TEN - TEC

# OWNER'S MANUAL

## MODEL 100
## Civil Air Patrol Transceiver

CONTENTS




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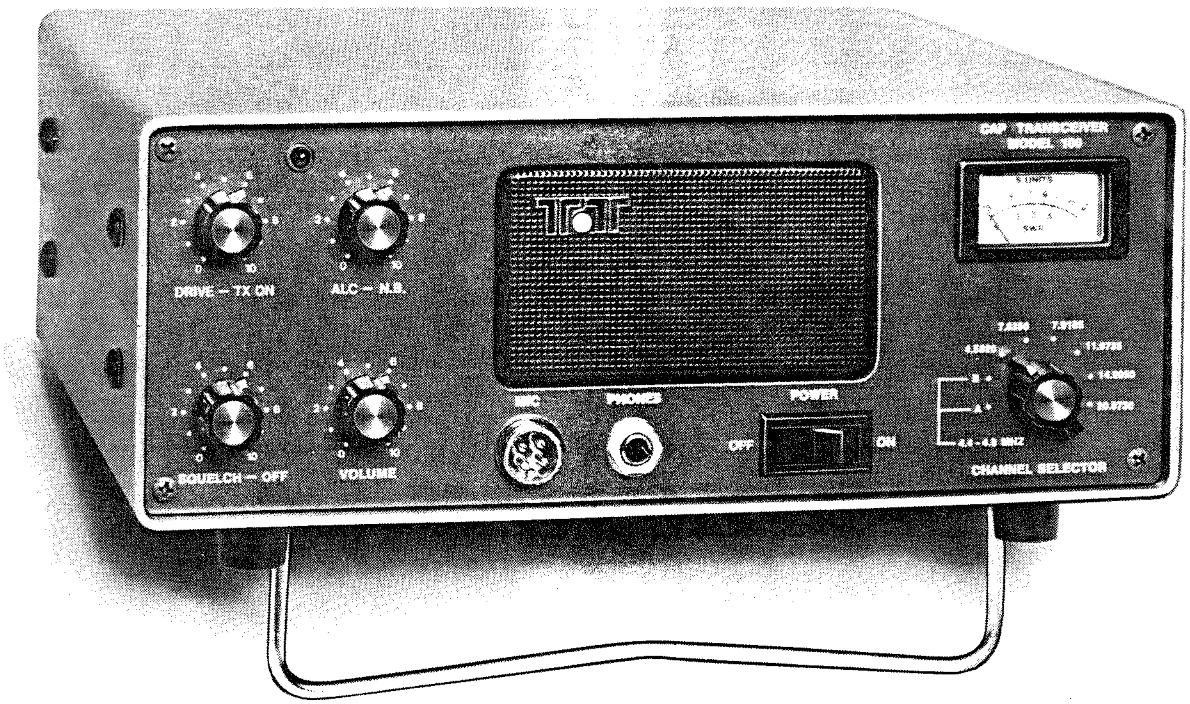



**Model 100**
civil air patrol
transceiver

# SECTION I

## UNPACKING

Carefully remove your Model 100 from the packing carton and examine it for signs of shipping damage. Should any damage be apparent, notify the delivering carrier immediately, stating the full extent of the damage. Retain all damaged cartons. Liability for shipping damage rests with the carrier.

It is recommended that you keep the shipping carton and fillers. In the event that storage, moving or reshipment becomes necessary, they come in handy. Accessory hardware, etc. are packed with the transceiver. Make sure that you have not overlooked anything.

## INTRODUCTION

The TEN-TEC Model 100 Civil Air Patrol Transceiver is a medium power single sideband hf transceiver employing the latest techniques in solid state technology. It was designed and tested in close cooperation with CAP officials so that all desired channels and operating features for this service are provided for in one unit. These include broadband circuits, which reduce operator transmitter and receiver adjustments to a minimum, eight crystal controlled channels with automatic selection of the proper sideband, basic 12 volt circuits for convenient mobile and portable operations and a sensitive receiver section with frequency response characteristics tailored for best articulation and intelligibility. A full line of matching accessories customize your station for your particular needs.

Because of the low voltage solid state design, with its corresponding low operating temperature, Model 100 will provide you with a very dependable means of communication at its top performance level for years to come.

## SPECIFICATIONS

### GENERAL

FREQUENCY CHANNELS: Eight Position Selector Switch. All channels crystal controlled.

OPERATING FREQUENCIES: Two user selected frequencies between 4.400 and 4.800 MHz, 4.5820, 7.6350, 7.9185, 11.9735, 14.9050 and 20.8730 MHz. All frequencies are carrier reference frequencies.

OPERATING MODE: Upper sideband on all channels except lower sideband on 14.9050 MHz. A3J emission.

FREQUENCY TOLERANCE: $\pm$ 50 Hz for supplied crystals. Internal adjustments to calibrate all channels.

TEMPERATURE RANGE: $0^{\circ}$ to $40^{\circ}$ C.

POWER REQUIREMENTS: 12-14 V dc, 18 A maximum, regulated to 5%.

CONSTRUCTION: All circuits solid state. Case and chassis all metal.

SIZE: HWD 5" x 11-3/8" x 12-1/8" overall (bail not extended).

WEIGHT: 10 lbs.

### RECEIVER

SENSITIVITY: 0.3 uV for 10 dB S+N/N, maximum.

SELECTIVITY: 2.4 kHz bandwidth. Standard 4 pole crystal ladder i-f filter supplied. 2.7:1 shape factor @ 6/50 dB.

DYNAMIC RANGE: 85 dB, typical.

I-F FREQUENCY: 9.003300 MHz.

I-F REJECTION: Greater than 60 dB.

S-METER: Automatically switched on when receiving.

ANTENNA INPUT: Low impedance, unbalanced.

AUDIO OUTPUT: 1 watt @ 8 ohms. Built-in speaker and squelch.

TRANSMITTER

MAXIMUM INPUT POWER: 200 watts.

POWER OUTPUT: 85-100 watts, all channels @ 13.5 V dc.

RF OUTPUT IMPEDANCE: 50 ohms, unbalanced.

SIDEBAND GENERATION: Balanced modulator through 4 pole filter at 9.003300 MHz.

SWITCHING MODE: Push-To-Talk (PTT) switch on microphone.

METER: Automatically reads Standing Wave Ratio (SWR) when transmitting.

CARRIER SUPPRESSION: 40 dB, minimum.

UNWANTED SIDEBAND SUPPRESSION: 30 dB, minimum.

SPURIOUS RESPONSES: Greater than 40 dB down from full power level.

AUTOMATIC LEVEL CONTROL: Adjustable threshold with LED indicator.

MICROPHONE INPUT: High or low impedance types with 5 mV level, minimum. Polarizing voltage for Model 214 Electret Microphone supplied.

FRONT PANEL CONTROLS

CHANNEL SELECTOR switch: VOLUME control: POWER ON/OFF switch: DRIVE-TX ON control and pull switch: ALC-N.B. control and pull switch: MIC connector: PHONES jack: SQUELCH-OFF control and pull switch.

REAR PANEL CONNECTORS

POWER socket: ANTENNA socket: PHONES/SPEAKER jack: PATCH IN and OUT jacks: 12 VDC jack: COUNTER jack: T/R control jack: XTALS OUT and IN jacks: EXTRA.

# SECTION II

# INSTALLATION

## GENERAL

For fixed station installations, choose an operating location that is cool and dry. Allow adequate ventilation around the heat sinks on the rear panels of both transceiver and power supply. For normal intermittent transmissions, natural convection cooling is all that is required. During mobile operation, free access to cool air should be provided to the heat sink also. Do not direct the outlet vent of the automobile's heater directly at the transceiver.

To reduce the possibility of stray rf pickup on interconnecting cables, which may cause undesirable parasitic oscillations, and provide a measure of safety to the operator from possible shock in ac powered systems, all station equipment should be well grounded to earth. It is also important to strap the equipment chassis together with short heavy leads, preferably with braid. This procedure brings all metal components that are accessible to the touch to the same potential, removing the possibility of shock when touching more than one piece of equipment. Also, the extra strap between transceiver and power supply chassis serves to reduce voltage loss on the negative 12 volt supply lead caused by resistances in the lead and connector contacts. If a metal operating table is used, be sure to ground it also. In mobile installations, connect a ground strap between the rear panel GND post and the automobile chassis (dash board if it is metal).

Earth ground leads should be of heavy wire or braid and be as short as possible and attached securely to a ground rod driven into the earth near the operating position.

## FIXED STATION INTERCONNECTIONS

A supply of 12 to 14 volts dc, capable of supplying 18 to 20 amperes, negative ground, is required. Voltage regulation of 5% or better between no load and full load is required for distortion-free transmissions. (e.g. A 13.5 volt no load supply should not go below 12.8 volts at 18 amperes.) Model 100 may be operated directly from an automobile type storage battery in fixed locations, provided that the voltage under full load does not fall below 11 volts. This requirement dictates that the battery be near full charge and that the internal resistance be low (a relatively new battery). It is permissible to connect a slow charger across the battery to maintain the full charge condition. However, if the charger is left across the battery during operation, some unfiltered ac ripple from the charger may cause a slight amplitude modulation on the transmitted signal at the line frequency. If relatively short periods of use are common, it is recommended that the charger be disconnected while operating. In all cases of battery operation, Model 1140 Circuit Breaker should be used in series with the +12 volt lead to provide over-current protection.

For 115 or 230 volt ac installations, a well regulated supply is required. TEN-TEC Models 255 and 280 supplies are recommended. Both have over-current and over-voltage protection circuits.

## POWER CONNECTIONS

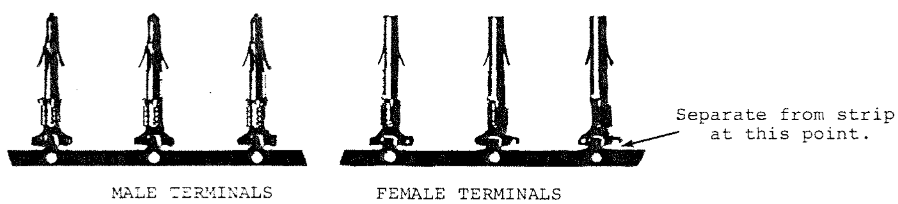
Power is supplied to the transceiver by means of the four pin AMP MATE-N-LOC connector. The chassis connector is of the male type and mates directly with the cable connector supplied and attached to Models 255 and 280 supplies. It is only necessary to insert cable connector into chassis receptacle with the red wire in the cable going to the topmost pin, marked + on rear panel.

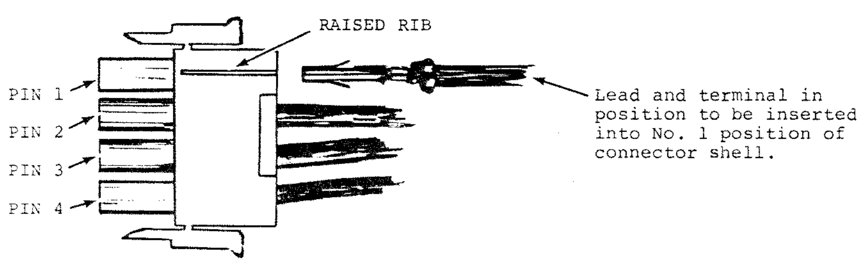
When used with these supplies, the power on/off function is controlled by the front panel POWER switch on the Model 100. The POWER switch on the power supply must be left in the 'on' position at all times, otherwise the supply will not be energized. The two switches are connected in series and to the incoming ac line to the transformer primary winding in the power supply.

When using a dc source other than a TEN-TEC power supply, it will be necessary to construct a power cable using the accessory AMP connector supplied with the transceiver. Wires for carrying the 12 volt current should be at least 14 gauge copper, with 12 gauge recommended. Leads should be kept as short as possible to reduce line voltage drop. Pin connections (see AMP MATE-N-LOC detail drawing) are as follows: Pin 1 = GND; Pins 2 and 3 = ON/OFF switch; Pin 4 = 12 to 14 volt positive dc. Pin 1 has a rib on the plastic shell of the cable connector and Pin 4 has a rib on the chassis connector. Pins 2 and 3 need not be used with supplies that do not have the remote on/off switching capability. When they are used, wire gauge can be 16 or 18.

Model 1140 Circuit Breaker should be installed in series with the + 12 volt lead when either a supply other than a TEN-TEC model or a battery is used. The same precautions on wire size and length should be heeded when using a battery. The switch on the front panel of the transceiver may be used to switch the 12 volt dc line directly by constructing the cable as follows: With a short length of heavy insulated wire, connect Pin 1 to Pin 2. Connect the +12 volt supply lead to Pin 3 and the -12 volt lead to Pin 4.

AMP Universal MATE-N-LOC Connector - This connector is intended for high production with automatic staking of the wire to the pin terminals. However, it can be assembled in the field without staking machinery by crimping and soldering the leads to the terminals, and inserting the terminals into the plastic shell. To do this, refer to the detail drawing below and proceed as follows:




AMP MATE-N-LOC CONNECTOR DETAIL

1. The terminals are supplied connected to a strip of flat metal. Break the individual connectors from the strip by bending back and forth at the point of narrow attachment, or by clipping them off with diagonals.

2. Wire sizes that can be accomodated range between 12 and 18 gauge. Strip insulation 1/4" back from end.

3. Insert stripped end into barrel far enough so that insulation just starts between large thin and small wide tabs.

4. With long nose pliers, roll over small wide tabs so that they hold bare wire.

5. Solder leads to rolled tabs by applying iron tip to top of rolled tabs while feeding rosin core solder between wire and tabs. Do not allow solder to run down into hollow tube.

6. After terminals are well soldered, roll large thin tabs down over insulation and crimp with pliers.

7. Insert terminals into plastic shell from solid plastic end so that they finally locate in individual tubes. The terminals will automatically lock

into place when inserted to the proper depth. MAKE ABSOLUTELY CERTAIN THAT TERMINALS ARE INSERTED INTO CORRECT HOLES SINCE REMOVAL IS DIFFICULT.

To remove terminals, an extractor is necessary to collapse the lanced holding tabs on the sides of each barrel. The extractor can be a metal tube, at least one half inch long, with an outside diameter between 0.125" and 0.135" and an inside diameter of 0.100". Insert the extractor tube into the pin end of the shell, over the terminal to be removed, to a depth of about 1/2". Pull on the wire and extract terminal.

Additional connector kits are available from TEN-TEC at $1.00 each, with a minimum order of $2.00. When ordering, ask for AMP 4 pin MATE-N-LOC cable connector and specify male or female terminals.

Complete the power connections by plugging line cord of power supply into wall socket and interconnect Model 100 and power supply chassis with a short heavy grounding wire or braid.

## ANTENNA CONNECTION

Any matched antenna presenting 50 to 75 ohms impedance, one side ground, will load satisfactorily. Random length wire antennas and open wire feed systems will require a matching network such as the TEN-TEC Model 227 Antenna Tuner. (See Appendix I for specific CAP antenna information.) Use coaxial RG-58 cable between the Model 100 and antenna or output side of the tuner. If a tuner is used, locate it as far as is practical from the immediate transceiver location. Do not place tuner on top of transceiver or close to microphone or cables going to the transceiver or power supply. If different antennas are used for multiple channel operations, either an antenna switch or Model 227 should be used to facilitate antenna changes.

A type PL-259 coaxial connector is required to connect the antenna to the ANTENNA connector. The center conductor is connected to the pin and the cable shield braid to the shell of the connector.

For a detailed explanation of antenna and transmission line theory, see Appendix II.

## MICROPHONE CONNECTIONS

The microphone input circuit will accept any high or low impedance crystal, ceramic, dynamic or electret type microphone, providing it produces at least 5 millivolts of signal. It should incorporate a normally open Push-To-Talk switch which shorts to common GND when in the 'transmit' mode. TEN-TEC Model 214 Electret Microphone is especially well suited and compatible with the transceiver circuits.

The microphone connector is a standard four pin female mike plug with a threaded locking ring. The pin numbers, which are usually molded into the plastic portion of the connector, are connected as follows: Pin 1 = microphone signal; Pin 2 = common GND; Pin 3 = Push-To-Talk; Pin 4 = polarizing voltage for Model 214 microphone. If you use a microphone other than an electret type, Pin 4 does not require a connection.

