

MAINTENANCE SERVICE MANUAL

FT-221 SERIES



YAESU MUSEN CO., LTD.

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TOKYO, JAPAN

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INTRODUCTION

The purpose of this manual is to provide the reader with the essential information that is needed to keep his FT-221 (of whatever vintage) running at top efficiency. While we have made an effort to include many technical details where it was felt desirable, this manual is written toward the serviceman/owner, rather than the engineer/designer.

Use of this manual is entirely at the user's risk. We believe that the information herein is accurate and factual, but should damage to your equipment occur, or erroneous data be present, we assume no liability for such damage or erroneous information.

No manual, no matter how well written, detailed, or carefully edited, can take the place of experience and judgement.

For this reason, we have departed from the traditional "military format" in writing technique and the style may seem too informal on first reading, however, remember that our goal was to make this manual easy to use.

You will find inside these covers, not just a list of clipped out circuit descriptions and re-drawn prints, but all the tricks and neat stuff that the factory developed - extras that never show up in operators' manuals, such as part location data, test points, a wealth of "How To Do It" instructions, and the special information our service files contained.

We are grateful to the many Yaesu factory people and dealers' servicemen, all of whom contributed freely of their time and effort to make this manual a useful tool.

We hope you find it is worth double what it cost you, and that you seldom have any need for it, except to better understand THE RADIO.

VY 73,



Bernard E. Tower, W6RNW
General Manager

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GENERAL DESCRIPTION

The model FT-221 two meter transceiver is a precision built, compact, high performance transceiver of advanced design, providing all mode operation: SSB (LSB or USB selectable), AM, CW, and FM with repeater offset capability. Advanced PLL (Phase Lock Loop) circuitry offers unsurpassed stability and clean, spurious free signals. The transceiver operates at an input of 20 watts on 144 through 148 MHz, in eight 500 kHz segments permitting 1 kHz accurate dial readout. All circuits are fully transistorized and computer type plug-in modules are used for increased reliability and service ability.

Adoption of pre-set passband tuning and wide band amplifier techniques, provide the optimum selectivity and performance needed on today's active 2 meter band.

The transceiver is self contained, requiring only an antenna and power source for home, portable or mobile operation. The transceiver may be operated from 100/110/117/200/220 or 234 volt AC when the power transformer is appropriately wired. The FT-221 is normally supplied for 117 volt AC and 12 volt DC operation. Two power cords are supplied with the transceiver. Selection of AC or DC operation is automatically made when the proper line cord is inserted into the receptacle on the rear panel.

Deluxe features such as VOX, break-in CW with side tone, 100 kHz calibrator, noise blanker and squelch are built-in. In addition to continuous VFO coverage, 88 crystal-controlled channels (11 channels x 8 bands = 88 channels), clarifier and speaker are all integral parts of the unit. A "tone burst" generator with automatic tone actuation circuit (patent pending) is included.

The entire transceiver weighs approximately 8.5 kg, and is 280 m/m wide, 125 m/m high, and 295 m/m deep. Construction of heavy gauge steel provides an extremely rugged package, virtually immune to the effects of vibration and shock encountered in rugged mobile service.

The FT-221R differs slightly, in that the function switches are arranged to provide not only the standard 600 kHz repeater shift, but can also utilize any odd split within 1 MHz, using special crystals.

A BRIEF HISTORY OF THE FT-221

The FT-220 was the "Granddaddy" of the FT-221, however, it was never distributed within the USA, and only a few thousand were manufactured and distributed throughout the world, so little information is available on it from a service standpoint.

In 1974, the FT-220 underwent a complete redesign, and emerged as the FT-221, incorporating traditional Yaesu "computer style" plug-in card modules, and a phase lock loop circuit. It appeared on the US market in 1975 as the first PLL stabilized, broad banded, two meter transceiver with "all modes" capability.

As with other Yaesu products, production changes occurred that are of interest to the serviceman, without model change identifications. Consequently, early, mid, and late versions exist, all identified as "FT-221".

Early versions had a phase lock loop board with only a single control for setting up the lock range. "Mid" versions had a PLL board with a trimmer capacitor in the upper corner, and late versions, including the FT-221R, had temperature compensating capacitors installed, as well as the trimmer.

Mid and late (after S/N 302500) PLL boards are not interchangeable with early versions. The "mid" version (S/N 302500 to S/N 307000) can be interchanged with late versions.

The FT-221R was developed to handle those "odd splits" so popular in California and New York, but was otherwise identical to the late version FT-221.

It is interesting to note that several thousand FT-221's (and a few hundred competing units) have begun what appears to be a minor revolution on two meters. SSB activity was formerly so tiny a fraction of the total activity that anyone who home brewed his way to SSB capability on two was promptly written up in all the ham magazines as a unique human, and a superb ham.

Today, activity on SSB is so extensive and satisfying that the lower end of two is almost as busy as the upper half.

So the history of the FT-221 is necessarily incomplete - it has had an enviable record so far, but interest in this fine piece of equipment is still increasing, as more and more hams conclude that for two meters, it is indeed -

"THE RADIO"

INSTALLATION

GENERAL

The FT-221 transceiver has been designed primarily for base service, requiring only an antenna. However, the transceiver provides for efficient mobile service. The transceiver has been factory pre-tuned and requires no adjustment for normal operation into a matched 50 ohm load.

The antenna and its location are the most important consideration in both base and mobile installations, where effective communication range is directly related to antenna height. The antenna should always be as high and in the clear as possible, and a minimum distance of 5 feet should be maintained between the VHF and other antennas. In a mobile installation, it is advisable to locate the antenna as far from the engine as practical in order to minimize any ignition noise pickup. In all installations, the most popular antenna types are either a 1/4 wave length whip with unity gain or a 5/8 wave length whip with a base matching device affording approximately 3.5 dBd gain.

To minimize loss in the antenna system, use the shortest length of coaxial cable that is practical, avoiding any sharp angles or kinks. Use type RG-8/U cable if the transmission line length exceeds 25 feet, while RG-58/U may be used for shorter lengths.

BASE STATION INSTALLATION

The transceiver is designed for use in many areas of the world where the supply voltage may differ from the operator's local supply voltage. Therefore, before connecting the AC cord to the power outlet, be sure that the voltage marked on the rear of the transceiver agrees with the local AC supply voltage. If not, please refer to Pg. 1-20 for rewiring of the transformer primary connections.

CAUTION

PERMANENT DAMAGE WILL RESULT IF IMPROPER AC SUPPLY VOLTAGE IS APPLIED TO THE TRANSCEIVER. OUR WARRANTY DOES NOT COVER THE DAMAGE CAUSED BY SUCH AN IMPROPER SUPPLY VOLTAGE.

Be sure that the proper fuse is used according to the local supply voltage: 2 amps for 117 volts and 1 amp for 220 volts. The transceiver should be connected to a good ground. The ground lead should be connected to the terminal marked GND located on the rear panel of the transceiver.

It is recommended that excessively warm locations be avoided. The transceiver should be placed in a location that has adequate space to permit free air circulation through the cabinet openings. A fan is not required.

MOBILE INSTALLATION

The transceiver will operate satisfactorily from any 12 volt negative ground battery source by connecting the DC power cord to the rear panel receptacle. In the car, a location should be selected that is clear of heater ducts to protect it from excessive heat. No special mounting precautions need to be observed if adequate ventilation space is available.

A minimum of two inches air space above the cabinet top and on all sides is recommended to allow proper air flow around the cabinet. You may put it on the seat but be sure that there is clearance between the transceiver bottom and seat. Since the transceiver requires an average of 3 amps on transmit, the fuse in the DC power cable should be rated at 5 amps.

When making connections to the car battery, be certain that the RED lead is connected to the positive (+) terminal and the BLACK lead to the negative (-) terminal of the battery. Reversed connection could permanently damage the transceiver. The BLACK lead should run directly to the negative terminal of the battery. The power cable should be kept away from ignition wires and be as short as possible to minimize voltage drop and to provide a low impedance path from the transceiver to the battery.

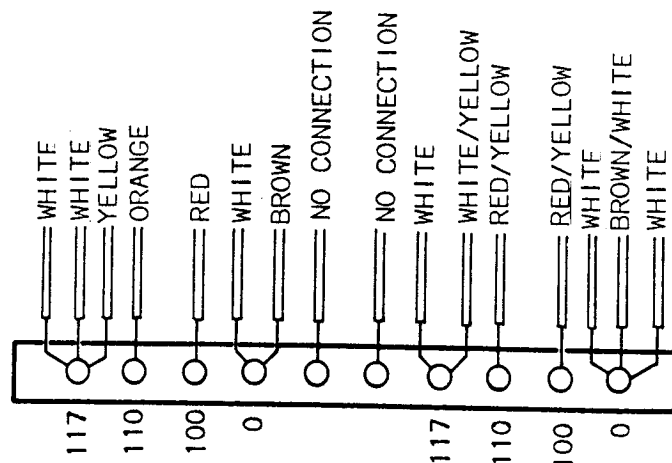
Prior to operating the transceiver in a mobile installation, the voltage regulator setting should be checked. In many vehicles, the voltage regulators are very poor and in some cases the regulator may be adjusted for an excessively high charging voltage. As the battery and regulator age, the maximum voltage while charging can increase to a very high level which is not only detrimental to the battery but could cause damage to the transceiver. The transceiver is designed to operate from a source voltage range of 11 to 14 volts. It is necessary to carefully set the auto voltage regulator so that the highest charging voltage does not exceed 14 volts.

The transceiver should be switched "OFF" when the vehicle is started in order to prevent voltage transients from damaging the transistors.

It is recommended that the microphone furnished with this transceiver be used, however any other microphone of 500 to 600 ohm impedance may be used. Refer to Pg. 1-20 for the microphone plug connections. The microphone bracket may be put on the side of the cabinet. It may also be put at any convenient place by making two 2.5 m/m holes spaced 14 m/m.

A speaker is built into the transceiver, however the audio output is also available for external speaker use. Any speaker having a 4 ohm impedance may be used, and when the external speaker plug is plugged into the EXT SP jack on the rear panel, the built-in speaker is disabled.

TRANSFORMER TERMINAL WIRING
FOR 117 VAC INPUT



Refer to page 1-20 for various supply voltages.

SPECIFICATIONS

FT-221/221R

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GENERAL

Frequency Range:

144.0 - 144.5 mHz
 144.5 - 145.0 mHz
 145.0 - 145.5 mHz
 145.5 - 146.0 mHz
 146.0 - 146.5 mHz
 146.5 - 147.0 mHz
 147.0 - 147.5 mHz
 147.5 - 148.0 mHz

Four bands are installed to meet the customer's local requirements and the others are available as option. For USA, the standard covers 144.0 through 148.0 mHz.

Frequency Readout:

Better than 1 kHz

Emission:

SSB (LSB or USB selectable), AM, FM and CW.

Power Output:

SSB 12 Watts PEP
 FM, CW 14 Watts
 AM 2.5 Watts

Frequency Stability:

Within 100 Hz during any 30 minute period after warm up. Not more than 20 Hz with a 10% line voltage variation.

Antenna Impedance:

50 ohms unbalanced

Repeater Burst Signal:

1500 to 2000 Hz adjustable

Power Requirement:

AC 100/110/117/200/220/234 volts
 50/60 Hz
 DC +12 - 14.5 volts, negative ground

Power Consumption:

AC Receive 30VA
 Transmit 90VA at 10 watts output
 DC Receive 0.6A
 Transmit 3A at 10 watts output

Size:

280(W) x 125(H) x 295(D) m/m

Weight:

Approximately 8.5 kg

RECEIVER

Sensitivity:

SSB/CW 0.5 μ V for 10dB S/N
 FM 0.75 μ V for 20dB QS
 AM 1.0 μ V for 10dB S/N

Selectivity:

SSB/CW/AM 2.4 kHz at 6dB
 4.1 kHz at 60dB
 FM \pm 6 kHz at 6dB*
 \pm 12 kHz at 60dB*
 (* US Model)

Image Ratio:

Better than -60 dB

Spurious Response:

Better than 1 μ V at antenna input

Speaker Impedance:

4 ohms

Audio Output:

2 watts at 10% distortion

TRANSMITTER

Audio Response:

300 - 2700 Hz \pm 3 dB

Carrier Suppression:

40 dB or better

Unwanted Sideband Suppression:

40 dB or better at 1 kHz

Spurious Radiation:

Down 60 dB or better

FM Deviation:

Maximum 12 kHz: Factory set at \pm 5 kHz

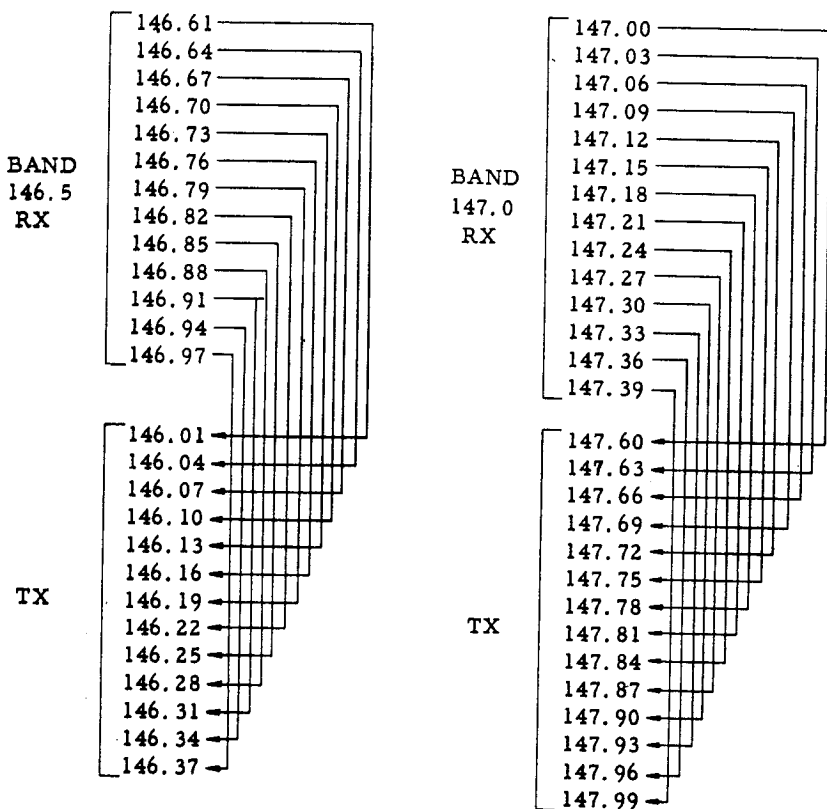
CRYSTAL DATA - FT-221

The FT-221 series has provision for eleven fixed frequency positions, both to improve mobile operation, and to allow instant selection of "favorite frequencies". The crystals are inserted into the Fix Unit (PB-1453) with channel #1 on the left.

Since eight 500 kHz segments are used to cover the 144-148 MHz amateur band, the eleven crystals can provide up to 88 channels, if desired, since the crystal remains active on all band positions. A trimmer capacitor is associated with each crystal position that will allow about ± 1 kHz of "swing", to let you net your rig with fellow hams on the same desired frequency.

For most purposes, the formula $F_x = f_o - f_i$ will give you the crystal frequency, where F_o = operating frequency desired
 f_i (from table (i))

Getting into crystal calculations for out of band (MARS) work is in - "Getting California Splits and Other Things" which follows.



Repeater Frequency Chart for U.S. Model

BAND (MHz)	LSB (kHz)	USB (kHz)	F _i (MHz)
144.0-144.5	136001.5	135998.5	136000
144.5-145.0	136501.5	136498.5	136500
145.0-145.5	137001.5	136998.5	137000
145.5-146.0	137501.5	137498.5	137500
146.0-146.5	138001.5	137998.5	138000
146.5-147.0	138501.5	138498.5	138500
147.0-147.5	139001.5	138998.5	139000
147.5-148.0	139501.5	139498.5	139500

Table 1

Example (1)– Find the proper crystal frequency for 144.15 MHz USB operation

**From the Table 1, f_i for USB is 135998.5.
 Therefore, $f_x = 144.15 - 135.9985 = 8151.5$ kHz**

Example (2)– 144.72 MHz FM operation

$f_x = 144.72 - 136.5 = 8220$ kHz

CRYSTAL DATA - FT-221

FUNCTION	HOLDER	RANGE (MHZ)	MODE	LOAD C	SERIES R
Local	HC-18/U	13.92222	F	34 pf	20 ohms
		13.97777	F	"	"
		14.03333	F	"	"
		14.08888	F	"	"
		14.14444	F	"	"
		14.20000	F	"	"
		14.25555	F	"	"
		14.31111	F	"	"
FM 2nd Local	HC-18/U	10.245	F	29.5pf	20 ohms
SSB LSB	HC-18/U	10.7015	F	23.5	20 ohms
SSB USB	HC-18/U	10.6985	F	23.5	20 ohms
AM/CW	HC-18/U	10.6993	F	23.5	20 ohms
FM Carrier	HC-18/U	10.7000	F	30	20 ohms
Local (Repeater)	HC-25/U	13.92222-14.32222	F	34	20 ohms
Fixed Chan	HC-25/U	8.000 - 8.500	F	27.5	35 ohms

HOW TO GET "CALIFORNIA SPLITS", AND OTHER THINGS

The FT-221 uses a pair of crystals located on the PB1454 local unit board to generate precise 600 kHz offsets on the 146.5 MHz band position, and the 147.0 MHz segment.

When your band switch is on 146.5 MHz, and the normal-reverse switch is in NOR position, you will transmit 600 kHz below your dial indication. Under the same conditions but using the 147.0 MHz position, you transmit 600 kHz above your dial frequency.

Now the fun begins: If you flip the NOR-REV switch to the reverse (REV), the main tuning dial will indicate where you are transmitting, but your receiver will be listening 600 kHz below the dial indication if you are on the 146.5 segment, or 600 kHz above the dial indication if your band switch is on the 147.0 segment.

It's confusing, but read on, it gets easier.

The FT-221 achieves this by selecting one of two special band crystals for transmitting, and then returning to the normal crystal during receive. (The relay that does this switching is not located on the PB-1454 unit, it's found on PB1461, the tone burst unit - surprise!)

If you go into the "REPEAT" mode on any band switch setting other than 146.5 or 147.0, the unit will just "blink" at you, indicating of course that the PLL is unlocked, and you cannot transmit or receive.

On the 146.5 MHz setting, you normally use the crystal in position #5 (14.14444 MHz) for simplex transceive. However, if you shift to "RPT" the rig continues to listen where the dial indicates, but when you transmit, the relay on PB1461 activates the diode crystal select circuit in such a way that position #5 is "out", and position #10 is activated. Position #10 is a special crystal, exactly 600 kHz below the dial setting (14.1333 MHz).

The same thing occurs when operating on the 147.0 MHz band position except the crystal in position #11 is inserted that is 600 kHz above the dial setting (14.3222).

Some of the more observant among you will immediately discern that we have two "extra" holes on the local unit, positions 9 and 12. More on those two later.

<u>BAND</u>	<u>LOCAL FREQUENCY</u>	<u>BAND</u>	<u>LOCAL FREQUENCY</u>
144.0	125.3 MHz	146.0	127.3 MHz
144.5	125.8 MHz	*146.5	127.8 MHz
145.0	126.3 MHz	*147.0	128.3 MHz
145.5	126.8 MHz	147.5	128.8 MHz

* Only these two are factory wired, the others take some rewiring to activate.

The frequency scheme is fairly simple.

The local unit produces 125.3 - 128.8 MHz, which when heterodyned in the mixer Q303 of the PLL board PB1455, produces an 8.0 to 8.5 MHz difference signal. This difference signal is compared to the VFO output (also 8.0 - 8.5 MHz) and any difference voltage developed is rectified, amplified and used to control the VCO on the PLL board in such a way as to reduce the difference to zero.

The VCO produces 133.3 - 137.3 MHz, which both supplies the mixer signal and is also the exciting frequency for the balanced mixers, on PB1466 (exciter unit). The sum of the VCO frequency and the carrier frequency produce the 144.0 - 148.0 MHz output frequency.

So now that you understand how it works(?), here is how to do it.

Calculate the new shift crystal as follows:

$$\frac{\text{Band 146.5}}{\text{Crystal frequency in MHz} = \frac{127.8 - \text{shift frequency}}{9}}$$

$$\frac{\text{Band 147.0}}{\text{Crystal frequency in MHz} = \frac{128.3 + \text{shift frequency}}{9}}$$

Order the suitable crystal, type HC-25/U, shunt capacitance 34pf, drive level 5 MW, resistance below 20 ohms, tolerance 20 PPM, fundamental mode. (Yaesu does not carry odd split crystals).

If your Rx side is in the 146.5 band, install the new crystal in place of X-210 if you have a 221, or in X-209 if it is a 221R.

If you have to Rx in the 147.0 band position, put the new crystal in the place of X-211, or X-212 if an FT-221R.

Note that the formulas give you Tx below Rx for the 146.5 band setting, and Tx above Rx for the 147.0 MHz setting.

When you use an even split (500, 700, etc.) you can use the internal calibrator to get you right on the nose, without extra equipment.

Here's how:

Turn on the internal marker and zero beat one of the marker signals close to the desired frequency. Then set the "RPT switch on, and the NOR-REV switch to REV. Adjust the trimmer TC-210 or TC-211 for a zero beat, go back to NOR and zero beat the dial again - then switch to REV and re-set the trimmer. Repeat this until you get an exact zero beat for both NOR and REV positions.

For the odd splits, (750, 431, 219, etc.) use a frequency counter to set them to the desired transmit shift.

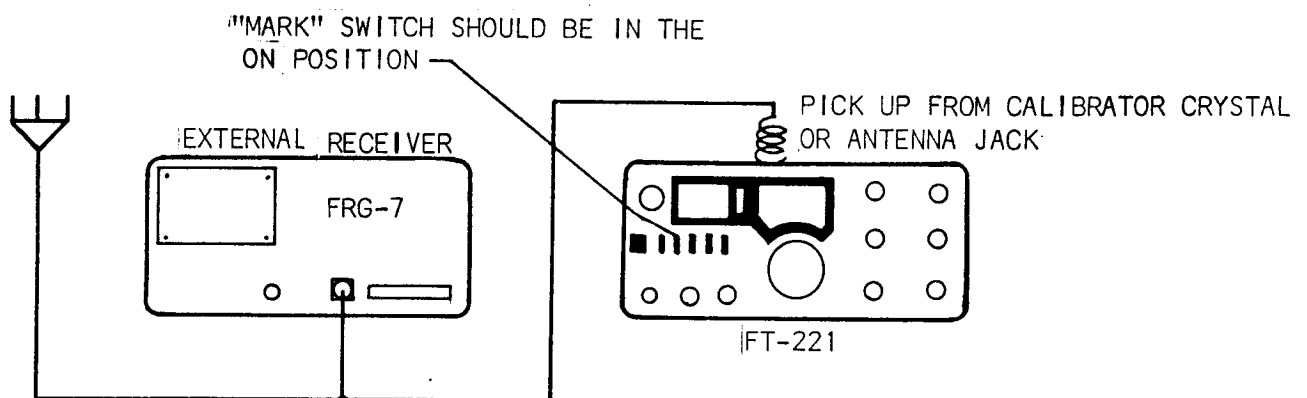
The curse of all this is that once set up for an odd split, you cannot easily go back to the normal 600 kHz split without changing crystals back, which means (usually) a re-alignment of TC-210 and VFO again.

The FT-221R answers this by providing a front panel switch that allows you to put in an odd ball split, yet still retain the normal 600 kHz split. So it solves the "cover lifting" problem nicely.

To set up a spot frequency, turn on the marker. Turn the main tuning drum to the nearest 100 kHz marker, and zero beat it. Then set "0" on the inner dial, and press the CALIB button down, to clamp the plastic dial. This will "stop" it's motion, and allow you to align exact zero beat with the zero on the dial. When you have set it precisely, release the button, turn the marker off. You can then dial in the desired frequency.

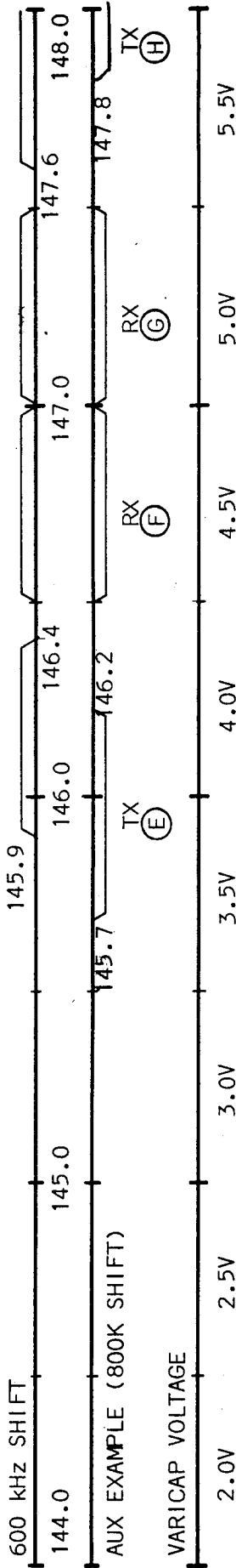
MARKER CALIBRATION

Set up an external receiver so WWV is heard on 10 MHz. With the FT-221 turned on, and the "mark" switch in the up position, pick up the radiated signal from the marker, using a length of insulated wire. Wait until WWV is transmitting carrier without the tone, and adjust TC-701 until the signals are zero beat. The clarifier must be "off" during this adjustment.

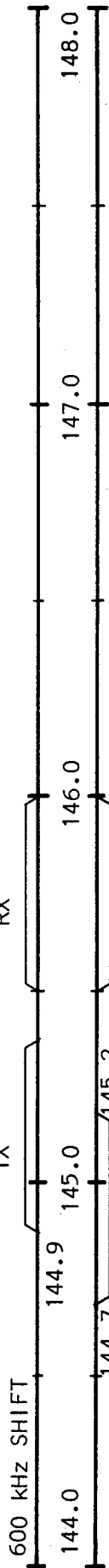


FT-221 (NORMAL/REVERSE SWITCH SET TO NORMAL. IN REVERSE POSITION TX-RX WILL BE REVERSED)

U.S.A. REPEATER



EUROPEAN REPEATER



NOTE: EUROPEAN REPEATERS USE 144.0 - 146.0 MHz HOWEVER, THE MODEL FT-221 IS WIRED FOR (E)(F)(G)(H)

PB-1454

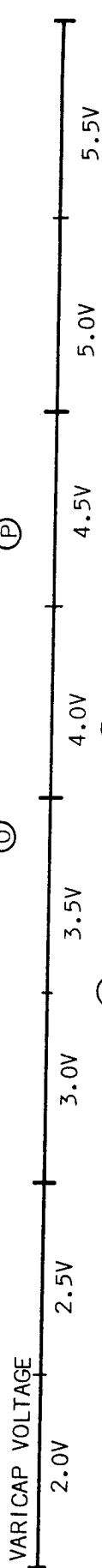
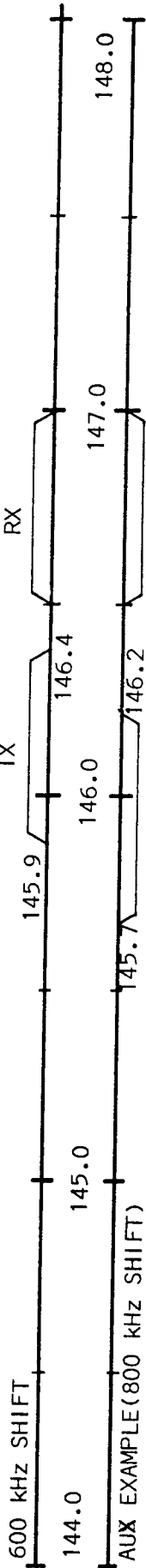
RX BAND	TX BAND	LOC. XTAL	LOCAL OSC	PC BOARD SKT PIN#	BAND SW. S2A	BAND SW. S2B	VARICAP VOLTAGE	MARKER BD SKT PIN#	BAND SW. S2C	BAND SW. S2D
(A) 146.5	146.0	X 210	14.1333 MHz	29	6	6	4.0V	7	6	
(B) 147.0	147.5	X 211	14.3222 MHz	32	7	7	5.5V	10	7	
(E) 146.5	146.0	X 209	(14.1111 MHz)	30	6	6	3.5V	6	6	AUX(800KHZ)
(H) 147.0	147.5	X 212	(14.3444 MHz)	31	7	7	5.5V	10	7	AUX(800KHZ)
(I) 145.5	145.0	X 210	14.0222 MHz	29	4	4	3.0V	5	4	
(K) 145.5	145.0	X 209	(14.0000 MHz)	30	4	4	2.5V	4	4	AUX(800KHZ)

PB-1459

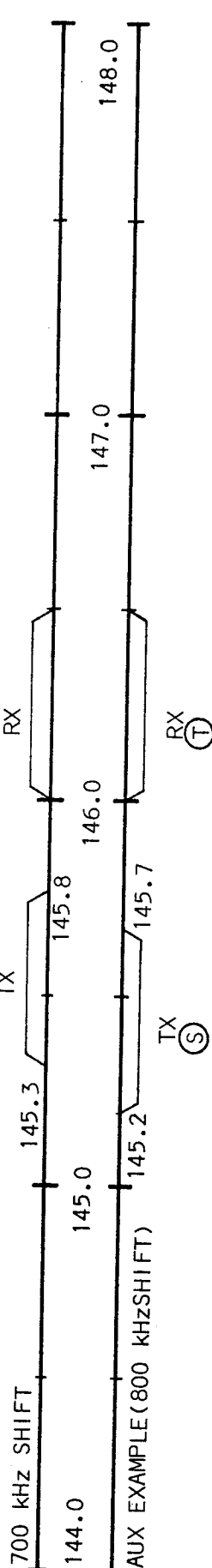
RX BAND	TX BAND	LOC. XTAL	LOCAL OSC	PC BOARD SKT PIN#	BAND SW. S2A	BAND SW. S2B	VARICAP VOLTAGE	MARKER BD SKT PIN#	BAND SW. S2C	BAND SW. S2D
(A) 146.5	146.0	X 210	14.1333 MHz	29	6	6	4.0V	7	6	
(B) 147.0	147.5	X 211	14.3222 MHz	32	7	7	5.5V	10	7	
(E) 146.5	146.0	X 209	(14.1111 MHz)	30	6	6	3.5V	6	6	AUX(800KHZ)
(H) 147.0	147.5	X 212	(14.3444 MHz)	31	7	7	5.5V	10	7	AUX(800KHZ)
(I) 145.5	145.0	X 210	14.0222 MHz	29	4	4	3.0V	5	4	
(K) 145.5	145.0	X 209	(14.0000 MHz)	30	4	4	2.5V	4	4	AUX(800KHZ)

WHEN THE UNITS ARE WIRED FOR AUX, THE VARICAP CAN SHIFT 800 KHZ - 1200 KHZ.

AUSTRALIAN REPEATER



NEW ZEALAND REPEATER



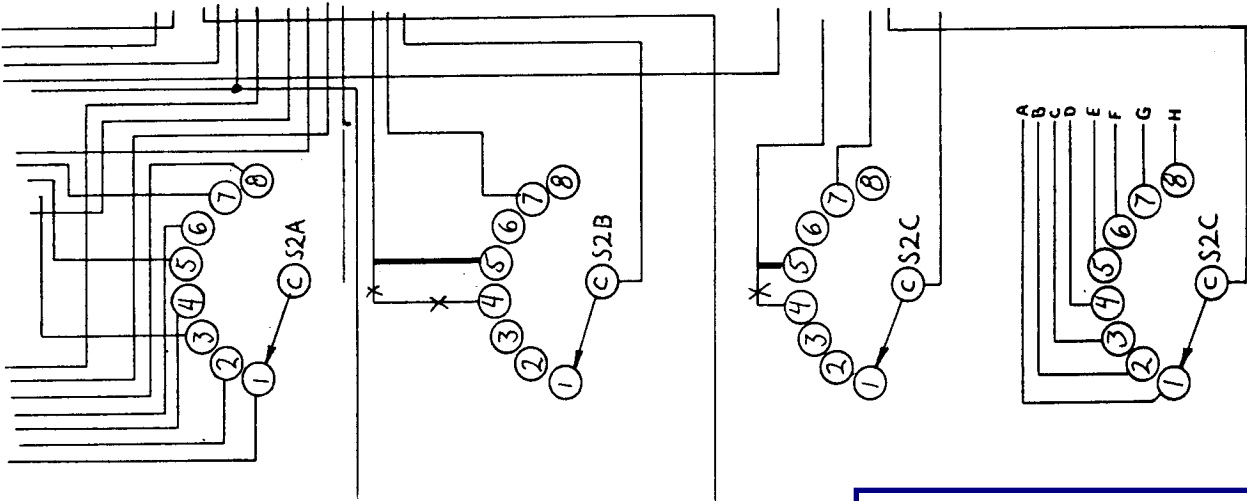
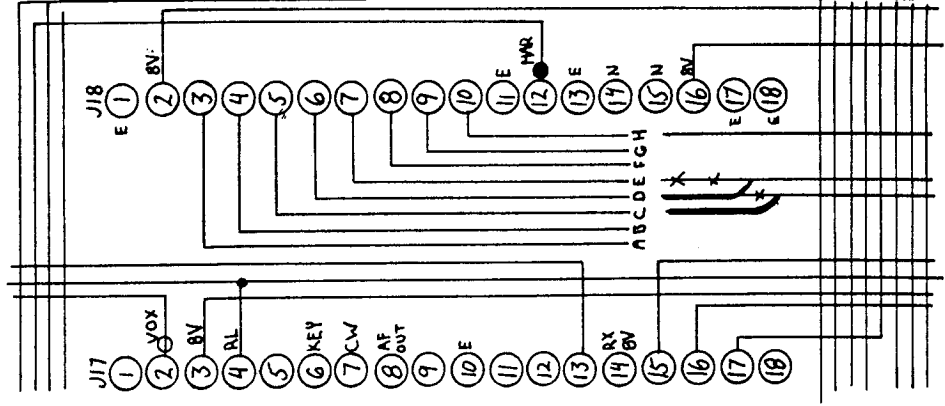
RX BAND	TX BAND	LOCAL XTAL	LOCAL XTAL FREQUENCY	PB-1454 LOC. BD. SKT PIN#	BAND SW. S2A	BAND SW. S2B	VARICAP VOLTAGE	PB-1459 MARKER BD SKT PIN#	BAND SW. S2C	BAND SW. S2D
146.5	146.0	X 210	14.1333 MHz	29		6	4.0V	7	6	USA (A) (B)
146.5	146.0	X 209	(14.1111 MHz)	30		6	3.5V	6	6	USA (E) (F)
146.0	145.5	X 210	14.0666 MHz	29		△ 5	3.5V	△ 6	△ 5	
146.0	145.5	X-209	(14.0555 MHz)	30		△ 5	3.0V	△ 5	△ 5	

(M) (O) (Q) (S)

NOTE: △ NEED TO BE REWIRED FOR NEW ZEALAND USE

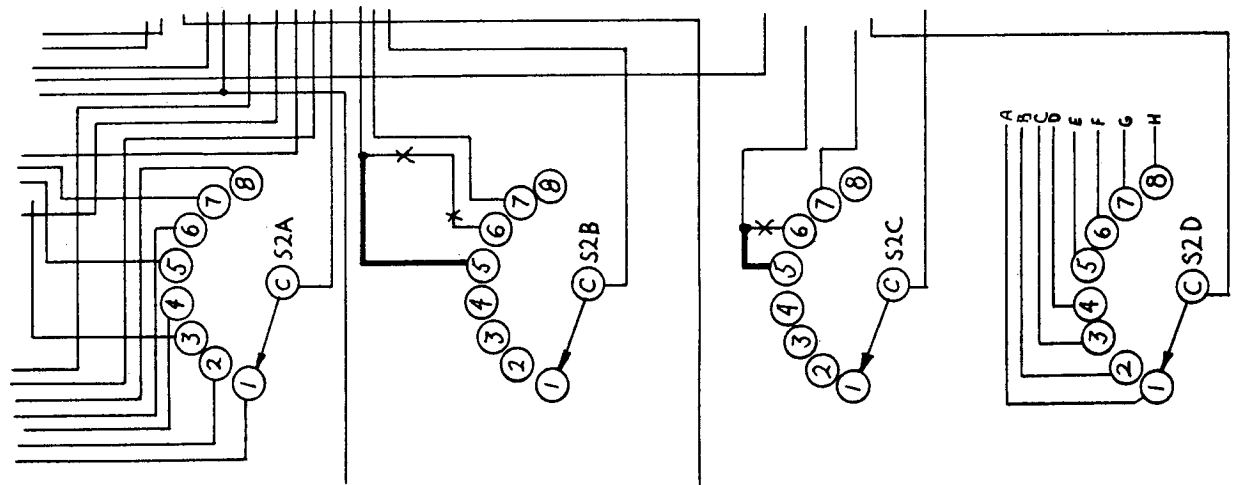
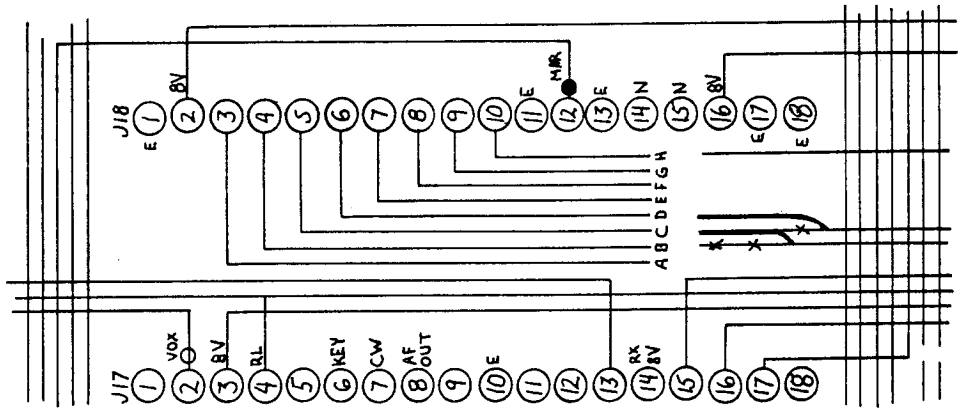
NOTE: THE FREQUENCIES SHOWN IN BRACKETS ARE GIVEN AS AN EXAMPLE OF AN 800 KHZ SHIFT. FOR OTHER SHIFTS, SEE THE TEXT, OR USERS MANUAL.

MODIFICATION-FROM EUROPE
TO NEW ZELAND

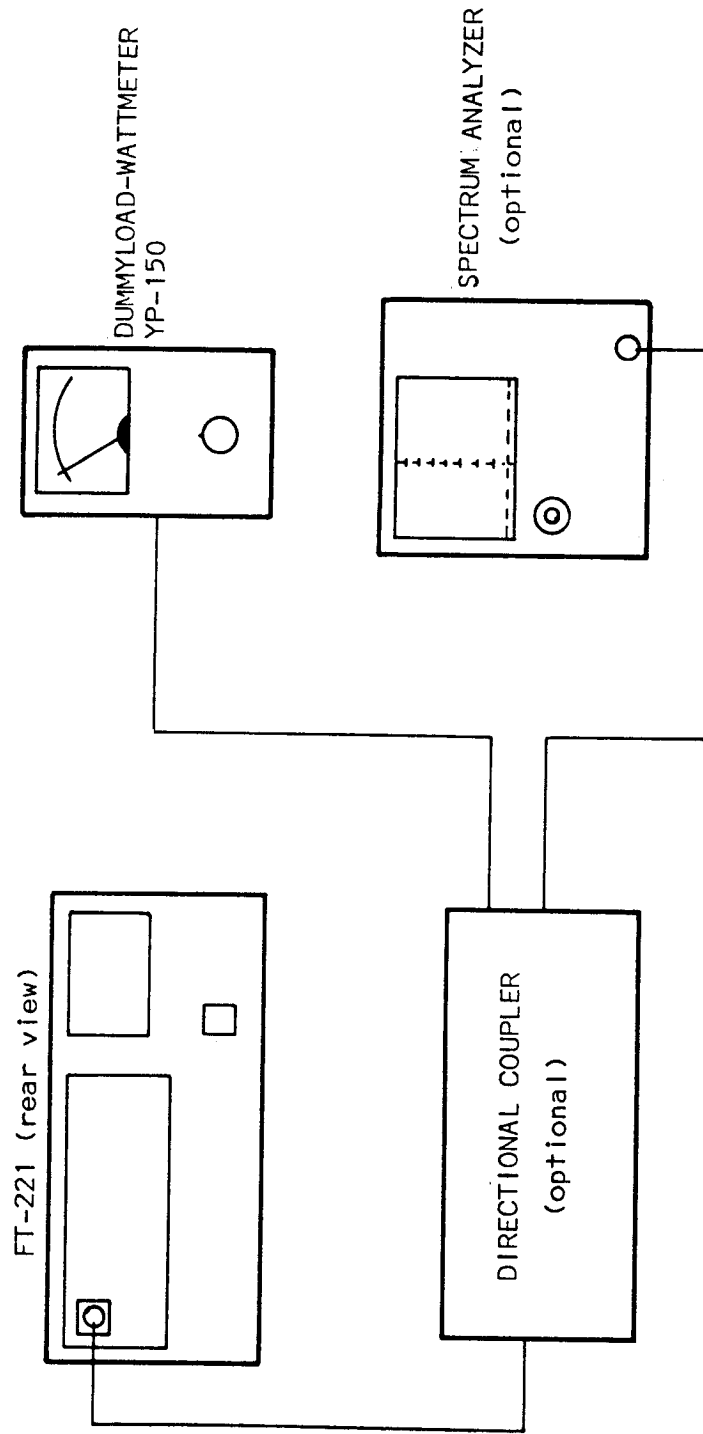


Downloaded by RadioAmateur.EU

MODIFICATION-FROM U.S.A.
TO NEW ZELAND



TEST SET-UP FOR FT-221

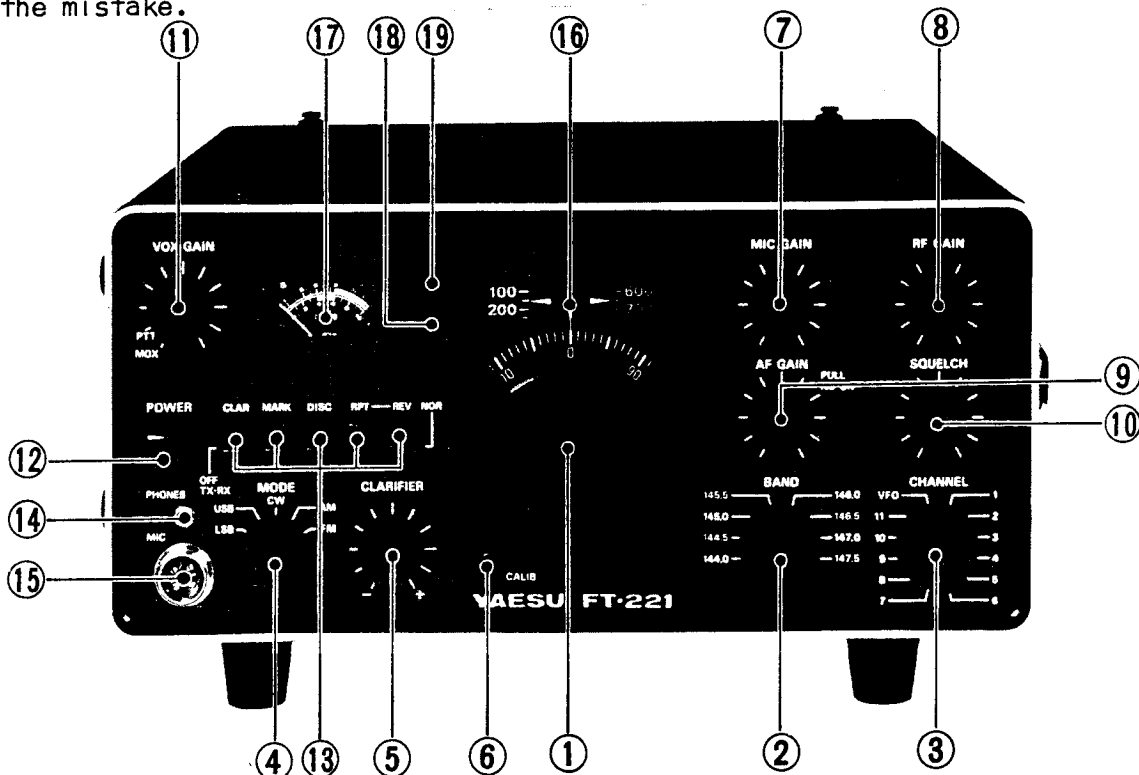


*The FT-221 can be connected directly to the YP-150 without using the Directional Coupler or the Spectrum Analyzer.

CONTROLS AND SWITCHES

The transceiver has been specifically designed for flexible operation and versatility. All internal controls have been preset at the factory. Several of the controls are unusual in operation, and improper adjustment may result in poor quality signals. The various front panel controls and their functions are described in the following section. Be certain that you thoroughly understand the function of each control before operating the transceiver.

Remember, if you set up an out of band or "forbidden" condition (repeating on 144.0 mHz) the rig will blink at you, and remain inoperative until you correct the mistake.



(1) MAIN TUNING Control

The tuning knob, located below the dial window, determines the actual frequency of operation in combination with the BAND switch. A dual rate, concentric dial drive system is employed for a fast and slow setting of the operating frequency.

(2) BAND Switch

The BAND switch is an eight position switch that selects one of the 500 kHz segments in the two meter amateur band. These segments are:

144.0 - 144.0 to 144.5 mHz	146.0 - 146.0 to 146.5 mHz
144.5 - 144.5 to 145.0 mHz	146.5 - 146.5 to 147.0 mHz
145.0 - 145.0 to 145.5 mHz	147.0 - 147.0 to 147.5 mHz
145.5 - 145.5 to 146.0 mHz	147.5 - 147.5 to 148.0 mHz

(3) CHANNEL Switch

The CHANNEL switch selects one of 11 crystals for crystal controlled operation. This switch also selects the VFO for continuous tuning with the main tuning knob. When this switch is set to an inactive crystal position, the lights will flash to warn you.

(4) MODE Switch

The MODE switch is a five position switch. This switch selects the mode of operation: LSB (lower side band), USB (upper side band), CW (code operation), AM (amplitude modulation) and FM (frequency modulation).

(5) CLARIFIER Control

The CLARIFIER control provides a means of offsetting the receiver frequency approximately 4 kHz to either side of the transmitting frequency. Thus it is possible to set the pitch of the voice or signal you are receiving to the most readable point without affecting your transmitting frequency. Its use is particularly valuable in "net" operation when several participants may be transmitting slightly off frequency. The CLARIFIER control may be switched off with CLARIFIER switch and the receiver locked to the transmitting frequency. Normally you will want to keep the CLARIFIER in the OFF position until the initial contact is made. The CLARIFIER switch may also be used to change both transmitting and receiving frequencies simultaneously when the CLARIFIER switch is put in the Tx-Rx position.

(6) CALIB.

When depressed, this button stops the 1 kHz dial for calibration of the dial with the marker signal.

(7) MIC GAIN Control

The MIC GAIN control varies the audio level from the microphone amplifier stages. The control has sufficient range to permit the use of any 600 ohm dynamic microphone. Higher impedance microphones will work, with proper compensation, and sometimes improved voice quality.

(8) RF GAIN Control

The RF GAIN control varies the gain of the receiver RF and IF amplifiers. Maximum sensitivity is obtained when the control is set to the fully clockwise position. Best sensitivity/selectivity is achieved by adjusting the RF GAIN when the band is crowded.

(9) AF GAIN Control & Switch

The AF GAIN control adjusts the audio output level to the speaker and phone jack. Clockwise rotation increases the audio output. When the knob is pulled out, the noise blanker is activated in order to minimize pulse type noises.

(10) SQUELCH Control

This control adjusts the receiver squelch threshold level, when in the FM mode.

(11) VOX GAIN Control and Switch

This controls the VOX gain and functions for push to talk, stand-by or manual operation.

CAUTION

THE SNAP SWITCH FELT AND HEARD AT THE EXTREME CCW POSITION IS THE MOX POSITION - MOX TURNS THE TRANSMITTER "ON". MORE THAN ONE HAM HAS SNAPPED THE CARRIER ON AND WALKED AWAY, CONFIDENT THAT HE HAD JUST TURNED THE POWER OFF.

(12) POWER Switch

The POWER switch turns transceiver "ON" and "OFF" for both AC and DC operation.

(13) FUNCTION Switches

CLAR: Clarifier switch. Activates the Rx CLARIFIER control in the upper position, and off in middle position. In the Tx-Rx position, the CLARIFIER control works for both transmit and receive.

MARK: When this switch is raised, the 100 kHz oscillator will be activated, producing a beat note every 100 kHz across the dial. Used with (6) CALIB. button. NOTE: Rx is disabled when MARK is activated.

DISC: This switch sets the meter to read the discriminator center point for FM reception.

RPT: This switch is used for repeater operation. In the NOR (normal) position, the transmitter frequency shifts 600 kHz down and in the REV (reverse) position, the receiver frequency shifts 600 kHz up.

(14) PHONE Jack

This jack is for use of external headphones or an external speaker. The internal speaker is disconnected when the headphone plug is inserted. RTTY converters and recorders can also be plugged into this jack if impedance matching considerations are observed.

(15) MIC Jack

The microphone supplied is the recommended one for use with the transceiver, however any microphone having a minimum 500 to 600 ohm impedance may be used.

(16) DIAL

Dial window for frequency readout. The coarse scale indicates 100 kHz increments and fine scale dial indicates 1 kHz increments.

(17) METER

The meter indicates signal strength, FM discriminator center current (in receive) and relative power output in transmit.

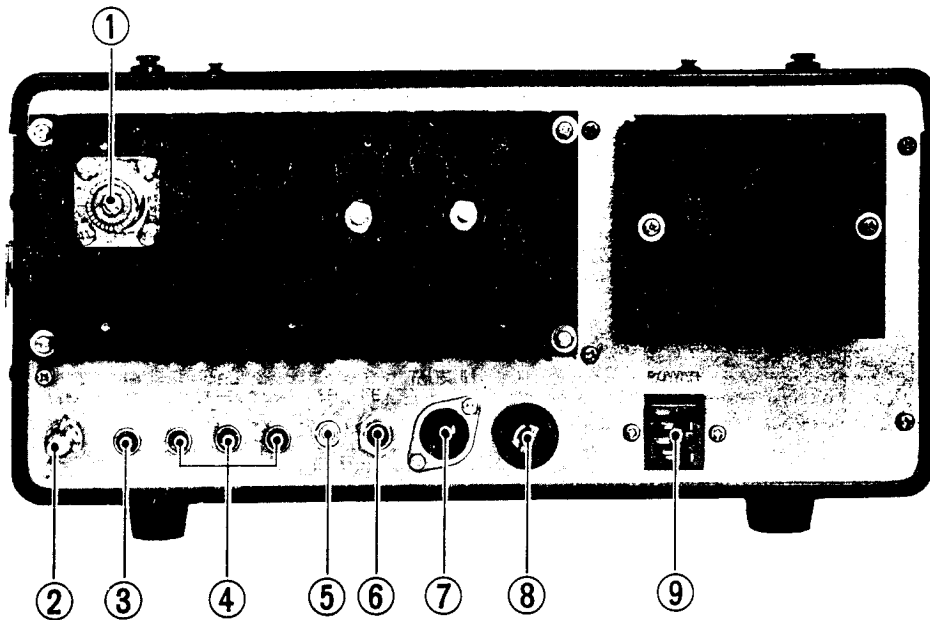
(18) CLAR Lamp

This lamp lights when the CLARIFIER is in use, to warn you that your dial is not necessarily accurate during CLARIFIER use.

(19) RPT Lamp

This lamp lights when the repeater switch is ON. The RPT function can only be activated in the FM mode.

REAR PANEL CONNECTIONS



(1) ANT

Coaxial connector for an antenna.

(2) GND

Ground connection. Always ground your equipment for safety.

(3) ALC

ALC (automatic level control) input. Used with external linears to avoid distortion and overdriving.

(4) RL

Relay contacts for the control of external equipment, such as a linear or RTTY setup.

(5) SP Jack

External speaker audio output. If you don't want to use the headphone jack, here's another audio output.

(6) KEY Jack

Key jack for code operation. Must be an actual key with less than 6Ω total resistance. Some keyers will work O.K., others will not. Check with the keyer manufacturer.

(7) TONE-IN

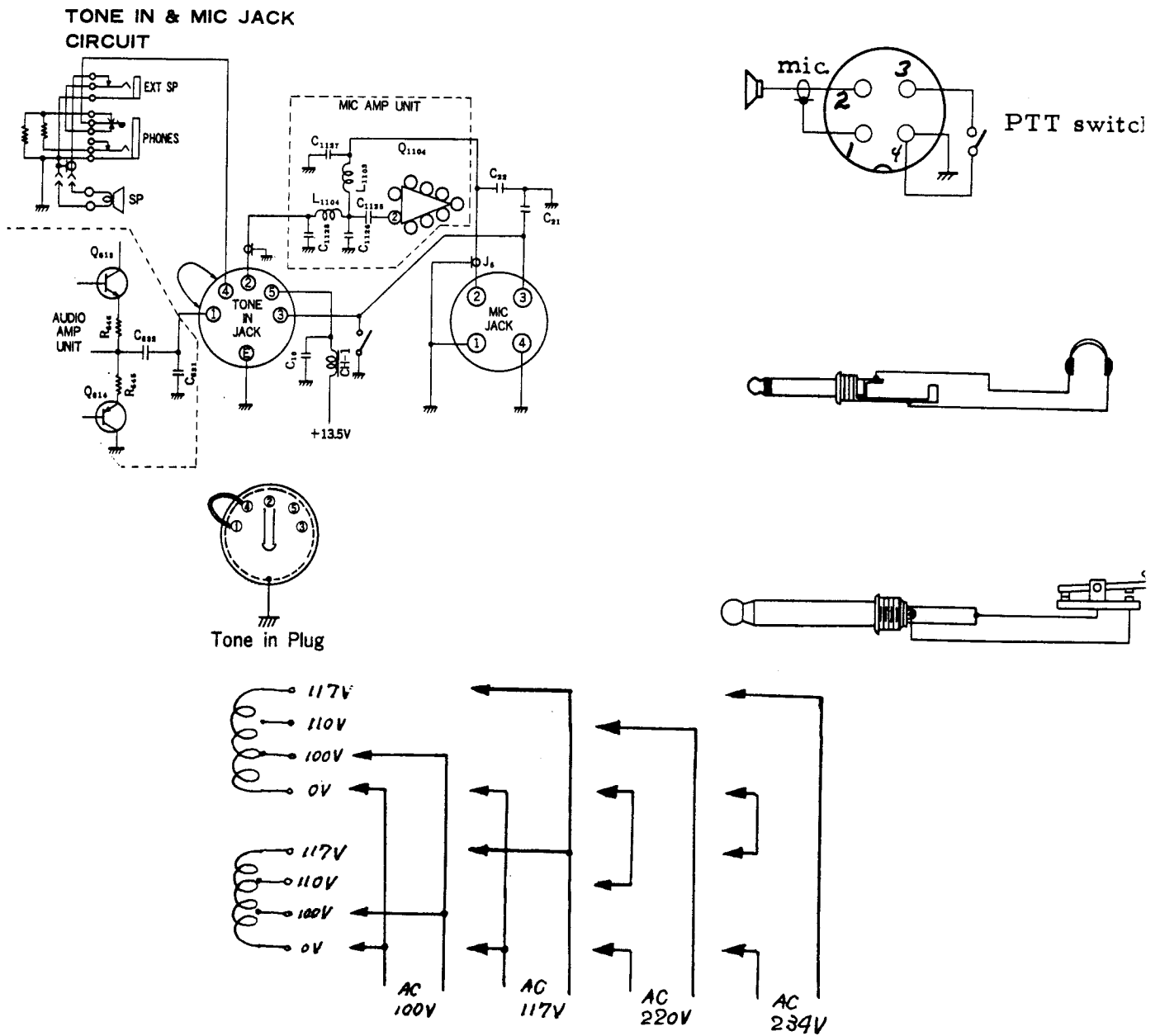
Tone pad Input jack. Typical touch tone input.

(8) FUSE

Fuse holder. For AC operation, a 2 amp fuse is used on 100/117 volts and, a 1 amp fuse on 200/234 volts.

(9) POWER Receptacle

Both AC and DC cables are supplied with the transceiver.



Transformer Primary Wiring

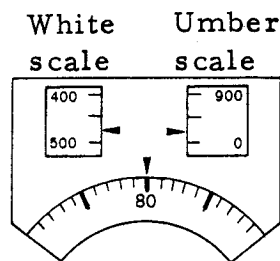
OPERATION

CAUTION

PERMANENT DAMAGE WILL RESULT IF IMPROPER SUPPLY VOLTAGE IS APPLIED TO THE TRANSCEIVER. WARRANTY DOES NOT COVER THE DAMAGE CAUSED BY IMPROPER SUPPLY VOLTAGE.

DIAL READOUT

The main tuning drum is color-coded with the band selector switch for proper frequency readout. When the band selected is marked in white on the transceiver front panel, the operator reads the white scale on the main tuning drum. When the band selected is marked in umber the operator reads the umber scale. The main tuning drum is marked in 50 kHz increments. This provides a coarse frequency setting within the band. The round subdial on the dial window surrounding the tuning knob is scaled in 1 kHz increments and provides fine settings of the transceiver operating frequency. The following example will familiarize you with the relationship of the main and subdial frequency readouts.



Read the white scale on main dial for the bands 144.0, 145.0, 146.0 and 147.0, and umber scale for 144.5, 145.5, 146.5 and 147.5.

Then the setting shown in the example would be 144.480 MHz on 144.0 BAND switch setting, and 145.480 MHz on 145.0. And also, the frequency would be 144.980 MHz on 144.5 BAND switch setting, and 145.980 MHz on 145.5.

INITIAL CHECK SETTINGS

After the transceiver is properly set up for operation, set the controls and switches as follows:

POWER	Down to "OFF" position
MODE	Desired mode
BAND	Desired band
CALR	Lever position horizontal to OFF position
MARK	Lever position horizontal to OFF position
DISC	Lever position horizontal to OFF position
RPT	Lever position horizontal to OFF position
NOR-REV	"NOR" position
MAIN TUNING DIAL	Desired operating frequency
VOX GAIN	PTT
AF GAIN	Desired audio level
RF GAIN	Fully clockwise position
CHANNEL	VFO
SQUELCH	Fully counter-clockwise position

Connect the cord supplied to the appropriate power source, and an antenna to antenna connector on the rear panel.

Turn on the POWER switch. The dial and meter lamps should light up, and the transceiver is now ready to operate. If the dial lamps blink, turn to Section 4.

(1) SSB and AM Modes

Using the main tuning control (VFO), tune in an incoming signal. USB (upper side band) is mostly used for 2 meter SSB operation. When the received signal can not be heard clearly, then change to the opposite side band. The RF GAIN control is normally set to the fully clockwise position, but if the incoming signal is extremely strong, it will be necessary to turn this control back, to prevent overload of the front end. When there is noise caused by automobiles, pull the AF GAIN control out to switch in the NB (noise blanker) in order to eliminate these pulse type noises.

