



## SSB TRANSCEIVER

# Model TS-520S



## OPERATING MANUAL

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# TS-520S SPECIFICATIONS

## GENERAL

**FREQUENCY RANGE**..... 160 meter band — 1.80 to 2.00 MHz  
 80 meter band — 3.50 to 4.00 MHz  
 40 meter band — 7.00 to 7.30 MHz  
 20 meter band — 14.00 to 14.35 MHz  
 15 meter band — 21.00 to 21.45 MHz  
 10 meter band — 28.00 to 28.50 MHz (A)  
 — 28.50 to 29.10 MHz (B)  
 — 29.10 to 29.70 MHz (C)  
 WWV — 15.0 MHz (receive only)

**MODE**..... SSB (USB, LSB) or CW

**ANTENNA IMPEDANCE**..... 50 ~ 75 ohms

**FREQUENCY STABILITY**..... Within 100 Hz during any 30 minute period after warmup  
 Within ±1 kHz during the first hour after 1 minute of warmup

**TUBES AND SEMICONDUCTORS**..... Tubes 3  
 Transistors 52  
 FETs 19  
 Diodes 100

**POWER REQUIREMENTS**.....

	120/220V AC, 50/60 Hz operation	13.8V DC operation
Receive	45 watts (heaters on) 26 watts (heaters off)	5A (heaters on) 0.6A (heaters off)
Transmit	280 watts (maximum)	15A (maximum)

**DIMENSIONS**..... 333 (13.2") wide × 153 (5.9") high × 335 (13.2") deep

**WEIGHT**..... 16 kg (37.4 lbs)

## TRANSMITTER

**RF INPUT POWER**.....

	120/220V AC, 50/60 Hz operation	13.8V DC operation
	200 watts PEP for SSB operation 160 watts DC for CW operation	120 watts PEP for SSB operation 90 watts DC for CW operation

**CARRIER SUPPRESSION**..... Better than 40 db

**SIDEBAND SUPPRESSION**..... Better than 50 db

**SUPRIOR RADIATION**..... Better than 40 db

**MICROPHONE**..... High impedance microphone (50k ohms)

**AF RESPONSE**..... 400 to 2,600 Hz, within — 6 db

## RECEIVER

**SENSITIVITY**..... 0.25μV S+N/N 10 db or more

**SELECTIVITY**..... SSB — 2.4 kHz ( — 6 db)  
 — 4.4 kHz ( — 60 db)  
 CW\* — 0.5 kHz ( — 6 db)  
 — 1.5 kHz ( — 60 db)  
 \* (with optional CW filter installed)

**IMAGE RATIO**..... Better than 50 db

**IF REJECTION**..... Better than 50 db

**AF OUTPUT POWER**..... 1 Watt (8 ohms load, with less than 10% distortion)

**AF OUTPUT IMPEDANCE**..... 4 to 16 ohms

# SECTION 1. INTRODUCTION

## 1-1 KENWOOD TS-520S

The TS-520S is a highly sophisticated solid state amateur radio transceiver employing only three vacuum tubes.

Operating on all amateur bands between 1.8 and 29.7 MHz, this unit is constructed modularly. All major electronic circuits are wired on easily removed or installed circuit boards. The TS-520S includes many built-in features usually found as extras on other transceivers. Included in the equipment are a VOX circuit, a 25 kHz crystal calibrator, an RIT circuit, a RF attenuator, and an effective noise blander. The TS-520S also includes automatic gain control (AGC), automatic level control (ALC), provisions for break-in CW with sidetone, a speech processor, and built-in power supplies.

The TS-520S also can connect a Digital Display, Model DG-5, (optional). The DG-5 is useful for reading the TS-520S operating frequency as precise as an order of 100 Hz.

Designed for operation on SSB or CW, the TS-520S delivers more than 200 watts PEP input. The low power consumption of the TS-520S, resulting from its solid state design, makes the transceiver ideal for portable and mobile operation. Any complicated electronic equipment will be damaged if operated incorrectly, and this transceiver is no exception. Please read all of the operating instructions before putting the TS-520S on the air.

## 1.2 REQUIREMENTS FOR OPERATION

### ■ AC OPERATION

The TS-520S requires no external power supply for operation. For fixed station operation, the TS-520S operates from any 120/220V AC, 50/60 Hz power source capable of supplying 280 watts or more. The transceiver has a built-in 8 ohm speaker.

### ■ DC OPERATION

The TS-520S make possible for a mobile operation by using optional DS-1A.

### ■ ANTENNA

**Fixed Station**— Any of the common antenna systems designed for use on the high frequency amateur bands may be used with the TS-520S, provided the input impedance of the transmission line is not outside the capability of the pi-output matching network. The transmission line should be of the coaxial cable type. An antenna system which shows a standing wave ratio of less than 2 : 1 when using 50 or 75 ohm coaxial transmission line, or a system that results in a transmission line input impedance that is essentially resistive, and between 15 and 200 ohms will take power from the

transceiver with little difficulty. If openwire or balanced type transmission line is used with the antenna, a suitable antenna tuner is recommended between the transceiver and the feed line. Methods of construction and operating such tuners are described in detail in the ARRL Antenna Handbook, and similar publications. For operation on the 160, 75 and 40 meter bands, a simple dipole antenna, cut to resonance in the most used portion of the bands, will perform satisfactorily. For operation of the transceiver on the 10, 15, and 20 meter bands, the efficiency of the station will be greatly increased if a good directional rotary antenna is used. Remember that even the most powerful transceiver is useless without a proper antenna.

**Mobile Station**— Mobile antenna installations are critical, since any mobile antenna for use on the high frequency bands represents a number of compromises. Many amateurs lose the efficiency of their antenna through improper tuning. Remember the following points when using the TS-520S with a mobile antenna.

The "Q" of the antenna loading coil should be as high as possible. There are several commercial models available which use high "Q" coils.

The loading coil must be capable of handling the power of the transceiver without overheating. In the CW mode the power output of the transceiver will exceed 80 watts.

The SWR bridge is a useful instrument, but unfortunately it is quite often misunderstood, and overrated in importance. Basically, the SWR bridge will indicate how closely the antenna load impedance matches the transmission line. With long transmission lines, such as will be used in many fixed station installations, it is desirable to keep the impedance match fairly close in order to limit power loss. This is particularly true at the higher frequencies. The longer the line, and the higher the frequency, the more important SWR becomes. However, in mobile installations the transmission line seldom exceeds 20 feet in length, and an SWR of even 4 to 1 adds very little to power loss. The only time SWR will indicate a low figure is when the antenna presents a load close the 50 ohms, but many mobile antennas will have a base impedance as low as 15 or 20 ohms at their resonant frequency. In such a case, SWR will indicate 3 or 4 to 1, and yet the system will be radiating efficiently.

The really important factor in your mobile antenna is that it should be carefully tuned to resonance at the desired frequency. The fallacy in using an SWR bridge lies in the fact that it is sometimes possible to reduce the SWR reading by detuning the antenna. Field strength may actually be reduced in an effort to bring SWR down. Since field strength is the primary goal, we recommend a field strength meter for antenna tuning.

For antenna adjustments, the transceiver may be loaded lightly, using the TUN position instead of operating at full power output. This will limit tube dissipation during adjustments, and will also help to reduce interference on the frequency. In any case, do not leave the transmitter on for very long at one time. Turn it on just long enough to tune and load, and get a field strength reading. Start out with the antenna whip at about the center of its adjustment range. Set the VFO to the desired operating frequency and then adjust the PLATE control for a dip, and then the LOAD control. Then observe the field strength reading. The field strength meter may be set on top of the dash, on the hood, or at an elevated location some distance from the car.

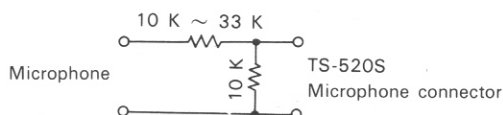
Change the whip length a half inch, or so at a time, retune the finals each time, and again check the field strength at the antenna. Continue this procedure until the point of maximum field strength is found. This adjustment will be most critical on 75 meters, somewhat less critical on 40, until on 10 meters the adjustment will be quite broad. After tuning the antenna to resonance, the finals can be loaded to full power.

#### ■ MICROPHONE

The microphone input is designed for high impedance (50k ohms) microphones only. The choice of microphone is important for good speech quality, and should be given serious consideration. The crystal lattice filter in the transceiver provides all the restriction necessary on audio response, and further restriction in the microphone is not required. It is more important to have a microphone with a smooth, flat response throughout the speech range.

The microphone manufacture's instructions should be followed in connecting the microphone cable to the plug. With many microphones, the push-to-talk button must be pressed to make the microphone operative. For VOX operation, this feature may be disabled, if desired, by opening the microphone case and permanently connecting the contacts which control the microphone.

The standard microphone sensitivity is within the range of - 50 db to - 60 db. If a microphone having a higher sensitivity is used, the ALC circuit will not function properly. In this case, insert an attenuator as shown in the illustration at right or connect a resistor (10k ~ 33k ohms) in parallel with the capacitor 100 pF (C13) in the generator unit (X52-1090-00) of the transceiver.



#### ■ EXTERNAL SPEAKER AND HEADPHONES

Receiver audio output from the TS-520S is 1 watt at 4 to 16 ohms. The TS-520S has a built-in speaker. However, if an external speaker is desired for fixed station or mobile operation, simply connect it to the SPEAKER jack on the rear panel. The speaker may be any good 8 ohm permanent magnet type in the 4 inch or larger size. The internal speaker is disconnected when an external speaker is used. The SP-520 is a speaker designed for use with the TS-520S. Headphones should also be 8 ohms impedance. When the headphones are connected to the front panel PHONES jack the speaker is disabled.

# SECTION 2. INSTALLATION

## 2.1 UNPACKING

Remove the TS-520S from its shipping box and packing material and examine it for visible damage. If the equipment has been damaged in shipment, save the boxes and packing material and notify the transportation company immediately. It is a good idea to save the boxes and packing material in any case because they are very useful for shipping or moving the equipment.

The following accessories should be included with the transceiver:

Operating Manual .....	1	AC Power Cord .....	1
Microphone Plug.....	1	Speaker Plug .....	1
Jumpered 9-pin Plug .....	1	8P US Plug .....	1
RCA Phono Plugs .....	3	Fuse (6A × 2, 4A × 2,	
Alignment Tool .....	1	2A × 1).....	5
Plastic Extension Feet with Screws .....	2		

## 2.2 OPERATING LOCATION

As with any solid state electronic equipment the TS-520S should be kept from extremes of heat and humidity. Choose an operating location that is dry and cool, and avoid operating the transceiver in direct sunlight. Also, allow at least 3 inches clearance between the back of the equipment and any object. This space allows an adequate air flow from the ventilating fan to keep the transceiver cool.

## 2.3 CABLING (See Figure 1)

### ■ GROUND

So preventing to receive an electric shock, TVI and BCI, select a good, effective ground for installation and then connect an earthing wire to the backside of GND terminal. Use a heavy earth line as big as possible, it is because short-line wiring is regarded as most effective for operation.

### ■ ANTENNA

Connect a 50 ohms antenna feedline to the coaxial connector on the rear panel.

### ■ KEY

If CW operation is desired, connect a key to the KEY jack.

### ■ POWER CONNECTIONS

Make sure the POWER switch on the front panel of the TS-520S is turned off, the stand-by switch is put in the REC position, and that the voltage switch on the back of the TS-520S is switched to the correct line voltage (120 or 220). Connect the POWER cord to an appropriate external power source.

### ■ SPEAKER

If an external speaker is desired, connect a cord to the SPEAKER jack on the back of the TS-520S and to the SPEAKER jack on the back of the SP-520 (or to an external 8 ohm speaker).

### ■ MICROPHONE

Attach the microphone connector to a suitable microphone as shown in Fig. 2. Be sure that the PTT switch of the microphone is separate from the microphone circuit, as shown in Fig. 3.

It should be noted that a microphone with a 3P plug having a common earth terminal cannot be used.

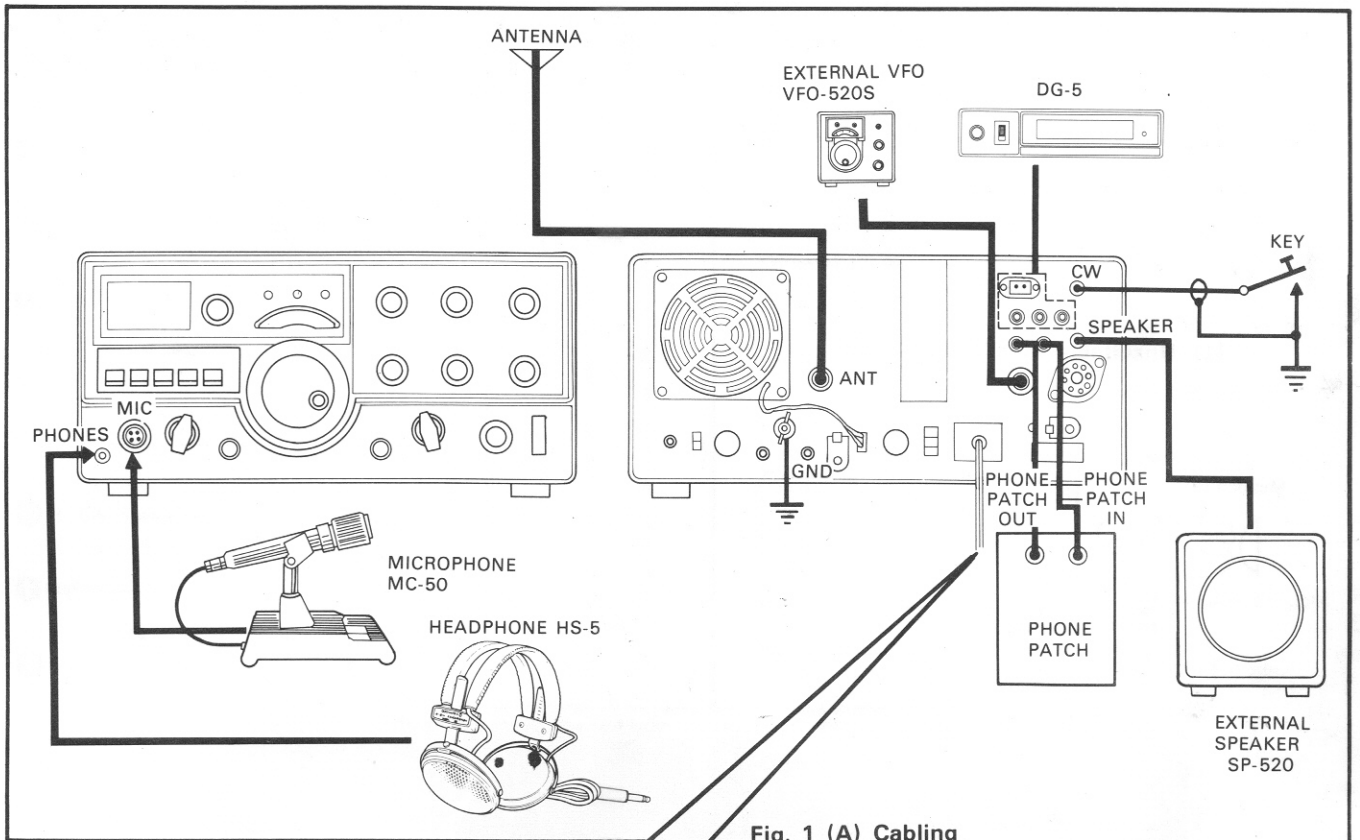
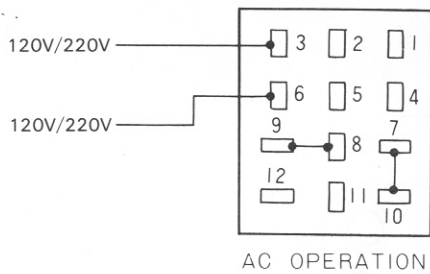


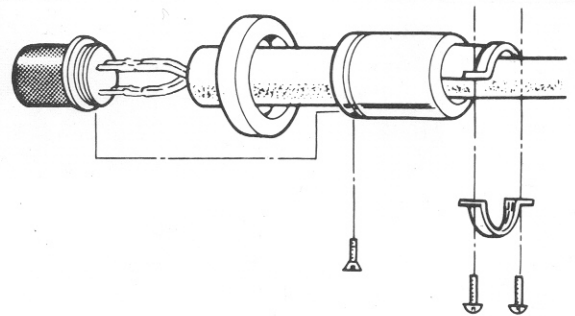
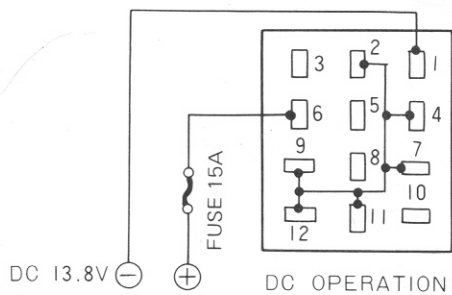
Fig. 1 (A) Cabling

Fig. 1 (B) Power Plug Wiring

IMPORTANT-When wiring a new power plug, confirm that the pin numbering on the new plug is identical to the pin numbering on the POWER connector. The transceiver can be damaged by incorrect pin wiring.



By use of optional DC-DC converter DS-1A.



seen from the cord.

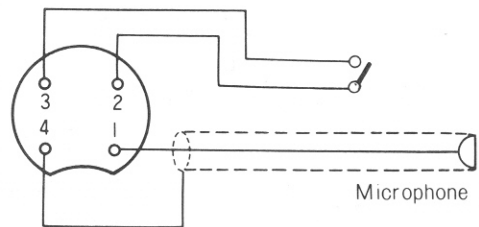
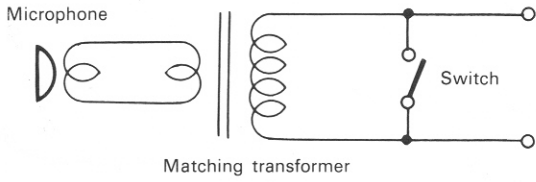
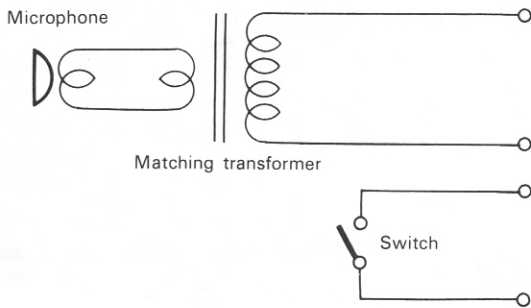


Fig. 2 Microphone Connector Wiring



(1) Unsuitable for PTT operation.



(b) Suitable for PTT operation.

Fig. 3 A Suitable PTT Microphone

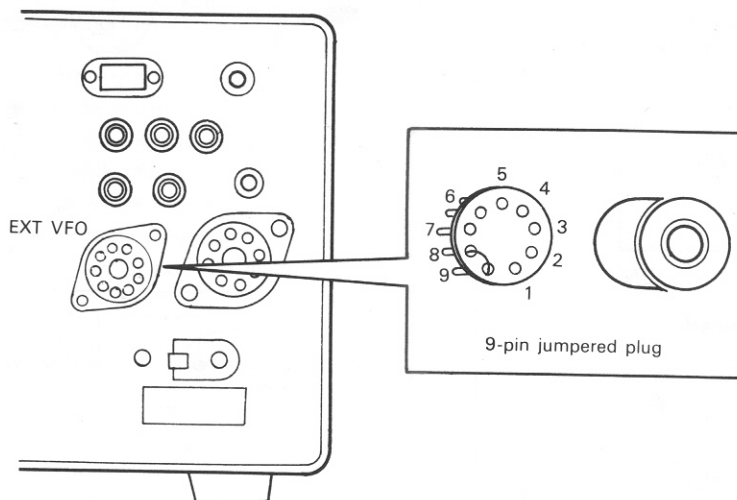


Fig. 4 Back Panel Jumpered EXT VFO Connector



# SECTION 3. OPERATING CONTROLS

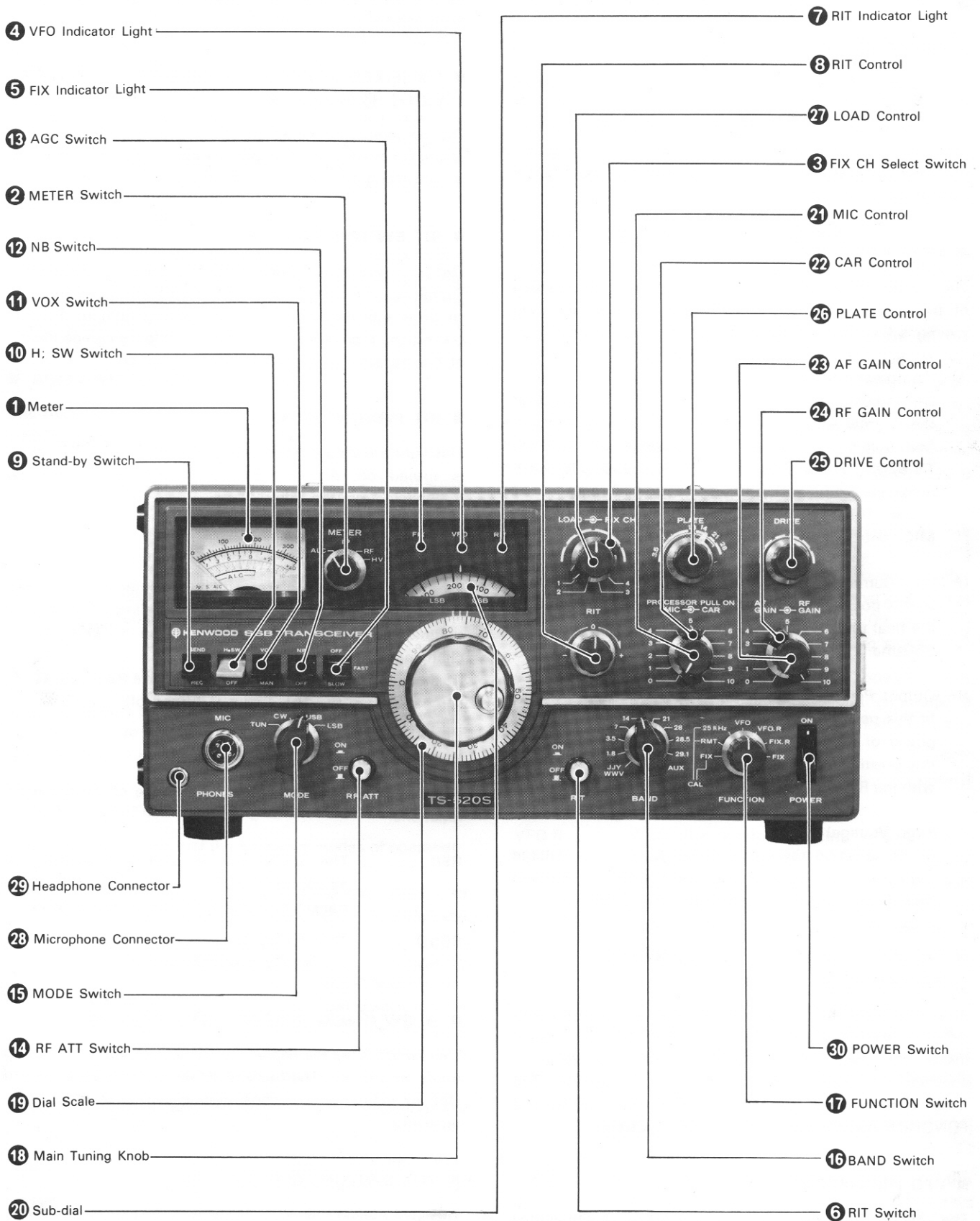


Fig. 5 Front Panel Controls

### 3.1 FRONT PANEL CONTROLS (See Figure 5)

#### ■ METER (1 on Figure 5)

The meter monitors five different functions, depending on the position of the METER switch. In receive the meter is automatically an S-meter. The S-meter shows received signal strength on a scale of 0 to 40 db over S9. In transmit the meter function depends on the position of the METER switch, as described below.

