	2. Transmit Mode.....	25
	3. Synthesizer.....	26
8.0	CALIBRATION.....	28
	A. Carrier Oscillator Frequency.....	33
	B. Sidetone Adjustment.....	33
	C. AGC and S-Meter.....	33
	D. VOX.....	34
	E. Microphone Scan Rate.....	35
	F. Component Replacement and Repair Notes....	35

1.0 INTRODUCTION

The Swan ASTRO-150 is a digitally tuned 80M-10M (160M-15M on Model 151) all solid-state SSB transceiver. The built-in digital synthesizer with LED readout provides over 100,000 crystal controlled frequencies with 100 HZ resolution. Precision tuning is available with VRS (variable rate scanning) rotary control or with "up" and "down" scanning switches on the included microphone. Frequency selection is the only tuning necessary when operating into a matched antenna with a VSWR of 2:1 or less. Fixed tuned filters are used to assure unmatched receiving and transmit performance.

Standard features include: Full break-in or semi-break-in CW operation; narrowband crystal CW filter; VOX; Noise blanker; peak reading wattmeter; and IF gain control. The basic single conversion design has been proven in thousands of the popular Swan transceivers. Mechanical and electrical designs are exceptional for years of trouble free operation, even in a rugged mobile environment.

The unit is designed for fixed and mobile use with minimum interconnections and simple mobile mount included.

For fixed station operation an auxiliary speaker/power supply, Model PSU-5A, provides 13.8 VDC from 115/230 VAC. A matching antenna tuner, Model ST-3, is also available.

2.0 SPECIFICATIONS

General Specifications:

Frequency Coverage:

160M	1.8-2.4 MHZ (Model 151 only)
80M	3.0-4.5 MHZ
40M	6.0-8.3 MHZ
20M	13.8-16.0 MHZ
15M	20.8-23.0 MHZ
10M	28-30 MHZ (Model 150 only)

Frequency Control: Digital synthesizer with 100HZ steps, plus fine and RIT controls.

Modes of Operation: SSB with selectable sideband. CW with automatic 800 HZ offset on transmit and full or semi-break-in.

Power Input Required: 12-14 VDC negative ground only. No damage 10-15 VDC. 20 Ampere peak current.

Electromagnetic Interference:

Transmit: Five element lowpass filter on each band.

Receive: Three pole bandpass filter on each band.

Dimensions: 3.75" H x 9.75" W x 11.75" D
9.53cm X 24.8cm X 30.2cm
Weight: 13 pounds (5.9kg)

Rear Panel:

Power Connector

Pin 1	13.6 BDC
2	Ground
3	Ground (used for tuner meter lamps)
4	13.6 VDC
5	Ground
6	13.6 VDC fused to 2 amps (used for tuner meter lamps)

Antenna Connector
UHF SO-239

External Speaker/Phones
Phone Jack

External Relay
RCA

Key Modulation
RCA

Fuse
2 Amp fast blow

Typical Receiver Specifications:

Circuit Design: Single conversion to 9.0165 MHz IF using double balanced mixer. Exceptional immunity to overload and cross modulation.

Sensitivity: 0.35 uV for 10dB $\frac{S+N}{N}$ Typical

Selectivity: Crystal bandpass 8 pole filter. Bandwidth 2700 HZ @ 6dB down, 4320 HZ @ 60dB down. 1.6 shape factor.

Internally Generated Spurious Response: 0.5 uV equivalent input signal

AGC: 6dB change in audio level over input range of 1.5 uV to .1V (100dB)

Audio Output: 3 Watt available @ 10% distortion, 300-3000 HZ, 4 ohms

Meter: S-Unit from 1-9, 20, 40, and 60dB over S-9

Typical Transmitter Specifications:

Circuit Design: Excellent harmonic and TVI suppression. ALC limits SSB peak power and CW power to 100 watts.

Power Input: 235 Watts PEP input at 13.8 VDC input

Power Output: 100 Watt PEP into 50 ohm non-reactive load at 13.8 VDC input

Unwanted Sideband Rejection: 60dB down at 1000 HZ audio

Harmonic Output: 50dB below peak power level

Carrier Suppression: 50dB below peak power level

Spurious Output: 50dB below peak power level

Transmit Control for SSB: PTT and VOX standard

CW Transmit: Full or Semi-break-in with sidetone standard. Automatic 800 HZ offset on transmit frequency

Microphone Input: 47K ohm input impedance

Audio Response: 300 to 3000 HZ \pm 6dB

Meter: Reads peak power on transmit

Cooling: Large capacity heatsink fins supplied. For SSTV, RTTY, and semi-continuous transmit, forced air cooling such as a small muffin fan on heatsink fins required

3.0 REQUIREMENTS FOR OPERATION

A. AC Operation

The ASTRO-150 transceiver requires +13.8 VDC at up to 20 amperes in transmit mode. For operation 110/220 VAC at 50/60 HZ the PSU-5 matching Speaker/Power Supply is recommended.