(2) CW Mode

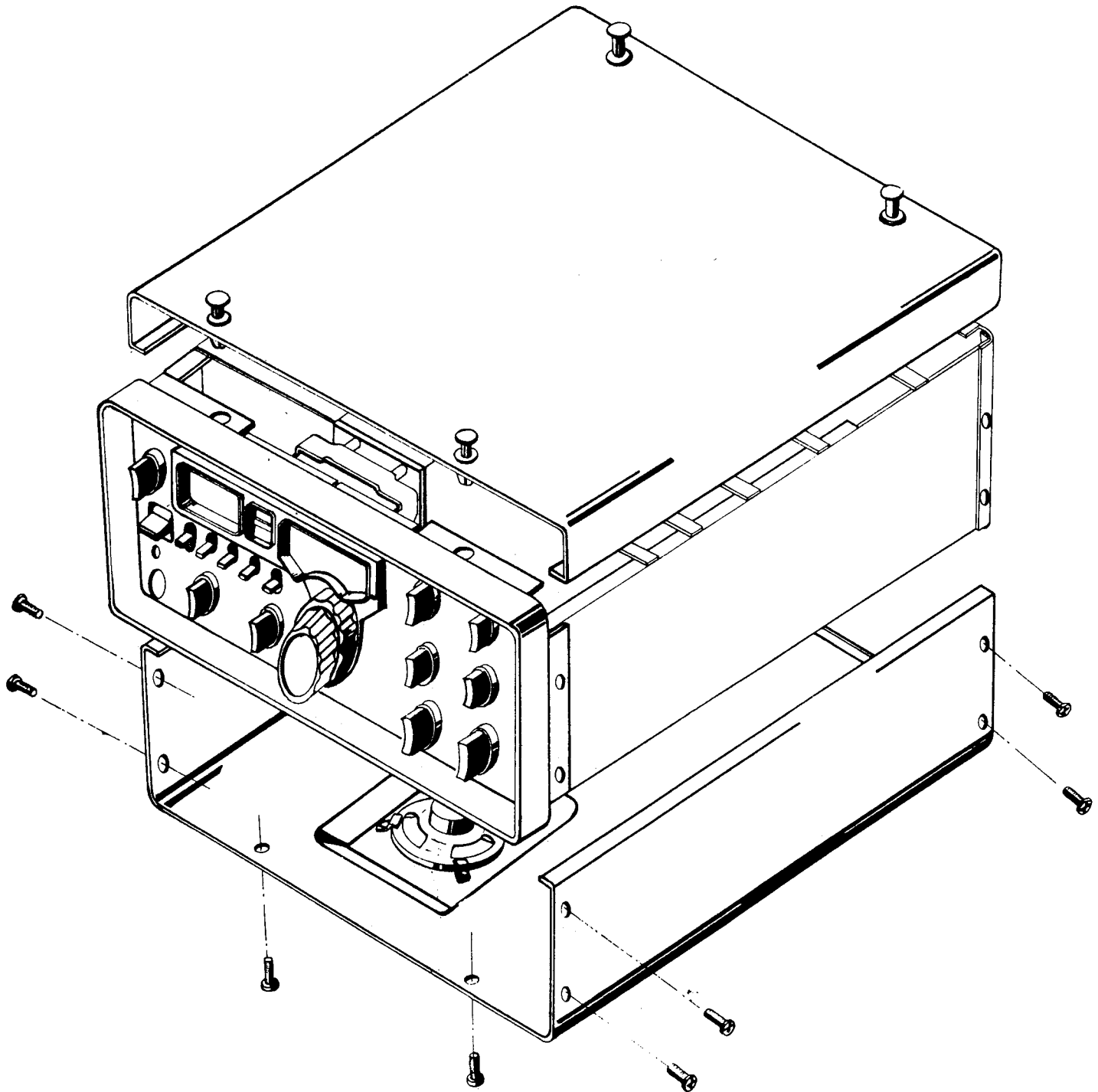
With the CLARIFIER switch in the OFF position, tune in a signal until an 800 Hz beat tone is heard. Under this condition, your transmitting frequency coincides with the received signal. If you desire to hear a beat tone of your choice, then use the CLARIFIER control in the Rx position (up).

(3) FM Mode

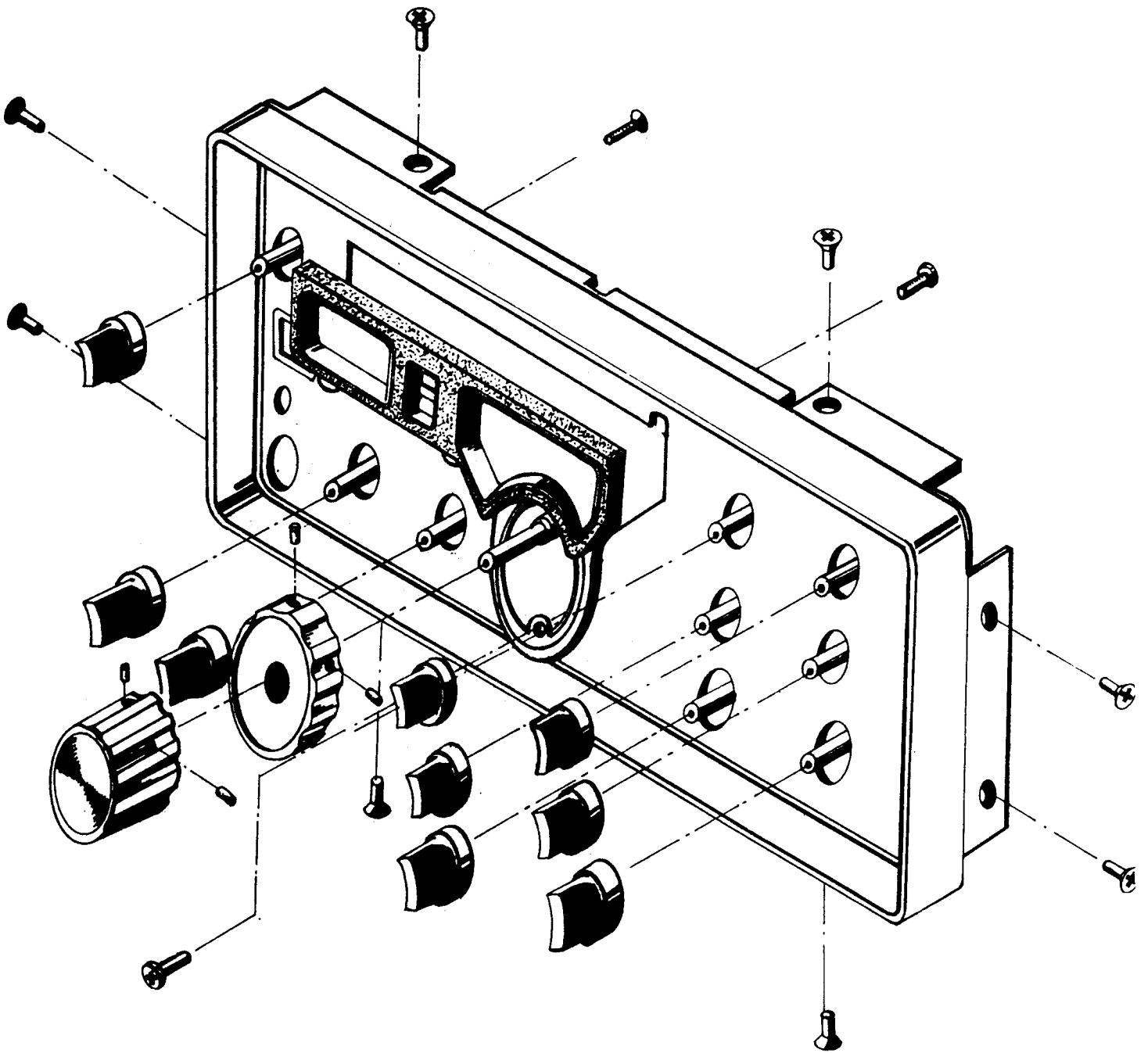
Using the main tuning control, tune in an incoming signal for a maximum and steady S-Meter reading where a natural voice is heard. For accurate tuning, set the DISC switch to the upper ON position. Carefully readjust the tuning control until the meter indicates zero (center of the green).

If the S-Meter indication wobbles or if a clean audio output is not available, it is very likely that the signal is in the SSB mode. In this case, turn the MODE switch to USB or LSB position, and carefully tune the tuning control until a clear voice is heard. It is important that the CLARIFIER switch be set to the OFF position when calling another station. After the initial contact is made, then the CLARIFIER may be used for the desired voice quality.

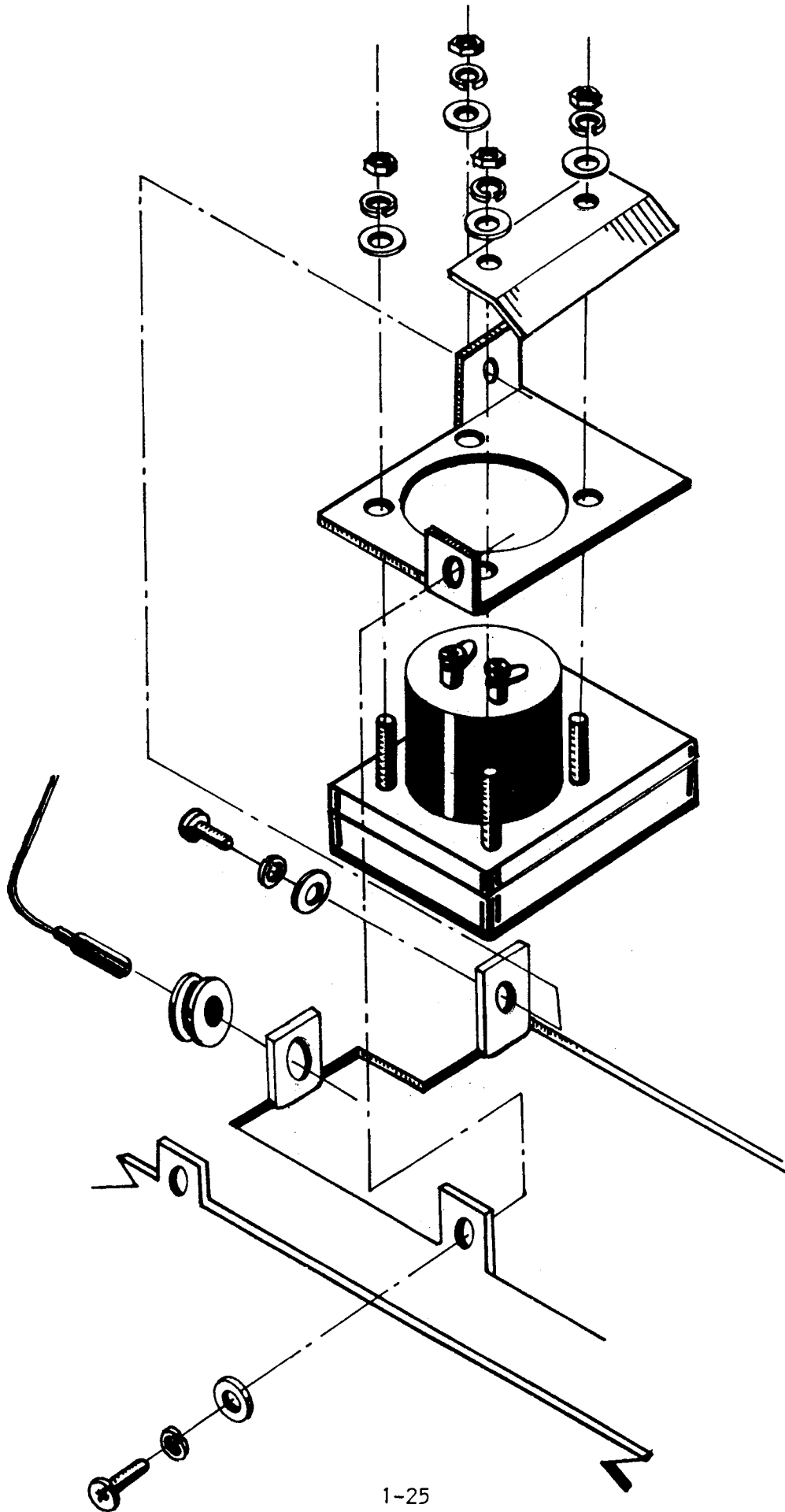
CABINET ASSEMBLY



FRONT PANEL ASSEMBLY

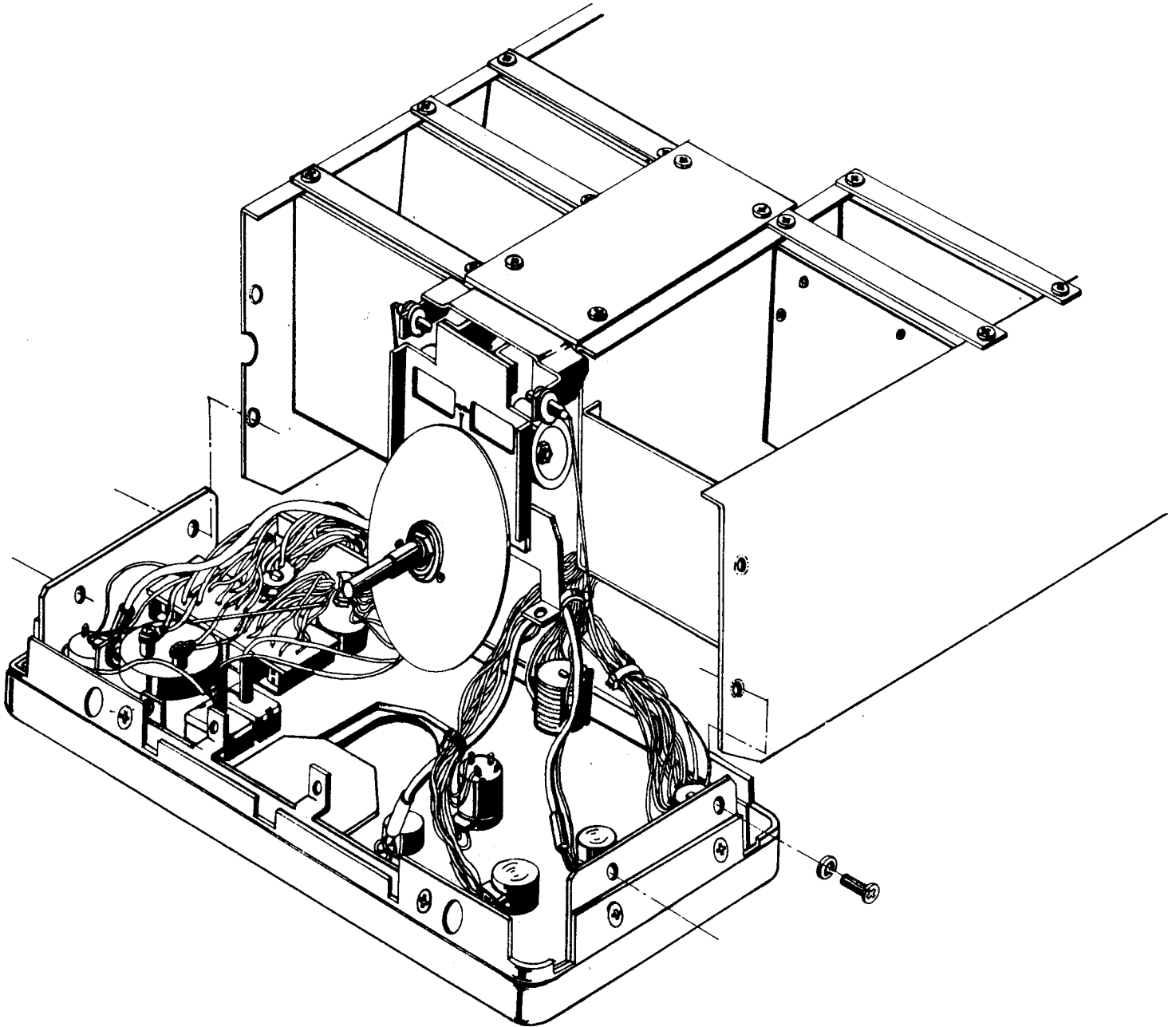


S-METER ASSEMBLY

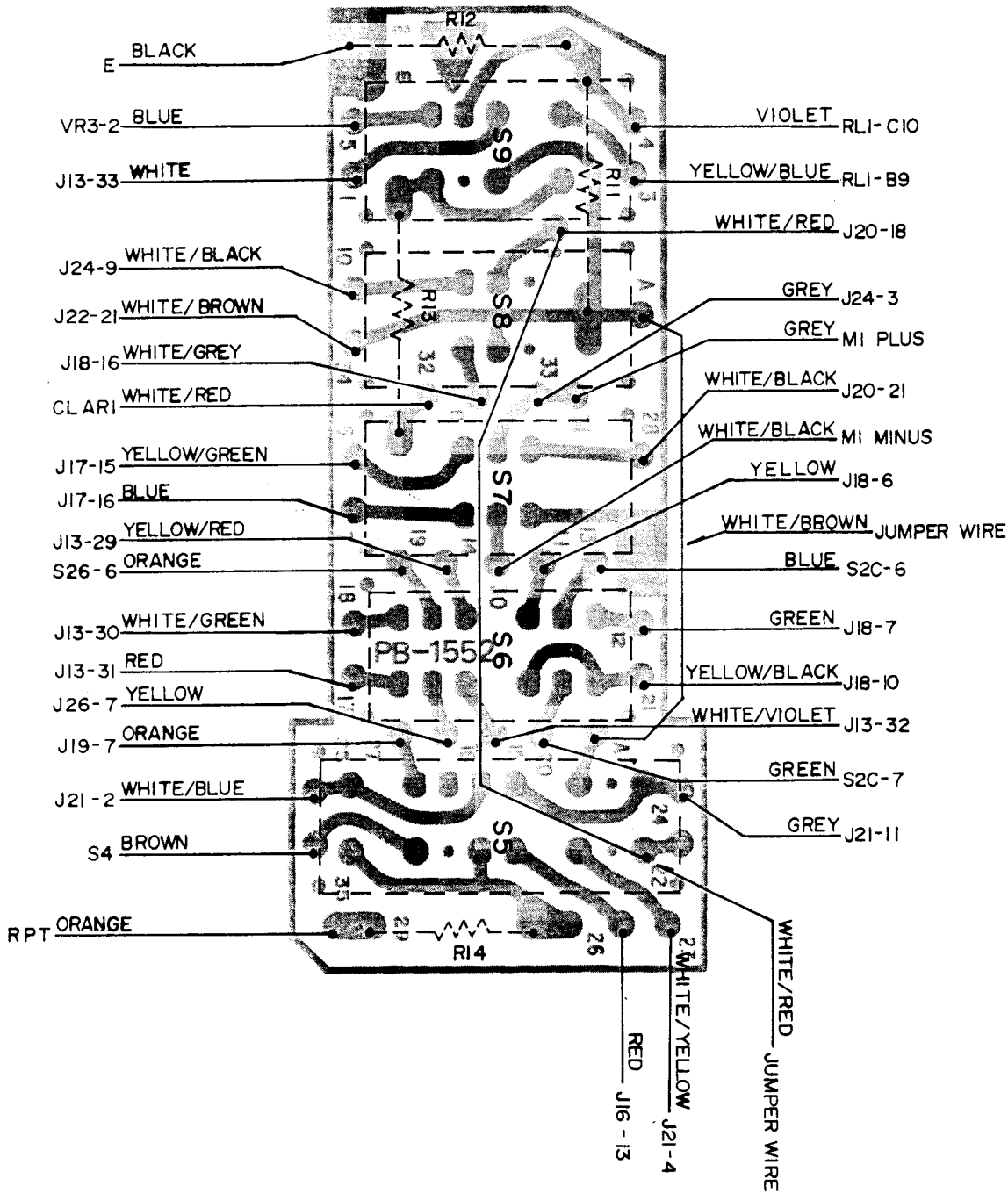


FRONT PANEL REMOVAL

WITH WIRING INTACT

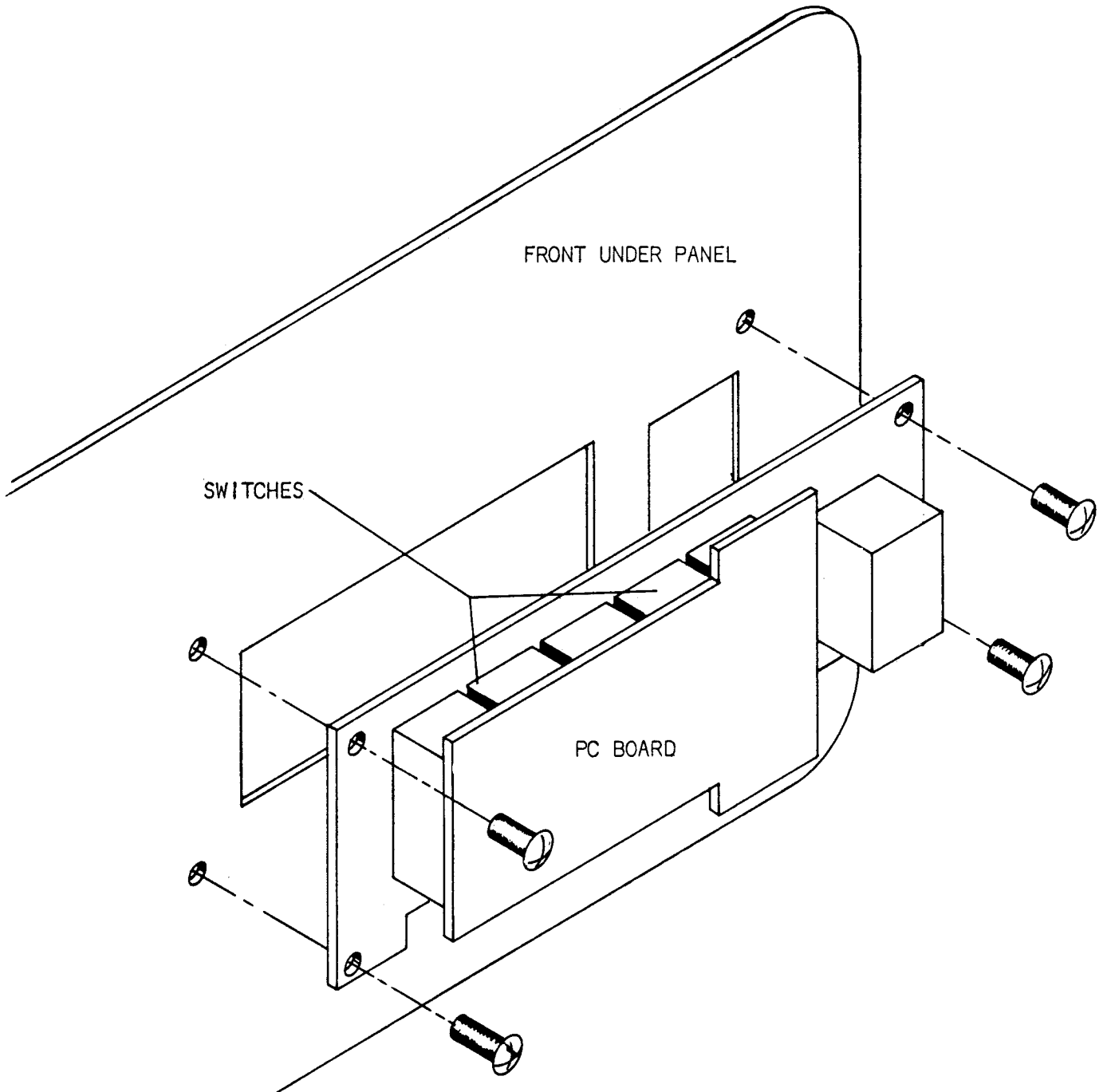


Viewed from Solder Side

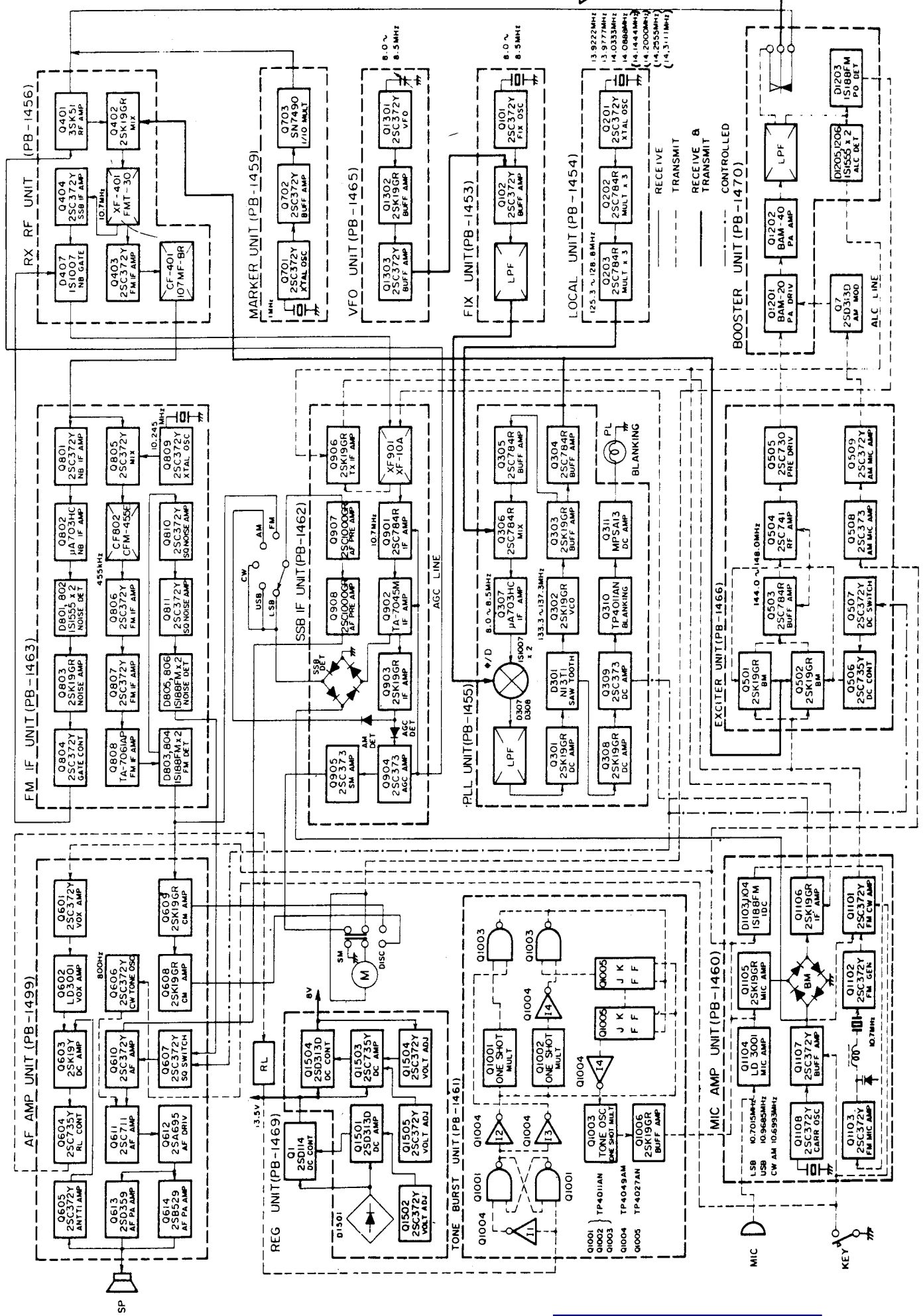


PB-1552
SWITCH DECK

SWITCH DECK MOUNTING



FT-221 BLOCK DIAGRAM



FAULT IDENTIFICATION AND LOCALIZATION

The process of troubleshooting any electronic equipment is highly individualistic, however, it is essentially a process of logical elimination.

Begin with a visual inspection for broken, discolored or charred components. Smell the unit. (Transformers smell differently than resistors, etc). Check for loose modules or tubes.

Set up the unit as shown on Page 1-14 and be sure to use a dummy load. Do not troubleshoot using an antenna.

Initially, turn on the receiver only, and check out the entire Rx side of the transceiver. Repair anything you detect as a malfunction in the receiver, before attempting to repair or key up the transmitter side.

Since much (most) of the circuitry is used for both Tx and Rx, you may clear a Tx fault at the same time you are repairing the Rx malfunction.

The technique to follow when trying to identify a fault is to first localize it to a function (Rx inoperative on LSB) then to a board, a circuit, (LSB oscillator) then a component (2SC372Y). If you get lost, back up and begin again, using the data given in this manual to help you.

Naturally, if the Rx is normal, move to the Tx side and troubleshoot it the same way (function - board - circuit - component). Doing the Rx first, eliminates fully 80% of the problem, so you can concentrate on the 20% unique to the Tx side.

Once you have localized the problem to a board, using the block diagrams, find the appropriate drawing of it in Section 4. Using an extender board (available from Yaesu) check for correct DC voltages at the edge connector. If they are correct, but the board still is inoperative, use an RF probe on your VTVM and check the gains, as shown in each drawing.

Somewhere along the line you will discover an abnormal condition, and be able to trace it to a component. Locate the part, using the part location drawing, and remove/replace it, using care not to create lifted pads or solder bridges.

Re-install and test for operation. If you need to realign the board or stage, we have included the data you need, right in the same section.

SIGNAL TRACING THROUGH THE FT-221

Probably the most useful signal in the FT-221 series that most servicemen either overlook or fail to use to the maximum advantage, is the internal calibrator.

A quick look at the block diagram of the FT-221 will disclose that it is fed into the transceiver right at the antenna terminal, and in a normally operating FT-221 will read about "10 over S-9" on the meter when you are on 146.000 MHz. Knowing this little fact can usually separate antenna problems from receiver problems in one quick move.

Factory techs rarely have recourse to a signal generator since with a little practice it is possible to do almost a full alignment of the receiver section, using the calibrate signal and with a little more practice, you can learn to pinpoint a blown FET or other receiver problems in moments.

We have re-done the block diagram to show you where the signals can best be verified, but the easiest way to get a defunct FT-221 back into a customer's arms is to carry a set of substitute boards. Just plunk in a new board, and mail the dud into a Yaesu Service Center. This is also a fairly expensive way, but it is fast and efficient.

The second technique is to use a set of extender boards and using the block diagrams boil it down to a board, find out what voltage is missing/wrong, and replace the defective component. (Most owners and techs do this).

The third technique is to use this chapter and by finding where you lose the signal, identify the errant board, remove it, and find the defect by resistance checks. (Not many folks do this, because besides being slow and tedious, the success ratio is low).

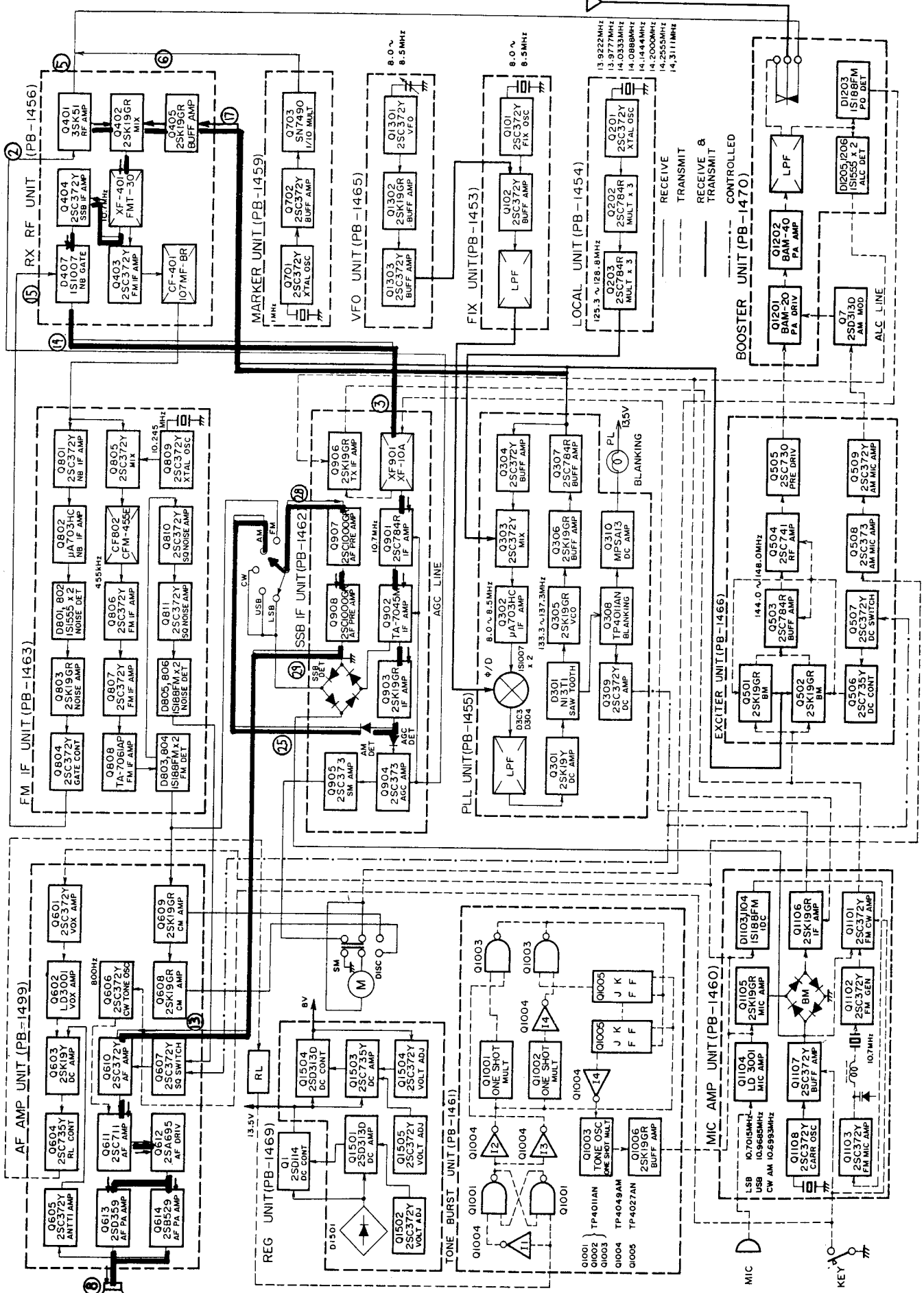
This manual will allow you to use all three methods or even a combination, if you wish, to avoid using the fourth method.

The fourth method is packing the unit carefully and sending it to a Yaesu Service Center. This is recommended only if your rig is in serious trouble, and you have really used this manual to the best of your ability.

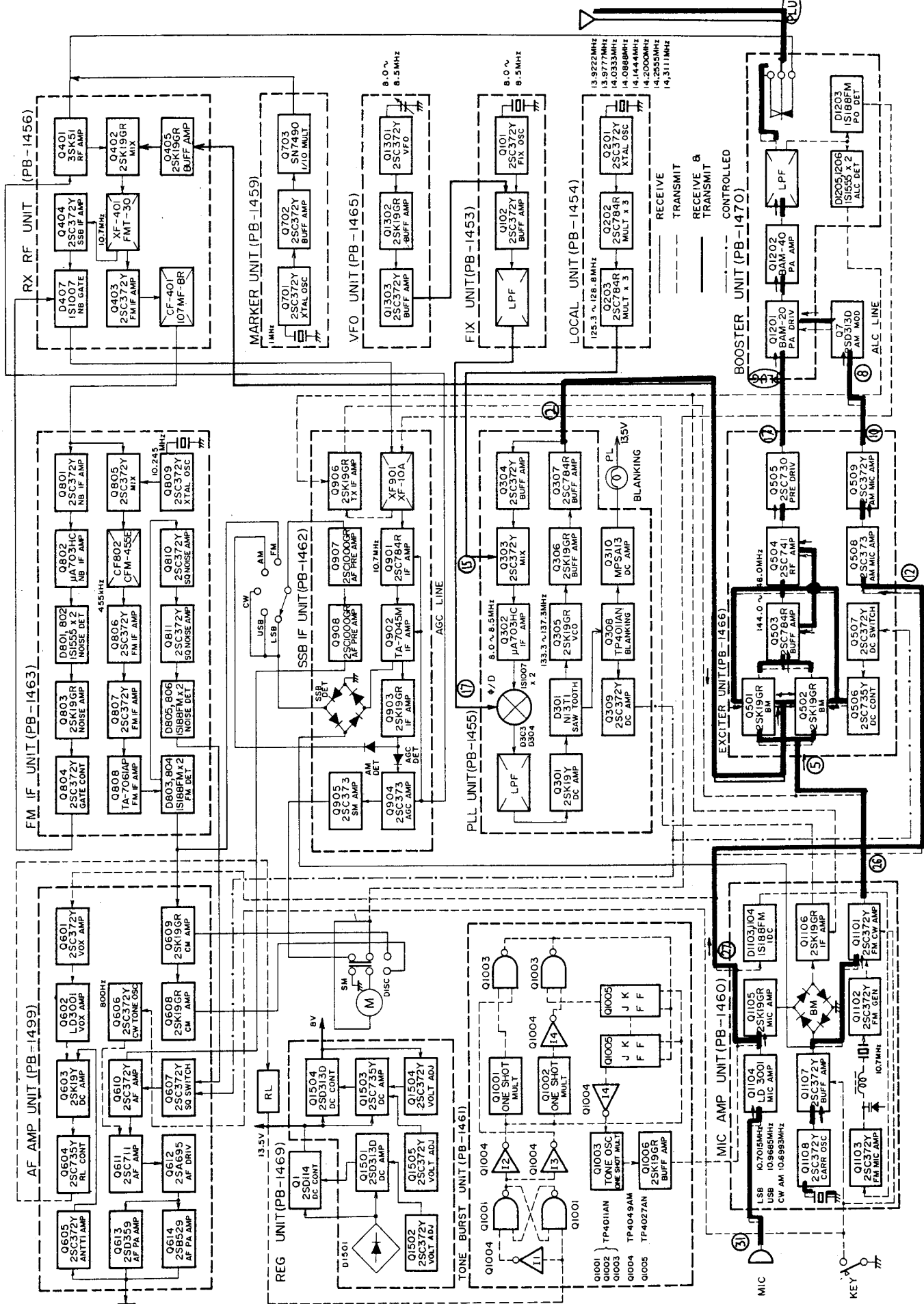
If you must ship it back, pack the unit well, using the original double boxes and styrofoam packing (if you have it yet) and insure it for full value.

Do not include cords, microphones, or manuals, but if you have some pet modifications installed, we will leave them in place if you tape a note to the side of the rig (not the box) to that effect.

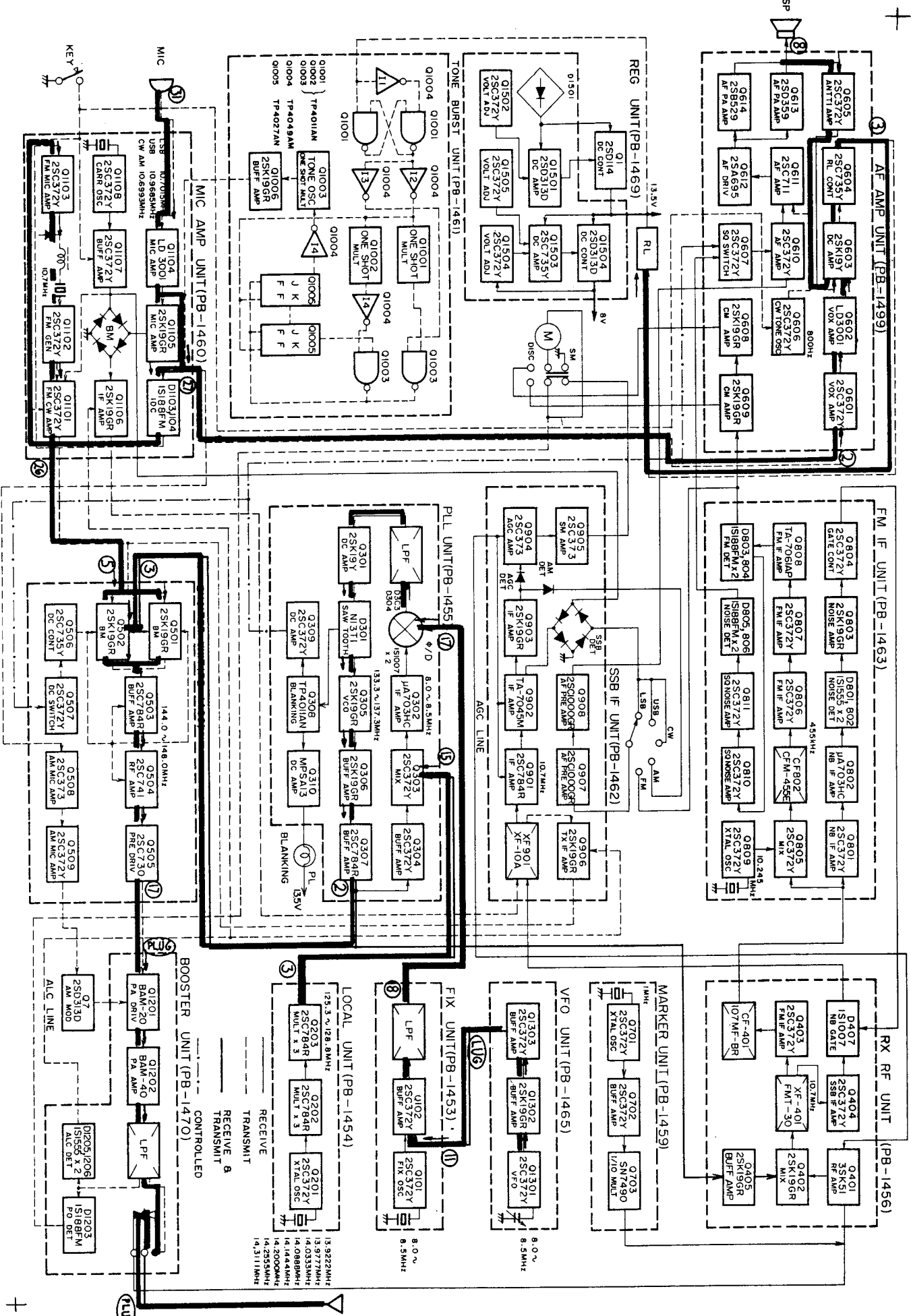
FT-221 AM MODE RX



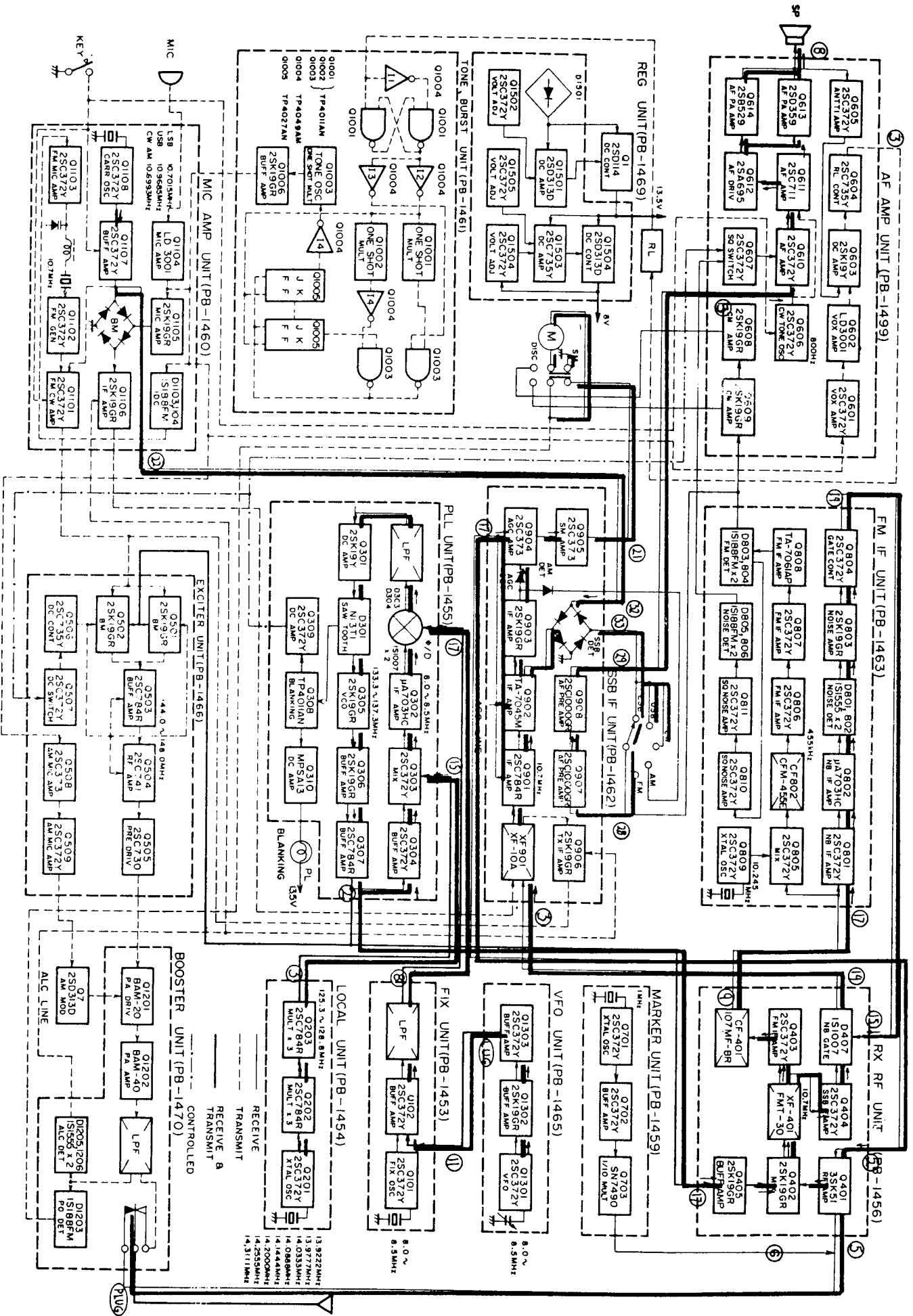
FT-221 AM MODE Tx



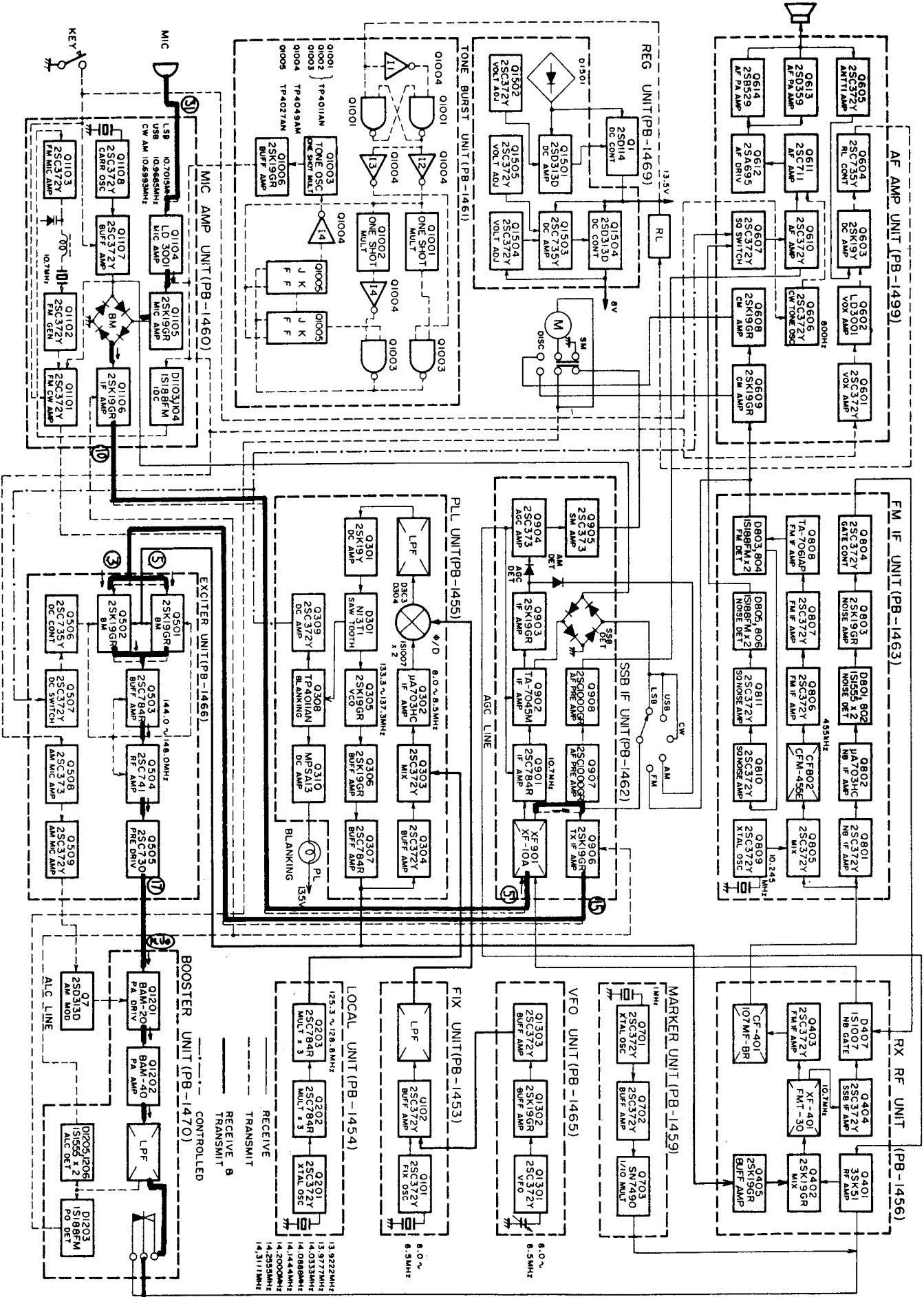
FT-221 FM MODE TX



FT-221 SSB MODE RX



FT-221 SSB MODE TX



FACTORY ALIGNMENT PROCEDURES

1. Regulator Board PB-1469
 - a. Check the voltage at brown wire of PB-1469. Adjust VR1 to 13.5 volts.
 - b. Check the voltage at white/brown wire. Adjust VR2 to 8.0 volts.

2. VFO Frequency Adjustment
 - a. Connect a frequency counter to J12-11. Set main tuning dial to "0" and CHANNEL to VFO. Set TC-1301 to the center. Adjust TC-1302 to 8000 mHz counter readout.

3. S-Meter Calibration
 - a. Set MODE switch to AM and RF GAIN control to a fully CCW position. Adjust VR902 on PB-1462 until S-meter indicates 10.
 - b. Set RF GAIN control to a fully CW position. Adjust VR903 on PB-1462 until S-meter indicates zero.
 - c. Repeat procedures (a) and (b) until tracking is completed.

4. PLL Circuit Adjustment
 - a. Set BAND switch to 144.0 and CHANNEL selector switch to 1. If a channel crystal is installed in CH1 socket, remove the crystal from the socket.
 - b. Rotate VR301 and set it to the point shown in Fig. 1.
 - c. Connect VTVM to the drain of Q301. Set the main tuning dial to a fully CCW position and CHANNEL selector switch to VFO position. Adjust TC-301 for 4.5VDC VTVM reading when the meter light is on (not flickering).
 - d. Check the PLL lock (meter light is on) at the lower edge and higher edge of the VFO dial and all band segments.
 - e. Set the RPT (repeater) switch to ON position and check the PLL lock at NOR and REV positions for 146.5 and 147.0 segments.

5. Carrier Balance and Frequency Set

- a. Set RF GAIN to fully CCW position, MODE to USB, BAND to 144.0 and CHANNEL to VFO.

Set TC1102, TC1103 and TC1104 on PB-1460 to center (half capacitance).

Adjust VR901 and TC901 (PB-1462) alternately with the MODE switch at USB and LSB positions until the S-meter indicates same value for AM, USB and LSB (refer to Fig. 2).

- b. Set the RF GAIN to a fully CW position (RF GAIN maximum). Adjust TC1102 and TC1103 (PB-1460) until received noise is heard in the same pitch when the MODE SWITCH is changed to the opposite sideband.
- c. Check that the meter indication does not move when the sideband is changed. If it moves, readjust TC1102 and TC1103. Refer to Fig. 3.

6. MARKER Calibration

- a. Set MARKER to ON and MODE to USB position.
- b. Apply standard signal (calibrated to WWV) to antenna terminal and adjust TC701 (PB-1459) for zero beat against the standard signal.

7. Local Oscillator Frequency Calibration

- a. Set MODE to USB, BAND to 144.0, CHANNEL to VFO and MARK to ON.
- b. Tune the VFO for zero beat at 144.0 MHz. If zero beat is not obtained, adjust TC201.
- c. Change the BAND to 144.5 and adjust TC202 for zero beat.
- d. Repeat this procedure for all BAND switch settings - - - 144.5 . . . TC203, 145.0 . . . TC204 .

8. VFO Linearity Alignment

- a. Set BAND to 144.0, CHANNEL to VFO, MODE to USB or LSB and CLAR to OFF. Connect a frequency counter to pin 8 of J12.
- b. Rotate VFO dial to a fully CW position. Set the 100 kHz dial to 0. Slowly rotate VFO dial in a CCW direction until the 100 kHz dial is set to 0 (one rotation of 100 kHz dial). Adjust TC1302 for 8.5 MHz counter readout.
- c. Rotate the VFO dial until the 100 kHz dial is rotated to the next 100 kHz position. Adjust the space between stator and the rotor of the VC1301 until calibration is completed against the marker signal. Calibration should be within 500 Hz. The VC1301 is a dual variable capacitor for VFO tuning. Adjust the rotor of the rear half of the VC1301. Repeat this procedure for every 100 kHz point.

9. Receiver RF Amplifier

- a. Set BAND to 144.0, CHANNEL to VFO, RF GAIN to a fully CW position and MODE to USB.

Tune the VFO to 144.20 MHz. Connect a signal generator to the antenna connector and set to 144.20 MHz and 10 dB output. Receive this signal and peak TC401, TC402, TC403 and TC404 (PB-1450) for a maximum S-meter reading.

10. Receiver Tuning Capacitor Voltage

- a. After previous Procedure 9, adjust VR701 for maximum S-meter reading.
- b. Set the BAND to 144.5 and receive a marker signal at 144.70 MHz and adjust VR702 for maximum S-meter reading. Set the Band to 145.0 and receive 145.20 MHz marker and peak VR703 for maximum S-meter reading. Repeat this procedure for other bands accordingly.

11. Squelch Threshold

- a. Set BAND to 144.0, CHANNEL to VFO, RF GAIN to a fully cw position, MODE to FM and SQUELCH to 9 o'clock position.
- b. Set VR801 (PB-1463) to threshold point.

12. Center Meter Setting

- a. After Procedure 11, set DISC to OFF position. Set VR606 to 1 o'clock position as illustrated in Fig. 4. Set MARKER switch to ON and receive the marker signal. Carefully set the VFO dial to the center of the passband carefully observing the S-meter indication.

Set the DISC to ON position. Adjust VR605 until meter indicates 12 o'clock position.

- b. Tune the VFO 10 kHz higher. Adjust VR606 (PB-1499) until the meter indicates 8 as illustrated in Fig. 5.
- c. Check the indication of the meter when the VFO dial is slowly rotated in both directions from the center (meter indication). The meter must show even deflection on both sides. If it does not, realign the discriminator.

13. Transmitter Alignment

FM

- a. Set BAND to 144.0, CHANNEL to VFO and MODE to FM. Connect dummyload power meter to antenna connector.

Set the VFO to 144.25 MHz. Remove the top cover from MARKER-AF AMP compartment and locate VR10 attached to chassis. Rotate VR10 fully clockwise. Set VOX GAIN to MOX position. Peak TC501, TC502, TC503, TC504 and TC505 (PB-1466) for maximum power output.

NOTE: Use an insulated screwdriver to adjust TC501 so as to avoid body effect.

- b. Set BAND to 146.25 and VFO to 146.25 MHz. Peak TC1201, TC1202, TC1203 and TC1204 for maximum power output. Adjust VR10 until power output becomes 14 watts.
- c. Adjust VR1202 (PB-1470) until P.O. meter shows 80% of full scale with 14 watts output.

AM

After completion of FM transmitter alignment (Procedure 13), set the MODE switch to AM.

Rotate VR1103 (PB-1460) to CW direction and set to the point where the power output starts to saturate. Then, set VR502 (PB-1466) to the point where the output power is 2.5 watts.

SSB

Carrier Balance

Set MODE to USB and MIC GAIN to 0 at 146.25 MHz. Use monitor receiver and adjust VR901 and TC901 (PB-1462) alternately at both USB and LSB positions for a minimum S-meter reading of the monitor receiver.

14. ALC Threshold

- a. Tune the transceiver at 146.0 MHz. Set MIC GAIN to 12 o'clock position. Connect the power meter to the antenna connector and two-tone signal generator output to MIC connector.
- b. Set the output of two-tone generator for 5 watts power meter reading.

Adjust VR1201 (PB-1470) until output power reduces to 3 watts.

15. FM Modulation (Deviation)

(Only applicable to sets bearing serial numbers before 110999)

- a. Connect FM analyzer to antenna connector and audio signal generator output to MIC connector. Tune up the transceiver on FM mode. Set MIC GAIN to a fully CW position.
- b. Apply 1000 Hz 10 mV audio signal to the microphone input. Adjust VR1101 (PB-1460) for 5 kHz deviation.

(Only applicable to sets bearing serial numbers before 120001)

- a. Set up as described above and set MIC GAIN to 12 o'clock position. Set VR1104 to the center of its travel and VR1101 to a fully clockwise position.
- b. Apply 1000 Hz 3 mV audio signal to microphone input. Adjust VR1104 until the sine wave pattern is obtained on the screen of the FM analyzer.
- c. Set the MIC GAIN to a fully CCW position. Connect a frequency counter to the output of T1101. Adjust L1101 to 10.700 MHz counter readout.
- d. Set the MIC GAIN to 12 o'clock position and audio signal input level to 8 mV. Adjust VR1101 for 5 kHz deviation.

16. VOX Adjustment

- a. Connect a hand microphone to MIC jack on front panel.
- b. Set VOX gain to PTT position. Rotate VR602 (PB-1499) fully CW and slowly rotate back in a CCW direction and set it to the point where the transceiver turns to receive mode.
- c. Set the VOX GAIN to 12 o'clock position. Check that the transceiver actuates into transmit mode when normally speaking into the microphone.
- d. Adjust VR603 (PB-1499) until the speaker output does not trip the transceiver.
- e. Adjust VR601 (PB-1499) for suitable delay time.

17. CW Sidetone Level

Key the transmitter on CW mode. Adjust VR604 (PB-1499) for suitable sidetone output from the speaker.

18. SSB Carrier Frequency

- a. Apply audio signal to the microphone input and tune up the transceiver on USB mode. Adjust MIC GAIN control for 10 watts output.
- b. Set the audio signal frequency to 350 Hz. Adjust TC1103 (PB-1460) until output power becomes 2.5 watts.
- c. Set the MODE switch to LSB and adjust TC1102 (PB-1460) for 2.5 watts output.

19. CW Carrier Frequency

- a. Tune the transceiver on USB mode. Tune a monitor receiver to receive transmitted USB signal for normal tone reception.
- b. Set the MODE switch to AM and transmit AM carrier. Adjust TC1104 until an 800 Hz tone is heard from the monitor receiver.