#### ■ METER SWITCH (2 on Figure 5)

The position of the METER switch determines the function of the meter. The switch selects one of the following functions (see Table 4 for nominal meter readings):

##### ALC (Automatic Level Control)

In this position the meter monitors the ALC voltage of the internal ALC circuit (or the ALC voltage feedback from a linear amplifier operated in conjunction with the TS-520S). For SSB operation the ALC reading for voice peaks should be within the indicated ALC range of the meter. The ALC voltage adjustment is made with the MIC control for SSB and with the CAR control for CW.

##### IP (Plate Current)

In this position the meter monitors the plate current of the final tubes. The meter scale is calibrated from 0 to 350 ma.

##### RF (Output Power)

In this position the meter monitors the relative output power of the transceiver. There is no meter scale for this position. Normally the reading should be adjusted with the RF VOLT control for a 2/3 scale meter reading.

##### HV (High Voltage)

In this position the meter monitors the high voltage from the power supply. The meter scale is calibrated from 6 to 10, indicating 600 to 1000 volts.

#### ■ CH. (FIXED CHANNEL) SELECT SWITCH (3 on Figure 5)

This four-position rotary switch selects between four different fixed frequency channels which can be installed inside the transceiver. Fixed frequency operation is convenient for operation on often used frequencies. The fixed channel oscillator replaces the VFO when the FUNCTION switch is placed in the FIX position.

#### ■ VFO INDICATOR LIGHT (4 on Figure 5)

The VFO indicator is a light emitting diode which illuminates whenever the TS-520S's internal VFO is controlling the

transceiver's operation. The indicator is not lighted during fixed channel, or remote VFO, operation.

#### ■ FIX (FIXED CHANNEL OPERATION) INDICATOR LIGHT (5 on Figure 5)

The FIX indicator is a light emitting diode which illuminates whenever the TS-520S's internal fixed frequency oscillator is controlling the transceiver's operation.

#### ■ RIT SWITCH (6 on Figure 5)

This push-button switch turns the RIT (Receiver Incremental Tuning) circuit on and off. With the switch depressed, the circuit is activated and the RIT indicator is lighted. The RIT control can then adjust the receiver frequency independently of the transmit frequency for VFO operation.

#### ■ RIT INDICATOR (7 on Figure 5)

This light emitting diode is illuminated when the RIT circuit is turned on, showing that the transmit and receive frequencies may be different.

#### ■ RIT CONTROL (8 on Figure 5)

When the RIT switch is pressed on, this potentiometer tunes the TS-520S's receiver. The RIT circuit allows the operator to tune the receive frequency more than  $\pm 2$  kHz without changing the transmit frequency.

At the zero (mid-point) position the receive frequency is the same as when the RIT circuit is turned off.

#### ■ STAND-BY SWITCH (9 on Figure 5)

This two-position lever switch selects one of the following functions:

REC ..... The transceiver is receiving unless the microphone PTT switch is switched to transmit, or the VOX circuit is activated.

SEND ..... The TS-520S is locked into the transmit mode in this switch position.

#### ■ H. SW (Heater) SWITCH (10 on Figure 5)

This switch turns the heater circuits of the three transmitting tubes on and off. The heaters would normally be turned to OFF to reduce power consumption in mobile or portable receiving.

#### ■ VOX SWITCH (11 on Figure 5)

This two-position lever switch selects one of the following functions.

MAN..... With the switch in this position, the transceiver is switched into transmit or receive by the stand-by switch or the PTT switch on the microphone.

VOX..... With the switch in this position, the VOX circuit is turned on for voice operated transmit on SSB semi-automatic break-in operation on CW.

■ **NB SWITCH** (12 on Figure 5)

The NB switch turns the built-in noise blanker circuit on and off. The noise blanker is designed to reduce pulsating ignition type noises. When the lever switch is flipped up, the circuit is turned on.

■ **AGC SWITCH** (13 on Figure 5)

The AGC switch controls the AGC (Automatic Gain Control) circuit giving the operator three choices:

OFF..... It may be desirable to turn the AGC off when receiving a very weak signal.

FAST..... The FAST AGC position is designed for use in CW operation.

SLOW..... Use the SLOW AGC position for SSB operation.

■ **RF ATT SWITCH** (14 on Figure 5)

With this switch set to ON, ATT (attenuator) of about 20 db is connected to the antenna circuit, protecting the RF amplifier and mixer circuit from strong input signals.

■ **MODE SWITCH** (15 on Figure 5)

This switch selects one of the following modes of operation.

TUN..... Turn the MODE switch to this position to generate a low power carrier for tuning the transceiver.

The mode switch is also used for frequency setting and calibration during CW operation. In the TUN position the input power into the final section is reduced to prevent tube damage during tuning. Normal operation is not possible in this mode.

CW..... This position is used for operating the TS-520S in the CW mode.

USB..... This switch position selects the USB circuits for operating on upper sideband. International amateur practice dictates the use of USB on the 14, 21, and 28 MHz bands.

LSB..... This switch position selects the LSB circuits for operating on lower sideband. International amateur practice dictates the use of LSB on the 1.8, 3.5 and 7 MHz.

■ **BAND SWITCH** (16 on Figure 5)

This 10-position switch selects all the necessary circuits to tune the transceiver to the desired 600 kHz band.

■ **FUNCTION SWITCH** (17 on Figure 5)

This 7-position rotary switch selects one of the following transceiver functions.

CAL-FIX..... This position allows calibration of the TS-520S's internal VFO to one of the transceiver's fixed frequency channels (if an optional fixed channel crystal is installed). With the switch in this position a signal is generated at the selected fixed channel frequency and the main tuning knob can be tuned to zero beat the calibrating signal.

CAL-RMT..... This position allows calibration of the VFO-520S (remote VFO) to the transceiver's operating frequency. With the switch in this position, the transceiver generates a calibrating signal and the VFO-520S can be tuned to zero-beat the calibrating signal.

CAL-25 kHz. With the switch in this position, the transceiver's calibrator circuit generates a marker signal at every 25 kHz for normal calibration of the internal VFO.

VFO..... The switch is kept in this position for normal transceiver operation.

VFO.R..... With the switch in this position, the TS-520S's internal VFO controls the receive function and the internal fixed channel oscillator controls the transmit function (if fixed channel crystals are installed in the oscillator).

FIX.R..... With the switch in this position, the TS-520S's internal VFO controls the transmit function and the built-in fixed channel oscillator controls the receive function (if fixed channel crystals are installed in the oscillator). The VFO.R and FIX.R allow cross-channel operation without an external VFO.

FIX..... With the switch in this position, the TS-520S's fixed channel oscillator controls the transmit and receive function of the

transceiver (if accessory fixed channel crystals are installed in the transceiver).

■ **MAIN TUNING KNOB** (18 on Figure 5)

This control turns the VFO and dial scale to select the frequency to be added to the band frequency to establish the transceiver's operating frequency.

The TS-520S also has a Fast Forward Tuning control.

■ **DIAL SCALE** (19 on Figure 5)

The dial scale provides a direct frequency readout, calibrated to 1 kHz from 0 to 100 kHz. The sub-dial is calibrated to display the frequency every 25 kHz. The frequency displayed on the dial scale, when added to the base frequency of the chosen band and the frequency shown on the sub dial, shows the exact operating frequency of the transceiver. One revolution of the dial scale is 100 kHz.

■ **SUB-DIAL** (20 on Figure 5)

The sub-dial is turned with the main tuning knob to select the operating frequency of the transceiver. It is calibrated at 25 kHz intervals from 0 to 600 kHz. The operating frequency of the TS-520S is determined by adding the frequency shown on the BAND switch, this sub-dial, and the dial scale.

■ **MIC CONTROL (PROCESSOR PULL ON)**  
(21 on Figure 5)

The MIC gain control adjusts the gain of the microphone amplifier for SSB operation as well as switching a speech processor for DX operation. For normal operation, push the knob in and adjust the MIC GAIN for an in scale ALC meter reading on voice peaks. Adjusted in this way, the transceiver generates a natural sounding transmission.

For difficult DX operation however, pull the control out and readjust the MIC GAIN for an in scale ALC reading on voice peaks. Turn the speech processor off for normal operation.

■ **CAR CONTROL** (22 on Figure 5)

This control turns a variable resistor that adjusts the output carrier level during CW operation. The control is adjusted for 200 ma of plate current for CW operation.

■ **AF GAIN CONTROL** (23 on Figure 5)

This control adjusts the gain of the receiving audio amplifier. The audio volume of the received signal increases as the control is turned clockwise.

■ **RF GAIN CONTROL** (24 on Figure 5)

This control adjusts the gain of the receiver section's RF amplifier. Turn the knob fully clockwise for maximum gain and for a correct S-meter reading. Turn the control counter-clockwise to reduce the gain.

■ **DRIVE CONTROL** (25 on Figure 5)

The DRIVE tuning control tunes the plate tank circuit of the 12BY7A driver as well as the receiver's antenna and mixer coils. In receive the DRIVE control is tuned for maximum sensitivity (maximum S-meter deflection). In transmit the DRIVE control is tuned for a maximum ALC reading. When the control is correctly tuned for transmission it will be correctly tuned for reception.

■ **PLATE CONTROL** (26 on Figure 5)

The PLATE control adjusts the plate tuning of the two final amplifier tubes.

■ **LOAD CONTROL** (27 on Figure 5)

The LOAD control adjusts the loading of the pi-circuit between the final section and the antenna. The control is adjusted as described in Section 4 for impedance matching.

■ **MIC CONNECTOR** (28 on Figure 5)

The microphone connector is four pronged, allowing use of the PTT microphone. Figure 2 shows how to wire the plug on the microphone cable.

■ **PHONES JACK** (29 on Figure 5)

The headphones jack allows use of a 4 to 16 ohm set of headphones with a 1/4" phone plug attached. When the phones are plugged into the transceiver, the speaker is disconnected.

■ **POWER SWITCH** (30 on Figure 5)

The POWER switch turns all the power on and off in the TS-520S.

### 3.2 SIDE PANEL CONTROLS

The 5 controls located on the left side of the transceiver are covered by a protective panel. The cover is removed by simply pulling the two black fasteners.

#### ■ RF VOLT CONTROL (1 on Figure 6)

Use the RF VOLT control to adjust the sensitivity of the RF output function of the meter. Adjust it for a 2/3 scale reading during CW transmission.

#### ■ BIAS CONTROL (2 on Figure 6)

The BIAS control adjusts the bias voltage of the two S2001A (6146B) amplifier tubes. Turning the control clockwise increases the idling plate current of the tubes. Section 4 describes adjustment of the bias current.

#### ■ DELAY CONTROL (3 on Figure 6)

The DELAY control adjusts the holding time of the VOX circuit for VOX or break-in CW operation. The control will have to be adjusted to the preference of the individual operator.

#### ■ ANTI VOX CONTROL (4 on Figure 6)

This control adjusts the level of the anti VOX signal fed in to the VOX circuit. Adjust the control to prevent feedback of the speaker from tripping the VOX circuit.

#### ■ VOX GAIN CONTROL (5 on Figure 6)

This control adjusts the sensitivity of the VOX circuit by adjusting the gain of the VOX amplifier, for voice control led operation.

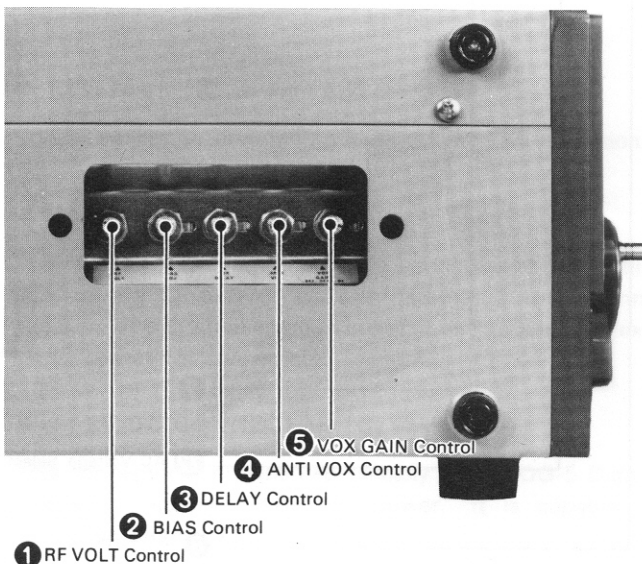


Fig. 6 Side Panel Controls

### 3.3 REAR PANEL CONTROLS (See Figure 7)

#### ■ COOLING FAN (1 on Figure 7)

This fan cools the RF amplifier section of the TS-520S to insure reliable and efficient operation.

#### ■ TRANSVERTER OUT JACK (2 on Figure 7)

This is the low level RF output jack for use with a VHF transverter.

#### ■ TRANSVERTER IN JACK (3 on Figure 7)

This is the RF input jack for input from a VHF transverter.

#### ■ TRANSVERTER CONNECTOR (4 on Figure 7)

This 12-pin connector is used to control an accessory VHF transverter.

PIN	FUNCTION	PIN	FUNCTION
1	ALC	7	Transverter in
2	No connection	8	Normally closed relay contact
3	+210V DC	9	Ground
4	No connection	10	+210V DC
5	-100V DC	11	No connection
6	Transverter in	12	Ground

#### ■ XVERTER SWITCH (5 on Figure 7)

When VHF Transverter (TV-502S) is connected to the transceiver, the selection of HF or VHF is automatically accomplished by setting the transverter switch to ON or OFF.

#### ■ ANTENNA CONNECTOR (6 on Figure 7)

This SO-239 coax connector should be attached to a suitable antenna for transmitting and receiving. See Section 1.2 for a discussion of an appropriate antenna.

#### ■ POWER SUPPLY CONNECTOR (7 on Figure 7)

This 12-pin connector is used to connect an AC or DC power source to the transceiver.

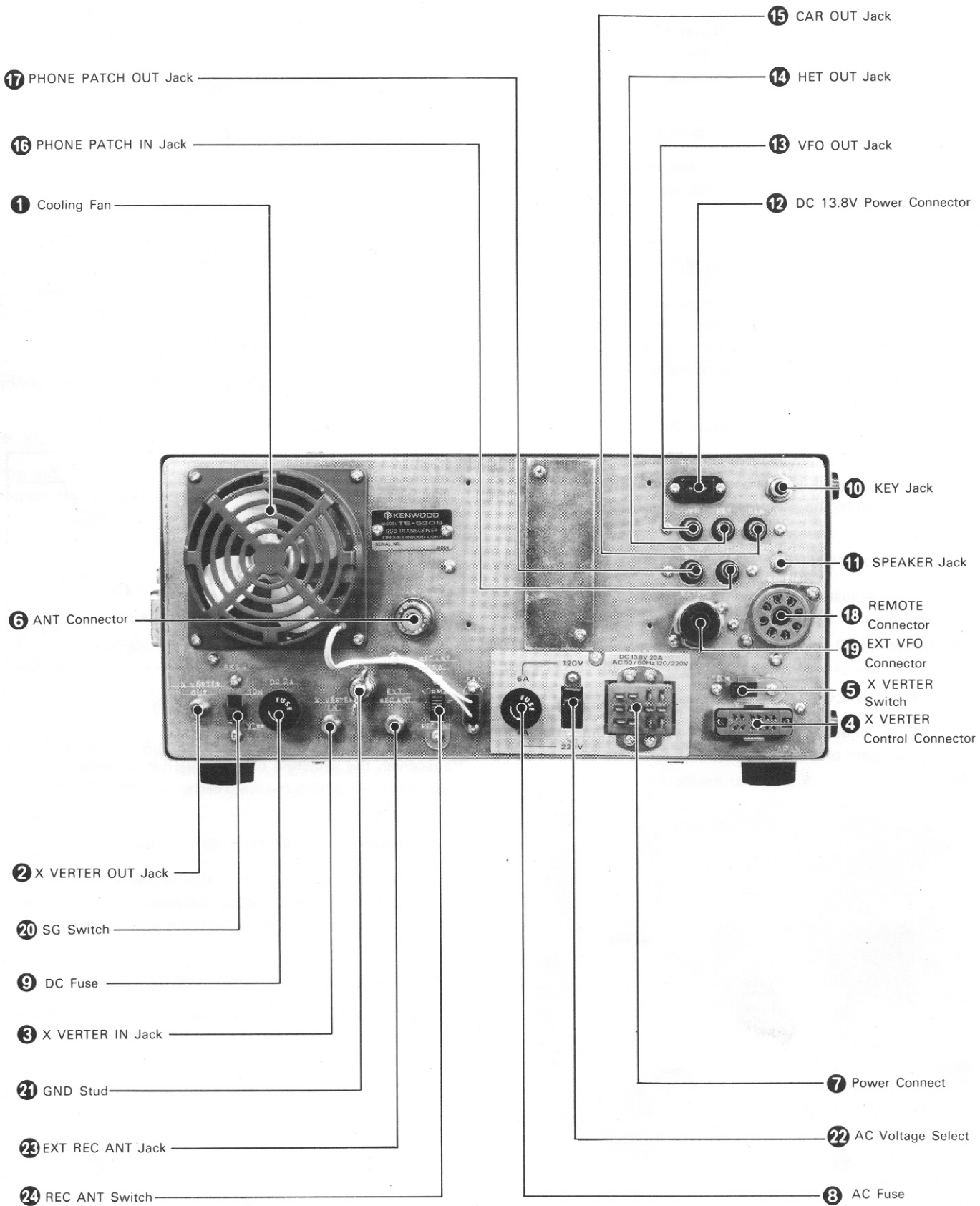


Fig. 7 Rear Panel Controls

PIN	FUNCTION	CONNECTION FOR AC OPERATION	CONNECTION FOR DC OPERATION
1	Ground	No connection	⊖ 13.8V DC
2	Power direct (Connect to pin 3 for remote AC power switching)	No connection	Jumper to 4, 7, 9, 11 and 12
3	AC power common	120/220V AC	No connection
4	+13.8V DC to control DC module	No connection	Jumper to 2, 7, 9, 11 and 12
5	No connection	No connection	No connection
6	Power switching	120/220V AC	⊕ 13.8V DC
7	12.6V AC (or 13.8V DC) to heaters	Jumper to 10	Jumper to 2, 4, 9, 11 and 12
8	13.8V DC to pin 9 in AC operation	Jumper to 9	No connection
9	13.8V DC to operate solid state circuits	Jumper to 8	Jumper to 2, 4, 7, 11 and 12
10	12.6V AC to pin 7 in AC operation	Jumper to 7	No connection
11	+13.8V DC to DC module	No connection	Jumper to 2, 4, 7, 9 and 12
12	+13.8V DC to DC module	No connection	Jumper to 2, 4, 7, 9 and 11

The power plug wiring is shown in Figure 1C.

■ **AC FUSE** (⑧ on Figure 7)

This fuse is a 3AG, 4 amp fuse which protects the power supply of the transmitter against short circuits. Never use a higher amperage fuse than the one specified. An improper one can cause extensive damage to the transmitter. When the fuse blows out, try to determine the cause before replacing it.

When the position of the AC Voltage Selector Switch is changed, it is also necessary to change the power fuse. For 120 volt operation a 6 ampere fuse, for 220 volt operation a 4 ampere fuse provided with the TS-520S should be used.

■ **DC FUSE** (⑨ on Figure 7)

This is a 2A fuse holder, placed in the 13.8V DC power source.

■ **KEY JACK** (⑩ on Figure 7)

Connect a key to this 1/4" phone jack for CW operation.

■ **SPEAKER JACK** (⑪ on Figure 7)

The receiver audio output can be connected through this jack to the SP-520 or another external 4 to 16 ohm speaker. The internal speaker is disconnected when an external speaker is connected.

■ **13.8V DC CONNECTOR** (⑫ on Figure 7)

This connector is provided specifically for the DG-5 Digital Display to supply 13.8V DC power. It is capable of delivering around 1A.

**CAUTION:** \_\_\_\_\_

The connector output power contains a large amount of ripples. Do not use it for units other than the DG-5 unless absolutely necessary.

■ **VFO OUT JACK** (⑬ on Figure 7)  
**HET OUT JACK** (⑭ on Figure 7)  
**CAR OUT JACK** (⑮ on Figure 7)

These jacks feed the respective local oscillator outputs to the DG-5 Digital Display.

■ **PHONE PATCH IN JACK** (⑯ on Figure 7)

This is a phone patch input terminal for transmission of SSTV or other line inputs.

■ **PHONE PATCH OUT JACK** (⑰ on Figure 7)

This is line output terminal for phone patch on recording. It is also used for connection to the input of FSK demodulator or SSTV.

■ **REMOTE CONNECTOR** (⑱ on Figure 7)

The REMOTE connector is an 8-pin socket for use in interconnecting a linear amplifier, an external speaker, or another accessory item. (See Figure 30)

PIN	FUNCTION	PIN	FUNCTION
1	Ground	5	Normally open relay contact
2	No connection	6	ALC feedback ALC threshold level approx. -6V
3	Normally closed relay contact	7	No connection
4	Ground	8	External speaker Load impedance 4 ~ 16Ω

■ **EXTERNAL VFO CONNECTOR (19)** on Figure 7)

This 9-pin connector provides a means of interconnecting the KENWOOD VFO-520S, another external VFO. The interconnecting cable is provided with the VFO-520S. The 9-pin jumpered VFO plug provided with the TS-520S must be inserted in this socket for normal transceiver operation.

PIN	FUNCTION	PIN	FUNCTION
1	VFO signal	6	Calibrator signal (9V DC)
2	VFO signal shield	7	No connection
3	Ground	8	9V DC to internal VFO (pin 9)
4	12.6V AC	9	9V DC to external VFO
5	Relay voltage (+ on transmit)		

■ **SG SWITCH (20)** on Figure 7)

The SG slide switch controls the screen grid voltage on the final tubes. For tuning or neutralizing the TS-520S you can set the switch to the OFF position. Turn the switch back to the ON position for normal operation. The SG voltage is on when the switch is up and off when the switch is down.