## LINEAR AMPLIFIER CONNECTIONS

To facilitate switching a high power linear amplifier on in the transmit mode, Model 100 incorporates a T/R relay that is energized whenever the PTT switch is closed, or when the TX ON knob is pulled out. The contacts for this relay are brought out to the phono jack on the rear panel marked T/R. The center pin contact shorts to chassis GND during transmit. If the relay in the linear that controls this function is a 115 V ac type, do not use the T/R line directly to activate it since this will connect the transceiver chassis to one side of the ac line -- possibly the wrong or 'hot' side! Rather use an intermediate 12 volt dc relay between the T/R line and the ac relay. The +12 volts for this relay may be drawn from the AUX 12 VDC phono socket on the rear panel.

To reduce the possibility of rf pickup on interconnecting cables, use coaxial cable from the T/R jack, either RG-174 miniature cable or RG-58/9.

## PHONE PATCH CONNECTIONS

Two phono jacks are provided on the rear panel to gain access to the transceiver's speaker and microphone lines. The PATCH IN jack connects directly across the speaker, thus providing an audio signal into the phone patch circuits for transmission to the calling party. The voltage level on this line is approximately 1/2 volt under normal speaker volume, and is controlled by the VOLUME control on the front panel. If the phone patch requires a lower voltage, a resistance attenuator should be inserted at the PATCH IN output.

The PATCH OUT jack bridges the microphone input line so that the signal from the calling party out of the phone patch is applied to the transmitter section. The input impedance of this line is greater than 150 kohms so that it will not materially affect the operation of the station microphone. Voltage level from the phone patch should be in the neighborhood of 10 millivolts to match that of the microphone. A separate level control of the patch's output level is recommended so that a balance between its signal and the microphone level can be attained. The DRIVE control will adjust both simultaneously after they are balanced.

Use shielded cables for both phone patch connections, types RG-174 or RG-58/9.

# MOBILE STATION INTERCONNECTIONS

## POWER CONNECTIONS

Power requirements for mobile operation are the same as those outlined for fixed stations. When operating mobile, a power input cable will have to be constructed using the extra AMP connector supplied. Construction details are given in the previous paragraphs. The transceiver's POWER switch, or the Model 1140, can be used for the on/off function.

The maximum current drain of approximately 18 amperes is substantial enough to warrant special care to keep cable losses to a minimum. A separate set of 12 gauge or larger wires should be run directly from the battery terminals to the transceiver, with the circuit breaker in series and located near the transceiver. Only automobiles with negative ground systems should be used. Do not rely on the chassis to provide the negative connection, but run a wire directly from the negative battery terminal to the Model 100 power connector.

## ANTENNA CONNECTIONS

Most mobile whip antennas will provide a near optimum match to a 50 ohm input. In some cases, additional matching components may be required to achieve an acceptable SWR. Since whip antennas use the automobile's body as the ground plane, it is important that the shield of the coaxial cable at the base of the antenna be connected to a good chassis point. Trunk lids and some bumpers may require additional bonding to the main chassis with flexible straps or braid.

Resonating the whip at the operating frequency is a relatively easy procedure since the SWR bridge is built into the transceiver. With ALC control fully counterclockwise and with the TX ON knob pulled out, the resonant point can be determined by adjusting the whip length above the coil for minimum SWR. Make changes in 1/8 or 1/4" increments since the resonance dip is quite narrow, especially on the lower frequency channels. If the resonant SWR is above 2 to 1, a better match can be achieved by connecting a small capacitor across the base of the antenna to chassis. For single channel operation, the value can be determined and the capacitor permanently soldered in place. For multi-channel operation, a rotary switch in a small box can be located near the antenna base, in the trunk for instance, and the proper capacitor selected in this manner. Use mica capacitors with at least 500 volt ratings. Typical values for the 4 MHz band may be between 470 pF and 1000 pF. For 7 MHz, 270 to 820 pF, and for the higher channels, proportionately smaller values. Addition of the capacitor will require a slight touch-up in antenna length.

Although the Model 231 Noise Blanker accessory is effective in reducing ignition noise, it is best that the installation be such that ignition noise is reduced as much as possible without it. Use of resistor spark plugs and low noise ignition cable and noise suppressors in the distributor circuits are very effective in reducing interference. Also, strap the hood to a good chassis point with flexible metal or braid if it is not already well grounded. Locate the antenna as far as is practical from the engine - either on the rear trunk deck or bumper. And since the muffler and exhaust system on most cars are supported and effectively insulated from the chassis with rubber-shocked brackets, they may carry ignition noise currents to the antenna location at the rear of the automobile. Strapping the tail pipe or muffler to the chassis with flexible strapping may substantially reduce ignition noise pickup.

XTALS IN/OUT JACKS:

These two jacks on the rear panel are for use with optional accessory Model 233 External Crystal Oscillator. When used with this accessory, the jumper plug that is inserted into these two sockets should be removed. Installation instructions are given with Model 233. When the external oscillator is not used, the jumper plug <u>must</u> be inserted.

# SECTION III

## OPERATION

Special care has been taken in the design of the Model 100 to insure stable frequency characteristics. As a consequence, no warm-up time is necessary when first turning the unit on or when changing channels. The unit is ready to transmit or receive the second it is switched on.

### RECEIVING

There are only three controls that need be adjusted when in the receiving mode, CHANNEL SELECTOR, SQUELCH-OFF and VOLUME.

CHANNEL SELECTOR - Rotate this switch to the desired channel.

SQUELCH-OFF - This control sets the level of incoming signal over which the audio signal is passed on to the speaker. When turned fully counterclockwise, signals over approximately one microvolt will open the audio channel. As the control is rotated clockwise, higher levels of incoming signals will be required to open the audio. In the full clockwise position, the channel will remain closed at all times.

Squelch is most used when monitoring a channel and the background noise is disturbing. With the VOLUME control set to its normal position, rotate the SQUELCH control clockwise until the background noise is turned off. Any signal coming in above the noise level will open the audio channel. In cases where atmospheric noise bursts are present, adjust the SQUELCH control just a bit past where the normal background noise is eliminated to catch some of the lower noise bursts. Of course, if they are too severe, the channel will be opened momentarily. To fully disable the squelch function, pull the SQUELCH-OFF knob out.

VOLUME - This control sets the level of audio from the speaker. It also sets the level from either the PHONES or PHONES/SPEAKER jacks on the front and rear panels, as well as the level present at the PATCH IN jack.

PHONES and PHONES/SPEAKER jacks - These two phone jacks connect in series with each other and with the speaker so that if either one is used, the speaker is disconnected. The PHONES jack on the front panel takes preference over the PHONES/SPEAKER jack on the rear panel. If headphones are plugged into both at the same time, only the front panel jack will be operational. (If it is desired to access the speaker line without disabling the internal speaker, use the PATCH IN jack.)

Although the audio amplifier is designed for an 8 ohm load, external speakers between 4 and 16 ohms will work satisfactorily. Headphones of any impedance will also work directly from these jacks. However, since the amount of power needed to drive headphones to a satisfactory level is much less that for a speaker, it is recommended that an attenuator be used between the PHONES jack and low impedance headphones. The attenuator will greatly reduce residual noise and audio feed-through when transmitting. A simple resistor network consisting of a 15 ohm resistor in series with the phones and a shunt resistor of 2.7 or 3.3 ohms across the phones should suffice. The resistors, both 1/4 watt types, can be soldered to the phone plug terminals and concealed in the shell of the male plug. The attenuator is not necessary with high impedance headphones since the power to them is automatically reduced when connected to a low impedance source.

### TRANSMITTING

Other than the CHANNEL SELECTOR switch, there are two front panel transmitter controls, ALC-N.B. and DRIVE-TX ON. The PTT switch on the microphone controls the transmitter turn-on.

ALC-N.B. - The ALC (Automatic Level Control) portion of this control sets the maximum level of transmitted power to the load. When this level is reached, as indicated by the flashing of the Light Emitting Diode (LED) on voice peaks, any further attempt to increase output power by increasing the DRIVE control setting or by speaking louder into the microphone will be unsuccessful. When the control is fully clockwise, maximum rated power of between 85 and 100 watts will be delivered to a 50 ohm load. This is the most used position of this control.

In cases where the SWR is high enough to repeatedly trip the over-current circuits in the power supply or the Model 1140 circuit breaker, a reduction in the ALC setting will allow operation at a lower power level without having the trip circuits constantly shutting down the station. Another use for the ALC control is when the transceiver is driving a high power linear amplifier that does not require the full 85 to 100 watts of drive available. The ALC control should temporarily be set to the full clockwise position and the DRIVE advanced just far enough to fully drive the linear. Then the ALC control is rotated CCW to a point where the LED just lights on voice peaks. At this setting of the controls, the linear will be driven to full power without being overdriven, even if the DRIVE control is advanced.

The N.B. pull switch on the ALC control activates the optional Model 231 Noise Blanker when it is installed. This is a receiver function and has no effect when transmitting.

DRIVE - This control is the microphone gain control and increases output power up to the ALC threshold level. It should be advanced just far enough so that the LED flashes on voice peaks. Advancing the DRIVE beyond this point will not materially increase output power, but may cause an increase in distortion and affect intelligibility.

The TX ON pull switch on the DRIVE control puts the transceiver in the transmit mode without having to actuate the PTT switch. It also unbalances the modulator so that a carrier is present at all times. This mode of operation is used for antenna SWR measurements and for setting the crystal oscillators on frequency.

MEASURING SWR - To measure Standing Wave Ratio (SWR) accurately, two conditions must be met. First, the ALC control has to be rotated to the full clockwise position and second, the LED must be 'on'. It is possible that the LED will not glow on some of the higher frequency channels when the TX ON knob is out. (This is especially true if the optional Model 220 I-F Filter is incorporated in the transceiver.) To measure SWR under these conditions, push the TX ON switch 'in', operate the PTT switch and whistle a steady tone into the microphone with sufficient DRIVE setting so that the LED does light. The SWR reading so obtained will be accurate.

## OPERATING HINTS

1. The movable bail is primarily intended to raise the front panel to a convenient slanting position. It may be used as a carrying handle.

2. The S-Meter is factory calibrated for a 50 uV input signal reading of S9.

3. Increasing DRIVE beyond that required to just light the LED on voice peaks will not increase output power appreciably, but may increase audio distortion products.

4. Due to the possibility of high voltage transients being generated in the output rf amplifier during channel switching, change channels only in the receive mode.

5. Although improper antennas will not damage the transceiver, an SWR below 2 to 1 will produce maximum power and performance. In cases where the antenna cannot be matched to a suitable ratio, operate the transceiver at reduced power by turning the ALC control CCW. Full CCW produces about 25 watts.

6. When operating mobile, always turn transceiver 'off' when starting or stopping engine. High voltage transients from the generator may appear on the 12 volt line before the regulator contacts close.

7. A lightening arrestor on all antenna leads is good insurance.

8. During lightening and thunder storms, disconnect antenna from transceiver and close down operations. Ground all antennas if possible.

## IF YOU HAVE TROUBLE

Below is a list of common faults that may cause the transceiver to malfunction. All are caused by faulty components external to the Model 100, or from an oversight on the operator's part. If trouble is suspected within the transceiver, refer to the Service Policy section for information on handling in and out-of-warranty service.

| SYMPTOM | POSSIBLE CURE |
|---|---|
| Transceiver dead. No meter lamp illumination. Receiver and transmitter inoperative. | Make sure power switch is on.<br>If using TEN-TEC supply, make sure its switch is in the 'on' position.<br>Check power cable from supply or battery.<br>Check battery or supply for correct voltage.<br>Check 20 A fuse inside transceiver, located on back subpanel. (Remove top.) |
| 20 A fuse blown. | Check for reverse polarity on 12 volt line. Correct cable wires or connector termination. |
| Set seems alive but received signals are weak or non-existant. High SWR. | Check antenna system and cables.<br>Check settings of antenna tuner if used.<br>Try dummy load to determine if problem is in antenna system. (SWR should be near 1 to 1 with 50 ohm dummy load.) |
| Receiver dead. Transmits OK. | Check to see if headphones are plugged in, disabling speaker.<br>Make sure SQUELCH control is not advanced too far clockwise. |
| Receiver OK. Does not switch to transmit mode when PTT switch is pressed. | Check microphone cable, connector and PTT switch. |
| Receiver OK. Switches to transmit mode but LED does not come on when speaking into mike. | Check microphone, cable and connector.<br>Check setting of DRIVE control. |

## CHANNEL FREQUENCY ADJUSTMENTS

NOTICE: THIS EQUIPMENT COMES UNDER THE JURISDICTION OF FCC RULES AND REGULATIONS WHICH STATE THAT REPAIR AND/OR ADJUSTMENT MADE TO FREQUENCY DETERMINING CIRCUITS ARE TO BE MADE ONLY BY HOLDERS OF FCC COMMERCIAL LICENSES.

There are two subassemblies in Model 100 which carry crystal oscillators that determine the channel frequency the single sideband generator assembly with the 9.003300 MHz carrier oscillator and the crystal oscillator subassembly with the individual crystals for each channel. Field adjustments to bring the channels on frequency should be made only on the crystal oscillator board, since the carrier oscillator affects all channels simultaneously. Access to the adjustments is through the cut-out in the bottom cover under the small cover plate.

It is necessary that an accurate digital counter be used, one that is accurate to ± 5 Hertz, and preferably calibrated to WWV. Remember, a counter is only as accurate as the calibration of its internal time base oscillator. Just because it reads down to ± 1 Hertz is no guarantee that it is accurate enough for calibrating the oscillators in the transceiver.

To calibrate the oscillators, turn the ALC control fully CCW, connect the counter to the COUNTER jack and the ANTENNA jack to a 50 ohm dummy load. Pull the DRIVE-TX ON knob out. Use an insulated tuning wand and carefully adjust the appropiate trimmer as indicated on the diagram on the cover plate to within 5 Hertz of the channel frequency. The adjustment is very critical. If any crystal is removed from its socket, be sure to replace the rubber band around the group of four crystals when it is replaced. The crystal cases should not be left to intermittently touch one another since this affects the oscillation frequency. Also, the adjustments must be made with the bottom cover in place.

# SECTION IV

## LIMITED WARRANTY AND SERVICE POLICY

TEN-TEC, Inc. warrants Model 100 CAP Transceiver to be free from defects in material and workmanship for a period of one year after date of purchase under the conditions listed below. NOTICE: This equipment comes under the jurisdiction of FCC rules and regulations which state that repair and/or adjustments made to frequency determinining circuits are to be made only by holders of FCC commercial licenses.

### IN-WARRANTY REPAIRS

1. Registration: The warranty card must be returned promptly to establish the warranty period. Our card file also serves as a check on stolen equipment which may be sent in for repair. Please notify us immediately if your TEN-TEC equipment is stolen.

2. Original Purchaser: This warranty applies only to the original purchaser. Your warranty card establishes you as the original owner.

3. Communication with the Factory: If trouble develops, contact the factory directly or an Authorized TEN-TEC Civil Air Patrol Service Agency. If you are capable of performing field repairs, you will be advised whether to return the transceiver to us or to try a replacement subassembly that will be sent to you. If the indicated trouble area is one of the two subassemblies that carry the frequency determining components, they will be sent to you only if you have an FCC commercial license. If you do not have the necessary technical knowledge or the license (in the case of the two subassemblies), return the entire transceiver. To facilitate service calls to the factory, please use our direct Repair Department telephone number, 615-428 0364. (NO COLLECT CALLS, PLEASE.)

4. In-Warranty Field Repairs: To expedite repairs TEN-TEC will send replacement assemblies prior to receiving the suspected defective one from you. The replacement will be billed on a 30 day memo, and credit will be issued when the defective unit is returned to us. No remittance or deposit is required. If the defective assembly is not returned within 30 days, you will be billed. Unit will be shipped to you, transportation paid by TEN-TEC. Shipping charges to the factory are to be borne by you.

5. Proper Delivery: If the transceiver is returned to us, it must be adequately packed. A note should be included outlining the problem, conditions under which it appears, and attempted remedies. The more specific you are, the better the possibility of a complete fix. Shipping charges to the factory are to be borne by you. Unit will be returned transportation paid by TEN-TEC.

6. Exclusions: This warranty does not apply to damage by mishandling, lightning, voltages in excess of rating or changes in circuits. Claims for damage in transit should be filed with the carrier. Under no circumstances is TEN-TEC liable for consequential damage to person or property by use of this transceiver.