If other than the recommended power supply is used the following requirements must be met by the power supply to assure satisfactory performance:

1. Output voltage 13.8 VDC
2. Load Regulation 13.0 VDC @ 20 amp
3. Ripple 0.25 Vpp @ 20 amp

NOTE: All parameters measured at input connector of transceiver.

B. DC Operation

For operation from battery supplies (with or without alternator/generator charging) several points must be noted for proper operation:

1. Excessive noise on the power leads may cause damage due to over voltage or reverse voltage. Large voltage transients may be caused by activating motors, solenoids, and similar electro-mechanical devices connected to the same battery supply. In mobile use it is always advisable to start engine with set turned off.

2. Because of the large currents (up to 20 amps) required by the power amplifier it is not possible to switch the transmitter supply on and off with the front panel power switch. Voltage for the transmitter power amplifier is supplied directly from Pins 1 and 4 of the power connector. This connection allows a leakage current of up to 20ma to flow at all times the transceiver is connected to the battery. In standby mode the microprocessor is in partial operation with a current drain of 60ma. This could discharge the battery if the unit is left connected for extended periods without charging. For example, about 30 days for a fully charged 60Ahr battery.

3. Reverse polarity protection is provided by an internal, shunt connected diode. For this reverse protection diode to function properly an external 20 ampere inline fuse is required. The 2 ampere fuse located on the rear panel is to protect all circuits in the set except the power amplifier from over voltage or short circuit, not reverse voltage.

4. The transceiver is rated for operation at 13.8 VDC; the normal operation voltage of a 12.6 VDC battery system with alternator/generator operating. In a typical mobile application the transceiver may be several feet from the battery power source. For completely satisfactory operation (but at reduced peak transmitter power) the supply voltage at the transceiver power connector should never drop below 11.0 VDC. For safe operation the resistance of the power leads should not exceed 0.04 ohms. Listed below is the maximum recommended length of power lead vs wire gauge. Remember the length listed is total wire length; the distance to the battery is only one half this distance (hot lead and its return).

<u>Gauge</u>	<u>Total Length</u>
8	60 feet
10	39 feet
12	24 feet
14	15 feet
16	10 feet

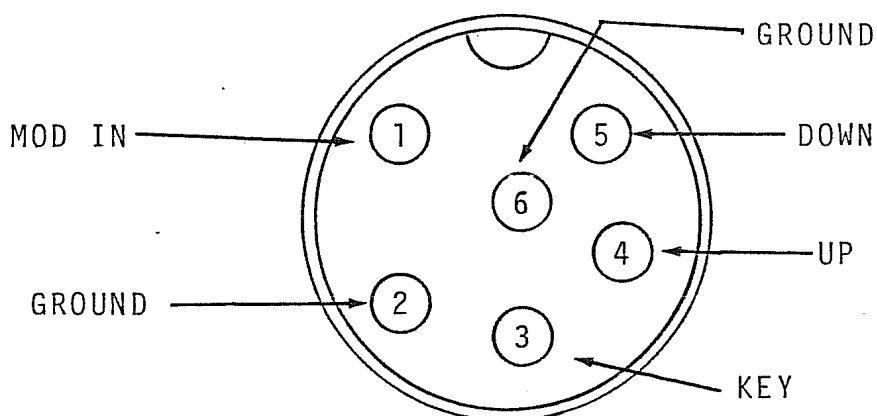
C. Antenna

The antenna may be of any type selected by the operator, provided the VSWR is 2:1 or less. For antennas that are not designed with a VSWR of 2:1 or less, an antenna tuner such as the Swan ST-3 should be installed between the transceiver and the antenna. For tune-up procedure see Section 6, paragraph B, transmitter tuning.

D. Microphone

The microphone input is high impedance, approximately 47K ohms. Almost any standard microphone will provide satisfactory performance. The unit is supplied with a high quality microphone that has self-contained tuning switches for fixed rate scanning and single step 100 HZ tuning.

If the operator should prefer a desk or other type microphone a mating connector type 342-026 wired to the microphone cable according to Figure 3-D-1 is required.



FRONT VIEW
FIGURE 3-D-1

Both mobile and desk type microphones are available from Swan; for mobile use Model 404, and for desk type Model 444. The microphone manufacturer's instructions should be followed in connecting the microphone cable to the plug. Many microphones require that the push-to-talk button must be pressed to connect the microphone element to the radio input. For VOX operation, this feature must be disabled by opening the microphone case and jumpering the switch section that controls the microphone element connections.

E. Speaker/Headphones

The unit comes equipped with a built-in speaker. Audio output is also available to drive an external speaker or headset from a phone type jack on the rear panel. Speaker impedance should be between 3.2 and 8 ohms nominal.

The available Speaker/Power Supply unit has a speaker matched to the transceiver audio system. The Speaker/Power Supply unit has preassembled cables for audio and main power. The ASTRO-150 system Interconnect Diagram details these functions.