■ **GND (Ground) LUG (21)** on Figure 7)

To prevent accidental shocks from the chassis, as well as interference, connect a good earth ground to this lug.

■ **AC VOLTAGE SELECT SWITCH (22)** on Figure 7)

This slide switch switches the primary of the power transformer to select 120 or 220V AC operation.

■ **EXTERNAL RECEIVER ANTENNA JACK (23)** on Figure 7)

This is an antenna connector to which an external receiver, for example, a sub-receiver, is connected.

■ **RECEIVER ANTENNA SWITCH (24)** on Figure 7)

This switch connects the antenna to the TS-520S at the NORMAL position and to the external receiver at the REC ANT position.

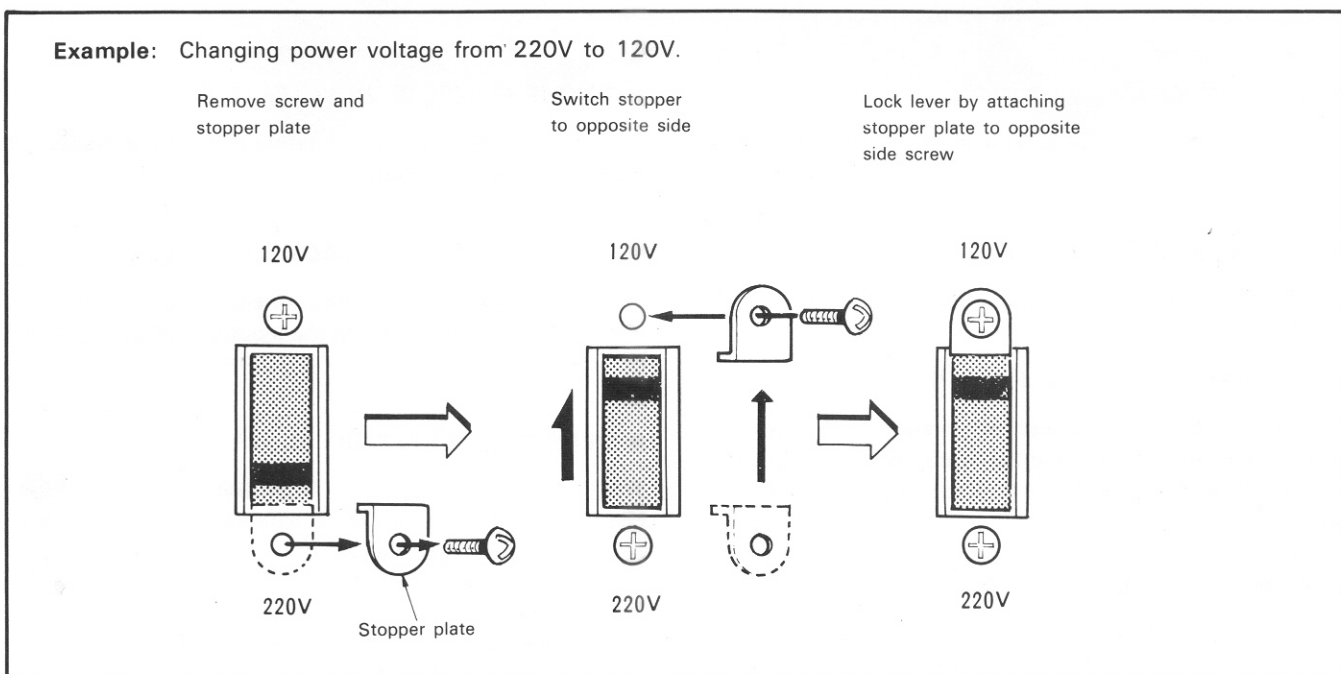


Fig. 8 Changing Power Voltage



# SECTION 4. OPERATING INSTRUCTIONS

## 4.1 PRELIMINARY PROCEDURE

Set the MIC and CAR controls to zero and the MODE switch to LSB, USB, or CW to prevent accidental transmit conditions before tuning. The TS-520S must be operated into a 50 ohm antenna or dummy load with an SWR less than 2 : 1. Random length wire antennas or light-bulb dummy loads cannot be used. Conventional half-wave dipoles and beam antennas should only be used at or near their resonant frequency. Exceeding an SWR of 2 : 1 can damage the components in the output stage of the transceiver. Refer back to Section 1.2.

Be sure to complete all of the required cabling, as described in Section 2.3.

With a suitable antenna and microphone (or key) connected to the transceiver, set the TS-520S switches to the positions described in Table 1.

## 4.2 RECEIVER TUNING

Refer to Table 1 for the initial switch settings of the TS-520S for receiving, and then continue with the described procedure.

Push the POWER switch on. The meter, dial scale, and VFO indicator will light, indicating that the transceiver is operating. The receiver section is fully solid-state allowing

reception with the H. SW switch turned to OFF. Advance the AF GAIN control clockwise until some receiver noise is heard in the speaker. Turn the main tuning dial within the frequency range of the amateur band chosen until a signal is heard. Tune the signal for the clearest possible reception, and then adjust the DRIVE control for maximum deflection of the S-meter.

The RF GAIN control varies the AGC feedback voltage which effects the S-meter reading. With the RF GAIN control fully clockwise, the S-meter gives a proper signal strength reading. Turning the control counter-clockwise reduces the RF gain, reducing signal strength and band noise.

## 4.3 READING THE OPERATING FREQUENCY (See Figure 9)

The operating frequency of the TS-520S is the sum of three different readings — the base frequency of the band (1.8, 7.0, .....), the reading of the sub-dial (0, 100, 200, .....), and the reading of the dial scale (0, 10, 20, .....)

The sub-dial is calibrated in 25 kHz intervals from 0 to 600. The dial scale is calibrated in 1 kHz intervals from 0 to 100. Four revolutions of the main tuning knob turns the dial scale once, covering 100 kHz. Six turns of the dial scale covers the entire band from 0 to 600 kHz.

**TABLE 1. Initial Switch Settings for Receiving**

CONTROL LOCATION	CONTROL	POSITION
FRONT PANEL CONTROLS	BAND Switch	Desired band
	POWER Switch	OFF
	H. SW Switch	OFF
	Stand-by Switch	REC
	NB Switch	OFF
	RIT Switch	OFF
	FUNCTION Switch	VFO
	AGC Switch	SLOW or FAST
	MODE Switch	To the appropriate sideband or CW
	RF ATT Switch	OFF
	PLATE Control	Middle of the range for the band
	DRIVE Control	Centered
	RIT Control	Centered
	AF GAIN Control	Fully counter-clockwise
	RF GAIN Control	Fully clockwise
	REAR PANEL CONTROLS	EXT VFO Connector
SG Switch		ON (up position)
XVERTER Switch		OFF
REC ANT Switch		NORMAL

The remaining controls do not affect reception so they may be in any position.

Example: BAND Switch — 14.0  
 Sub-dial — between 200 and 300  
 Dial Scale — 80  
 Operating Frequency —  
 14.0 MHz + 200 kHz  
 + 80 kHz = 14.280 MHz

When the TS-520S is correctly calibrated, as described below, the center dial pointer shows the operating frequency for CW. The left dial pointer shows the operating frequency for LSB operation and the right dial pointer shows the operating frequency for USB operation.

During CW operation, the center dial pointer provides two different readings, one for transmission and the other for reception.

In transmitting mode, the reading on the center dial pointer is the transmit frequency. In receiving mode, however, the mode switch should be set to TUNE and the main dial of VFO adjusted to zero beat the desired receive frequency. Then, the reading on the center dial pointer is the receive frequency.

Under such a condition, the receiving signal can be clearly heard as a 700 Hz tone by setting the mode switch to CW. The transmit/receive frequency of the transceiver will now be set to the operating frequency of the other station.

If a modification is made on the wiring of the carrier unit, no beat tones will appear on either side of the zero beat. In this case, the reading at the mid-position between the LSB pointer and the center dial pointer, which is obtained when the beat tone of receiving signal is about 800 Hz, is the transmit/receive frequency.

For modification of the wiring, disconnect the brown lead from the CWR terminal and connect it to the LSB terminal; similarly, disconnect the gray lead from the CWT terminal and connect it to the CWR terminal.

## 4.4 CALIBRATION

### ■ NORMAL TRANSCEIVER CALIBRATION

Turn the FUNCTION switch to CAL-25 kHz to activate the crystal calibrator. Be sure the RIT switch is OFF. Turn the main tuning knob to receive one of the marker signals which are generated at 25 kHz intervals. For greatest accuracy choose a calibrator signal near the desired operating frequency.

LSB ..... Set the MODE switch to LSB and tune the main tuning knob to zero beat one of the marker signals. If the dial scale reading under the left-hand LSB dial pointer is not on an even 25 kHz marking, hold the main tuning knob with one hand and turn the dial scale shows the correct reading.

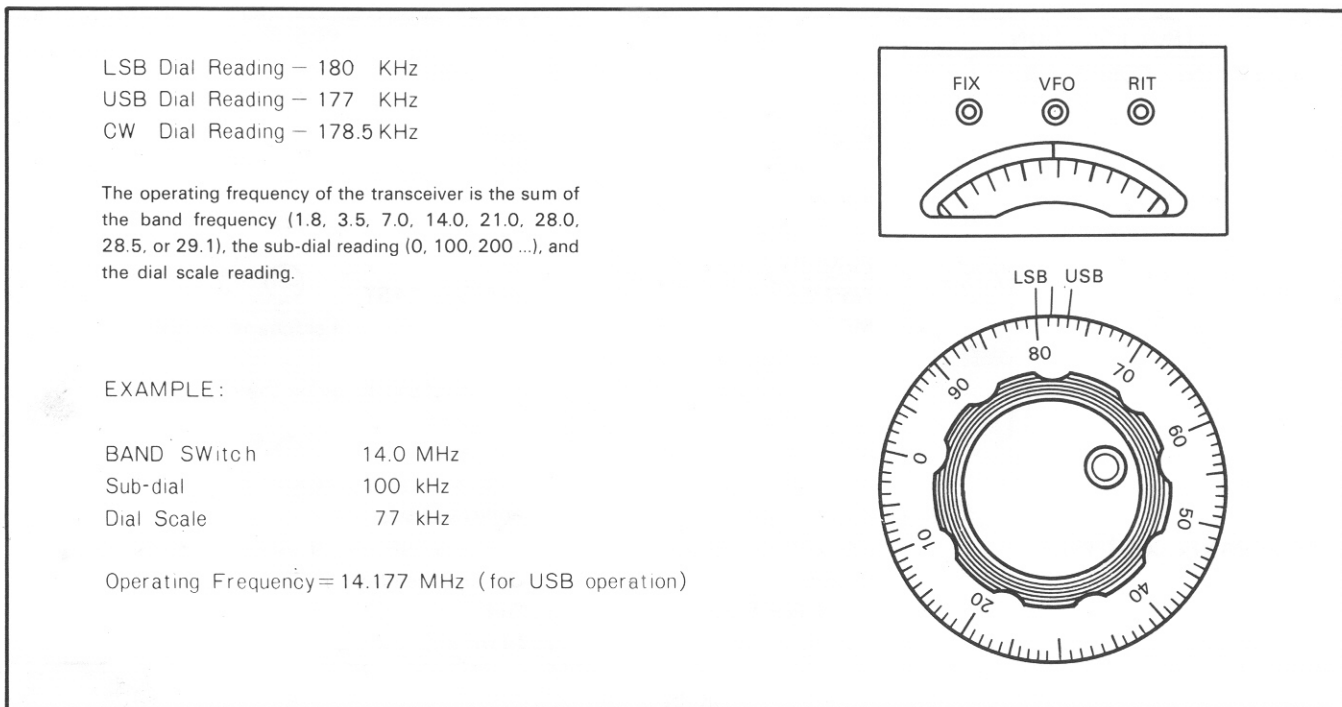


Fig. 9 Reading the Operating Frequency (Refer to Section 4.3)

USB..... Use the procedure described above with the MODE switch turned to USB. Use the USB (right-hand) dial pointer.

CW ..... Set the mode switch to TUNE to zero beat the marker signal. Then, turn the main dial and calibrate the frequency using the center dial pointer.

If the TS-520S has a CW filter installed, tune the VFO for maximum S-meter deflection when receiving the marker signal. Calibrate the dial scale to the center pointer as described above.

#### ■ CALIBRATING THE TS-520S TO A FIXED CHANNEL FREQUENCY

Turn the FUNCTION switch to CAL-FIX to calibrate the TS-520S's VFO to a fixed channel frequency. Tune the VFO to the channel frequency selected and zero beat the generated marker signal. At zero beat the VFO and crystal frequencies coincide.

By calibrating the VFO for normal operation, as described above, the VFO can be used as a frequency standard for netting accessory fixed channel crystals.

#### ■ CALIBRATING THE TS-520S WITH THE VFO-520S

Turn the FUNCTION switch to CAL-RMT to calibrate the TS-520S with the VFO-520S a receiver, or another remote VFO. Tune the remote VFO to the frequency selected on the TS-520S and zero beat the generated marker signal.

At zero beat, the TS-520S and remote VFO frequencies coincide.

By calibrating the TS-520S for normal operation, as described previously, the TS-520S can be used as a frequency standard for calibrating the remote VFO.

#### ■ CALIBRATING THE TS-520S MARKER TO WWV

To check that the marker signals are correctly adjusted, beat the calibrator signal against WWV at 15 MHz. Receive WWV at 15 MHz as described in Section 4.5. Turn the FUNCTION switch to CAL-25 kHz and the MODE SWITCH to TUN. The calibrator signal and WWV signal should overlap and zero beat at the zero marking on the sub-dial. If they do not, adjust the calibrator to zero beat with TC1 on the MARKER (X52-0005-01) board.

### 4.5 WWV RECEPTION

The TS-520S will receive WWV at 15 MHz when the BAND switch is turned to WWV and the sub-dial is turned to zero.

The DRIVE control does not tune the transceiver for WWV reception.

### 4.6 RF GAIN

RF GAIN is controlled by changing the voltage of the AGC circuit. Adjust the RF GAIN knob so that the S-meter does not cause excessive deflection. This minimizes the noise during reception and allows the S-meter to indicate the correct signal strength. For normal operation, this knob should be turned fully clockwise for maximum sensitivity.

### 4.7 NOISE BLANKER

The TS-520S has a sophisticated built-in noise blanker designed to reduce ignition type impulse noise. The noise blanker is particularly important for mobile operation. When necessary, activate the noise blanker circuit by flipping the NB switch up.

### 4.8 AGC (AUTOMATIC GAIN CONTROL)

Set the AGC switch to the position appropriate for the received signal. Generally for SSB reception set the AGC switch to SLOW, for CW reception set the AGC switch to FAST, and for reception of a very weak signal the switch may be set to off.

### 4.9 RIT (RECEIVER INCREMENTAL TUNING)

With the RIT switch turned off the TS-520S receives and transmits at the same frequency. At times the received signal may drift off frequency and become less intelligible. When this happens, flip the RIT switch up to activate the RIT circuit and return the received signal to an intelligible state using the RIT control. The RIT control varies the receive frequency about  $\pm 3$  kHz. The RIT circuit has no effect on the transmit frequency. When the RIT switch is turned on the RIT light is illuminated. Be careful to turn the RIT to the OFF position when returning to normal transceive operation to prevent unintentionally transmitting and receiving on different frequencies.

VR2 on the FIXED CHANNEL-AVR board adjusts the zero point of the RIT control (see Section 6.6).

#### 4.10 RF ATT

If the transceiver is operated in a short-distance (within several hundred meters) and strong signals of nearby frequencies are received, the wanted signals are blocked. Also, if the wanted signals are very strong, the S-meter is scaled out. In this instance, set the RF ATT switch to ON. The input signals to the RF amplifier are attenuated by about 20 db, providing distortionless reception.

#### 4.11 TRANSMITTER TUNING

Connect the TS-520S to a 50 ohm dummy load or a 50 ohm antenna with an SWR of less than 2 : 1 before making any transmitter adjustments. The life of the final tubes is directly related to the SWR of the antenna and to the length of tuning periods.

Refer to Table 2 for the initial switch settings of the TS-520S for transmitting. Tune the main tuning knob to the desired operating frequency.

#### ■ PLATE IDLING CURRENT (See Figure 10)

Turn the main tuning knob to the desired operating frequency within the amateur band selected. Flip the stand-by switch to SEND and check that the plate current (IP) is 60 ma. If the plate current is not correct, adjust the side panel BIAS control for a correct 60 ma of idling current and return the stand-by switch to REC.

#### CAUTION:

If the plate current is very much higher than 60 ma do not leave the stand-by switch on for more than a few seconds. Excessive plate current shortens the life of the final tubes.

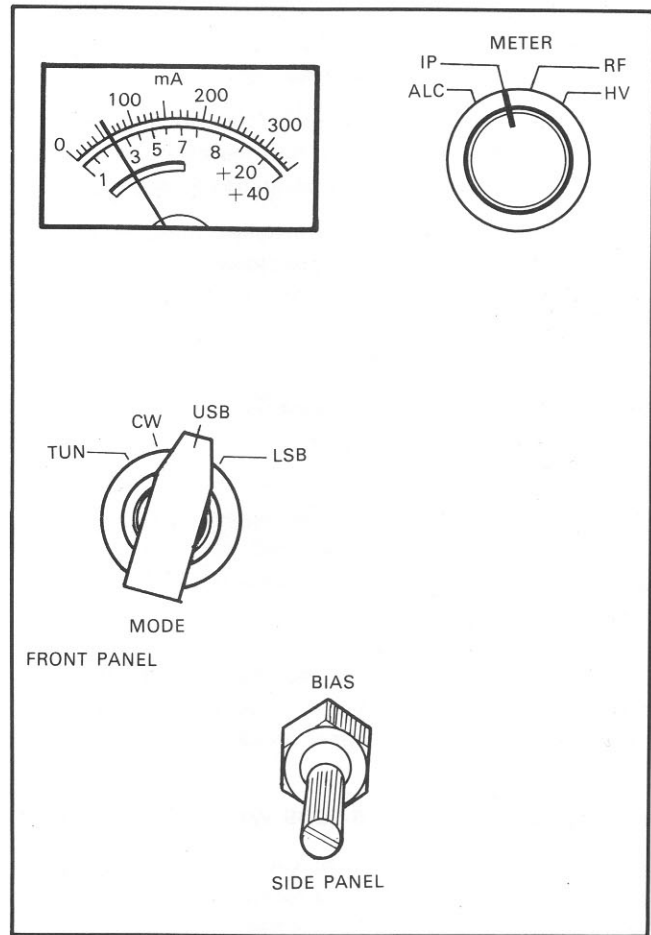


Fig. 10 Adjustment of the Plate Idling Current

TABLE 2. Initial Switch Settings for Transmission (The controls not described should be set as described in Table 1)

LOCATION	CONTROL	POSITION	
FRONT PANEL CONTROLS	BAND Switch	Desired band	
	POWER Switch	ON	
	H. SW Switch	ON	
	Stand-by Switch	REC	
	MODE Switch	USB or LSB depending on selected band	
	VOX Switch	MAN	
	MIC Control	Fully counter-clockwise	
	CAR Control	Centered	
	METER Switch	IP	
	PLATE Control	Middle of the range for the band	
	DRIVE Control	Centered	
	FUNCTION Switch	VFO	
	REAR PANEL CONTROLS	RIT Switch	OFF
		SG Switch	UP (ON)
EXT VFO Connector		Jumpered plug inserted	

■ **DRIVE TUNING** (See Figure 11)

Shift the METER switch to ALC and the MODE switch to TUN and peak the ALC reading (maximum meter deflection) with the DRIVE control. The stand-by switch is in the SEND position for adjustment.

**NOTE:**

If there is no ALC reading indicated, increase the CAR control until there is an ALC reading.

■ **PLATE TUNING** (See Figure 11)

Turn the METER switch back to IP, leave the MODE switch at TUN and flip the stand-by switch to SEND. Quickly adjust the PLATE control to dip the plate current (a minimum meter reading). Return the stand-by switch to REC.

**NOTE:**

The TUNE position permits tuning of the final tank circuit at reduced power without danger to the tubes. With the MODE switch is in the TUN position, the screen voltage of the finals is reduced to approximately 50% and the keying circuit is shorted.

■ **PLATE AND LOAD TUNING**

**CAUTION:**

When the MODE switch is in the CW position the final tubes draw full plate current in transmit. Final tube life is directly related to the length of tune-up periods. Do not transmit with the tubes out of resonance for more than 10 seconds at a time.

Turn the MODE switch to CW, turn the METER switch to RF, and set the stand-by switch to the SEND position. Quickly adjust the PLATE control and then the LOAD control alternately to peak (maximum meter deflection) the power output. If necessary, adjust the RF VOLT control on the side panel to bring the output reading to about a 2/3 scale reading.

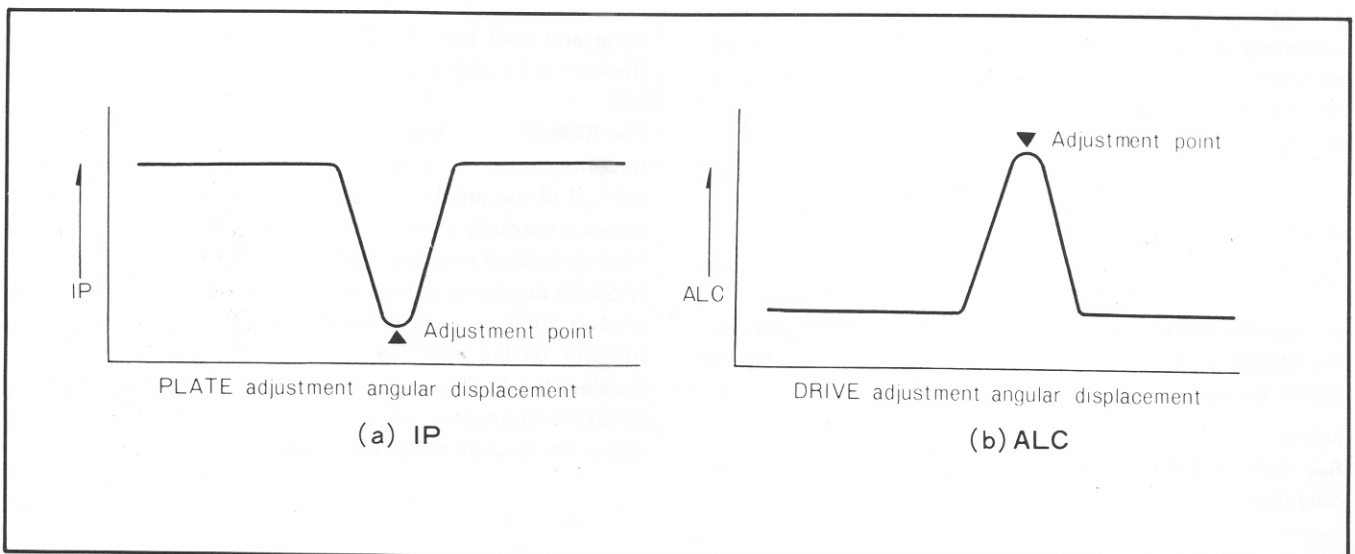
**4.12 SSB OPERATION**

■ **PTT OPERATION**

Tune the TS-520S as described in Sections 4.1 to 4.11. Set the MODE switch to USB or LSB and connect a microphone to the MIC connector.