7. Extended Pro-Rata Warranty on Output Transistors: The output transistors are unconditionally guaranteed against damage for a period of one year after date of purchase, under any load condition or mode or operation, except for static discharge on the antenna or direct lightning strike. If they fail after the warranty period, the following replacement schedule will apply, provided that our service department makes the repair. (Prices listed are maximum and subject to reduction, depending on current transistor prices at time of repair.)

| 1 to 2 Years | 2 to 3 Years | 3 to 5 Years |
|---|---|---|
| $12.00 each | $15.00 each | $18.00 each |

(Two transistors per transceiver. Labor not included.)

8. TEN-TEC reserves the right to make any improvements to its products which it may deem desirable without obligating itself to install such improvements in its previously manufactured products.

9. This warranty is given in lieu of any other warranty, expressed or implied.

## OUT-OF-WARRANTY REPAIRS

1. Field Repairs: New circuit boards or discrete components can often be supplied to eliminate the cost and bother of shipping the complete unit to us, provided that the license conditions mentioned above are met. A nominal charge will be made for material sent.

2. Returned Units: Along with the transceiver, please submit a complete report on the nature of the malfunction and the conditions under which it occurs. This will enable our service department to pay special attention to your problem area and reduce overall labor costs. No matter what the malfunction is, every unit will be given a complete alignment and operational check before being returned to you.

3. Quotations: Quotations on repair work will be given on request, after examination of the unit. The amount quoted will be firm for the specific work outlined in the quotation. Should additional material or labor requirements come to light after the repair is initiated, you will be contacted for approval before this phase of the repair is started.

4. Repair Charge Payment: A report of all work done and parts used will accompany the bill. Prepayment will be required before the unit is returned. One of three methods of payment may be selected. 1.) Upon completion of the work the billing will be made but the unit will be held here. Upon receipt of the payment, the unit will be shipped. 2.) The unit will be returned to you on a COD basis, with COD charges borne by you. 3.) The repair charges may be paid by either MasterCard or VISA.
   Approval for COD or charge card options can be given either at the time the unit is submitted to us (in the accompanying letter) or when contacted upon completion of the repair. Please submit all raised information on your charge card when paying by this means.

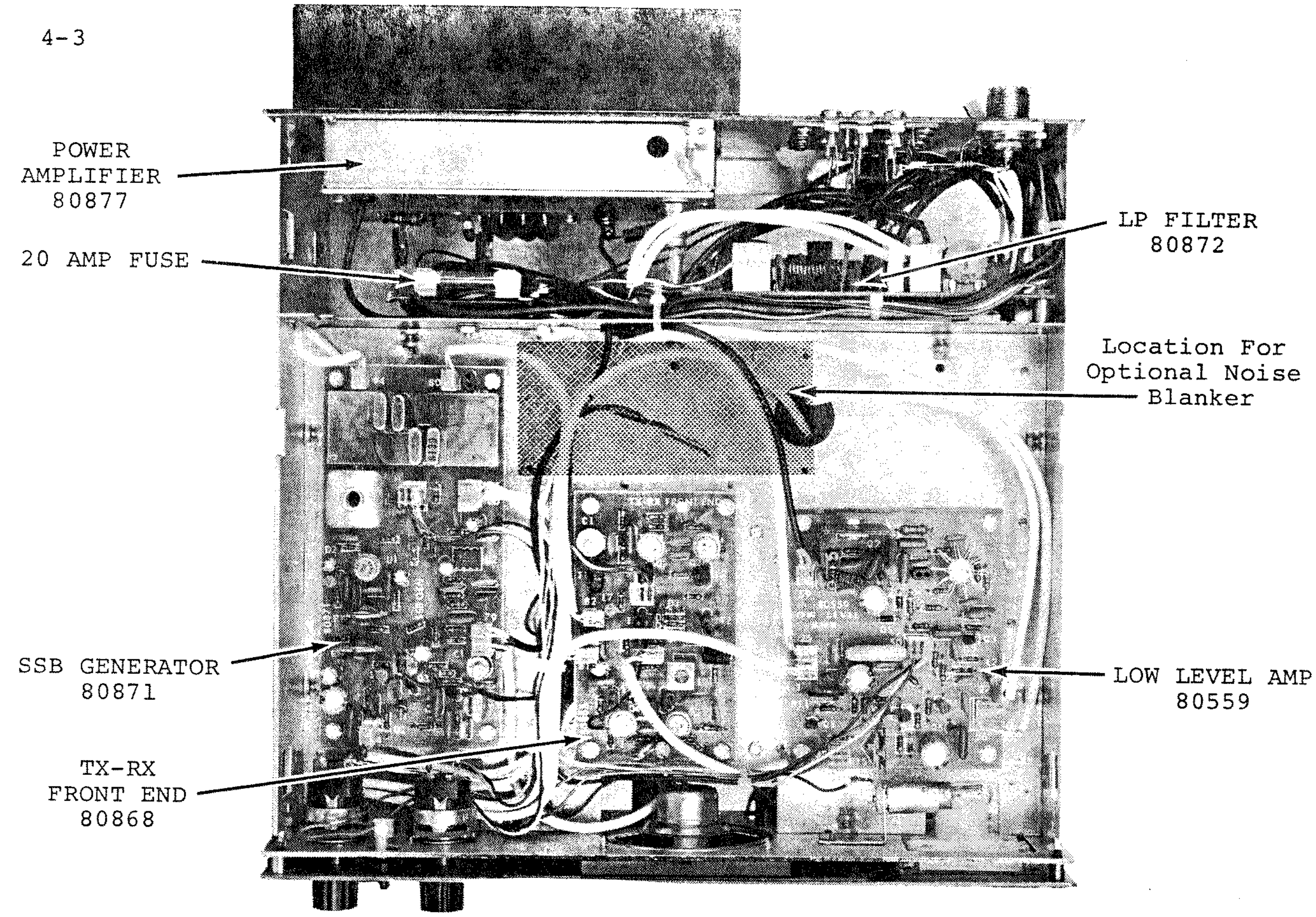
5. Transportation Charges: Units should be returned, transportation and insurance charges prepaid. Return transportation and insurance charges will be billed to you with other costs.

## REPLACING MODULAR SUBASSEMBLIES

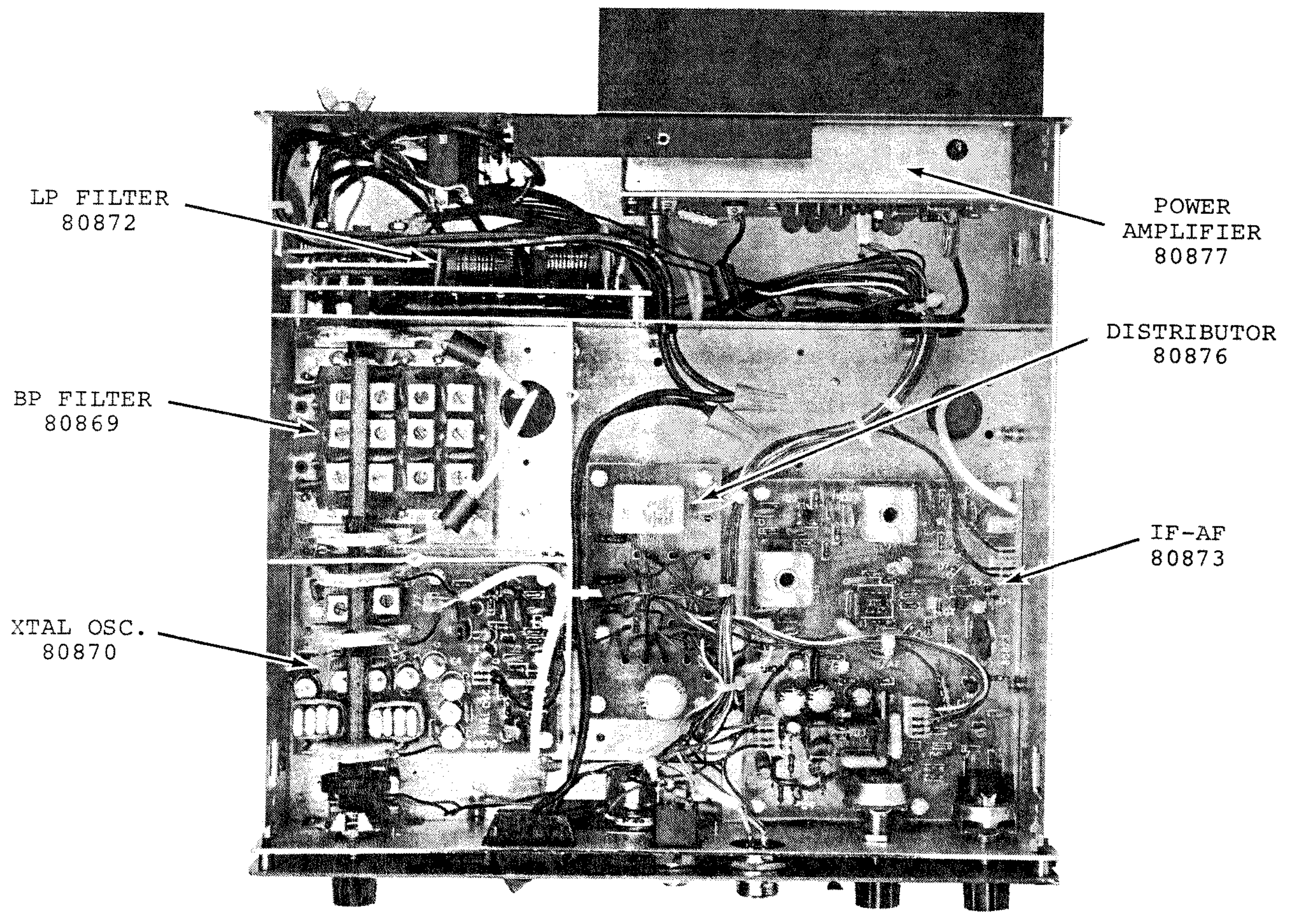
There are nine modular subassemblies in the Model 100. With the exception of the POWER AMPLIFIER 80877, all are easily removed without soldering operations by unplugging the top-mounted cables and removing the four mounting screws. The power amplifier requires unsoldering one red wire. Subassembly locations are shown on the inside photographs on Page 4-3.

Three modules require minor mechanical operations before removal is possible. XTAL OSC 80870, BP FILTER 80869 and LP FILTER 80872 have a common CHANNEL SELECTOR switch shaft running through them which will have to be removed. To do this, remove the plug button in the rear panel below the GND post, loosen the #6-32 set screw in the shaft coupler located in the XTAL OSC compartment and withdraw the shaft through the rear panel. To remove the LP FILTER it will also be necessary to unsolder the white wire at the ANTENNA connector location, remove the four screws holding the rear panel to the side panels and swing the panel out of the way. If one of the three assemblies with switch deck/s is removed, it is necessary to orient the position of the switch rotors correctly before replacing the shaft. A half-round notch on one side of the flatted shaft hole in the rotor is the key to proper alignment. This notch should be on the same flat for all switch decks in the transceiver. (It is possible to have the rotor 180° out of alignment.)

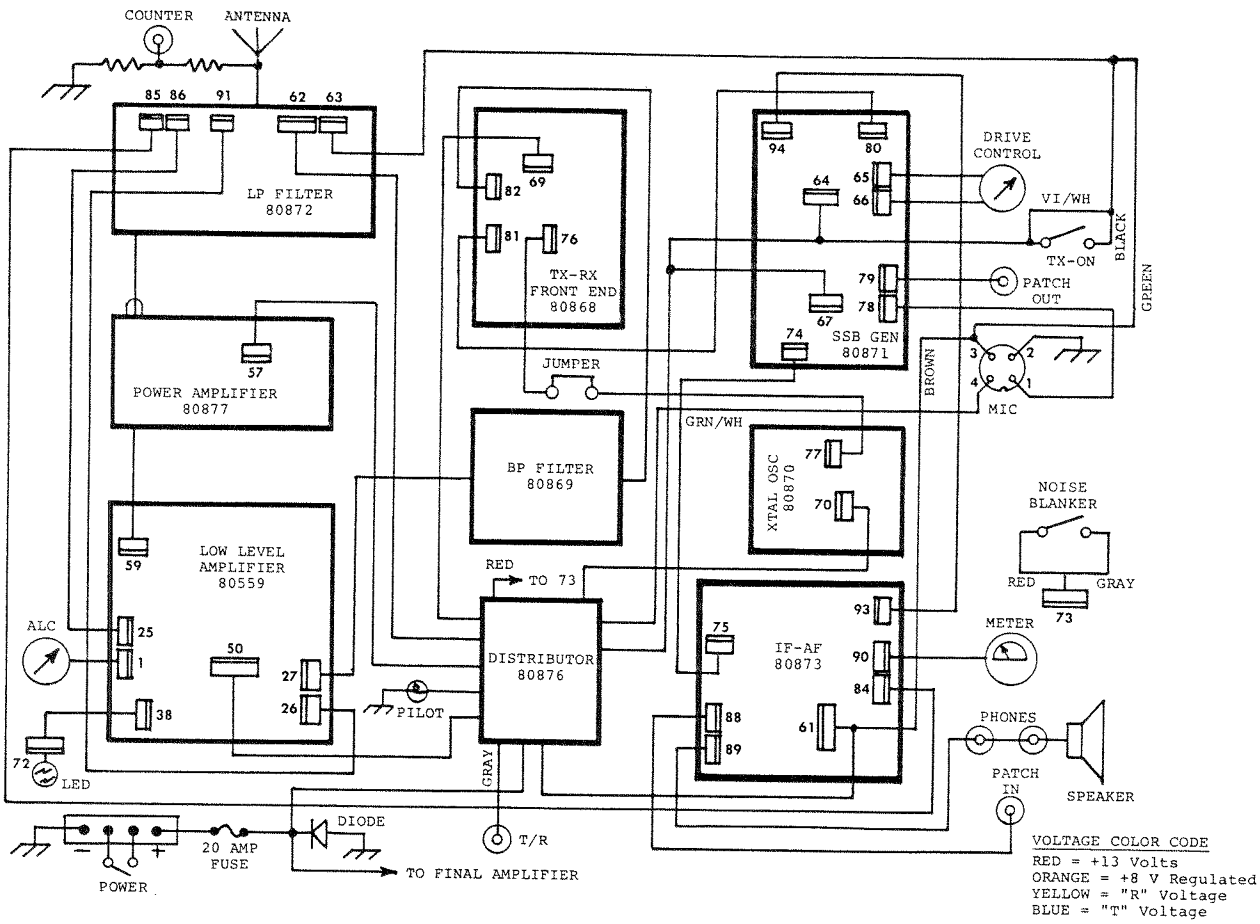
All plug-in cables are numbered and coded to the numbered sockets on the PC assemblies. The cable diagram on Page 4-4 shows the interconnections between the boards and other components.



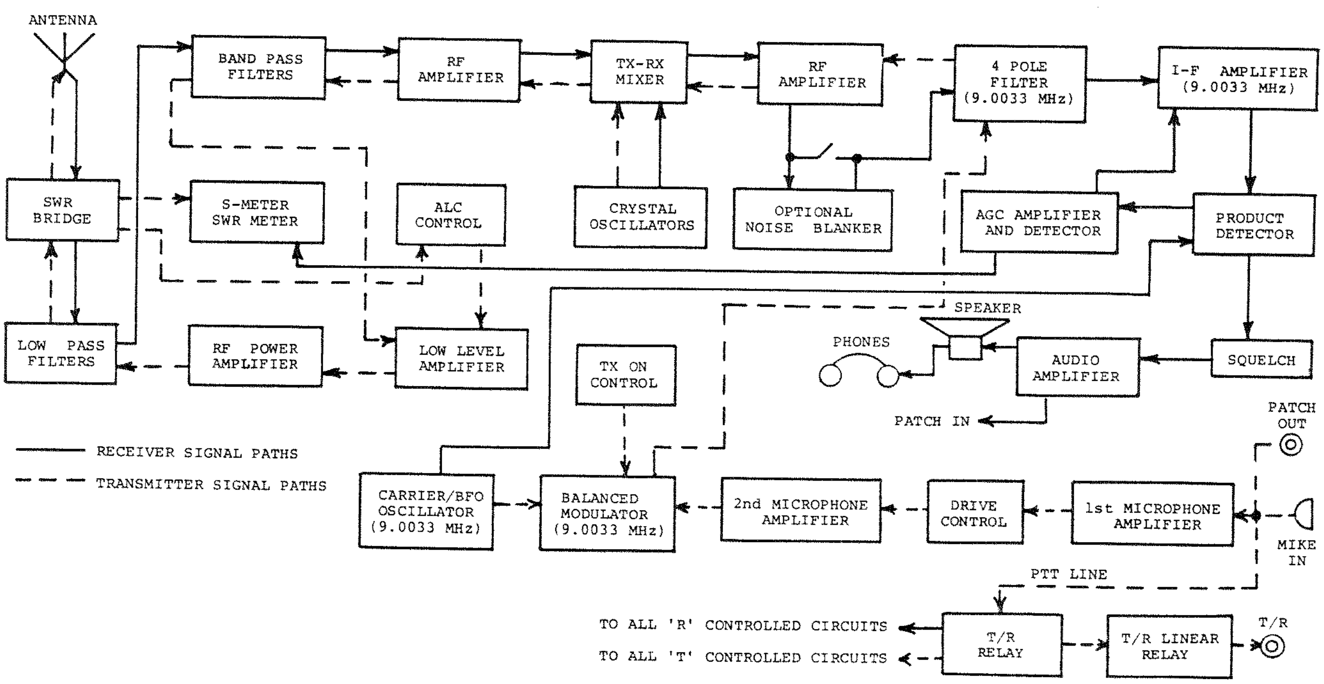

MODEL 100 - TOP VIEW




MODEL 100 - BOTTOM VIEW




MODEL 100 - CABLE DIAGRAM




MODEL 100 - BLOCK DIAGRAM

# APPENDIX I

# ANTENNAS FOR CIVIL AIR PATROL FREQUENCIES

## GENERAL

There are several basic types of antennas that are suitable and easy to construct for the CAP frequencies. Several considerations should be undertaken before making a choice of antenna type. The number of channels you intend to cover and the available space are certainly two important ones. Also to be considered is the decision to invest or not in a tower and its impact on your landscaping (and neighbors).