4.0 INSTALLATION

A. Accessories included in package:

1. Power mating connector
2. RCA phone plug (3)
3. Owner's manual
4. Mobile mounting bracket with hardware
5. Audio Phone Plug

B. Location/Ventilation

1. Fixed. The transceiver is designed to be table top mounted in any available location. The only limitations are associated with transmitter power amplifier cooling. The heatsink provided is adequate for normal SSB or CW communication, however, space must be allowed around the unit for convection cooling. It is recommended that a clear space of at least 2 inches above and to the rear of the heatsink be provided.

For continuous or semi-continuous transmitter operation, a small fan should be used to force cooling air over the heatsink. For best cooling efficiency, the fan should be located below the heatsink with airflow directed upward through the heatsink fins.

2. Mobile. A simple mobile mounting bracket is provided, or the operator may choose to fabricate his own. In any case, the only critical factors are:

- a. Maintain cooling space as mentioned above.
- b. Mount unit in a manner to minimize shock and vibration. Using the mobile mount, installation in cars and trucks should be simple and trouble free.
- c. Power connection should be made per Requirements for Operation section; Item 3.0B, DC OPERATION.

C. Cabling

1. Antenna. The antenna connector on the transceiver is SO-239 type. Connection to the antenna should be made with coaxial cable of 50 ohm characteristic impedance. For runs up to 50 feet, RG58A/U cable, or equivalent, is recommended for best performance.

2. Power. See Requirements for Operation section.

3. Grounding. For best performance the transceiver should be grounded to a good earth ground by the grounding screw located just below the external relay connector. The ground lead should be as short as practical. The lead should be made from 14 gauge wire or equivalent.

D. Linear Amplifier Interface

The ASTRO-150 will interface directly with linear amplifiers that require a grounded contact for operation. RCA type connector, linear is connected to a normally open transistor collector. The transistor switch is intended to provide a low resistance path to ground for a positive voltage to key a linear amplifier. The transistor is reverse polarity protected. Signal characteristics are as follows:

Mode Switch: Selects desired sideband or CW function. The CWN position activates the narrowband IF crystal filter.

Full/Semi Break-in: Switch selects receiver mode when operating in CW or CWN.

Noise Blanker: Switch selects noise blanker on or off.

VOX: Switch selects VOX mode or PTT mode for SSB operation.

Power: Switch selects power on, standby, off. In standby mode synthesizer memory is active to store last tuned frequency on each band.

B. Rear Panel

External Speaker Connection: The receiver audio is available for external speaker or headphone connection at the rear panel jack labeled "EXT SPKR." This jack accepts a standard single circuit plug to which the speaker or headphones are connected. The external device is automatically connected and the internal speaker disconnected when the plug is inserted. The external speaker impedance may be anywhere between 3.2 and 8 ohms.

Auxiliary Switching: External devices may be keyed in unison with the unit through the "linear" jack on the rear panel. This jack requires the insertion of an RCA type audio plug to make connection to the internal transistor switch. The center connection of the plug is connected to chassis ground through 10 ohms when the unit is keyed.

Key: The transmitter may be keyed on by grounding the center connection of the RCA jack labeled "key."

Modulation: An auxiliary modulation input is provided for AFSK or other uses. This input is summed with the normal mic input and level is controlled by mic gain control.

Power: The unit operates on 13.8 VDC @ up to 20 amps. The power connector uses two parallel input pins for this current and its return leads. Figure 5B-1 shows the pin layout and function.

Mode Switch: Selects desired sideband or CW function. The CWN position activates the narrowband IF crystal filter.

Full/Semi Break-in: Switch selects receiver mode when operating in CW or CWN.

Noise Blanker: Switch selects noise blanker on or off.

VOX: Switch selects VOX mode or PTT mode for SSB operation.

Power: Switch selects power on, standby, off. In standby mode synthesizer memory is active to store last tuned frequency on each band.

B. Rear Panel

External Speaker Connection: The receiver audio is available for external speaker or headphone connection at the rear panel jack labeled "EXT SPKR." This jack accepts a standard single circuit plug to which the speaker or headphones are connected. The external device is automatically connected and the internal speaker disconnected when the plug is inserted. The external speaker impedance may be anywhere between 3.2 and 8 ohms.

Auxiliary Switching: External devices may be keyed in unison with the unit through the "linear" jack on the rear panel. This jack requires the insertion of an RCA type audio plug to make connection to the internal transistor switch. The center connection of the plug is connected to chassis ground through 10 ohms when the unit is keyed.

Key: The transmitter may be keyed on by grounding the center connection of the RCA jack labeled "key."

Modulation: An auxiliary modulation input is provided for AFSK or other uses. This input is summed with the normal mic input and level is controlled by mic gain control.

Power: The unit operates on 13.8 VDC @ up to 20 amps. The power connector uses two parallel input pins for this current and its return leads. Figure 5B-1 shows the pin layout and function.