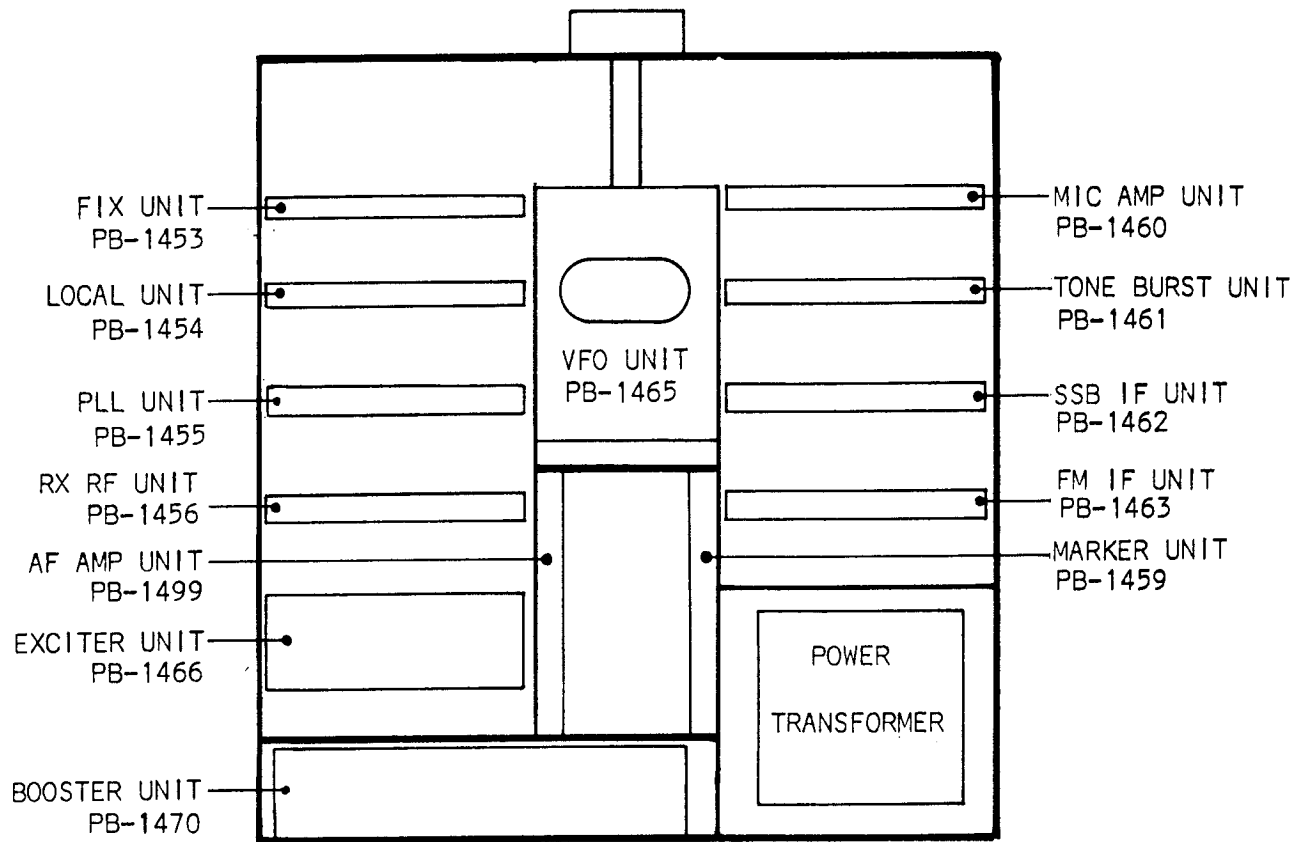
20. Repeater 600 kHz Frequency

- a. Set BAND to 146.5, CHANNEL to VFO, RPT to ON, CLAR to OFF, NOR-REV to NOR and MODE to USB.

Receive 146.50 MHz marker signal and zero beat against the marker signal.

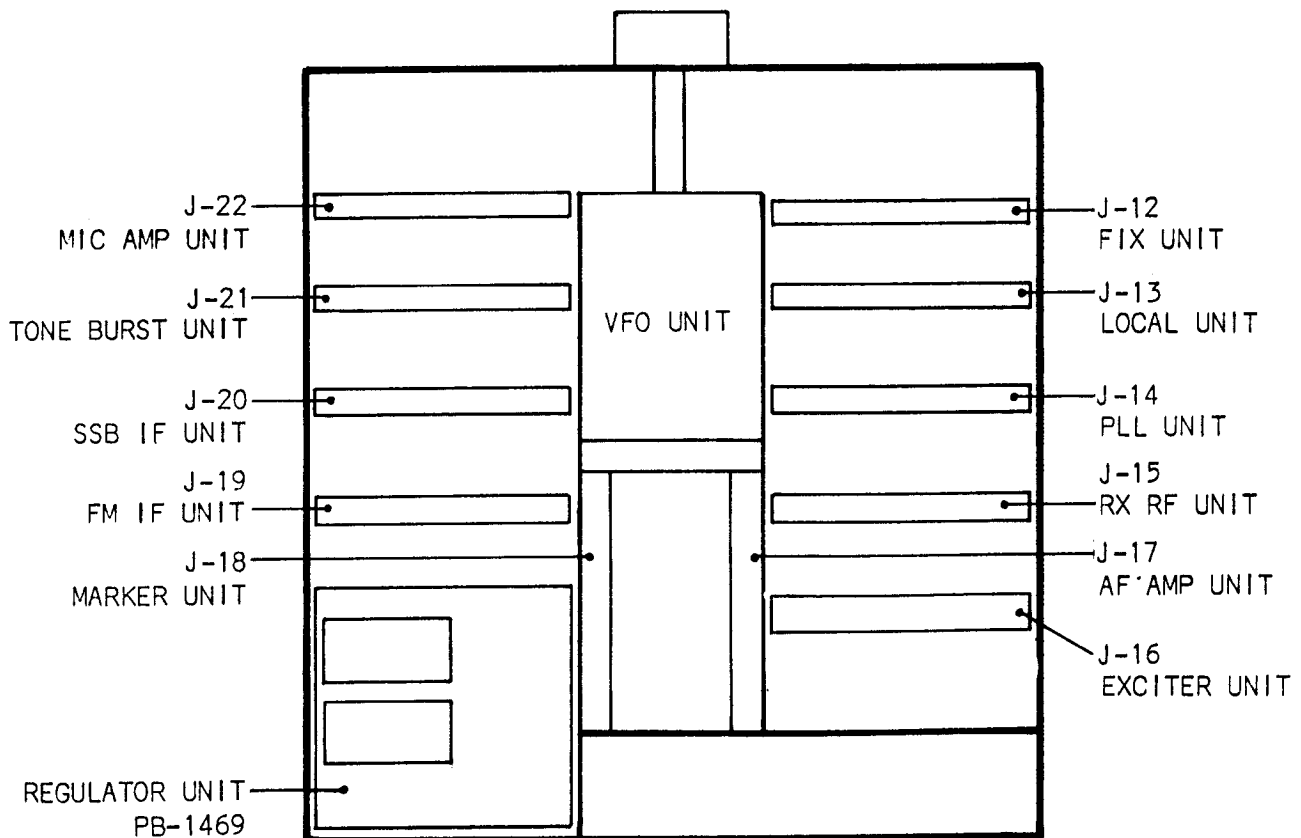
- b. Set the NOR-REV switch to REV position and zero beat against the marker signal by adjusting TC210 (PB-1454).
- c. Set BAND to 147.0 and NOR-REV to NOR. Receiver 147.00 marker signal and zero beat.
- d. Set the NOR-REV to REV. Zero beat against the marker signal by adjusting TC211 (PB-1454).

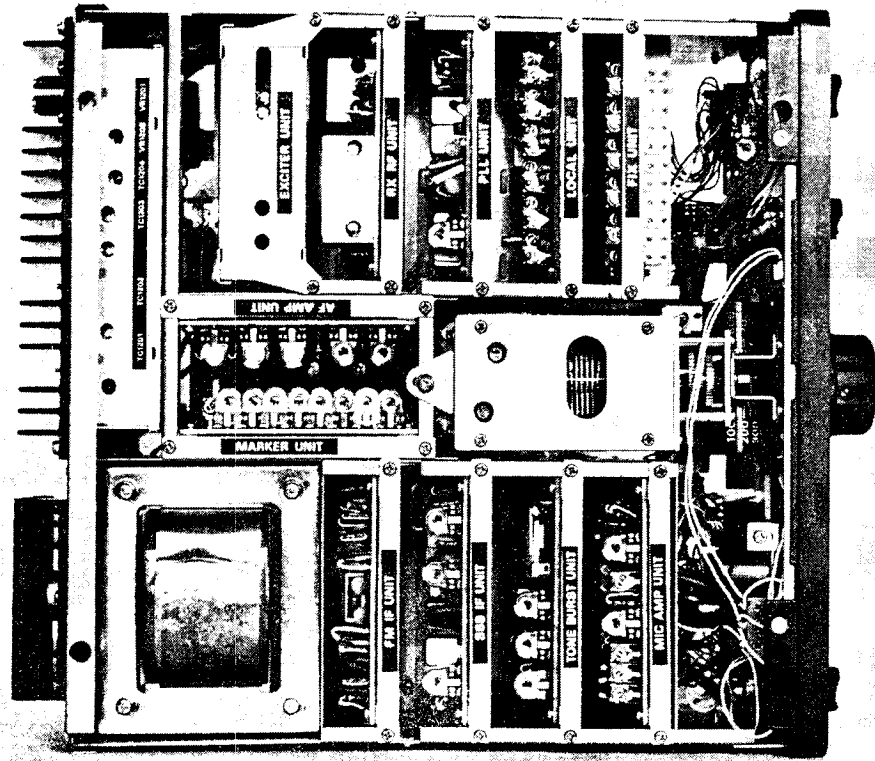
BOARD LOCATIONS



TOP VIEW

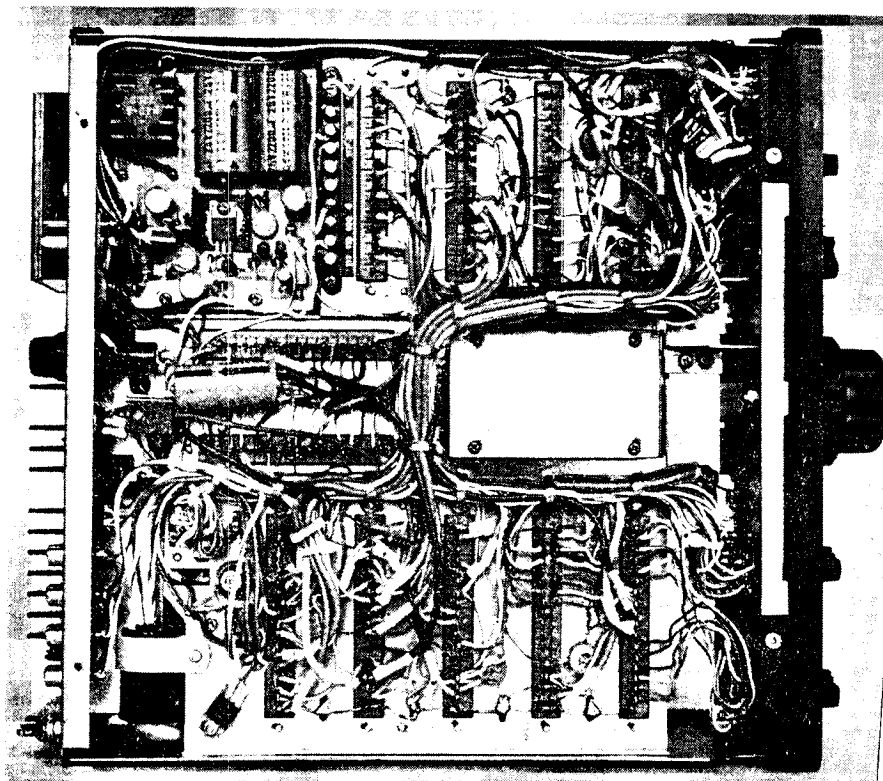
BOTTOM VIEW



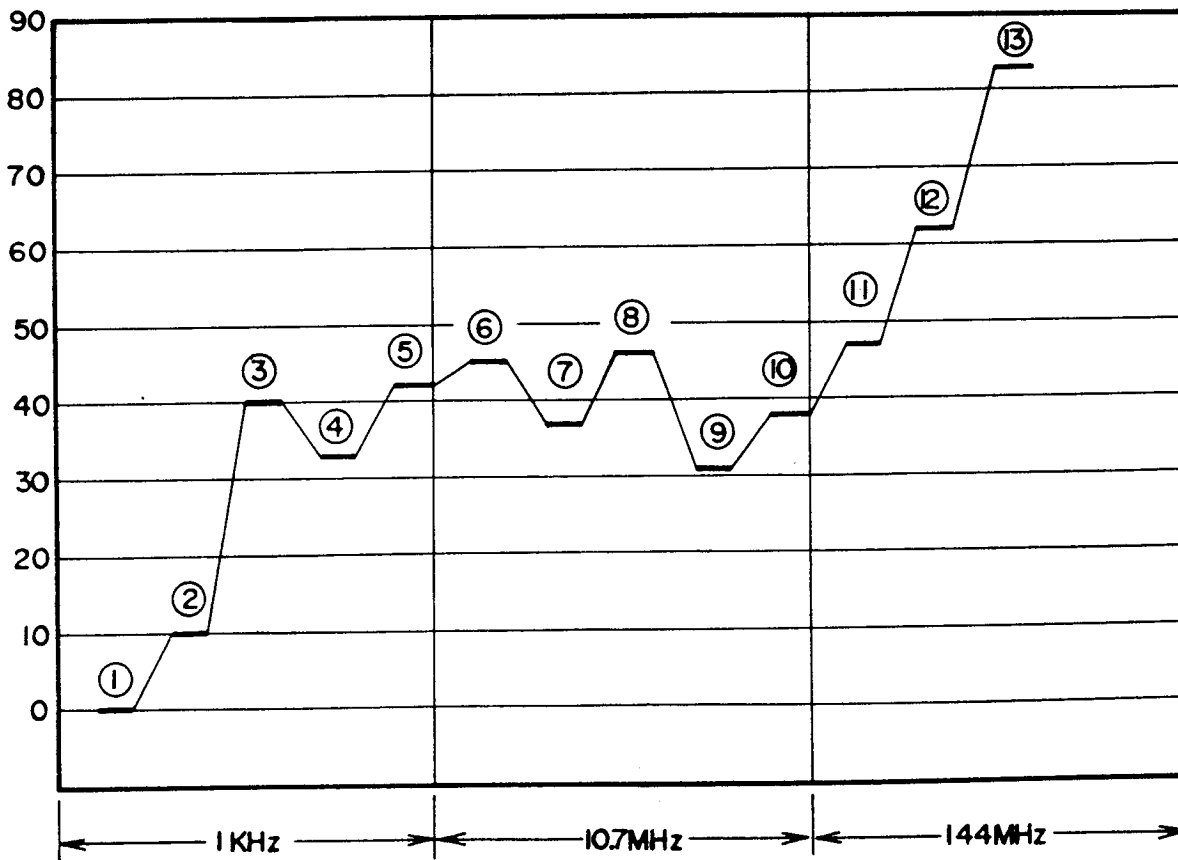
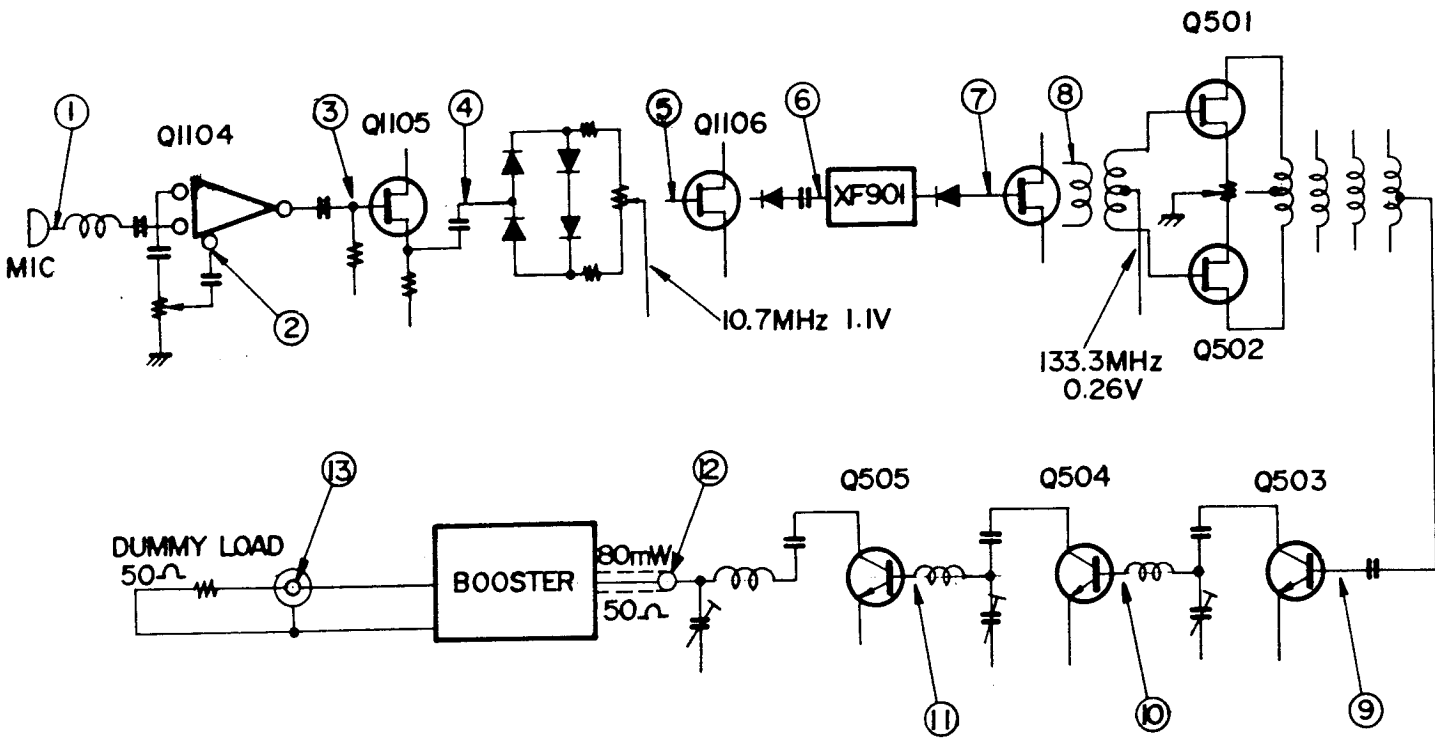


TOP VIEW

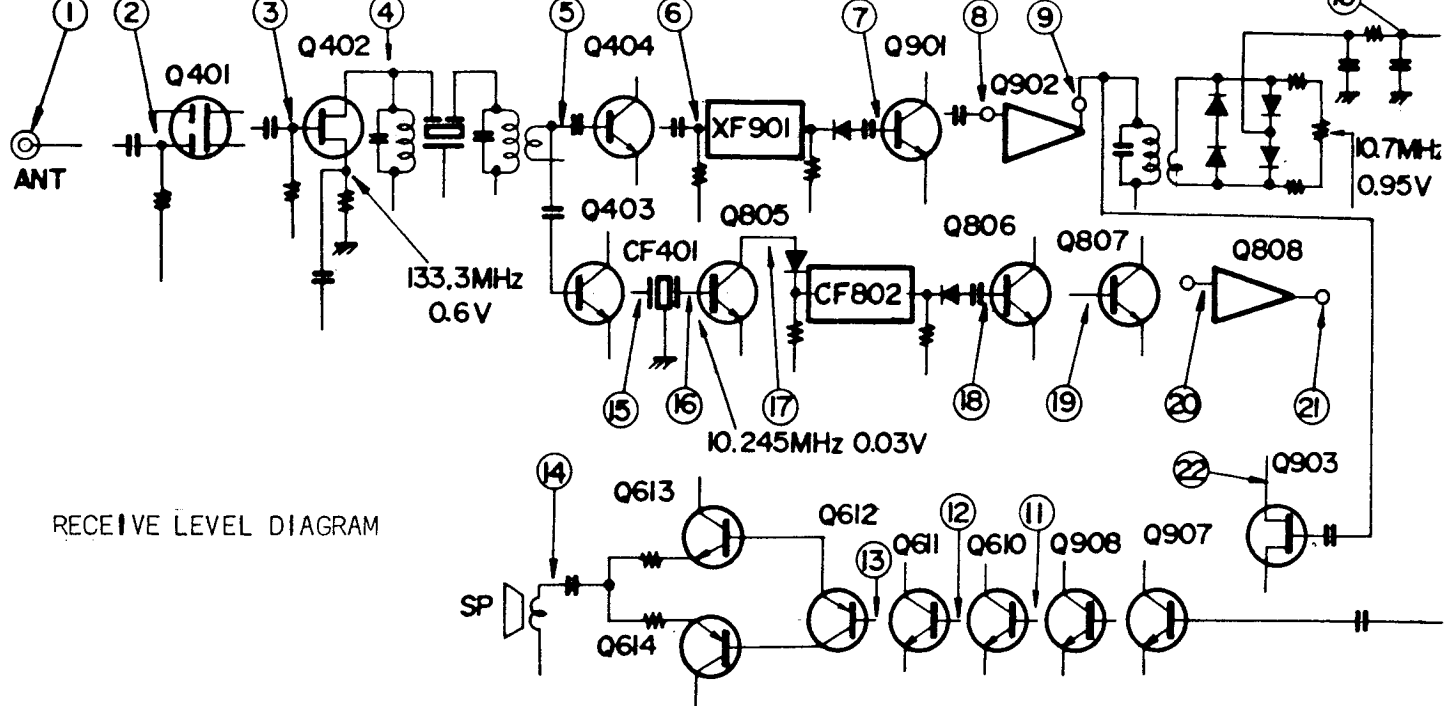
Downloaded by RadioAmateur.EU



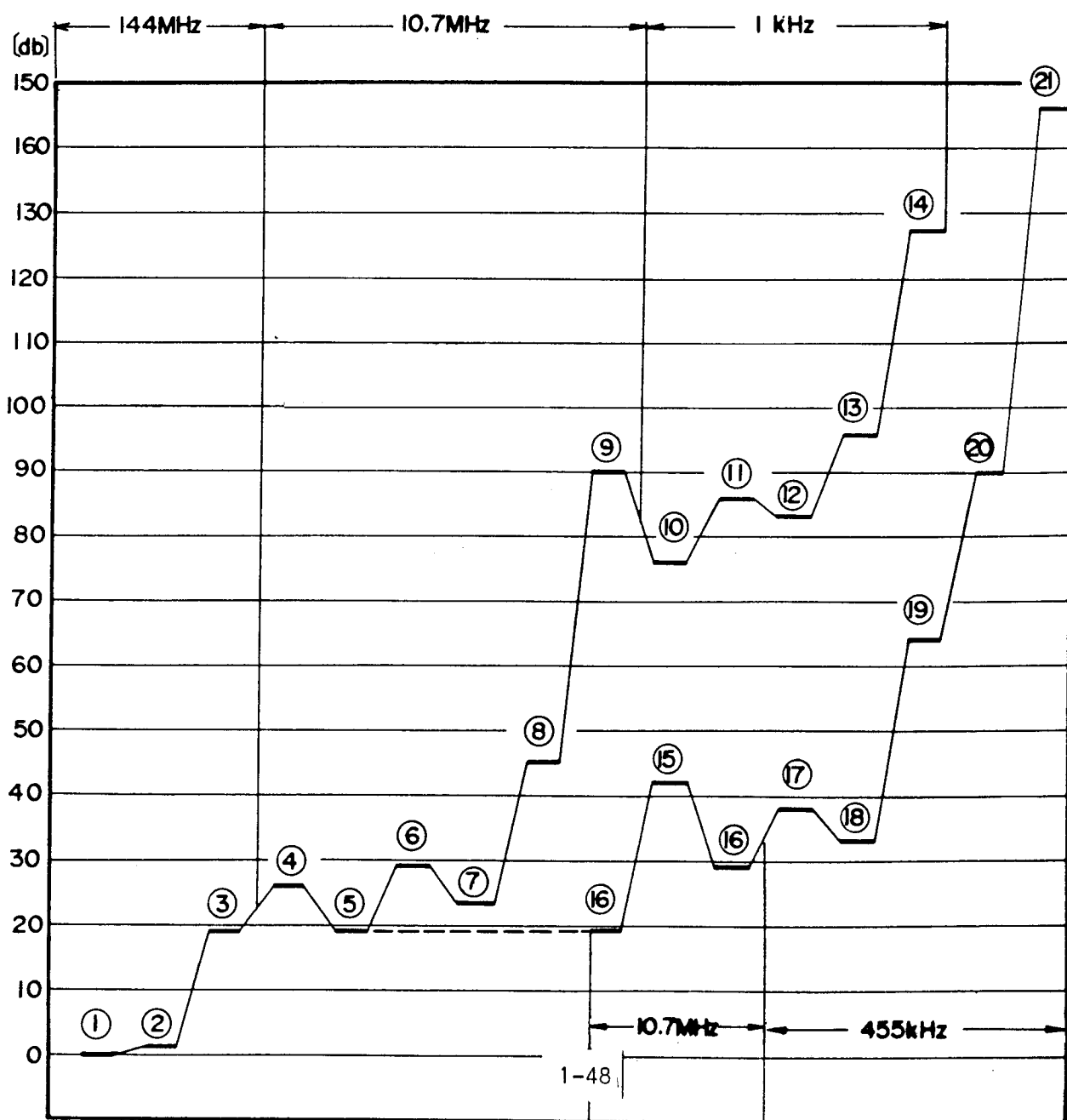
BOTTOM VIEW



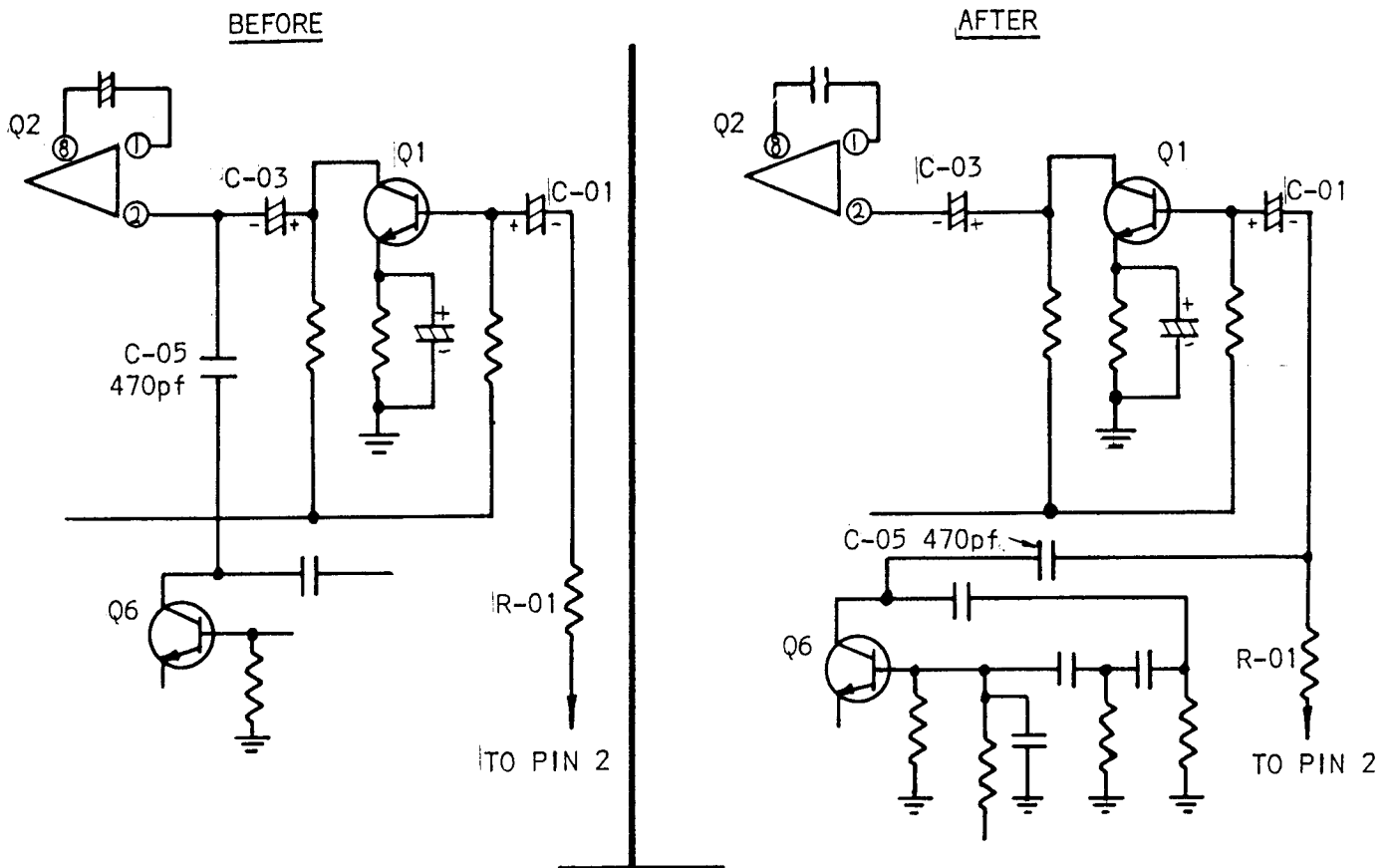
TRANSMIT LEVEL DIAGRAM



RECEIVE LEVEL DIAGRAM



To eliminate RF feedback, reposition C-05 on AF AMP UNIT, PB-1499A as shown



FM TX AND RX FREQUENCY ADJUSTMENT

This adjustment is made in the FM mode when the receive and transmit frequencies are not the same. An extender board must be used on two of the following adjustments:

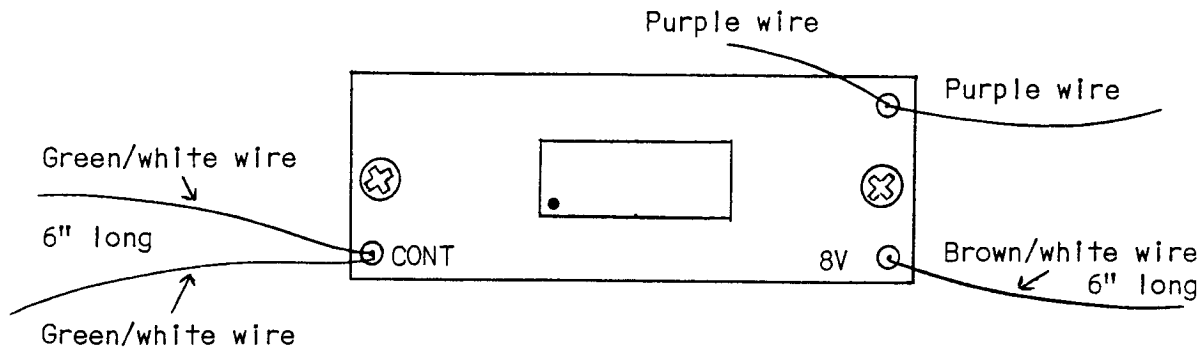
- A. Insert a known frequency at the antenna input. Use a frequency that will fall on the marker. (Example: 146.000 MHz) Use the extender board and monitor TP-801 on the FM IF board with a VTVM for zero volts. If the voltage is not zero, adjust the main tuning knob for zero. Do not move the main tuning knob after this adjustment.
- B. Place the meter switch in the DISC position. If the meter is not reading center scale, adjust VR-605 on the AF AMP unit.

Disconnect the 146 MHz signal and connect a dummy load.

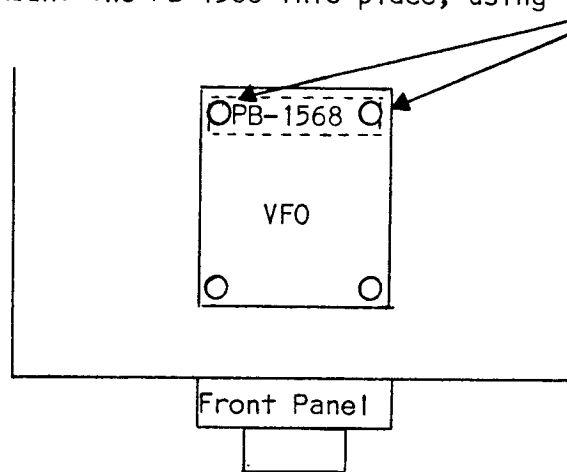
Turn on the marker switch and adjust TC-701 on the Marker unit for center scale. Key the transmitter and monitor the output frequency with a frequency counter. If the frequency is not 146.000 MHz, use the extender board to adjust L-1101 on the MIC AMP unit until the counter reads 146.000 MHz. The transceiver is now transmitting and receiving on the same frequency in the FM mode.

KEY CLICK MODIFICATION

Pre-wire the board PB-1568 as shown:

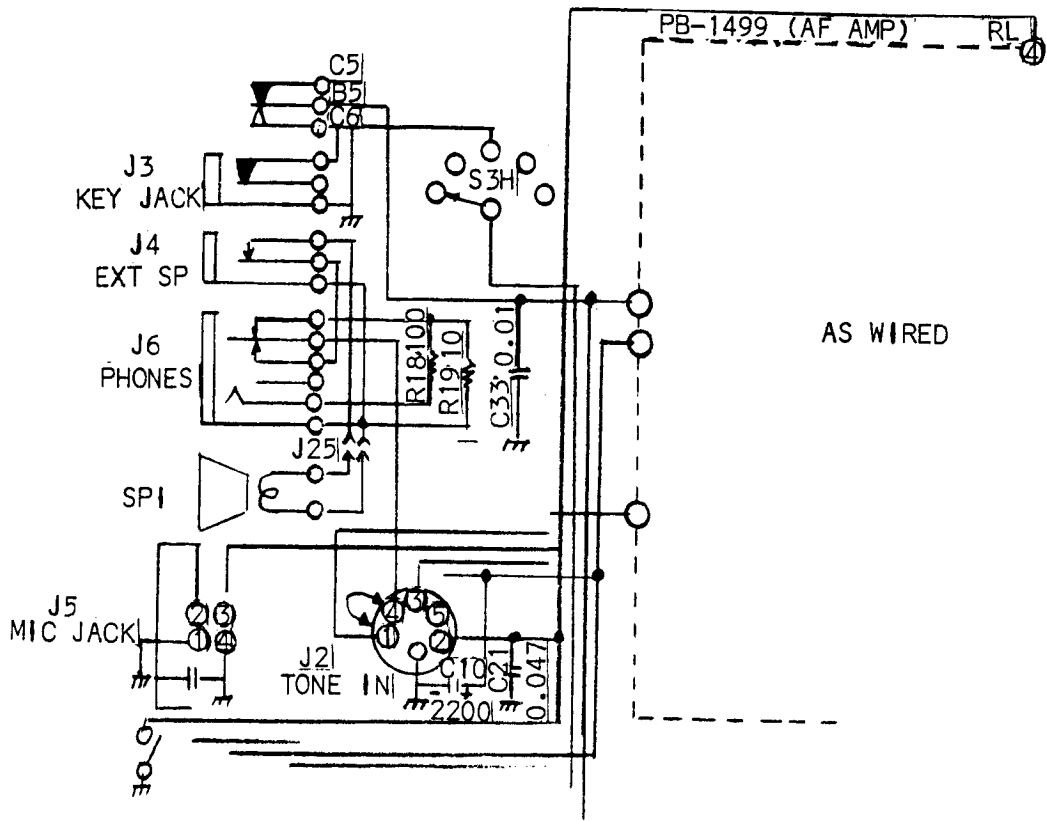


Remove the covers, turn the unit upside down, with the front toward you. Remove the two screws from the VFO bottom cover that are closest to the center, and discard. Mount the PB-1568 into place, using the old VFO screw holes.

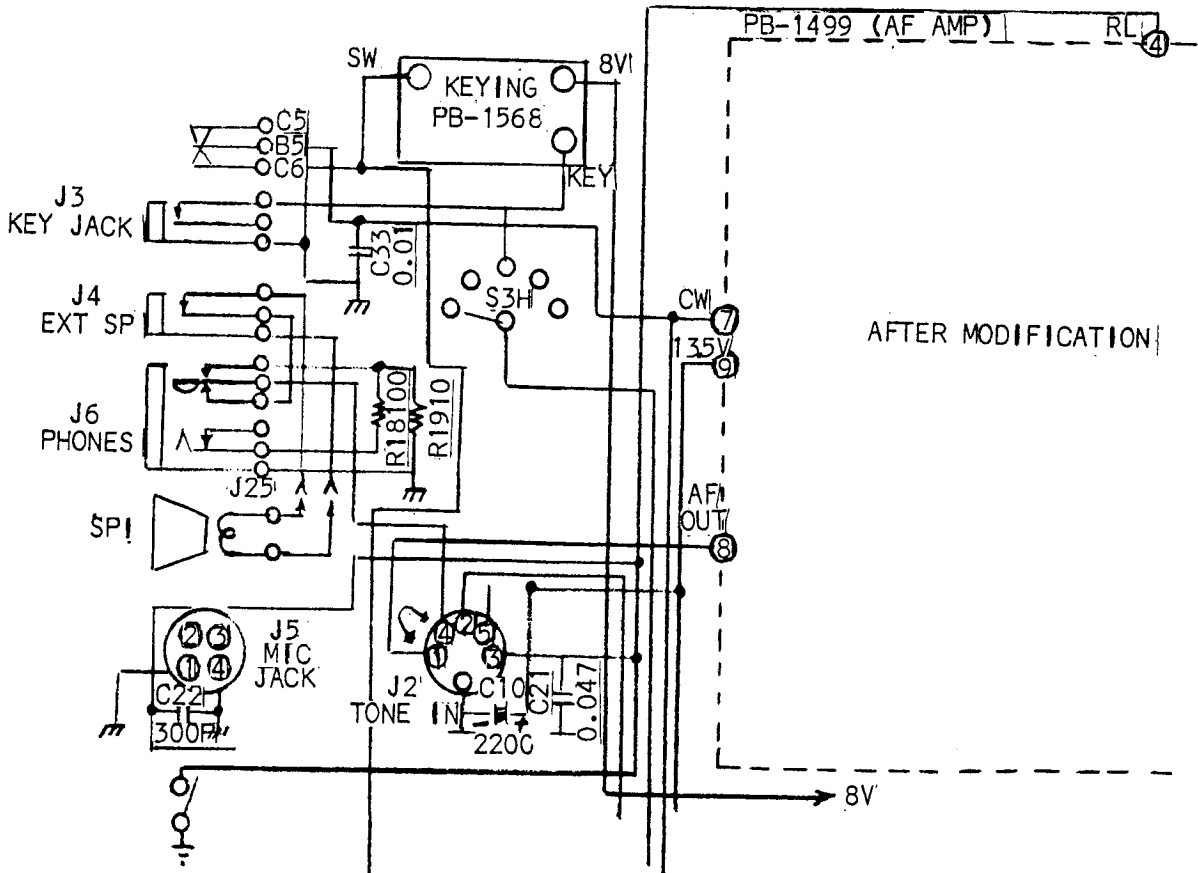


Now open up the wire hold downs - those plastic covered soft metal strips that hold the wire bundle in shape.

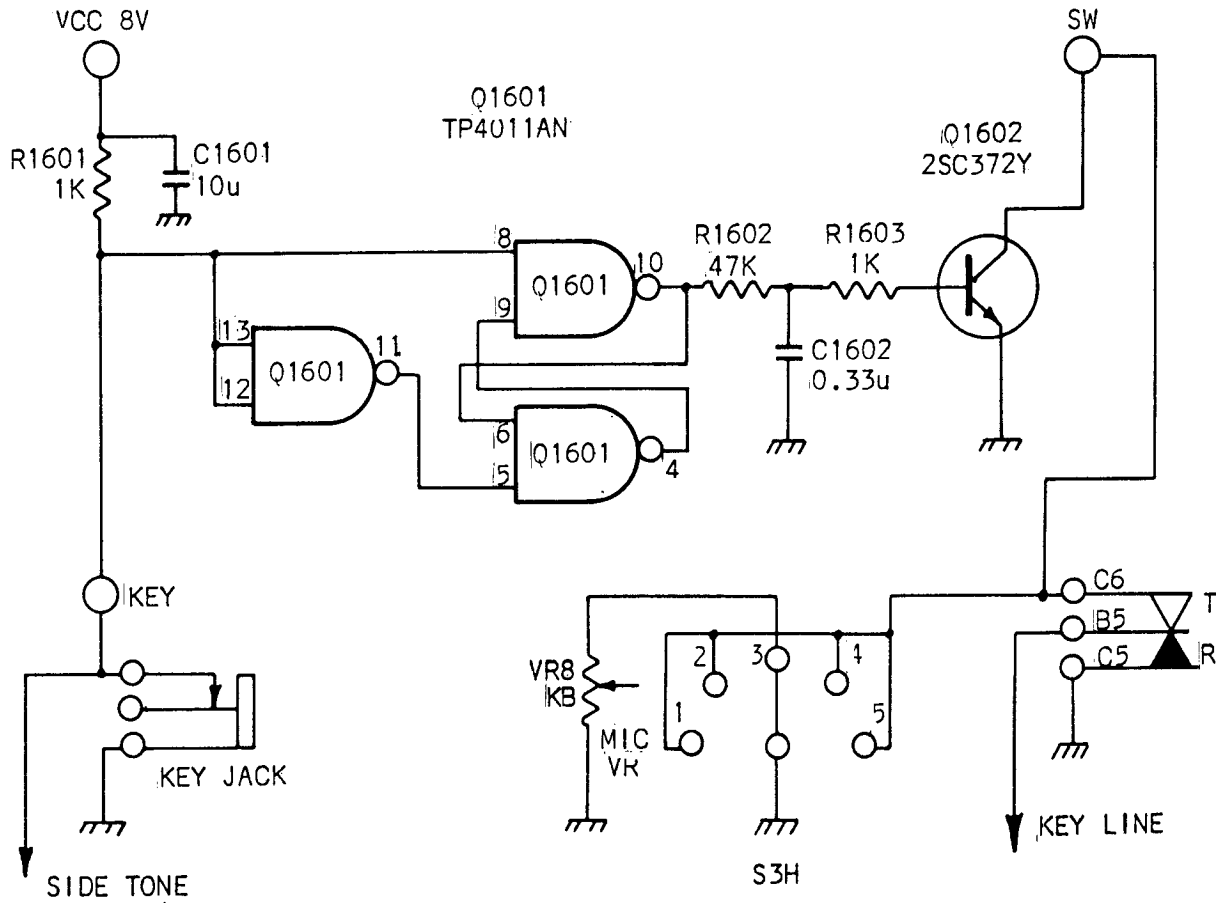
1. Run the brown/white 8 volt wire from PB-1568 to the lug marked "8 volts" on PB-1469, the regulator board.
2. Cut the purple wire that runs between the rear lug of the key jack and the VOX relay at the lug of the key jack. Now don't cut them both off! Just one! Strip the purple wire, slip on the 1" piece of sleeving supplied, and splice it to one of the green/white leads coming from the "CONT" lug of PB-1568.
 - a. Now trace the second purple wire through the bundle, and tug it up where it runs closest to the "KEY" lug on PB-1568. Clip the wire, strip the ends, and solder both ends to the "KEY" lug, or; just open the insulation, push it back and wrap a turn around the "KEY" lug, solder and go on to step 3.



W&R&W

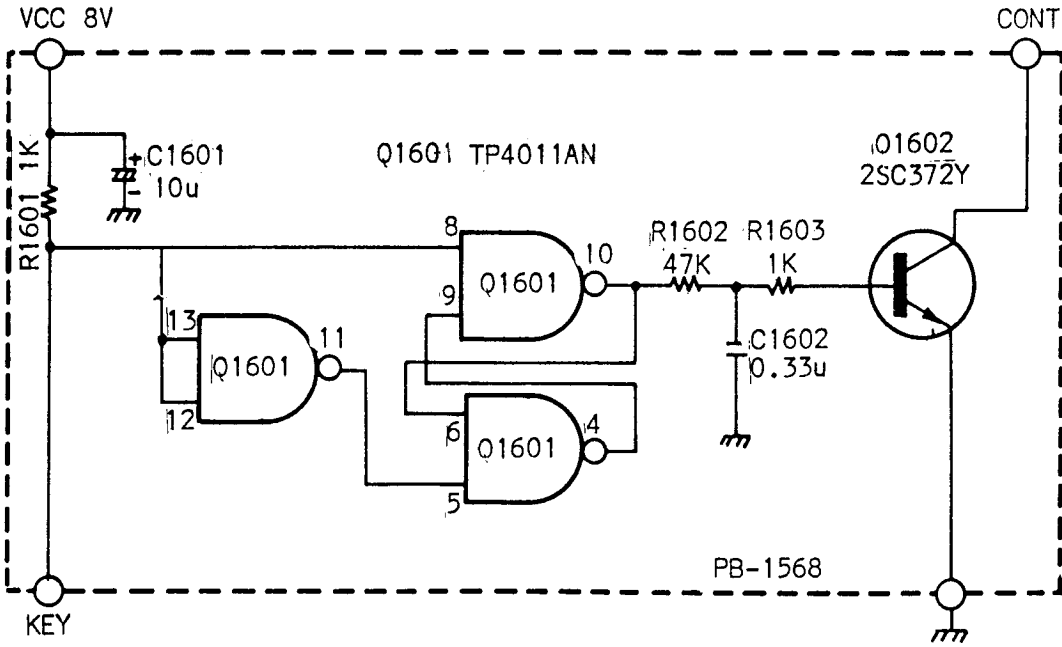
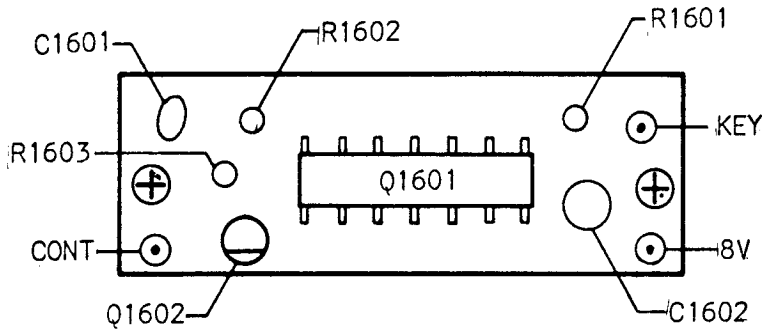


KEYING CIRCUIT



KEYING UNIT

PB-1568



FM FILTERS-Wide/Narrow Modification

While many user/owners of the FT-221 use SSB in 90% of their operations, narrow band FM is still in wide use, and especially where repeaters exist.

The FT-221 was designed to handle a wide band FM system, as well as the narrow band system popular in the USA, because in several areas of the world wide band FM is still in widespread use on amateur bands. So on PB-1463 (FM IF) there is a space for an optional 15 kHz filter, and it can be activated if desired.

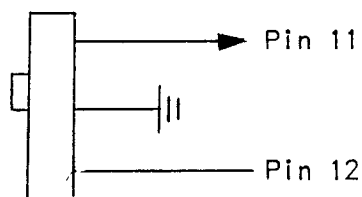
The filters are Murata CFM units, (or equivalent) with characteristics as follows:

	<u>NB UNIT 455E</u>	<u>WB UNIT 455A</u>
Center	455 kHz	455 kHz
3dB BW	±5.5 kHz	±13 kHz
6dB BW	±8 kHz	±17.5 kHz
50dB BW	±16 kHz	±30 kHz
Min. spurious	35 dB	40 dB
IN/OUT Z	1500 Ω	1000 Ω
Insertion loss	6 dB (max)	4.5
Temp. range	-20 to +80°C	-20 to +80°C

To install the wide filter, remove PB-1463, and install the filter in the space provided. Then remove the ground from pin 11.

At this point, you have to provide a means of selecting the wide/narrow filter, so solder a SPDT slide switch onto the inner lip of the chassis, in the space behind the meter.

Wire it like this:



Now when the slide switch grounds pin 11, the narrow filter will be in the circuit, and when pin 12 is grounded (and 11 opened) the wide filter will be in the circuit.

Naturally, to set up for wide band transmit, you have to reset the deviation pot (VR1101 on PB-1460) with a deviation meter on the output.

FT-221/FT-221R MODIFICATION
FOR DIGITAL DISPLAY UNIT YC-221

This modification should be applied in order to be able to use the YC-221 Digital Display unit in conjunction with the earlier models of the FT-221/FT-221R VHF transceivers.

Please note that the FT-221R transceivers bearing serial numbers ending in a "D", will not require this modification as it will be incorporated in the design.

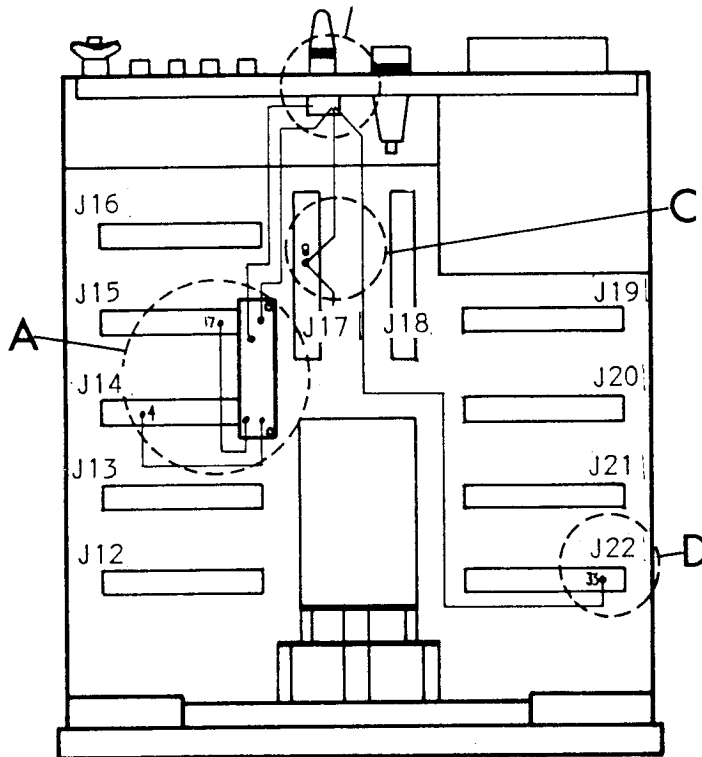
PARTS REQUIRED:

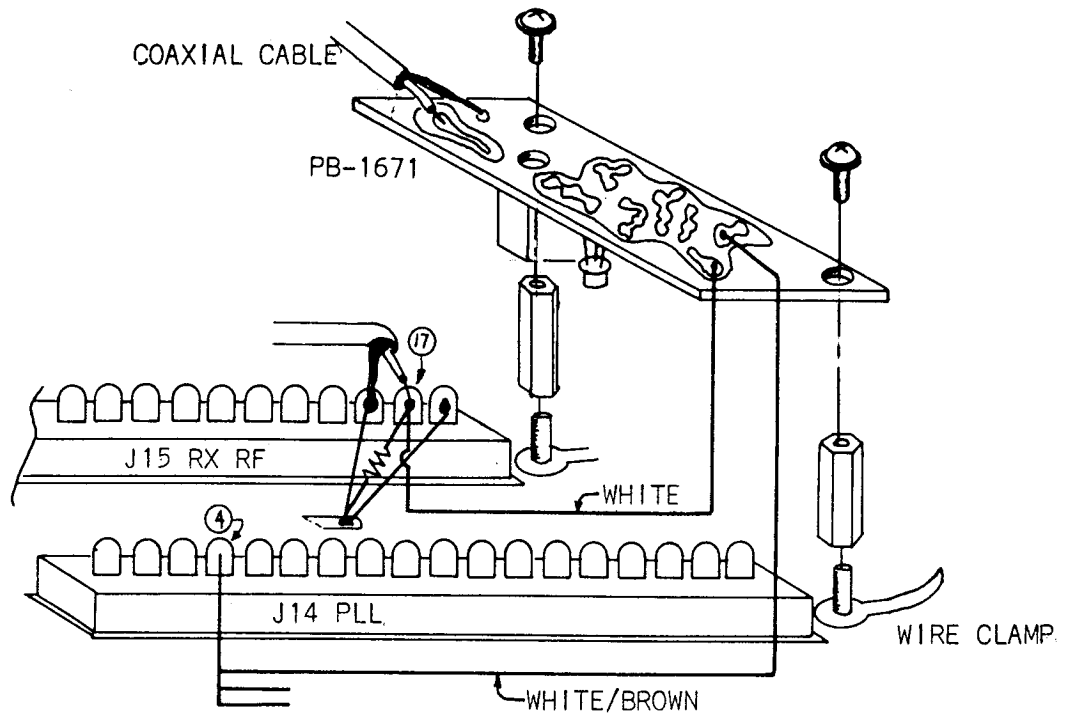
Buffer Printed Board	PB-1671 Completed	(1 piece)
Spacers	M3 x 18	(2 pieces)
Screws	M3 x 8	(2 pieces)
Coax Cable	1.5D 2V	(18 cm)
Wire	0.18 x 7 White	(10 cm)
Wire	0.18 x 7 White/Brown	(12 cm)
Insulator		(1 piece)
Display Label		(1 piece)

MODIFICATION:

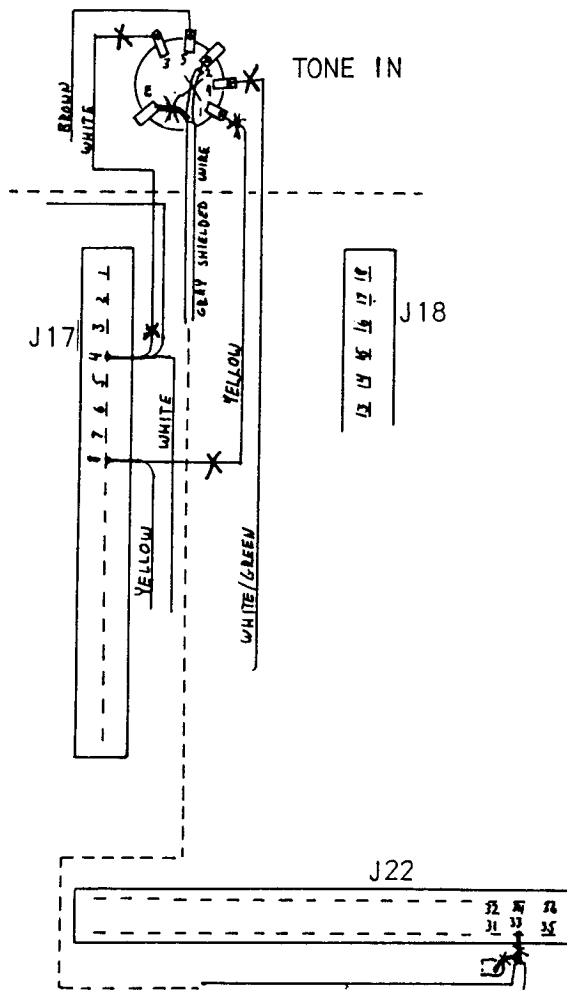
1. Remove the bottom cover from the cabinet. Figure 1 shows the location of the modification work within the dotted circles.
2. Remove the nuts holding J14 and J15 and replace them with the tapped spacers as illustrated. Be careful not to damage the wires when the spacers are tightened.
3. Solder the white wire to pin 17 of J15 and the white/brown wire to pin 4 of J14. Solder the other ends to the printed board PB-1671 and install the printed board as illustrated in Figure 2.
4. Locate the TONE IN jack, J2, on the rear panel. Remove the white wire from pin 3 of J2 and pin 4 of J17. Refer to Figure 3. Also remove the yellow wire from pin 1 of J2 and pin 8 of J17. Unsolder the white/green wire from pin 4 of J2 and solder this wire to pin 8 of J17.
5. Remove the grey shielded wire from pin 2 of J2 and pin 33 (17A) of J22.
6. Connect pin E of J2 to the ground terminal between J17 and J18 with the yellow wire removed after step (4). Solder both ends.
7. Solder the inner conductor of the coax cable supplied to pin 1 of J2 and its outer conductor (shield) to pin E of J2.
8. Solder the coax cable, white and white/brown wires to the printed board PB-1671 as illustrated in Figure 3.

9. Glue the insulator board to the inside surface of the bottom cover where the installed printed board PB-1671 will touch.
10. Adhere the "DISPLAY" seal to the rear panel at the TONE IN mark.
11. Connect the speaker plug and replace the bottom cover.