The dimensions given below are mean values and may vary slightly depending on antenna height, proximity of buildings and trees (especially near the ends of dipoles), and in the case of mobile whips, the location of the antenna and the type of body on the automobile. In most cases the dimensions given should produce an operating SWR below 2 to 1.

## FIXED STATION ANTENNAS

Common antenna types for fixed stations include half wave dipoles, inverted vees, multi-dipoles, long wires, verticals and beams. A brief discussion of each follows.

Half Wave Dipoles - Certainly the dipole is one of the easiest antennas to construct. It resonates at the fundamental frequency where its electrical length is equal to one half wavelength, and can be used with the same lead-in at frequencies three and five times the fundamental without matching networks. Unfortunately none of the CAP frequencies have this three or five relationship to each other, so unless an antenna tuner is used, the dipole can be used only for one band. However, since every antenna has an acceptable range of frequencies (bandwidth) where the SWR is below 2 to 1, it is possible to use one antenna to cover two or more channels in the same band, if cut to a length midway between the extremes desired. For dipoles at these frequencies the bandwidth for a 2 to 1 SWR limit is approximately 3-1/2% to 4% of the operating frequency. No problem should exist in using a single antenna to cover any two or more frequencies in the 4 MHz band and a single antenna cut to 7.775 MHz will serve both the 7.6 and 7.9 MHz channels.

Dipoles can be fed with 50 or 75 ohm coaxial cable directly. They are cut so that the final end-to-end length is that given in the tables. An egg insulator should be placed exactly in the center and the center conductor of the cable connected to one leg and the cable shield braid to the other. The feed line can be any length. It is a good procedure to strip the insulation from the ends of the wire where it connects to the egg insulator and at the outer ends so that no loops of insulated indeterminate length are present. Support the ends with nylon or Dacron line to available trees, poles or buildings. Do not use wire for the supporting lines since the end effect on the dipole is greater than with plastic. Stay away from cloth type clothesline since it absorbs water and stretches greatly. Antenna wire can be any insulated or bare wire of a minimum 18 gauge, preferably copper covered steel (copper-weld). If solid copper is used, it may stretch in time if the gauge is too small. Aluminum wire is satisfactory if suitable connections can be made to the coaxial cable -- usually a mechanical joint that is moisture-proof.

The directivity pattern of a simple dipole is a figure eight with the directions of maximum radiation broadside to the wire and near perfect nulls off the ends. If you have a preferred direction of transmission, orient the dipole accordingly if space permits.

Antenna height should be at least a quarter of a wavelength for the lower frequencies, and half wave for the higher channels. The table in this section gives recommended heights.

Inverted Vee Antennas - The inverted vee is basically the dipole with a different type of support. The center of the antenna, where the lead-in is attached, is mounted on a non-conducting pole and the legs slanted downward so that the included angle is between 90° and 120°. The ends should be kept a reasonable distance above ground. Because of the increased end capacity to ground, the length of this antenna is somewhat shorter than the dipole. The amount of decrease depends on the included angle and height of the ends from earth. If this height is reasonable, it is an easy task to start with a length longer than indicated and trim the ends for minimum SWR at the operating frequency. The feedline should be 50 ohm coax as with the dipole.

Multi-Dipole Antenna Arrays - It is possible to feed several or more dipoles with the same cable. Just tie them all together at the center. A good plan is to run the individual antennas at angles to each other -- at least 30° or 45° between dipoles. With a 45° spacing, four dipoles can be accommodated with a single feed line. Several dipoles can also be connected together and run in the same vertical plane as long as one is a considerable distance from the other vertically at their ends. This arrangement is not as satisfactory since some interaction will occur due to the proximity of the legs. A minimum of about 15° should be held between legs.

Long Wire Antennas - These are the simplest of antennas to construct and erect. They can be used at any frequency, but have several disadvantages. First the long wire must be matched to the transceiver with an antenna tuner, such as the TEN-TEC Model 227. The tuner settings will be different for each channel, but a chart of settings can be compiled for fast return to the proper adjustments. Another disadvantage is that the single lead has to be brought into the operating room, usually through a feed-through insulator. This may present rf pickup problems on the interconnecting cables. Special attention to where the feed line is run is important. Keep it and the tuner as far as is practical from the transceiver and use 50 ohm coax between the transceiver and tuner.

It must be remembered that the lead-in portion of the long wire is also acting as a radiator, even though it is run vertically down the side of the house. When receiving, this portion of the antenna is more susceptible to the pickup of man-made noise within the house. The length of the long wire is not critical. A good rule to follow is to erect the antenna as high as possible and make it as long as possible. If it is found that one or the other channel just will not load, a small change in the overall length will usually remedy the situation.

Vertical Antennas - The vertical is a single band antenna unless traps are inserted at various locations along its length. It is beyond the scope of this discussion to delve into the design and construction of traps. However, when space is at a premium, a vertical may be the only answer. If cut to a quarter wavelength for the lowest frequency, it will match with a 50 ohm cable directly. If other frequencies are needed, an antenna tuner may present a passable match. However, it may be looked on as a 'last resort' antenna. And its height for the 4 MHz band is something over 50'. A good ground is required at the base of the antenna for the shield connection of the cable. Radials of at least 1/8 th wavelength or more will improve the ground requirement. They may be buried just under the sod and all connected to a ground rod driven into the earth near the antenna base. The more radials the better. The available trapped Amateur Radio verticals are not adaptable to CAP frequencies.

Beam Antennas - For the higher frequencies (11.9 through 20.8 MHz) a two or three element beam antenna will give the best performance. It is highly directional, so a rotator is required. Beams are usually installed on top of a 40' or higher tower. They usually have a single coaxial 50 ohm lead-in for the two or three channels covered.

Amateur 20 meter beams can be shortened to resonate at 14.9 MHz and a 15 meter beam will work without alteration at 20.9 MHz, provided that is is initially adjusted for the low end of the ham band. Unfortunately there are no Amateur beams to cover the 11.9 MHz channel, so unless one is adept at constructing beams, this channel is best covered with one of the other antenna types.

If an Amateur beam is contemplated, we recommend that a straight-forward single band beam be selected. Trapped multi-band beams may be difficult to alter to the CAP frequencies. Recommendations on using the Hy-Gain beams are given below, as are the dimensions for dipoles and verticals.

## MOBILE ANTENNAS

The mobile whip antenna is almost universally used in Amateur work. It likewise is a good choice for CAP installations. Precautions to observe when installing a whip are given in the forward section of this manual.

The usable bandwidth over which the SWR is below 2 to 1 is much less than that of the full length dipole or beam antenna. As little as 1/8th inch change in the whip length can alter the SWR beyond the 2 to 1 ratio on the 4 MHz band. As frequency increases, the usable bandwidth does increase and length adjustments are not as critical, but still tricky.

Specific dimensions for using the Hy-Gain and Hustler Amateur antennas follow below. Base capacitance loading to improve SWR is discussed in the forward section.

## ANTENNA DIMENSIONS

Dipoles: End-to-end half wave dimensions. Start with lengths about 1 or 2 percent larger and trim for 1 to 1 SWR. Height dimensions are minimums.

| FREQUENCY MHz | LENGTH Feet | Inches | HEIGHT Feet |
|---|---|---|---|
| 4.4645 | 106' | 5" | 45' |
| 4.4675 | 106' | 4" | " |
| 4.5045 | 105' | 5" | " |
| 4.5075 | 105' | 4" | " |
| 4.585 | 103' | 7" | " |
| 4.5995 | 103' | 3" | " |
| 4.6025 | 103' | 2" | " |
| 4.6270 | 102' | 8" | " |
| 4.6300 | 102' | 7" | " |
| 7.6350 | 62' | 2" | 30' |
| 7.9185 | 60' | 0" | " |
| 7.7750 * | 61' | 0" | " |
| 11.9735 | 39' | 8" | 25' |
| 14.9050 | 31' | 10" | " |
| 20.8730 | 22' | 9" | " |

* This dimension should be used to cover both 7.6 and 7.9 MHz.

Verticals: Use one half of the lengths given for dipoles above. Bottom of the antenna should be several inches above ground and insulated from it. Keep away from metal buildings or walls that have foil vapor barrier insulation, or from metal rain gutters and downspouts.

Beams: There are two HY-GAIN three element monoband beams designed for the Amateur bands that can be used on the 20.87 and 14.9 MHz CAP channels.

Model 153BA 15 meter beam can be used on the 20.87 MHz channel if the CW dimensions are used in setting the element lengths.

Model 203BA 20 meter beam can be used on the 14.9 MHz channel by shortening the DRIVEN element end sections to 65" (shown as 67" for the phone portion in the instructions supplied with the beam). The DIRECTOR elements should be shortened to 64" instead of 66-1/4" and the REFLECTOR ends to 66-1/2" instead of 68-1/2".

If both beams are to be used, they can be stacked one over the other on the same tower. Spacing between beams is not important, but a minimum of three feet is recommended. There is no preference as to which beam should be on top.

Mobile Whips:

HY-GAIN has a commercial HF mobile antenna that will cover all CAP frequencies with the proper resonator coils. The lower mast is their Model 276. Hy-GAIN does not supply specific data for tip lengths for the various CAP channels so they will have to be determined by trial and error. Move in increments of 1/8" since the resonant indication is quite narrow. To lower the resonant frequency, increase tip length: to increase frequency, shorten length. The table below lists the resonator coil part numbers:

| Channels | HY-GAIN Part No. |
|---|---|
| All 4.4 MHz | 3762AA |
| Both 7 MHz | 3763AA |
| 11.9 and 14.9 MHz | 3764AA |
| 20.89 MHz | 3765AA |

HUSTLER Amateur mobile whips and approximate tip lengths are given in the table below. Measure tip length from where it emerges from the locking nut to the tip. The ground plane of the particular automobile will determine the actual length necessary, so use the stated lengths as a guide only. Either Model MO-1 or MO-2 lower mast can be used with the listed resonator assemblies.

| Channels | Resonator Pt. | Length in inches |
|---|---|---|
| 4.4645/4.4675 | RM-75 | 12-1/4 |
| 4.4645/4.4675 | RM-75S | 11-3/4 |
| 4.5045/4.5075 | RM-75 | 11-1/2 |
| 4.5045/4.5075 | RM-75S | 10-3/4 |
| 4.5850 | RM-75 | 10-3/8 |
| 4.5850 | RM-75S | 9-5/8 |
| 4.5995/4.6025 | RM-75 | 10-1/8 |
| 4.5995/4.6025 | RM-75S | 9-3/8 |
| 4.6270/4.6300 | RM-75 | 9-5/8 |
| 4.6270/4.6300 | RM-75S | 8-3/4 |
| 7.6350 | RM-40 * | 17-3/8 |
| 7.9185 | RM-40 * | 14-3/4 |
| 11.9735 | NONE | ------ |
| 14.9050 | RM-20 | 10-3/4 |
| 14.9050 | RM-20S | 11-3/8 |
| 14.9050 | RM-15 | 28-3/4 |
| 20.8730 | RM-15 * | 9-1/8 |
| 20.8730 | RM-10 * | 25-1/8 |

* The "S" model resonator can be used with same lengths shown.

APPENDIX II

ANTENNA AND TRANSMISSION LINE THEORY

## ANTENNA SYSTEMS MATCHING THEORY

Most transmitters are designed to work into a 50 to 75 ohm resistive load, and they are not able to effectively supply rf power to loads that depart far from these values. However, many antenna systems, which include the antenna and the transmission line, have complex impedances that make it difficult if not impossible to load the transmitter properly. These impedances are a function of the operating frequency, type of antenna, type and length of transmission line, height of antenna and its proximity to other objects.

An antenna tuner provides a coupling method to convert the resistive/reactive load to a pure resistance of 50 ohms that will accept maximum power from the transmitter. This is not to say that any and all antennas, when converted to a 50 ohm resistive impedance by means of a tuner, will give identical performance. Other variables such as angle of radiation, directivity and ground losses enter into the overall performance of a given antenna.

THE ANTENNA - Any conductor that has rf currents flowing in it can be looked on as an antenna or radiator. The extent to which power leaves the conductor and radiates into the surrounding medium depends on many factors -- length, frequency, amount of current, configuration, etc. Since the antenna absorbs power from the device feeding it, it can be replaced with a resistance whose value is such that the power delivered to this resistance is the same as that delivered to the antenna. The value of this resistance is now a measure of the radiating effectiveness of the antenna and is termed "radiation resistance". For a given value of antenna current, the higher this resistance, the higher the radiated power. ($P=I^2R$)

Due to the fact that an antenna has physical length, that current travels at a velocity less than instantaneous and that the conductor possesses a certain amount of self-inductance and capacitance, the current at the feed point may not be in phase with the voltage at this point. As a result, the impedance at this point may not look like a pure resistance as first suspected, but as an impedance consisting of resistance and either inductive or capacitive reactance. This added reactance will limit the amount of current supplied to the antenna for a given voltage, and therefore reduce the amount of radiated power. The reactance does not absorb power in itself -- only a resistance can do that -- but its presence reduces the overall antenna current and hence radiated power.

There are two ways to restore the power to its non-reactive value. The first, which is not the preferred way because it does not maximize power transfer, is to raise the feed point voltage enough so that the current returns to its original value. The second, and preferred method, is to add a reactance in series, equal in value but opposite in type (sign) to the reactance value of the antenna. For example, if the antenna at the operating frequency presents an inductive reactance of 100 ohms (+j100) along with a resistance of 50 ohms, inserting a capacitor whose reactance is also 100 ohms (-j100) in series has the effect of cancelling out the reactance of the antenna, leaving only the 50 ohms resistance. This can be looked on as a series R,L,C circuit that is in resonance, whose total impedance is only that of the resistance. Another term for this approach to maximize power transfer is "conjugate impedance matching".

In the above example, we used a value of 50 ohms for the radiation resistance. If this value were not 50 but 150 ohms, the impedance after cancelling the reactance out would be 150 ohms. Connecting this load to the transmitter designed to operate with 50 ohms load would not result in optimum power transfer. It would, however, be better than leaving the inductive reactance in, since the antenna current is maximized for the conditions that do exist. To obtain design performance, it is necessary to transform the 150 ohms to 50. This can be done with a transformer with a turns ratio of 1.73 to 1. (Impedance transformation is equal to the square of the turns ratio.) It is also possible to accomplish this transformation with a parallel tuned circuit with primary and secondary taps properly located on the inductor, or by using two or more capacitors in series with taps taken from the series string. Under these conditions, the transceiver will deliver rated power to the antenna.

One last observation before we go on. The antenna impedance in the above example was stated as that at the feed point. If we now feed the antenna at a different location along the conductor, the impedance will be different, both resistive and reactive components. There are an infinite number of impedance choices available, depending on where the tap is made. This factor is helpful in designing and matching antennas. The factors that determine this impedance are the current and voltage values at this point, and the phase between them.