4. Microphone. The microphone amplifier and audio bandpass is optimized for use with the tuning microphone provided.

5. Mounting. See Section 4, paragraph B-2.

5.0 OPERATING CONTROLS AND CONNECTORS

A. Front Panel

Each front panel control and function is described herein to assist the operator in understanding the operation of the transceiver. From left to right: See Figure 5-1 for transceiver front panel layout, and Figure 5-2 for rear panel layout.

Key/Mic Connector: Six pin connector for connection of tuning microphone, key, or conventional microphone. See Section 3-D for pin connections.

Meter: Dual function meter reads "S" units to S-9 and dB over S-9 to 60dB. In transmit mode, calibration is true peak reading with 100 watts full scale.

AF Gain, IF Gain -- Dual Control: Audio gain is the inner knob of the control concentric pair. The outer knob is the receiver IF gain. The IF gain can be used to reduce receiver gain below that held by internal AGC control.

RIT, Fine -- Dual Control: Receiver incremental tuning (RIT) is the inner knob of the control concentric pair. This control will vary the receiver tuned frequency approximately ± 300 HZ. With the RIT knob at the 12:00 position receive and transmit frequencies are equal. Fine tuning is the outer knob. This control changes both receive and transmit frequencies approximately ± 75 HZ.

Mic-Gain: Mic gain control sets level of modulation signal in SSB operation. In CW operation the control serves as RF output power control.

Readout: Six digit LED readout in KHZ. Resolution is to 100 HZ. Frequency display is synthesizer tuned frequency and is independent of Fine or RIT controls.

VRS Tuning: The Variable Rate Scanning (VRS) Knob is used to scan the tuned frequency up or down at a rate proportional to the angle of rotation. A right turn increases frequency, and a left turn decreases frequency.

Mode Switch: Selects desired sideband or CW function. The CWN position activates the narrowband IF crystal filter.

Full/Semi Break-in: Switch selects receiver mode when operating in CW or CWN.

Noise Blanker: Switch selects noise blanker on or off.

VOX: Switch selects VOX mode or PTT mode for SSB operation.

Power: Switch selects power on, standby, off. In standby mode synthesizer memory is active to store last tuned frequency on each band.

B. Rear Panel

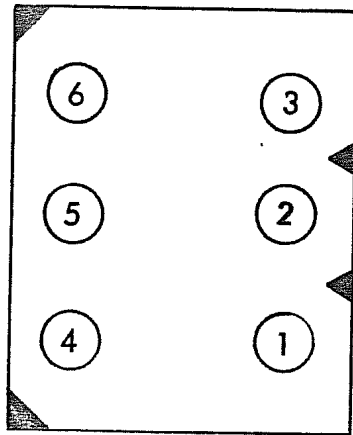
External Speaker Connection: The receiver audio is available for external speaker or headphone connection at the rear panel jack labeled "EXT SPKR." This jack accepts a standard single circuit plug to which the speaker or headphones are connected. The external device is automatically connected and the internal speaker disconnected when the plug is inserted. The external speaker impedance may be anywhere between 3.2 and 8 ohms.

Auxiliary Switching: External devices may be keyed in unison with the unit through the "linear" jack on the rear panel. This jack requires the insertion of an RCA type audio plug to make connection to the internal transistor switch. The center connection of the plug is connected to chassis ground through 10 ohms when the unit is keyed.

Key: The transmitter may be keyed on by grounding the center connection of the RCA jack labeled "key."

Modulation: An auxiliary modulation input is provided for AFSK or other uses. This input is summed with the normal mic input and level is controlled by mic gain control.

Power: The unit operates on 13.8 VDC @ up to 20 amps. The power connector uses two parallel input pins for this current and its return leads. Figure 5B-1 shows the pin layout and function.



<u>Pin</u>	<u>Function</u>
1	13.8V in
2	Ground
3	Ground
4	13.8V in
5	Ground
6	13.8V out

FIGURE 5B-1

NOTE: Pins 6 and 3 used to power ST-3 Tuner meter lamps.

Fuse: A Little fuse, P/N 312002 or equivalent 2 ampere fuse is used to protect internal circuits. This fuse is not for reverse polarity protection.

Antenna Connector: S0-239 type for use with 50 ohm coaxial systems.

6.0 OPERATING INSTRUCTIONS

A. Receiver Operation

The ASTRO-150 is normally in the receive mode of operation unless either of the two key line pins are connected to chassis ground by a path of 100 ohms or less. Power is applied to the unit by placing the power switch in the "on" position. If the PSU-5 power supply is providing power for the unit its power switch must also be "on." The correct power-on condition is indicated by a red pilot lamp on the PSU-5 and meter backlight on the ASTRO-150. The frequency readout will also come on after a 0.5 second delay.

SSB Operation: To operate the ASTRO-150 in the SSB receive mode set the controls as follows:

AF Gain	At desired noise level
IF Gain	Full clockwise
RIT	Knob to 12 o'clock
Fine	Knob to 12 o'clock
Mic Gain	Full Counterclockwise
Mode Switch	LSB or USB
Bandswitch	To desired band
Noise Blanker	Off
VOX/PTT	PTT
VRS Tuning	Set desired frequency as described below

Note: With the exception of frequency selection all pre-selection and band tuning is preset by the band switch. In the case of a mismatched antenna see discussion in transmitter tune up section.