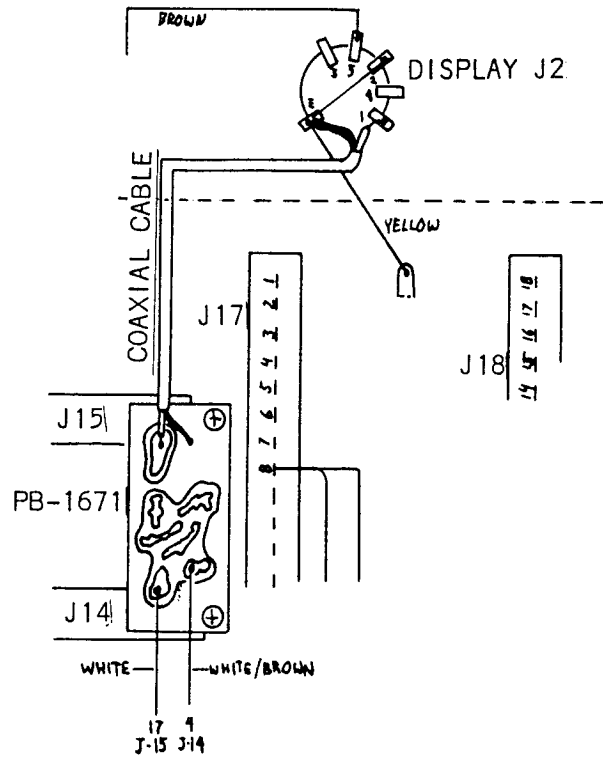




BEFORE MODIFICATION

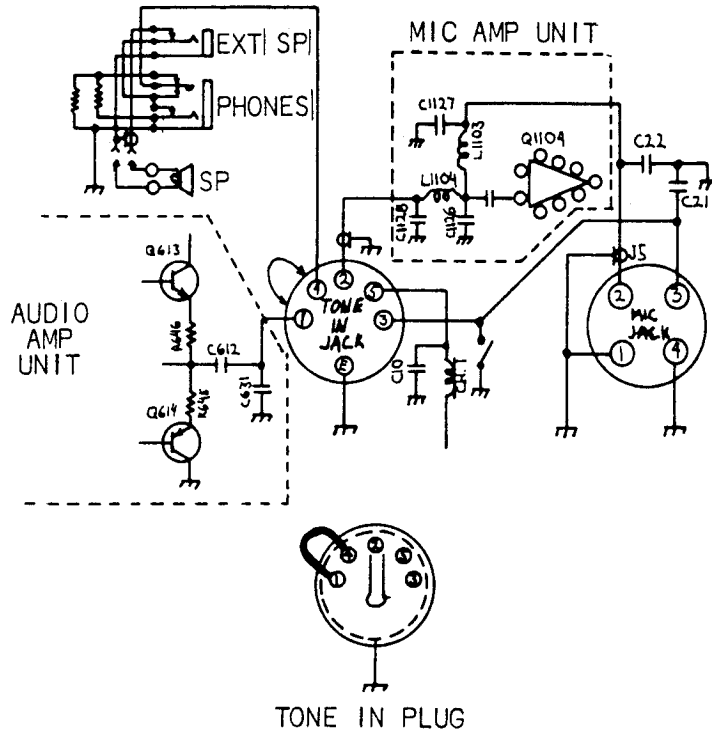


AFTER MODIFICATION

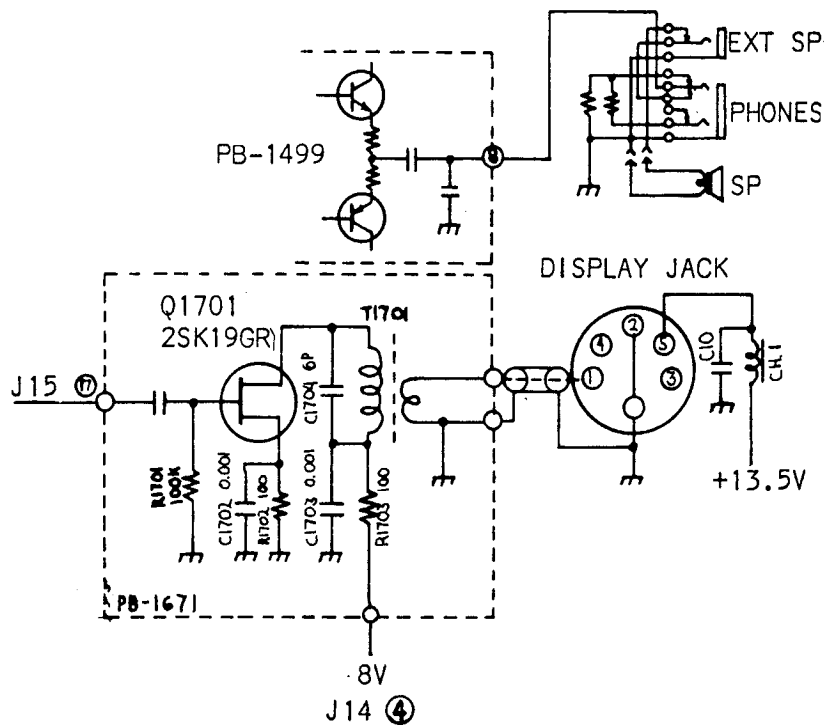


TONE IN & MIC JACK CIRCUIT

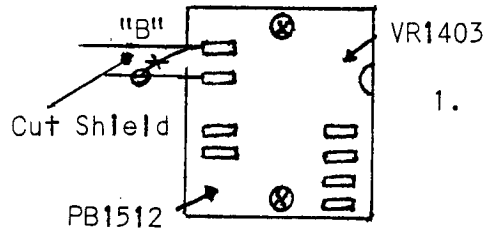
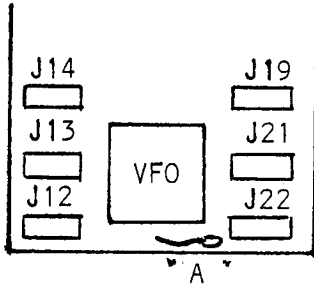
BEFORE MODIFICATION



AFTER MODIFICATION

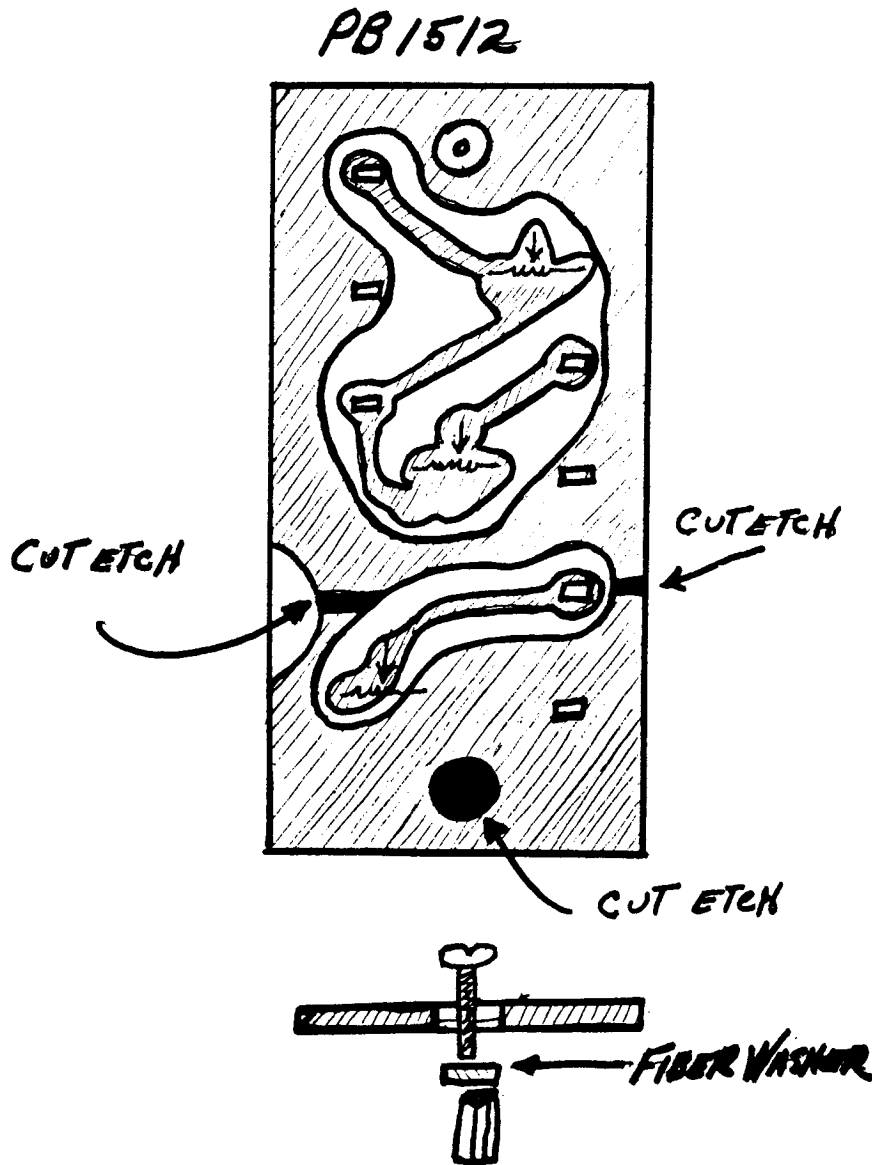


If you have a hum problem with FT-221's built prior to lot 005, the cure may be as simple as relocating the ground, as shown below:



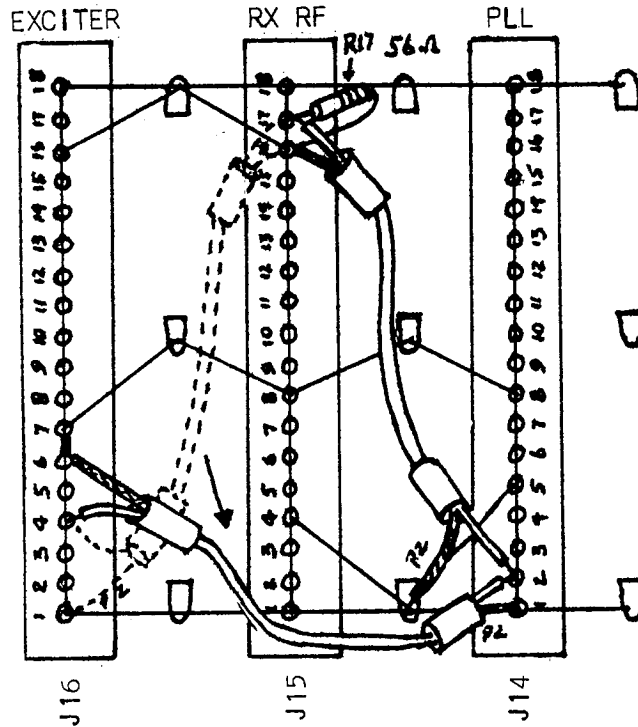
1. Ground "B" at point "A" with a single wire.

2. Now cut the etch on PB1512 as indicated, to relocate the ground point of VR1403. Be sure you cut the etch away from the screw head far enough to assure that the head will not touch. Install a fiber washer as shown:



SPURIOUS REDUCTION

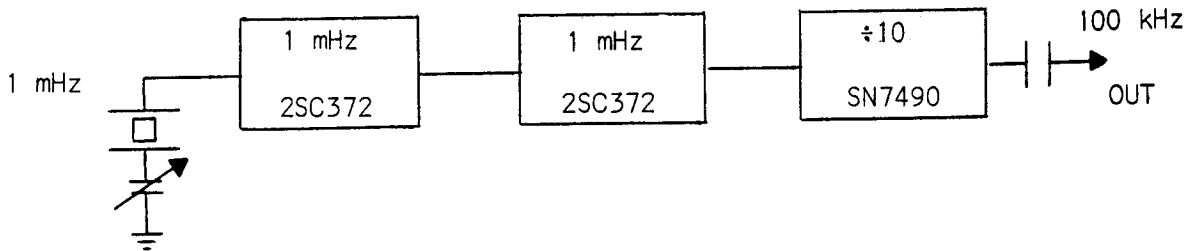
Beginning with lot 008, the wiring between J15 and J16 was modified slightly, and R17 was added. To install, move the blue coax as indicated, and add R17.



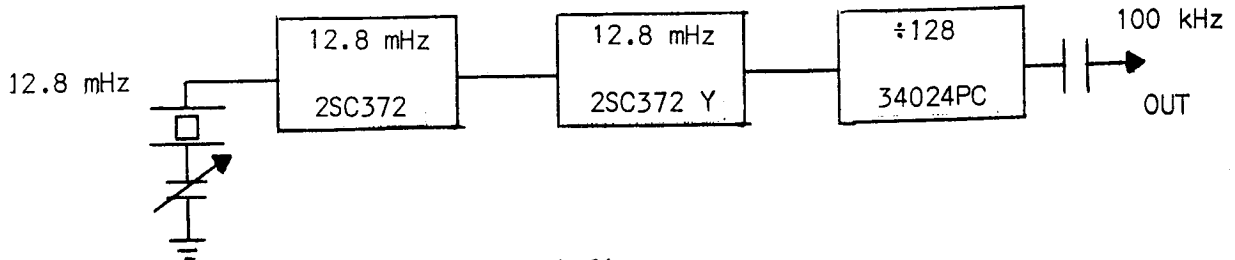
MARKER BOARD CHANGE

At lot 009, the 1 mHz crystal was changed to a 12.8 mHz crystal. The new division scheme is shown below. The boards are interchangeable, and the change was made to avoid 1 mHz "glitches" that were finding their way into the receiver.

LOT 008 AND EARLIER

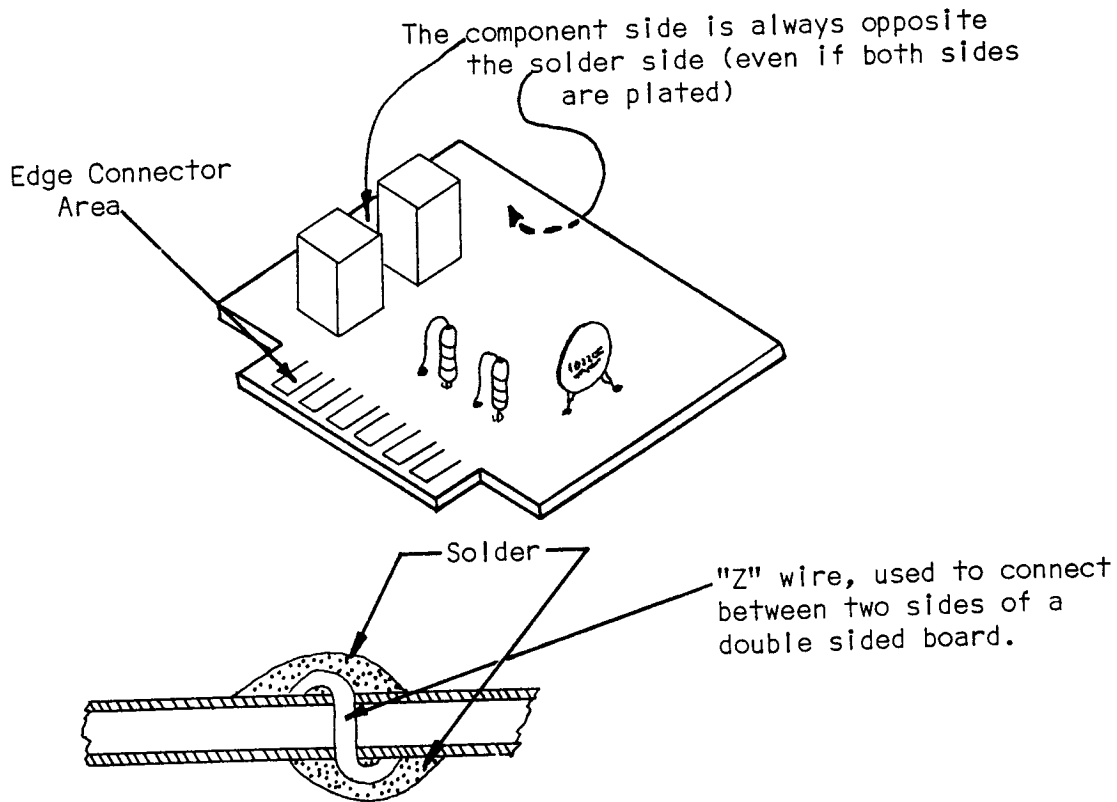
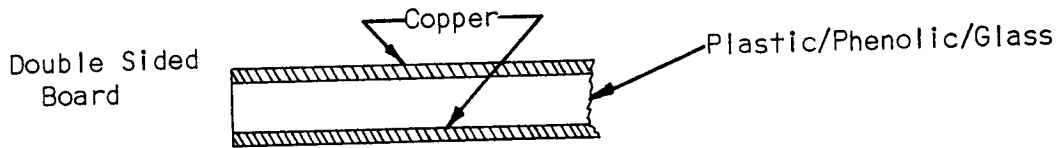
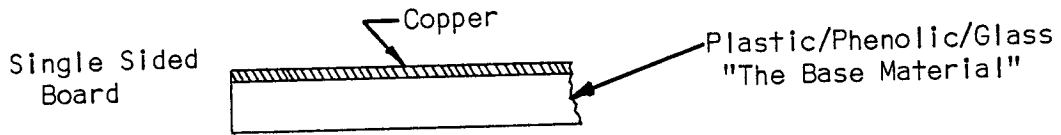


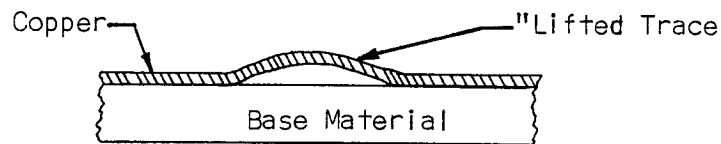
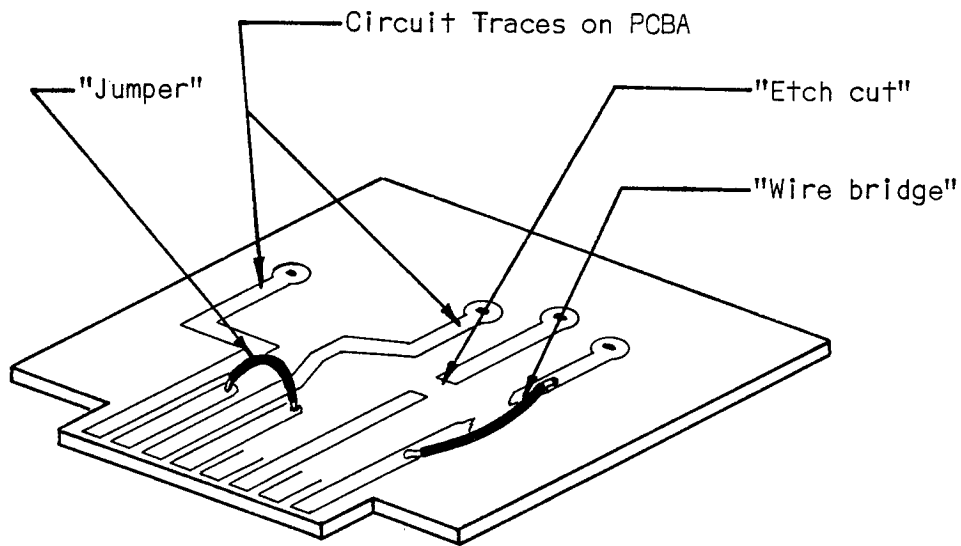
LOT 009 AND LATER



CIRCUIT TRACE REPAIR

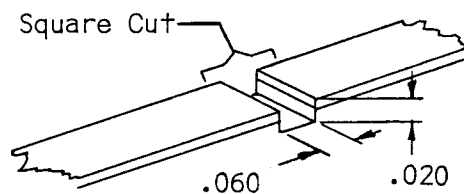
Most of the printed (plated) circuit board assemblies (PCBA's) appear in FT-221's in only single sided versions, however, certain boards such as PB-1459 and PB-1462, use a double sided board for the shielding it provides. The terminology we will use is explained by the sketches:





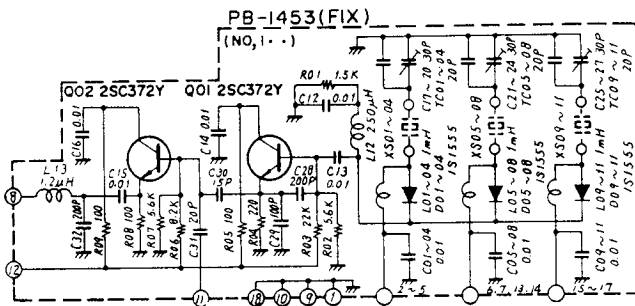
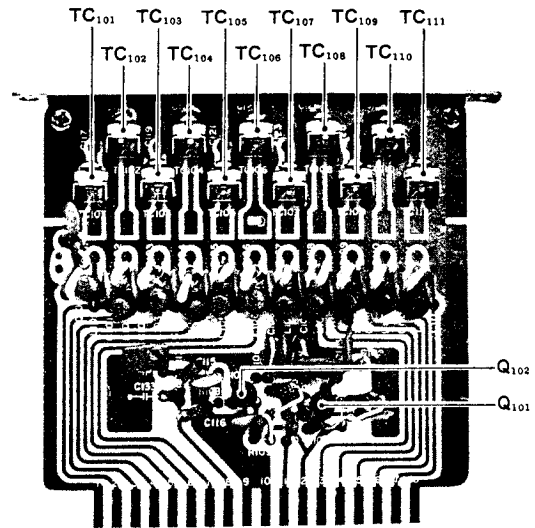
Sometimes, after the designers and draftsmen have finished the artwork and tape up, a board is made with an error in it. (This is being charitable - managers have been known to faint dead away when first informed of this kind of development). Thus etch cuts and jumpers at the factory level usually represent the "fine tuning" of a design, and they are best left in place, unless you enjoy improving the design engineers effort. In that case, you should know how to cut a trace professionally.

Like this:



Coat Cut Area With Eastman 910

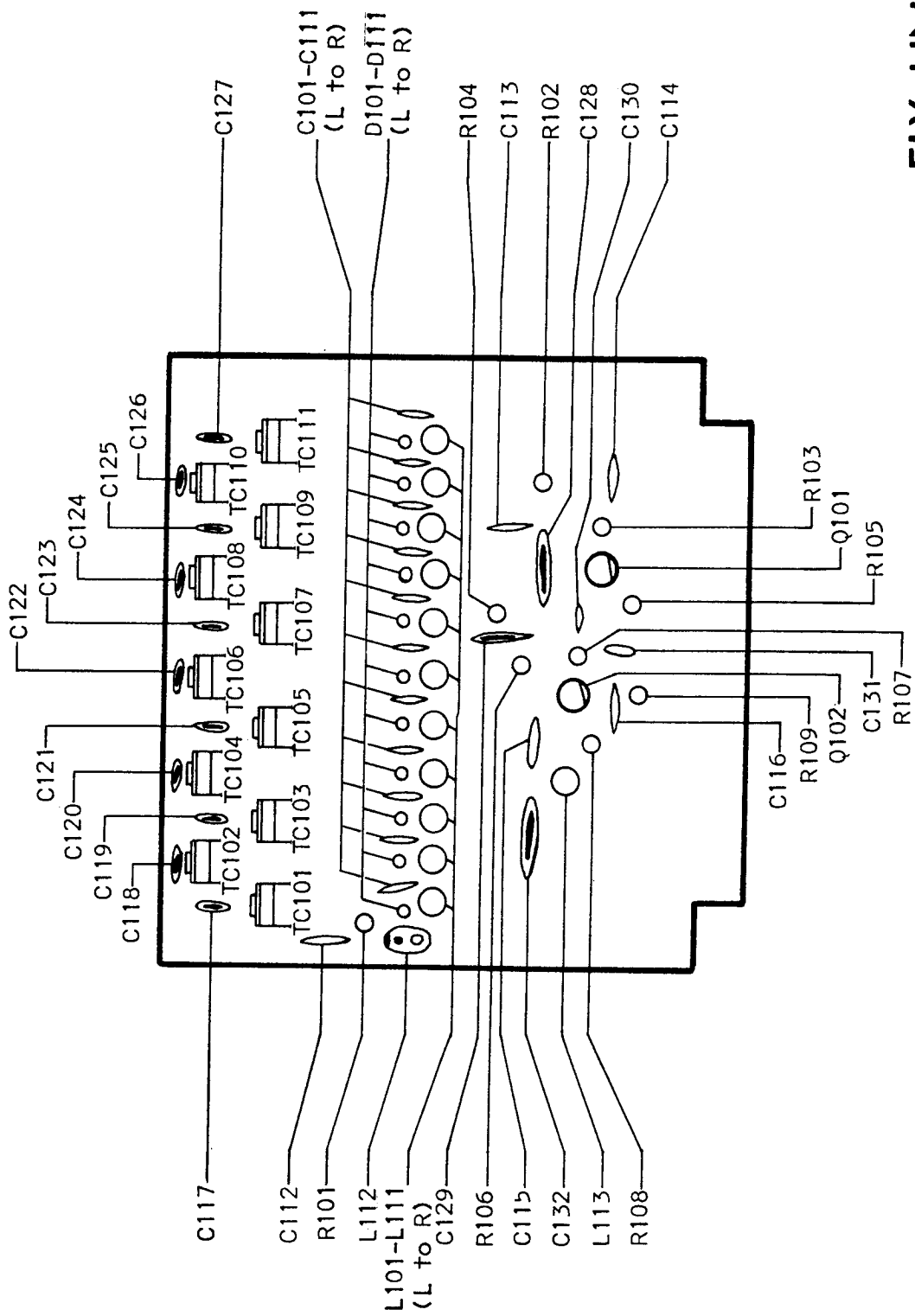
FIX UNIT (PB-1453)



	E	B	C		E	B	C
Q 101	0.9	1.4	7.7	Q 102	2.2	2.9	5.8

FIX UNIT (PB-1453)

Eleven fixed crystals can be installed on this board if desired. The crystal calculations and operating data are in the "General" section of this manual. There are only two transistors on this board, Q101 (2SC372Y) acting as the crystal oscillator, and active whenever the channel selector is set to one of the crystal positions 1 through 11. Selection of the proper crystal is accomplished through diode switches D101 through D111 (1S1555). The second transistor, Q102, acts as a Buffer AMP for both the crystal oscillator and the VFO output, depending on which is selected. The 8.0 - 8.5 MHz VFO signal arrives at pin 11 of the board when the SELECT switch is on VFO. The diode enable voltages arrive at the board via pins 2 - 5, 6, 13, 17, activating the selected crystal and disabling the VFO. All RF signal depart from the board at pin 8, and are applied to pin 17 of the PLL board, PB-1455.



FIX UNIT
PB - 1453

The crystal controlled oscillator Q201, (2SC372Y) oscillates at the fundamental frequency of the crystal. A varactor diode D226, (1SV50) connected to the base of Q201, is used as a clarifier to shift the oscillator frequency for receiver off-set tuning.

The output from the oscillator is fed to the frequency multiplier stage, Q202 and Q203, (2SC784R) selecting the ninth harmonic for its output, using T202 and T203. The band crystal is selected by the diode switch connected to the band switch. The relation between the frequency and band is shown on the schematic. The multiplied signal is then fed from pin 3 to the PLL unit.

For repeater operation, a fundamental crystal at 14.1333 MHz, (X210) is used to generate a heterodyne signal of 127.2 MHz which is 600 kHz higher than the normal heterodyne signal when the band switch is set to the 146.5 MHz segment and X211 (fundamental frequency 14.3222 MHz) is used to generate 128.3 MHz signal which is 600 kHz higher than the normal heterodyne signal when the band switch is set to the 147.0 segment. A relay, RL1001 in the tone burst unit (PB-1461) is used to select the above crystals with the repeater switch, S8, in the ON position. When the NORMAL-REVERSE switch, S9, is set to the NOR position, the relay selects the repeater crystal on transmit that shifts the transmitting frequency down 600 kHz in the 146.5 MHz segment and shifts up 600 kHz in the 147.0 MHz band. The main VFO tuning dial indicates the received frequency.

With S9 in the REV position, the relay selects the repeater crystal on receive that shifts the receiver frequency down 600 kHz in the 146.5 MHz segment and shifts up 600 kHz in the 147.0 MHz segment. The main tuning dial now indicates the transmitted frequency.

ALIGNMENT

Set the MODE switch to USB, the BAND switch to VFO, MARKER off, RPT off. Connect a frequency counter, (YC-500 or equivalent) to test point TP201, and adjust TC201 to set the oscillator to exactly 41.7666 MHz.

Now verify the MARKER signal with the YC-500, or WWV (as described in the alignment for PB-1459). When you have both the 41.7666 MHz and 1 MHz frequencies set, turn the MARK switch on and zero beat the MARKER signal at 144.0 MHz on the VFO tuning dial. This is your starting point. Do not re-adjust the VFO again during the following steps. Switch the BAND switch to 144.5 MHz and adjust TC202 for zero beat. Switch to 145.0 MHz and adjust TC203, then TC204 for the 145.5 MHz position, TC205 for 146.0 MHz, TC206 for 146.5 MHz, TC207 for 147.0 MHz, and TC208 for 147.5 MHz.

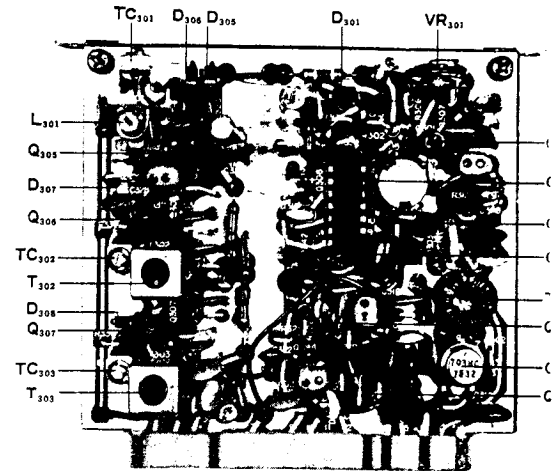
For the "standard" 600 kHz offset, switch to RPT-REV. If you have an FT-221R, put the AUX/600 switch in the 600 kHz position. Set the BAND switch to 146.5 MHz, and the MARKER "ON". Adjust TC210 for zero beat.

Change the BAND switch to 147.0 MHz and adjust TC211 for a zero beat.

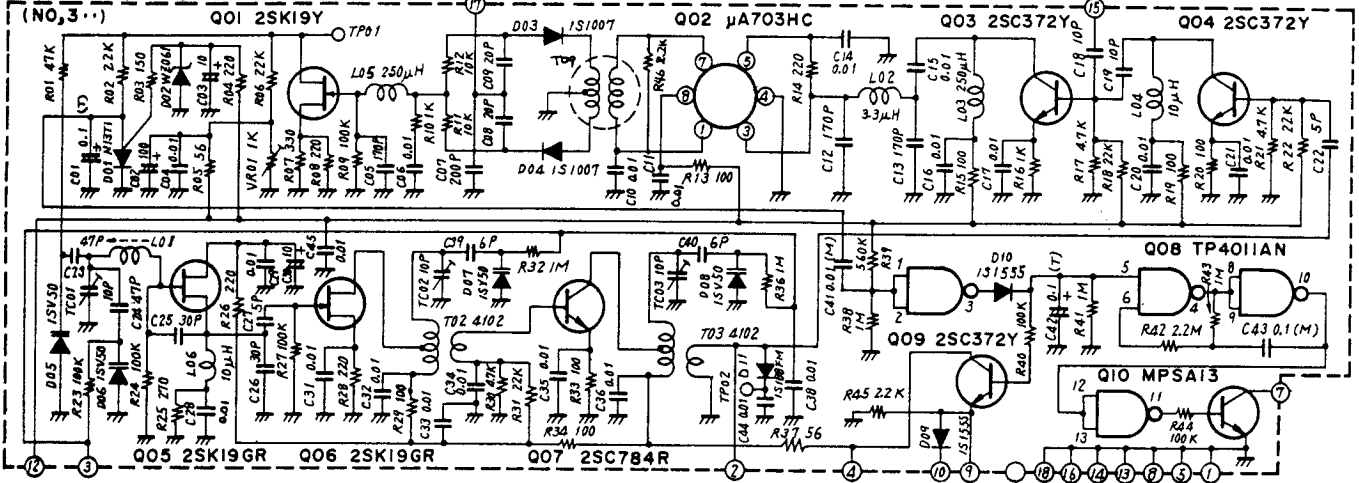
For odd ball offsets, see "CALIFORNIA SPLITS".

Now, move the VFO slightly to get about an 800 Hz note, and check your work by running the band switch from 144.0 MHz to 147.5 MHz and listening for the 800 Hz note. Differences in pitch represent the amount and direction of error. This won't make a frequency meter out of your FT-221, but it will be the next thing to it.

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PB-1455(PLL)



	E(S)	B(G)	C(D)		E(S)	B(G)	C(D)		E(S)	B(G)	C(D)
Q 301	1.9	0.4	4.5	Q 305	1.6	0	5.4	Q 309	0	0.5	8.0
Q 303	0.8	1.3	7.9	Q 306	0	0.9	6.0	Q 310	0	0.7	1.3
Q 304	0.4	1.1	7.5	Q 307	0.5	0.9	7.2				

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Q 302	7.0	-	1.4	-	1.4	-	7.0	7.5						
Q 308	5.4	5.4	0.8	8.0	0.5	6.0	0	8.0	8.0	0	8.0	0	0	8.0

The Phase Locked Loop is a feedback system comprised of a phase comparator (Q302, D303, D304, T309, R311, R312), a low pass filter (L305 and associated components), an error amplifier in the forward path (Q301), and a voltage controlled oscillator (VCO) in the feedback path. (Q305).

The VCO Q305 (2SK19GR) generates a signal between 133.3 MHz and 137.3 MHz, as determined by the settings of L301, TC301, C324, D305 and D306. The varactor diode D305 increases or decreases in value in accord with a DC voltage, which is delivered from the phase detector amplifier Q301 (2SK19Y). A second varactor diode D306 is used to insert a precise fixed offset, in accordance with the band switch setting, to assure a stable lock of the VCO. These adjustments are preset in accord with the table provided in the PB-1456 (Rx RF Unit) circuit description.

The PLL board is active in both transmit and receive modes, using the output of the VCO to establish a high precision mixer source voltage. The VCO output is amplified through two buffer stages Q306 (2SK19GR) and Q307 (2SC784R) to provide isolation from the subsequent receive mixer (Q405 on PB-1456) and transmit mixers Q501 and Q502, located in the Exciter unit, PB-1466.

A portion of the VCO output is also continuously fed to the input of Q304 (2SC372Y) which acts as a buffer amplifier for the mixer Q303 (2SC372Y).

The second (Mixing) signal arrives at Q303 from the local board (PB-1454) through pin 15 which supplies a precise crystal controlled reference signal, nine times greater than the fundamental crystal frequency, providing a local frequency 125.3 - 128.8 MHz (depending on the selected crystal for a given band).

The difference signal is 8.0 to 8.5 kHz, and provides the reference half of the phase comparator. The VFO signal, generated from PB-1465 arrives at the board at pin 17, where it is compared with the local frequency. Any difference is rectified by D303 and/or D304 into a DC voltage, while the sum frequency is filtered out with the L305 network. The DC voltage is amplified through Q301 (2SK19GR) and applied to D305 (1SV50) varactor to drive the VCO in the direction necessary to reduce the phase difference to zero, or "Phase Lock".

When the circuit is initialized, the VCO has no special reference to lock onto, so a programmable unijunction transistor D301 (N13T1) generates a sawtooth DC voltage, which drives the VCO into it's lock/capture range by varying it's output through the VCO's full range. At some point, the PLL senses coincidence, and the PLL theory as outlined takes effect. Should the sawtooth DC voltage reach it's peak several times without achieving a lock, C301 will charge sufficiently to couple a triggering voltage into Q308 (TP4011AN). When the resulting trigger is rectified by D310 (1S1555) and the pulse is stretched with C342, the base of Q309 (2SC372Y) is biased to allow conduction. This in turn causes Q607 on PB-1499 (AF AMP) to conduct, effectively shorting out the audio circuits, and producing a series of slow "popping" sounds as Q607 goes into and out of conduction. Simultaneously, Q507 on PB-1466 (Exciter) is enabled, preventing conduction of Q506, which effectively disables the transmitter, until the PLL "locks".

To warn the operator/user that an unlocked condition is present, the remaining three sections of Q308 (TP4011AN) are wired to provide a blanking pulse, driving the base of Q310 (MPSA 13), the pilot light driver. This causes the pilot lights to flash on and off, which is pretty hard to miss if you are looking at the rig.

ALIGNMENT AFTER REPAIR

1. Set the band switch on the FT-221 to 145.5 and run the VFO to "500".
2. Adjust TC-301 until the voltage at TP-301 reads +5.5 VDC.
3. Set up the range pot, VR301 until the unit stays locked at all positions of VFO and band switch between 144.0 and 148.0, in accord with the instruction book.

For good temperature compensation, D505 1S1555 should be firmly bonded to the heatsink of 2SC730, Q509.

MODIFICATIONS: (PLL UNIT - MID) (About 500 units have this factory mod)

After considerable experience with the PLL unit, it turns out that the Mod using a Zener, chassis re-wiring, etc., can be done much easier, and with all the work done on the board. (No chassis re-wiring required).

This revision "A" modification, supercedes the previous instructions, and eliminates the need for re-wiring of chassis.

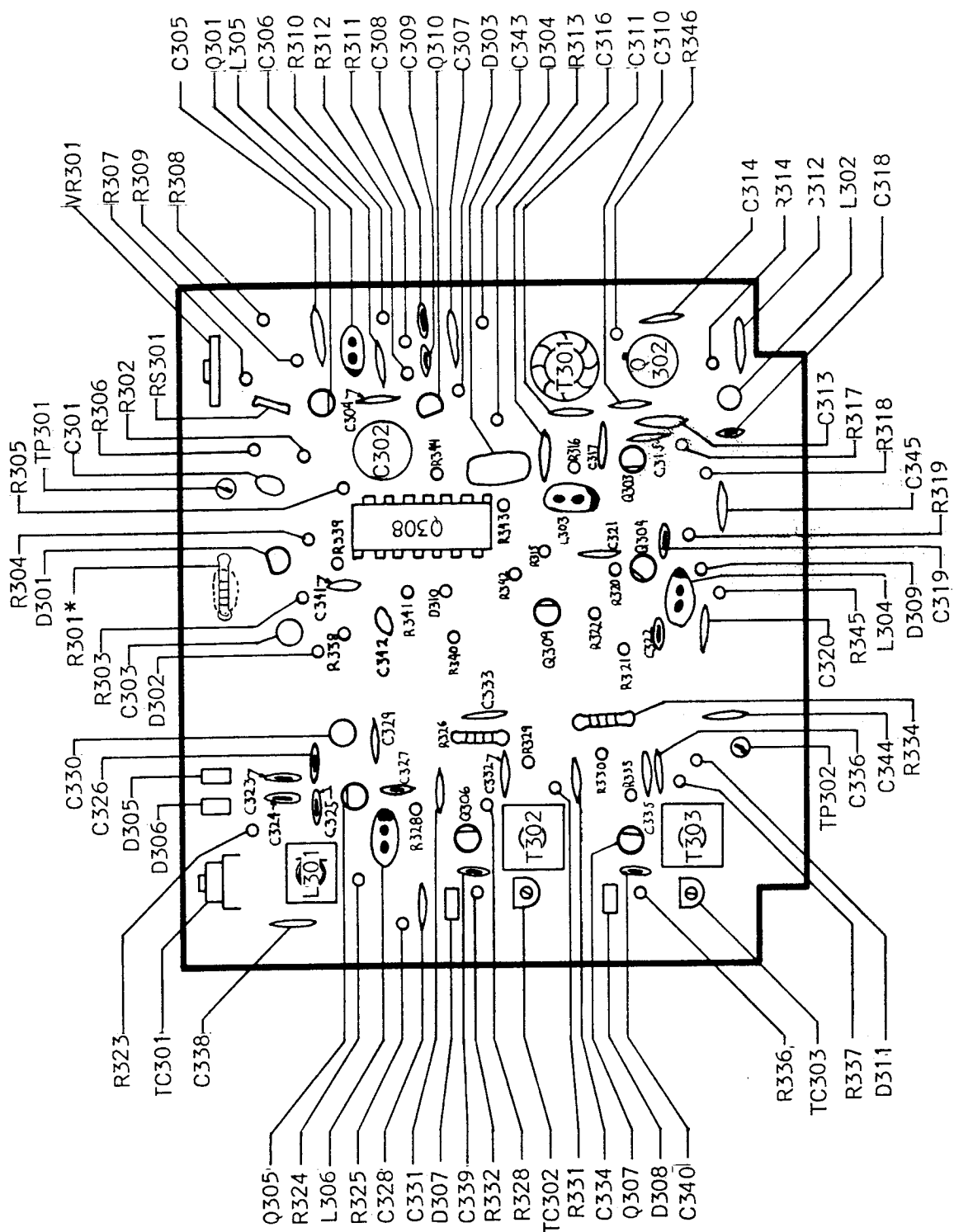
Before beginning this modification, remove all supply voltage from unit.

FOR THIS MOD YOU REQUIRE:

- 2) UJ27 (or 30) pf NPO capacitors
- 1) .001 μ f at 50 WV
- 1) 10mH choke

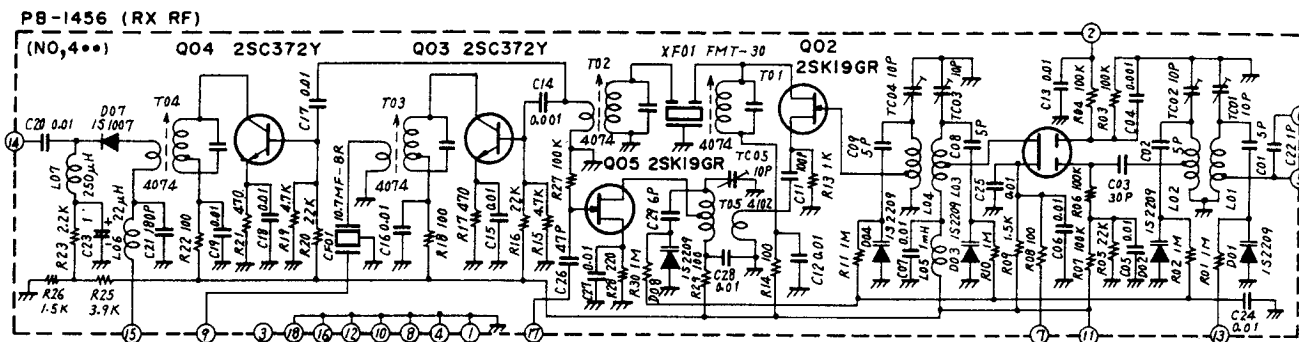
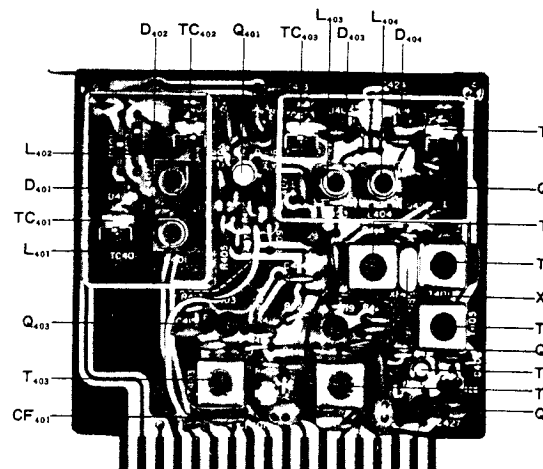
1. Raise the four plastic retaining pins; locate and remove the PLL unit and set transceiver aside, for this board modification.
2. Remove the shield plate from the solder side of the PLL unit by removing the six (6) small screws. Be careful not to lose any screws, since you will need them later for re-assembly.
3. If Q302 and Q303 are MJF-1033 (Motorola) units, replace them with 2SK19GR.
4. Remove C325 and C326, and replace them with two UJ27pf capacitors. These are temperature compensated units.
5. Remove C328 and replace it with a .001 μ f at 50 WV capacitor.
6. Install a 10mH choke across R301 on the solder side of the board.
7. Re-install the shield cover and plug the PLL back into the FT-221.

PLL UNIT PB-1455C



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*NOTE: On some PLL units R301 has been replaced with a 250mH choke.



	E (S)		B (G)		C (D)		G ₂			E (S)		B (G)		C (D)	
	R	T	R	T	R	T	R	T		R	T	R	T	R	T
Q401	1.5	0	1.6	0	8.0	0.1	3.9	0	Q404	0.7	0	1.4	0	7.9	0.1
Q402	1.6	1.1	0	0	7.9	0.1			Q405	1.0	0	0	0	7.7	0
Q403	1.2	0	1.8	0	7.8	0.1									

Rx RF UNIT (PB-1456)

The incoming 144 - 148 MHz signal from the antenna is fed through the Rx contacts of relay RL-1201, located on PB-1470 (inside the Booster Unit) out pin 2 of PB-1470 connector plug to pin 5 of the Rx RF unit. The incoming signal is amplified by Q401, (3SK51) a low noise FET, and then fed to the gate of Q402, (2SK19GR) which acts as the first mixer. The heterodyne oscillator signal originating in the Phase Lock Loop circuit (PB-1455) is fed to the board through pin 17, at 133.3 to 137.3 MHz, producing a difference signal of 10.7 MHz at the drain of Q402.

The input and output circuits of the RF Amplifier are precisely tuned to the center of each of the eight band segments by varactor diodes D401 through D404 (IS2209). As each segment is selected by positioning switch S-2, sections S2C and S2D apply preset voltages to the varactors, in accord with table on page 2-13. These adjustments are located on PB-1459 (Marker Unit).

The 10.7 MHz IF signal is filtered through XF401, a crystal filter (type FMT-30) and applied across two amplifier inputs.

One amplifier, Q404 (2SC372Y) handles the 10.7 MHz signal that will be used for SSB-CW-AM, the other amplifier, Q403 handles the 10.7 MHz used for FM.

Following the SSB-CW-AM mode first, it is amplified by Q404, then passed through a noise blanker gate diode D407 (1S1007) and departs the board at pin 14, to appear at the input of PB-1462 (SSB IF) on pin 3.

The 10.7 MHz FM IF is amplified by Q403, and again filtered through a ceramic filter, CF401 (10.7 MFBR) and departs the board at pin 9, to be applied to the input of the FM-IF board, PB-1463 at pin 17.

ALIGNMENT AFTER REPAIR

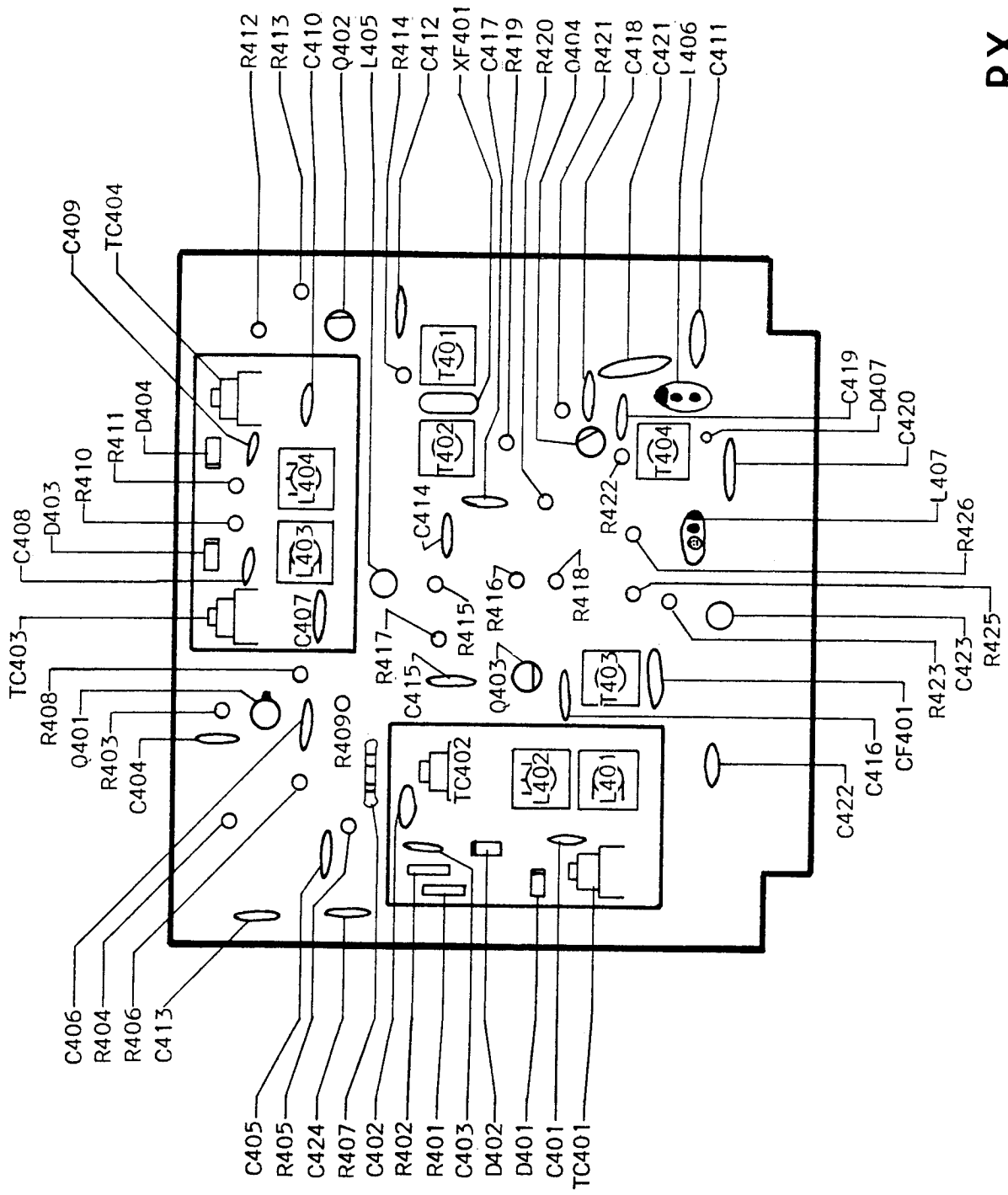
1. Preset the varicap tuning by measuring the voltages with a VTVM connected between the indicated pin and chassis ground, and adjust the variable resistors to get the indicated DC voltages. These potentiometers are located on the Marker Unit, PB-1459. Once set, do not disturb them during subsequent alignment. (Or all the rice will leak out).

Pin No.	3	4	5	6	7	8	9	10
Adjust. VR No.	701	702	703	704	705	706	707	708
Volt. DC. V.	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5

2. Preset the controls as follows:

Band Switch	146
Channel	VFO
RF Gain	Full CW
Mode	USB

3. Set the VFO to 146.200 MHz, with the calibrator signal, and peak TC401, 402, 403 and 404 for maximum indication on the "S" meter.



**RX RF UNIT
PB-1456 A**

MARKER UNIT (PB-1459)

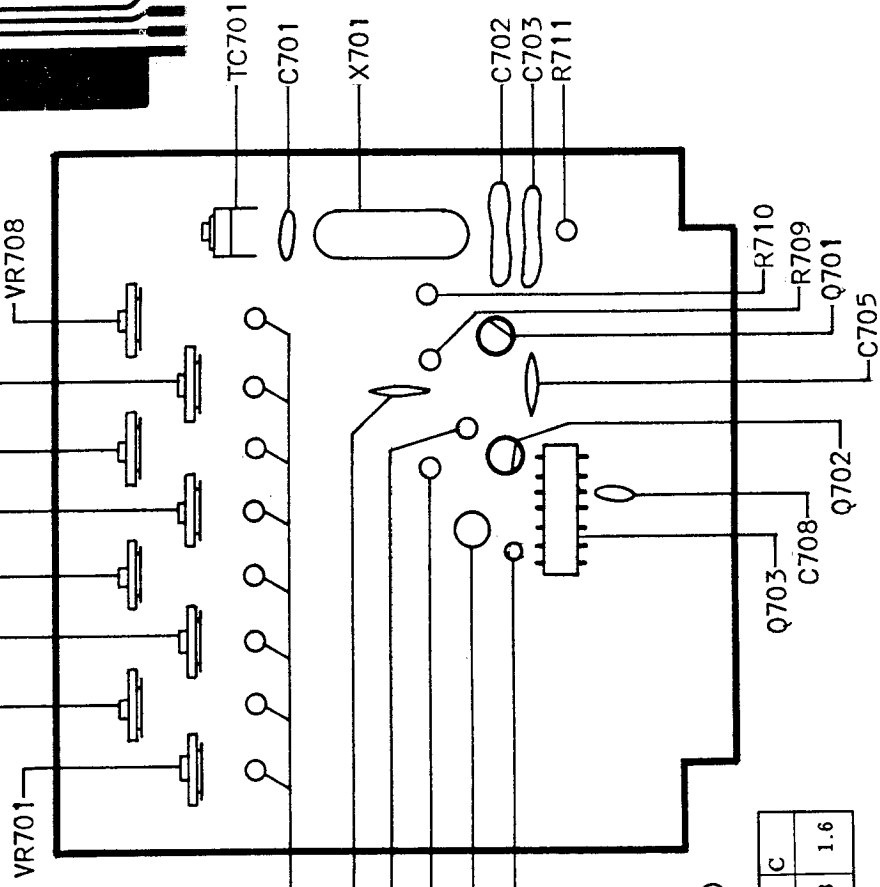
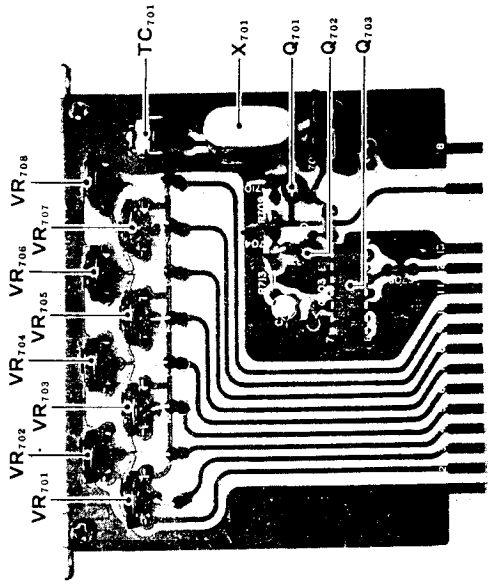
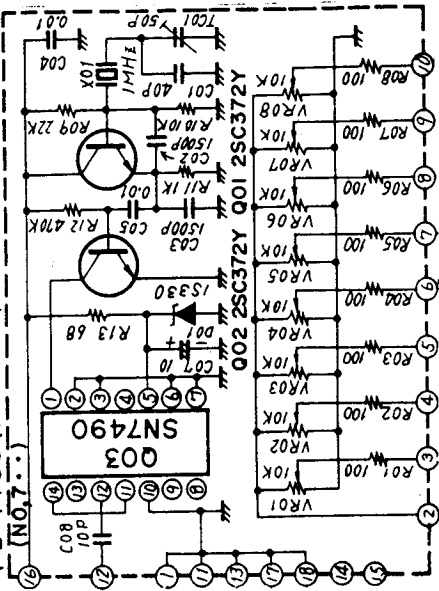
Transistor Q701 (2SC372Y) is arranged in a modified pierce oscillator circuit operating at 1 MHz (fixed by crystal X701). A sine wave signal is coupled through Q702, (2SC372Y) which acts as a Buffer/Amplifier stage for Q703, (SN7490), a "divide by 10" integrated circuit. The 100 kHz output from Q703 leaves the board at pin 12. Closure of switch S-6 (MARK) applies a regulated 8 volts DC to the board through pin 16, and an unregulated 13.5 VDC to relay RL1201 in the Booster Unit (PB-1470). This opens the antenna circuit, and activates the Marker board.

The potentiometers VR1 through VR8 are mounted on this board, but perform no functions related to the Marker. They are used to preset various varactors in the VCO, Rx RF and Exciter tuned circuits. For a more complete discussion of these pots and how to set them, see the circuit description of PB-1456.

ALIGNMENT AFTER REPAIR

Connect a frequency counter (YC-500S) through a 100pf capacitor to the collector of Q702 (2SC372Y). Adjust TC-701 to set the crystal frequency to exactly 1 MHz.

If a counter is not available, use an FRG-7 receiver, and calibrate the fifth or tenth harmonic of the 1 MHz crystal against WWV.



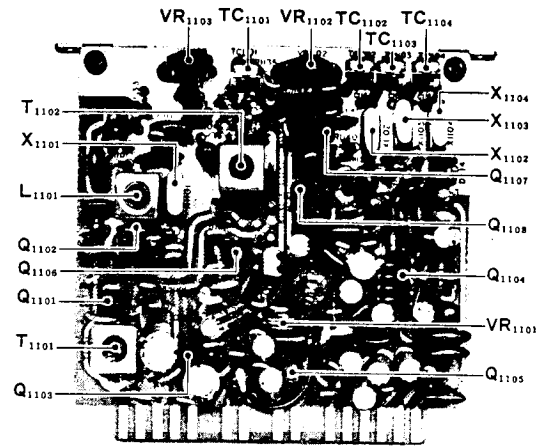
MARKER Unit (Marker Switch.....ON)

	E	B	C	E	B	C	
Q701	1.9	2.4	8.0	Q702	0	0.3	1.6

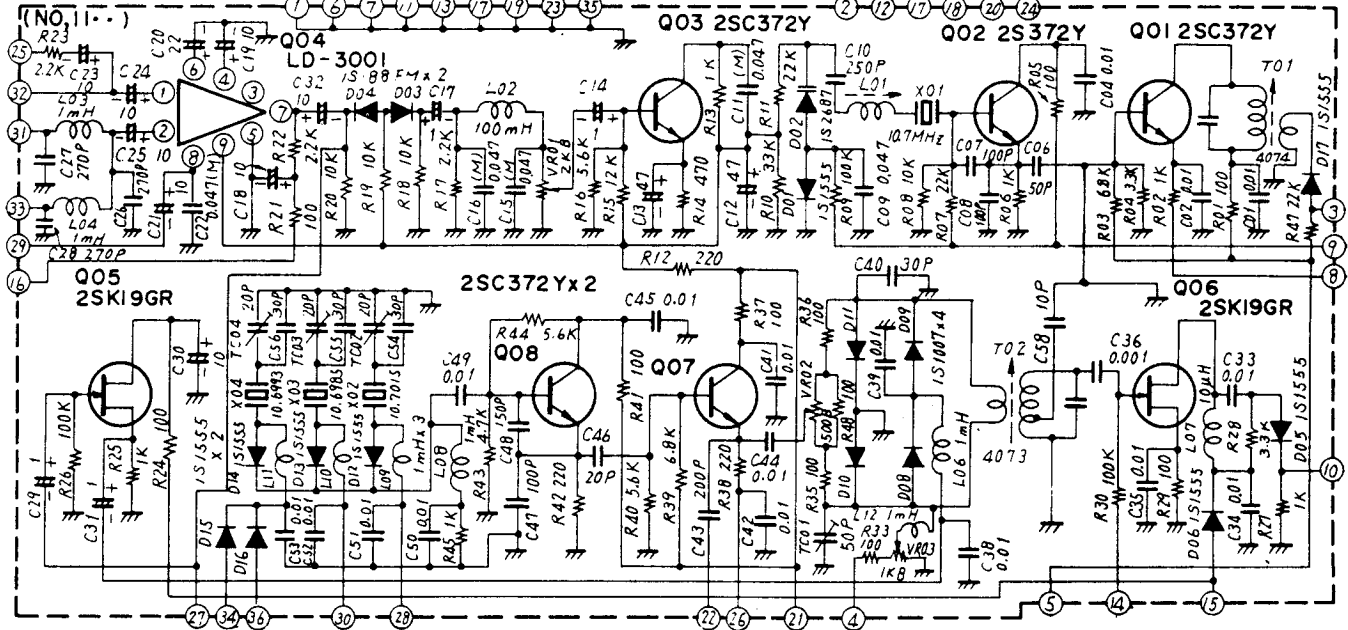
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Q703	1.6	0	0	0	5.1	0	1.4	1.4	0	0.7	1.7	0	0.7

MARKER UNIT PB-1459

MIC AMP UNIT (PB-1460)



PB-1460(MIC AMP)



	LSB						USB						CW						AM						FM					
	E(S)		B(G)		C(D)		E(S)		B(G)		C(D)		E(S)		B(G)		C(D)		E(S)		B(G)		C(D)		E(S)		B(G)		C(D)	
	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T
Q1101	0	0	0	0	0	0	0	4.9	0	2.6	0	8.0	0	1.9	0	2.6	0	7.8	0	2.2	0	2.6	0	7.8						
Q1102	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.6	0	2.2	0	7.2						
Q1103	1.5	1.5	2.1	2.1	3.9	3.9	1.5	1.5	2.1	2.1	3.9	3.9	1.5	1.5	2.1	2.1	3.9	3.9	1.5	1.5	2.1	2.1	3.9	3.9						
Q1105	0	2.2	0	0	0	7.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
Q1106	0	0.7	0	0	0	7.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
Q1107	3.0	3.0	3.4	3.4	6.8	6.8	3.0	4.9	3.4	3.4	6.8	8.0	2.7	3.0	3.4	3.4	6.8	6.7	2.7	2.7	3.4	3.4	6.8	6.8						
Q1108	2.5	2.5	1.9	1.9	6.8	6.8	2.5	2.5	2.1	2.3	6.8	6.8	2.3	2.5	1.4	1.8	6.9	6.8	2.3	2.3	1.3	1.4	6.9	6.9						

	1 2 3 4 5 6 7 8 9									
	R	T	R	T	R	T	R	T	R	T
	Q1104	4.1	2.4	1.8	1.7	0	0	0	0.7	6.2
	T	4.1	2.4	1.8	1.7	0	0.5	3.3	1.2	6.9

MIC AMP UNIT (PB-1460)

The speech signal from the microphone is fed from pin 2 of J5 to pin 31 through the first microphone amplifier, Q1104, (LD3001). The input impedance of the microphone amplifier is 600 ohms. This audio signal is controlled in amplitude by the MIC GAIN control between pins 29 and 32, and is amplified by the second microphone amplifier, the other half of Q1104, then applied to the source follower Q1105, (2SK19GR) to be delivered to the ring modulator D1108 through D1111, (1S1007).

The carrier oscillator Q1108, (2SC372Y), oscillates at 10.7015 MHz for LSB, 10.6985 MHz for USB and 10.6993 MHz for AM/CW depending upon the MODE switch position. In the CW mode, the carrier oscillator oscillates at 10.6993 MHz for transmit and 10.6985 MHz for receive producing an 800 Hz beat note in the receive mode. In the AM mode, the carrier oscillator does not function while receiving. The MODE switch selects the crystal by means of a diode switch. The output from the oscillator is fed through the buffer amplifier Q1107, (2SC372Y) to the balanced ring modulator D1108 through D1111 (1S1007). The carrier signal output from the buffer amplifier, Q1107, is fed from pin 22 to the SSB IF unit for SSB and CW reception. Carrier balance is obtained with potentiometer, VR1002, and the trimmer capacitor, TC1101. The double sideband, suppressed carrier signal is amplified by Q1106, (2SK19GR) and fed from pin 10 to pin 5 of the SSB IF unit (PB-1462). In the AM and CW modes, the balanced modulator is unbalanced by the DC voltage applied from pin 4 and the carrier signal is fed through T1102 to carrier amplifier Q1101, (2SC372Y). The amplified carrier is fed from pin 3 to the EXCITER unit (PB-1466).

The audio signal output from Q1104 is fed from pin 27 to pin 12 of the EXCITER unit to be amplified to a sufficient level for low level AM modulation.

In the FM mode, a crystal oscillator Q1102, (2SC372Y) generates a 10.7 MHz signal which is shifted by the varactor diode D1102, (1S2687) in accordance with the speech voltage. The audio signal from the microphone amplifier, Q1104, is applied to the IDA (instantaneous deviation adjustment) circuit. The IDA circuit, composed of diodes D1103 and D1104, (1S188FM) clips both positive and negative peaks when they exceed a pre-determined level in order to limit the maximum deviation of the transmitter.