THE TRANSMISSION LINE - In the above example, we assumed that the transmitter output was connected directly to the feed point. This is hardly practical. So that the transmitter can be located at a distance from the antenna, we use a transmission line to deliver the power. Unless we have a perfectly matched system, i.e. antenna, line and output impedances all the same value without reactive components, the addition of the transmission line completely changes the picture. The transmitter will not see the antenna impedance of 50 ohms resistive and 100 ohms inductive reactance, but some other combination It will depend on the electrical length of the line, its characteristic impedance and frequency. The impedance at the transmitter end is what we are interested in, and the inductive component may even be changed to capacitance. (Only when the electrical length of the line is an exact multiple of the half wavelength will the impedance at the transmitter be the same as the antenna impedance.)

Briefly, the line characteristic impedance is determined by the physical dimensions of the line -- wire diameter and spacing -- and the dielectric of the material in between. Length does not influence the characteristic impedance. The wire also possesses a resistive component which will dissipate power when current flows through it to the antenna. This shows up as heat loss and dictates use of low loss cable. Formulas for coax and open wire line impedances are given in the handbooks.

Since rf currents in the transmission line are flowing, one may ask if it then becomes an antenna. In the case of coaxial lines, the current should flow on the inside surface of the outer conductor and on the outer surface of the inner conductor. The electric and magnetic fields caused by the current flow are confined between the two, so none can escape and be radiated. If a system configuration results in some rf current flowing on the outer surface of the outer conductor, such as when a dipole is fed with coax without a balun or other means of changing the feed line from an unbalanced to balanced configuration, it will radiate power. In the case of parallel lines, the current in one conductor at a given location should be flowing in the opposite direction to the current in the adjacent conductor, and if the system is well balanced, the amplitudes of the two will be equal. Under these conditions, the two sets of fields exactly cancel each other and very little radiation will result. If the two currents are not equal or are not in exact opposite phase, there will be radiation. Also, if the spacing between lines is a considerable portion of the wavelength, radiation will occur. This is not a factor below VHF.

One final characteristic of transmission lines should be mentioned. The rf current flowing in the line travels at a speed less than that of radiated power in a vacuum, or the speed of light, both 186,000 miles per second. This slowing is caused by the dielectric property of the medium through which the field traverses. In coax cables it is polyethelene between inner and outer conductors, and in parallel lines, it may be the plastic between the conductors in the case of twin-lead type line, or the air and plastic spacers in open wire types. The ratio of the speed in the line to the speed in a vacuum (air is almost the same) is called the velocity factor of the cable. It is always less than unity. Because of this slowing, the physical length of a transmission line is not the same as the electrical length. For example, the wavelength in free space of a 30 MHz signal is exactly 10 meters. A transmission line 10 meters long will be one full wavelength only if the dielectric between the conductors is air. In the case of coax cable with polyethelene dielectric, the velocity factor runs about 0.67. The same 10 meter length of cable will now appear electrically as an open wire or air dielectric cable 15 meters long (10 divided by 0.67). This is equivalent to one and one half wavelengths. A polyethelene type cable would only have to be 6.70 meters long to be one wavelength.

EFFECT OF TRANSMISSION LINE ON ANTENNA IMPEDANCE - As a result of all of the above, in situations where we do not have a matched system throughout, and this is most of the time, the impedance presented to the transmission line by the antenna sets up standing waves on the line. These standing waves will alter the antenna impedance all along the line toward the transmitter. What we really want to accomplish with the antenna tuner is to take whatever impedance that is established at the transmitter end of the line and alter it to a 50 ohm resistance. Then the transmitter will be happy, at least. The tuner will not affect the mismatch of antenna to line -- only constructing the antenna differently will do that -- nor eliminate a standing wave on the transmission line. It will eliminate a standing wave on the line between transmitter and tuner input, but not on the output side of the tuner. A good antenna is still needed to 'get out'. If the antenna has a low resistance, the tuner will transform it, along with the cable loss resistance, to 50 ohms. The full power will enter the system, but it will be divided between radiation and cable heat loss. It is not uncommon that more than half of the available power is wasted in cable losses, even with low loss cable. It just gets a bit hotter. The split depends entirely on the ratio of radiation resistance to loss resistance.

What is the impedance established at the transmitter end of the line? It depends first on the antenna impedance, which is then transformed by the line. This transformation is dependent on frequency, length of the line and the loss in the line. When many different frequencies are used with the same antenna, there will be a multitude of impedances presented to the tuner, so adjustment of the matching network will be required as frequency is changed.

STANDING WAVE RATIO - A measure of how badly a system is mismatched is given by the standing wave ratio (SWR) on the line. SWR is the ratio of the maximum voltage encountered along the line to the minimum voltage, provided that the line is greater than a half wavelength long. It is also the ratio of maximum to minimum current. The more nearly uniform the voltage distribution along the line, the closer matched it is, and the ultimate is when the voltage is constant down the length of a lossless line, or drops slowly and uniformly along a line with losses. This is the matched condition, represented by a 1 to 1 SWR. The impedance at the load end of such a line is the same as that at the generator end. When adjusting a matching network properly, the way to do it is to observe the SWR and tune for as low a ratio as possible.

The SWR is also an indication of the value of resistance at the load end. The ratio is the same as the ratio of load resistance to line characteristic impedance. This ratio can mean that the load is either greater or less than the line's impedance. For example, if the SWR on a length of 50 ohm line is 3 to 1, the load resistance is either 150 ohms or 16.7 ohms (3 times 50 or one third of 50). This is only accurate with pure resistive loads.

It can be shown mathematically that a 2 to 1 SWR in a system which has the transmitter output impedance equal to the line impedance delivers 89% of the power to the load that it would if perfectly matched. This relates to a power loss of half a decibel -- hardly noticeable in signal strength. At a 3 to 1 ratio, the loss becomes appreciable with 25% of the power lost. So in adjusting antenna tuners, it is a nice feeling if you achieve a 1 to 1 match, but in reality, anything below 2 to 1 is satisfactory. Line losses do increase a bit also with increasing SWR, but it is a small fraction of a dB at 2 to 1.

To obtain maximum performance from your antenna system, additional reading is recommended. The ARRL Antenna Handbook, ARRL Amateur Radio Handbook and other antenna books published by the publishers of Amateur Radio magazines are excellent sources of information.

SERVICE INFORMATION
MODEL 100
CIVIL AIR PATROL TRANSCEIVER

TEN-TEC, Inc.
Sevierville, TN 37862

Pt. No. 74124

Printed in USA

# SERVICE AND ALIGNMENT
# Model 100 CAP Transceiver

## GENERAL

Since a majority of CAP communicators are not technically oriented extensive alignment and service information is not given in the Owner's Manual supplied with the transceiver. For those with the required electronic background to service solid state equipment, these additional pages of service information should be sufficient to effect field repair of the transceiver in a majority of cases. If more technical help is needed, our Repair Department stands ready to be of service. Details of our in and out-of-warranty service procedures, as well as inside photographs of the Model 100 are given in the Owner's Manual and are not repeated here.

The information that is presented here consists of a complete set of schematics for the individual assemblies, an interconnection diagram, a block signal path diagram and a list of alignment adjustments, locations and procedures for making the adjustments. The schematics are arranged by assembly part numbers in ascending order, with the accessory Model 231 Noise Blanker at the head of the list.

## COLOR CODED WIRES

The interconnecting cables have several standard color coded wires throughout the transceiver. This facilitates the taking of voltage readings at the various connector points. The standard wiring is as follows:

| | |
|---|---|
| BLACK | Chassis ground and reference point for all voltage measurements. |
| RED | Positive supply voltage of 13.5 V dc. |
| ORANGE | Positive regulated voltage of approximately 9 V dc. |
| YELLOW | Positive supply voltage of 13.5 V dc to the receiver circuits that is turned 'off' during transmit functions. (Designated 'R' voltage.) |
| BLUE | Positive supply voltage of 13.5 V dc to the transmitter circuits that is turned 'off' during receive functions. (Designated 'T' voltage.) |

## RECEIVER ALIGNMENT

1.) Receiver 9 MHz Trap - This trap is located on the TX-RX FRONT END assembly 80868 and is designated C1. Set CHANNEL switch to one of the 7 MHz positions and apply a large enough signal from a signal generator to the ANTENNA jack at 9.002300 MHz so that an S-Meter reading of S4 or S5 is obtained. Tune C1 for a minimum meter deflection, readjusting generator output as needed to keep reading below S5.

2.) Band Pass Filters - These filters, located on subassembly 80869 are used in both the receive and transmit modes. The 4 MHz and 7 MHz filters are overcoupled to produce a wide bandpass characteristic. Adjustments are rarely needed due to their wide passband, except when a component is replaced. If realignment is required, connect a signal generator to the ANTENNA jack and an ac VTVM across the speaker terminals. When adjusting the 4 MHz filter set the CHANNEL switch to the 4.5820 position to center the receiver in the passband. For the 7 MHz filter, select the most used channel for the alignment procedure. At the center coil location there is a test terminal on the PC assembly. Connect a 150 ohm resistor from this terminal to ground. Adjust generator level for a VTVM reading that is above the noise level but not great enough to activate the AGC line (as evidenced by no S-Meter deflection). Adjust L1 and L3 for maximum output in the case of the 4 MHz alignment and L4 and L6 for the 7 MHz band. Remove the resistor and readjust the generator output downward so that no S-Meter deflection is given. Adjust L2 and/or L5 for maximum output on the VTVM.

For the remaining channels, adjust generator to the correct frequency and its output for a suitable reading as before. Adjust appropiate coils for maximum VTVM readings.

3.) Receiver I-F Amplifier - There are two i-f transformers T1 and T2 on the IF-AF assembly 80873. These two transformers are in metal cans and require a plastic hex tool for tuning. With a small amount of signal applied to the ANTENNA jack on any channel, adjust input level so that a S-Meter reading of about S4 is obtained. Tune both transformers for maximum S-Meter reading, always keeping applied signal below S4.

If Model 231 Noise Blanker is installed, also adjust the metal i-f transformer on this assembly in the same way.

4.) S-Meter Calibration - With a 50 uV signal applied to the ANTENNA jack at one of the 7 MHz frequencies, fine tune signal generator frequency for a maximum S-Meter deflection. Adjust R35 on the IF-AF assembly 80873 so that meter reads S9.

5.) BFO Oscillator - The 9 MHz carrier oscillator is on the SSB GEN. assembly 80871. Its frequency is adjusted by means of C1. When the 4 pole i-f filter is installed, set C1 so that an accurate counter connected to the hot lead in connector 94 reads 9.003300 MHz. Use a 10:1 probe on the counter to reduce any capacitive load on the oscillator. When the 8 pole Model 220 filter is installed, set carrier to 9.003150 MHz. (Note: This affects all channel frequencies and all channel crystal frequencies have to be adjusted accordingly.)

## TRANSMITTER ALIGNMENT

1.) Power Amplifier Bias Adjustment - This control is located on the small PC assembly 80575 that is attached to the outside cover of the final amplifier assembly 80877. Disconnect the heavy red lead going to the lug on 80877 and connect a 0 to 1 ampere meter in series with this lead. With DRIVE control fully CCW, place the transmitter in the transmit mode by shorting pin 3 in the MIC socket to ground. (Pin 3 is the PTT line.) Adjust R23 FINAL BIAS pot for a 500 mA reading. After adjustment is made, resolder heavy red lead to lug.

2.) Carrier Balance - Two balance potentiometers, R11 and R13, are located on the SSB GEN. assembly 80871. With a dummy load connected to the ANTENNA jack and a rf oscilloscope across the load, place the transmitter in operation by shorting pin 3 of the MIC socket to ground. Rotate DRIVE control fully CCW. Alternately adjust R11 and R13 for minimum 'scope deflection. It should be less than 2 volts peak-to-peak with the 4 pole filter and considerably less with the 8 pole filter.

3.) SWR Bridge - There are two adjustments for the SWR bridge, both located on the LP FILTER assembly 80872. The first, C1, is a null adjustment and the second, R2, a calibration setting. With a 50 ohm dummy load connected to the ANTENNA jack, insert a 1 kHz audio signal of about 10 mV amplitude into pin 1 of the MIC socket while shorting pin 3 of this socket to ground. Set CHANNEL switch to the 20.8730 position. Adjust the DRIVE control so that approximately 50 watts of output are obtained. This can be ascertained either with a wattmeter in the output line or by observing and setting the power supply dc current to about 8 or 10 amperes. Adjust C1 for a null reading on the meter. It should go down to the "1" on the SWR scale if the dummy load is a pure 50 ohm resistance.

With another 50 ohm dummy load connected in parallel (to effect a 25 ohm load), increase DRIVE and/or audio level so that approximately 90 watts of output power is achieved. Set R2 for a meter reading of "2", indicating a 2 to 1 SWR.

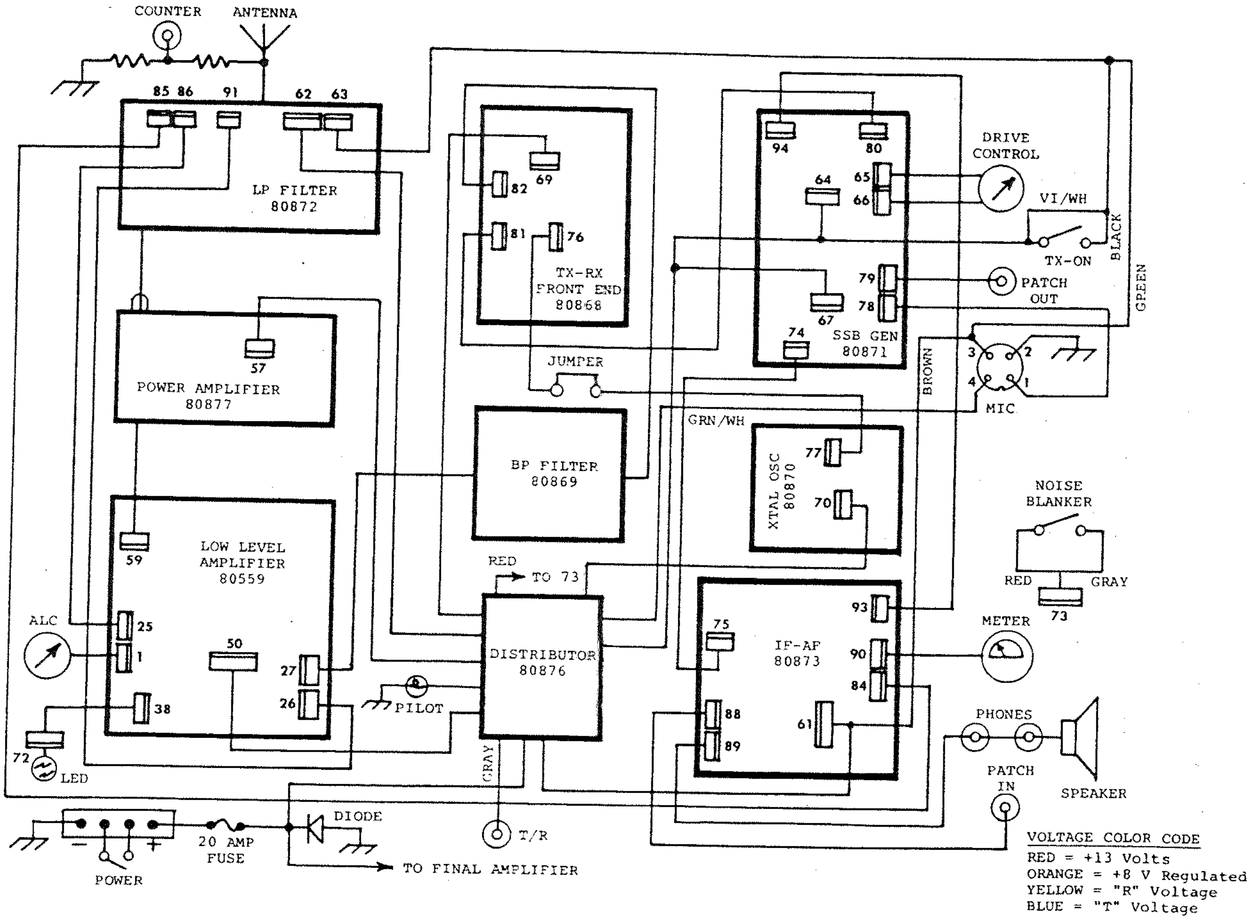
4.) ALC Level Adjustments - NOTE: The SWR null adjustment must be made before the ALC adjustment is made. There are two ALC adjustments located on the LOW LEVEL AMP assembly 80559. The first sets the LED performance and the second limits the output power. With the transceiver in the transmit mode (pin 3 of MIC socket to ground) and with no DRIVE, adjust R15 ALC LIGHT control so that the LED is definitely out but not too far past this point. This is not a critical adjustment but if it is at the point where the LED is just about to come on, it may stay on if the transceiver is used with slightly higher voltage power supplies.