**TABLE 3. Summary of Transmitter Tuning Procedures**

MODE Switch	METER Switch	Stand-by Switch	Procedure
USB or LSB	IP	SEND	Adjust BIAS control for 60 ma.
TUN	ALC	SEND	Peak the ALC reading with the DRIVE control.
TUN	IP	SEND	Dip plate current with PLATE control.
CW	RF	SEND	Peak RF output by alternately adjusting the PLATE and LOAD controls.



**Fig. 11 Plate and Drive Tuning**

**NOTE:** International amateur practice dictates using USB or LSB on the following bands.

1.8 MHz Band	CW
3.5 MHz Band	LSB
7.0 MHz Band	LSB
14.0 MHz Band	USB
21.0 MHz Band	USB
28.0 MHz Band	USB

Key the transmitter and speak into the microphone with the tone of voice used in normal operation. Adjust the MIC control until voice peaks are just within the top limit of the ALC range printed on the meter scale. The METER switch is in the ALC position. If the transmitter section is driven beyond this range, the transmitted signal will be distorted.

#### ■ VOX OPERATION

Adjust the transceiver as described in the previous paragraph. Flip the VOX switch on and close-talk into the microphone, increasing the VOX GAIN control (on the left side of the TS-520S) until the VOX relay just operates. For VOX operation it is desirable to close-talk the microphone to prevent background noises from tripping the TS-520S into transmission.

Check that the ALC reading for voice peaks is still within the ALC range on the meter. If necessary, adjust the MIC control for a proper ALC reading.

If the VOX circuit is activated by speaker noise, adjust the ANTI-VOX control (on the side panel). Increase the control as necessary for proper VOX operation.

Do not use more VOX GAIN or more ANTI VOX gain than necessary to control VOX operation. If the VOX circuit transfers between words, or holds too long, adjust the release time constant by turning the DELAY control on the side panel.

### 4.13 CW OPERATION

Tune and load the TS-520S as described in Sections 4.1 through 4.11. Connect a key to the back panel KEY jack, set the MODE switch to CW, and set the stand-by switch to SEND for transmitting.

**NOTE:** See Section 4.4 for information on dial calibration for CW operation.

CW transmissions are automatically monitored through the speaker of the transceiver. The audio gain of the sidetone can be adjusted with VR2 on the AF board (X50-0009-01).

For semi-break-in operation, turn the VOX switch on. Hold the key down and increase the VOX GAIN control, on the left side of the transceiver, until the VOX relay just operates. It is desired to change the release time constant of the VOX circuit, adjust the DELAY control, also on the left of the transceiver.

The plate current for CW operation should be about 200 ma. Use the CAR control to adjust the carrier level for CW operation. At 200 ma of IP there may be no ALC reading.

**TABLE 4. Meter Switch Positions for Different Modes**

MODE	METER Switch	Approx. Readings
TUN	* ALC or * IP or * RF or HV	Peaked 75 ma 1/3 scale 800V
CW	ALC or * IP or RF or HV	None or within ALC range 200 ma 2/3 scale 750V
USB or LSB	* ALC or IP or RF or HV	Within the ALC range on voice peaks 60 to 250 ma 0 to 2/3 scale 800V

\* Recommended monitoring position during operation.

### 4.14 OPERATION WITH A LINEAR AMPLIFIER (See Figure 32)

Tune and load the TS-520S as described in Sections 4.1 through 4.11 and adjust it for the selected mode.

The REMOTE connector on the back panel is provided for interconnections with an amplifier. See the instruction manual of the amplifier to determine whether the linear requires a normally open (during receive) or a normally closed (during receive) relay contact. Connect either pin 3 (normally closed to ground during receive) or pin 5 (normally open to ground during receive) of the REMOTE connector to the control jack on the amplifier.

Connect the ALC feedback from the amplifier to pin 6 of the REMOTE connector. The output of the TS-520S is quite adequate to drive most amplifiers to full rated output.

## 4.15 FIXED FREQUENCY OPERATION

The TS-520S has a built-in crystal controlled oscillator for fixed frequency operation. This feature is most useful for commonly used frequencies, nets, or any situation where crystal controlled operation is required. To use the fixed frequency oscillator, turn the FUNCTION switch to the FIX position. Select one of the four available channels with the fixed channel selector switch and tune and load the TS-520S as described in Sections 4.1 through 4.11. Simply operate the transceiver as described in Sections 4.12 and 4.13.

Section 6.2 (page 38) describes installation and netting of fixed channel crystals. The crystal frequency is determined by the following formulas.

### ■ LSB OPERATION

Crystal Frequency (MHz) = 5.5015 MHz + X - Operating Frequency (MHz)

### ■ USB OPERATION

Crystal Frequency (MHz) = 5.4985 MHz + X - Operating Frequency (MHz)

### ■ CW OPERATION

Crystal Frequency (MHz) = 5.5 MHz + X - Operating Frequency (MHz)

- X = 1.8 for the 160 meter band
- X = 3.5 for the 80 meter band
- X = 7.0 for the 40 meter band
- X = 14.0 for the 20 meter band
- X = 21.0 for the 15 meter band
- X = 28.0 for the 10 meter band or
- X = 28.5 for the 10 meter band or
- X = 29.1 for the 10 meter band

Crystal Specifications: HC-25/U holder, 4.9 to 5.5 MHz oscillation frequency, and see Figure 12 for type of oscillation circuit.

Example: Desired Operating Frequency = 7.255 MHz  
 Crystal Frequency (for CW) = 5.5 MHz + 7.0 MHz - 7.255 MHz = 5.245 MHz

This same crystal will operate on each band.  
 Operating Frequency (CW) = 5.5 MHz + X (in MHz) - Crystal Frequency (in MHz)

Example: Crystal Frequency = 5.245 MHz  
 On the 14 MHz band the crystal will oscillate at  
 Operating Frequency (CW) = 5.5 MHz + 14.0 MHz - 5.245 MHz = 14.255 MHz

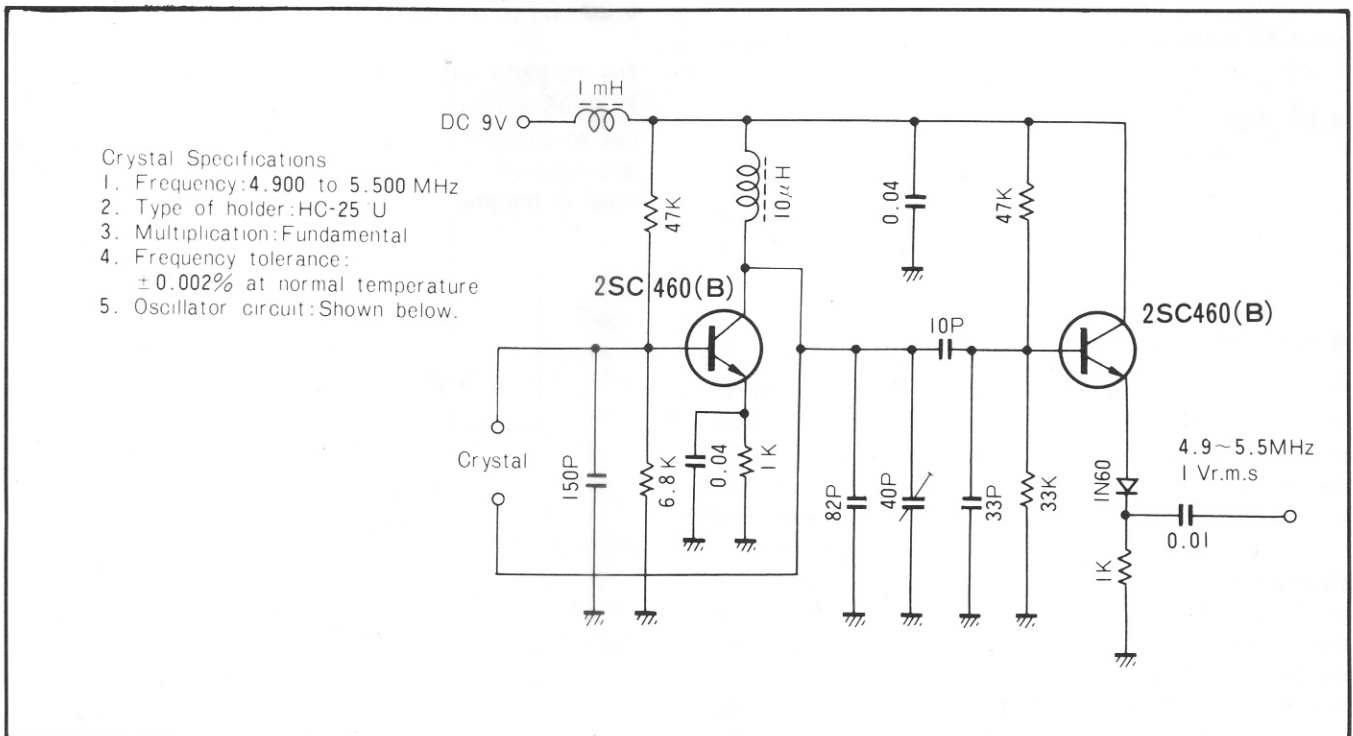


Fig. 12 Crystal Oscillator Circuit

## 4.16 INTERNAL CROSS CHANNEL OPERATION

The TS-520S contains a unique design feature which allows cross channel operation without a separate external VFO. The TS-520S's internal VFO is used together with the fixed frequency oscillator to allow reception and transmission on different frequencies. The fixed channel oscillator must have one or more accessory crystals installed for this feature to work.

FUNCTION SWITCH	TRANSMIT CONTROL	RECEIVE CONTROL
VFO	VFO	VFO
VFO.R	Fixed channel oscillator	VFO
FIX.R	VFO	Fixed channel oscillator
FIX	Fixed channel oscillator	Fixed channel oscillator

## 4.17 MOBILE OPERATION

The compact size and solid-state design of the TS-520S make it ideal for mobile use, by using optional DS-1A. Be sure to use a mobile antenna which meets the requirements described in Section 1.

The normal operating procedures, described previously, apply to mobile operation. The noise blanker should be used to reduce ignition and impulse noises for clear reception. Remember that during transmission the transceiver draws about **15 amps** so be careful not to drain the car's battery.

## 4.18 DX OPERATION (Use of PROCESSOR PULL ON)

This control knob is used to adjust MIC input to the optimum level for quality SSB transmission. The speech processor is activated by pulling the knob toward you.

### ■ HOW TO USE SPEECH PROCESSOR

The speech processor built in TS-520S is composed of a circuit having voice compression and ALC (automatic level control) functions, and is designed on the basis of our standard MC-50 (see Note below). It is factory adjusted so that the indication on the ALC meter remains the same even when the processor switch is set to ON or OFF.

However, the ALC function is sometimes affected depending on the type of microphone used or the loudness of voice. If the indication on the ALC meter differs excessively between the ON and OFF positions of the processor switch, adjust the PROCESSOR LEVEL at the bottom of the unit until the meter indicates a minimum difference. For adjustment, refer

to the instruction label on the bottom of the TS-520S. This adjustment should be made while speaking into your microphone in normal loudness of voice.

It should be noted that the use of a high output microphone may result in distortion of tone quality.

In that case, insert an attenuator to the microphone circuit or connect a 10 ~ 33k ohm resistor (depends on the type of microphone used) in parallel with C13 (100pF) in the generator unit (X52-1090-00) as shown in page 5.

10 ~ 33k ohm (select according to the type of microphone used)

### NOTE:

MC-50: Sensitivity to be  $-55 \text{ dB} \pm 3 \text{ dB}$  at about 5 cm from microphone (MIC input: 10 mV, 1 kHz)

## 4.19 SSTV OPERATION

The TS-520S will adapt very well to slow scan television operation. The only cabling required are connections between the PHONE PATCH IN jack (or MIC connector) of the TS-520S and the output of the television console, and between the PHONE PATCH OUT jack (or SPEAKER jack) of the TS-520S and the input of the television console.

Be careful to keep the input power of the transceiver down to a safe level with the MIC control. If you exceed the plate power dissipation capability of the tubes, they will be damaged.

## 4.20 OPERATION WITH A PHONE PATCH

The TS-520S has rear panel jacks to facilitate using the TS-520S with a phone patch. The PHONE PATCH OUT jack has an impedance of 8 ohms and the PHONE PATCH IN jack requires a high impedance input. See the instruction sheet of the phone patch for cabling instruction.



# TS-520S BLOCK DIAGRAM (FIGURE 13)

**TABLE 3. FIX XTAL**

TYPE	HC-25U
FREQ.	5.5 - 4.9MHz

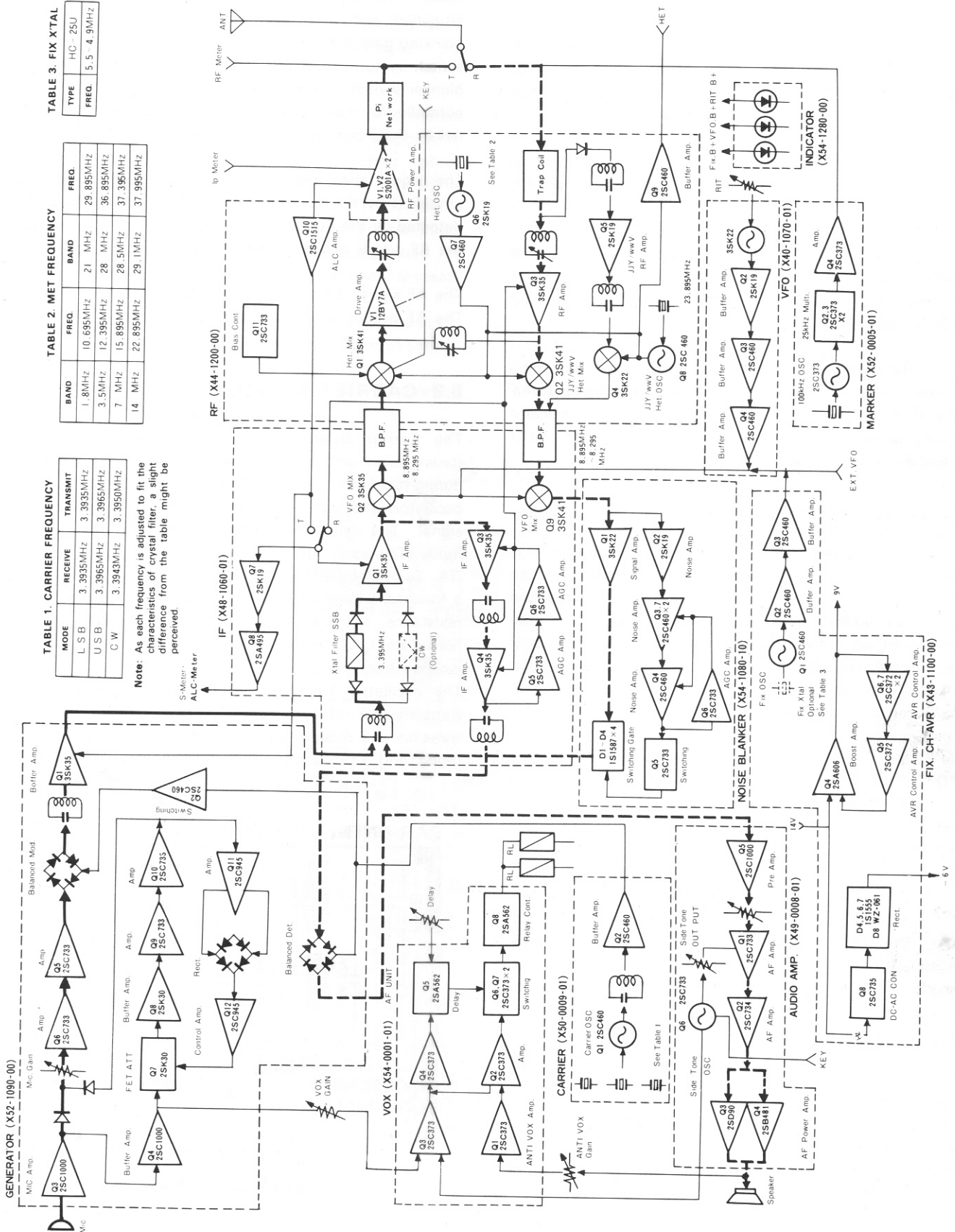
**TABLE 2. MET FREQUENCY**

BAND	FREQ.	BAND	FREQ.
1.8MHz	10.695MHz	21 MHz	29.895MHz
3.5MHz	12.395MHz	28 MHz	36.895MHz
7 MHz	15.895MHz	28.5MHz	37.395MHz
14 MHz	22.895MHz	29.1MHz	37.995MHz

**TABLE 1. CARRIER FREQUENCY**

MODE	RECEIVE	TRANSMIT
L-S-B	3.3935MHz	3.3935MHz
U-S-B	3.3965MHz	3.3965MHz
C-W	3.3943MHz	3.3950MHz

Note: As each frequency is adjusted to fit the characteristics of crystal filter, a slight difference from the table might be perceived.



# SECTION 5. CIRCUIT DESCRIPTION

## 5.1 GENERAL DESCRIPTION

Figure 13 shows the block diagram of the TS-520S. To better understand the transceiver's circuit, refer to the block diagram as you read this circuit description. The transceiver is totally solid state, except for the two final tubes and the driver, utilizing 19 FETs, 52 transistors, and 101 diodes.

Modular construction techniques place all circuitry, on printed circuit boards. These modules greatly simplify trouble shooting and repair procedures.

Receiver circuitry is designed in a double superheterodyne configuration. The transistorized transmitter section employs a dual conversion configuration using a filter type SSB generator.

Dual gate MOS FET's are used throughout the transmit/receive amplifier, except for the three power tubes and the AF amplifier. The used of these transistors allows excellent two-signal performance as well as excellent AGC (and ALC) characteristics.

### ■ TRANSMITTER SECTION (Refer to Figure 13)

The current generated by audio at the microphone is amplified by the microphone amplifier (located on the GENERATOR board). The output from the microphone amplifier is injected, along with a 3.395 MHz carrier, into the four diodes which form the balanced modulator. The DSB output produced by the balanced modulator is fed to the first IF amplifier and then through the crystal filter (on the IF board) resulting in an SSB signal.

The 3.395 MHz SSB signal is mixed with the output of the VFO (5.5 to 4.9 MHz) by the first transmit mixer creating the second transmit IF signal (8.895 to 8.295 MHz). This signal is mixed with the output of the heterodyne crystal controlled oscillator, by the second transmit mixer, to produce the final transmitted SSB frequency.

The SSB signal is amplified by the 12BY7A driver tube to drive the two S2001A (6146B) amplifier tubes in the final stage. They operate in class AB1. The output signal is transmitted through a pi-network to the antenna. The impedance of the pi-network is 50 ohms.

### ■ RECEIVER SECTION (Refer to Figure 13)

The incoming signal from the antenna is fed through the antenna coil to the RF section, where it is one-stage amplified. The amplified signal is passed to the first receiver mixer for conversion to the first IF signal (8.895 to 8.295 MHz). The first IF signal is mixed with the VFO output by the second receive mixer to generate the second IF signal.

The AGC voltage is extracted at the output of the second mixer. The signal passes to the NB board where it is amplified and passes through the blanking gate. The blanking gate is turned on, or open, when the noise blanker switch is turned to the OFF position. When the noise blanker switch is turned on, the gate opens and closes as controlled by the noise components separated from the signal by the input filter of the noise blanker circuit.

The signal then feeds through the crystal filter to be amplified by the two-stage amplifier on the IF board and detected by the detector on the GENERATOR board. Here the RF signal is transformed to AF.

The AF signal is amplified by the complimentary amplifier. The AF output impedance is 4 to 16 ohms.

## 5.2 CARRIER BOARD (X50-0009-01)

The Carrier Board produces a carrier signal during transmission and acts as the BFO for the ring detector during reception. The transistor Q1 comprises a Pierce B-E oscillator. The buffer amplifier, Q2, delivers a steady output signal. The oscillation frequency switching for a desired mode of operation is made by diode switchings, D1 through D4. Each diode forms the respective oscillator circuit when a forward voltage is applied across it to reduce its internal resistance. If the forward voltage is not applied, the diode resistance becomes so high in the resistance that it is isolated from the circuit. This disables the oscillation.

The oscillation frequency is 3396.5 kHz for both USB transmit and receive modes, 3393.5 kHz for both LSB transmit and receive modes, 3394.3 kHz for CW receive mode, and 3395.0 kHz for CW transmit mode.

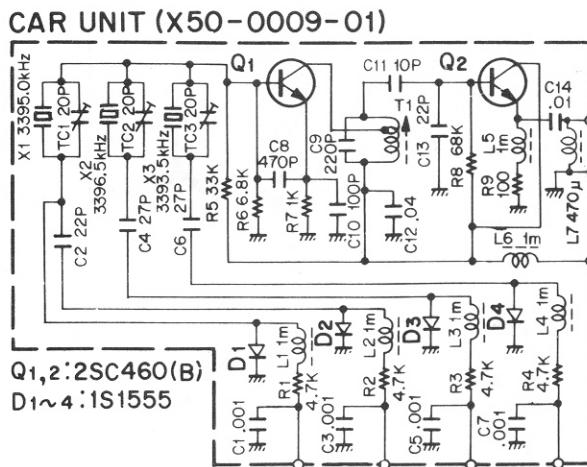


Fig. 14 Carrier Board

### 5.3 GENERATOR BOARD (X52-1090-00)

The Generator Board, which is a heart of this SSB transceiver, produces a DSB (double side band) signal. The operation is as follows.

The AF signal coming from the microphone is amplified through Q3, Q6, and Q5. The amplified signal is applied to the ring modulator, comprised of four diodes, which produces a carrier-suppressed DSB signal. This DSB signal is amplified through the buffer amplifier, Q1 (FET), and is delivered to the succeed IF Board. The crystal filters contained in the IF Board, then, further suppresses the carrier and undesirable side band of the DSB signal to create a complete SSB signal.

In the CW mode of operation, a DC voltage is applied at the ring modulator to unbalance it to obtain the required carrier.

The Generator Board, also, has a microphone compressor

circuit, which is activated by the PROCESSOR switch located on the front panel. The AF signal output of Q3 is further amplified through Q4, Q8, Q9, and Q10. The amplified signal is delivered to Q6 through the diode switching, which is activated by the PROCESSOR switch. Gain control is made in the manner that the output of Q10 is phase-inverted by Q11, is bridge-rectified by the four diodes, and is DC-amplified through the control amplifier, Q12, to produce a pinch-off voltage which controls the attenuator, Q7 (FET). The desired time constant is obtained at the output of Q12. The actual microphone compression is around 20 db for 10 mV microphone input. The microphone gain can be set irrespective of the PROCESSOR switch as the MIC GAIN control is placed at the input end of Q6.