The limited audio signal is applied through a low pass filter and deviation potentiometer, VR1101, to the audio amplifier Q1103, (2SC372Y) where it is amplified and applied to the modulator, varactor diode D1102. The low pass filter limits the transmitter modulation spectrum by attenuating the frequencies above the speech range.

The frequency modulated signal is then amplified by Q1101, (2SC372Y) and fed through the output transformer T1101 to pin 5 of the EXCITER unit (PB-1466).

When the MODE switch is in the CW position, the emitter circuit of Q1107 and Q1101 are connected to the key jack through pin 8 and pin 26.

ALIGNMENT

Connect a dummy load (YP-150) to the antenna receptacle and insert a key into the key jack (J-3). Switch the mode to CW, depress the key and peak T1101 and T1102 as indicated on the YP-150.

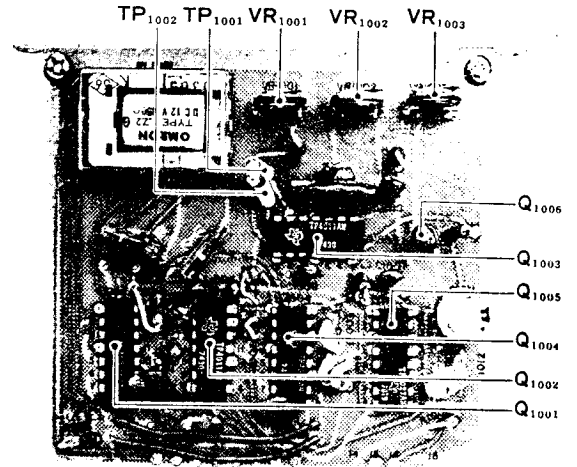
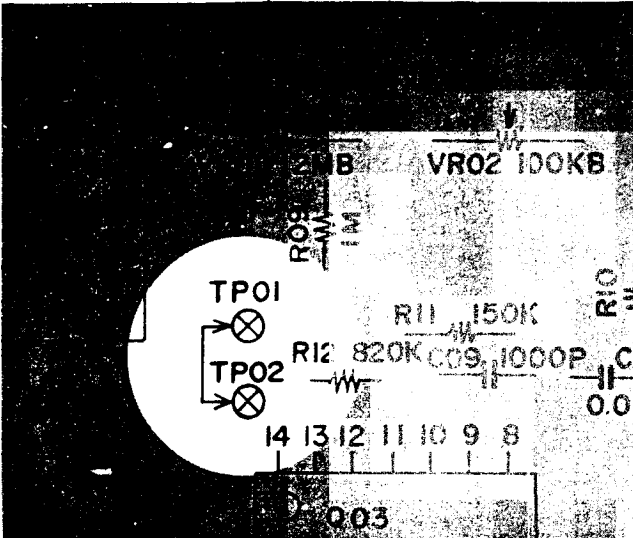
Adjust VR1103 until the transceiver output begins to saturate. Release the key and switch to USB. Adjust VR1102 and TC1101 for minimum power when PTT/MOX switch is in MOX (unit transmitting) and MIC GAIN control is full CCW. The best suppression detector is an external receiver tuned to the output frequency. When using an external receiver, adjust VR1102 and TC1101 for minimum "S" meter reading.

Connect the output of an audio oscillator to the microphone input. Set the MODE switch to an SSB mode. Apply 1 kHz audio signal to the microphone input and adjust the MIC GAIN control or the output level from the audio oscillator for 10 watts RF output on the dummy load. Change the audio frequency to 350 Hz, and adjust TC1102 for LSB and TC1103 for USB to obtain 2.5 watts output. Check if the power output decreases to 2.5 watts when the audio frequency is moved to approximately 2600 Hz.

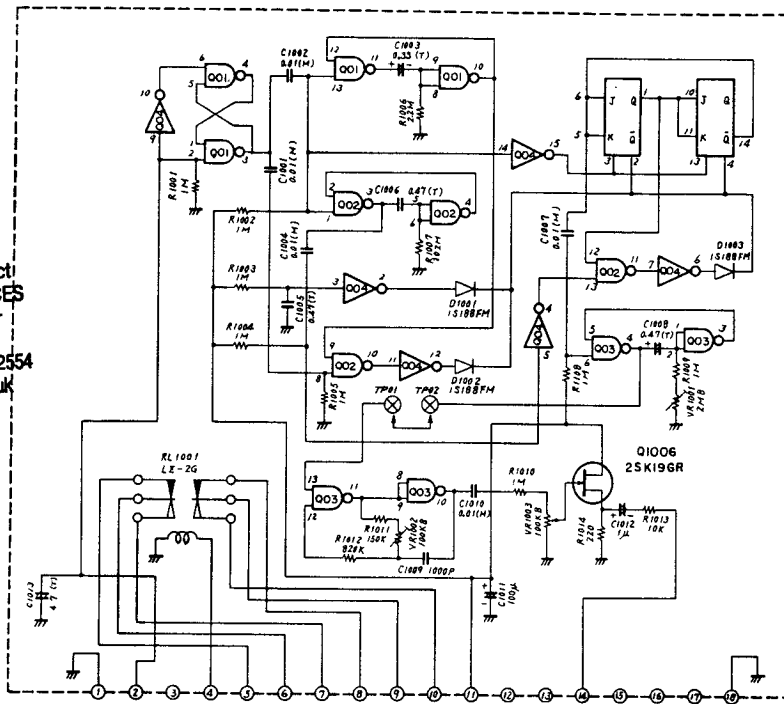
Tune the transceiver in the USB mode and monitor the transmitted USB signal for the most natural voice quality while using another receiver. Change the mode of the transceiver to AM (with the monitor receiver in the USB mode), and adjust TC1104 for a zero beat against a carrier signal.

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		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Q1001	R	0	0	8.0	0	8.0	8.0	0	0	0	8.0	0	8.0	7.2	8.0		
	T	8.0	8.0	0	8.0	0	0	0	0	0	8.0	0	8.0	7.2	8.0		
Q1002	R · T	7.2	8.0	0	8.0	0	0	0	0	8.0	8.0	8.0	0	0	8.0		
Q1003	R · T	0	0	8.0	0	8.0	7.3	0	8.0	8.0	0	8.0	7.2	0	8.0		
Q1004	R	8.0	0	7.2	0	7.3	0	8.0	0	0	8.0	8.0	0	0	7.2	0	8.0
	T	8.0	0	7.2	0	7.3	0	8.0	0	8.0	0	8.0	0	0	7.3	0	8.0
Q1005	R · T	0	8.0	0	0	8.0	8.0	0	0	0	0	0	0	0	8.0	0	8.0

	S	G	D
Q1006	0.9	0	8.0

TONE BURST UNIT (PB-1461)

The tone burst can be activated only when the unit is in the FM mode, and the RPT switch is on.

Keying the microphone PTT switch twice within one second will activate the unit and supply a tone between 1 kHz and 2 kHz (adjustable with VR1002), and for a duration up to one second (adjustable with VR1001). The signal level is set using VR1003.

The rapid switching transients caused by keying the unit twice are integrated through R1015 and C1013, which triggers the one shot multivibrator and control circuits, made up of Q1001, Q1002, Q1003 (TP4011AN) and Q1004 (TP4049AN). A positive logic enables the tone oscillator Q1003 (TP4011AN) whose output is buffered and smoothed through Q1006 (2SK19GR). The tone burst leaves the board at pin 14, and is applied to pin 29 of the MIC AMP unit (PB-1460).

ALIGNMENT

The adjustment of this unit should be done after the FM deviation alignment has been completed. Remove the tone burst unit from the chassis and unsolder the connection between the two test points TP01 and TP02 in order to obtain a continuous tone signal during the alignment. Insert the unit back into its socket.

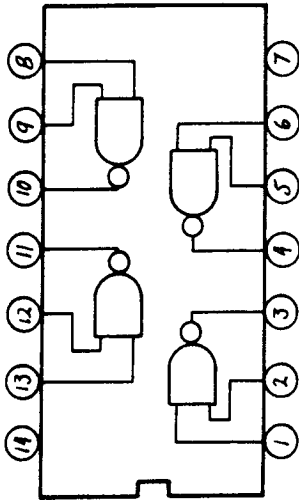
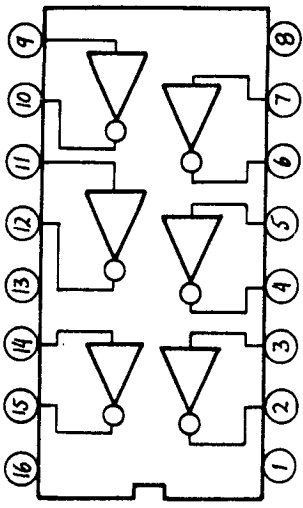
Set the MIC GAIN control to the 2 o'clock position and the VOX GAIN control to the MOX position. Measure the burst tone signal frequency at pin 14, with a frequency counter (such as a YC-500) then adjust VR1002 to the desired frequency. Adjust VR1003 for ± 3.5 kHz deviation.

Set the VOX GAIN control to the PTT position and remove the unit from its socket. Resolder the disconnected test points and reinstall it into its socket.

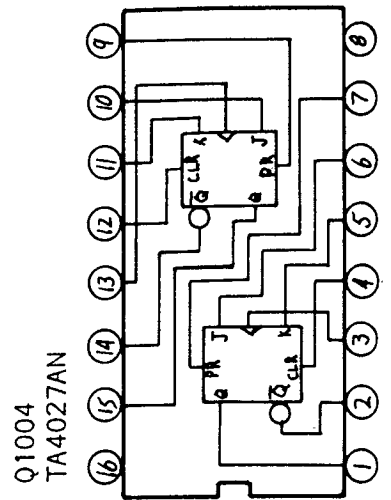
The burst signal will be automatically transmitted when the PTT switch on the microphone is keyed twice as, i.e., key 0.5 second, receive 0.5 second and then transmit. The deviation of the burst signal is preset at the factory to approximately 0.5 second. It may be adjusted with VR1001. A clockwise rotation produces a longer deviation.

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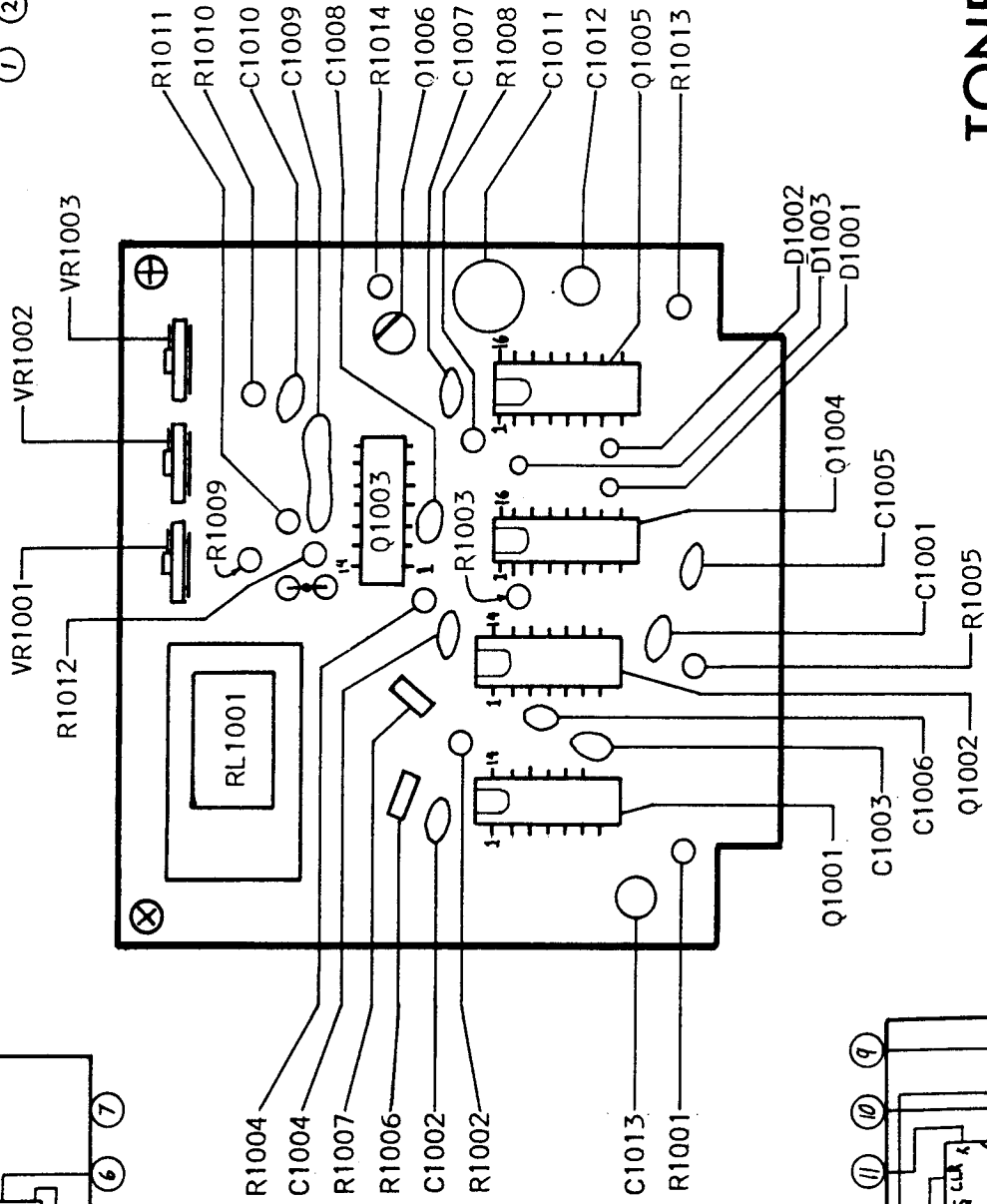
Q1005
TA4027AN



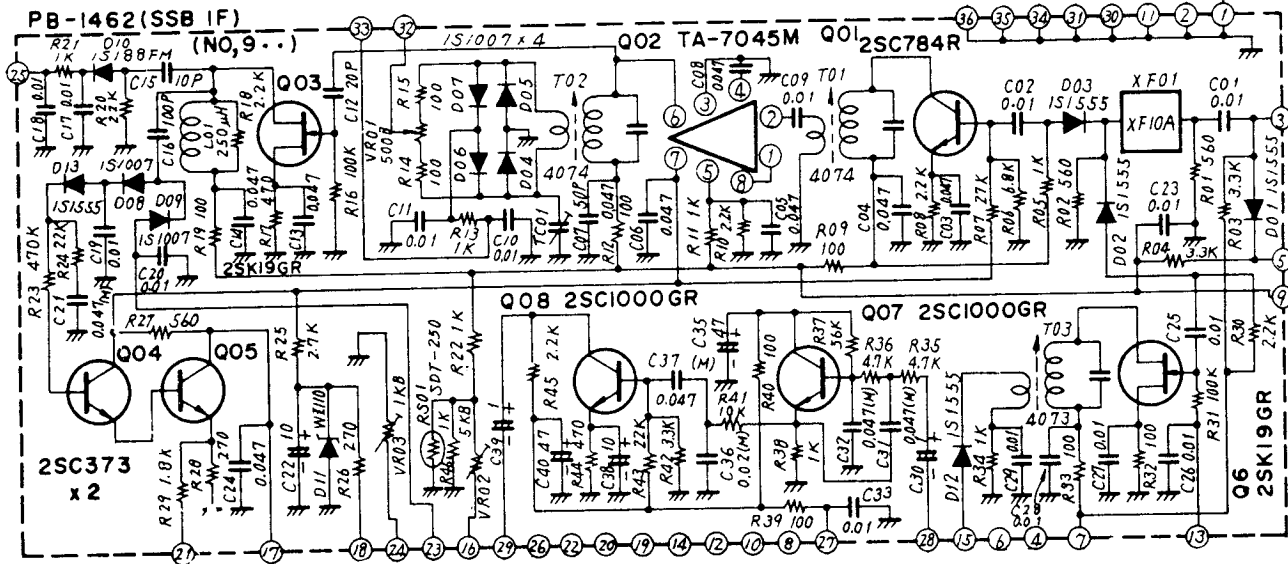
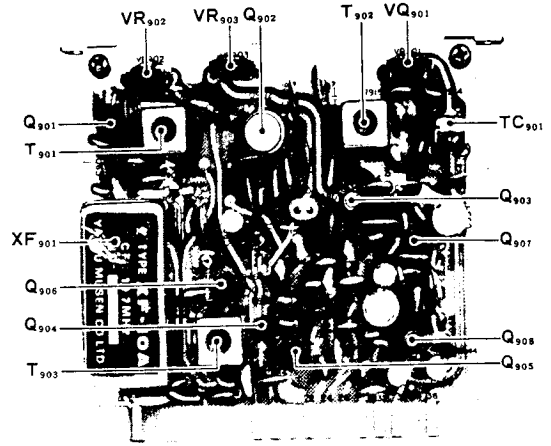
Q1001-Q1003
TP4011AN



Q1004
TA4027AN



tone burst unit PB-1461



	E(S)		B(G)		C(D)			E(S)		B(G)		C(D)			E(S)		B(G)		C(D)	
	R	T	R	T	R	T		R	T	R	T	R	T		R	T	R	T	R	T
	Q901	0.7	0	0.7	0	7.3		0	Q905	0	0	0.7	0		7.2	0	Q908	0.3	0.3	1.0
Q903	1.1	0	0	0	7.8	0	Q906	0	0.6	0	0	0	7.0							
Q904	0.7	0	0.7	0	7.3	0	Q907	5.3	5.3	5.9	5.9	6.8	6.8							

		1	2	3	4	5	6	7	8
Q902	R	0	1.2	0	1.8	5.5	7.6	7.3	0
	T	0	0	0	0	0	0	0	0

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SSB IF UNIT (PB-1462)

In addition to performing SSB IF functions, this board also has a two stage audio amplifier, the AGC/S-meter amplifiers, and AM detection functions.

On receive, the incoming 10 MHz from pin 14 of the receiver RF board (PB-1456) is applied to pin 3, and is fed through the crystal filter XF-10A (XF901) to the IF amplifiers Q901 (2SC784R) and Q902 (TA7045M). The output is applied to the ring demodulator consisting of diodes D904 through D907 (1S1007x4).

Carrier injection is applied to the demodulator through pin 32, using R914, R915, TC901 and VR901 to balance the network.

Selection of USB/LSB is accomplished by supplying the demodulator with either 10.6993 MHz, or 10.7015 MHz from the MIC AMP board oscillators.

The detected SSB audio output leaves the board at pin 33, passes through mode switch S3D and re-enters the board at pin 28, where Q907 and Q908 (2SC1000GR) pre-amplify the audio. The pre-amplified audio leaves the board at pin 29 and goes to the AF AMP unit (PB-1499).

AM detection is provided by picking off the 10.7 MHz IF signal from Q902, (TA7045M) amplifying it through Q903, and detecting it with diode D910 (1S188FM), filtering with a low pass network consisting of C917, R921 and C918, and feeding the resulting audio out of the board from pin 25 to switch S3D, returning to the board at pin 28 for amplification.

AGC is picked off Q903 through C916, rectified with diode D913 (1S1555), and D908 (1S1007).

The half wave rectified signal is amplified through Q904 (2SC373) and controls the gain of IF amplifiers Q901 and Q902. Q905 output leaves the board at pin 17 to control the gain of the RF amplifier Q401, located in the Rx RF unit, (PB-1456).

Q905 also acts as the "S" meter driver, sending out a DC voltage proportional to the AGC voltage through pin 21 to the DISC/SM switch and then to the "S" meter.

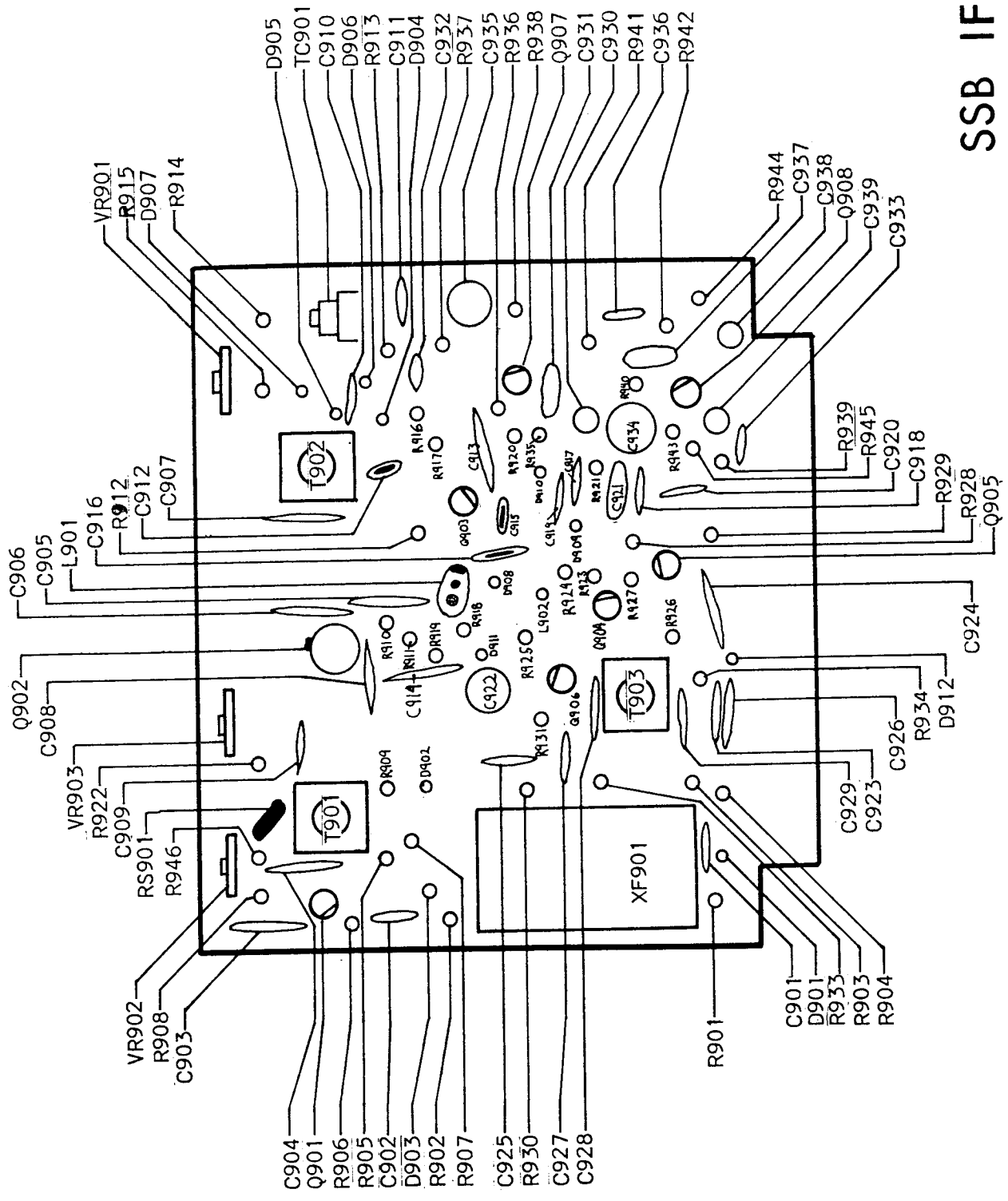
In the transmit mode, RF at the desired frequency is generated as selected by the mode switch S3, in the MIC AMP board (PB-1460) and arrives at the SSB IF at pin 5, as a modulated DSR signal. In the transmit mode, +8 volts is applied to steering diodes D901 (1S1555) and D902, routing the signal through filter XF901 (XF-10A). The resulting SSB signal is amplified through Q906 (2SK19GR) and leaves the board at pin 15 enroute to pin 3 of the Exciter (PB-1466).

ALIGNMENT

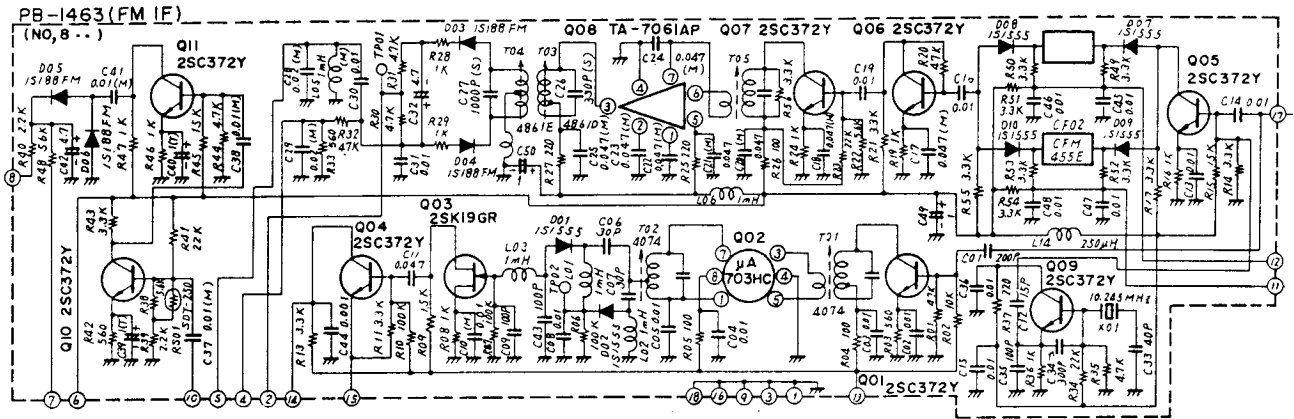
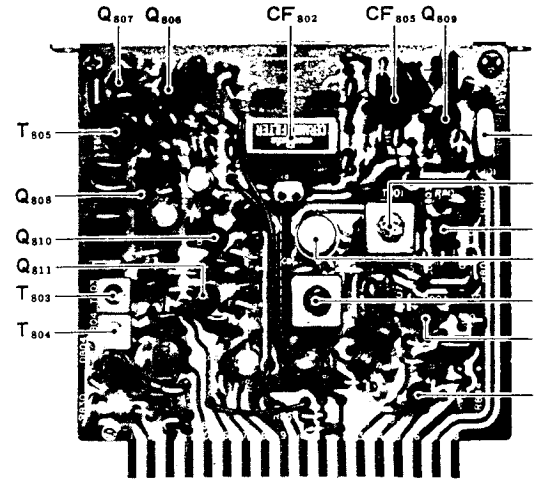
Set the controls as follows:

CHANNEL	-	VFO
MODE	-	CW
DSC	-	OFF
RF GAIN	-	FULL CW
MARKER	-	ON (up position)

Tune the transceiver for maximum S-meter reading at a marker signal, then peak T901 and T902. Switch the calibrator off, and set the mode switch to either LSB or USB, with the RF GAIN fully CCW. Adjust VR901 and TC901 (Carrier Null) until the S-meter reads exactly full scale. Switch the mode switch to the CW position and verify it is still exactly full scale.



SSB IF UNIT
PB-1462



	LSB.USB.CW AM			FM				LSB.USB.CW AM			FM				LSB.USB.CW AM			FM		
	E(S)	B(G)	C(D)	E(S)	B(G)	C(D)		E(S)	B(G)	C(D)	E(S)	B(G)	C(D)		E(S)	B(G)	C(D)	E(S)	B(G)	C(D)
Q801	1.8	2.5	7.7	1.8	2.5	7.7	Q805	0	0	0	0.6	1.3	2.9	Q809	0	0	0	0.6	1.3	7.0
Q803	0	1.9	5.1	0	1.9	5.1	Q806	0	0	0	1.4	2.1	2.5							
Q804	5.8	5.8	5.3	5.8	5.8	5.3	Q807	0	0	0	0.7	1.4	7.0							

★FM Transmit.....0V

		1	2	3	4	5	6	7	8
Q802	T · R	7.0	—	1.5	0	1.5	—	7.0	7.5
Q808	FM · R	1.8	1.8	6.8	0	5.5	1.8	1.8	
	T · R	0	0	0	0	0	0	0	

FM IF UNIT (PB-1463)

The FM IF signal from pin 17 of this unit is fed to the second mixer Q805, (2SC372Y) where the 10.7 MHz signal is mixed with 10.245 MHz signal generated by the second heterodyne oscillator Q809, (2SC372Y) producing a 455 kHz second IF signal. The 455 kHz IF signal is fed through the ceramic filter, CF802, to the second IF amplifiers Q806 and Q807, (2SC372Y) and the amplifier limiter Q808, (TA7061AP) which removes any amplitude modulation component on the signal. The output from Q808 is applied to the discriminator D304 and D305, (1S188FM). The discriminator produces an audio output which is then fed to the common audio amplifier stage in SSB IF unit through the MODE switch.

When no carrier is present in the 455 kHz IF, the noise at the discriminator output is fed through the squelch threshold potentiometer, VR6, to the noise amplifiers Q810 and Q811, (2SC372Y) and rectified by D805 and D806, (1S188FM). The DC voltage is applied from pin 8 to the squelch controller Q607, (2SC372Y) located on the AF AMP unit, (PB-1499).

The 10.7 MHz signal is also applied to the noise blanker amplifier Q801, (2SC372Y). The signal is amplified by Q801, (2SC372Y) and Q802, (μ A703HC).

The noise rectifier diodes D801 and D802, (1S1555) produce a DC pulse which is amplified by following noise pulse amplifier Q803, (2SK19GR).

Under normal conditions, Q803 conducts, producing a cut-off voltage to the base of the gate controller Q804, (2SC372Y) in turn the high collector voltage of Q804 is supplied from pin 15 to the gate diode D407, (1S1007) in the Rx RF unit on PB-1456 which then conducts to pass the signal freely. With narrow pulse noise, Q804 conducts, causing its collector voltage to drop and causing the gate diode D407 to disconnect the IF signal during the period that the noise pulse exists.

ALIGNMENT OF THE FM IF UNIT PB-1463

Alignment of this board requires a stable, precise source of 455 kHz, (with a precision attenuator) a high impedance VTVM, and an extender board.

Step 1

- a. Install the PB-1463 with the extender board, and turn the FT-221 on.
- b. Connect the VTVM to TP-802 (bottom right, as you face the board).
- c. Soften the wax holding the slugs on the two large metal transformer cans and with your nylon hex tool, tune T-801 and T-802 for peak reading on the meter.
- d. Reseal the slugs by melting the wax, and move the VTVM to TP-801 (bottom left, as you face the board).

Step 2

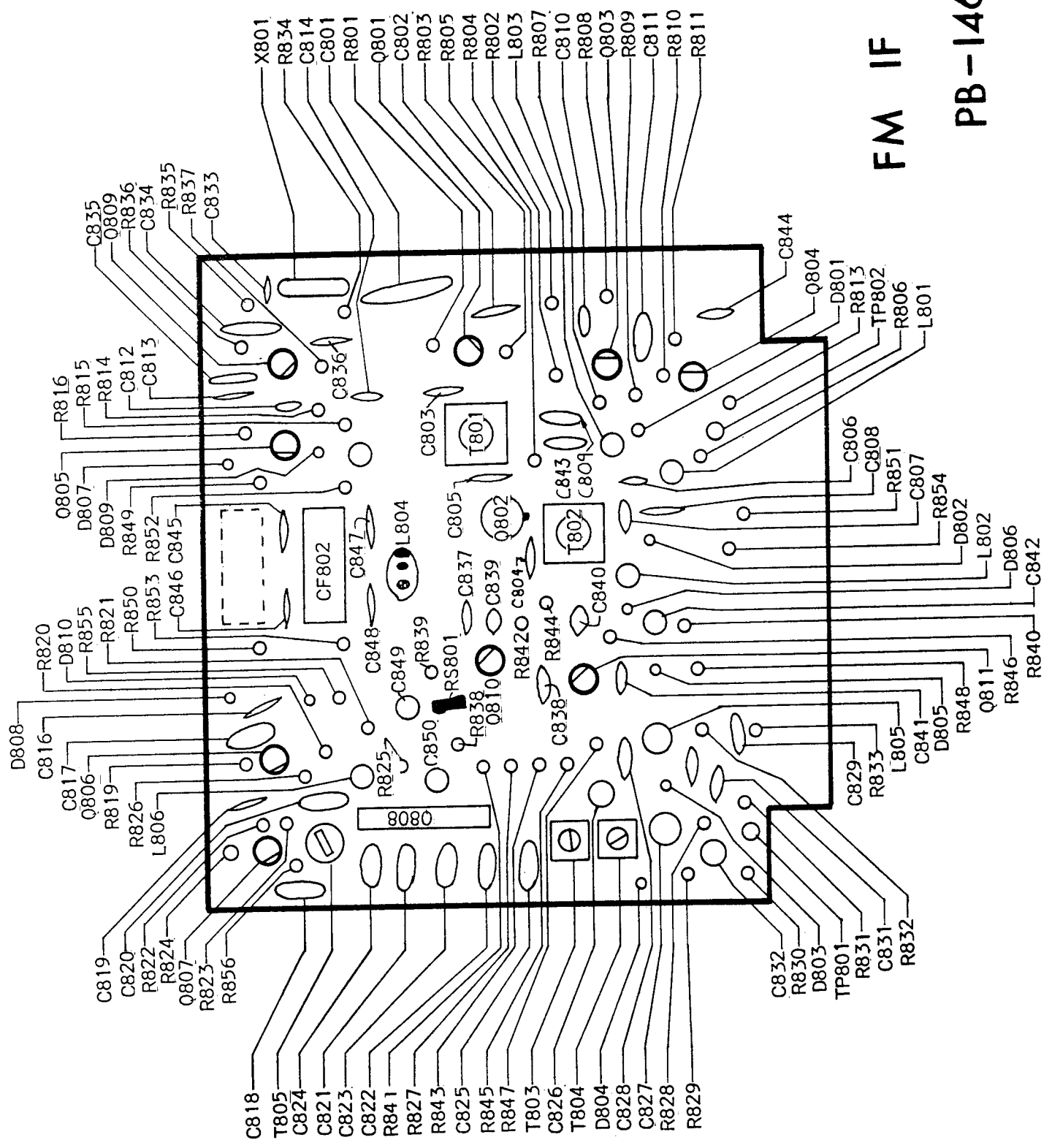
- a. Detune T-804 slightly (1/4 turn) and then apply a 455 kHz unmodulated signal to pin 17.
- b. Reduce the signal input level to as low a level as possible while still getting a reading on the VTVM.
- c. Peak T-803 and T-804, reducing the generator level as required to minimize limiting.
- d. Retune T-804 to zero (null) position, then turn off the unit.
- e. Remove the test equipment and extender. Re-install PB-1463.

Reset the discriminator meter center as follows:

Preset the controls:

CHANNEL	-	VFO
MODE	-	FM
DISC	-	OFF (Down position)
RF GAIN	-	Full CW
MARKER	-	ON (Up position)

Tune the FT-221 for maximum S-meter reading at a marker signal. This maximum has a 3 kHz width, and the VFO should be set to the center of the signal. Turn the DISC switch on (up) and adjust VR-605 (on PB-1499, AF AMP) until the meter indicates mid point on the scale. Check that the meter moves left and right when the VFO is moved up and down in frequency. Now set the VFO exactly 10 kHz lower than the zero frequency (center meter) indication, and adjust the "DISC" pot VR-606 until the meter indicates "2" on the lower scale.



FM IF UNIT

PB-1463

VFO UNIT (PB-1465)

The printed board assembly is mounted inside the VFO mechanical assembly, as shown. Q1301 (2SC372Y) generates an 8.000 to 8.500 MHz signal, providing a 500 kHz spread. Drift is minimized through use of numerous high quality components, rigid mechanical construction, and a differential trimmer capacitor (TC1301) arranged to compensate the parallel tuned Colpitts oscillator for temperature drifts. The oscillator output is coupled through the FET buffer Q1302 (2SK19GR) to provide impedance isolation, and a second buffer Q1303 (2SC372Y) increased the power level sufficiently to drive the next stage, located on the FIX unit (PB-1453). The oscillator signal leaves the VFO through a feed through capacitor (C1317) and is applied to pin 11 of PB-1453.

ALIGNMENT

Set the capacitor to full mesh. Adjust the dial drum and face plate to line up the "end of travel" marks. Go to the other extreme limit (out of mesh) and verify that it also lines up properly.

Tracking and drift compensation requires patience and a delicate touch. The rear section of the dual gang capacitor (VC1301) has its end plates slotted in four places, providing five plate segments.

Once the mechanical limits are established and correct, those segments must be carefully bent to provide accurate electrical tracking to within 1 kHz across the dial.

Set the drum at 200/700 indicated position, and the 0-100 dial to zero, so the mechanical alignment is tracking properly.

Now turn on the MARKER, and locate the zero beat point.

Loosen the lock nut on TC1302 and move the capacitor slightly. Locate your zero beat again. Move the capacitor in small increments until the zero beat point agrees exactly with the dial indicated frequency, then re-tighten the lock nut.

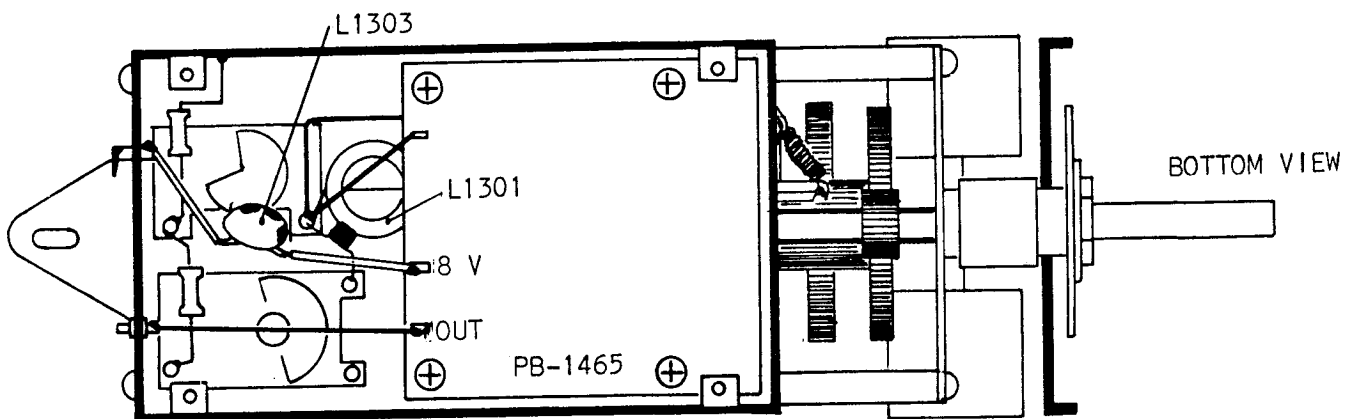
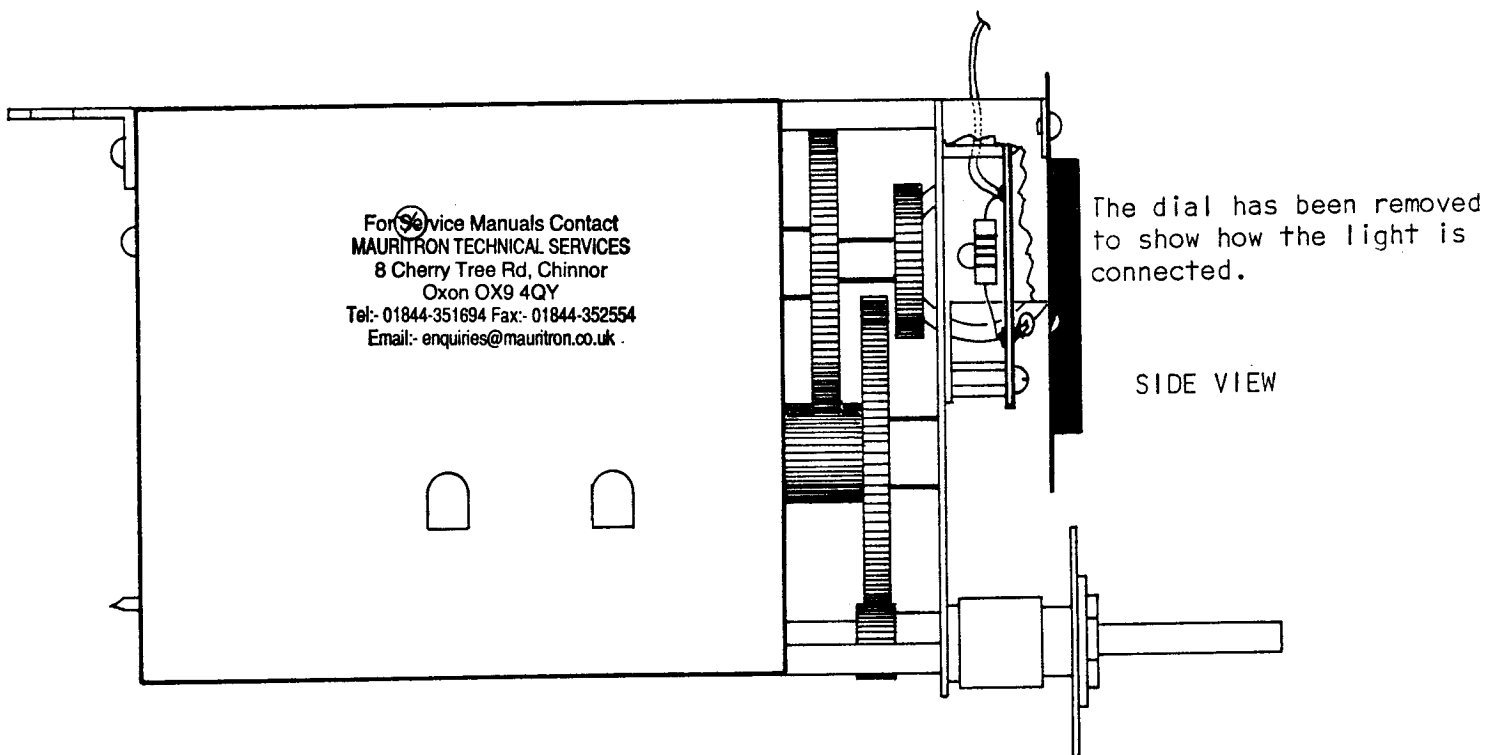
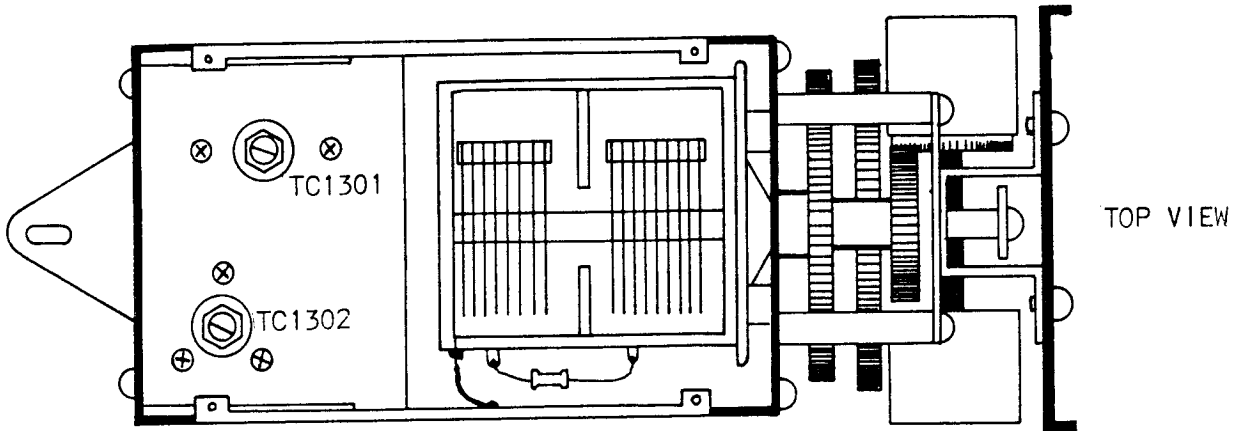
Now check the tracking by rotating the dial through its range and verify that the zero beat and indicated agree within 1 kHz at each calibration point.

If non linearity is apparent, bend the individual five segments on the rear plate of the dual capacitor in or out to flatten the curve. A chunk of graph paper is very useful, especially for the relatively new tech.

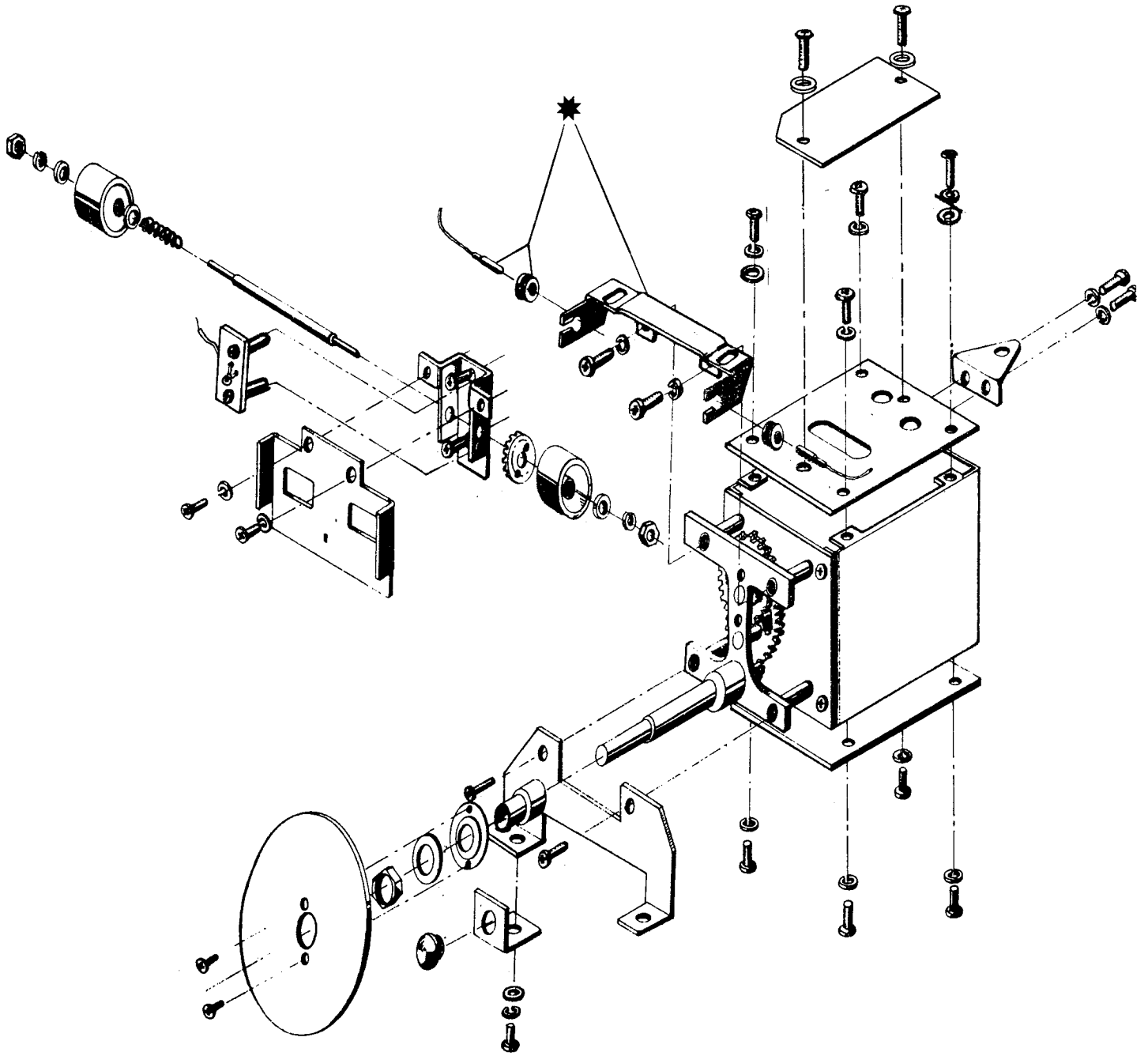
While VFO tracking alignment is time consuming, and even a bit frightening to some, once you do a few, and understand the principals, it is a normal shop activity thereafter.

VFO UNIT

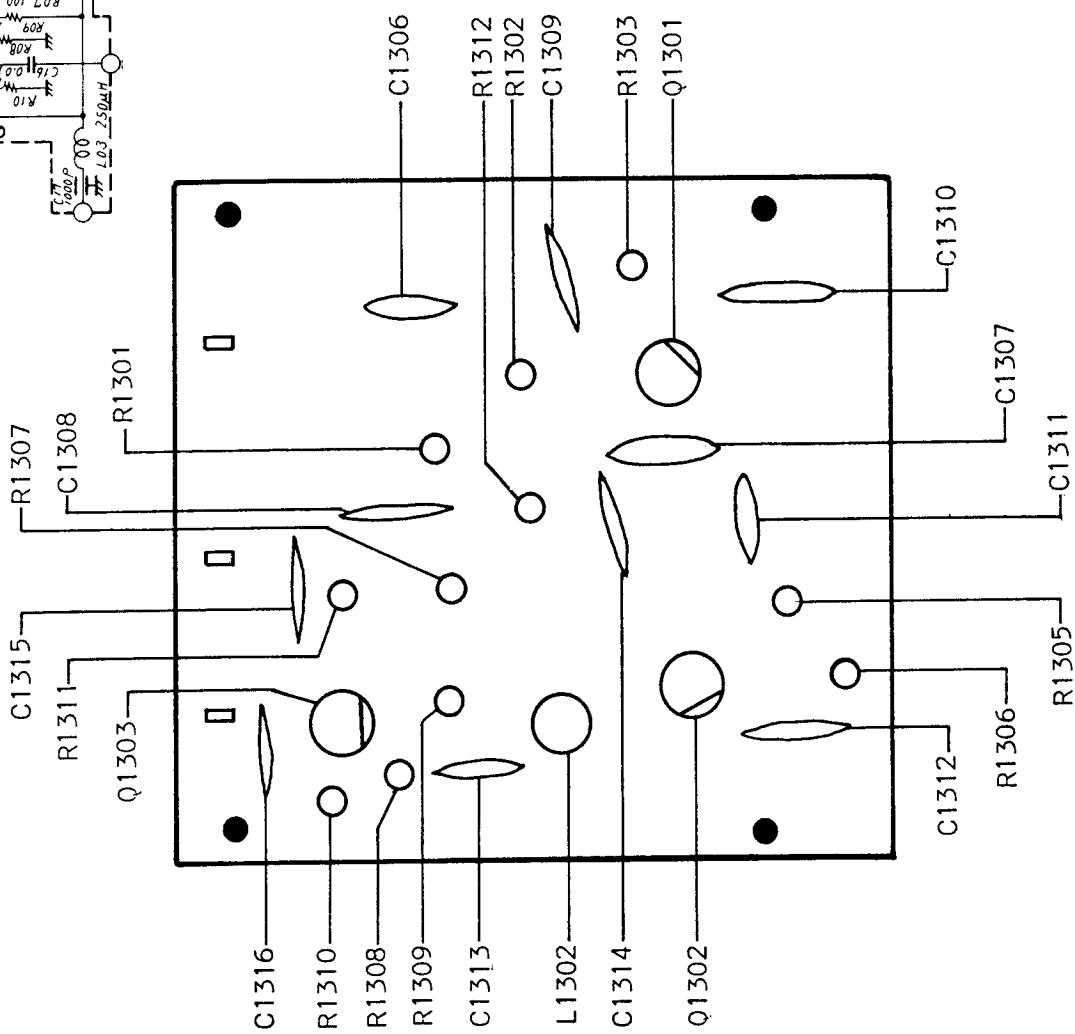
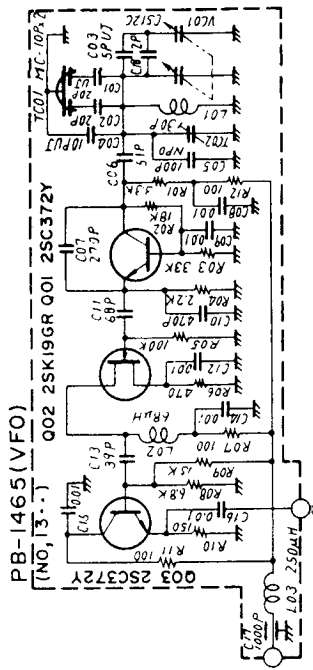
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VFO ASSEMBLY



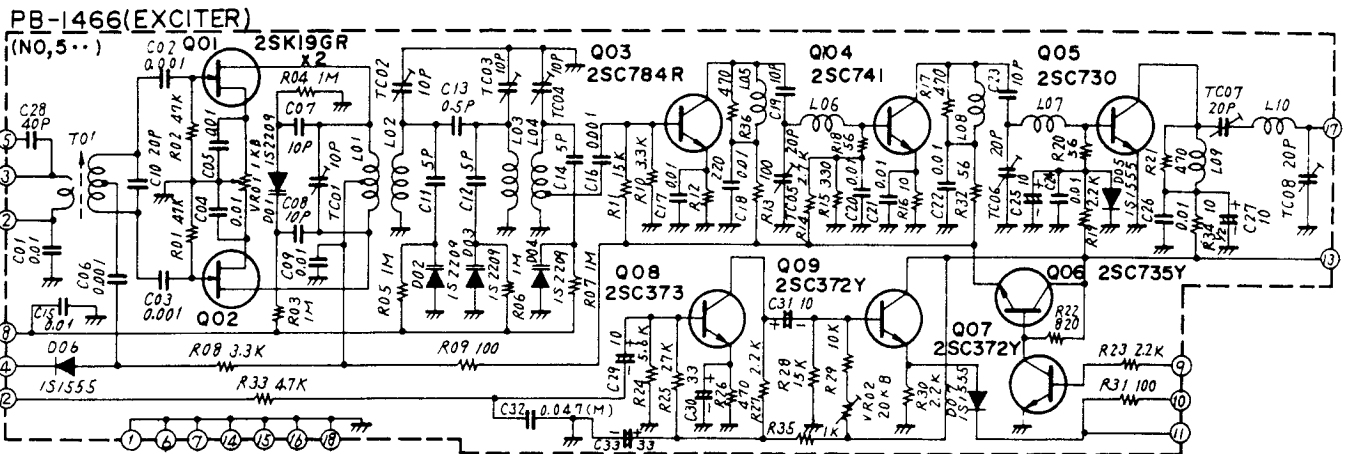
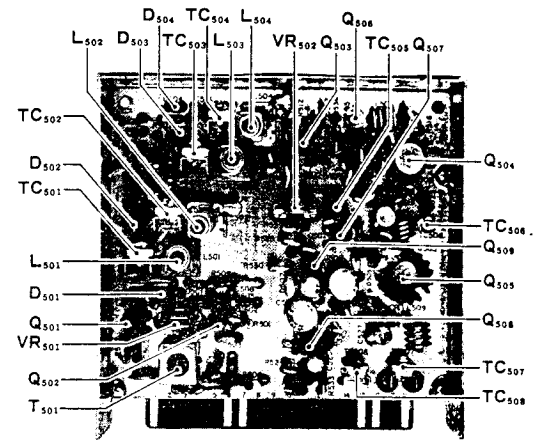
* Lightbulb and lightbulb holder
are part of FT-221R ONLY



VFO UNIT PB-1465

	E(S)	B(G)	C(D)	E(S)	B(G)	C(D)	E(S)	B(G)	C(D)
Q1301	2.1	2.7	4.4	Q1302	1.6	7.6	Q1303	1.6	6.9

EXCITER UNIT (PB-1466)



EXCITER Unit (on Transmit)

	LSB.USB.CW			AM.FM				LSB.USB.CW			AM.FM				LSB.USB.CW			AM.FM.		
	E(S)	B(G)	C(D)	E(S)	B(G)	C(D)		E(S)	B(G)	C(D)	E(S)	B(G)	C(D)		E(S)	B(G)	C(D)	E(S)	B(G)	C(D)
Q 501	1.3	0	12.1	2.2	0	11.8	Q 504	0.4	1.2	10.1	0.4	1.2	10.0	Q 507	0	0	13.3	0	0	13.3
Q 502	1.6	0	12.1	1.9	0	11.7	Q 505	0	0.7	13.4	0	0.7	13.4	Q 508	1.1	1.8	5.4	1.1	1.8	5.4
Q 503	1.2	1.9	12.0	1.2	1.9	11.9	Q 506	12.5	13.3	13.5	12.5	13.3	13.5	Q 509	4.9	5.5	13.5	4.9	5.5	13.5

Receive.....0V

EXCITER UNIT (PB-1466)

The SSB, AM, CW and FM output signal (10.7 mHz) from the MIC AMP unit are fed to the EXCITER unit at pins 3 and 5.

The 10.7 mHz signal is fed to the balanced mixer, consisting of Q501 and Q502, (2SK19GR) where the signal is mixed with the 133.3 to 137.3 mHz heterodyne signal delivered to pin 4 from the PLL unit (PB-1455), producing a 144 to 148 mHz signal. The output signal from the balanced mixer passes through the tuned circuits consisting of L501 through L504, which are tuned by the varactor diodes D501 through D504, (1S2209) in which voltages are preset in accordance with the band switch position. Thus the circuit is tuned exactly to the operating frequency reducing any spurious radiation. The signal is then amplified by the amplifier chain Q503, (2SC784R) Q504, (2SC741) and Q505, (2SC730) and exits the board from pin 17 to the BOOSTER unit.

The DC voltage for Q501 through Q504 is supplied through Q506, (2SC735Y). When the phase lock loop circuit is unlocked, the controller transistor Q507, (2SC372Y) stops conducting which in turn opens the DC supply for Q501 through Q504, preventing the user from transmitting when the PLL is unlocked.

The speech signal from pin 27 of the MIC AMP unit (PB-1460) is fed through the AM amplifier Q508, (2SC373) and emitter follower Q509, (2SC372Y) to the AM modulator Q7, (2SD313D) which controls the supply voltage for Q1201, BAM-20, in the BOOSTER unit (PB-1470).

NOTICE

WHEN ALIGNING THIS UNIT, IT IS ESSENTIAL THAT SOME FREQUENCY VERIFICATION BE PRESENT, SUCH AS A YC-500 COUNTER, IN ADDITION TO THE DUMMY LOAD.

IT IS POSSIBLE TO TUNE UP THE EXCITER ON THE DIFFERENCE FREQUENCY, RATHER THAN THE SUM FREQUENCY, RESULTING IN A "PLL WON'T LOCK" SITUATION, SO PERFORM THE ALIGNMENT WITH THIS IN MIND.