Frequency Tuning: When turned on from the "off" position each band will come on tuned near the center of the amateur band. To scan the band only requires a "twist-of-the-wrist." A slight rotation of the VRS will start a scan upward (twist right) or downward (twist left) at a rate of about 200 HZ per second. As the knob is rotated farther the rate of scan increases until full rotation gives a scan rate near 100 KHZ per second. To stop scan it is only necessary to return the VRS knob to center position. For single 100 HZ steps the VRS knob can be rotated slightly and then returned to center.

For tuning from the microphone it is only necessary to press the up or down switch; a single push for a single step or hold for a fixed rate scan.

NOTE: For proper operation do not operate both tuning modes at the same time. This will cause the unit to be confused as to desired rate and when to stop scan. No damage will result and proper performance will resume when one scan is stopped.

NOTE: Do not change bands with VRS in scan mode. This will result in improper signals to the microprocessor and result in failure of synthesizer to lock, and improper readout. No damage will result and proper performance will resume when scan is stopped.

A normal tuning sequence would be a rapid scan (VRS knob rotated about 90°) to the band area of interest and then a reduced scan rate to listen for a desired station. As a station is "scanned-in" the rate can be further reduced and stopped as the station comes on frequency. If the frequency is in error a 100 HZ step or two will usually set you "right on."

Fine Tuning: In those cases where the 100 HZ steps do not set the frequency close enough the fine tune control can be used as a vernier. A fine adjustment of about +75 HZ is available with the fine frequency adjustment. This control effects both transmit and receive.

RIT: For net or CW operation the receive only frequency may be varied about +300 HZ by the RIT control. This control is always active and should be held at the 12 o'clock position for transmit and receive on the same frequency.

IF Gain Control: The IF gain control is normally at the full clockwise (maximum) position to realize the maximum sensitivity of the receiver. When a relatively strong signal is received, it will quiet the receiver background noise. However, during extended speech pauses, the AGC will decrease and the background noise will return until the operator resumes talking. Reducing the sensitivity of the receiver with the IF gain control will minimize this effect. The IF gain control operates on the AGC line to reduce the receiver sensitivity. Note that turning the control counterclockwise, in the absence of a signal, causes the S-Meter to deflect upwards. The position of the S-Meter, under such no-signal conditions, indicates the level of the signal that must be received to be heard. If the IF gain control is turned counterclockwise while receiving a signal to the point where the meter does not fall back during speech pauses, the background noise will not be heard.

Noise Blanker: The noise blanker (NB) will minimize the effects of pulse type noise such as automobile ignition noise. It is placed in operation by placing the NB switch in the NB position.

CW Operation: For receive CW operation the function is identical to SSB except for mode selection and break-in selection. The mode should be set to CW or CWN as desired. The CWN position activates the narrowband crystal IF filter. This filter has 300 HZ bandwidth centered at 800 HZ audio. The RIT control can be used to center signals in the narrowband filter passband.

Semi-break-in or full-break-in can be switch selected. In semi-break-in the delay adjustment is available on the left side of the unit (see Figure 8-3).

B. Transmitter Operation

Single Sideband Operation: The ASTRO-150 is placed in the SSB transmit mode by first setting up the receiver for single sideband and on the desired operational frequency.

Transmitter Tuning: The transmitter is designed to operate into a 50 ohm load impedance with a VSWR of 2:1 or less. No transmitter tuning is required if a matched antenna is used in the usual operating bands. If the antenna has an unknown VSWR the proper tune-up procedure is as follows:

With an antenna of unknown characteristics it will be necessary to install an antenna tuner, such as Swan ST-3, between the ASTRO-150 and the antenna. To properly adjust the antenna tuner, set the function switch to CW mode and the mic gain to full counterclockwise rotation. Activate the transmitter by CW key or microphone switch and set forward power with the mic gain control about 20 watt output to the antenna. Adjust the antenna tuner per the tuner instructions to achieve minimum VSWR.

NOTE: It is not always possible to achieve full scale power because the VSWR shutdown will limit output when operating into a mismatch.

The transmit power reduction as a function of VSWR is a slow, gradual power reduction to protect the transmitter, but still permit operation in the event VSWR rises above 2:1. Listed below is the approximate power available vs VSWR.

<u>VSWR</u>	<u>Power Watts</u>
1:1	100
1.5:1	100
2:1	80
3:1	60
α	30 (voltage equivalent)

After antenna tuning is complete, return function switch to desired mode and press the microphone button and, while speaking into the microphone, rotate the MIC GAIN control slowly in the clockwise direction until the Watt Meter deflects up to 100 Watt on voice peaks.