Connect an accurate wattmeter and dummy load to the ANTENNA jack and preset the ALC ADJ. control R11 for no ALC. (Turn pot towards center of transceiver all the way.) Set CHANNEL switch to one of the 7 MHz channels, ALC-N.B. control fully clockwise and place transceiver into transmit mode by shorting pin 3 in MIC socket to ground. Insert a 1 kHz audio signal at pin 1 of the same socket and adjust both DRIVE and input audio so that wattmeter reads 100 watts output. NOTE: Without ALC it will be very easy to overdrive the transmitter, resulting in excessive current being drawn from the power supply. Adjust ALC ADJ. control R11 so that output power decreases to 90 watts. At this setting the LED should turn on.

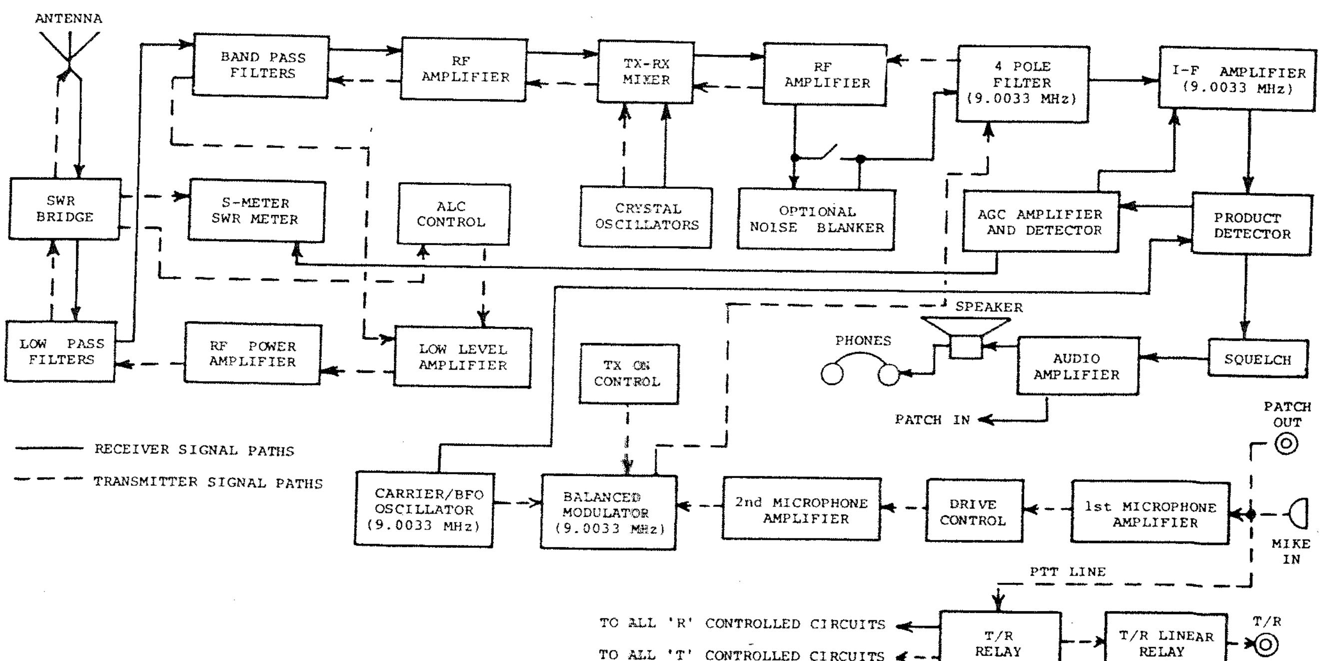
## CHANNEL FREQUENCY ADJUSTMENTS

Calibration of the individual crystals on the XTAL OSC. subassembly 80870 is covered in the Owner's Manual on Page 3-4. However, when Model 220 Eight Pole Filter is used, some revisions to these procedures may be necessary. They are covered in the Model 220 instructions but are repeated here.

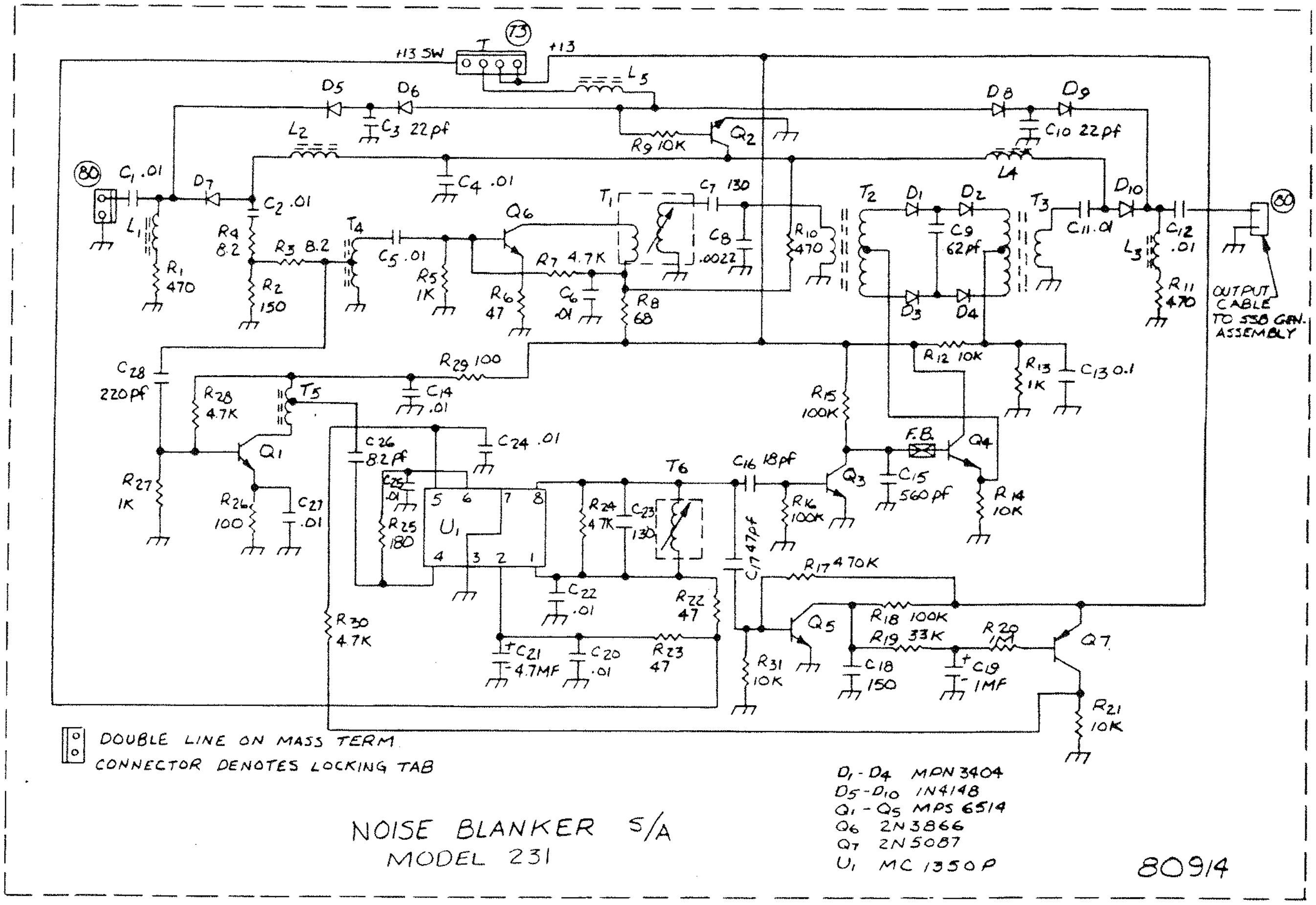
With the sharper skirts attainable with the 8 pole filter, it will be found that when the DRIVE-TX ON knob is pulled out and carrier inserted, the added attenuation at the carrier frequency will reduce the amount of signal passing through to the ANTENNA jack and hence the COUNTER jack. When making channel frequency adjustments first check to see if sufficient signal is present at the COUNTER jack to present a reliable counter readout on all channels. If there is not sufficient signal to drive the counter, it will be necessary to jumper around the filter with a 10 pF capacitor. Temporarily connect the capacitor from the upper left filter terminal pin to the lower right pin as viewed on Page 4-3 of the Owner's Manual. After all adjustments are made, remove the capacitor. To make SWR measurements, a steady whistle into the microphone while transmitting, with enough DRIVE to light the LED, and with the ALC-N.B. control fully clockwise, will be necessary.