ALIGNMENT

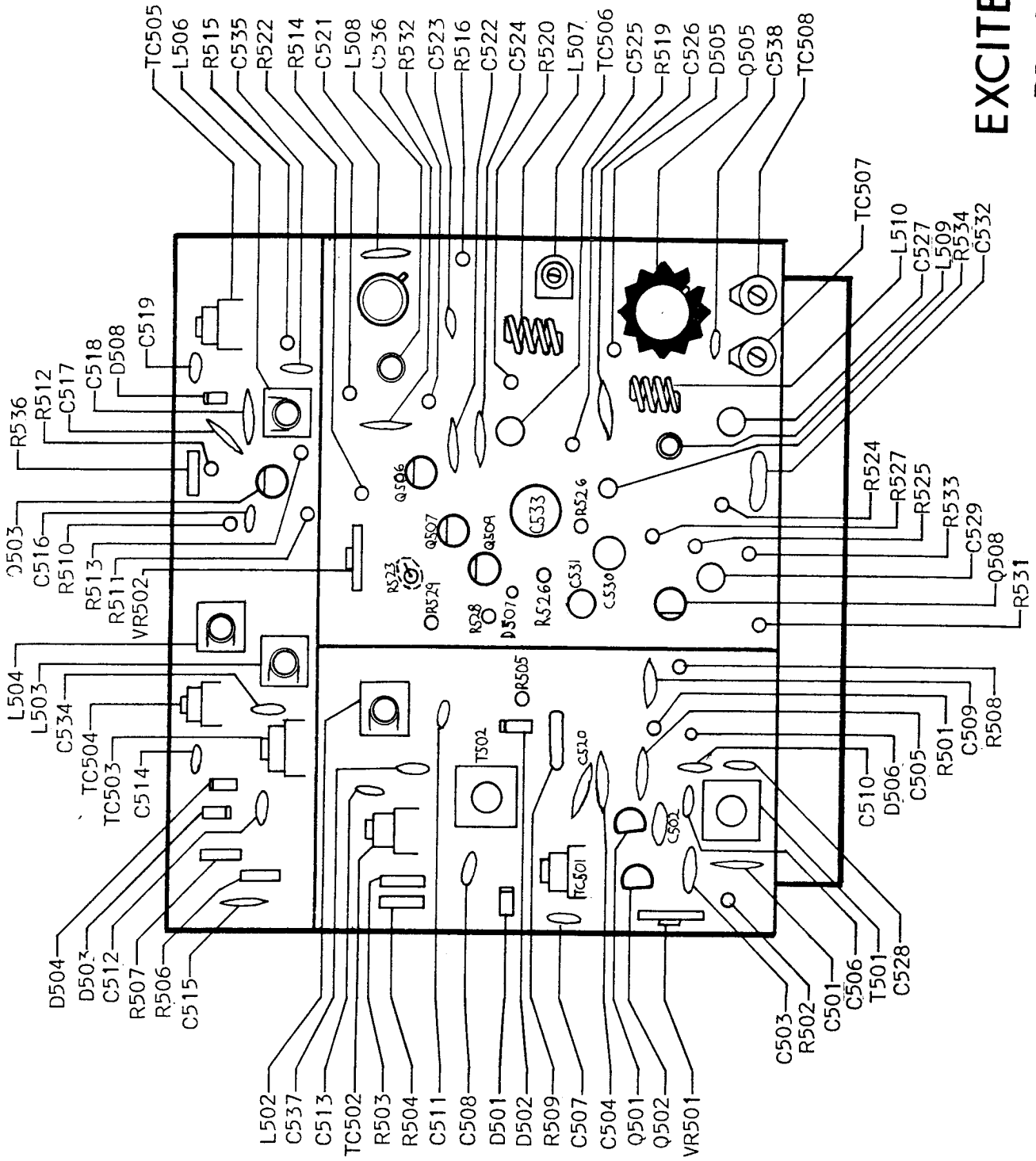
Connect a dummy load to the antenna receptacle, such as a Yaesu YP-150. Pre-set the controls as follows:

MODE - FM
BAND - 146.0 MHz
RPT - NORMAL (OFF)

Switch the VOX GAIN to MOX position and peak T501, TC501, TC502, TC503, TC504, TC505, TC506, TC507 and TC508 for maximum power output.

Switch the MODE to USB, and adjust VR501 for best null (minimum power out). Return the MOX switch to PTT. Verify that the power output at 144.0 MHz and 148.0 MHz is at least 10 watts.

EXCITER UNIT PB-1466 C



HUM REDUCTION

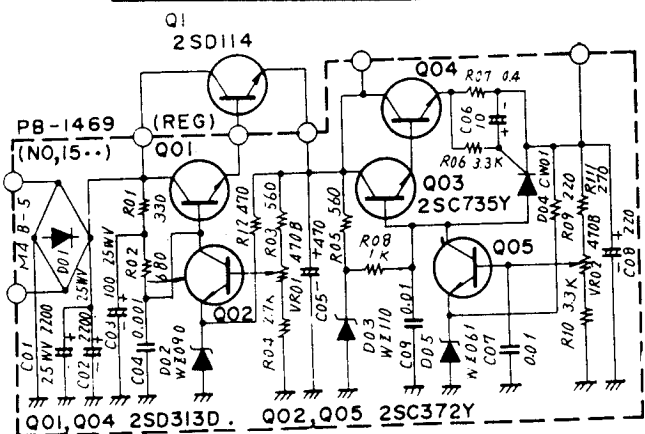
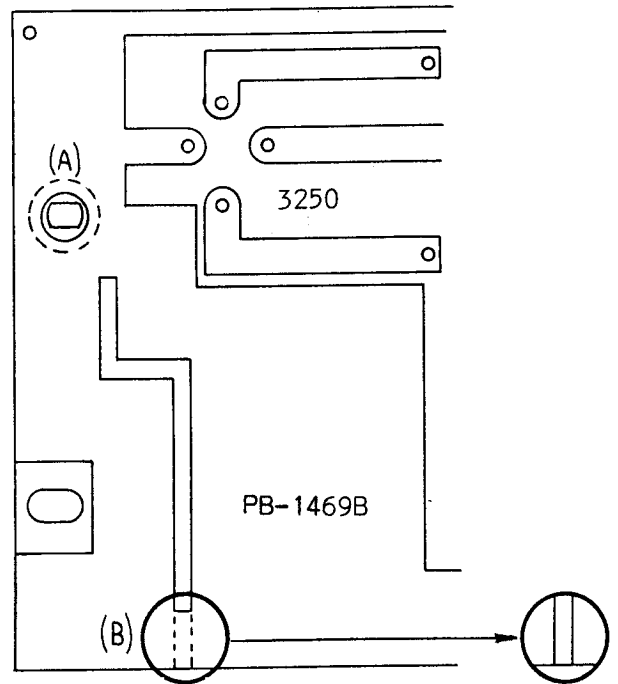
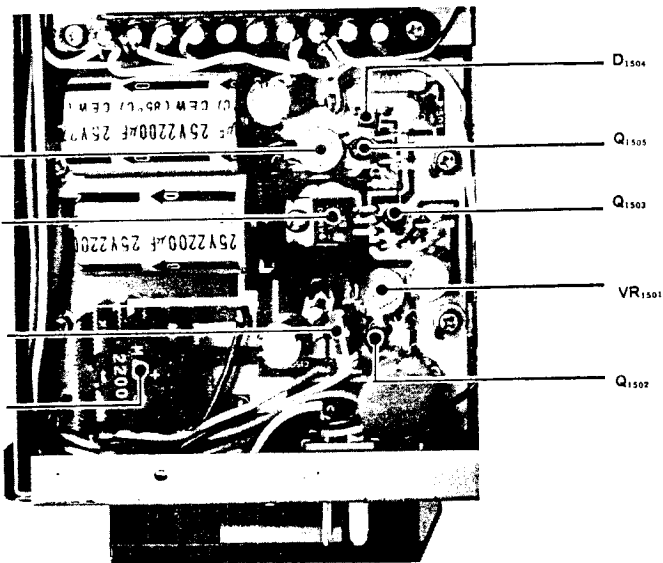
The FT-221R uses PB-1469B Regulator, which had a slightly modified etch, as shown in the sketch.

If you experience a seeming "untraceable" hum, suspect this board. The "fix" is to cut the etch away as shown, leaving a clear separation of the ground areas.

Owners of FT-221's will not see this problem, since the old PB-1469A had the slot carried through to the board edge already.

Solder a washer to the board (as shown) to improve grounding on either model.

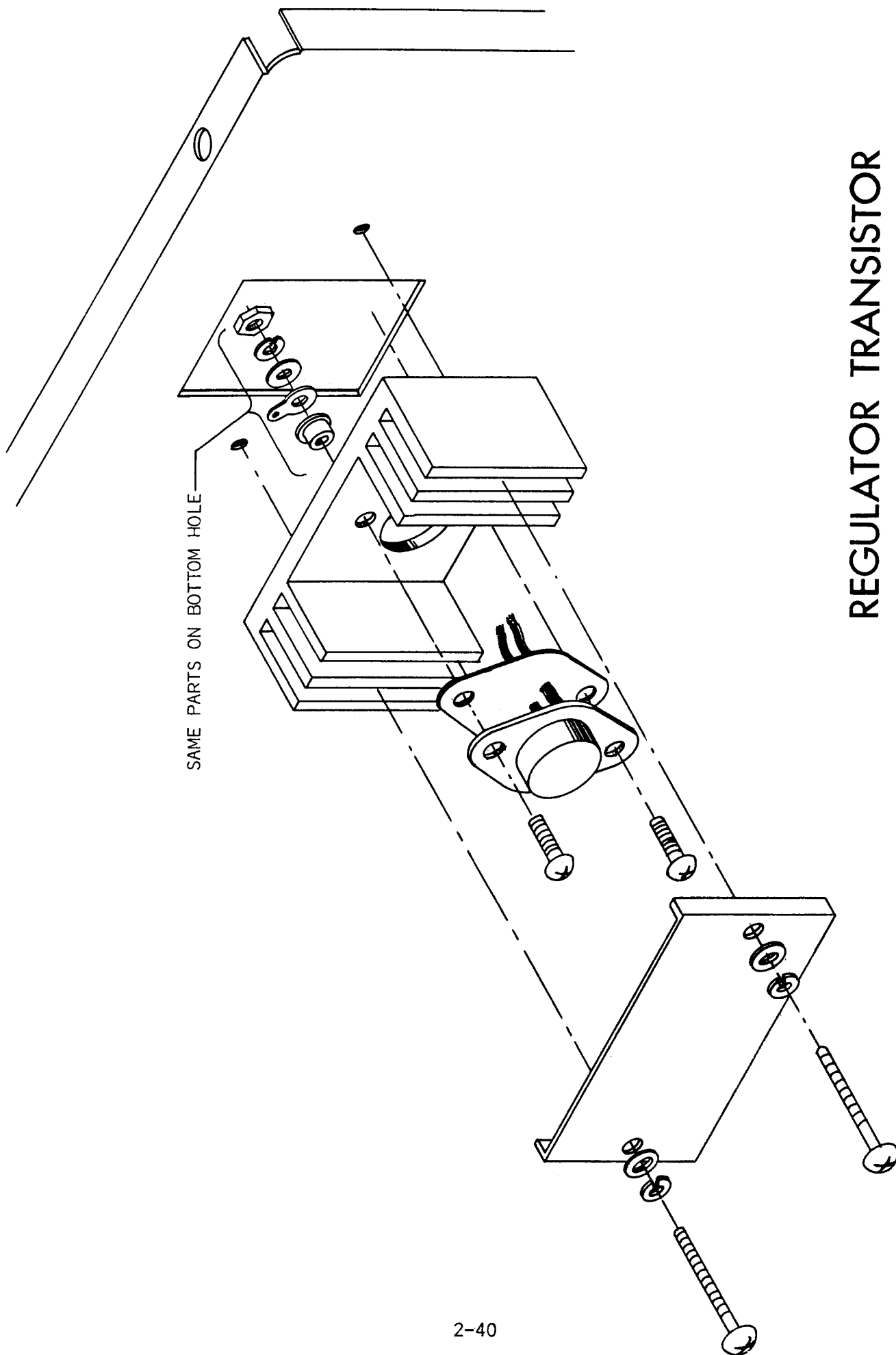
You will not have to remove the board completely, just remove the four screws holding the Regulator in place and cut the etch, solder on the washer and re-assemble.



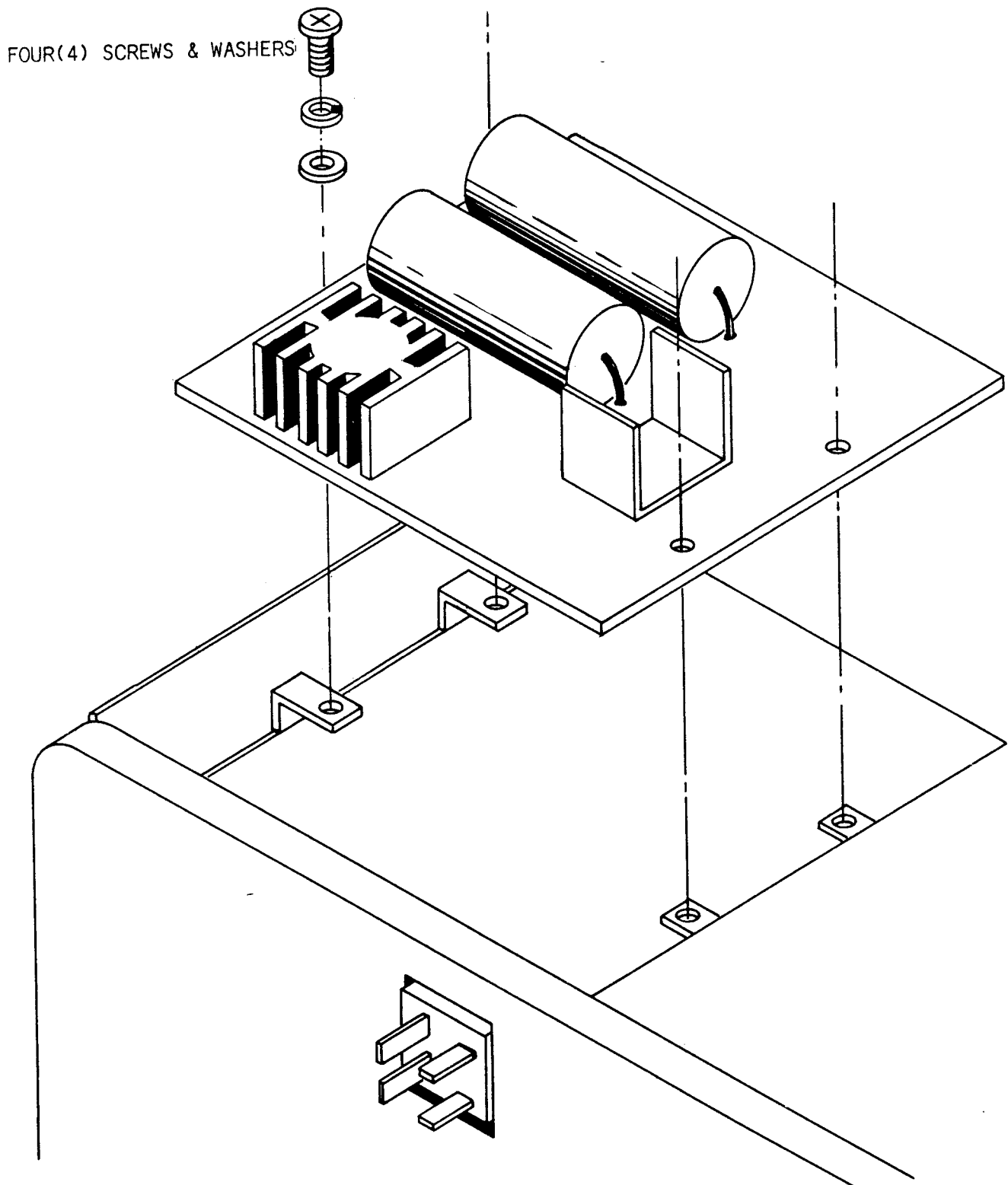
REGULATOR UNIT (PB-1469)

	E	B	C		E	B	C		E	B	C
Q1501	14.1	14.6	22.6	Q1503	8.7	9.3	13.5	Q1505	6.1	6.7	9.3
Q1502	9.0	9.7	14.6	Q1504	8.0	13.5	8.7	Q1	13.5	14.1	22.5

REGULATOR TRANSISTOR HEAT SINK ASSEMBLY

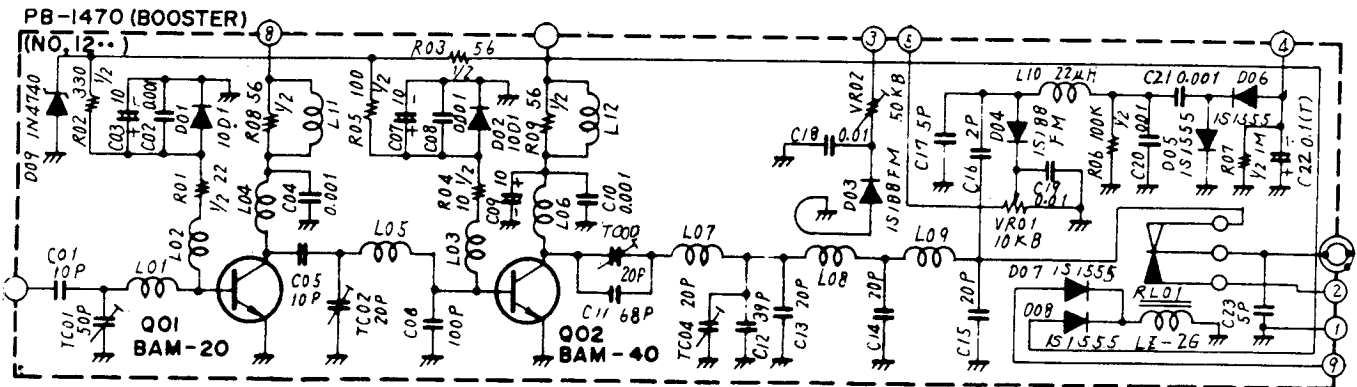
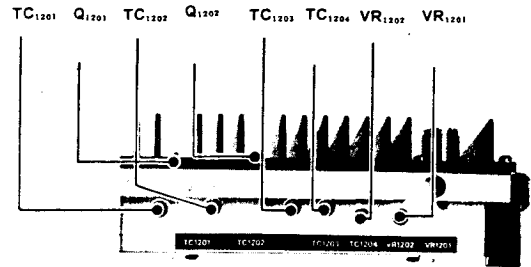


REG. UNIT MOUNTING



BOOSTER UNIT (PB-1470)

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BOOSTER Unit (on Transmit)

	LSB.USB.CW			AM			FM				LSB.USB.CW			AM			FM		
	E(S)	B(G)	C(D)	E(S)	B(G)	C(D)	E(S)	B(G)	C(D)		E(S)	B(G)	C(D)	E(S)	B(G)	C(D)	E(S)	B(G)	C(D)
Q1201	0	0.7	12.3	0	0.6	3.6	0	0.6	11.7	Q1202	0	0.7	13.5	0	0.4	13.3	0	0.2	13.1

Receive.....0V

BOOSTER UNIT (PB-1470)

The signal from EXCITER unit is fed to the BOOSTER unit and amplified by the driver amplifier Q1201, (BAM-20) and the final amplifier Q1202, (BAM-40) which delivers 10 watts of RF power to the antenna through a two stage, low pass filter. The DC voltage to Q1201 is supplied through the AM modulator Q7 (2SD313D).

The bias voltage is stabilized at 9 volts by a zener diode D1209, (1N4740). Two diodes D1201 and D1202, (10D1) are used to protect the power transistor from damage due to heating by reducing the bias voltage when the temperature rises. A small portion of the RF output is rectified by a diode D1203, (1S188FM) which delivers a resulting DC voltage to the meter where it provides an indication of relative power output from the transceiver.

The DC voltage obtained from rectifying a small portion of the RF output by the ALC diodes D1205 and D1206, (1S1555) which are biased by the ALC threshold control VR1201, is applied to the gate of Q906 in the SSB IF unit and Q1106 in the MIC AMP unit. This controls their gain in order to automatically control the driving level to the PA transistors in order to prevent any distortion caused by overdrive.

Block diodes D1207 and D1208 disconnect the supply voltage to Q1202 while the antenna is disconnected for marker calibration.

ALIGNMENT

Use an insulated wand for alignment of the booster unit. Connect a dummy load to the antenna receptacle. Set the BAND switch to 145.0, the CHANNEL switch to VFO and the MODE switch to FM. Set the VFO to 145.0 MHz. Set the VOX control to the MOX position. Peak TC501 through TC508 and TC1201 through TC1204 for maximum power output.

Change the frequency to 144.1 MHz and repeat above procedures for maximum power output. Change the frequency to 147.9 MHz and repeat above procedures for maximum power output.

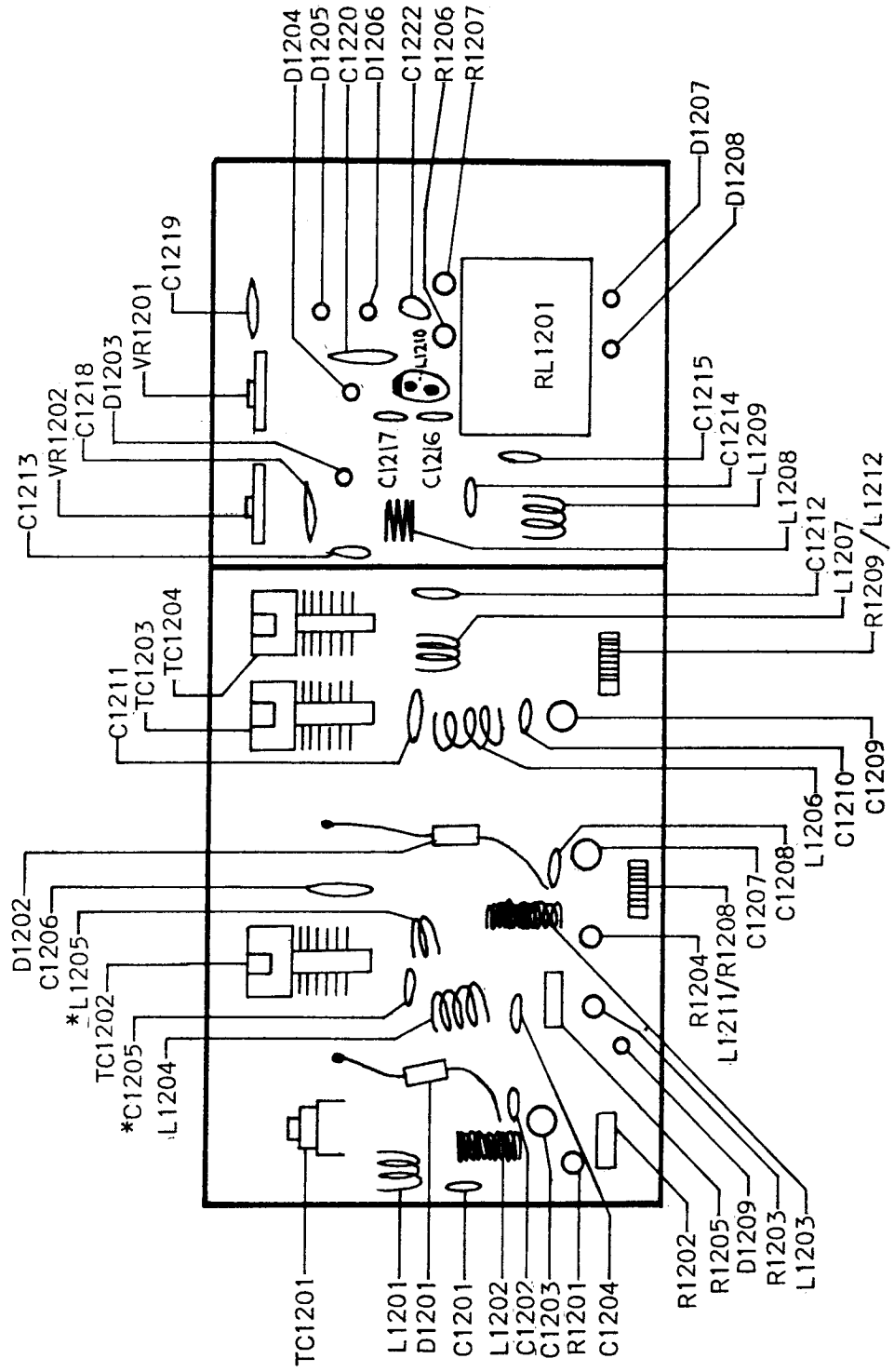
Repeat the procedures alternately on 144.1 MHz, 145.0 MHz and 147.9 MHz until even power output is obtained over 144 to 148 MHz.

MODIFICATIONS

Versions using BAM-20 and BAM-40's had a 3 turn L1205, and a 10pf in the position shown for C1205.

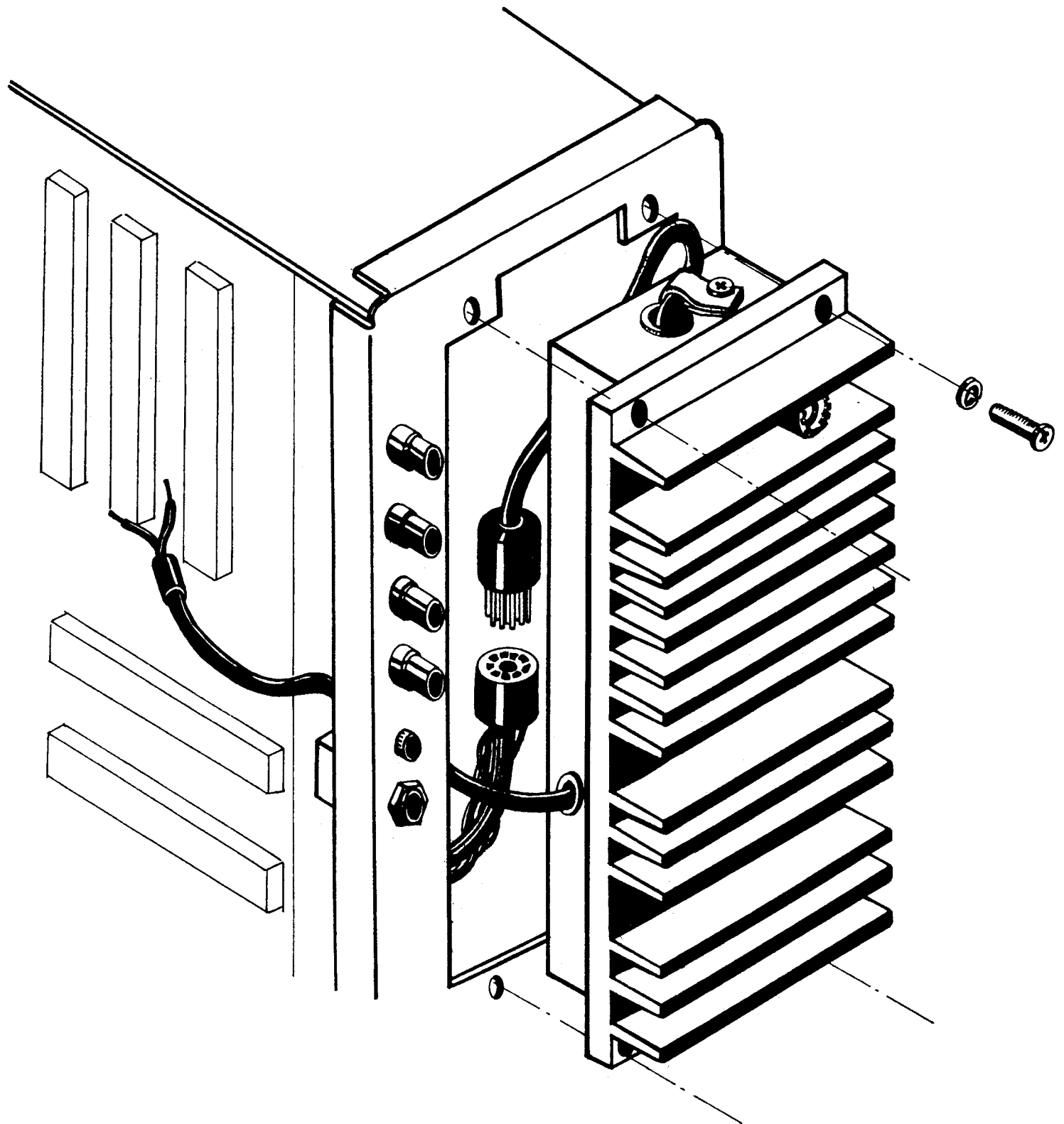
At Lot #9, a production change was made to use 2N5590's in place of the BAM-20, and 2N5591's in place of BAM-40's. When using the 2N's, replace L1205 with a 1 turn coil, and C1205 with a 33pf.

BOOSTER UNIT PB-1470



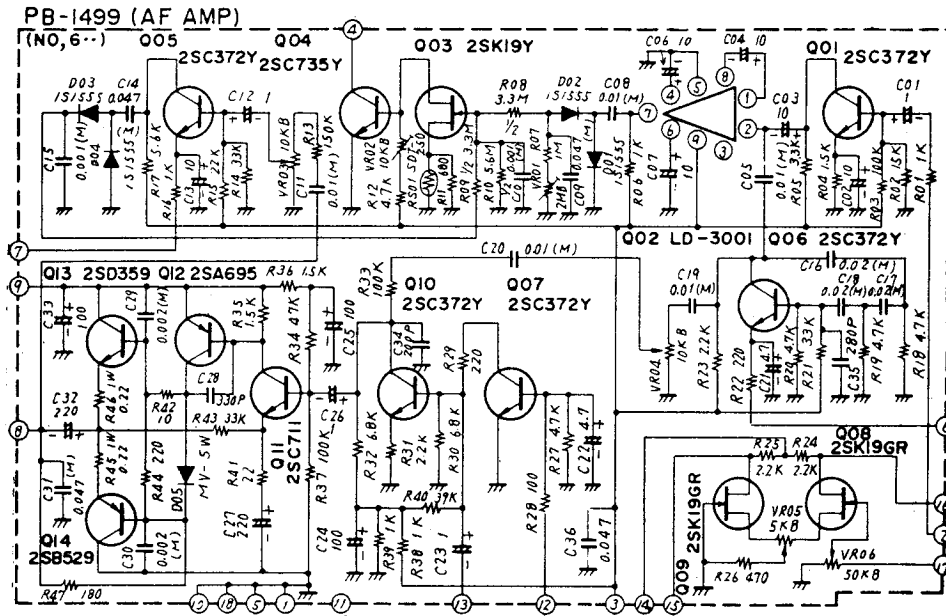
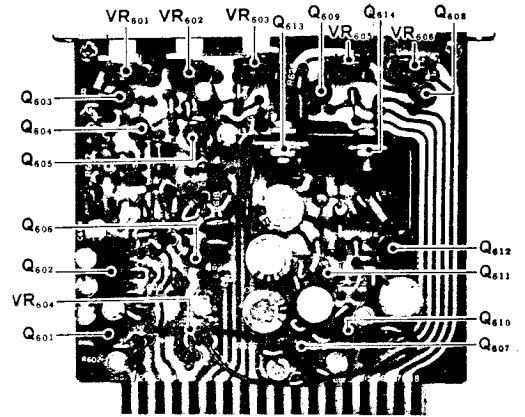
*See modification note

BOOSTER UNIT MOUNTING



AF AMP UNIT (PB-1499)

	1	2	3	4	5	6	7	8	9
Q 602	4.7	2.8	2.2	2.1	0	0.5	0.7	1.1	8.0



	LSB.USB.CW			FM				LSB.USB.CW			FM				LSB.USB.CW			FM		
	E(S)	B(G)	C(D)	E(S)	B(G)	C(D)		E(S)	B(G)	C(D)	E(S)	B(G)	C(D)		E(S)	B(G)	C(D)	E(S)	B(G)	C(D)
Q 601	0.4	1.0	7.0	0.4	1.0	7.0	Q 607	0	0	0.6	0	0	0.6	Q 612	13.5	12.9	7.5	13.5	12.9	7.5
Q 603	0.4	0	0.6	0.4	0	0.6	Q 608	0	0	0	1.9*	0	5.7*	Q 613	6.8	7.4	13.5	6.8	7.4	13.5
Q 604	0	0.6	12.9	0	0.6	12.9	Q 609	0	0	0	2.6*	0	6.3*	Q 614	6.8	6.2	0	6.8	6.2	0
Q 605	0.4	1.0	5.8	0.4	1.0	5.8	Q 610	0	0.6	3.8	0	0.6	3.8							
Q 606	2.9	1.0	8.0	2.9	1.0	8.0	Q 611	8.5	9.1	12.9	8.5	9.1	12.9							

★ FM Transmit.....0V

AF AMP UNIT PB-1499

In addition to the audio amplifier function, this board also contains the VOX circuitry, squelch, CW sidetone oscillator, and FM discriminator meter driver.

Detected audio is pre-amplified on PB-1462 (SSB IF), and delivered to this board (PB-1499) at pin 13. It is amplified by Q610 (2SC372Y), and Q611 (2SC711), and applied to Q612 (2SA695) which acts as a driver phase splitter, exciting the complementary PNP-NPN output, consisting of Q613 (2SD359) and Q614 (2SB529). Audio output of two (2) watts capability leaves the board at pin 8, to drive a 4 ohm speaker.

During FM reception, a squelch control voltage normally arrives from pin 8 of PB-1463 (FM-IF unit) and enters the board at pin 12. Q607 (2SC372Y) is used as a squelch controller which when conducting, grounds the audio input at the base of Q610 silencing the receiver when only noise is present.

The squelch line can also receive an override pulse from pin 9 of PB-1455 (PLL board) to pin 12 that is generated from the phase lock loop sensing circuit. This "pulsed squelch" will appear regardless of the mode switch setting to alert the operator audibly to an "unlocked" condition in the transceiver.

When a quieting signal appears (in FM mode), voltage on the base of Q607 is reduced, allowing Q610 to operate normally. In SSB, CW and AM mode, the voltage on the squelch line is held below cut off through switch S3-C, and the noise rectifier is ineffective.

The VOX circuit consists of three principal circuits, the relay controllers, Q603 (2SK19Y) and Q604 (2SC735Y), the VOX amplifier, which picks up a portion of the MIC AMP unit (PB-1460) output, and the anti-trip circuit, which uses a portion of the AF output to create a threshold to prevent the transceiver from activating on it's own speaker output.

The speech output from the first microphone amplifier is fed through the VOX GAIN control potentiometer, VR7, to the VOX amplifier Q601, (2SC372Y) and Q602 (LD-3001) from pin 2.

The amplified signal is fed to the VOX rectifier, D601 and D602 (1S1555). The rectified DC voltage is applied to the gate of the VOX relay controllers Q603, (2SK19Y) and Q604, (2SC735Y) causing them to conduct and actuate the VOX relay, RL1, on the main chassis.

The ANTITRIP circuit provides a threshold voltage to prevent the speaker output from tripping the transceiver into the transmit mode. The receiver audio output voltage is connected through the ANTITRIP potentiometer, (VR603) to the anti-trip amplifier Q605 (2SC372Y) and fed to rectifiers, D603 and D604, (1S1555). The negative DC output voltage from the rectifier is connected to the gate of Q603, and reduces the gain of the VOX control transistor, thus providing the necessary antitrip threshold. The ANTITRIP control, (VR603) adjusts the value of the anti-trip voltage threshold so that the speaker output will not produce an excessive positive voltage from the VOX rectifier that exceeds the negative voltage from the antitrip rectifier causing the controller transistor to actuate the relay. When speaking into the microphone, the positive voltage will exceed the negative anti-trip voltage and actuate the relay. VR602 provides coarse adjustment for relay sensitivity.

Relay hold time will be determined by the DELAY control potentiometer, VR601.

The tone oscillator Q606, (2SC372Y) operates when the MODE switch is in the CW position. It is a phase shift oscillator operating at approximately 800 Hz.

The tone output is activated by the keying circuit through the emitter circuit of Q606 and coupled through sidetone level control, (VR604) to the receiver audio amplifier, (Q601) for sidetone monitoring in CW operation. The output from Q606 is also coupled to the VOX amplifier, (Q602) for break-in CW operation. In the FM mode, a DC voltage at the discriminator output is applied from pin 17, to the differential amplifiers Q608 and Q609 (2SK19GR).

When the frequency of a received signal is shifted away from the discriminator center, the resulting DC \pm voltage causes either Q608 or Q609 to conduct, indicating the amount of shift on the meter when the DISC switch in the ON position. VR605 balances the differential amplifier and VR606 calibrates the sensitivity of the meter.

ALIGNMENT

CW break in "hang" time is set with VR601. The unit should not unkey between dots, and the operator should adjust the control for a release time to suit his own keying style.

Sidetone level should also be adjusted to suit the individual operator using VR604.

To set the VOX relay sensitivity and antitrip, set the controls as follows:

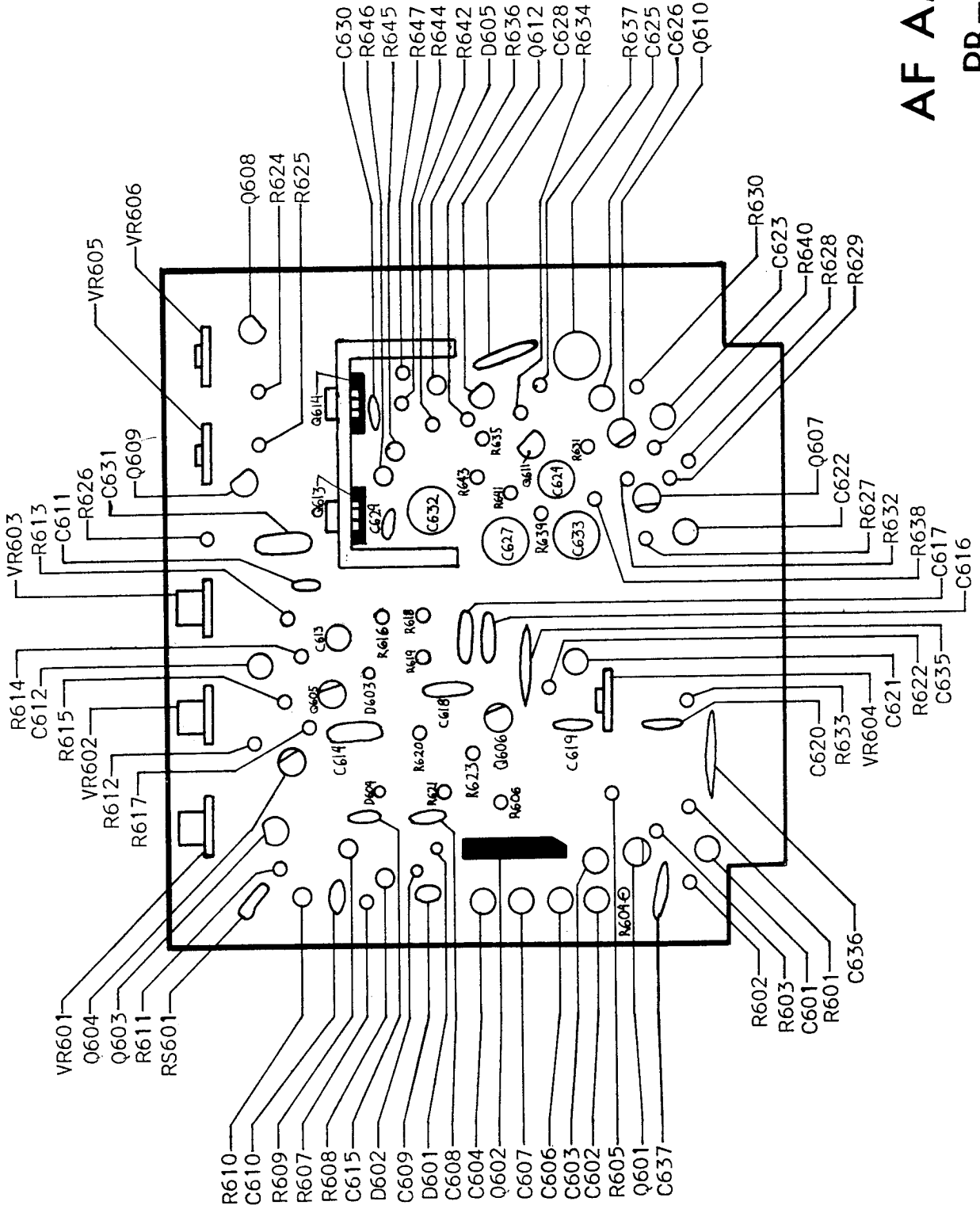
VR602 RELAY	Fully CCW
MIC GAIN	Fully CCW
VOX GAIN	PTT
MODE	LSB or USB

Slowly rotate the RELAY control, (VR602) until the relay activates, then return the control carefully counter clockwise until the relay releases. This release point is the proper setting for the RELAY sensitivity control. Set the MIC GAIN control to the 2 o'clock position and the VOX control on the front panel to the 12 o'clock position. Speaking normally into the microphone, make sure that your voice activates the relay. Tune in a signal and adjust the AF GAIN on the front panel to a comfortable listening level. Set the ANTITRIP control, (VR603) to the point that will prevent the speaker output from tripping the VOX. Adjust the DELAY control, (VR601) for a suitable relay release time.

Discriminator meter center, set the controls as follows:

CHANNEL	VFO
MODE	FM
DISC	OFF (down position)
RF GAIN	Fully CW
MARKER	ON (up position)

Tune the transceiver for maximum S-meter reading at a marker signal. This maximum reading has a 3 kHz width and the VFO should be set to the center of the signal. Turn the DISC switch on and adjust the center potentiometer, (VR605) until the meter indicates mid point on the scale. Check that the meter moves equally toward both ends when the VFO frequency is shifted equally up or down. Shift the VFO frequency 10 kHz lower than the zero center meter indication, and adjust the DISC potentiometer, (VR606) until the meter indicates 2.



AF AMP UNIT

PB-1499

PARTS LIST

MAIN CHASSIS				6, 7	SLE-12251
PB	PRINTED CIRCUIT BOARD			8, 9	SLE-14201
1471 (A~Z)	LED	BOARD			
1501 (A~Z)	SWITCH	BOARD		J	JACK
				1	QMS-AB4M
Q	TRANSISTOR			2	CS-250
1		2SD114		3	SG-7615
7		2SD313D		4	SG-8050
				5	FM-144J
D	DIODE			6	XG-8018
1	Si Bridge	DS-130-YD		7~10	CN-7017J
6~10	Si	10D-1		11	SO-239
11	LED	GD-4		12, 14~19, 21	3305-018-011
12		RD-4		13, 20, 22	1150-036-009
13		TLR-108		25	CN-1463
R	RESISTOR			P	PLUG
	CARBON COMPOSITION			24	SI-8501
16	1/4W	10K Ω			
15	1/4W	100K Ω		F	FUSE
19	1/2W	10 Ω		1	2A
18	1/2W	100 Ω		2	1A
14, 17, 22	1/2W	220 Ω			
13, 21	1/2W	470 Ω		FS	FUSE HOLDER
11, 12	1/2W	33K Ω		1	SN-1001 #2
VR	POTENTIOMETER			PL	PILOT LAMP
4	EWK-DOAS 15023	500 Ω B/500 Ω C		1~3	14V 40mA
5	VM13A-5M3121	5KA			
8	EVH-BOAS-15A53	5KA			
6	VM20A	5KB			
7	VM11A5M	10KA			
3	EVH-BOAS-15B54	50KB		PB	PRINTED CIRCUIT BOARD
10	EVH-BOAS-15B53	5KB		1453 (A~Z)	FIX OSC CIRCUIT
				1500 (A~Z)	CRYSTAL BOARD
C	CAPACITOR			Q	TRANSISTOR
	DIPPED MICA			101, 102	2SC372Y
16, 17, 18	50WV	100PF			
22	50WV	300PF		D	DIODE
	CERAMIC DISC			101~111	Si 1S1555
14, 28~32	50WV	0.001 μ F			
33	50WV	0.01 μ F		X	CRYSTAL
11~13, 15, 19~21, 23, 27	50WV	0.047 μ F		101~111	HC-25/U (OPTION)
24~26	500WV	0.01 μ F			
1, 2	1.4KV	0.0047 μ F		XS	CRYSTAL SOCKET
				101~111	S2-101P
PT	POWER TRANSFORMER				
1	52-36			R	RESISTOR
					CARBON FILM
CH	CHOKE COIL			105, 108, 109	1/4W 100 Ω
1	SN-8S-500			104	1/4W 220 Ω
				101	1/4W 1.5K Ω
M	METER			102, 107	1/4W 5.6K Ω
1	SP-38A			106	1/4W 8.2K Ω
				103	1/4W 22K Ω
SP	SPEAKER				
1	SA-70H			C	CAPACITOR
					DIPPED MICA
RL	RELAY			130	50WV 15PF
1	AE-3171			131	50WV 20PF
				117~127	50WV 30PF
RLS	RELAY SOCKET			129	50WV 100PF
1	AE-3860			128, 132	50WV 200PF
					CERAMIC DISC
S	SWITCH			101~116	50WV 0.01 μ F
1	ESR-E22CR15D				
2	ESR-448R15A			TC	TRIMMER CAPACITOR
3	ESR-485R15A			101~111	ECV-1ZW 20 \times 40 20PF
4	SP-2022				
5	SLE-14301			L	INDUCTOR

101~111	EL0610-102K	1mH	PLL UNIT		
112	EL0610-251K	250 μ H	PB PRINTED CIRCUIT BOARD		
113	FL-3H 1R2M	1.2 μ H	1455 (A~Z) PLL CIRCUIT		
			Q IC FET & TRANSISTOR		
LOCAL UNIT			302	IC	μ A703HC
PB PRINTED CIRCUIT BOARD			308		TP4011AN
1454 (A~Z) LOCAL OSC CIRCUIT			301	FET	2SK19Y
			305, 306	"	2SK19GR
Q TRANSISTOR			303, 304, 309		2SC372Y
201		2SC372Y	307		2SC784R
202, 203		2SC784R	310		MPSA13
			D DIODE		
D DIODE			D DIODE		
201~212	Si	1S1555	301	PUT	N13T1
225	Ge	1S188FM	309, 310	Si	1S1555
226	Varactor	1SV50	311	Ge	1S188FM
			303, 304		1S1007
X CRYSTAL			302	Zener	WZ061
201	HC-18/U	13.92222MHz	305~308	Varactor	1SV50
202	"	13.97777MHz			
203	"	14.03333MHz	R RESISTOR		
204	"	14.08888MHz	CARBON FILM		
205	"	★ 14.14444MHz	305, 337	$\frac{1}{4}$ W	56 Ω
206	"	★ 14.20000MHz	313,315,319,320,329,333~335	$\frac{1}{4}$ W	100 Ω
207	"	★ 14.25555MHz	303	$\frac{1}{4}$ W	150 Ω
208	"	★ 14.31111MHz	304, 308, 314, 326, 328	$\frac{1}{4}$ W	220 Ω
210 (Repeater)	HC-25/U	★★(14.13333MHz)	325	$\frac{1}{4}$ W	270 Ω
211 (Repeater)	"	★★(14.32222MHz)	307	$\frac{1}{4}$ W	470 Ω
			310, 316,	$\frac{1}{4}$ W	1K Ω
XS CRYSTAL SOCKET			302, 345, 346	$\frac{1}{4}$ W	2.2K Ω
201	S-14		317, 321, 330	$\frac{1}{4}$ W	4.7K Ω
			311, 312	$\frac{1}{4}$ W	10K Ω
R RESISTOR			306, 318, 322, 331	$\frac{1}{4}$ W	22K Ω
CARBON FILM			301	$\frac{1}{4}$ W	47K Ω
221, 225	$\frac{1}{4}$ W	100 Ω	309,323,324,327,340,344	$\frac{1}{4}$ W	100K Ω
217, 224	$\frac{1}{4}$ W	220 Ω	329	$\frac{1}{4}$ W	560K Ω
220	$\frac{1}{4}$ W	560 Ω	332, 336, 338, 341, 343	$\frac{1}{4}$ W	1M Ω
213, 216	$\frac{1}{4}$ W	1K Ω	CARBON COMPOSITION		
222	$\frac{1}{4}$ W	2.2K Ω	342	$\frac{1}{4}$ W	2.2M Ω
201~212	$\frac{1}{4}$ W	3.3K Ω			
215, 218	$\frac{1}{4}$ W	4.7K Ω			
214, 223	$\frac{1}{4}$ W	10K Ω	VR POTENTIOMETER		
219	$\frac{1}{4}$ W	22K Ω	301	KVL-SOAA-00B13	1KB
			C CAPACITOR		
C CAPACITOR			C CAPACITOR		
DIPPED MICA			DIPPED MICA		
242	50WV	1PF	322, 327	50WV	5PF
239	50WV	5PF	339, 340	50WV	6PF
240, 241	50WV	8PF	318, 319	50WV	10PF
213~224, 236, 238	50WV	30PF	308, 309	50WV	20PF
237	50WV	39PF	325, 326	50WV	30PF
234	50WV	150PF	323, 324	50WV	47PF
235	50WV	200PF	305, 312, 313	50WV	170PF
CERAMIC DISC			307	50WV	200PF
201~212, 225~230, 232, 233	50WV	0.01 μ F	CERAMIC DISC		
231, 243	50WV	0.047 μ F	304,306,310,311,314~317	50WV	0.01 μ F
			320,321,328,329,331~338,344		
TC TRIMMER CAPACITOR			MYLAR		
201~212	ECV-1ZW 20 \times 40	20PF	341	50WV	0.01 μ F
			343	50WV	0.1 μ F
L INDUCTOR			TANTALUM		
203	# 221026	3.2 μ H	301, 342	35WV	0.1 μ F
202, 204	EL0610-220K	22 μ H	ELECTROLYTIC		
201	EL0610-251K	250 μ H	303, 330	16WV	10 μ F
			302	16WV	100 μ F
T TRANSFORMER					
201	R-12 # 4797				
202, 203	R-12 # 4102				

511, 512, 514	50WV	5PF	634, 613	1/4W	47KΩ
507, 508, 519, 523	50WV	10PF	603, 633, 637	1/4W	100KΩ
510	50WV	20PF	607	1/4W	1MΩ
528	50WV	40PF			
CERAMIC DISC			CARBON COMPOSITION		
513	50WV	0.5PF	608, 609	1/2W	3.3MΩ
502, 503, 506, 516	50WV	0.001μF	610	1/2W	5.6MΩ
501, 504, 505, 509, 515,	50WV	0.01μF	WIRE WOUND		
517, 518, 520 ~ 522, 524, 526			645, 646	1W	0.22Ω
MYLAR					
532	50WV	0.047μF	RS	THERMISTOR	
ELECTROLYTIC			601	SDT-250	
525, 527, 529, 531	16WV	10μF			
530, 533	16WV	33μF	VR	POTENTIOMETER	
TC	TRIMMER CAPACITOR		605	EVL-SOAA-00B53	5KB
501 ~ 504	ECV-1ZW 10×40	10PF	602, 603	EVL-VOAA-00B14	10KB
505, 506	ECV-1ZW 20×51	20PF	604	EVL-SOAA-00B14	10KB
507, 508	ECV-1ZW 20×32	20PF	606	EVL-SOAA-00B54	50KB
			601	EVL-VOA -00B26	2MB
L INDUCTOR			C CAPACITOR		
501	# 221007		DIPPED MICA		
502, 503	# 221008		634, 637	50WV	200PF
504	# 221009		635	50WV	280PF
506, 507, 510	# 221018		628	50WV	330PF
505, 508, 509	# 221017		CERAMIC DISC		
			636	50WV	0.047μF
T	TRANSFORMER		MYLAR		
501	# 221015		610, 615	50WV	0.001μF
			629, 630	50WV	0.002μF
			605, 608, 611, 619, 620	50WV	0.01μF
AF UNIT			616 ~ 618	50WV	0.02μF
PB	PRINTED CIRCUIT BOARD		609, 614, 631	50WV	0.047μF
1499 (A~Z)	AF CIRCUIT		ELECTROLYTIC		
			601, 612, 623, 626	16WV	1μF
Q	IC FET & TRANSISTOR		621, 622	16WV	4.7μF
602	IC	LD-3001	602 ~ 604, 606, 607, 613	16WV	10μF
603	FET	2SK19Y	624	10WV	100μF
608, 609	"	2SK19GR	625, 633	16WV	100μF
612		2SA695	627, 632	16WV	220μF
614		2SB529			
601, 605, 606, 607, 610		2SC372Y	MARKER UNIT		
611		2SC711	PB	PRINTED CIRCUIT BOARD	
604		2SC735Y	1459 (A~Z)	MARKER CIRCUIT	
613		2SD359			
D	DIODE		Q	IC & TRANSISTOR	
601 ~ 604	Si	1S1555	703	IC	SN7490N
605	Varistor	MV-5W	701, 702		2SC372Y
R	RESISTOR		D	DIODE	
	CARBON FILM		701	Zener	1S330
642	1/4W	10Ω	X	CRYSTAL	
641	1/4W	22Ω	701	HC-6/U	1MHz
628	1/4W	100Ω	R	RESISTOR	
647	1/4W	180Ω		CARBON FILM	
622, 629, 644	1/4W	220Ω	713	1/4	68Ω
626	1/4W	470Ω	701 ~ 708	1/4	100Ω
611	1/4W	680Ω	711	1/4	1KΩ
601, 616, 638, 639	1/4W	1KΩ	710	1/4	10KΩ
604, 635, 636	1/4W	1.5KΩ	709	1/4	22KΩ
623, 624, 625, 631	1/4W	2.2KΩ	712	1/4	470KΩ
605, 614, 643	1/4W	3.3KΩ			
606, 612, 618, 619, 620, 627	1/4W	4.7KΩ	VR	POTENTIOMETER	
617	1/4W	5.6KΩ	701 ~ 708	EVL-SOAA-00B13	10KB
630, 632	1/4W	6.8KΩ	C	CAPACITOR	
602	1/4W	15KΩ		DIPPED MICA	
615	1/4W	22KΩ			
621	1/4W	33KΩ			
640	1/4W	39KΩ			

708	50WV	10PF	810,830,831,837,838,841	50WV	0.01 μ F
701	50WV	40PF	828,829	50WV	0.02 μ F
702,703	50WV	1500PF	811,817,818,820~825	50WV	0.047 μ F
CERAMIC DISC			STYROL		
704,705	50WV	0.01 μ F	826	50WV	330PF
ELECTROLYTIC			827	50WV	1000PF
707	16WV	10 μ F	TANTALUM		
			839,840	25WV	1 μ F
TC	TRIMMER CAPACITOR		ELECTROLYTIC		
701	ECV-1ZW	50 \times 40	50PF	849,850	16WV
			832,842	16WV	4.7 μ F
FM IF UNIT			L INDUCTOR		
PB	PRINTED CIRCUIT BOARD		804	EL0610-251K	250 μ H
1463 (A~Z)	FM IF CIRCUIT		801~803,806	EL0610-102K	1mH
			805	EL0610-202K	2mH
Q	IC FET & TRANSISTOR		T TRANSFORMER		
802	IC	μ A703HC	801,802	R-12	4074
808	"	TA7061AP	803		4861D
803	FET	2SK19GR	804		4861E
801,804~807,809~811		2SC372Y	805		3004
D	DIODE				
801,802,807~810	Si	1S1555			
803~806	Ge	1S188FM			
			SSB IF UNIT		
X	CRYSTAL		PB PRINTED CIRCUIT BOARD		
801	HC-18/U	10.245MHz	1462 (A~Z) SSB IF CIRCUIT		
CF	CERAMIC FILTER		Q IC FET & TRANSISTOR		
802	CFM	455E(F)	902	IC	TA7045M
			903,906	FET	2SK19GR
			904,905		2SC373
			901		2SC784R
R	RESISTOR		907,908		2SC1000GR
CARBON			D DIODE		
804,805,826	$\frac{1}{4}$ W	100 Ω	901~903,912,913	Si	1S1555
825,827,837	$\frac{1}{4}$ W	220 Ω	910	Ge	1S188FM
824	$\frac{1}{4}$ W	470 Ω	904~909	G.B	1S1007
803,833,842	$\frac{1}{4}$ W	560 Ω	911	Zener	WZ110
808,816,819,828,829,	$\frac{1}{4}$ W	1K Ω			
836,846,847					
809	$\frac{1}{4}$ W	1.5K Ω	XF	CRYSTAL FILTER	
839,840	$\frac{1}{4}$ W	2.2K Ω	901	XF-10A	
811,813,814,821,843,	$\frac{1}{4}$ W	3.3K Ω			
849~856			R RESISTOR		
801,830,831,835,844	$\frac{1}{4}$ W	4.7K Ω	CARBON FILM		
822,838	$\frac{1}{4}$ W	5.6K Ω	909,912,914,915,919,	$\frac{1}{4}$ W	100 Ω
802	$\frac{1}{4}$ W	10K Ω	932,933,939,940		
815,845	$\frac{1}{4}$ W	15K Ω	926,927	$\frac{1}{4}$ W	270 Ω
823,834,841	$\frac{1}{4}$ W	22K Ω	917,944	$\frac{1}{4}$ W	470 Ω
820,832	$\frac{1}{4}$ W	47K Ω	901,902,927,905,911,	$\frac{1}{4}$ W	560 Ω
848	$\frac{1}{4}$ W	56K Ω	913,921,922		
806,807,810	$\frac{1}{4}$ W	100K Ω	934,938,946,947	$\frac{1}{4}$ W	1K Ω
			929	$\frac{1}{4}$ W	1.8K Ω
RS	THERMISTOR		908,910,918,930,945	$\frac{1}{4}$ W	2.2K Ω
801	SDT-250		925	$\frac{1}{4}$ W	2.7K Ω
C	CAPACITOR		903,904,942	$\frac{1}{4}$ W	3.3K Ω
DIPPED			935,936	$\frac{1}{4}$ W	4.7K Ω
812	50WV	15PF	906	$\frac{1}{4}$ W	6.8K Ω
814	50WV	27PF	941	$\frac{1}{4}$ W	10K Ω
806,807	50WV	30PF	920,924,943	$\frac{1}{4}$ W	22K Ω
833	50WV	40PF	907	$\frac{1}{4}$ W	27K Ω
809,835,843	50WV	100PF	937	$\frac{1}{4}$ W	56K Ω
801	50WV	200PF	916,931	$\frac{1}{4}$ W	100K Ω
834	50WV	300PF	923	$\frac{1}{4}$ W	470K Ω
CERAMIC DISC			RS THERMISTOR		
844	50WV	0.001 μ F	901	SDT-250	
802~805,808,813,815,	50WV	0.01 μ F			
816,819,836,845~848					
MYLAR			VR POTENTIOMETER		