CW Operation: The ASTRO-150 is placed in the transmit CW mode by first setting the receiver to desired modes, i.e., CW or CWN, and semi or full break-in. The key can be used with either the front panel microphone connector (see Section 3-D for connection) or the rear panel auxiliary key plug (RCA type). The key may be left connected to the auxiliary input and the microphone to the mic connector for convenient change from SSB to CW Mode.

The unit is now ready to transmit CW except for power output adjustment. To set power output with key down rotate the mic gain control clockwise until power output is as desired on the built-in watt meter. For best pulse shape it is best to set power for a reading of 100 watts or less. Normally power greater than 100 watts is not possible due to ALC action.

VOX Operation: The ASTRO-150 is equipped with a VOX feature as standard equipment. It operates in the SSB mode. A switch labeled VOX/PTT selects between the push-to-talk and VOX modes.

Continuous Operation: During the SSB and CW operation, the power output of the ASTRO-150 is 100 Watts peak. However, the duty cycle on CW is low and on SSB the average power is considerably less than 100 Watts. If the ASTRO-150 is operated at 100 Watts continuously in RTTY or slow scan TV service, the average power dissipation is 100 Watts which will overheat the power amplifier transistors and could cause a catastrophic failure. To avoid overheating during these types of operations, direct the air from a fan to the heatsink on the rear panel of the ASTRO-150 and reduce output power to not more than 50 Watts.

7.0 THEORY OF OPERATION

A. General Description

The ASTRO-150 is constructed using modular, plug-in circuit board techniques. Figures 7-1, 7-2, 7-3, and 7-4 are functional block diagrams of Receiver mode, Transmit mode, and the frequency synthesizer.

The transceiver utilizes generally separate receiver and transmitter circuitry for optimum performance. The receiver is single conversion with PIN diode AGC to achieve greater than 100dB dynamic range. The transmitter utilizes many broadband circuits to eliminate alignment problems. Three pole bandpass preselector filters for each band plus double balanced modulator and transmit mixer assure excellent spurious free performance.

B. Functional Description

The following functional descriptions of the ASTRO-150 are divided into three sections. The first referenced to Figure 7-1 describes the unit operating in the receive mode. The second referenced to Figure 7-2 describes the unit operating in transmit mode. The third section describes the frequency synthesizer.

The CW mode is not covered in these discussions since, in most respects, the system is operating as in the USB mode.

1. Receive Mode. The ASTRO-150 receiver incorporates a unique T-R switch to eliminate the high power T-R relay. The transmit power amplifier is always connected to the antenna through the transmit lowpass filter assembly. In receive mode the power transistors are biased off, thereby creating an open circuit on the transmitter output transformer. The receiver input is coupled to the transmitter output transformer secondary through a high speed reed relay. This relay and the direct transformer coupling of the power amplifier permit full break-in operation in CW mode. The received signal is therefore filtered by the transmit lowpass band filters and then coupled through the reed relay to the preselector bandpass filter. The preselector filters are PIN diode switched for each band of operation. Each filter has three sections fixed tuned for the particular band selected. This signal is then fed to a dual gate MOS FET RF amplifier. The gain of the RF amplifier is tailored with a rising characteristic vs frequency to optimize receiver performance on each band. This means receiver gain and threshold are better on 15 and 10 meter bands where atmospheric noise is much less. On 40 and 80 meter bands RF gain is reduced 4 to 6dB to reduce the effect of much higher atmospheric noise levels.

The RF amplifier feeds the single conversion receiver. The receive input mixer is a double balanced diode ring type. The LO is always 9.0165 MHz above the tuned frequency to generate the desired 9.0165 MHz IF. The IF is filtered by an eight pole crystal SSB filter. This filter is followed by an optimum combination of discrete and integrated circuit IF amplifier stages. After the IF amplifiers the signal drives an emitter-coupled product detector. The detected audio output is amplified by the audio preamplifier. This preamplifier output is used to derive the audio AGC. To generate AGC the preamplifier output is detected and filtered by a sample and hold lowpass filter. The filter output is compared to a fixed voltage reference and if greater than the reference it is amplified and feedback to the AGC attenuators. By this means the peak audio level is held nearly equal to a fixed value. A second output of the audio preamplifier feeds the volume control and the audio power amplifier.

2. Transmit Mode. A block diagram of the unit when operating in the transmit mode is shown in Figure 7-2. Microphone audio is amplified in the Mic Amp stage. The output of the Mic Amp is one input to the 1st Mixer. The Carrier Oscillator is the second input. In the transmit mode, the 1st Mixer operates as a balanced modulator to produce two sidebands adjacent to the 9 MHz suppressed carrier. The Crystal Filter removes one sideband and provides additional suppression of the carrier. The single sideband output of the Crystal Filter is mixed with the output of the synthesizer in the Transmit Mixer. The difference of these two inputs is the signal at the operating frequency. That signal is amplified in the 3 section Preselector Filter amplifier to attenuate the other mixer products. The output of the Preselector is then amplified to 100 Watts, by the Power Amplifier. The Low Pass Filter attenuates harmonics of the operating frequency that may have been generated in the Transmit Mixer or Power Amplifier. The Automatic Level Control (ALC) will produce an ALC signal for the Preselector whenever the peak power exceeds 100 Watts or when the standing wave ratio of the transmission line between the ASTRO-150 output and the antenna is 2:1 or greater and the voltage or current on the transmission line is equal to that for a 100 Watt peak signal. An amplifier in the Preselector amplifies the ALC voltage which is applied to gate 2 of the Preselector amplifier.