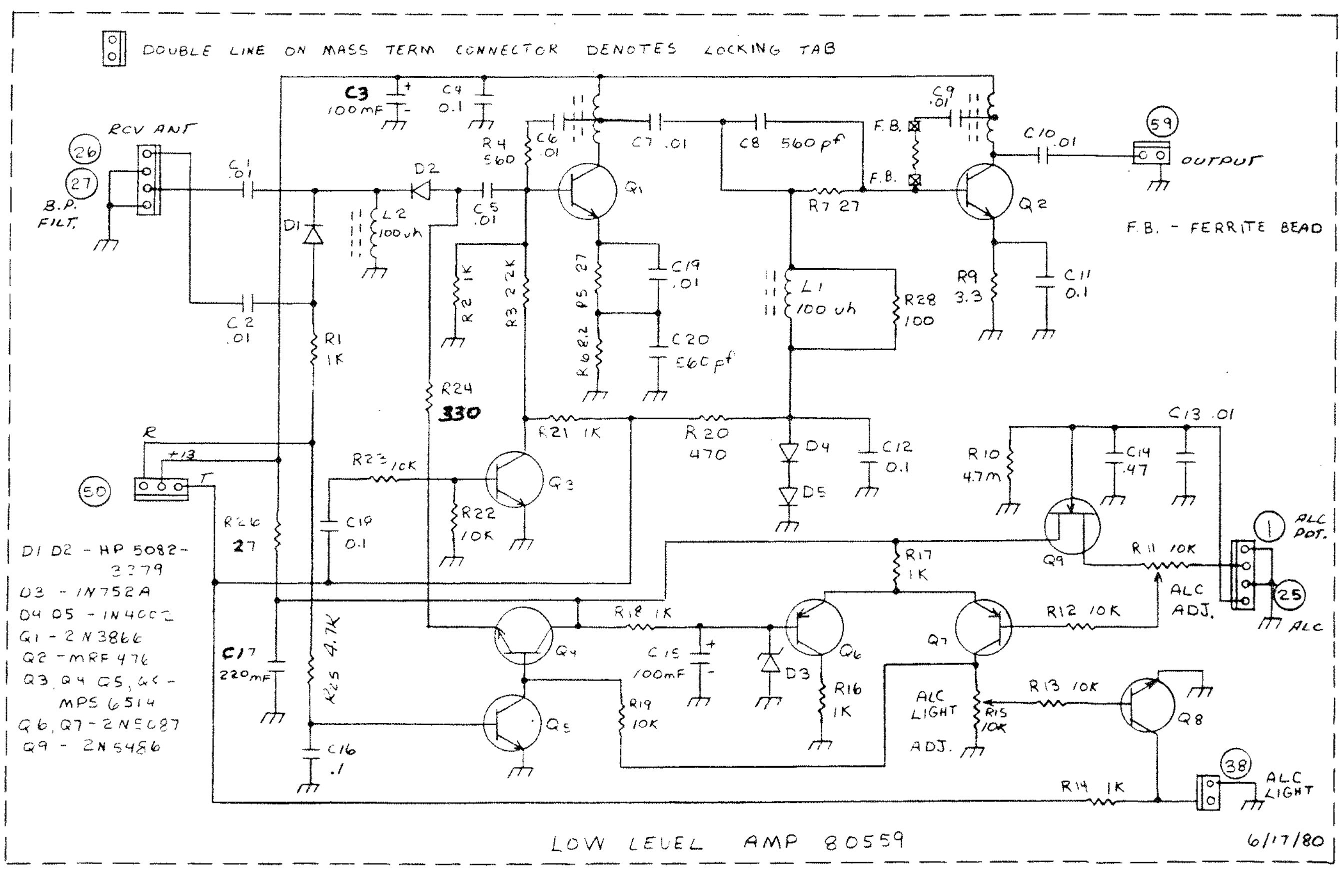


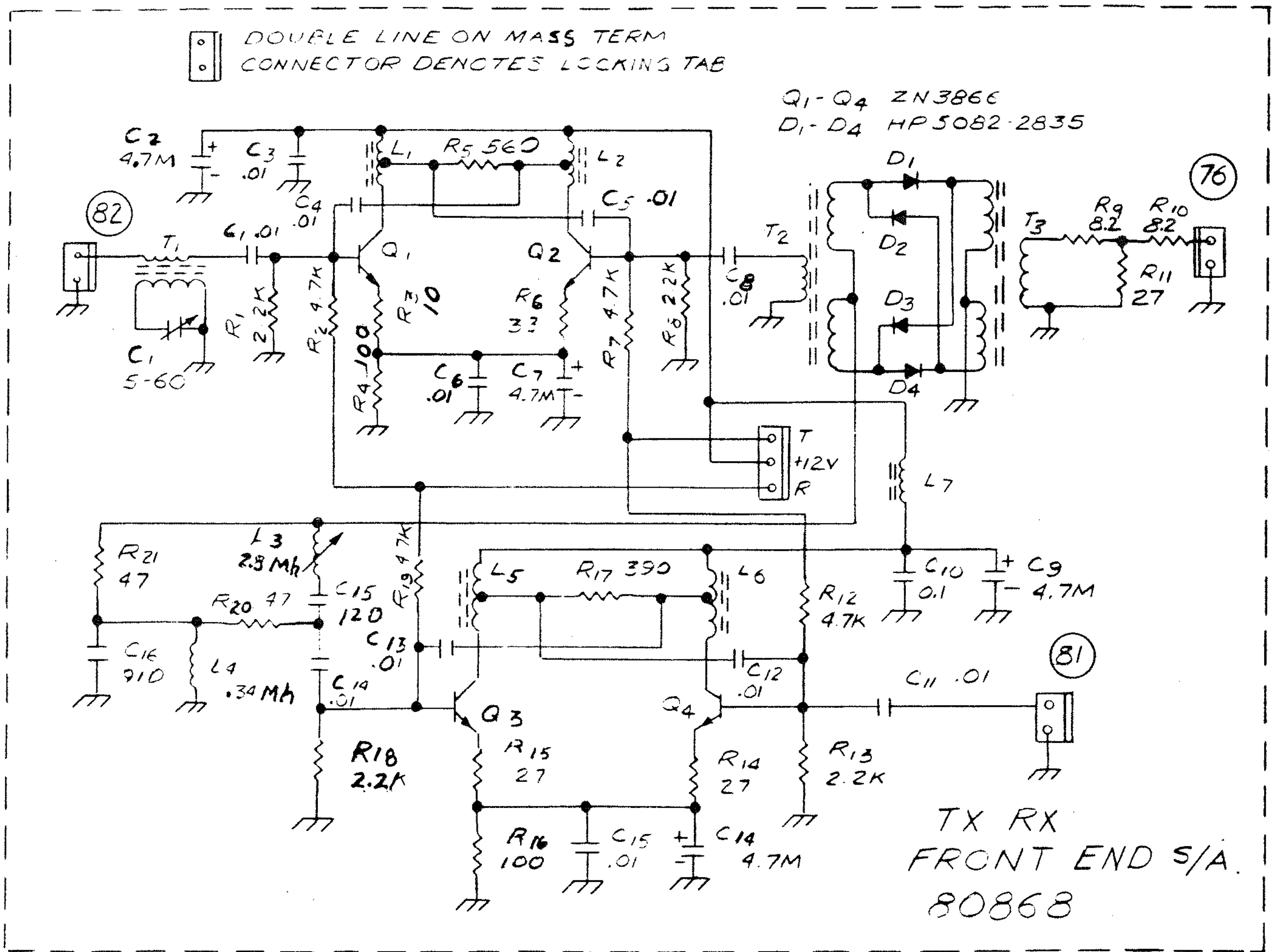

MODEL 100 - CABLE DIAGRAM

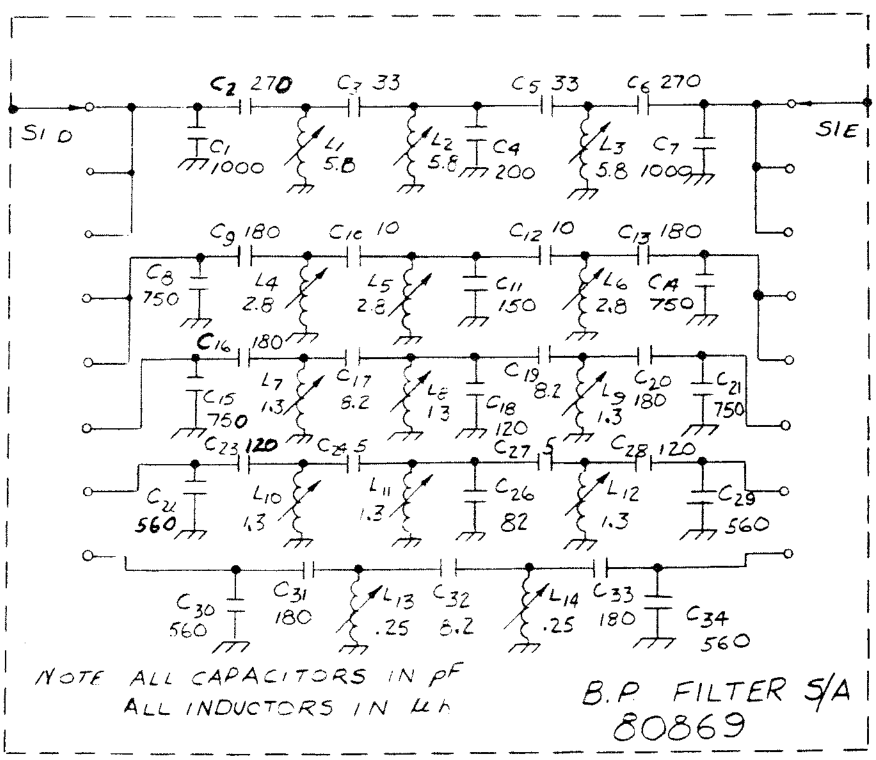


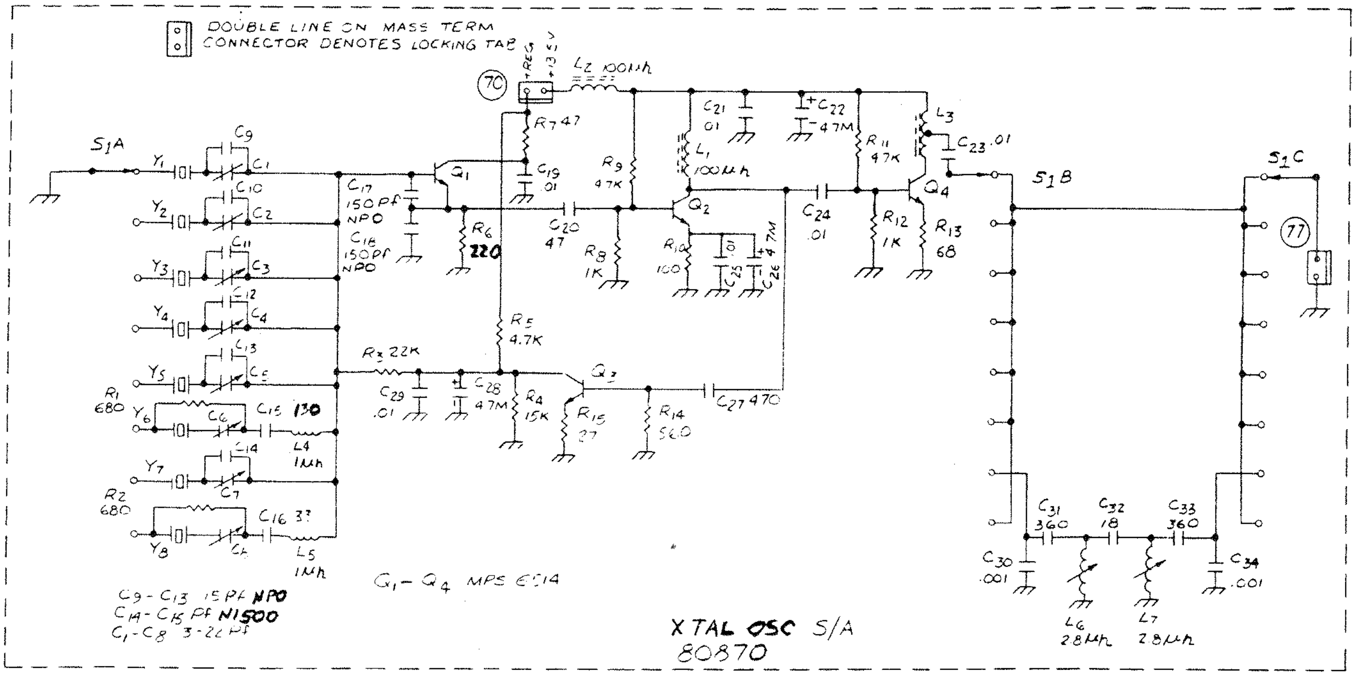

MODEL 100 - BLOCK DIAGRAM

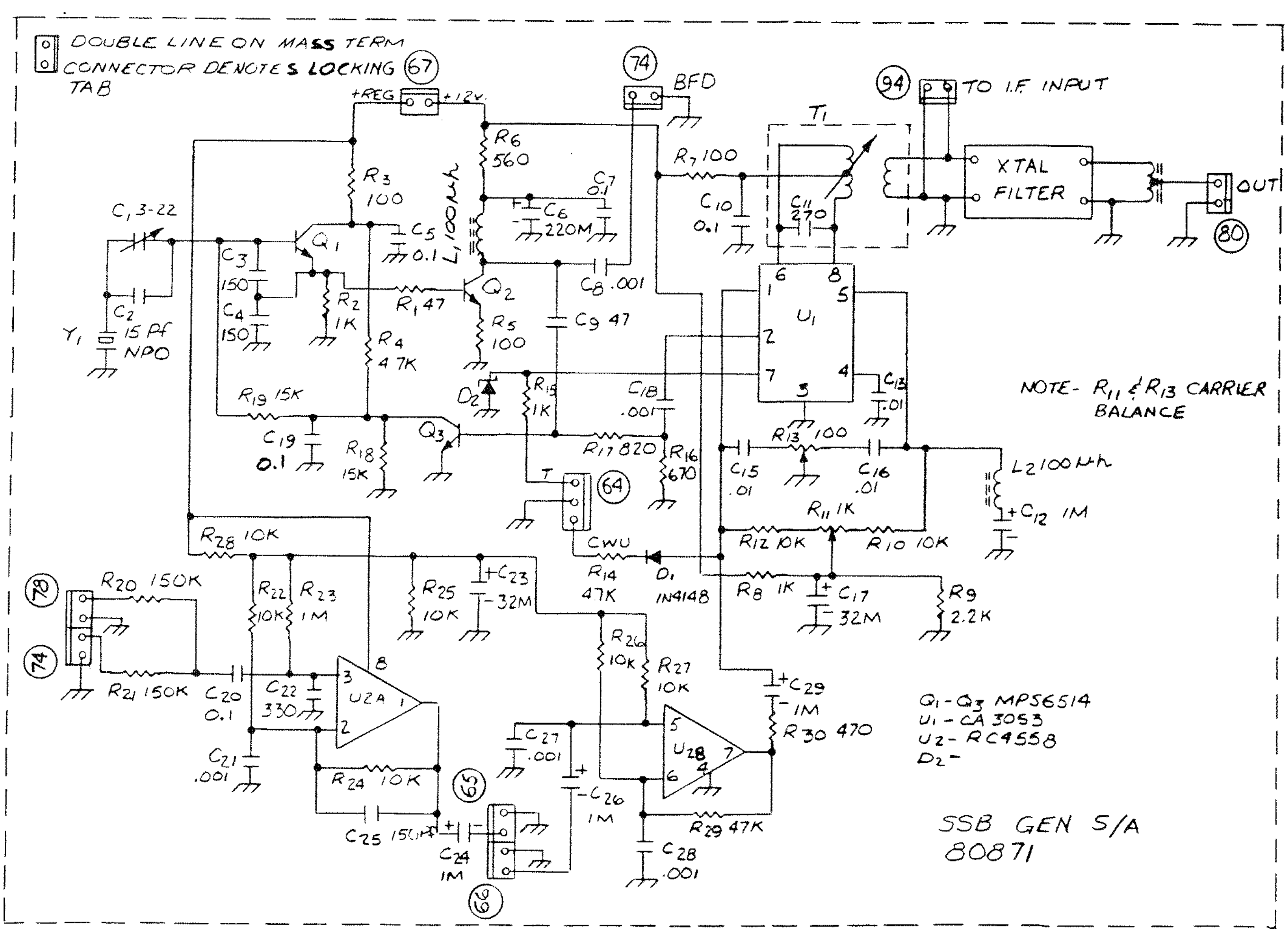

DOUBLE LINE ON MASS TERM CONNECTOR DENOTES LOCKING TAB
OUTPUT CABLE TO SSB GEN. ASSEMBLY
$D_1$-$D_4$ MPN 3404
$D_5$-$D_{10}$ 1N4148
$Q_1$-$Q_5$ MPS 6514
$Q_6$ 2N3866
$Q_7$ 2N5087
$U_1$ MC 1350P
NOISE BLANKER S/A
MODEL 231
80914

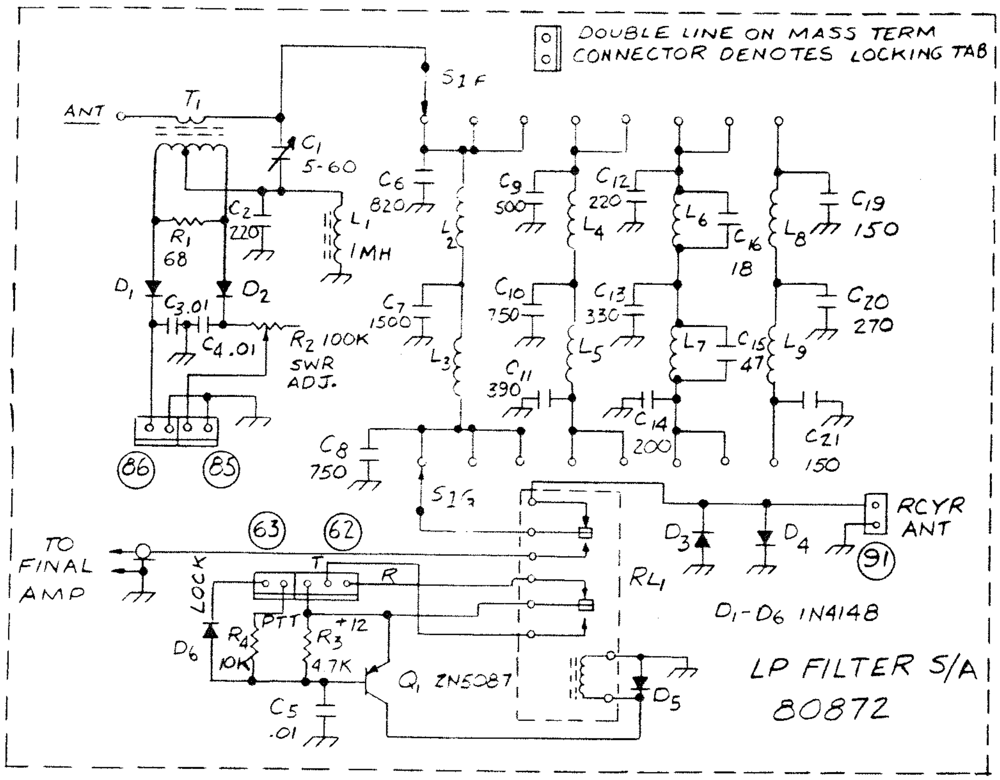

DOUBLE LINE ON MASS TERM CONNECTOR DENOTES LOCKING TAB
RCV ANT
B.P. FILT.
OUTPUT
F.B. - FERRITE BEAD
ALC POT.
ALC ADJ.
ALC
ALC LIGHT ADJ.
ALC LIGHT
D1 D2 - HP 5082-3379
D3 - 1N752A
D4 D5 - 1N4002
Q1 - 2N3866
Q2 - MRF 476
Q3, Q4, Q5, Q8 - MPS 6514
Q6, Q7 - 2N5087
Q9 - 2N5486
LOW LEVEL AMP 80559
6/17/80

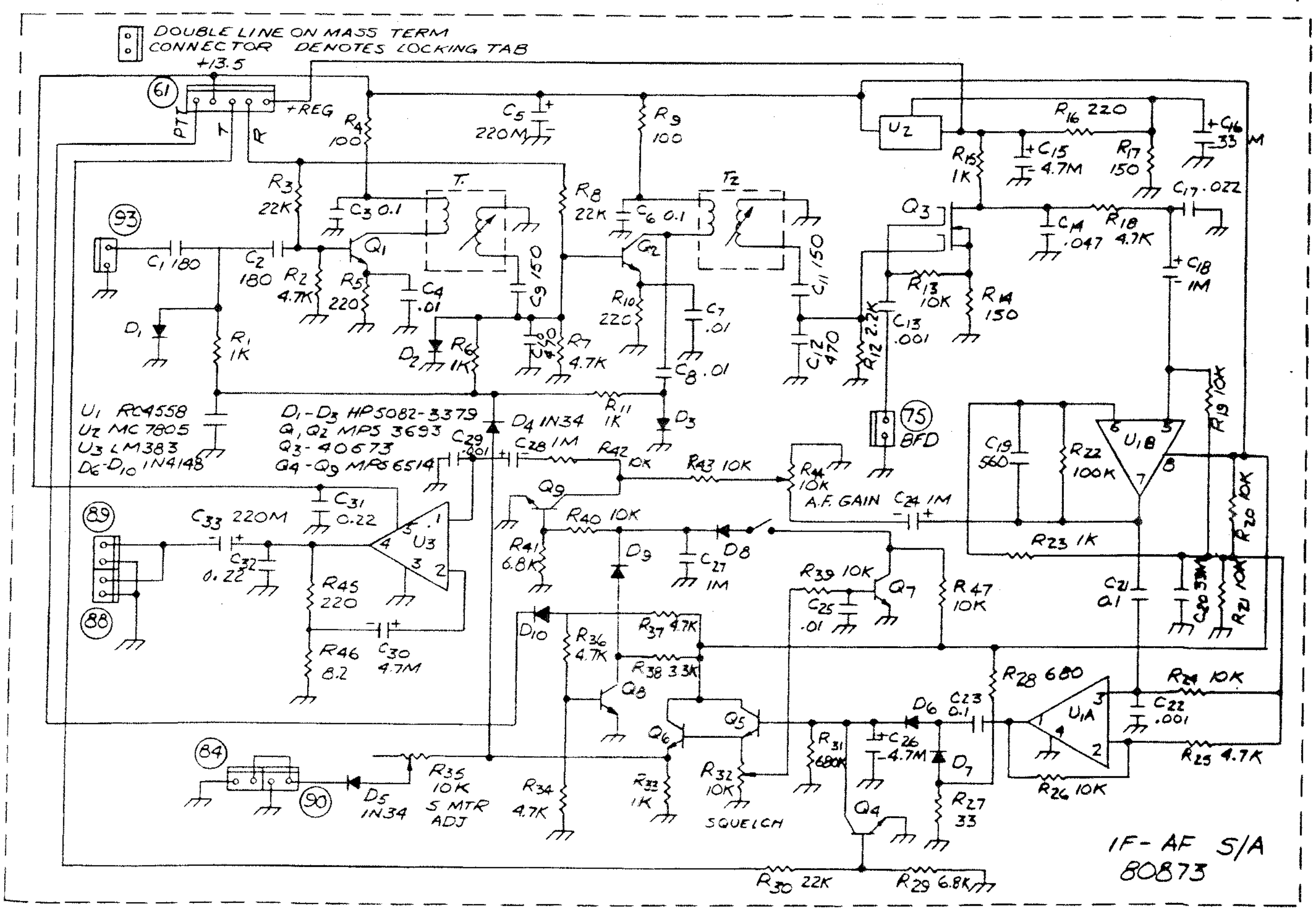

DOUBLE LINE ON MASS TERM
CONNECTOR DENOTES LOCKING TAB
Q1 - Q4 2N3866
D1 - D4 HP5082-2835
C2 4.7M
C3 .01
C4 .01
L1
R5 560
L2
C5 .01
82
T1
C1 .01
Q1
Q2
R1 2.2K
R2 4.7K
R3 10
R6 33
R7 4.7K
R8 22K
C8 .01
T2
D1
D2
D3
D4
T3
R9 8.2
R10 8.2
76
R11 27
C1 5-60
R4 100
C6 .01
C7 4.7M
T
+12V
R
L7
R21 47
L3 2.8 Mh
C15 120
R19 4.7K
L5
R17 390
L6
C10 0.1
C9 4.7M
R20 47
R12 4.7K
C16 910
L4 .34 Mh
C13 .01
C14 .01
C12 .01
C11 .01
81
Q3
Q4
R18 2.2K
R15 27
R14 27
R13 2.2K
R16 100
C15 .01
C14 4.7M
TX RX
FRONT END S/A
80868