901	EVL-SOAA-00B52	500B	1012	16WV	1 μ F
903	EVL-SOAA-00B13	1KB	1013	16WV	4.7 μ F
902	EVL-SOAA-00B53	5KB	1011	16WV	100 μ F
C CAPACITOR			RL RELAY		
DIPPED MICA			1001 LZ-2G		
915	50WV	10PF			
912	50WV	20PF			
916	50WV	100PF			
CERAMIC DISC			MIC AMP UNIT		
901, 902, 909~911, 50WV 0.01 μ F			PB PRINTED CIRCUIT BOARD		
917~920, 923, 925~929, 933			1460 (A~Z) MIC AMP CIRCUIT		
903~908, 913, 914, 924 50WV 0.047 μ F			Q IC FET & TRANSISTOR		
MYLAR			1104 IC LD-3001		
932	50WV	0.0047 μ F	1105, 1106 FET 2SK19GR		
936	50WV	0.02 μ F	1101~1103, 1107, 1108 2SC372Y		
921, 931, 937	50WV	0.047 μ F			
ELECTROLYTIC			D DIODE		
930, 939	16WV	1 μ F	1101, 1105, 1106, 1112~1117 Si 1S1555		
922, 938	16WV	10 μ F	1103, 1104 Ge 1S188FM		
934, 935	16WV	47 μ F	1108~1111 G.B 1S1007		
			1102 Varactor 1S2687		
TC TRIMMER CAPACITOR					
901	ECV-1ZW 50 \times 40	50PF	X CRYSTAL		
			1101 HC-18/U 10.7000MHz		
L INDUCTOR			1102 HC-18/U 10.7015MHz		
901	EL0610-251K	250 μ H	1103 HC-18/U 10.6985MHz		
			1104 HC-18/U 10.6993MHz		
T TRANSFORMER					
901, 902	R-12	4074	R RESISTOR		
903	R-12	4073	CARBON FILM		
			1101, 1105, 1121, 1124, 1129 $\frac{1}{4}$ W 100 Ω		
			1133, 1137, 1141, 1148, 1149		
TC TONE BURST UNIT			1112, 1135, 1136, 1138, 1142 $\frac{1}{4}$ W 220 Ω		
PB PRINTED CIRCUIT BOARD			1114 $\frac{1}{4}$ W 470 Ω		
1461 (A~Z) TONE BURST CIRCUIT			1102, 1106, 1113, 1125, 1127, 1145 $\frac{1}{4}$ W 1K Ω		
			1117, 1122, 1123, 1147 $\frac{1}{4}$ W 2.2K Ω		
Q IC & FET			1104, 1128 $\frac{1}{4}$ W 3.3K Ω		
1001~1003	IC	TP4011AN	1143 $\frac{1}{4}$ W 4.7K Ω		
1005		TP4027AN	1116, 1140, 1144 $\frac{1}{4}$ W 5.6K Ω		
1004		TP4049AN	1103, 1139 $\frac{1}{4}$ W 6.8K Ω		
1006	FET	2SK19GR	1108, 1118, 1120 $\frac{1}{4}$ W 10K Ω		
			1115, $\frac{1}{4}$ W 12K Ω		
D DIODE			1107, 1111 $\frac{1}{4}$ W 22K Ω		
1001~1003	Ge	1S188FM	1110, 1119 $\frac{1}{4}$ W 33K Ω		
			1109, 1126, 1130 $\frac{1}{4}$ W 100K Ω		
R RESISTOR			VR POTENTIOMETER		
CARBON FILM			1102 EVL-SOAA-00B32 300B		
1014	$\frac{1}{4}$ W	220 Ω	1103 EVL-SOAA-00B13 1KB		
1013	$\frac{1}{4}$ W	10K Ω	1101 EVL-SOAA-00B23 2KB		
1011	$\frac{1}{4}$ W	150K Ω			
1012	$\frac{1}{4}$ W	820K Ω			
1001~1005, 1008~1010	$\frac{1}{4}$ W	1M Ω	C CAPACITOR		
CARBON COMPOSITION			DIPPED MICA		
1006, 1007	$\frac{1}{4}$ W	2.2M Ω	1159 50WV 3PF		
			1158 50WV 10PF		
VR POTENTIOMETER			1146 50WV 20PF		
1002, 1003	EVL-SOAA-00B15	100KB	1140, 1154~1156 50WV 30PF		
1001	EVL-SOAA-00B26	2MB	1106 50WV 50PF		
			1107, 1108, 1147 50WV 100PF		
C CAPACITOR			1148 50WV 150PF		
DIPPED MICA			1143 50WV 200PF		
1009	50WV	1000PF	1110 50WV 250PF		
MYLAR			1126~1128 50WV 270PF		
1001, 1002, 1004, 1005, 1007, 1010	50WV	0.01 μ F	CERAMIC DISC		
			1136 50WV 0.001 μ F		
TANTALUM			1101, 1102, 1104, 50WV 0.01 μ F		
1003	35WV	0.33 μ F	1133~1135, 1138, 1139, 1141,		
1006, 1008	35WV	0.47 μ F	1142~1144, 1145, 1149~1153		
ELECTROLYTIC			1109, 1132 50WV 0.047 μ F		

MYLAR			1203, 1207, 1209	16WV	10 μ F
1111, 1115, 1116, 1122	50WV	0.047 μ F			
ELECTROLYTIC			TC TRIMMER CAPACITOR		
1114, 1117, 1129, 1131	16WV	1 μ F	1201	ECV-1ZW 50 \times 40	50PF
1118, 1119, 1121, 1123~1125,	16WV	10 μ F	1202~1204	TSN-P-100DS	20PF
1130					
1120	16WV	22 μ F	L INDUCTOR		
1112, 1113	16WV	47 μ F	1201, 1207	# 221019	
			1204~1206, 1208~1209	# 221020	
TC TRIMMER CAPACITOR			1211, 1212	# 221021	
1102~1104	ECV-1ZW 20 \times 40	20PF	1202, 1203	# 221022	
1101	ECV-1ZW 50 \times 40	50PF	1210	EL0610-220K	22 μ H
L INDUCTOR			RL RELAY		
1101	# 221024		1201	LZ-2G	
1107	EL0610-100K	10mH			
1103, 1104, 1106, 1108,	EL0610-102K	1mH			
1109, 1110, 1111, 1112					
1102	S8104J	100mH	VFO UNIT		
T TRANSFORMER			PB PRINTED CIRCUIT BOARD		
1101	R-12	# 4074	1465 (A~Z) VFO CIRCUIT		
1102	R-12	# 4073			
BOOSTER UNIT			Q FET & TRANSISTOR		
PB PRINTED CIRCUIT BOARD			1302 FET 2SK19GR		
1470 (A~Z) BOOSTER CIRCUIT					
Q TRANSISTOR			1301, 1303 2SC372Y		
1201	BAM-20				
1202	BAM-40				
D DIODE			R RESISTOR		
1201, 1202	Si	10D-1	CARBON FILM		
1205~1208		1S1555	1307, 1311, 1312	$\frac{1}{4}$ W	100 Ω
1203, 1204	Ge	1S188FM	1310	$\frac{1}{4}$ W	150 Ω
1209	Zener	1N4740	1306	$\frac{1}{4}$ W	470 Ω
R RESISTOR			1304	$\frac{1}{4}$ W	2.2K Ω
CARBON COMPOSITION			1301	$\frac{1}{4}$ W	3.3K Ω
1204	$\frac{1}{2}$ W	10 Ω	1308	$\frac{1}{4}$ W	6.8K Ω
1201	$\frac{1}{2}$ W	22 Ω	1309	$\frac{1}{4}$ W	15K Ω
1203	$\frac{1}{2}$ W	56 Ω	1302	$\frac{1}{4}$ W	18K Ω
1205	$\frac{1}{2}$ W	100 Ω	1303	$\frac{1}{4}$ W	33K Ω
1202	$\frac{1}{2}$ W	330 Ω	1305	$\frac{1}{4}$ W	100K Ω
1206	$\frac{1}{2}$ W	100K Ω	C CAPACITOR		
1207	$\frac{1}{2}$ W	1M Ω	DIPPED MICA		
VR POTENTIOMETER			1318	50WV	2PF
1201	EVL-SOAA-00B14	10KB	1302	50WV	20PF
1202	EVL-SOAA-00B54	50KB	1313	50WV	39PF
C CAPACITOR			1306	50WV	51PF
DIPPED MICA			1311	50WV	68PF
1216	50WV	2PF	1307	50WV	270PF
1217, 1223	50WV	5PF	1310	50WV	470PF
1201, 1205	50WV	10PF	CERAMIC DISC		
1213~1215	50WV	20PF	1308, 1309, 1312,	50WV	0.01 μ F
1212	50WV	39PF	1314~1316		
1211	50WV	68PF	CERAMIC TC		
1206	50WV	100PF	1303	500WV	5PF UJ
CERAMIC DISC			1304	500WV	7PF UJ
1202, 1204, 1208, 1210	50WV	0.001 μ F	1301	500WV	20PF UJ
1218~1220	50WV	0.01 μ F	1305	500WV	82PF NPO
MYLAR			CERAMIC FEED THRU		
1221	50WV	0.001 μ F	1317	ECK-L1H102PE	1000PF
TANTALUM			VC VARIABLE CAPACITOR		
1222	35WV	0.1 μ F	1301	C512C	
ELECTROLYTIC			TC TRIMMER CAPACITOR		
			1301	MC10P \times 2	
			1302	KC-30P	
			L INDUCTOR		
			1301	# 221025	
			1302	EL0610-680K	68 μ H
			1303	EL0610-251K	250 μ H

SUBSTITUTIONS

Narrow - CFM 455A/LF-C12 5 kHz CF
 Wide - - CFM 455C/LF-C25 12.5 kHz

Substitute RF PA Transistors

CTC BAM 20 2N5590
 CTC BAM 40 2N5591

2N5590	175 mHz	10W P	3W pin	Gain 5.2 dB	13.8 VDC
2N5591	175 mHz	25W P	9W pin	Gain 4.4 dB	13.6 VDC

IC Substitutions

<u>TI</u>	<u>MOTOROLA</u>	<u>FAIRCHILD</u>
TP 4011AN	MC 14011	34011PC
TP 4027AN	MC 14027	34027PC
TP 4049AN	MC 14049	34049PC

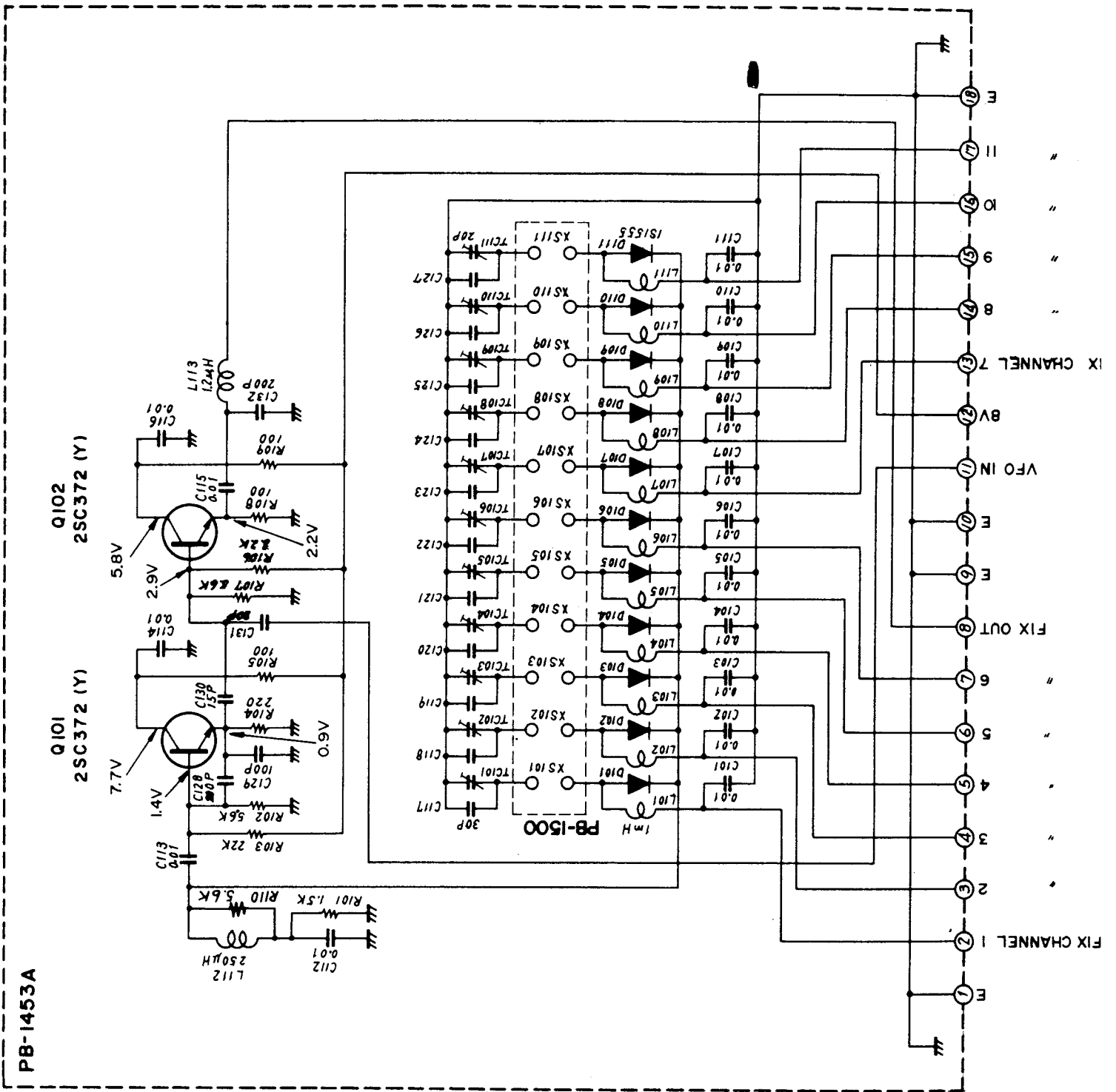
You only need one extender board for servicing the FT-221. Identified as PB-1104 it is an 18 pin extender, available from any Yaesu Service Center at nominal cost.

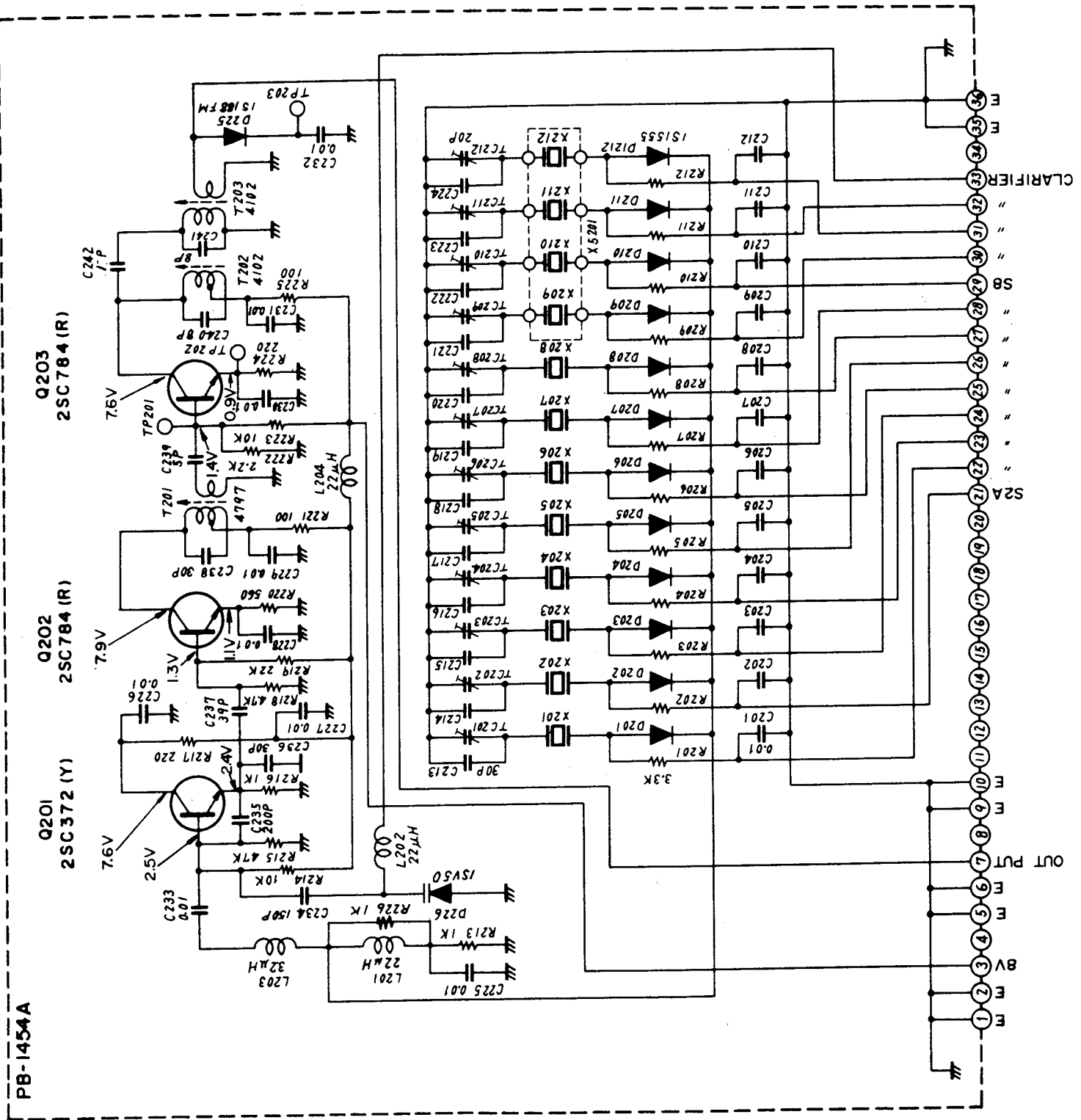
		VR POTENTIOMETER
	1501, 1502	SR-19R 470ΩB
		C CAPACITOR
		CERAMIC DISC
	1504	50WV 0.001μF
	1507, 1509	50WV 0.01μF
		ELECTROLYTIC
	1506	16WV 10μF
	1503	16WV 100μF
	1508	16WV 220μF
	1505	16WV 470μF
	1501, 1502	25WV 2200μF
REG UNIT		
PB PRINTED CIRCUIT BOARD		
1469 (A~Z)	REG CIRCUIT BOARD	
Q TRANSISTOR		
1502, 1505	2SC372Y	
1503	2SC735Y	
1501, 1504	2SD313D	
D DIODE		
1501	Si Bridge M4B-5	
1505	Zener WZ-061	
1502	WZ-090	
1503	WZ-110	
1504	Thyristor CW-01B	
R RESISTOR		
CARBON FILM		
1509	¼W 220 Ω	
1511	¼W 270 Ω	
1501	¼W 330 Ω	
1512	¼W 470 Ω	
1505	¼W 560 Ω	
1502, 1503	¼W 680 Ω	
1508	¼W 1K Ω	
1504	¼W 2.7K Ω	
1506, 1510	¼W 3.3K Ω	
WIRE WOUND		
1507	1 W 0.4 Ω	

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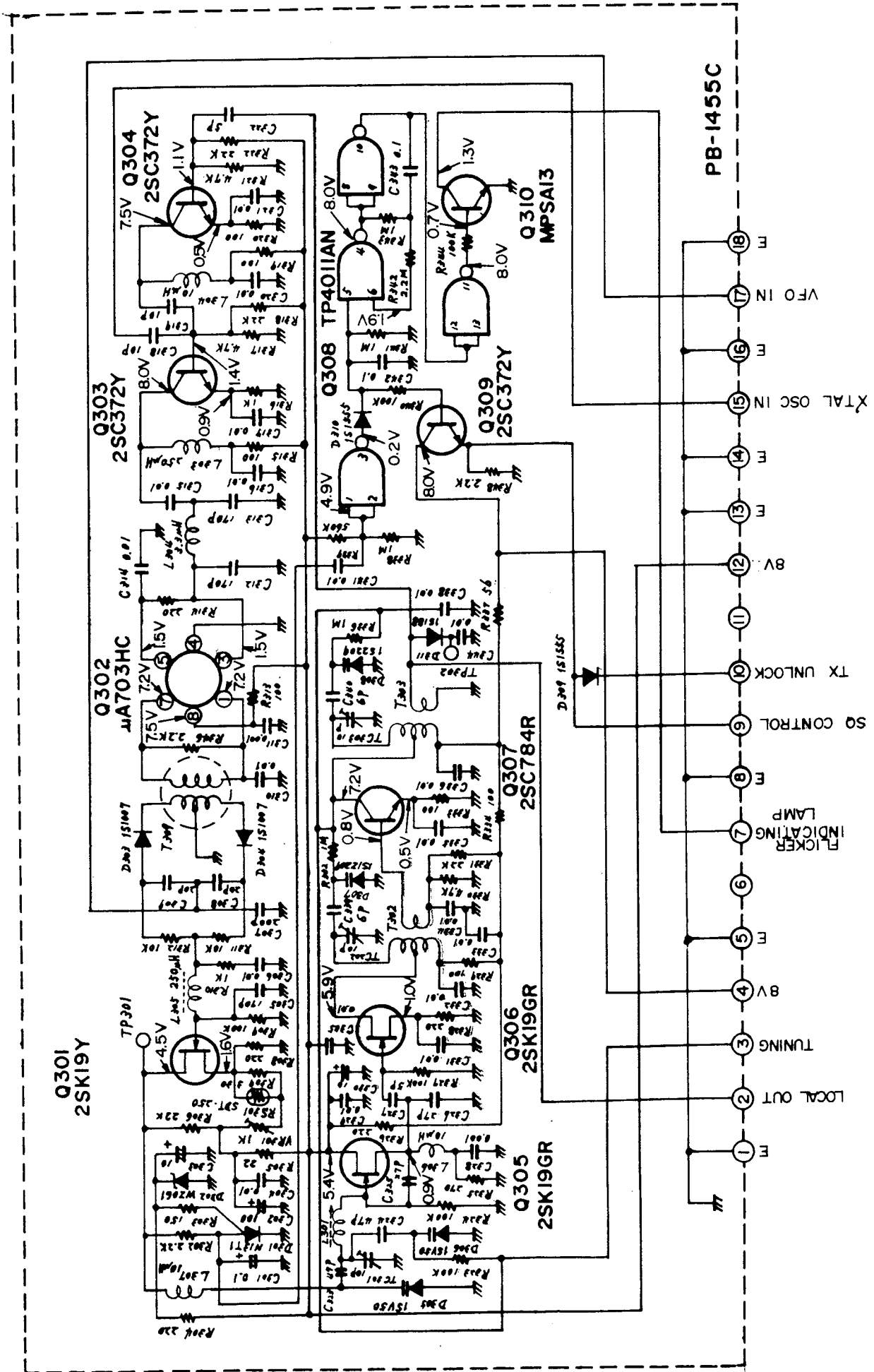
PB-1453A

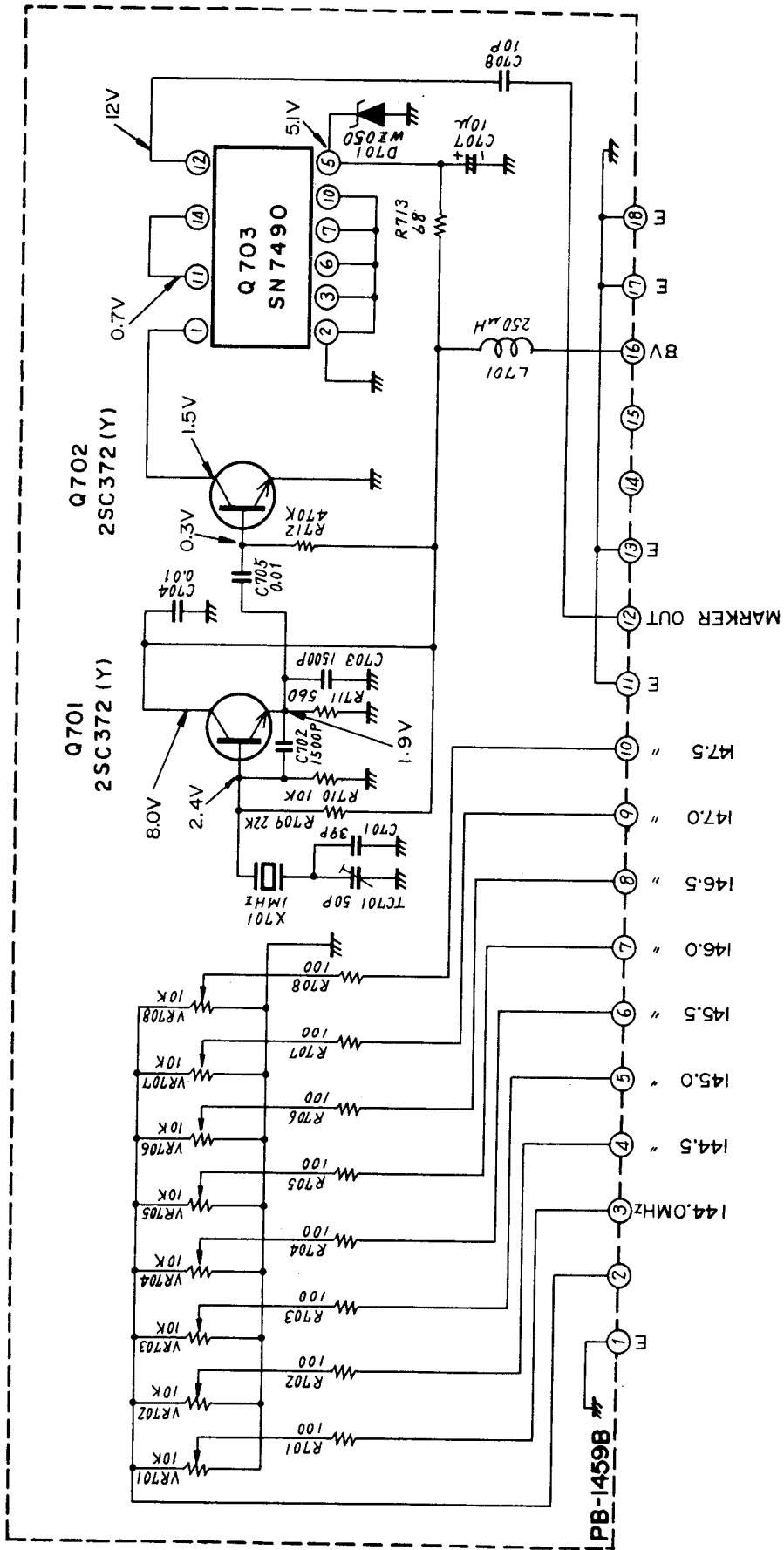


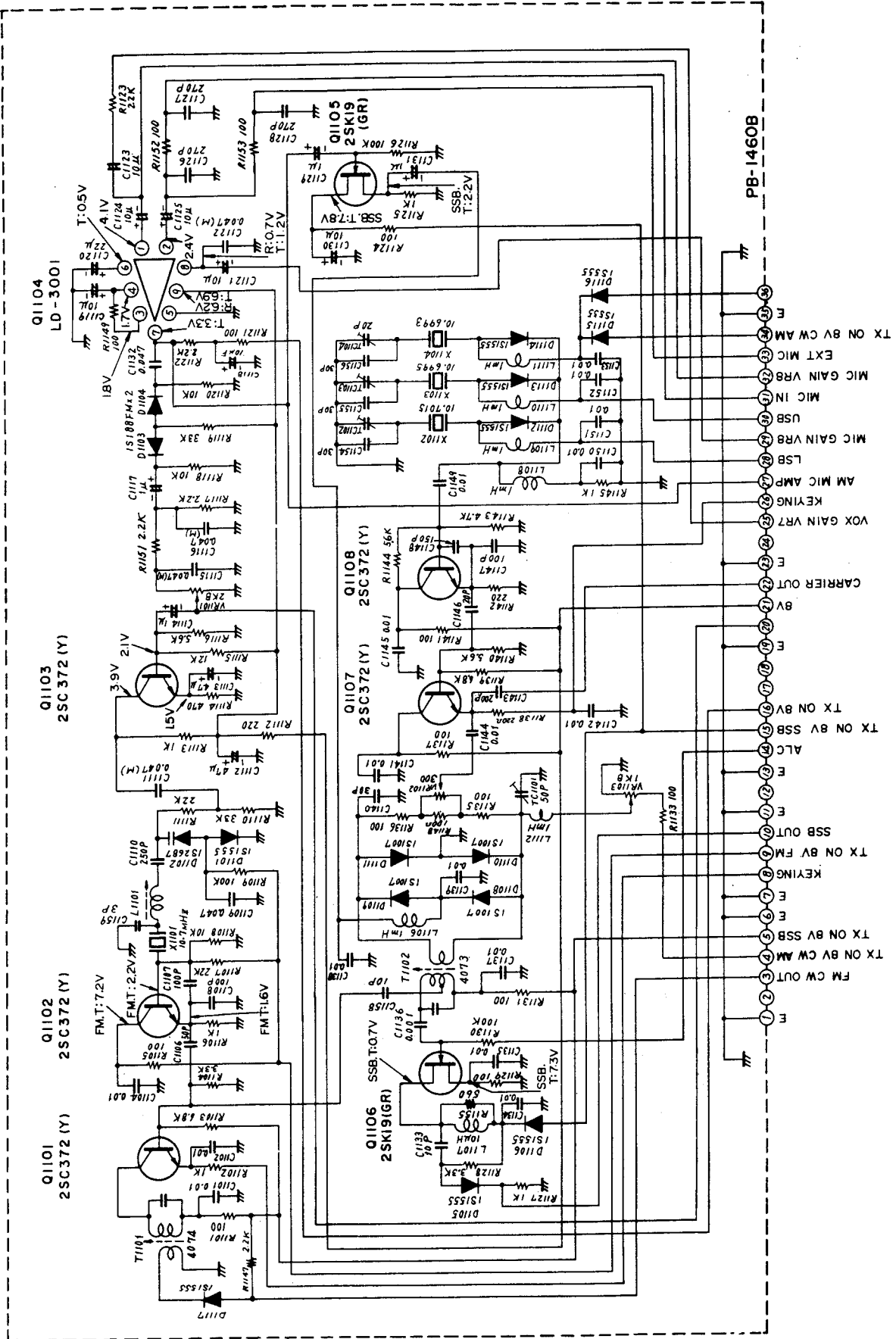


PB-1454A

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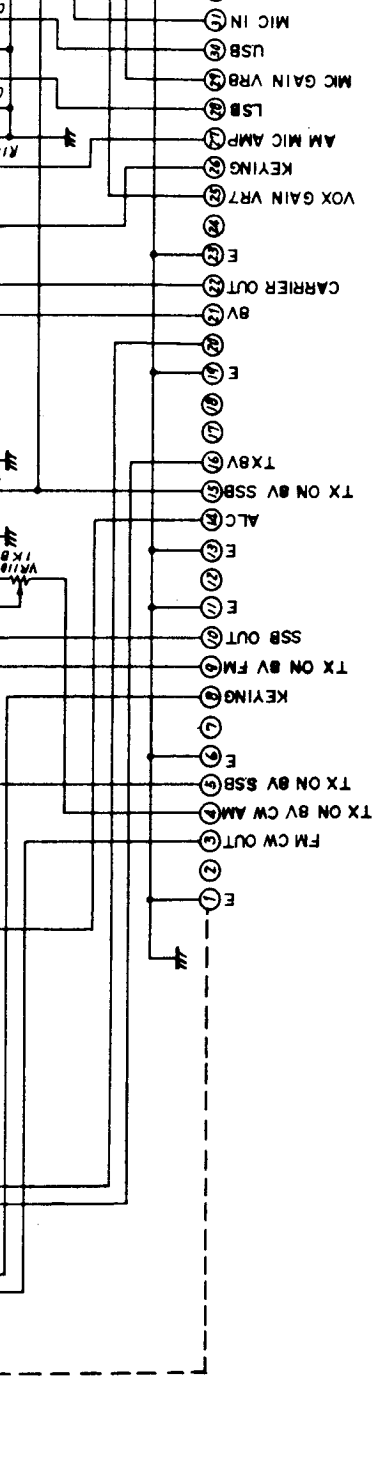
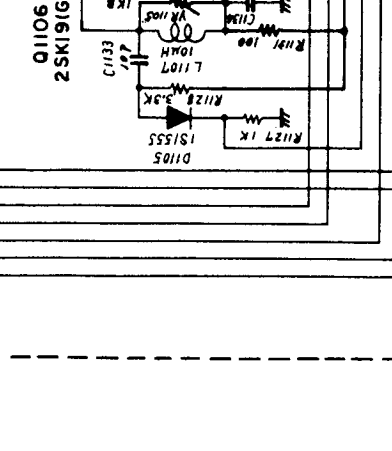
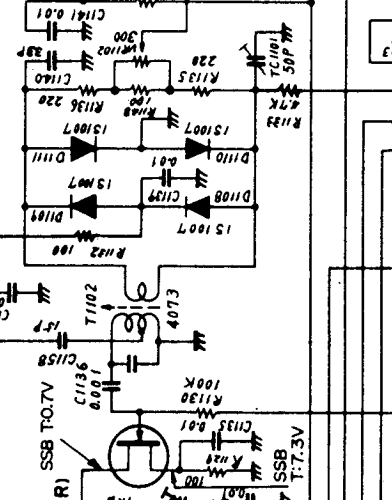
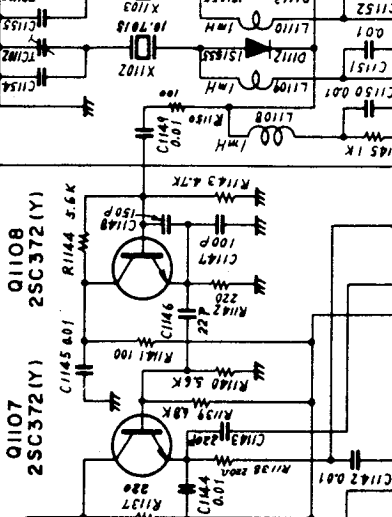
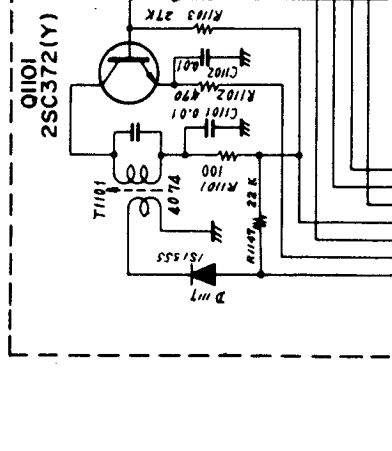
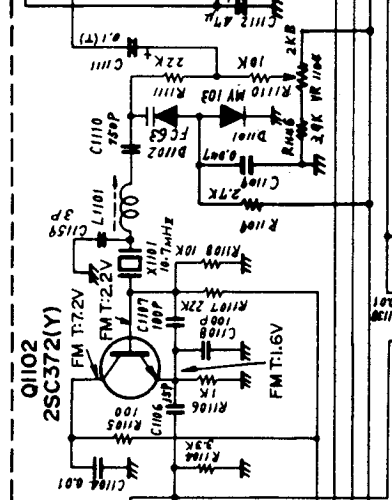
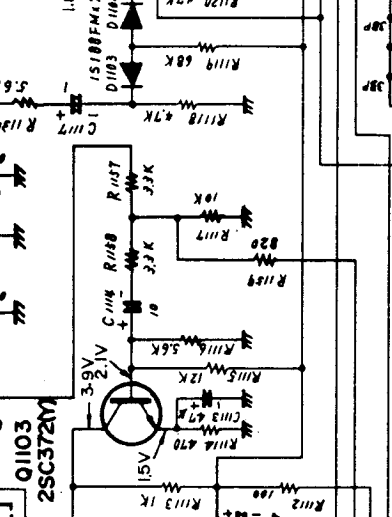
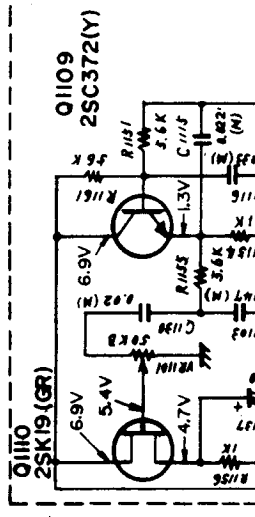


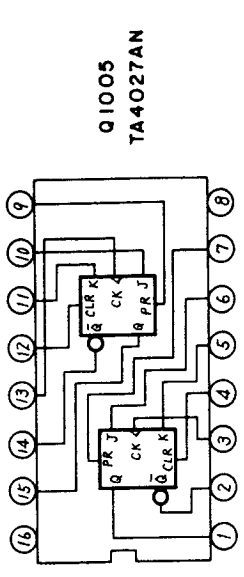
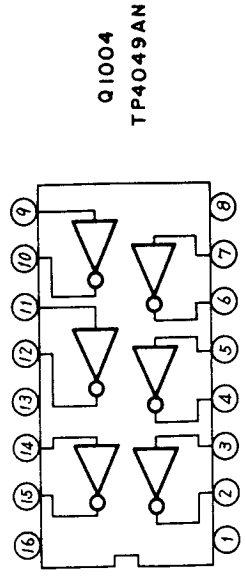
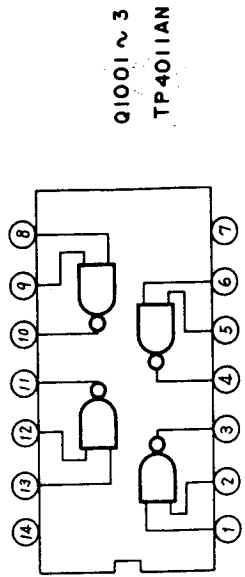




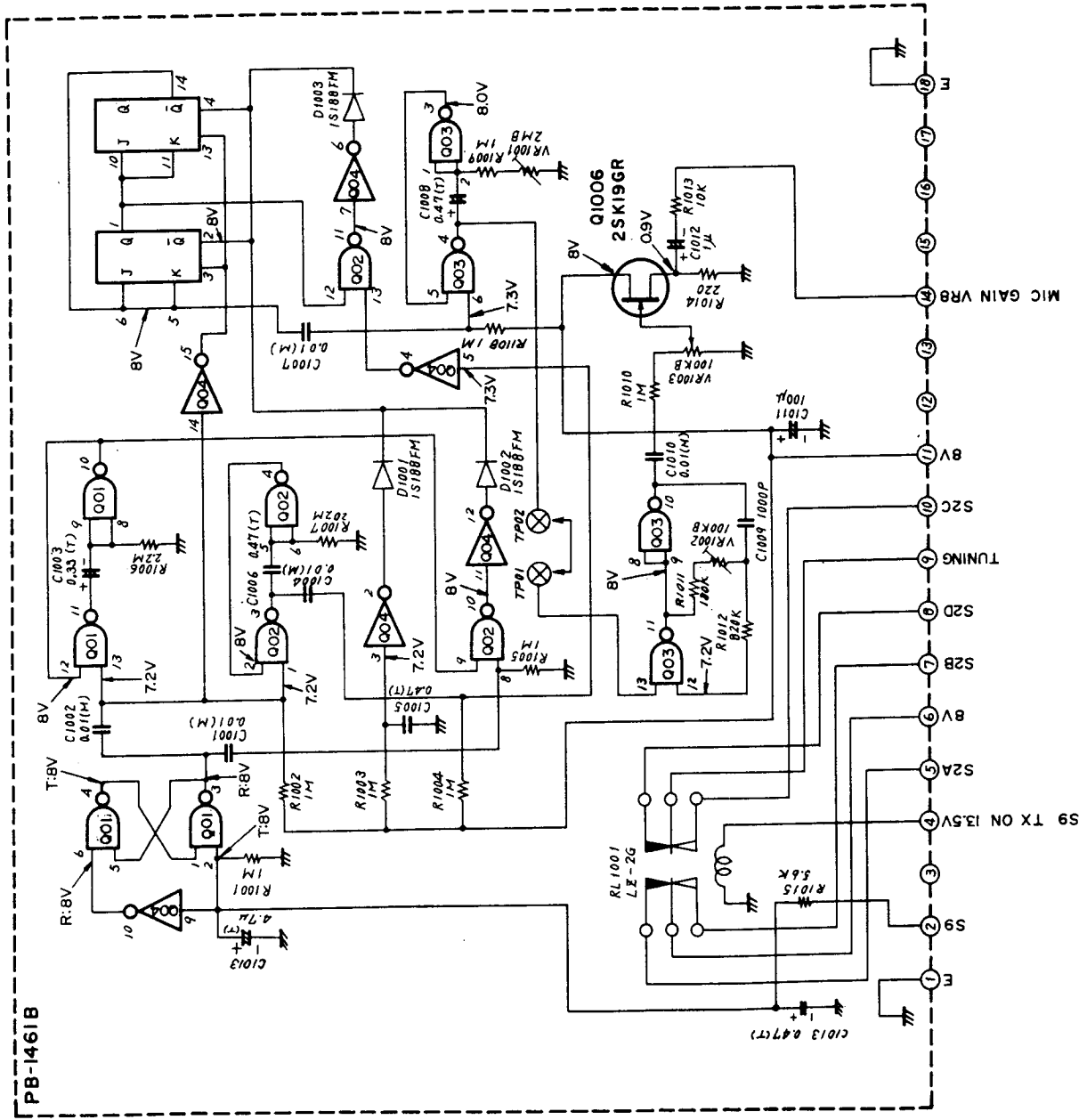
	LSB. USB			CW			AM			FM														
	E(S)		B(G)		C(D)		E(S)		B(G)		C(D)		E(S)		B(G)		C(D)							
	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T						
Q1101	0	0	0	0	0	0	0.49	0	2.6	0	8.0	0	1.9	0	2.6	0	7.8	0	2.2	0	2.6	0	7.8	
Q1107	3.0	3.0	3.4	3.4	6.8	6.8	3.0	4.9	3.4	3.4	6.8	8.0	2.7	3.0	3.4	3.4	6.8	6.7	2.7	2.7	3.4	3.4	6.8	6.8
Q1108	2.5	2.5	1.9	1.9	6.8	6.8	2.5	2.5	2.1	2.3	6.8	6.8	2.3	2.5	1.4	1.8	6.9	6.8	2.3	2.3	1.3	1.4	6.9	6.9

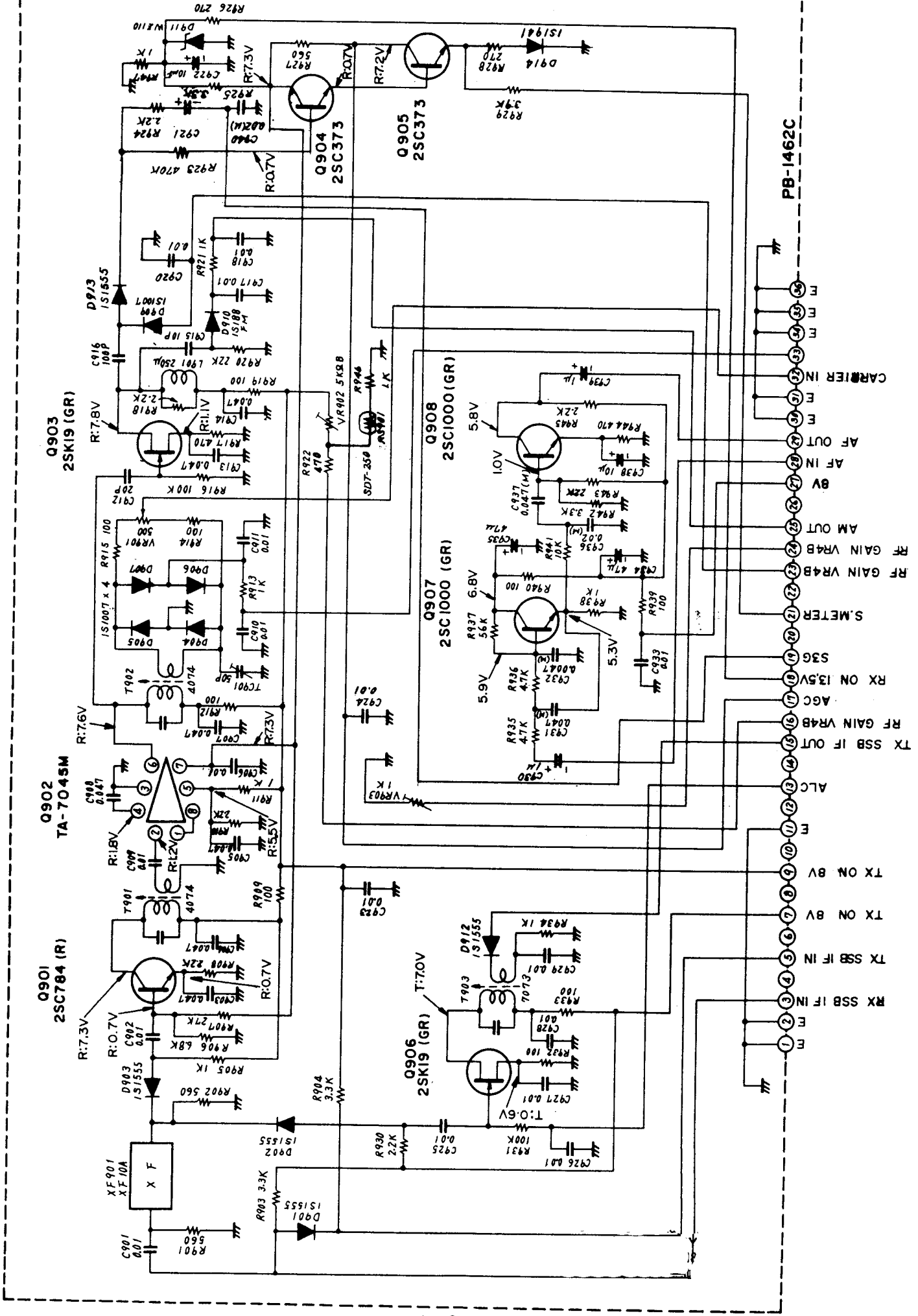
	LSB			USB			CW			AM			FM		
	E(S)	B(G)	C(D)	E(S)	B(G)	C(D)	E(S)	B(G)	C(D)	E(S)	B(G)	C(D)	E(S)	B(G)	C(D)
Q1101	0	0	0	0	0	0	0	19	0	0	0	0	2.2	0	0
Q1107	3.0	3.0	3.4	3.4	3.4	3.4	6.8	27	3.0	3.4	3.4	6.8	2.7	2.7	3.4
Q1108	2.5	2.5	1.9	1.9	6.8	6.8	2.3	2.5	1.4	1.8	6.9	6.8	2.3	2.3	1.3





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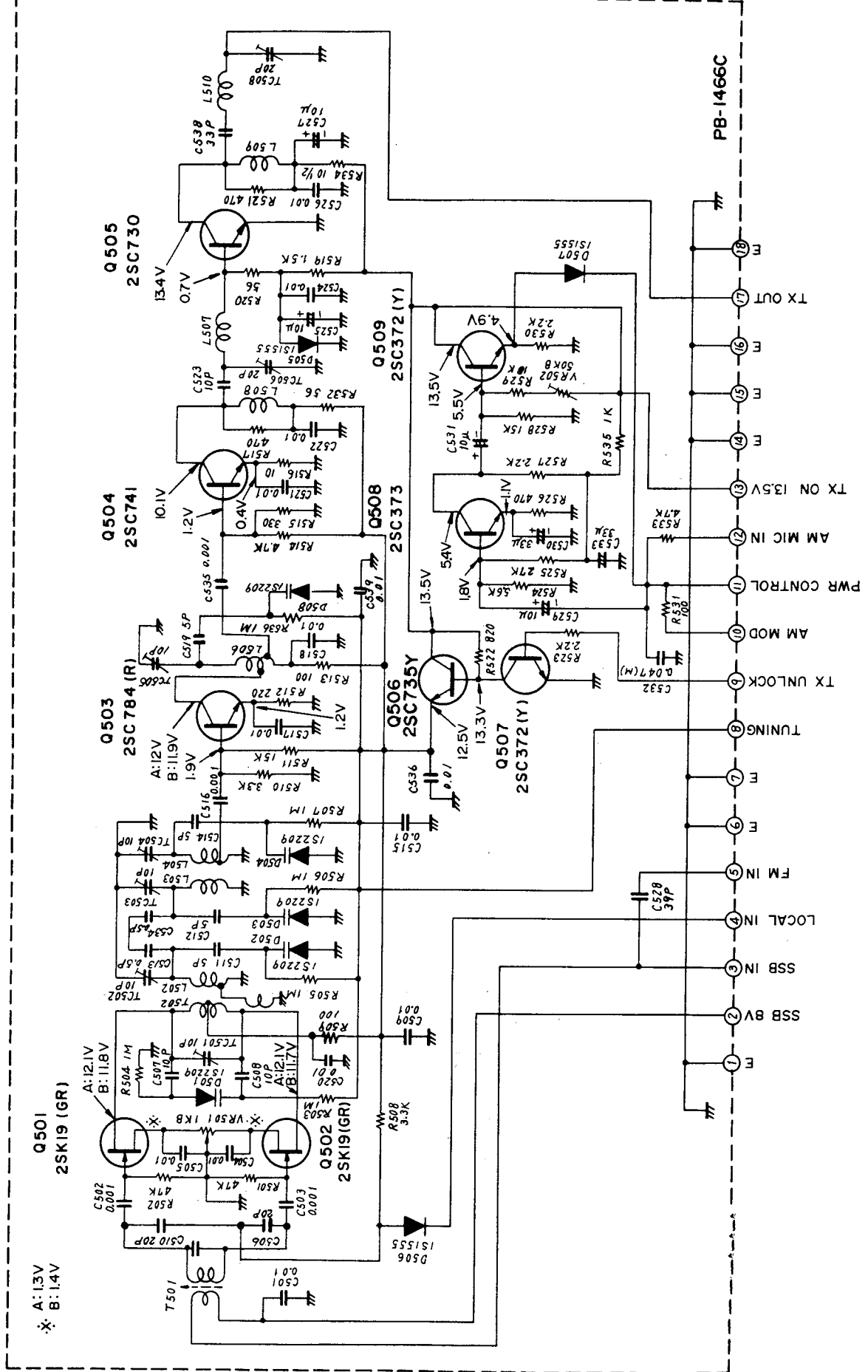
★ FM Transmit ---OV

The diagram shows a multi-stage FM transmitter circuit. Key components include:

- Q801:** 2SC372(Y) oscillator stage with a 7.7V supply.
- Q802:** μ A703HC buffer stage with a 7.0V supply.
- Q803:** 2SK19(GR) driver stage with a 5.1V supply.
- Q804:** 2SC372(Y) push-pull audio amplifier stage with a 5.3V supply.
- Q805:** 2SC372(Y) push-pull FM modulator stage with a 1.5V supply.
- Q806:** 2SC372(Y) push-pull FM modulator stage with a 1.5V supply.
- Q807:** 2SC372(Y) push-pull FM modulator stage with a 7.0V supply.
- Q808:** TA-7061AP push-pull FM modulator stage with a 5.8V supply.
- Q809:** 2SC372(Y) push-pull FM modulator stage with a 10.245 MHz crystal.
- Q811:** 2SC372(Y) push-pull FM modulator stage with a 7.0V supply.

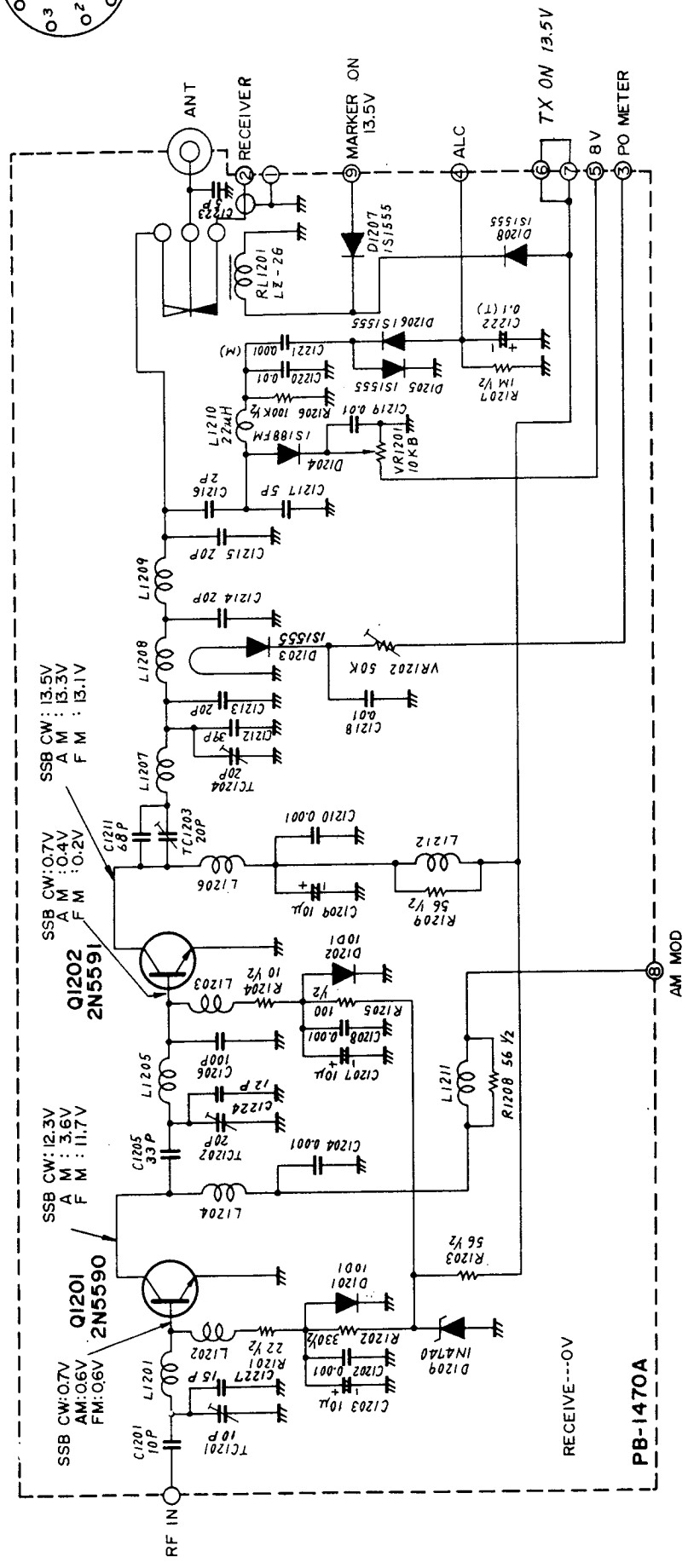
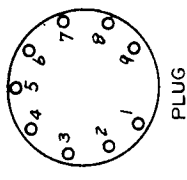
The circuit is powered by a 7.7V battery (Q801) and a 7.0V battery (Q802). The output is connected to a speaker (SP) and a speaker control (NB SW). The circuit is powered by a 7.7V battery (Q801) and a 7.0V battery (Q802). The output is connected to a speaker (SP) and a speaker control (NB SW). The circuit is powered by a 7.7V battery (Q801) and a 7.0V battery (Q802). The output is connected to a speaker (SP) and a speaker control (NB SW).