In addition, the Generator Board has a transistor switching circuit which prevents the carrier from entering the receive ring detector and transmit ring modulator during transmission and reception, respectively.

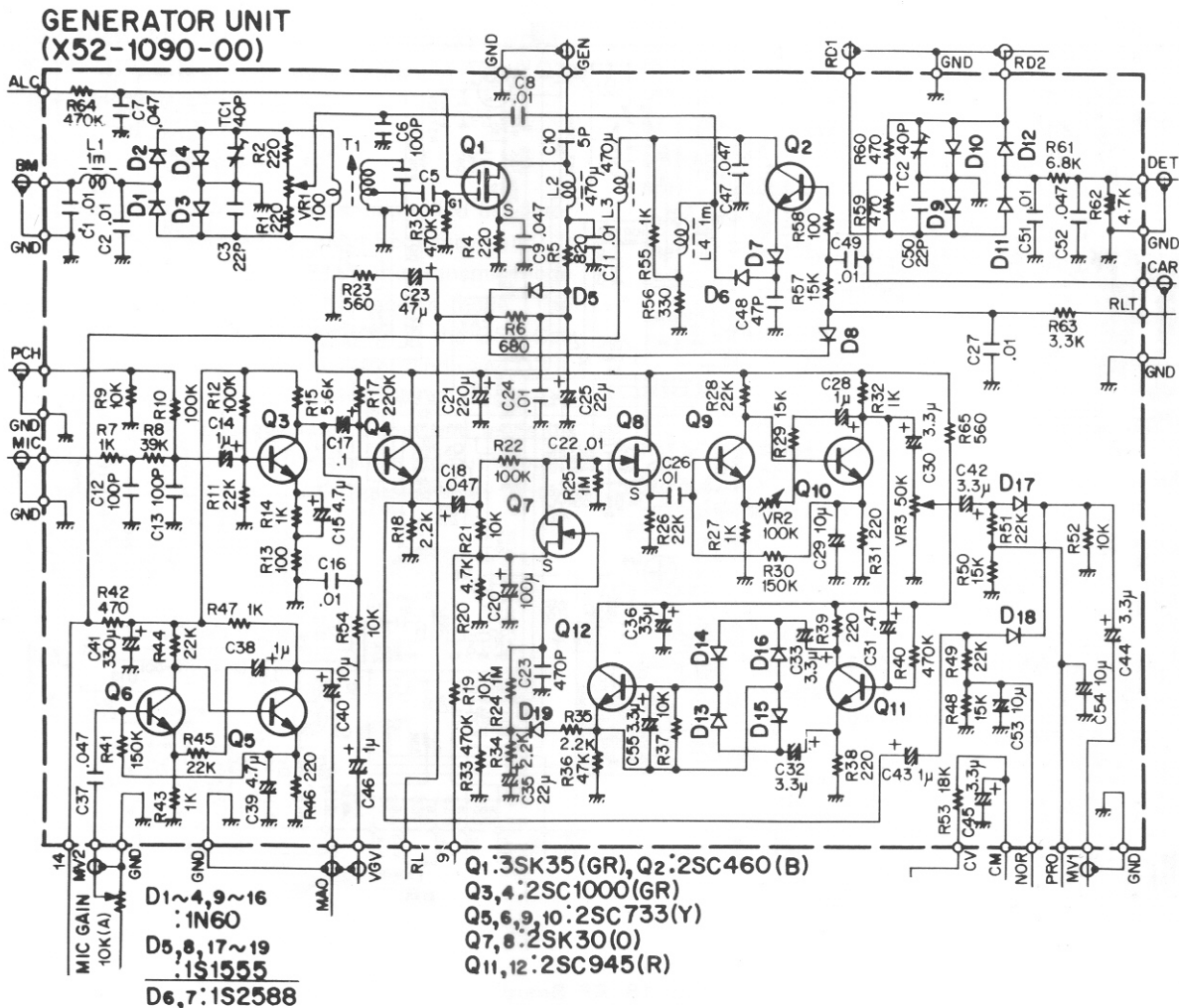


Fig. 15 Generator Board

## 5.4 RF BOARD (X44-1200-00)

The RF Board provides the most functions as compared with the other boards of the TS-520S. It consists mainly of a transmit system, a receive system, an ALC circuit, control circuits, and a local oscillator circuit.

### ■ TRANSMIT SYSTEM

The second IF signal from the IF Board passes through the bandpass filter and is frequency-converted to a desired RF signal in a given amateur band by the transmit second mixer, Q1. The RF signal, in turn, is amplified by the exciter, V1, to a level enough to excite the final power tube.

#### NOTE:

To the anode of V1 is connected the Drive Coil Board (X44-1220-00).

### ■ RECEIVE SYSTEM

An amateur band signal coming into the ANT connector enters the ANT Coil Board (X44-1170-00) through the 8 MHz IF trap coil. The signal, then, is stepped up by the frequency band coil and is applied to G2 of the receive first mixer, Q2, where it is converted to the receive first IF signal. The IF signal is fed through the bandpass filter to the IF Board.

#### NOTE:

The MIX Coil Board (X44-1180-00) connected to the drain of Q3 is also used with the Transmit System.

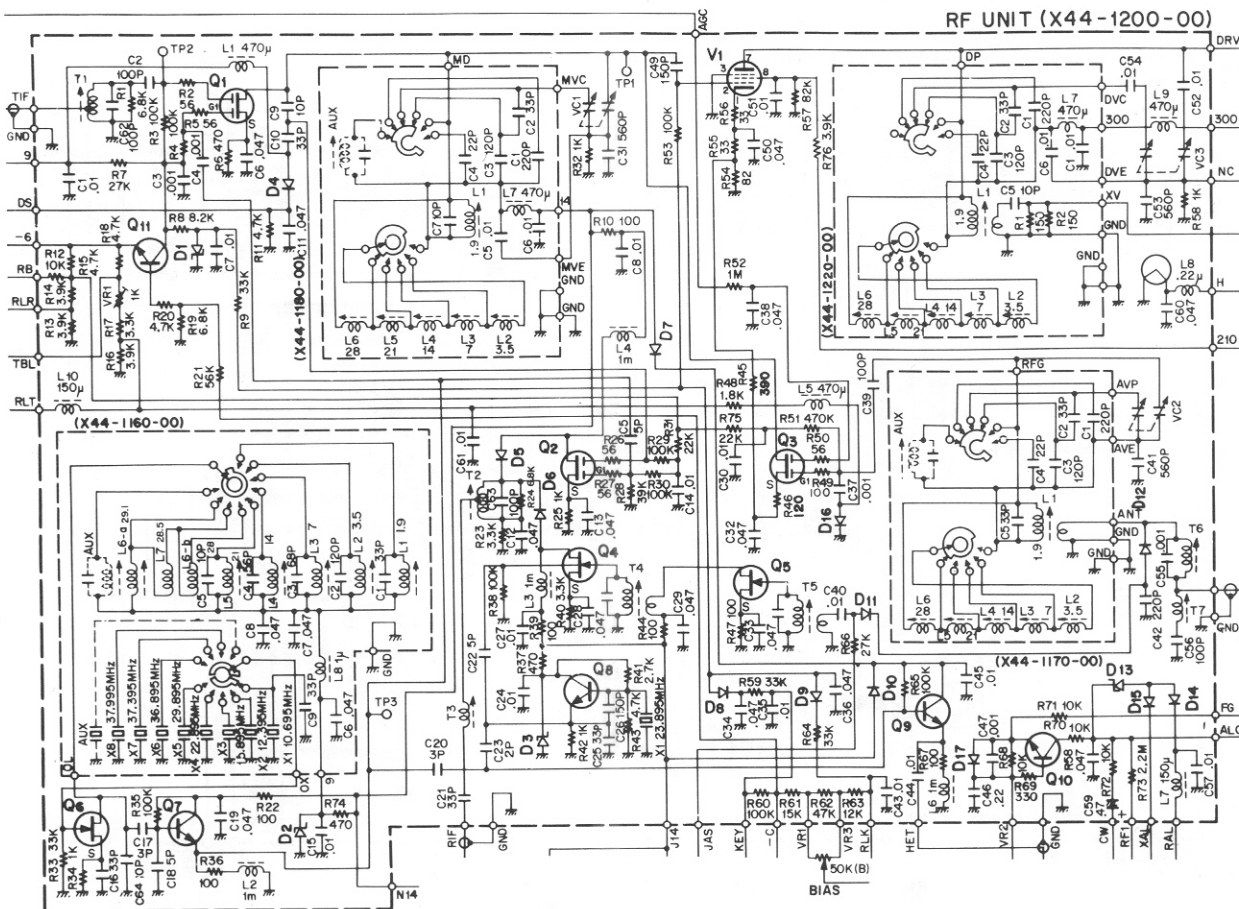


Fig. 16 RF Board

## ■ WWV RECEIVE CIRCUIT

The TS-520S has a converter circuit for specific use of receiving the WWV wave. The 15 MHz standard wave coming into the antenna passes through the diode switch interlocked with the BAND switch and is applied to T5 where it is stepped up. The signal, then, is RF amplified through Q5 and is frequency-converted to the receive first IF signal by Q4. The IF signal is fed to the IF Board through the same bandpass filter as in the usual RF signal reception.

## ■ ALC CIRCUIT

The ALC (Automatic Level Control) Circuit, which uses a transistor, Q10 of rather high breakdown voltage, produces the ALC voltage when a current around  $30\mu\text{F}$  flows to the grid of the final power tube. The ALC time constant is set "slow" in the SSB mode and "fast" in the CW and PROCESSOR-ON modes.

## ■ CONTROL CIRCUITS

The RF Board has a transmit and receive bias control circuit. The transistor Q11 cuts off the transmit second mixer, Q1, when the TS-520S is DC-powered.

## ■ LOCAL OSCILLATOR CIRCUIT

The Local Oscillator Circuit is a crystal-controlled oscillator which selects a crystal for each amateur frequency band. It serves as the second local oscillator in the transmit mode and as the first local oscillator in the receive mode. The crystals and oscillation coils are contained in the OSC Coil Board (X44-1160-00). Q6 is the oscillator diode and Q7 is the buffer amplifier. For receiving the WWV is used Q8 which forms a nonadjusting oscillator circuit and feeds its output to Q4. Each local oscillator output is fed out through the buffer amplifier, Q9, to the DG-5 Digital Display (optional).

## 5.5 IF BOARD (X48-1060-01)

The IF Board is important both for the transmit and receive operations. In the transmit mode of operation, the SSB crystal filter, XFI, suppresses the undesirable sideband and carrier of the DSB signal fed from the Generator Board to make a complete SSB signal. This SSB signal is amplified through G1 of the IF amplifier, Q1, which is also used for the reception and enters the transmit mixer, Q2. The local oscillator signal delivered from the VFO Board, on the other hand, passes through the lowpass filter around 7 MHz cut-off frequency, T10, T11, and T12, to G2 of Q2. The two signals, the SSB signal and local oscillator signal, are mixed by Q2, that is, the SSB signal is converted to the second IF signal. The second IF signal is delivered through the bandpass filter to the RF Board.

### NOTE:

In transmission, the receive IF amplifier, Q3 and Q4, and the receive VFO mixer, Q9, are cut off by the negative voltage appearing at the RB terminal.

On the other hand, in the receive mode of operation, the first IF signal delivered from the RF Board passes through the bandpass filter to the VFO mixer, Q9, which frequency-converts it to the second IF signal. This second IF signal enters through IFT the NB Board, the output of which comes through XF1 to the IF amplifier, Q1, which is also used for the transmission, as in the transmit state. In this stage and following two IF stages, Q3 and Q4, the IF signal is amplified and connected to the ring detector in the Generator Board.

### NOTE:

In reception, the transmit VFO mixer, Q2, is cut off by the negative voltage appearing at the TBL terminal. Q5 and Q6 form an AGC amplifier circuit. Q6 switches the AGC action to "slow", "fast", or "OFF" and serves for RF gain control.

The SSB crystal filter has a diode switching at each of the input and output ends. If the CW crystal filter (YG-3395C, optional) is installed, the diode switching circuit can select one of the crystal filters with the MODE switch interlocked to it.

Q7 and Q8 form an ALC meter circuit during transmission and function as S-meter circuit.

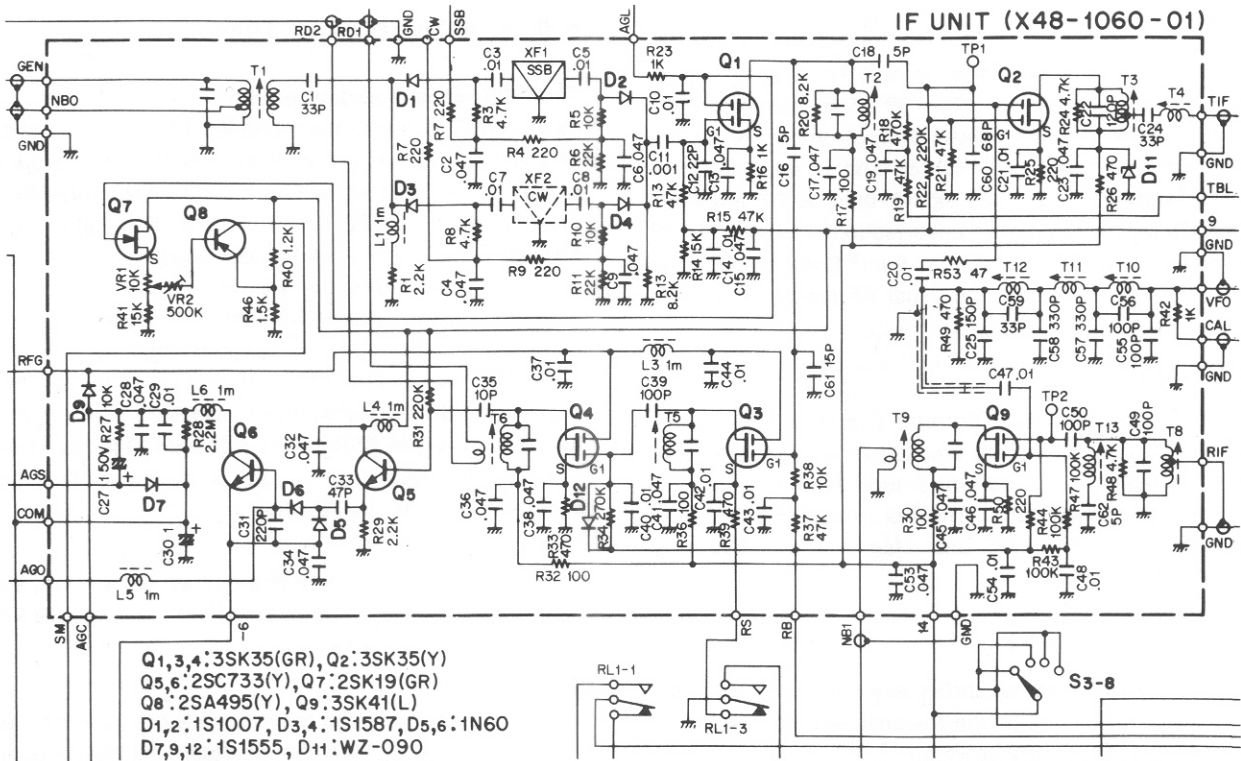


Fig. 17 IF Board

## 5.6 NB (NOISE BLANKER) BOARD (X54-1080-10)

The NB Board may roughly be classified into two circuit systems: a sound signal system and a noise signal system. In the signal system, the signal from the VFO mixer on the IF Board passes through the bandpass filter comprised of three IFTs and is amplified through Q1. The signal, in turn, passes through the balanced blanking gate and is led to the NBO terminal.

On the other hand, the noise signal is amplified through Q2, Q3, Q7, and Q4. The amplified signal passes through the noise rectifier circuit, comprised of D5 and D6, and is applied to the base of Q6. The AGC time constant circuit of Q6 is preset so that it may not respond to pulsed noises, but functions for short period, continuous signals like SSB. Therefore, Q3, Q7, and Q4 work at near the maximum gain when pulsed noise comes in and they are suppressed in the gain by the AGC voltage when continuous signal enters.

If the NB switch is turned on, the emitter of Q5 is grounded. When pulsed noise comes in, Q5 is turned on, which grounds its collector. The blanking gating diode connected to the collector of Q5, then, is inverse-biased for a certain period of time determined by the time constant circuit

comprised of R3 and C7. This opens the signal line, thereby eliminating the noise. The audio signal from which the pulsed noise has been removed can be produced as if a clear signal is received.

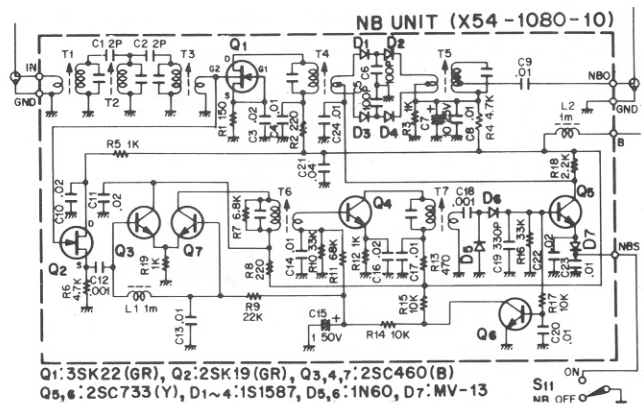


Fig. 18 NB Board

## 5.7 AF BOARD (X49-0008-01)

The AF Board contains a complementary, OTL AF amplifier, a CW semi-break-in circuit, a CW sidetone oscillator for monitoring, and a detector for calibration. Q5 comprises a preamplifier for amplifying audio signal delivered from the ring detector. C15 and C18 in the preamplifier circuit cut out high frequencies. The amplified signal passes through the AF GAIN control, and is amplified through Q1 and Q2, and is further power-amplified through Q3 and Q4.

### NOTE:

In transmission, Q5 is cut off by the positive voltage appearing at the RL terminal.

The sidetone oscillator, which is of a phase-shift type, oscillates a signal around 750 Hz. The oscillator works only when the MODE switch is set to the CW position and a key is plugged into the KEY jack and is closed.

### NOTE:

1. If the DS-1A DC-DC Module is installed in the TS-520S for operation by DC power and when the H.S.W switch is at the OFF position, the sidetone oscillator does not work. This is caused by the fact that turning the H.S.W switch off makes the DC-DC converter oscillation stop, which does not supply the bias voltage to Q6 and the control voltage to the switching diode D3.
2. VR2 is used to preset the sidetone oscillator output level.

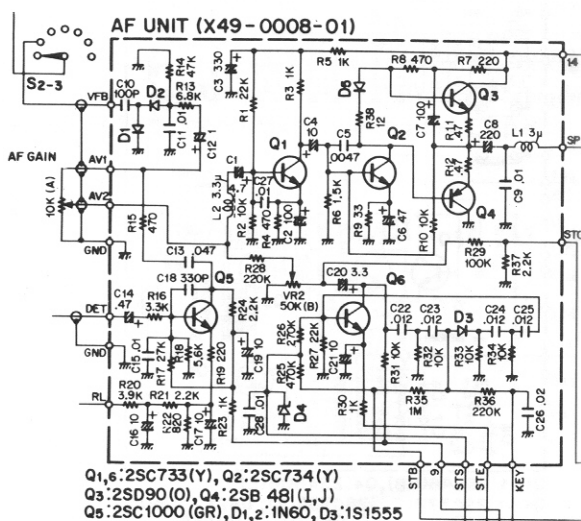


Fig. 19 AF Board

## 5.8 VFO BOARD (X40-1070-01)

The VFO Board produces a signal of variable frequency in the range from 5.5 MHz (at division "0" on the Sub-dial) to 4.9 MHz (at division "600"). The oscillator is of a modified Clapp type using a FET. The buffer also uses another FET, which assures very stable oscillation. The buffer follows a harmonic filter and a Darlington output amplifier, Q3 and Q4, which also assures stable operation against load change.

### CAUTION:

Do not change VFO Board mechanisms and circuits. If repairs are effected by anyone other than an authorized personnel, the performance warranty will become void.

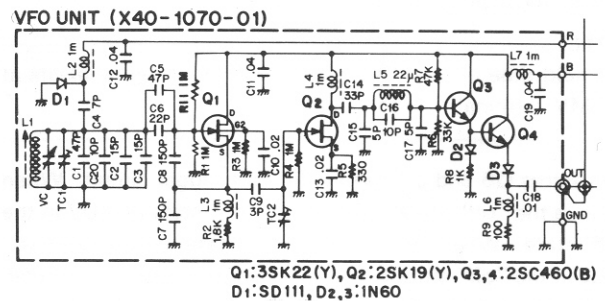


Fig. 20 VFO Board

## 5.9 MARKER BOARD (X52-0005-01)

The crystal-controlled oscillator, Q1, produces 100 kHz signal. The ceramic trimmer, TC1, connected to the collector of Q1 is used to precisely adjust the oscillation frequency. The oscillation signal of Q1 is waveform-shaped by the diode D1 and precisely synchronizes to 25 kHz the free-running multivibrator, comprised of Q2 and Q3, which is oscillating around 25 kHz. The 25 kHz signal is phase-inverted by Q4 and can be fed out for use with an external equipment.

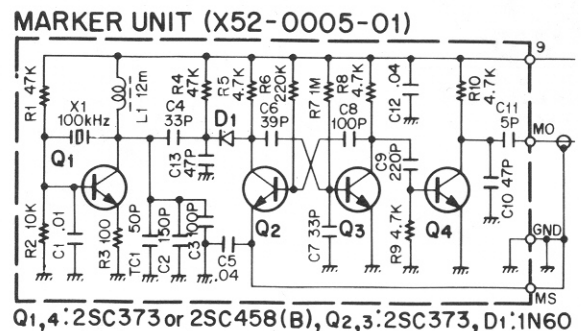


Fig. 21 Marker Board

## 5.10 VOX BOARD (X54-0001-00)

In the SSB mode of operation, the voice signal coming from the microphone amplifier (or the sidetone signal in CW) enters the MV terminal. The signal is amplified through Q3 and is rectified by D6 to a DC voltage in proportion to the input level. When the DC voltage is applied to the base of Q4, this is turned on and lowers the base potential of Q6 down.

If Q4 is cut off with no input signal, the base and emitter of Q5 are at the same potential, thus turning Q5 off. Therefore, C10 is charged through D7 by the voltage preset with the delay control. If Q4 is turned on with the voice signal coming into the MV terminal, on the other hand, it also turns on Q5, through which C10 discharges.

### NOTE:

The hold time of the VOX is when the voice signal exists at the MV terminal.

Transistors Q6 and Q7 form a Schmitt trigger circuit. When Q4 is in the "off" state, Q6 is in the "on" state and Q7 in the "off" state. When Q4 is in the "on" state, on the contrary, Q6 is in the "off" state and Q7 in the "on" state; in addition, Q8 also turns on, which activates the stand-by relay.