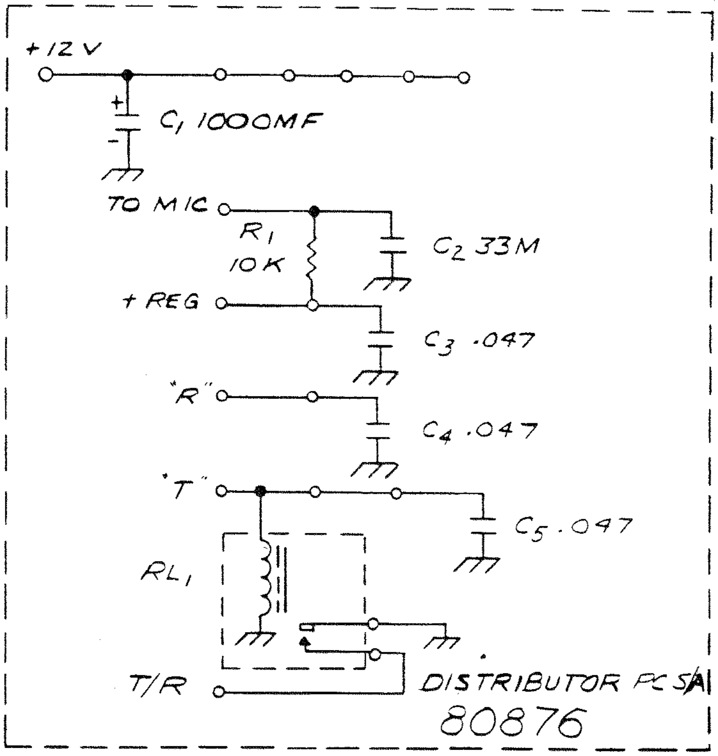

S1 D
S1E
C2 270
C3 33
C5 33
C6 270
C1 1000
L1 5.8
L2 5.8
C4 200
L3 5.8
C7 1000
C9 180
C10 10
C12 10
C13 180
C8 750
L4 2.8
L5 2.8
C11 150
L6 2.8
CA 750
C16 180
C15 750
L7 1.3
C17 8.2
L8 1.3
C18 120
C19 8.2
L9 1.3
C20 180
C21 750
C23 120
C24 5
C27 5
C28 120
C22 560
L10 1.3
L11 1.3
C26 82
L12 1.3
C29 560
C30 560
C31 180
L13 .25
C32 8.2
L14 .25
C33 180
C34 560
NOTE ALL CAPACITORS IN pF
ALL INDUCTORS IN μh
B.P FILTER S/A
80869

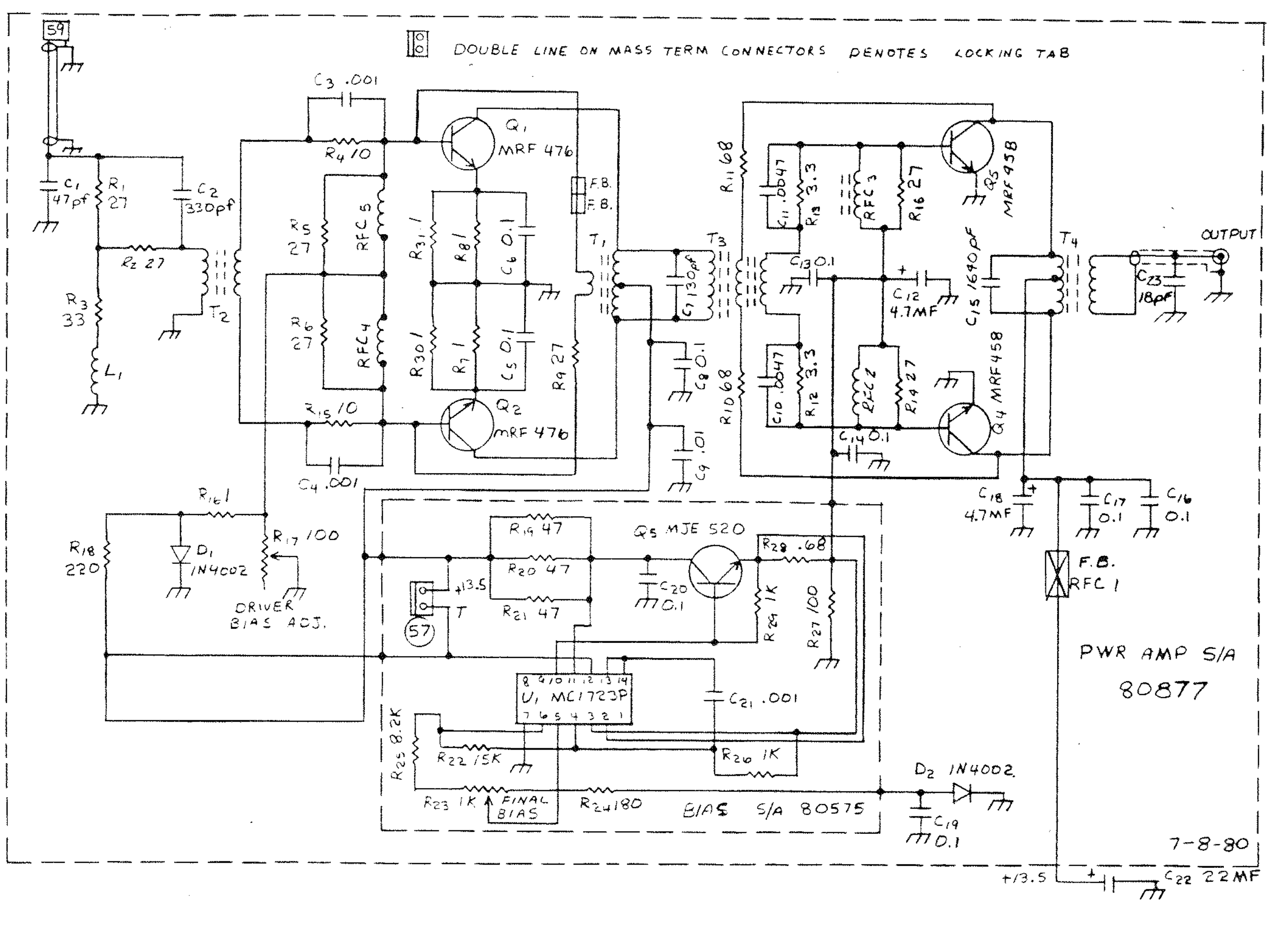

DOUBLE LINE ON MASS TERM CONNECTOR DENOTES LOCKING TAB
XTAL OSC S/A
80870
$C_9$ - $C_{13}$ 15 PF NPO
$C_{14}$ - $C_{15}$ PF N1500
$C_1$ - $C_8$ 3-22 PF
$Q_1$ - $Q_4$ MPS 6514


DOUBLE LINE ON MASS TERM CONNECTOR DENOTES LOCKING TAB
BFO
TO I.F INPUT
XTAL FILTER
OUT
NOTE- $R_{11}$ & $R_{13}$ CARRIER BALANCE
$Q_1$ - $Q_3$ MPS6514
$U_1$ - CA 3053
$U_2$ - RC4558
$D_2$ -
SSB GEN S/A
80871


DOUBLE LINE ON MASS TERM CONNECTOR DENOTES LOCKING TAB
ANT
$T_1$
$S_{1F}$
$C_1$ 5-60
$C_6$ 820
$C_9$ 500
$C_{12}$ 220
$C_{19}$ 150
$C_2$ 220
$R_1$ 68
$L_1$ 1MH
$L_2$
$L_4$
$L_6$
$C_{16}$ 18
$L_8$
$D_1$
$C_3$ .01
$D_2$
$C_4$ .01
$R_2$ 100K SWR ADJ.
$C_7$ 1500
$C_{10}$ 750
$C_{13}$ 330
$L_7$
$C_{15}$ 47
$C_{20}$ 270
$L_3$
$L_5$
$L_9$
$C_{11}$ 390
$C_{14}$ 200
$C_{21}$ 150
$C_8$ 750
86
85
$S_{1G}$
RCYR ANT
$D_3$
$D_4$
91
TO FINAL AMP
63
62
LOCK
T
R
PTT
+12
$RL_1$
$D_1$-$D_6$ 1N4148
$D_6$
$R_4$ 10K
$R_3$ 4.7K
$Q_1$ 2N5087
$D_5$
$C_5$ .01
LP FILTER S/A
80872


DOUBLE LINE ON MASS TERM CONNECTOR DENOTES LOCKING TAB
+13.5
61
PT
T
R
+REG
$R_4$ 100
$C_5$ 220M
$R_9$ 100
$U_2$
$R_{16}$ 220
$C_{16}$ 33M
$C_{15}$ 4.7M
$R_{15}$ 1K
$R_{17}$ 150
$C_{17}$ .022
$R_3$ 22K
$C_3$ 0.1
$T_1$
$R_8$ 22K
$C_6$ 0.1
$T_2$
$Q_3$
$C_{14}$ .047
$R_{18}$ 4.7K
93
$C_1$ 180
$C_2$ 180
$R_2$ 4.7K
$R_5$ 220
$Q_1$
$C_4$ .01
$C_9$ 150
$Q_2$
$R_{10}$ 220
$C_7$ .01
$C_{11}$ 150
$C_{12}$ 470
$R_{12}$ 2.2K
$C_{13}$ .001
$R_{13}$ 10K
$R_{14}$ 150
$C_{18}$ 1M
$D_1$
$R_1$ 1K
$D_2$
$R_6$ 1K
$R_7$ 4.7K
$C_8$ .01
75
BFD
$R_{19}$ 10K
$U_1$ RC4558
$U_2$ MC7805
$U_3$ LM383
$D_6$-$D_{10}$ 1N4148
$D_1$-$D_3$ HP5082-3379
$Q_1$ $Q_2$ MPS 3693
$Q_3$- 40673
$Q_4$-$Q_9$ MPS 6514
$D_4$ 1N34
$R_{11}$ 1K
$D_3$
$C_{29}$ .001
$C_{28}$ 1M
$R_{42}$ 10K
$R_{43}$ 10K
$R_{44}$ 10K A.F. GAIN
$C_{19}$ 560
$R_{22}$ 100K
$U_{1B}$
$Q_9$
$C_{24}$ 1M
$R_{20}$ 10K
89
$C_{31}$ 0.22
$C_{33}$ 220M
$U_3$
$C_{32}$ 0.22
$R_{41}$ 6.8K
$R_{40}$ 10K
$D_9$
$C_{27}$ 1M
$D_8$
$R_{23}$ 1K
88
$R_{45}$ 220
$R_{39}$ 10K
$Q_7$
$C_{25}$ .01
$R_{47}$ 10K
$C_{21}$ 0.1
$C_{20}$ 33M
$R_{21}$ 10K
$D_{10}$
$R_{36}$ 4.7K
$R_{37}$ 4.7K
$R_{38}$ 3.3K
$R_{46}$ 8.2
$C_{30}$ 4.7M
$Q_8$
$R_{28}$ 680
$R_{24}$ 10K
$U_{1A}$
$Q_6$
$Q_5$
$D_6$
$C_{23}$ 0.1
$C_{22}$ .001
84
$R_{31}$ 680K
$C_{26}$ 4.7M
$D_7$
$R_{25}$ 4.7K
$R_{26}$ 10K
90
$D_5$ 1N34
$R_{35}$ 10K S MTR ADJ
$R_{34}$ 4.7K
$R_{33}$ 1K
$R_{32}$ 10K SQUELCH
$Q_4$
$R_{27}$ 33
IF-AF S/A
80873
$R_{30}$ 22K
$R_{29}$ 6.8K


+12V
C1 1000MF
TO MIC
R1 10K
C2 33M
+REG
C3 .047
"R"
C4 .047
"T"
C5 .047
RL1
T/R
DISTRIBUTOR PC S/A
80876


DOUBLE LINE ON MASS TERM CONNECTORS DENOTES LOCKING TAB
59
C3 .001
R4 10
Q1 MRF 476
C1 47pf
R1 27
C2 330pf
R2 27
R3 33
L1
T2
R5 27
RFC 5
R6 27
RFC 4
R31 1
R8 1
C6 0.1
R30 1
R7 1
C5 0.1
R9 27
F.B.
F.B.
T1
C7 130pf
T3
C8 0.1
C9 .01
R15 10
Q2 MRF 476
C4 .001
R11 68
C11 .0047
R13 3.3
RFC3
R16 27
Q3 MRF 458
C13 0.1
C12 4.7MF
C15 1690pf
T4
OUTPUT
C23 18pf
R10 68
C10 .0047
R12 3.3
RFC2
R14 27
Q4 MRF 458
C14 0.1
C18 4.7MF
C17 0.1
C16 0.1
F.B.
RFC 1
R16 1
R18 220
D1 1N4002
R17 100
DRIVER BIAS ADJ.
R19 47
R20 47
R21 47
+13.5
T
57
Q5 MJE 520
C20 0.1
R28 .68
R29 1K
R27 100
U1 MC1723P
C21 .001
R25 8.2K
R22 15K
R26 1K
R23 1K
FINAL BIAS
R24 180
BIAS S/A 80575
D2 1N4002
C19 0.1
PWR AMP S/A
80877
7-8-80
+13.5
C22 22MF

Ten-Tec, Inc.
1185 Dolly Parton Parkway
Sevierville, TN 37862
Repair Service: (865) 428-0364

## LIMITED WARRANTY AND SERVICE POLICY, U.S.A. AND CANADA

Ten-Tec, Inc., warrants this product to be free from defects in material and workmanship for a period of one (1) year from the date of purchase, under these conditions:

1. THIS WARRANTY APPLIES ONLY TO THE ORIGINAL OWNER. It is important that the warranty registration card be sent to us promptly.

2. READ THE MANUAL THOROUGHLY. This warranty does not cover damage resulting from improper operation. Developing a thorough understanding of this equipment is your responsibility.

3. IF TROUBLE DEVELOPS we recommend you contact our customer service group direct at the address or phone number shown above. It has been our experience that factory direct service is expeditious and usually results in less down-time on the equipment. Some overseas dealers do offer warranty service and, of course, have our complete support.

4. EQUIPMENT RETURNED TO THE FACTORY must be properly packaged, preferably in the original shipping carton(s). You pay the freight to us and we prepay surface freight back to you. Canadian customers must have proper customs documentation sent with incoming repair equipment. Duties or fees charged due to improper documenting are the responsibility of the owner of the equipment.

5. EXCLUSIONS. This warranty does not cover damage resulting from misuse, lightning, excess voltages, polarity errors or damage resulting from modifications not recommended or approved by Ten-Tec. In the event of transportation damage, a claim must be filed with the carrier. Under no circumstances is Ten-Tec liable for consequential damages to persons or property caused by the use of this equipment.

6. TEN-TEC RESERVES the right to make design changes without any obligation to modify equipment previously manufactured, or to notify owners of changes to existing equipment.

7. THIS WARRANTY is given in lieu of any other warranty, expressed or implied.

## SERVICE OUTSIDE OF THE U.S.A. OR CANADA

Many of our international dealers provide warranty service on the equipment they sell. Many of them also provide out of warranty service on all equipment whether they sold it or not. If your dealer does not provide service or is not conveniently located, follow the procedure outlined above. Equipment returned to us will be given the same attention as domestic customers but roundtrip freight expense, customs and broker fees will be paid by you.

Part no. 74244