3. Synthesizer. The digital synthesizer is the heart of the versatility of the ASTRO-150 transceiver. Before describing the operation of this particular synthesizer, it is informative to review the fundamental operation of a basic phase locked loop. Figure 7-3 illustrates a simple form of a phase locked loop in a block diagram form.

The desired output frequency is phase locked, i.e., phase stable, to a crystal reference oscillator. In this example loop, the desired output frequency has the long term stability characteristics of the stable reference oscillator - hence, crystal stability for all frequencies over the entire VCO band of operation.

The x_0 is selected to operate at a frequency that is applicable to the particular frequency scheme of the radio, and optimum as far as a stable operating crystal frequency is concerned.

The output of the reference oscillator is divided by some number N such that the reference frequency F_r is compatible with the phase detector and the divided frequency from the voltage controlled oscillator (VCO). This reference frequency F_r also determines the digital frequency step resolution of the synthesizer, i.e., for a 100 HZ F_r , the synthesizer can produce phase locked output frequencies in 100 HZ steps.

The VCO operates over a band of desired output frequencies. The frequency of the VCO is determined by a DC control voltage. One of the outputs of the VCO is the desired output frequency. A second output is divided by some number M , and F_s is fed to the phase detector.

If $F_s = F_r$, the output of the phase detector will be some DC voltage, and for discussion purposes, let's say zero volts. If the VCO output frequency increases, the loop frequency, F_s , will increase, and the phase detector sees an increasing phase with respect to its stable reference F_r . The output of the phase detector will be a DC voltage that is filtered through a low pass filter which drives the VCO output to the exact frequency such that $F_r = F_s$ and thus "locks" the loop. If the VCO output frequency decreases, the phase detector DC output is of the opposite polarity and the DC control voltage drives the VCO in the opposite direction to regain $F_s = F_r$.

Again, for discussion purposes, let's assume a 10 MHz reference oscillator frequency and N is 100,000. This establishes $F_r = 100$ Hz. Now, assume that we desire a stable 5 MHz output frequency. If M is 50,000, then $F_s = 100$ Hz and the phase detector and filter will keep zero voltage applied to the VCO, or will correct the frequency to zero error with the proper DC error voltage. This action phase locks the 5 MHz output to the 10 MHz reference oscillator.

Now, let's say we want to change our desired output frequency to 5.5 MHz. We need only to change the programmable divider M to 55,000, then the $F_s = 100$ Hz for a 5.5 MHz desired output frequency and the loop will acquire phase lock.

It is now clear that by merely changing M, the programmable divider, a complete spectrum of output frequencies may be derived, each phase locked to the crystal stable reference oscillator. One further note, the output of the phase detector could by any reasonable DC voltage range for phase lock compatible to the VCO design (not necessarily centered around zero volts) and an increase in the zero "error" or control voltage from its zero error reference will drive the VCO in the opposite direction. In each case, the error voltage drives the VCO output frequency such that F_s will equal F_r .

The frequency synthesizer in the ASTRO-150 utilizes these fundamental principles in a two phase locked loop design.

The frequency synthesizer generates crystal controlled frequencies in 100 Hz steps for all amateur bands 80-10 meters (160-15 Model 151). Figure 7-4 is a block diagram of the complete synthesizer.

Two phase locked loops (PLL) are used to generate the crystal controlled frequencies. (It is noted that frequency generation of this nature obviously removes any requirement for the crystal calibrator since the derived frequencies are phase locked to the crystal controlled reference oscillator)

The two synthesizer loops perform functions similar to the conventional band crystal oscillators and PTO's or VFO's. The band PLL phase locks five different VCO's to a 500 KHz reference. The band VCO outputs are divided by a diode programmed divider so that band VCO frequencies are variable in steps of 500 KHz. The band switch sends a "true Level" to the proper VCO and diode program. This will phase lock the band frequency to the 500 KHz reference. The output of the selected band VCO is fed to a double balanced mixer to be summed with the tuning VCO.

The tuning PLL uses a 100 HZ reference to provide an output of 5 to 7 MHz in precise 100 HZ steps. This loop is controlled by the microcomputer. The output of the tuning VCO is the "signal" input to the synthesizer mixer. The mixer output is fed to the LO bandpass filters. The correct filter is selected by the bandswitch selected "true level." The output of the filter is the local oscillator for the transceiver.