The anti-VOX signal coming from the AF unit to the AV terminal is stepped up by T1 and is full-wave-rectified by D1 to D4. The rectified voltage cuts Q1 off. This charges C5 through R4 and at the same time, turns Q2 on. In turn, Q2 grounds the base of Q4 to turn off, thereby stopping the VOX.

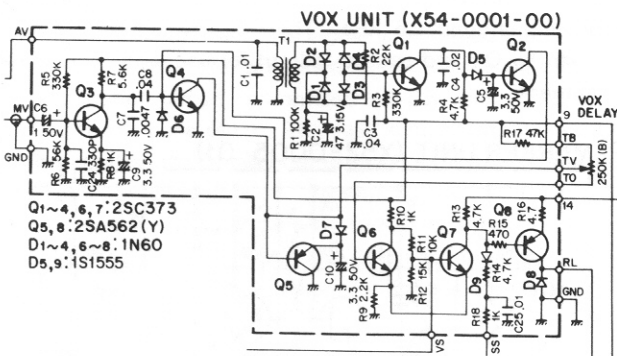


Fig. 22 VOX Board

## 5.11 FIXED CHANNEL-AVR BOARD (X43-1100-00)

This board consists of a fixed channel crystal-controlled oscillator, a 9V AVR (automatic voltage regulator), and a -6V DC-DC converter. The crystal-controlled oscillator, comprised of Q1, is of a Pierce C-B type. Q2 and Q3 form a Darlington buffer amplifier, which feeds the oscillation signal out. TC1 through TC4 are trimmers for precisely adjusting the oscillation frequency.

The 9V AVR supplies with 9V DC the main oscillator circuits and control circuits in the TS-520S. The transistor Q4 controls the current Q5 and Q6 magnify an error voltage. Q7 compensates the temperature characteristic of Q6. D3, a zener diode, gives a reference voltage.

In the -6V DC-DC converter, Q8 and T1 form a back coupling oscillator which produces a signal around 400 Hz. The signal is rectified by D4 through D7 to a -6V DC, which is stabilized by the zener diode D8.

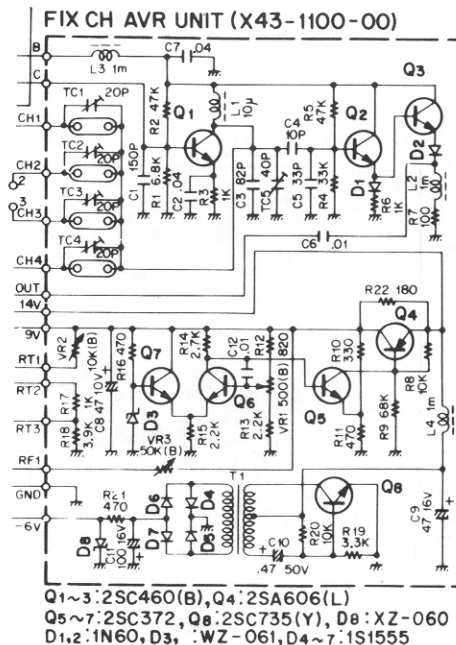


Fig. 23 Fixed Channel and AVR Board



### 5.12 RECTIFIER BOARD (X43-1090-02)

This board has all the rectifiers used with the TS-520S. The 800V high voltage is obtained by a voltage doubler rectifier, the 300V, 210V, and C-voltage by a half-wave rectifier, and the 14V voltage by a bridge rectifier.

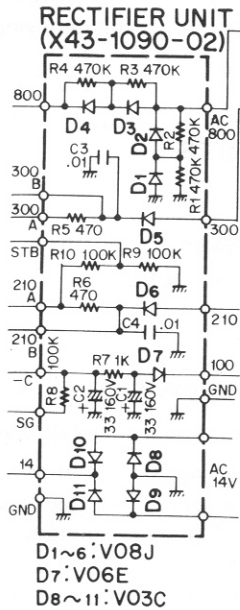


Fig. 24 Rectifier Board

### 5.13 HV BOARD (X43-1110-00)

The HV (High Voltage) Board has a voltage divider providing a voltage used to indicate the anode voltage of the final power tubes, a voltage divider providing a screen grid voltage of final power tubes in tuning the TS-520S.

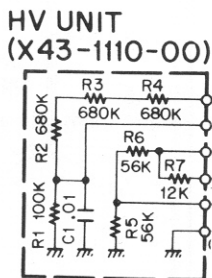


Fig. 25 HV Board

### 5.14 INDICATOR BOARD (X54-1120-00)

This board has light-emitting diodes "VFO", "FIX", and "RIT" located above the Sub-dial scale. Each diode indicates the turn-on states of the respective functional boards.

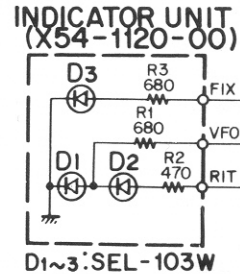


Fig. 26 Indicator Board

### 5.15 FINAL POWER AMPLIFIER BOARD (X56-1200-00)

This board contains all final power amplifier circuits except the pi output tank, which is placed at the power output end.

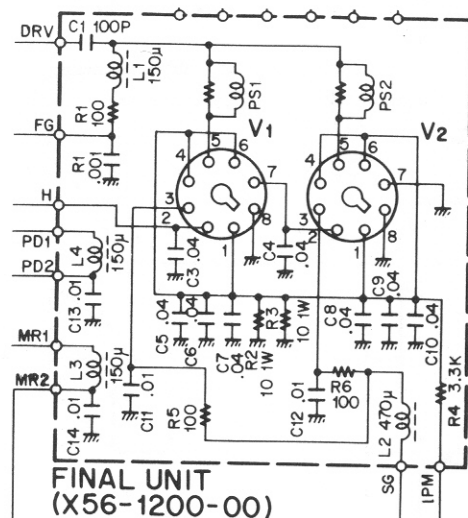


Fig. 27 Final Power Amplifier Board

# SECTION 6. MAINTENANCE AND ALIGNMENT

## CAUTION:

DANGEROUS HIGH VOLTAGES ARE PRESENT WITHIN THE CASE OF THE TS-520S WHEN THE TRANSCEIVER IS TURNED ON.  
EXERCISE EXTREME CAUTION TO AVOID ELECTRIC SHOCK.

## 6.1 GENERAL INFORMATION

The TS-520S has been factory signed and tested to specifications before delivery to the customer. Under normal circumstances the transceiver will be properly adjusted to operate in accordance with these operating instructions. In fact, the equipment owner can void the transceiver's warranty by attempting service or alignment without permission from the factory.

When operated properly, the transceiver can give years of service without requiring realignment. The information in this section gives some general service procedures which can be accomplished without sophisticated test equipment.

### ■ REMOVING THE CABINET (See Figure 28)

Figure 28 shows how to remove the TS-520S's cabinet. Remove the eight top cover screws and the nine bottom cover screws and lift away the panels. The speaker leads will still be attached to the chassis so be careful when removing the top cover. The leads can be unplugged, if necessary.

### ■ SERVICE POSITION (See Figure 29)

The TS-520S should be placed on its side, with the final

section up, for any alignment or service. This position permits adequate ventilation for the final tubes as well as easy accessibility to the modules. Most of the described adjustments can be made without removing the boards from the transceiver.

## 6.2 ACCESSORIES

### CAUTION:

BE SURE THE TRANSCEIVER IS UNPLUGGED AND TURNED OFF BEFORE REMOVING THE CASE.

### ■ INSTALLING THE CW FILTER (See Figure 30)

Remove the top and bottom covers from the transceiver (be careful of the speaker leads). Locate the IF board (it holds the SSB crystal filter) and move the brown wire from the SSB terminal to the CW terminal, as shown in Figure 30.

Remove the three screws securing the VR mounting hardware on the side panel and tilt the board down about 90 degrees from its normal position. Screw the filter onto the board with the provided nut and solder the filter's pins to the board. Be careful to use a low power soldering iron for only a short time. Too much heat will damage the crystal filter!

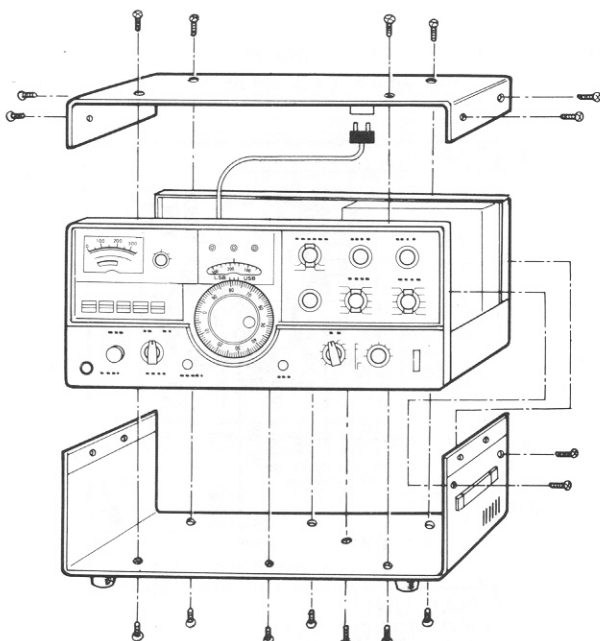


Fig. 28 Removing the TS-520S's Case

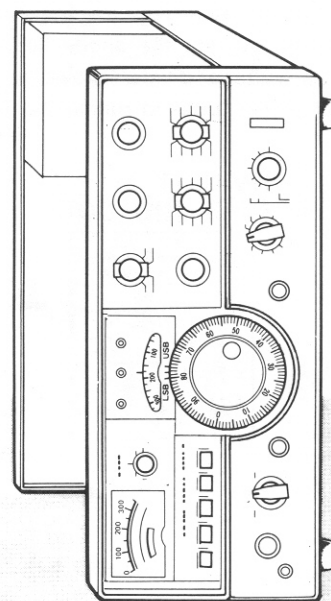
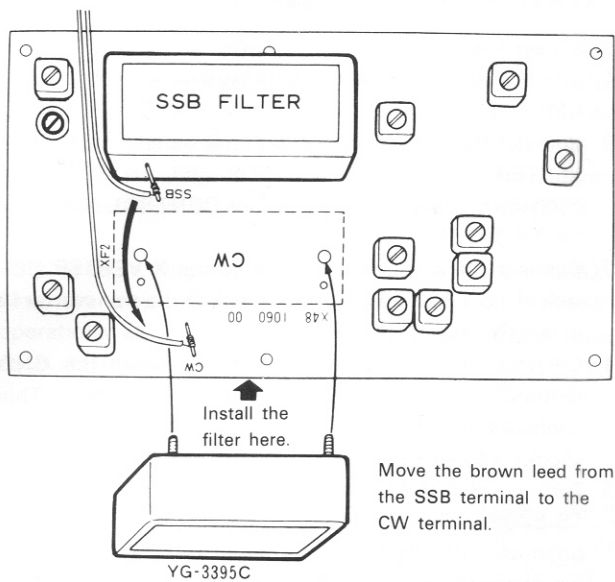


Fig. 29 Service Position for the TS-520S



**Fig. 30 Installing the Accessory CW Filter**

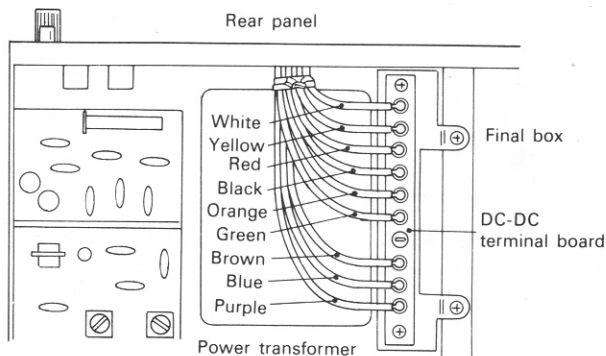
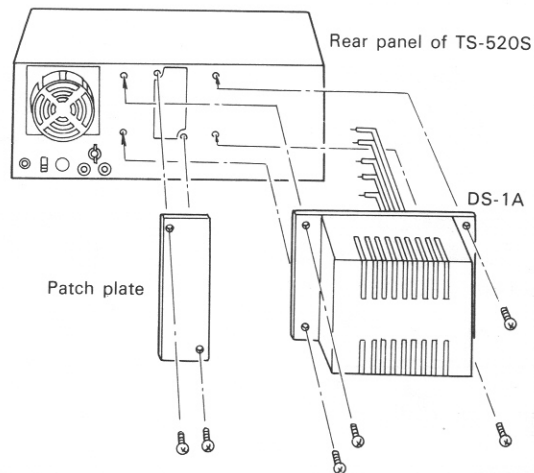
Reconnect the VR mounting hardware and replace the covers. If the speaker lead was disconnected, be sure to reattach that also.

**■ INSTALLING THE DC-DC CONVERTER (DS-1A)**

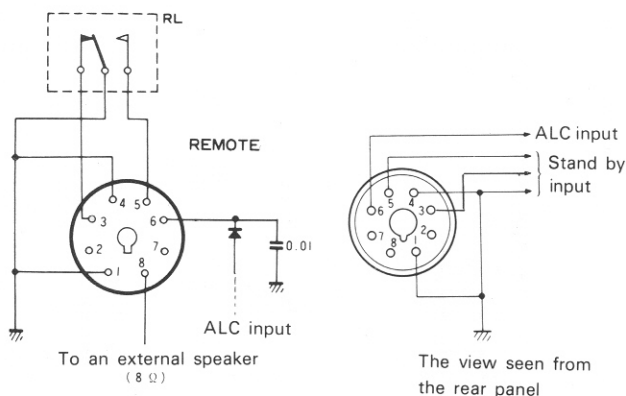
1. Remove the patch plate located on the rear panel of TS-520S.
2. Secure the DC-DC unit to the rear panel using the four tapping screws supplied with the unit.
3. Select the correct color coded lead from the DC-DC unit making sure that the color code corresponds to that of the lead connected to the DC-DC terminal board adjacent to the power transformer. Solder the lead onto the terminal board.

**■ REMOTE CONNECTIONS**

Figure 32 shows the REMOTE connector. This 8-pin plug can be used for attaching linear amplifiers, or other external accessories to the transceiver.



**Fig. 31 Installing the Accessory DC-DC Converter**



**Fig. 32 REMOTE Connector**

## ■ EXTENSION FEET

The TS-520S is provided with two extra feet which can be used to raise the front panel of the transceiver. In some operating positions the tilt makes it easier to read the dial and meter. Figure 33 shows how to install the feet.

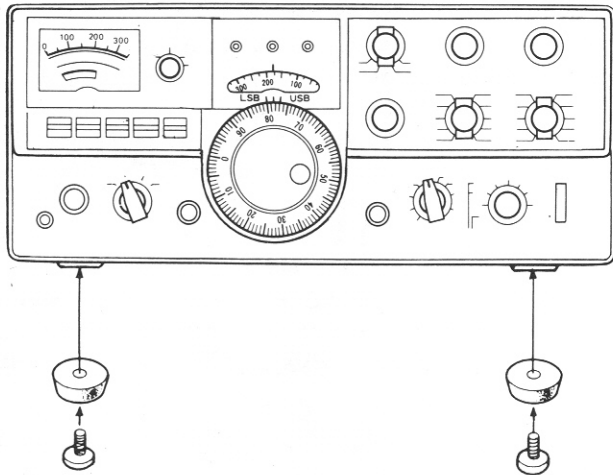


Fig. 33 Attaching the Extension Feet

## ■ TRANSVERTER (TV-502S)

To connect the transverter to TS-520S, proceed as follows:

1. Check that the power to the transverter and TS-520S is OFF.
2. Connect the cable supplied with the transverter to the XVERTER connector of TS-520S and the CONTROL connector of the transverter (2 m CONTROL connector for TV-502S).
3. Connect the supplied pin-cords to the XVERTER OUT jack of TS-520S and the TX IN jack of the transverter (2 m TX IN jack for TV-502S).
4. Connect the supplied earth cable between the GND terminals of TS-520S and the Transverter. This connection is necessary because it prevents electrical shocks and provides stabilized operation.
5. Turn on the transverter switch on the rear panel of TS-520S. The SG switch may be left in the ON position. Changeover between HF and VHF is automatically accomplished by the POWER switch of the transverter. Be sure to turn off the transverter switch when the transverter is not connected. TS-520S requires no modification for transverter operation.
6. Connect the antenna to the ANT terminal on the rear of the transverter (144 MHz for TV-502S).
7. Check to see that the POWER switch and the standby switch of TS-520S are set to OFF and REC respectively. Also, check that the POWER switch of the transverter is set to OFF. Then connect the power cords to AC outlet (or DC power source for DC operation).

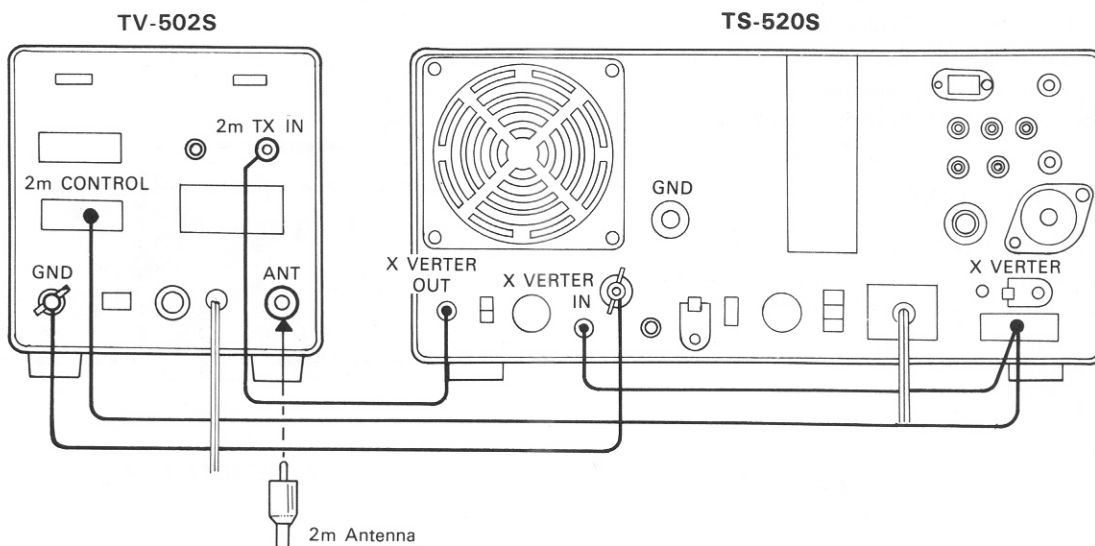


Fig. 34 Connecting of Accessory Transverter

### ■ CONNECTION OF VFO-520S

The VFO-520S is developed for further enhancing the capabilities of your TS-520S. Figure 35 shows a connection of the VFO-520S to the TS-520S. Keep the 9-pin MT plug put in the EXT VFO connector on the TS-520S until the VFO-520S is connected to it. The VFO interconnecting cable is supplied as an accessory with the VFO-520S.

Only by controlling the FUNCTION switch on the VFO-520S you can enjoy highly advanced and comprehensive operations as if you use two transmitters and receivers each. ↗

↗ To calibrate your TS-520S VFO output frequency with the VFO-520S output frequency, proceed as follows:

1. The FUNCTION switch on the TS-520S may be at any position.
2. Set the TS-520S in the receive mode of operation.
3. Set the FUNCTION switch to the CAL-RMT position.
4. Tune the TS-520S VFO output frequency and the VFO-520S output frequency until a zero beat is heard when two frequencies coincide with each other.

For more detailed information of the VFO-520S, read the "OPERATING MANUAL FOR VFO-520S".

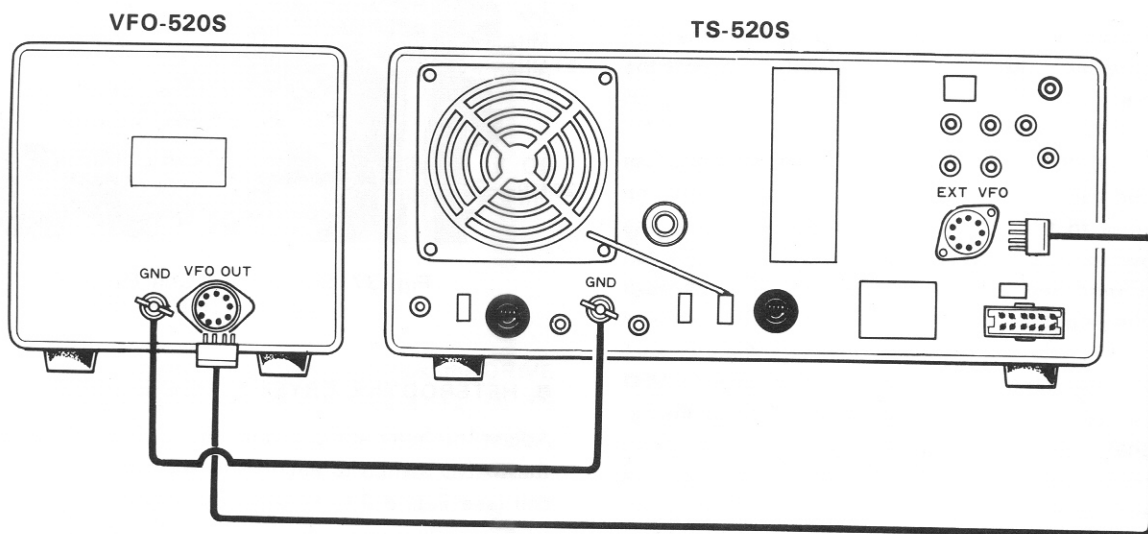


Fig. 35 Connecting of Accessory Remote VFO

### ■ CONNECTION OF DG-5 DIGITAL DISPLAY

Your TS-520S can connect the DG-5 by plugging the signal cable and power cable only as illustrated in Figure 36. Notice that the connectors on the two units are different in the arrangement. Be careful of inserting each pin plug-equipped coaxial cable of the same color into the connector jacks of the same reference. Now, turn on the POWER switch on the TS-520S, which will allow the DG-5 to run. The DG-5 is capable of reading the TS-520S operating frequencies as precise as an order of 100 Hz. For more detailed information, read the "OPERATING MANUAL FOR DG-5 DIGITAL DISPLAY".

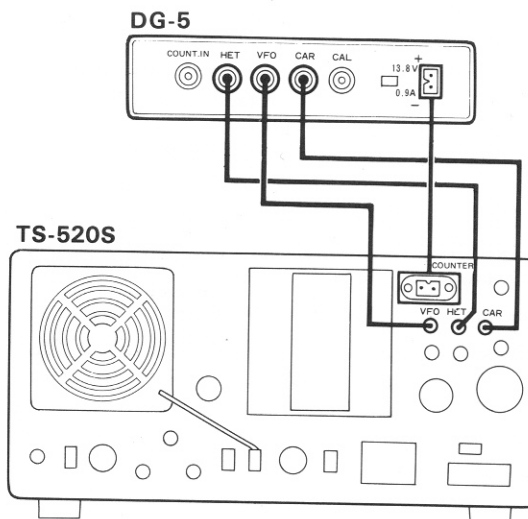


Fig. 36 Connecting of Accessory Digital Display

## ■ FIXED CHANNEL CRYSTAL INSTALLATION

Section 4.15 describes fixed frequency operation with the TS-520S. To install the accessory crystals, remove the transceivers top cover and locate the FIXED CHANNEL-AVR board directly behind the VFO.

Insert the crystal in the desired channel position (the positions are labeled on top of the VFO case) and use the appropriate trimmer (TC1 through TC4) to net the crystal. The CAL-FIX feature of the TS-520S can be used to net the crystals as described in Section 4.4.

## 6.3 RECEIVER RF SECTION ALIGNMENT

The stand-by switch of the transceiver should be in the REC position during all of the receiver adjustments. Connect the transceiver to a 50 ohm dummy load.

Turn the FUNCTION switch to CAL-25 kHz and use the output of the calibrator circuit to adjust the coils. Set the DRIVE control to the 12 o'clock position (the white line pointing towards the top of the transceiver). The coils can be aligned from the bottom of the transceiver without removing the boards.

Set the BAND switch to the correct band and tune the VFO to the frequency shown in the table below to receive the calibrator signal. Use the test rod included in the accessory bag to tune the antenna and mixer coils for a maximum S-meter reading. Figure 37 shows the location of the coils. Adjust the coils for each band as described below. When you finish, turn the calibrator off. Adjust only the antenna and mixer coils for a maximum S-meter reading. Adjustment of the heterodyne oscillator coils is described in the next paragraph and adjustment of the drive coils is described in Section 6.7.

Adjusting Order*	Band	Alignment Frequency
1	1.8 MHz	1.900 MHz
2	28.5 MHz	28.800 MHz
3	21.0 MHz	21.225 MHz
4	14.0 MHz	14.175 MHz
5	7.0 MHz	7.150 MHz
6	3.5 MHz	3.750 MHz

### ANTENNA\*, MIXER\*, and DRIVE Coil Alignment

## CAUTION:

The Antenna cores are fragile. Be careful not to break them during alignment.

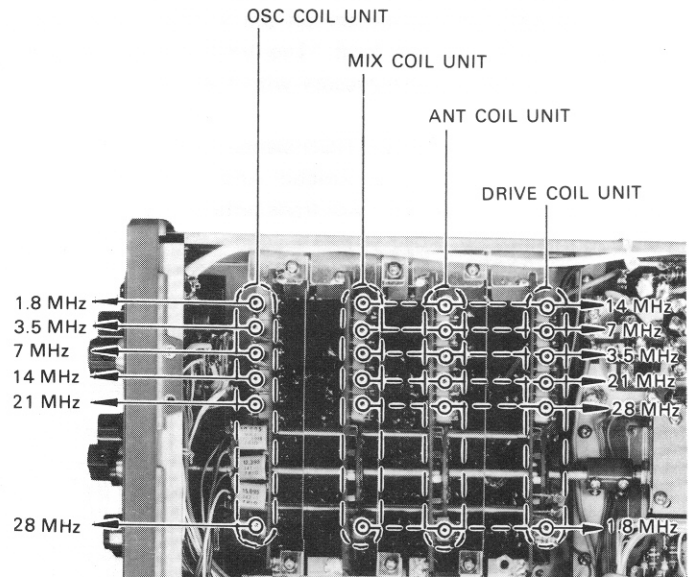


Fig. 37 RF Section Coil Diagram

## ■ HETERODYNE CRYSTAL OSCILLATOR

Adjust the heterodyne crystal oscillator's coils by switching the BAND switch to each band and tuning the appropriate coil (see Figure 37) as described below.

Turn the core of the coil clockwise until the crystal stops oscillating. You should be able to hear the point where this happens. From the point where the crystal stops oscillating, turn the core about one revolution back so that the crystal is again oscillating. If the core is left too near the threshold the oscillation may be unstable. Repeat the procedure for each band. For the 28 MHz band only the 28.5 MHz sub-band needs to be tuned. Tune the 1.8 MHz coil first and then tune the remaining coils (3.5, 7.0, 14.0, 21.0, and 28.5) in order.

Band	Oscillator Frequency
WWV	23.895 MHz
1.8 MHz	10.695 MHz
3.5 MHz	12.395 MHz
7.0 MHz	15.895 MHz
14.0 MHz	22.895 MHz
21.0 MHz	29.895 MHz
28.0 MHz	36.895 MHz
28.5 MHz	37.395 MHz
29.1 MHz	37.995 MHz

#### ■ WWV ALIGNMENT

Turn the BAND switch to WWV and tune the sub-dial to zero to receive the calibrator signal. Tune T4 and T5 on the RF board for a maximum S-meter reading. T3 is the WWV oscillator coil. Tune it for a maximum S-meter reading and then turn 1/4 turn counter-clockwise. The oscillator frequency is 23.895 MHz.

#### CAUTION:

Do not attempt to tune coils T1 and T2.

### 6.4 NOISE BLANKER BOARD ALIGNMENT

Tune in a calibrator signal on any band and adjust the DRIVE control for a maximum S-meter reading. Align coils T1 through T5 (on X54-1080-10) for a maximum S-meter reading.

Attach a 10V DC meter between the collector of Q6 (2SC733) and the chassis and tune coils T6 and T7 for a minimum voltage reading on the volt meter.

### 6.5 IF BOARD ALIGNMENT

Tune in a calibrator signal on any band and adjust the DRIVE control for a maximum S-meter reading. Adjust T2, T5, T6, and T9 (on X48-1060-01) for a maximum S-meter reading.

#### CAUTION:

Do not adjust T1, T3, T4, T8, T10, T11, T12 or T13.

#### ■ S-METER ZERO

If the S-meter requires recalibration, set the BAND switch to 14 MHz, turn the noise blanker off, and turn the RF GAIN control fully clockwise. With no antenna connected, set the zero adjust potentiometer, VR1 on the IF board, for a reading of zero on the S-meter.

#### ■ S-METER SENSITIVITY ADJUST

Apply a 14.175 MHz signal from an RF generator, accurately calibrated to produce a 50 $\mu$ V signal, at the antenna connector. Peak the S-meter for a maximum reading by tuning in the signal with the main tuning knob and by adjusting the DRIVE control. Then adjust the sensitivity potentiometer, VR2, for an S-meter reading of S9.

### 6.6 FIXED CHANNEL-AVR BOARD ALIGNMENT

#### ■ AVR CIRCUIT

Connect a 15V DC voltmeter between the 9 terminal (on X43-1100-00) and the chassis. Adjust VR1 for a 9 volt reading.

#### ■ RIT ZERO

When the RIT circuit is turned on, and the RIT control is set to zero, the receive frequency should be exactly the same as the transmit frequency. If the frequency is not the same, use the RIT zero control, VR2 to adjust it.

To zero the RIT, turn on the calibrator and tune the VFO for about a 1000 Hz calibrator tone. Turn the RIT control to zero. Turn on the RIT switch and adjust VR2 for the same 1000 Hz tone. Push the RIT switch on and off to be sure the tones are identical.

#### ■ AGC BIAS

Connect a 5V DC voltmeter between terminal RF1 and the chassis. Adjust VR3 for a meter reading of 3.3 volts. This adjustment may affect the S-meter readings so the meter will have to be recalibrated.

### 6.7 DRIVE COIL ALIGNMENT

Slide the back panel SG switch off (down), center the DRIVE control, and turn the METER switch to ALC. Be certain to connect a 50 ohm dummy load to the antenna connector. Turn the MODE switch to TUN or CW and flip the stand-by switch to SEND. Align the DRIVE coils (on X44-1190-00 in the RF section) at the frequencies and in the sequence shown in Section 6.3. Tune the coils for a maximum ALC reading. Slide the SG switch on.

### 6.8 CARRIER BALANCE ADJUSTMENT

Tune the TS-520S into a 50 ohm dummy load for operation at 14.175 MHz. Turn the MODE switch to LSB, set the METER switch to RF, and turn the RF VOLT control to its maximum level. If the ring modulator is out of balance, the meter will show output when the stand-by switch is set to SEND.

To balance the carrier, alternately adjust TC1 and VR2 on the GENERATOR board for a minimum RF meter reading. Switch back and forth between LSB and USB to minimize both readings.

## 6.9 TRANSMITTER NEUTRALIZATION

The TS-520S requires neutralization every time either of the final tubes is changed.

Tune up the TS-520S into a 50 ohm dummy load at 28.5 MHz for CW operation as described in Section 4. Set the SG switch to off (down) and place a sensitive RF voltmeter across the dummy load. Flip the stand-by switch to SEND and adjust TC1 (reached through the adjustment hole in the top of the final section) for a minimum reading on the voltmeter. After the final section is neutralized, flip the stand-by switch to REC and slide the SG switch on.

A good receiver tuned to 28.5 MHz, works very well for neutralizing if an RF voltmeter is not available. Instead of tuning for a minimum voltage, tune for a minimum S-meter reading.

### CAUTION:

Neutralization of the final section should be carried out with the chassis shield in place. Dangerous high voltages are present in the final section when the transceiver is turned on. Use an insulated tool to make this adjustment.

## 6.10 VFO CALIBRATION

The VFO should be calibrated with the dial scale. However if for some reason the VFO is too far off calibration for proper adjustment, there is an internal VFO adjustment.

Remove the TS-520S's case and locate TC1 on the VFO section. Turn the FUNCTION switch to CAL-25 kHz and tune the main tuning knob so that the dial pointer points to an even 25 kHz frequency. Adjust TC1 to zero beat the calibrator frequency.

## 6.11 CRYSTAL CALIBRATOR ALIGNMENT

The crystal calibrator is factory aligned and should need no further adjustment. If it should drift out of calibration, find TC1 on the MARKER board. Tune the receiver to WWV at 15 MHz and turn on the calibrator by switching the FUNCTION switch to CAL-25 kHz. Adjust TC1 until the calibrator signal is zero beat with WWV.

## 6.12 REPLACING THE FUSE

When the fuse blows, there is some cause. Be sure to find the cause before attempting operation. Use a 6 amp fuse for 120V AC operation, and a 4 amp fuse for 220V AC operation. Under no circumstances use a higher amperage

fuse than those specified. Extensive damage can be caused. Also, the warranty can be voided if an improper fuse is used.

## 6.13 CLEANING

The knobs, front panel and cabinet of the TS-520S are likely to become soiled after extended use. The knobs should be removed from the transceiver and cleaned with a neutral soap and warm water. Use a neutral soap (not harsh chemicals) and a damp cloth to clean the cabinet and front panel.

Use an air blower or a soft brush to keep the interior clean and dust free.

## 6.14 REPLACEMENT PARTS

### ■ TUBES AND TRANSISTORS

Operation of the TS-520S without proper tuning, or operation of the transceiver with a high voltage in excess of 1000 volts, will significantly reduce the life of the final amplifier tubes. A bad tube or tubes should be replaced with S2001A (6146B) tubes. Matched tubes are not required, however neutralization is required with new tubes. The driver is a 12BY7A.

The transistors in the TS-520S can easily be damaged by being shorted or shocked by metallic tools. Be very careful during service operations, and when possible, use insulated tools.

### ■ SERVICE PARTS

Be sure to use replacement parts of equal or better ratings when servicing the transceiver.

When ordering replacement or spare parts for your equipment, be sure to specify the following information:

Model number and serial number of the equipment  
— Schematic number of the part — and the board number on which the part is located.

Should it ever be necessary to return the equipment for repair be sure to pack it very carefully and include a full description of the problems involved.



# SECTION 7. TROUBLESHOOTING

## 7.1 GENERAL INFORMATION

The problems described in this table are failures caused in

general by improper operation or connection of the transceiver, not by defective components. There is a separate service manual for repair of the TS-520S.

## 7.2 TRANSMITTER AND RECEIVER CIRCUITS

SYMPTOMS	CAUSE	REMEDY
Pilot lights do not light and there is no receiver noise when the POWER switch is turned on.	<ol style="list-style-type: none"> <li>1. Bad power cable or connections.</li> <li>2. Blown power supply fuse.</li> <li>3. Wrong polarity connection for DC operation.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check cables and connections.</li> <li>2. Replace the fuse.</li> <li>3. Check for a negative ground power connection.</li> </ol>
Frequency difference between transmit and receive.  FMing on sideband operation.	<ol style="list-style-type: none"> <li>1. 9V DC supply not adjusted.</li> <li>2. Short circuit in 9 volt power supply or line.</li> <li>3. Improper battery voltage in mobile or portable operation.</li> </ol>	<ol style="list-style-type: none"> <li>1. See Section 6.6. (page 39)</li> <li>2. Check the 9 volt supply.</li> <li>3. Check battery or alternator voltage.</li> </ol>
VFO (or FIX) indicator does not light.	<ol style="list-style-type: none"> <li>1. Rear panel VFO plug not inserted.</li> </ol>	<ol style="list-style-type: none"> <li>1. Insert the jumpered plug.</li> </ol>
The relays operate with the stand-by switch in the REC position.	<ol style="list-style-type: none"> <li>1. Improper microphone connection.</li> </ol>	<ol style="list-style-type: none"> <li>1. Require the microphone connector.</li> </ol>
Signal reports of off frequency operation even though the dial scale is calibrated.	<ol style="list-style-type: none"> <li>1. Calibrator requires alignment.</li> </ol>	<ol style="list-style-type: none"> <li>1. See Section 6.11. (page 40)</li> </ol>

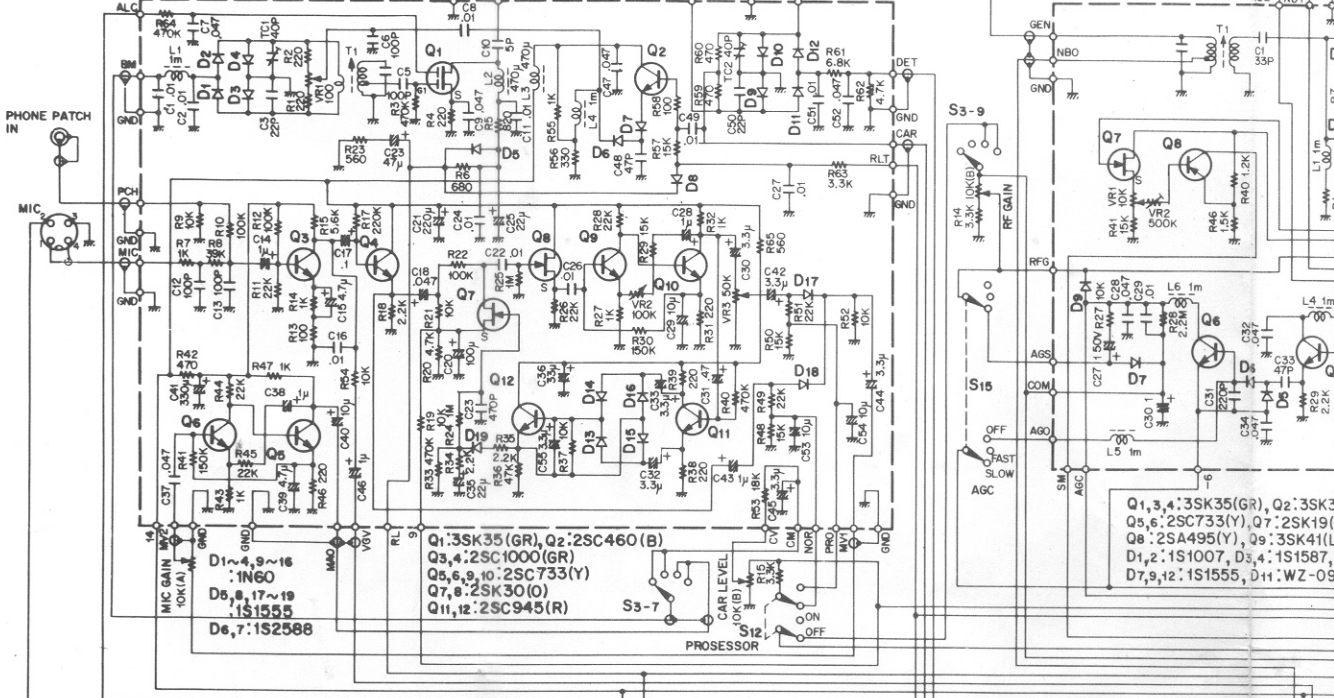
## 7.3 RECEIVER SECTION

SYMPTOMS	CAUSE	REMEDY
Accessory CW filter is installed but selectivity and intelligibility are poor.	<ol style="list-style-type: none"> <li>1. Wire on IF board not moved to CW.</li> <li>2. Bad CW filter.</li> </ol>	<ol style="list-style-type: none"> <li>1. See Section 6.2. (page 34)</li> <li>2. Replace the CW filter.</li> </ol>
An antenna is connected but no signals are heard.	<ol style="list-style-type: none"> <li>1. Inoperative VFO or FC oscillator.</li> <li>2. Microphone PTT switch (or stand-by switch) is in the transmit position.</li> </ol>	<ol style="list-style-type: none"> <li>1. Insert the shunt plug into back panel.</li> <li>2. Release the PTT switch.</li> </ol>
An antenna is connected and the calibrator signal is received, but no signals are heard.	<ol style="list-style-type: none"> <li>1. Bad T/R relay.</li> </ol>	<ol style="list-style-type: none"> <li>1. Replace the relay.</li> </ol>
One or more bands are operating but some are not.	<ol style="list-style-type: none"> <li>1. The heterodyne oscillator is not operating on the defective band.</li> <li>2. The antenna coil of the defective band requires alignment.</li> </ol>	<ol style="list-style-type: none"> <li>1. See Section 6.3. (page 38)</li> <li>2. See Section 6.3. (page 38)</li> </ol>
S-meter deflects without a received signal.	<ol style="list-style-type: none"> <li>1. Balanced detector is out of adjustment.</li> <li>2. IF board is out of adjustment.</li> <li>3. Low AC line voltage.</li> </ol>	<ol style="list-style-type: none"> <li>1. See Section 6.8. (page 39)</li> <li>2. See Section 6.5. (page 39)</li> <li>3. Use a step-up transformer to raise the line voltage.</li> </ol>
S-meter reads too high or too low.	<ol style="list-style-type: none"> <li>1. IF board is out of adjustment.</li> <li>2. RF gain control closed causing low sensitivity.</li> </ol>	<ol style="list-style-type: none"> <li>1. See Section 6.5. (page 39)</li> <li>2. Open RF GAIN control.</li> </ol>
Lack of sensitivity on one or more bands.	<ol style="list-style-type: none"> <li>1. Receiver section requires realignment.</li> </ol>	<ol style="list-style-type: none"> <li>1. See Section 6.3. (page 38)</li> </ol>
The RIT control is at zero with the RIT circuit on, but the receive and transmit frequencies are different.	<ol style="list-style-type: none"> <li>1. The RIT control is out of adjustment.</li> </ol>	<ol style="list-style-type: none"> <li>1. See Section 6.6. (page 39)</li> </ol>
RIT control inoperative.	<ol style="list-style-type: none"> <li>1. RIT circuit off.</li> </ol>	<ol style="list-style-type: none"> <li>1. Push RIT button.</li> </ol>
SSB signal unintelligible.	<ol style="list-style-type: none"> <li>1. MODE switch is set to wrong sideband.</li> </ol>	<ol style="list-style-type: none"> <li>1. Turn MODE switch to correct sideband.</li> </ol>

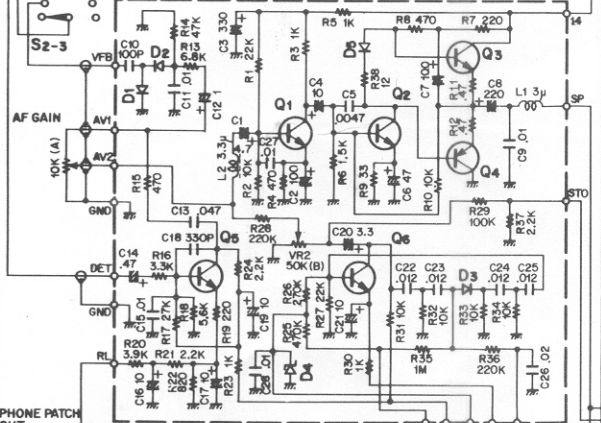
## 7.4 TRANSMITTER SECTION

SYMPTOMS	CAUSE	REMEDY
ALC meter deflects with no output (no plate current).	<ol style="list-style-type: none"> <li>1. No high voltage (+800V) on the final tubes.</li> <li>2. Bad final tubes.</li> <li>3. SG switch is turned off.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check the HV power supply.</li> <li>2. Replace the tubes.</li> <li>3. Slide the switch up.</li> </ol>
ALC meter does not deflect and there is output.	<ol style="list-style-type: none"> <li>1. Too little MIC gain.</li> </ol>	<ol style="list-style-type: none"> <li>1. Increase the MIC GAIN control.</li> </ol>
The TS-520S will not operate on SSB.	<ol style="list-style-type: none"> <li>1. Open microphone plug or bad microphone.</li> <li>2. Too little microphone gain.</li> <li>3. Defective microphone amplifier on the GENERATOR board.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check the microphone.</li> <li>2. Increase the MIC control.</li> <li>3. Repair the circuit.</li> </ol>
There is output, but the RF meter shows no output.	<ol style="list-style-type: none"> <li>1. RF VOLT control not adjusted correctly</li> </ol>	<ol style="list-style-type: none"> <li>1. Adjust control for 2/3 scale reading at full output.</li> </ol>
RF meter deflects too far.	<ol style="list-style-type: none"> <li>1. RF VOLT control not adjusted correctly.</li> </ol>	<ol style="list-style-type: none"> <li>1. Adjust control for 2/3 scale reading at full output.</li> </ol>
VOX does not operate.	<ol style="list-style-type: none"> <li>1. VOX GAIN control is closed.</li> <li>2. VOX switch is OFF.</li> </ol>	<ol style="list-style-type: none"> <li>1. See Section 4.12. (page 22)</li> <li>2. Turn the switch on.</li> </ol>
VOX trips with AF sound from the speaker.	<ol style="list-style-type: none"> <li>1. ANTI VOX control requires adjustment.</li> </ol>	<ol style="list-style-type: none"> <li>1. See Section 4.12. (page 22)</li> </ol>
VOX circuit releases between words or holds too long.	<ol style="list-style-type: none"> <li>1. VOX time hold control requires adjustment.</li> </ol>	<ol style="list-style-type: none"> <li>1. See Section 4.12. (page 22)</li> </ol>
Excessive plate current.	<ol style="list-style-type: none"> <li>1. Detuned final section.</li> <li>2. Low negative power supply voltage.</li> <li>3. Idling current requires adjustment.</li> </ol>	<ol style="list-style-type: none"> <li>1. See Section 6.9. (page 40)</li> <li>2. Check the power supply output.</li> <li>3. See Section 4.11. (page 20)</li> </ol>
Plate current is too high or too low for CW.	<ol style="list-style-type: none"> <li>1. Carrier requires adjustment.</li> </ol>	<ol style="list-style-type: none"> <li>1. Adjust CAR control.</li> </ol>
Low drive on one or more bands but not on all bands. Broad DRIVE tuning on one or more bands.	<ol style="list-style-type: none"> <li>1. Transmitter section requires alignment.</li> </ol>	<ol style="list-style-type: none"> <li>1. See Section 6.7. (page 39)</li> </ol>
No drive or intermittent drive on one or more bands.	<ol style="list-style-type: none"> <li>1. Heterodyne oscillator requires adjustment.</li> </ol>	<ol style="list-style-type: none"> <li>1. See Section 6.3. (page 38)</li> </ol>
Low drive and broad DRIVE tuning on all bands.	<ol style="list-style-type: none"> <li>1. Bad driver tube.</li> </ol>	<ol style="list-style-type: none"> <li>1. Replace the tube.</li> </ol>
Signal reports of carrier.	<ol style="list-style-type: none"> <li>1. Carrier requires balancing.</li> </ol>	<ol style="list-style-type: none"> <li>1. See Section 6.8. (page 39)</li> </ol>
Signal reports of distortion.	<ol style="list-style-type: none"> <li>1. Too much microphone gain.</li> </ol>	<ol style="list-style-type: none"> <li>1. Reduce MIC control.</li> </ol>
Plate current is too low. Tuning becomes very broad. Idling current increases.	<ol style="list-style-type: none"> <li>1. Bad final tubes.</li> </ol>	<ol style="list-style-type: none"> <li>1. Replace the tubes.</li> </ol>
Every time either of the final tubes is replaced, the TS-520S requires neutralization.		<ol style="list-style-type: none"> <li>1. See Section 6.9. (page 40)</li> </ol>