The microcomputer is used as a complex controller. The control functions are programmed on a read-only-memory to give precise control and frequency memory. The basic functions are:

- (a) Take input data for:
 - 1. Band
 - 2. Mode (USB, LSB, CW)
 - 3. VRS or tuning mic
- (b) Determine:
 - 1. Required tuning divider number
 - 2. Required frequency readout
- (c) Store last tuned frequency on each band

The microcomputer program must account for such variable as bandedge frequency, sideband shift, and tuning rate.

8.0 CALIBRATION

Most circuit alignment and calibration is factory performed at final check-out, and should require no further adjustment. In cases where it becomes necessary for some reason to align circuits other than those described in this section, it is recommended that the unit be returned to the factory for a complete alignment and check-out.

Figure 8-1 through 8-4 are top, bottom, and both side views with adjustment locations noted.

Operator-owner calibration and alignment may be desirable for the following functions.

A. Carrier Oscillator Frequency

Connect a 10:1 probe to Pin 1 of Z101 (1st Mixer). Connect the probe output to the high impedance input of a frequency counter. Terminate antenna connector in a 50 ohm dummy load.

1. With mode switch in the LSB position and Mic gain full CCW, key transmitter and adjust C2158 for a reading of 9000.00 KHz.

2. With mode switch in the USB position and Mic gain in full CCW, key transmitter and adjust C2152 for a reading of 9003.30 KHz.

3. With mode switch in the CW position and Mic gain in full CCW, key transmitter and adjust C2148 for a reading of 9002.50 KHz.

4. Repeat steps 1 through 3 as necessary to get all readings with ±10 HZ.

B. Sidetone Adjustment

1. Insure Mic Gain control is maximum CCW.

2. Switch unit to CW mode and key unit with CW key or microphone push-to-talk.

3. Adjust sidetone level (R2274) for desired volume.

C. AGC and S-Meter

1. Insure VOX/PTT switch is in PTT position, and mode switch is in LSB position. Remove microphone or CW key from mic jack.

2. Connect RF signal generator to antenna jack. Tune to 14200 KHz, CW output, 50 uv (-73dBm).

3. Tune unit to receive signal generator and adjust for approximately 1 KHz audio note in speaker.

4. Connect AC voltmeter to the high pin of volume control.

5. Adjust R2172 (AGC threshold) until voltmeter reads .21 vrms on high pin of volume control.

6. Adjust S-Meter Cal. (R2177) for an indication of S-9 on S-Meter.

7. Remove signal generator from antenna jack.

D. VOX

Three VOX adjustments are available on the left side of the unit. These are R2217 VOX gain, R2225 VOX antitrip, and R2222 VOX delay.

These adjustments are factory set for average operating conditions, but can easily be reset to suit the operator's microphone and noise environment. It is good practice to operate VOX gain set to lowest gain consistent with reliable operation. Delay is set to operator's preference (usually .1 to .2 seconds).

VOX adjustment Procedure:

1. Tune Transceiver for normal voice operation.
2. Rotate the transceiver MIC GAIN fully counter-clockwise. This will prevent audio from being transmitted but will not effect VOX operation.
3. Reduce receiver gain until no sound is heard in the speaker. This will prevent sounds from the receiver speaker from tripping the VOX during initial adjustments.
4. Place VOX/PTT switch in VOX position.
5. While speaking into the microphone in a normal manner, slowly rotate the VOX GAIN control clockwise until the VOX keys the transmitter. Do not use more VOX GAIN than necessary to assure positive operation at normal voice levels.
6. Increase the receiver gain until received signals are at a normal voice volume level. These signals will trip the VOX when picked up by the microphone.
7. With the microphone held in the normal operation position, very slowly increase the ANTI-VOX until received signals do not trip the VOX.

NOTE: Excessive ANTI-VOX gain will cause received signals to control so that no amount of sound at the microphone will key the transmitter. Satisfactory balance between the VOX GAIN and ANTI-VOX is easily obtained when the microphone is a foot or more from the speaker.

8. Adjust the DELAY Control until the transmitter stays on for the desired interval after you stop talking.

NOTE: A little experimenting on the air will reveal that only a small portion of the first spoken syllable is lost when the VOX is actuated. Short DELAY settings will result in most efficient operation.

E. Microphone Scan Rate

The microphone scanning rate is factory preset to about 1 KHz/second tuning speed. This rate can be increased or decreased by screwdriver adjustment available from the right side. A small screwdriver with at least a 4 inch shaft is necessary for this adjustment.

1. To set microphone scan rate engage microphone up or down tuning switch and adjust tuning speed as desired with R4112.

F. Component Replacement and Repair Notes

Should component replacement be necessary, it must be recognized that many of the circuit boards in the ASTRO-150 utilize double sided copper clad. Therefore, in order to remove components without destroying etch, the solder must be removed before the component is removed. Solder wick dipped in flux should be laid over the joint to be de-soldered. Apply heat with a 25 Watt iron over the braid (wick) and "wick" off the solder. Do not force pull out the component. They will come much easier and leave the etch if all solder is removed first. Do not use large hot irons for repair work.