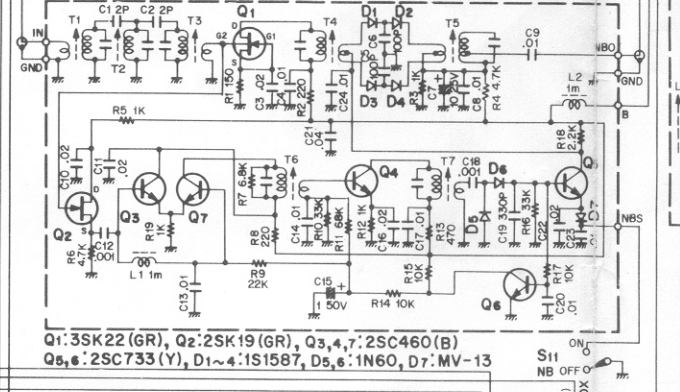
**GENERATOR UNIT  
(X52-1090-00)**



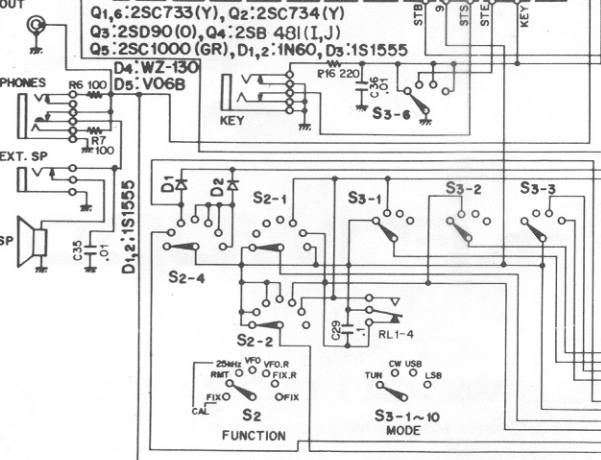
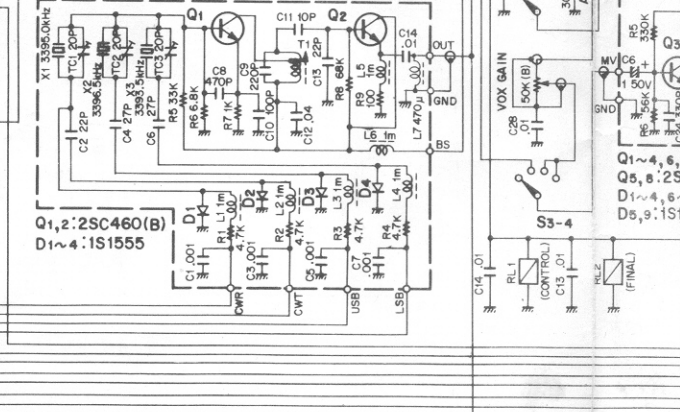
**AF UNIT (X49-0008-01)**



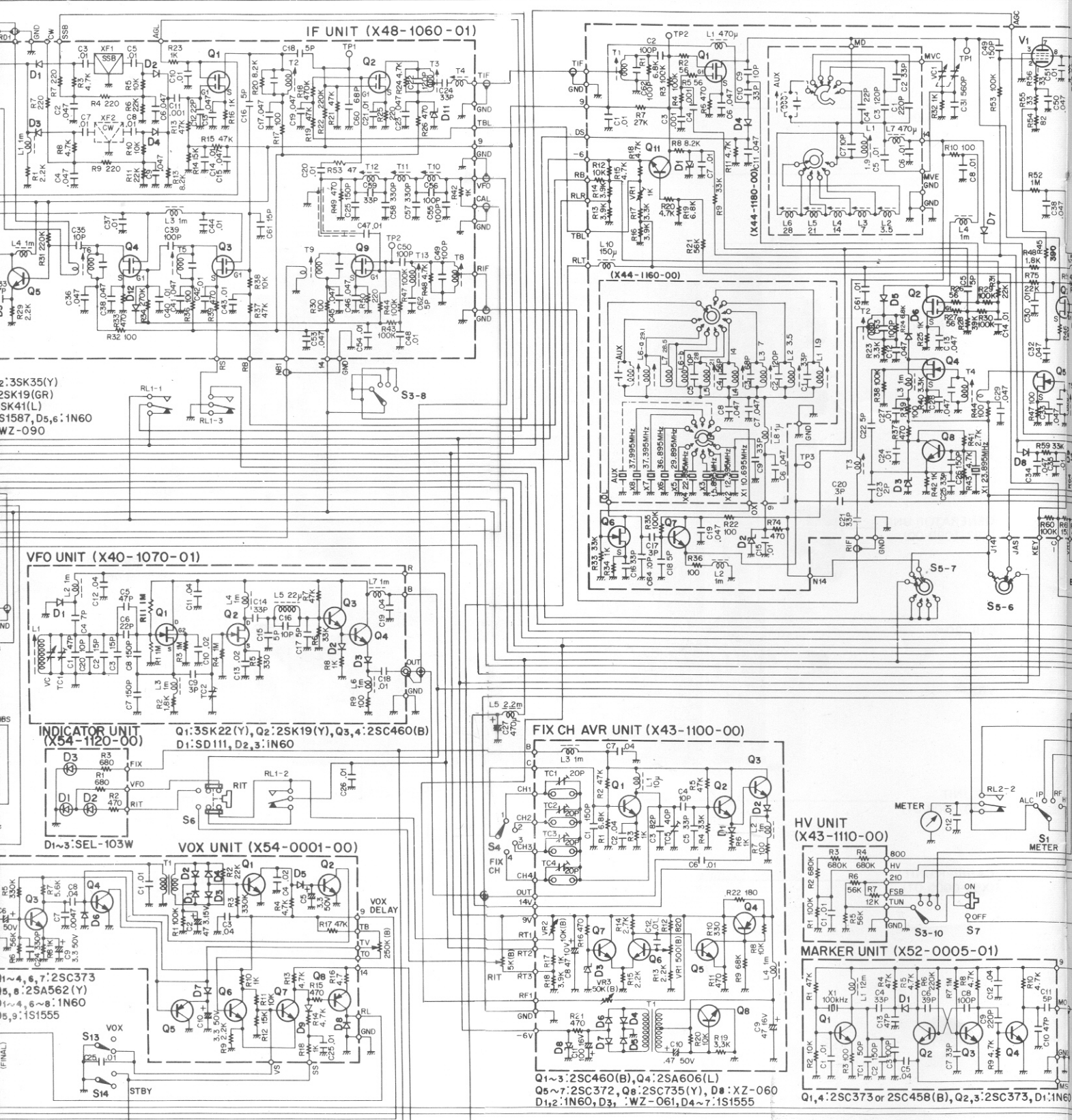
**NB UNIT (X54-1080-0)**



**CAR UNIT (X50-0009-01)**



# TS-520S SCHEMATIC (FIGURE 37)



Q2: 3SK35(Y)  
 Q3: 2SK19(GR)  
 Q4: 5K41(L)  
 S1: 51587, D5, 6: 1N60  
 WZ-090

Q1: 3SK22(Y), Q2: 2SK19(Y), Q3, 4: 2SC460(B)  
 D1: SD111, D2, 3: 1N60

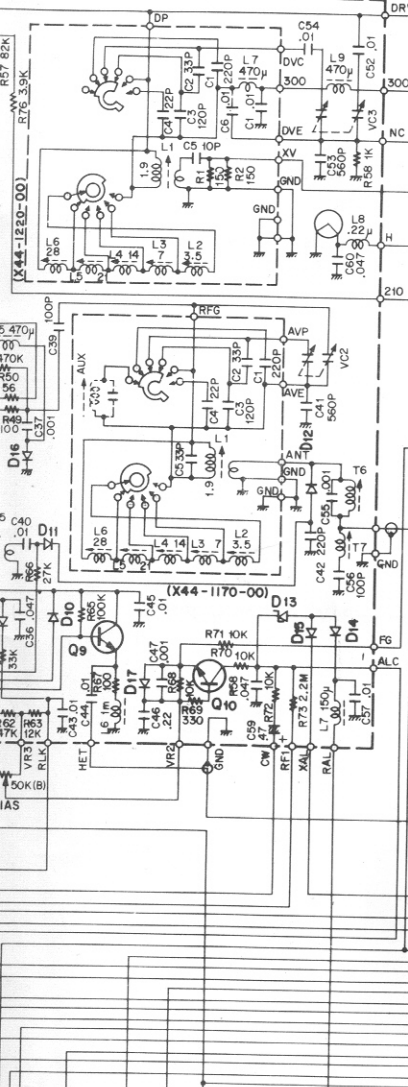
D1~3: SEL-103W

Q1~4, 6, 7: 2SC373  
 Q5, 8: 2SA562(Y)  
 Q9~11, 4, 6~8: 1N60  
 Q12, 9: 1S1555

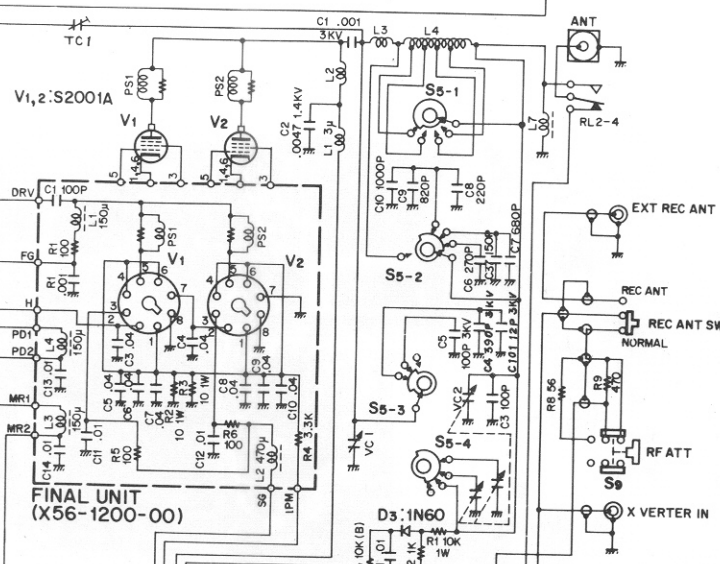
Q1~3: 2SC460(B), Q4: 2SA606(L)  
 Q5~7: 2SC372, Q8: 2SC735(Y), D8: XZ-060  
 D1, 2: 1N60, D3, 4: WZ-061, D4~7: 1S1555

Q1, 4: 2SC373 or 2SC458(B), Q2, 3: 2SC373, D1: 1N60

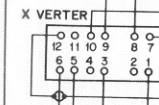
**RF UNIT (X44-1200-00)**



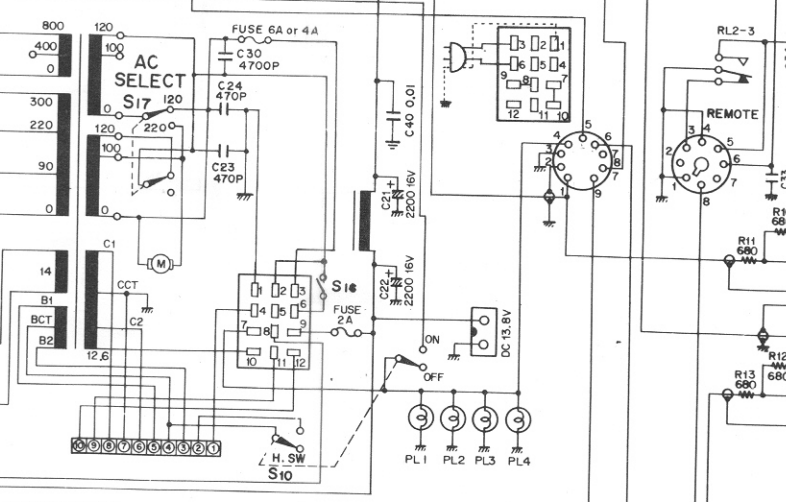
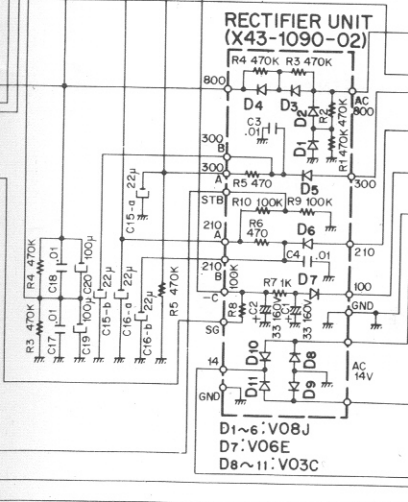
- Q1,2: 3SK41(L) or 3SK40(L)
- Q3: 3SK35(GR)
- Q4: 3SK22(GR)
- Q5,6: 2SK19(GR)
- Q7~9: 2SC460(B)
- Q10: 2SC1515(K)
- Q11: 2SC733(Y)
- D1~3,13: WZ090
- D4, 11, 12: 1S 2588
- D5, 6, 16: 1S1587
- D7, 10, 17: 1S1555
- D8, 9, 14, 15: V06B
- V1: 12BY7A



**FINAL UNIT (X56-1200-00)**



**RECTIFIER UNIT (X43-1090-02)**



**TS-5203 (K) (W)**

# TOP VIEW OF THE TS-520S (FIGURE 38)

FIX-CHAN-AVR UNIT  
(X43-1100-00)

IF UNIT  
(X48-1060-01)

METER

VFO UNIT  
(X40-1070-01)

RF UNIT  
(X44-1200-00)

LOAD V.C.

PLATE V.C.

CHOKE COIL

VOX UNIT  
(X54-0001-00)

MARKER UNIT  
(X52-0005-01)

TC1

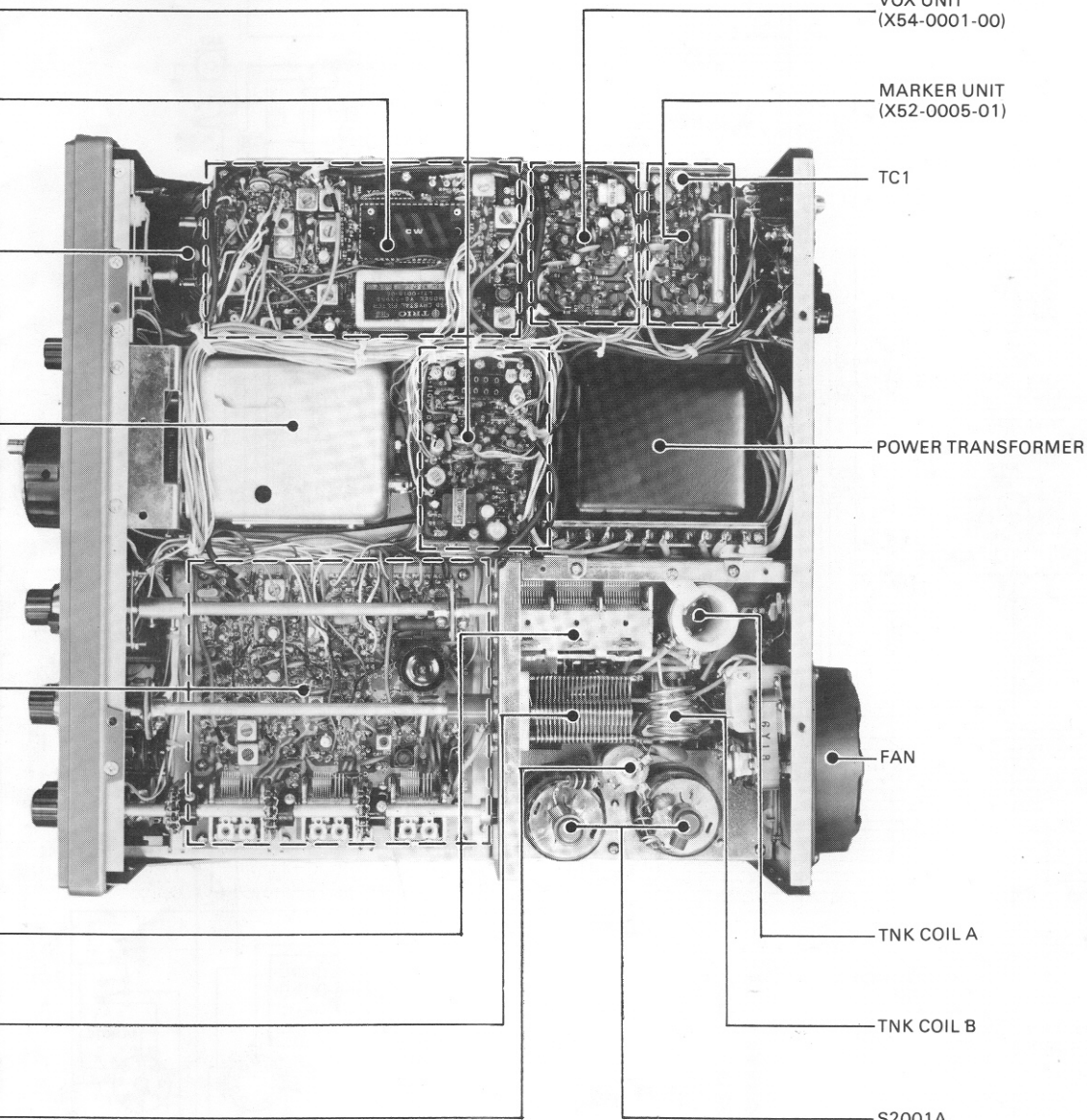
POWER TRANSFORMER

FAN

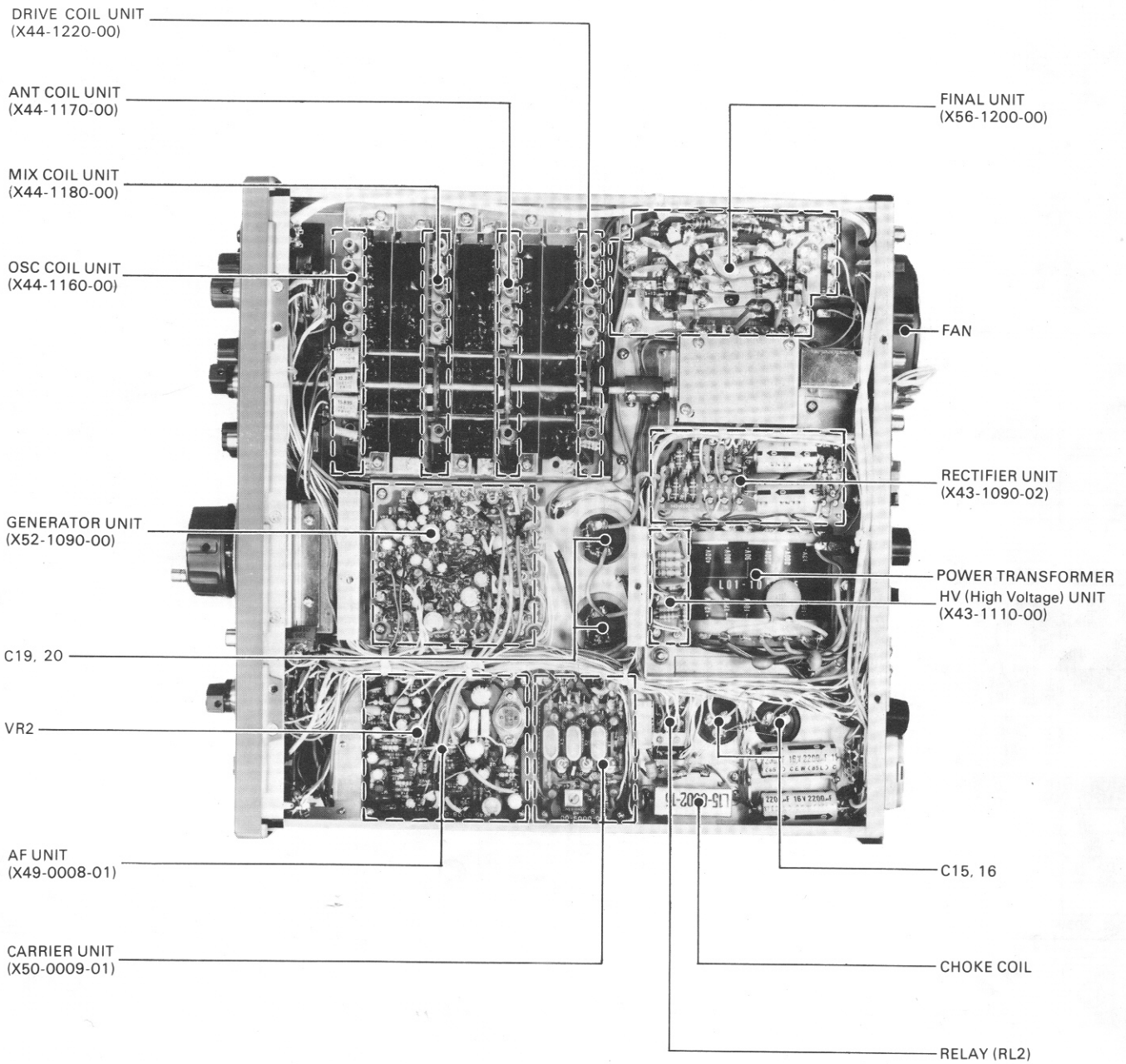
TNK COIL A

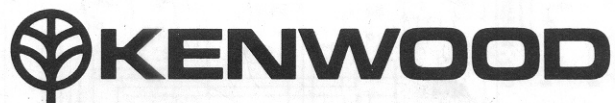
TNK COIL B

S2001A



# BOTTOM VIEW OF THE TS-520S (FIGURE 39)





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