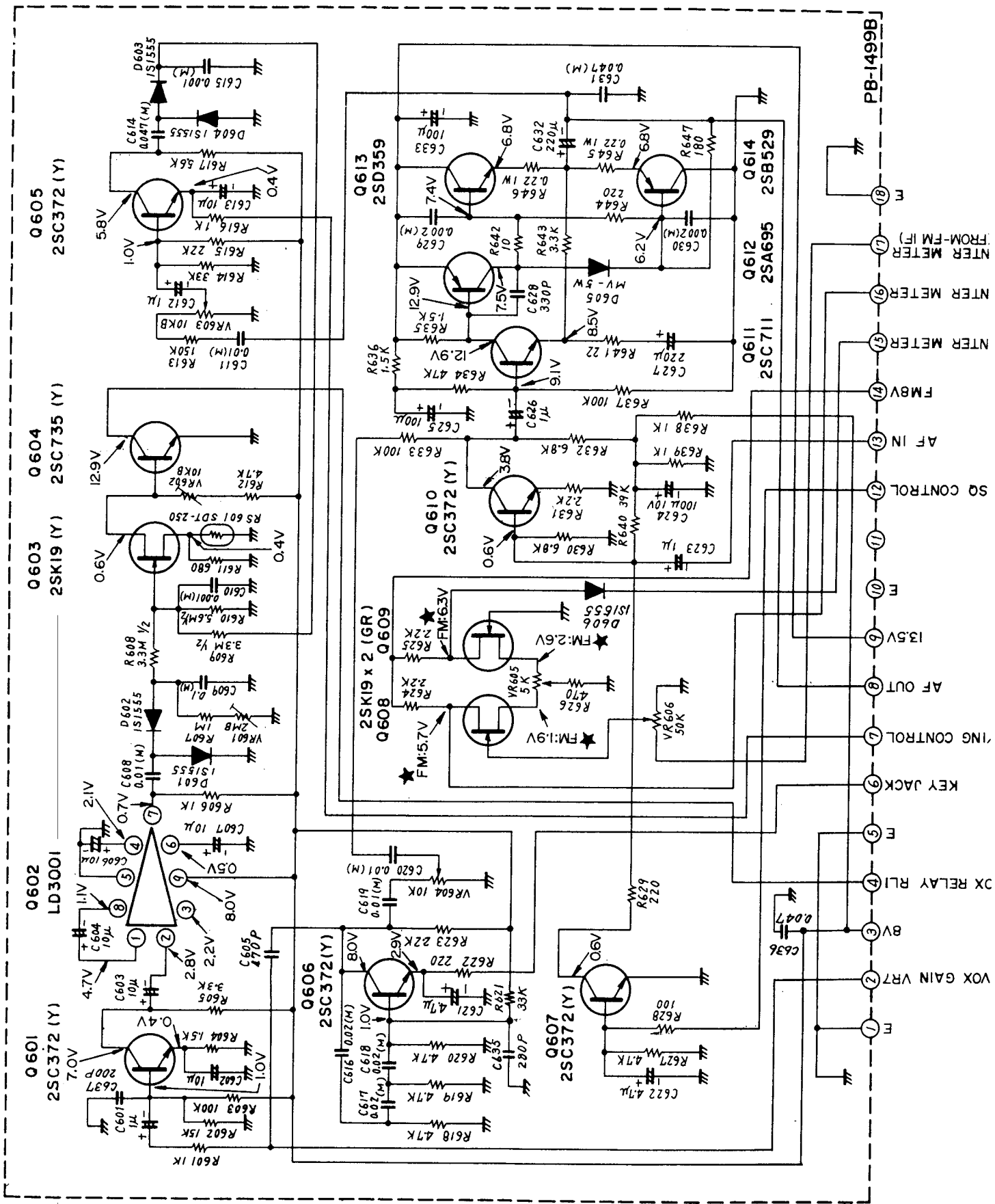
4-13



* A: 13V
 B: 14V

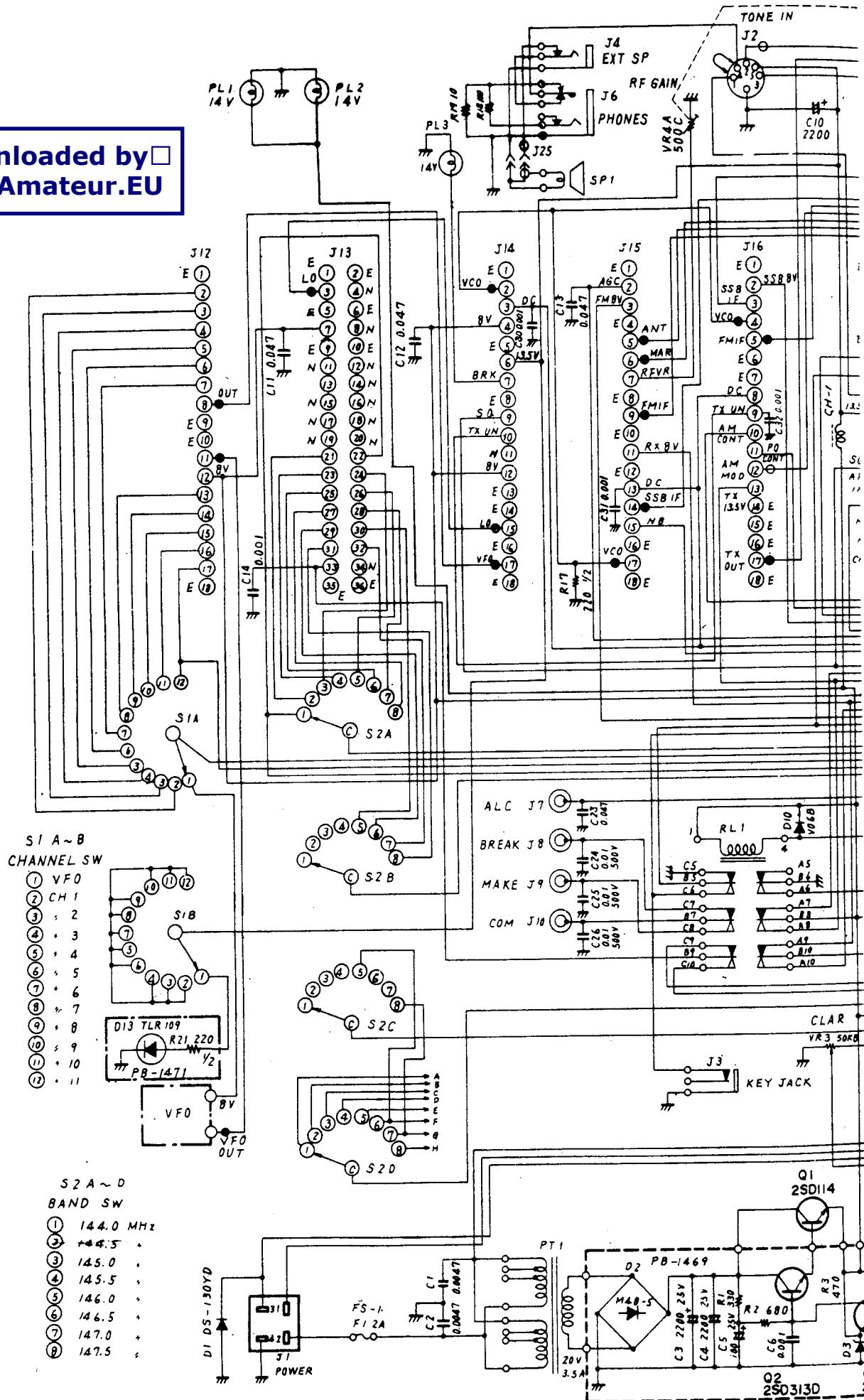
A: LSB USB CW
 B: AM FM

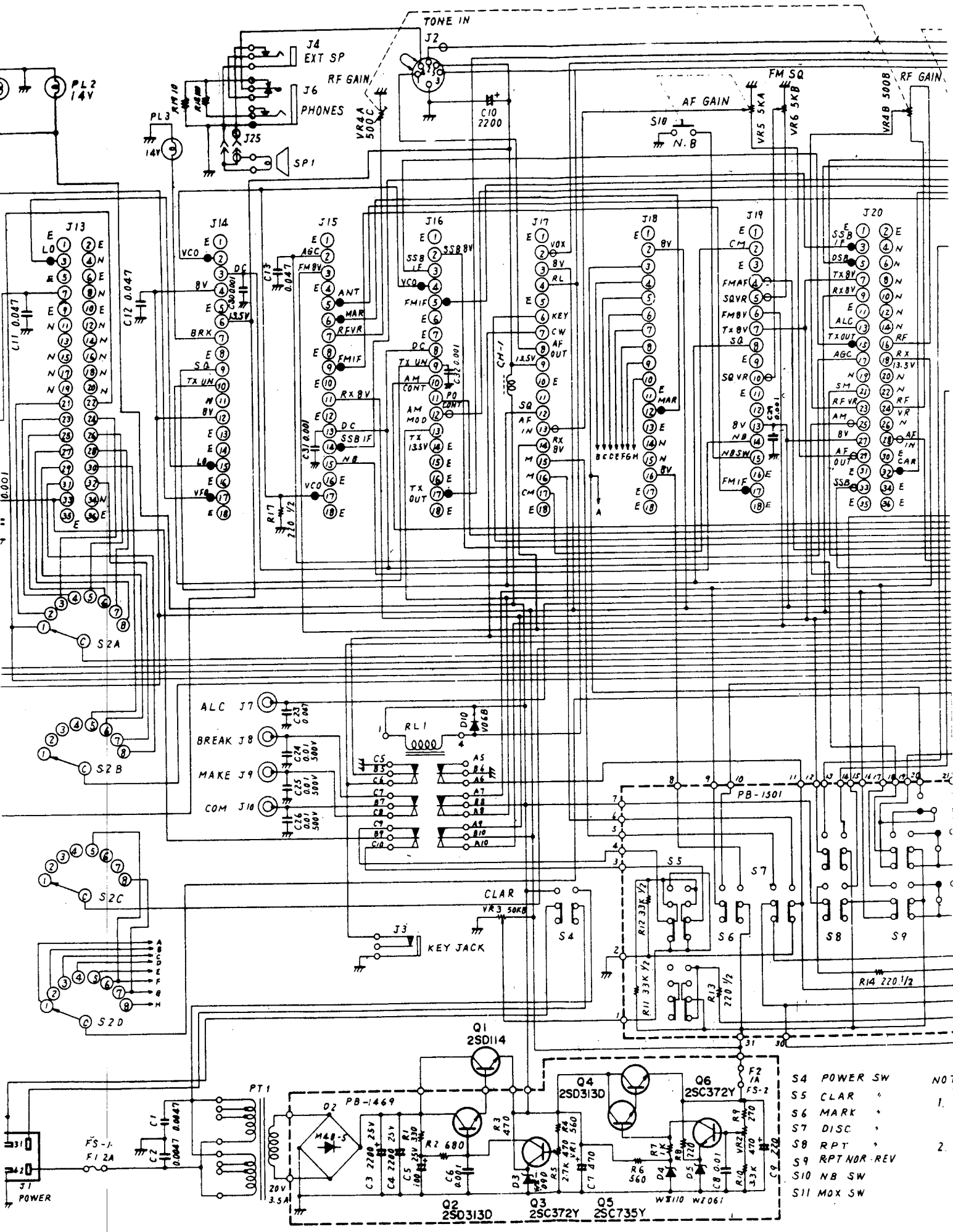




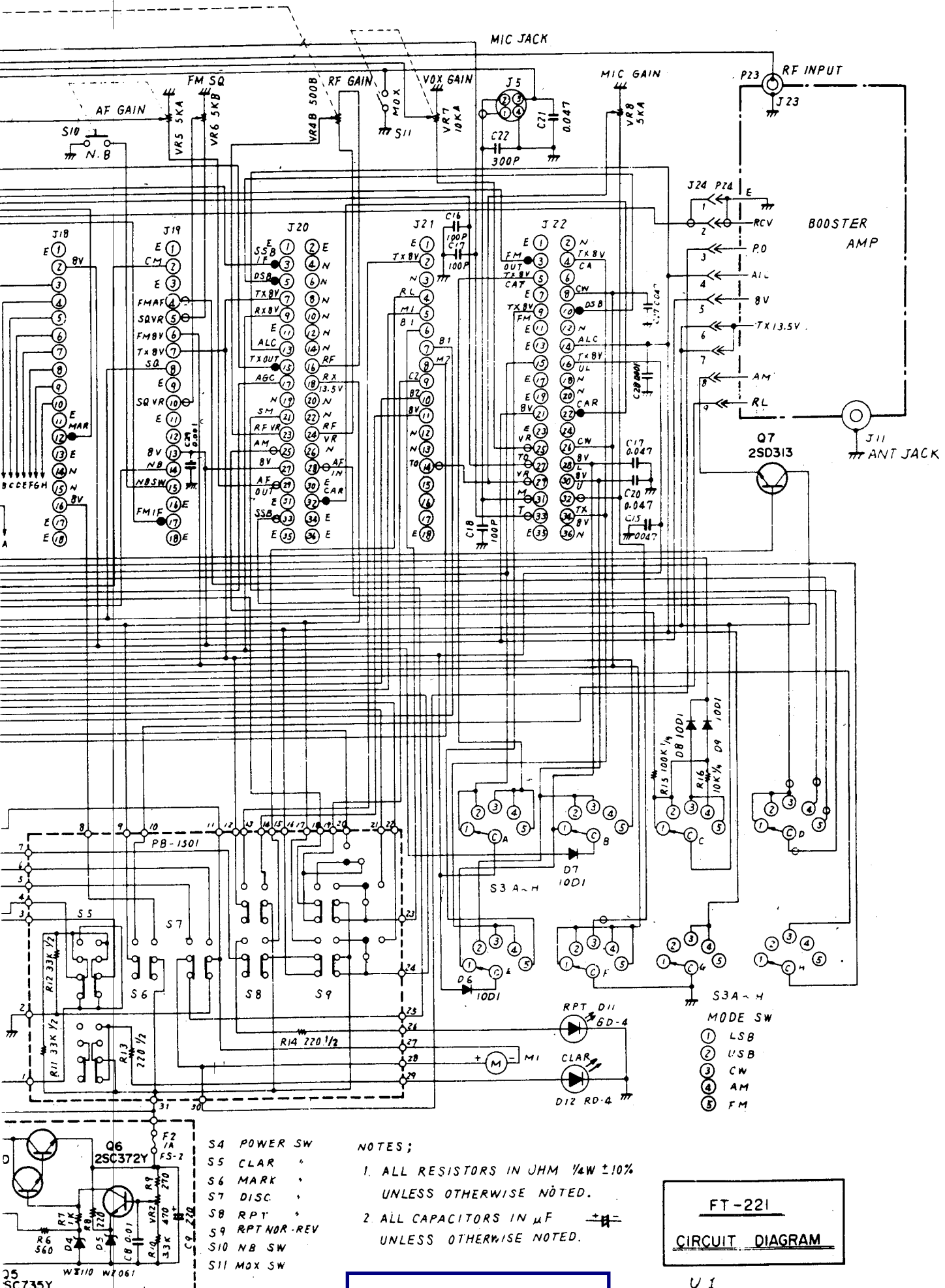
★:FM Transmit--OV

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- S4 POWER SW NOT
- S5 CLAR 1.
- S6 MARK 1.
- S7 DISC 1.
- S8 RPT 2.
- S9 RPT NR. REV 1.
- S10 NB SW
- S11 MOX SW

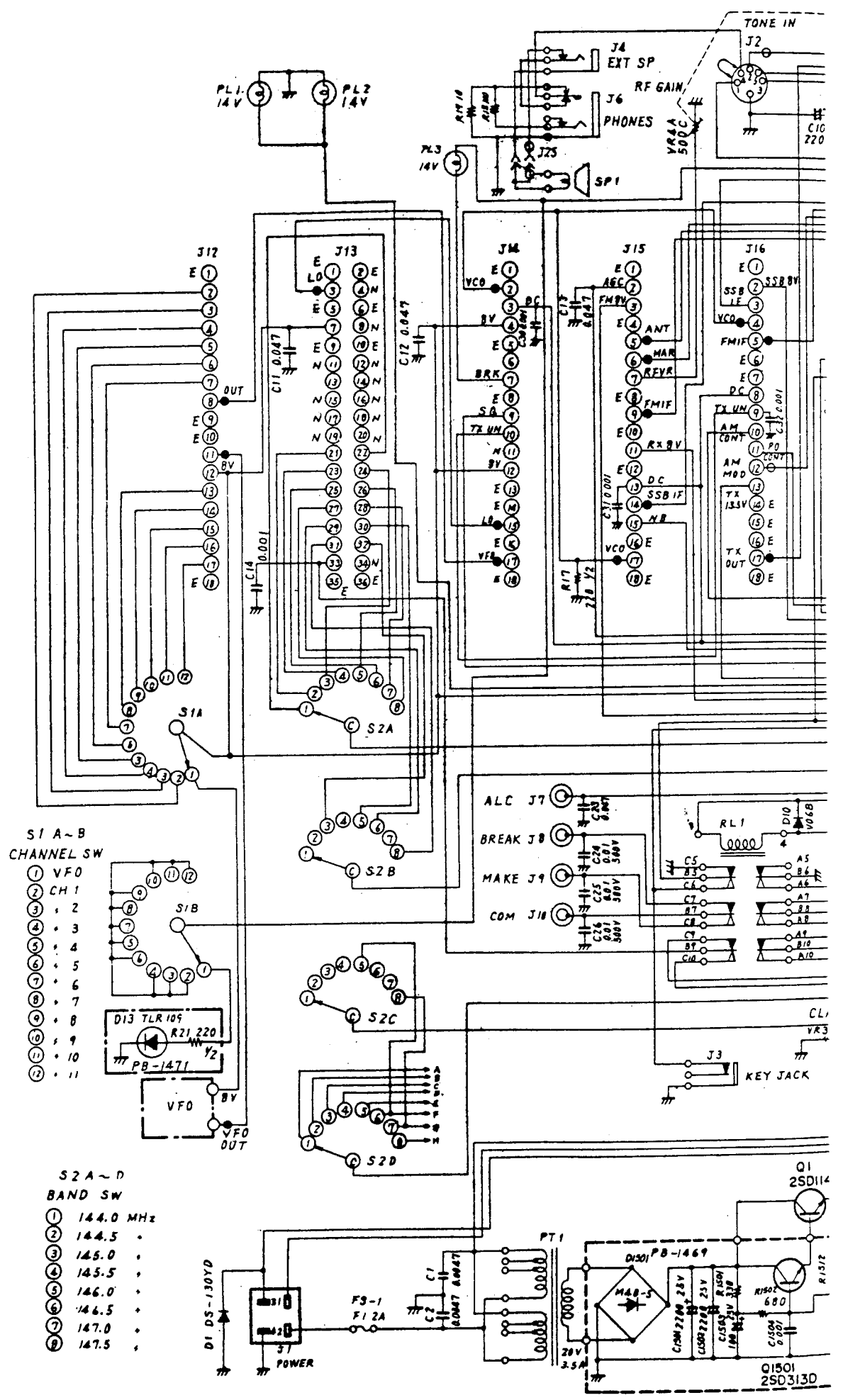


- S4 POWER SW
- S5 CLAR
- S6 MARK
- S7 DISC
- S8 RPT
- S9 RPT NDR-REV
- S10 NB SW
- S11 MOX SW

NOTES;

1. ALL RESISTORS IN JHM $\frac{1}{4}W \pm 10\%$ UNLESS OTHERWISE NOTED.
2. ALL CAPACITORS IN μF UNLESS OTHERWISE NOTED.

FT-221
CIRCUIT DIAGRAM



**S1 A~B
CHANNEL SW**

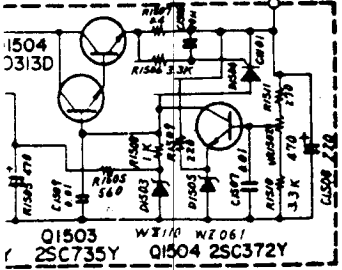
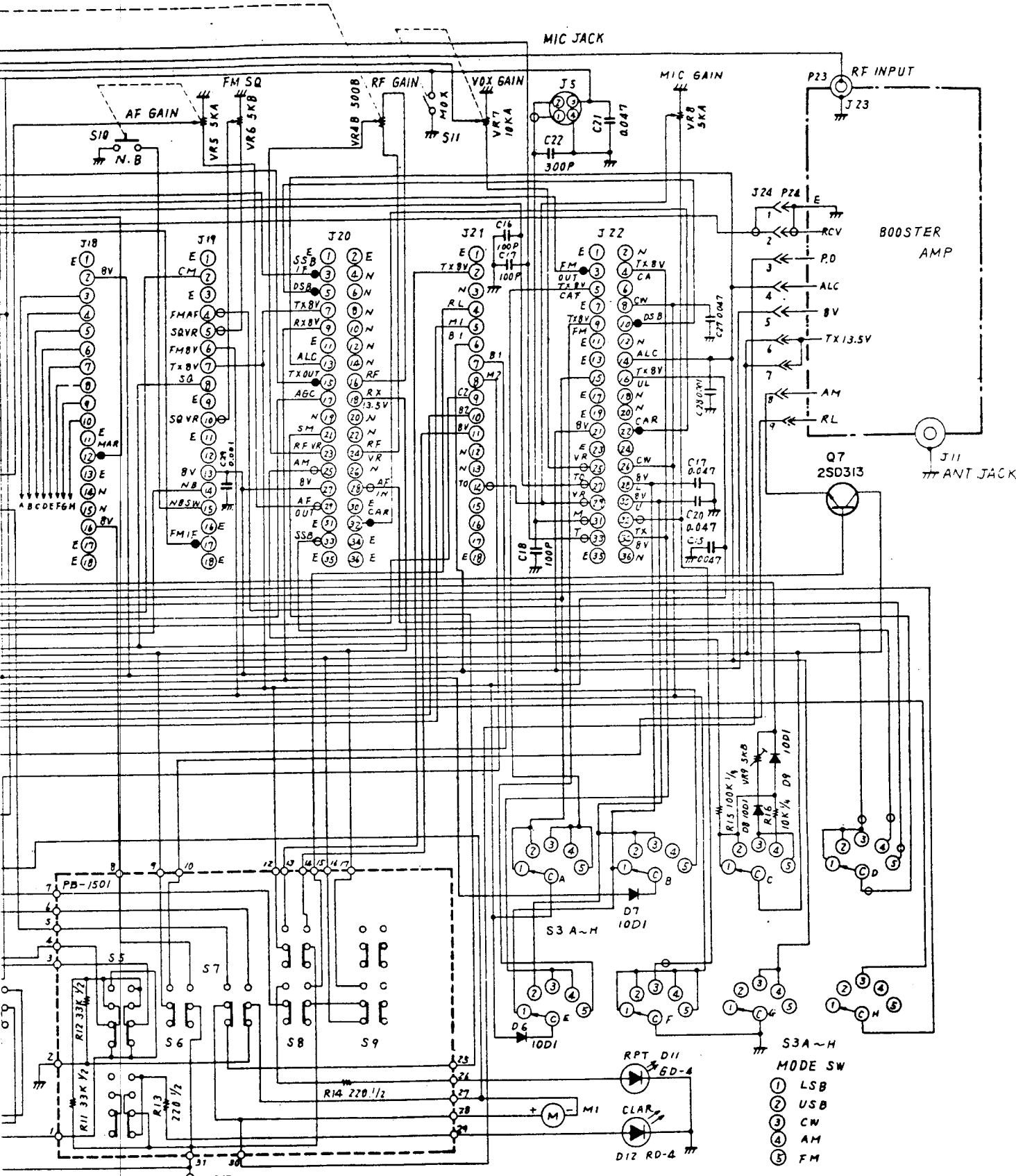
- 1 VFO
- 2 CH 1
- 3 2
- 4 3
- 5 4
- 6 5
- 7 6
- 8 7
- 9 8
- 10 9
- 11 10
- 12 11

**S2 A~D
BAND SW**

- 1 144.0 MHz
- 2 144.5 "
- 3 145.0 "
- 4 145.5 "
- 5 146.0 "
- 6 146.5 "
- 7 147.0 "
- 8 147.5 "

Q1
25D114

Q1501
25D313D



- S4 POWER SW
- S5 CLAR
- S6 MARK
- S7 DISC
- S8 RPT
- S9 RPT NOR-REV
- S10 NB SW
- S11 MOX SW

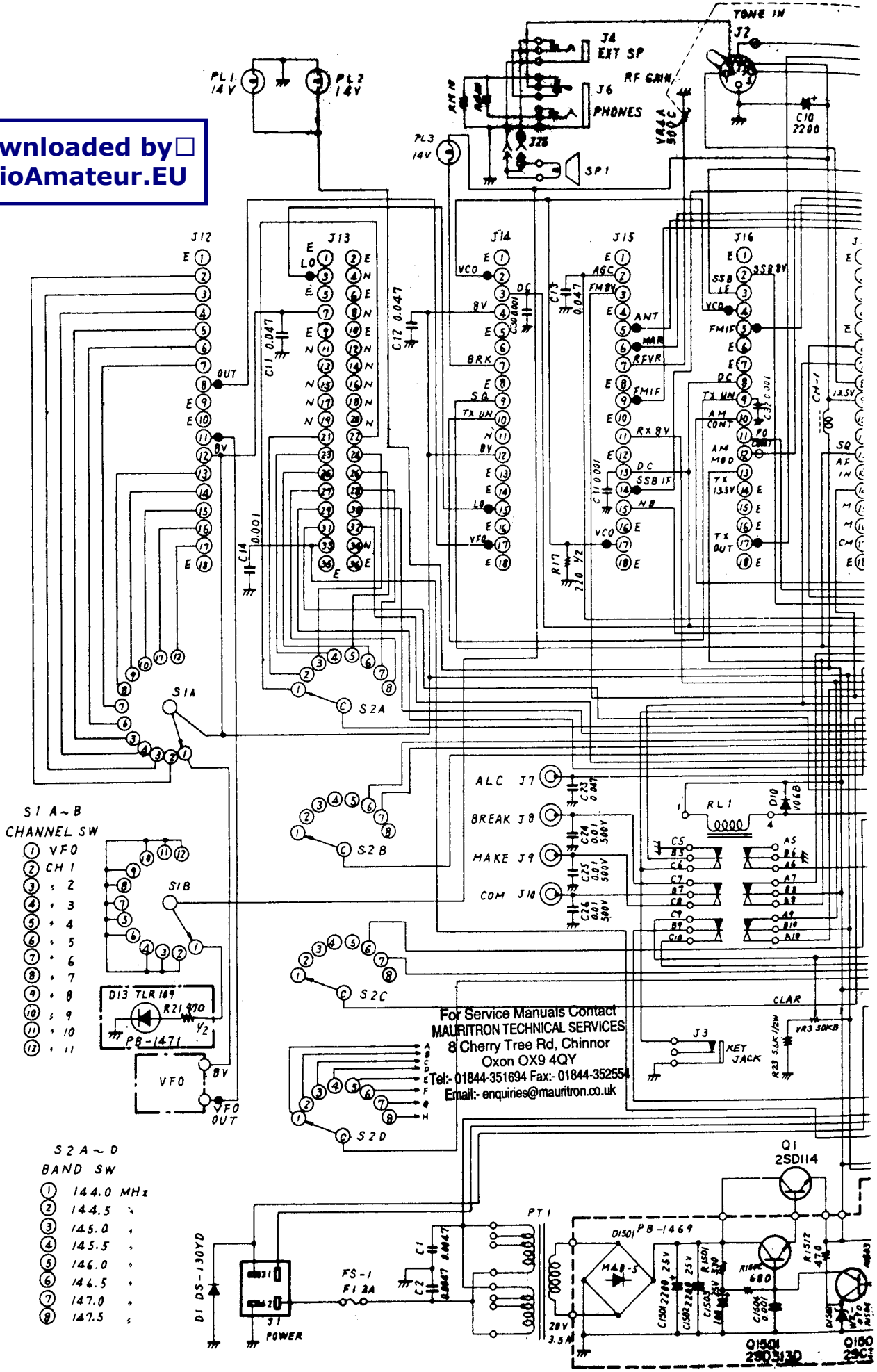
- NOTES;
1. ALL RESISTORS IN OHM 1/4W ±10% UNLESS OTHERWISE NOTED.
 2. ALL CAPACITORS IN μF UNLESS OTHERWISE NOTED.

FT-221
CIRCUIT DIAGRAM

U2

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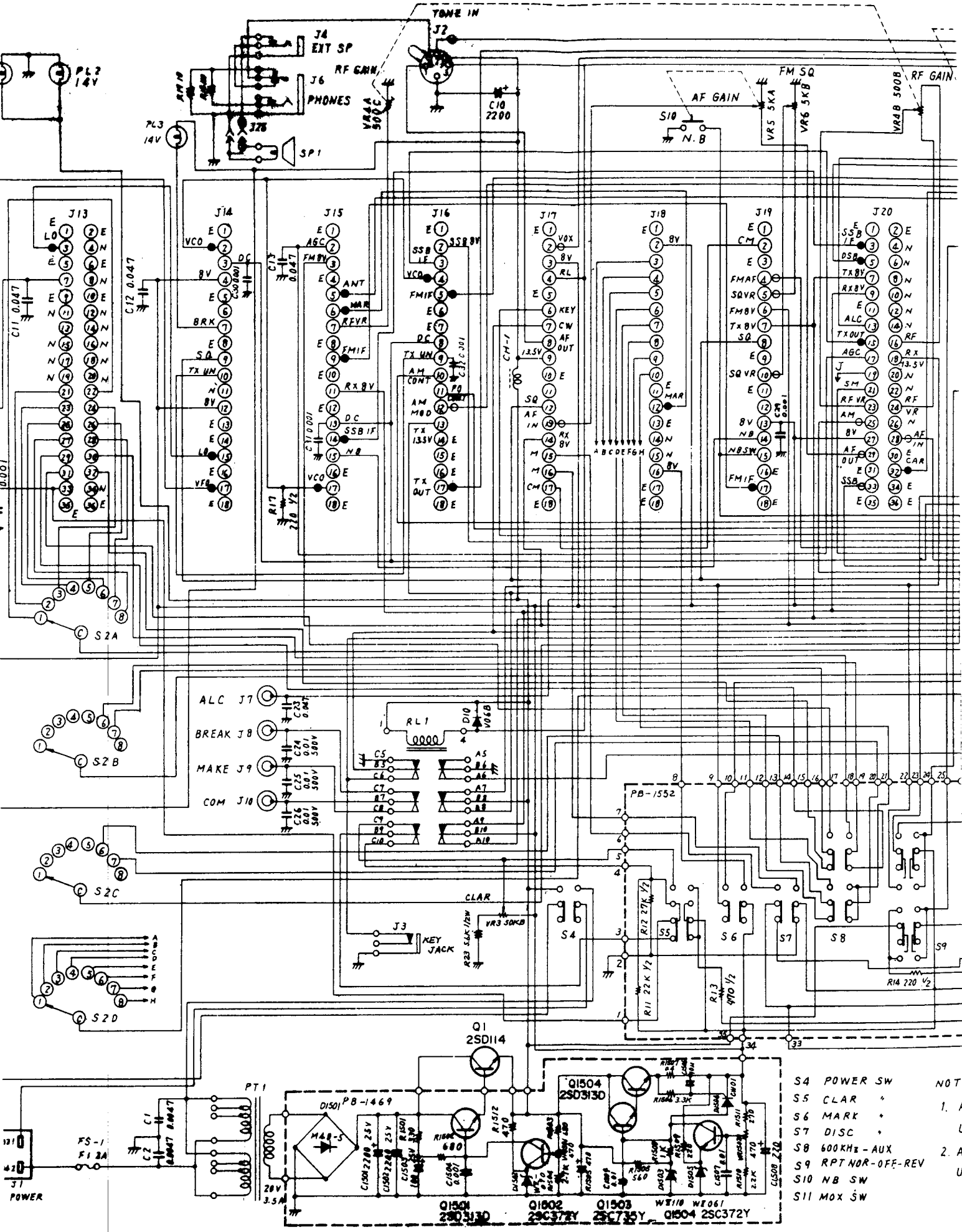
- S1 A~B**
CHANNEL SW
- 1 VFO
 - 2 CH 1
 - 3 + 2
 - 4 + 3
 - 5 + 4
 - 6 + 5
 - 7 + 6
 - 8 + 7
 - 9 + 8
 - 10 + 9
 - 11 + 10
 - 12 + 11

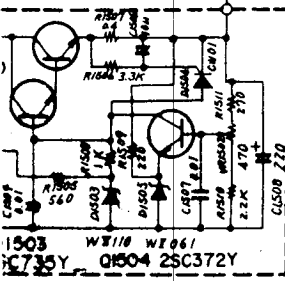
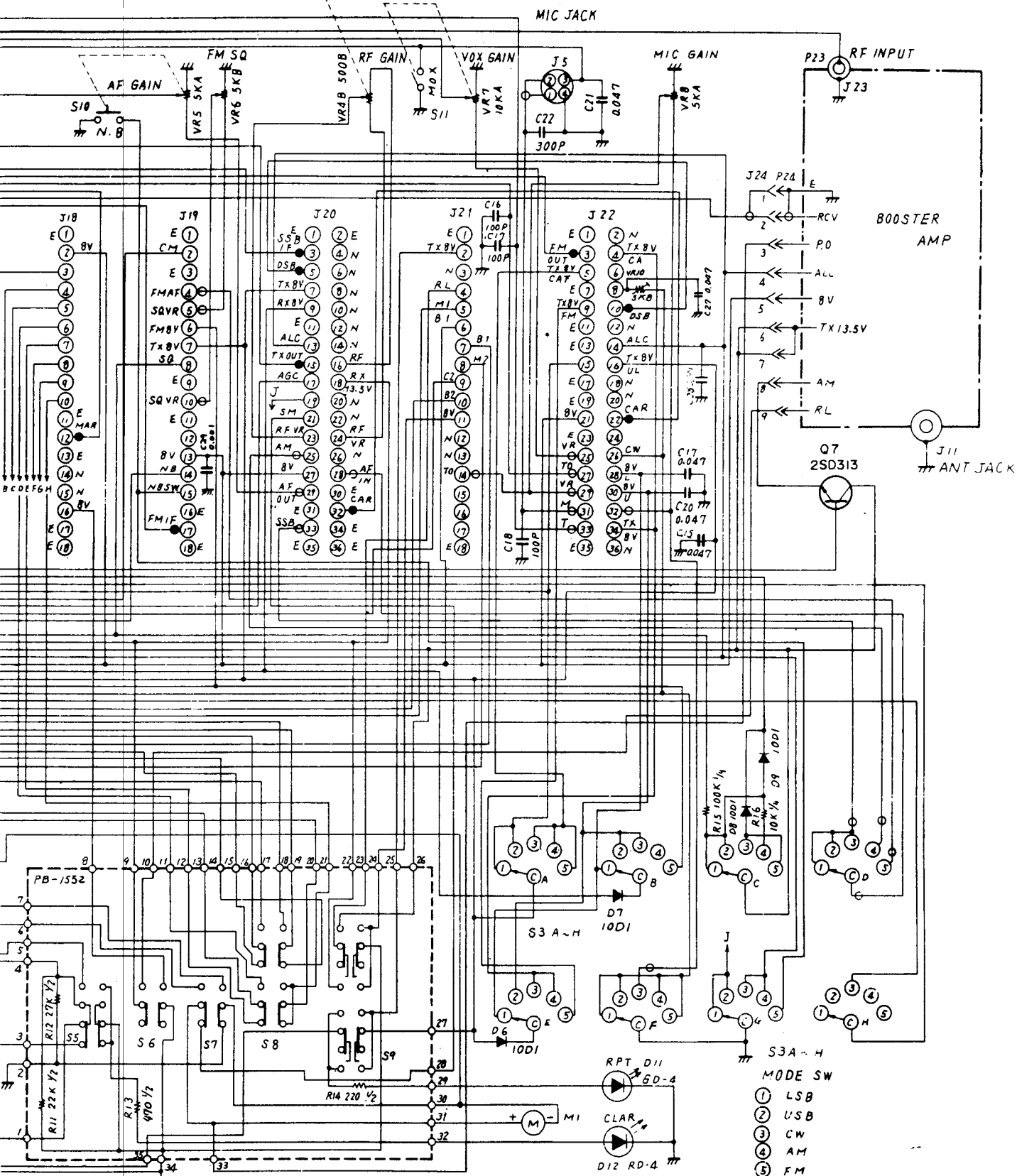
- S2 A~D**
BAND SW
- 1 144.0 MHz
 - 2 144.5 "
 - 3 145.0 "
 - 4 145.5 "
 - 5 146.0 "
 - 6 146.5 "
 - 7 147.0 "
 - 8 147.5 "

For Service Manuals Contact
MAURITRON TECHNICAL SERVICES
 8 Cherry Tree Rd, Chinnor
 Oxon OX9 4QY
 Tel: 01844-351694 Fax: 01844-352554
 Email: enquiries@mauritron.co.uk

CLAR
 J3
 KEY JACK
 R23 5.6K/2W
 VR3 500KB

Q1504
 280 3130
 Q1505
 280 3130

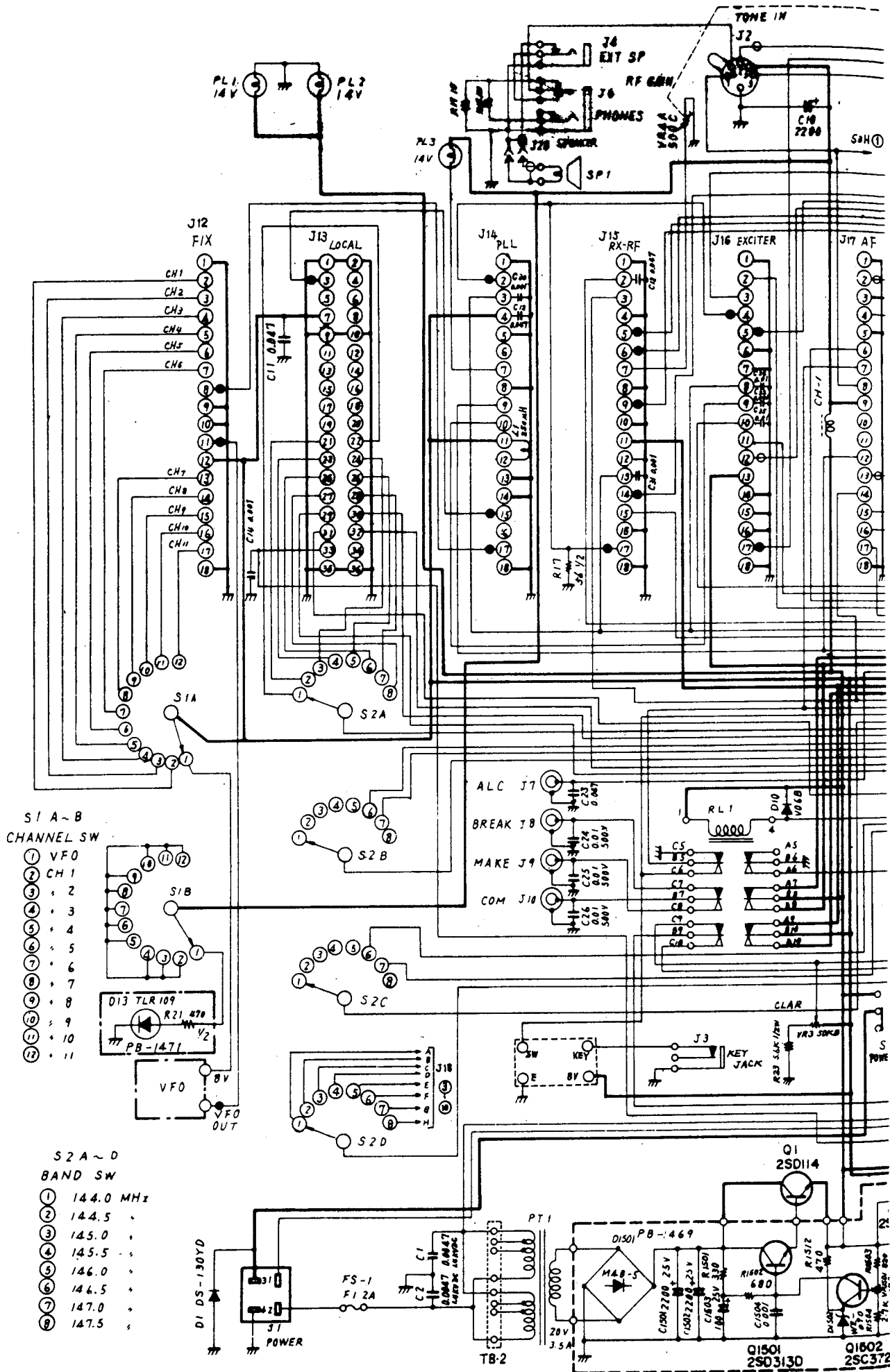




- S4 POWER SW
- S5 CLAR "
- S6 MARK "
- S7 DISC "
- S8 600KH_z-AUX
- S9 RPT NOR-OFF-REV
- S10 NB SW
- S11 MOX SW

NOTES;
 1. ALL RESISTORS IN UHM 1/4W ±10%
 UNLESS OTHERWISE NOTED.
 2. ALL CAPACITORS IN μF
 UNLESS OTHERWISE NOTED.

FT-221
CIRCUIT DIAGRAM

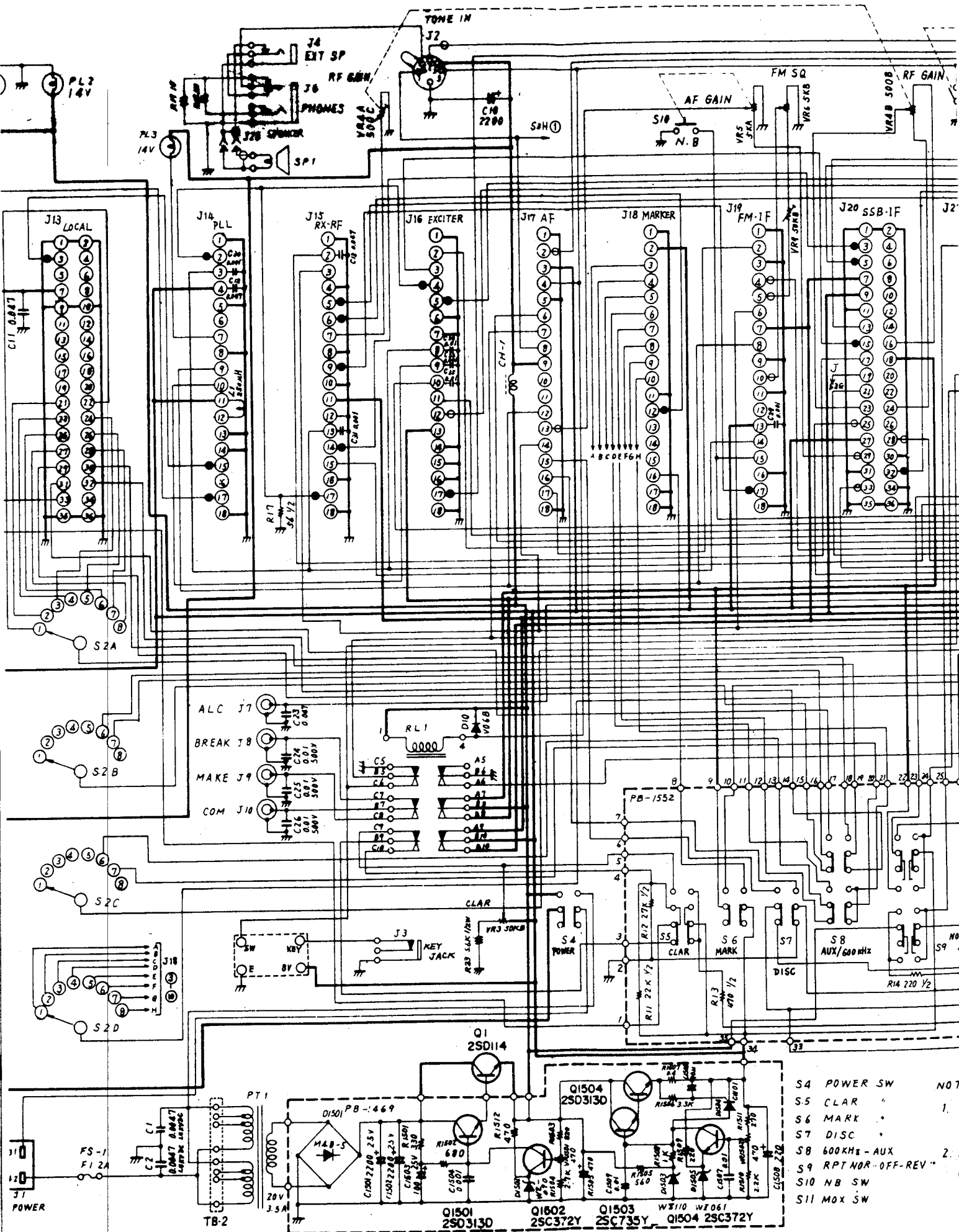


S1 A~B
CHANNEL SW

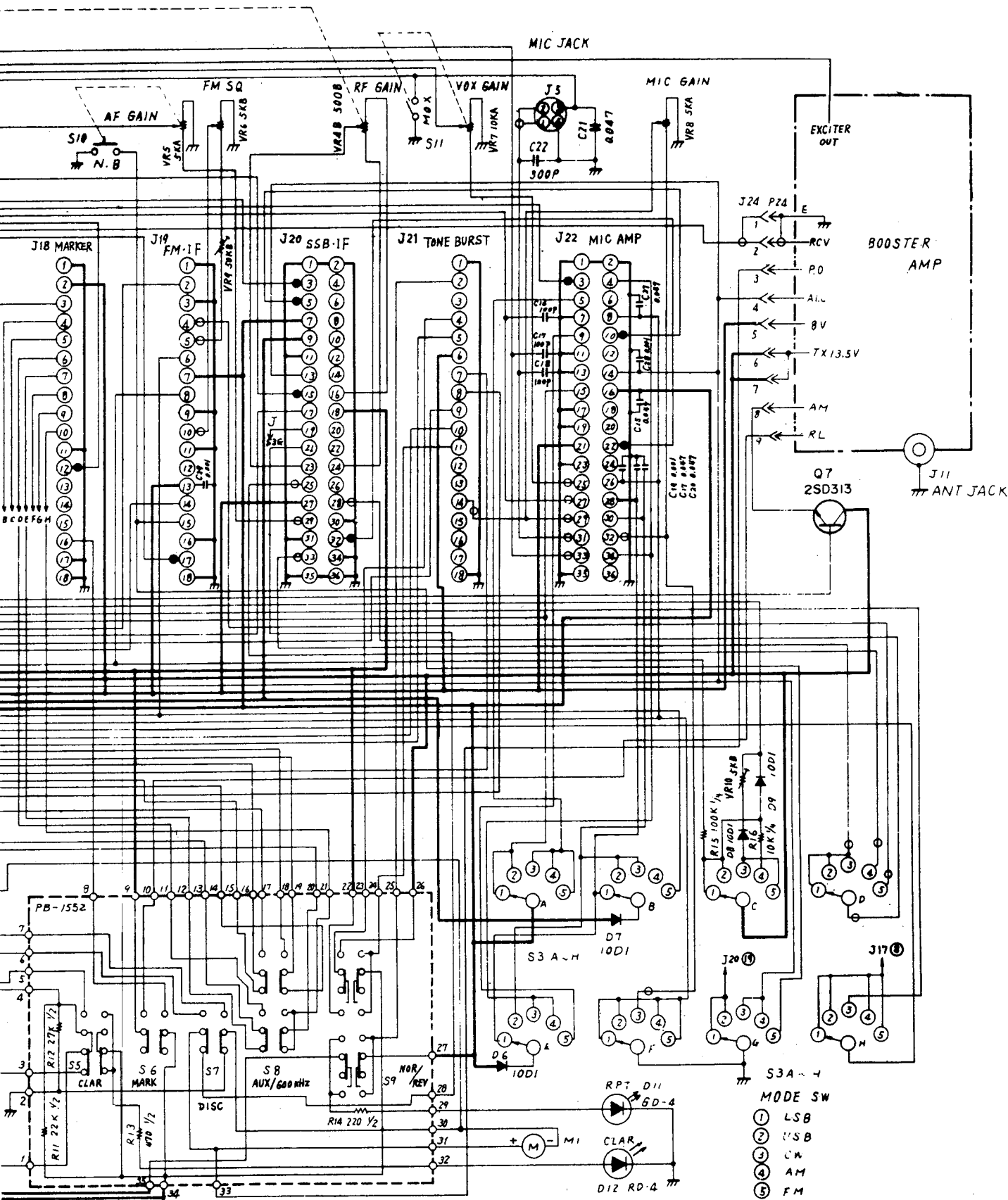
- 1 VFO
- 2 CH 1
- 3 " 2
- 4 " 3
- 5 " 4
- 6 " 5
- 7 " 6
- 8 " 7
- 9 " 8
- 10 " 9
- 11 " 10
- 12 " 11

S2 A~D
BAND SW

- 1 144.0 MHz
- 2 144.5 "
- 3 145.0 "
- 4 145.5 "
- 5 146.0 "
- 6 146.5 "
- 7 147.0 "
- 8 147.5 "



- S4 POWER SW NOT:
 S5 CLAR " 1. A
 S6 MARK " U
 S7 DISC " U
 S8 600 kHz - AUX 2. A
 S9 RPT NOR-OFF-REV " U
 S10 NB SW
 S11 MOX SW

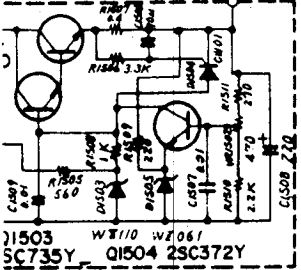


- S4 POWER SW
- S5 CLAR
- S6 MARK
- S7 DISC
- S8 600KHz - AUX
- S9 RPT NOR-OFF-REV
- S10 NB SW
- S11 MOX SW

NOTES ;

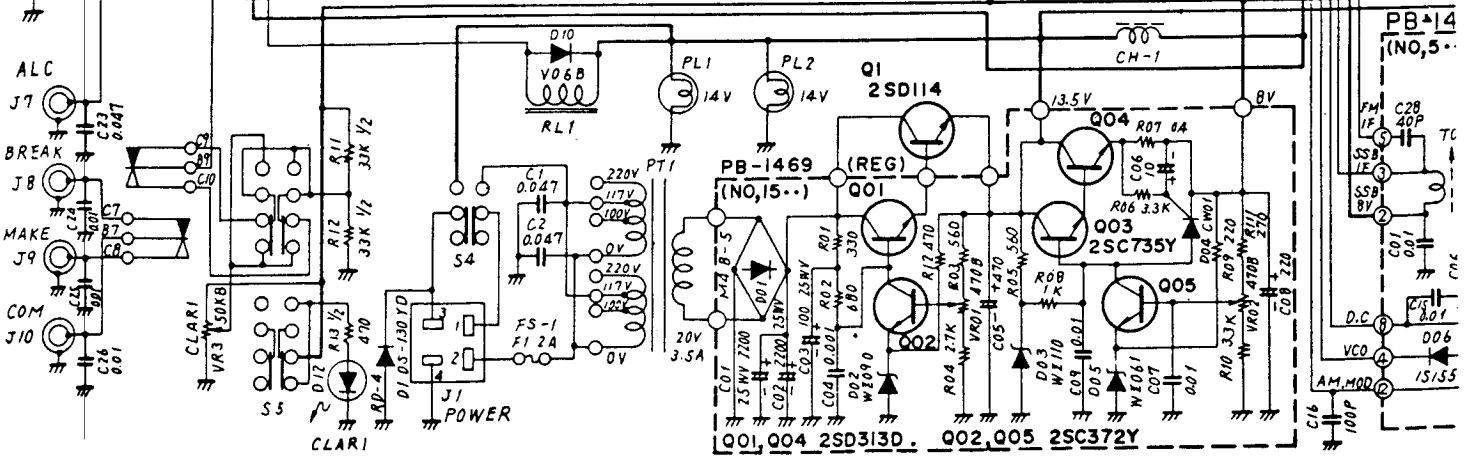
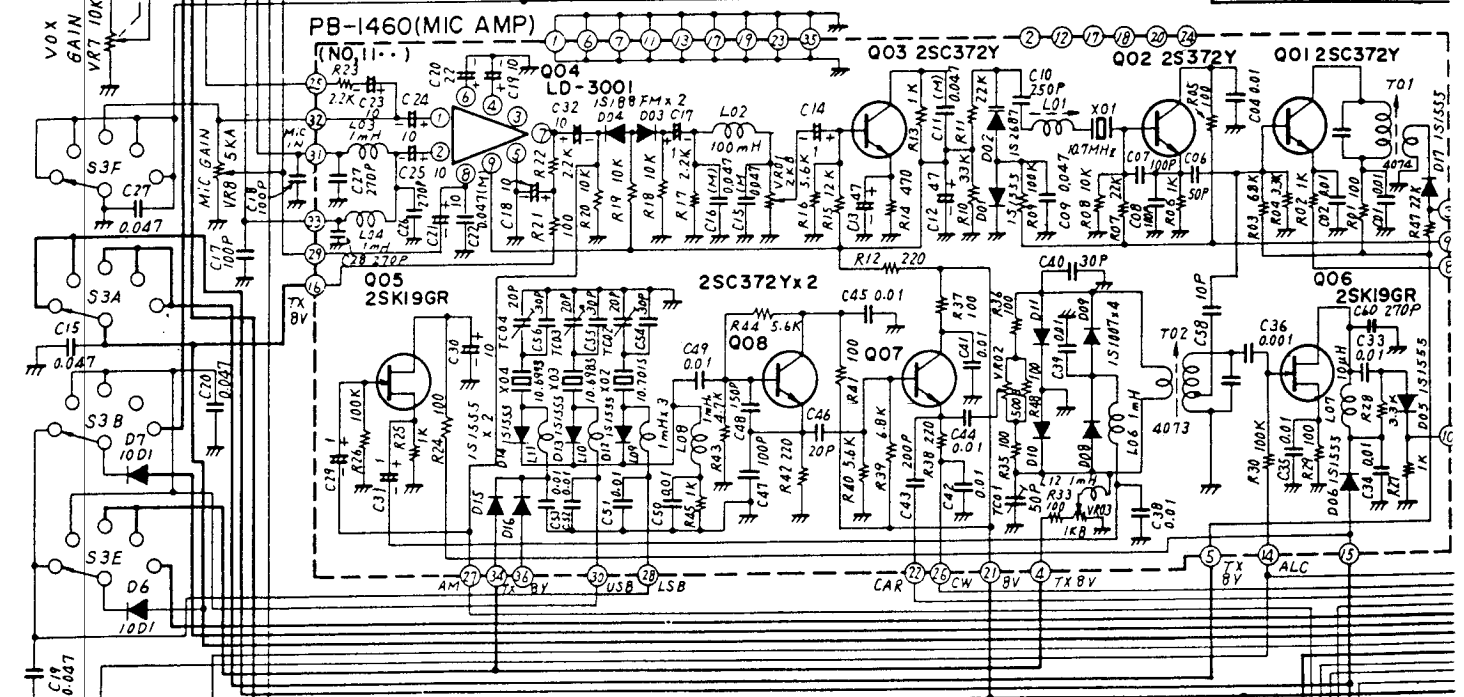
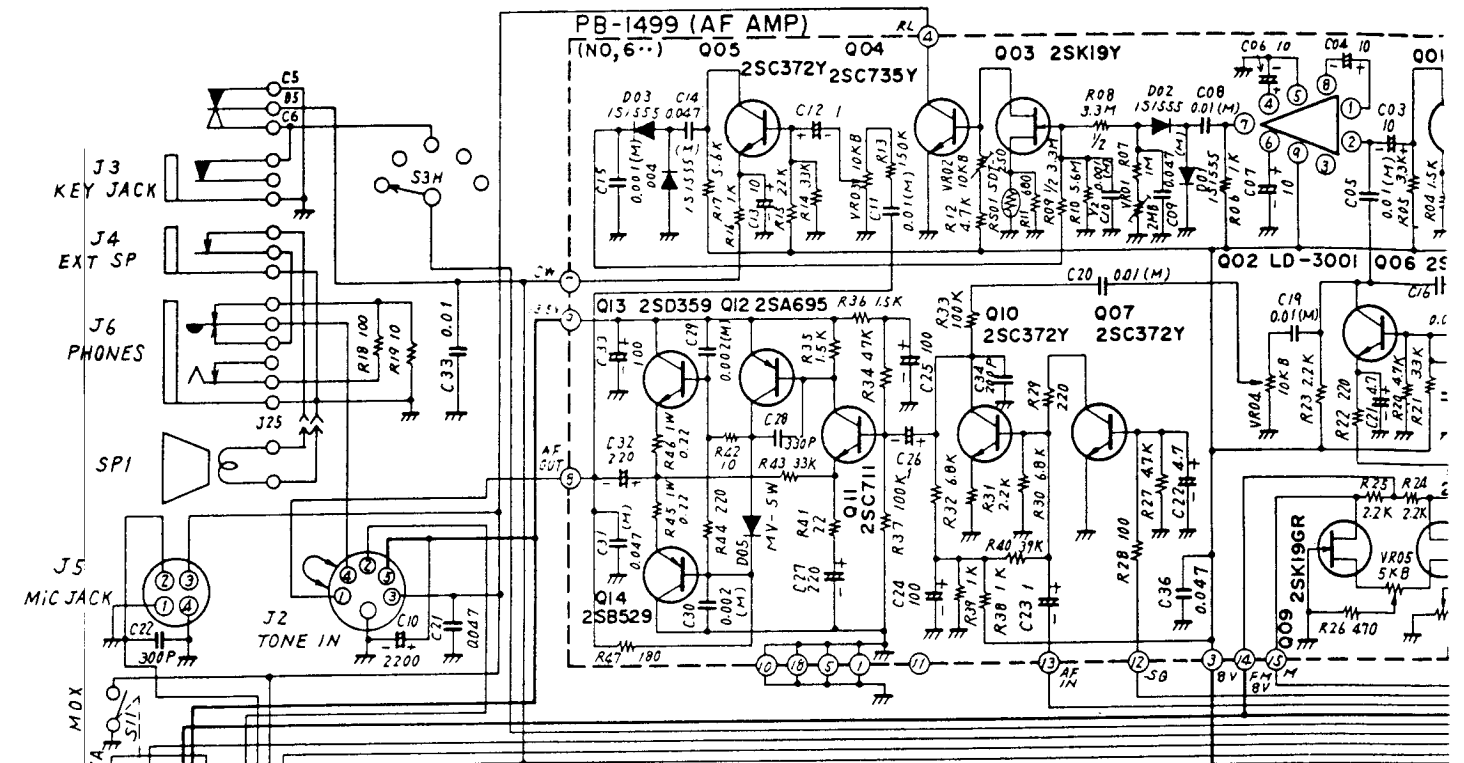
1. ALL RESISTORS IN OHM 1/4W ±10% UNLESS OTHERWISE NOTED.
2. ALL CAPACITORS IN μF UNLESS OTHERWISE NOTED.

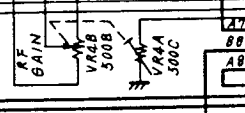
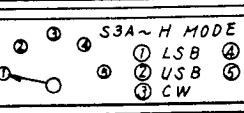
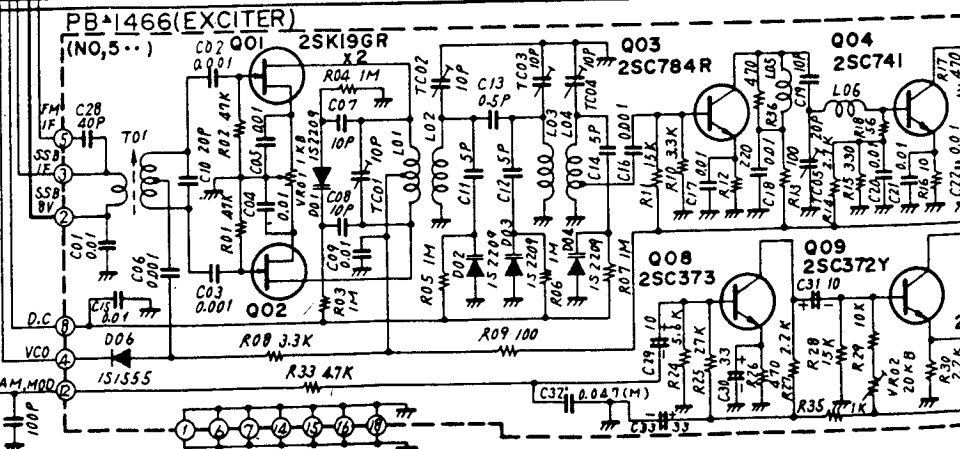
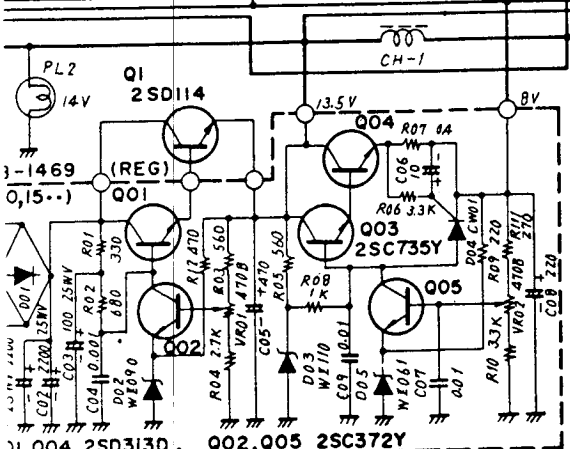
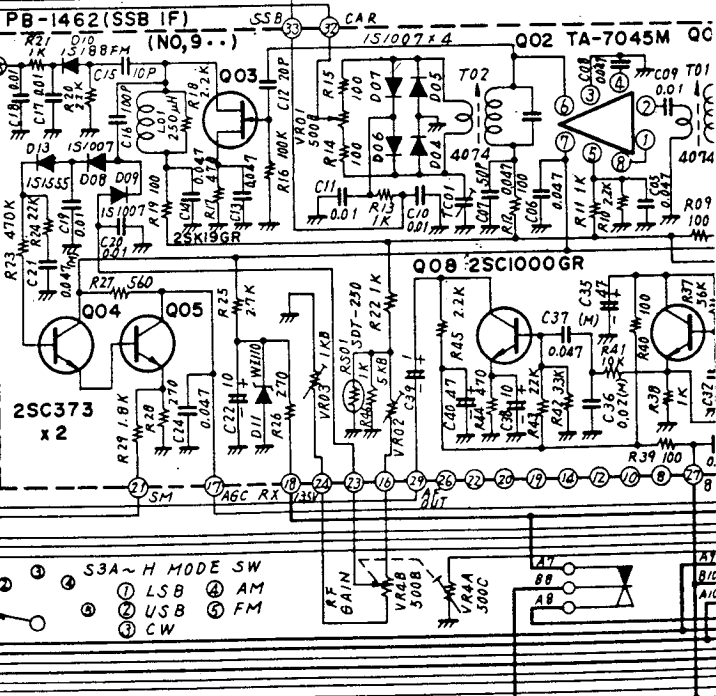
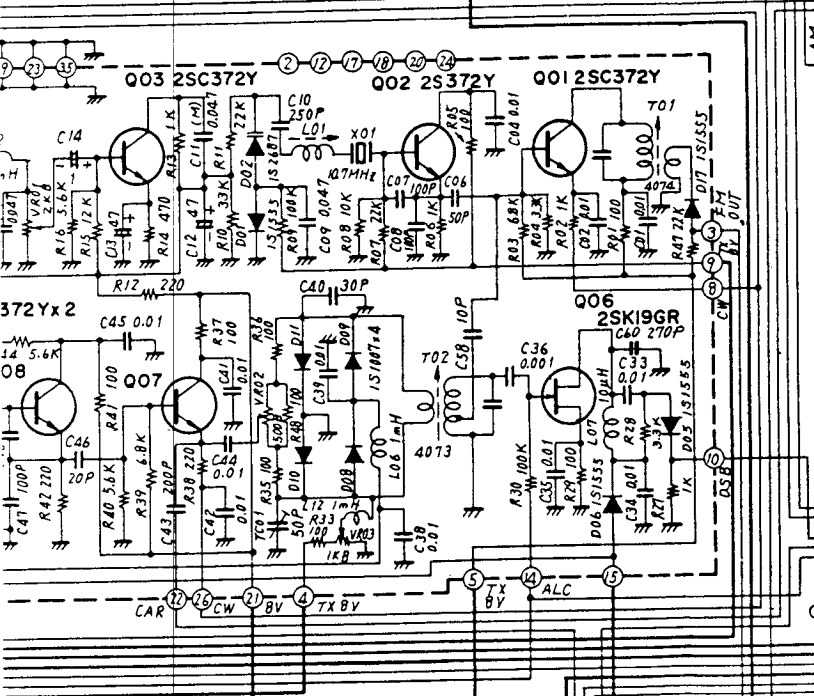
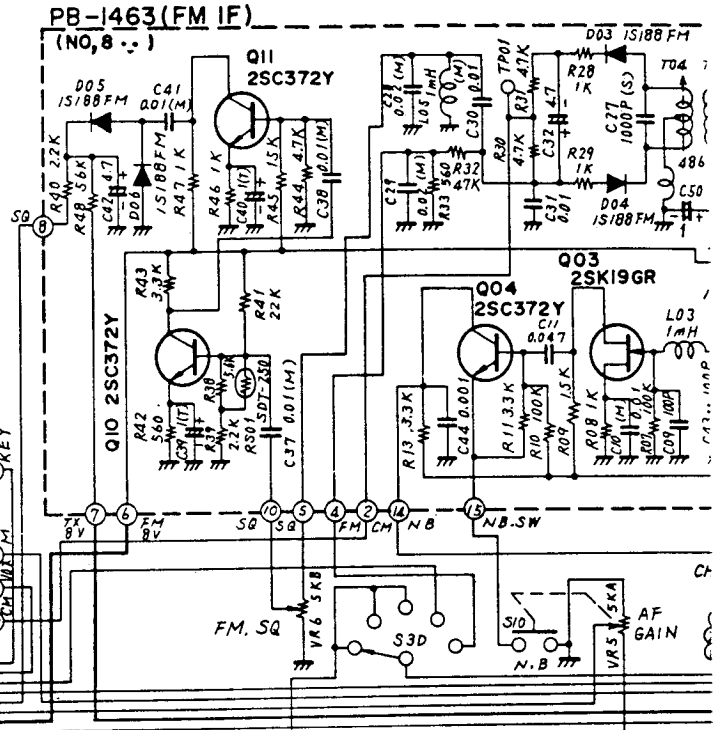
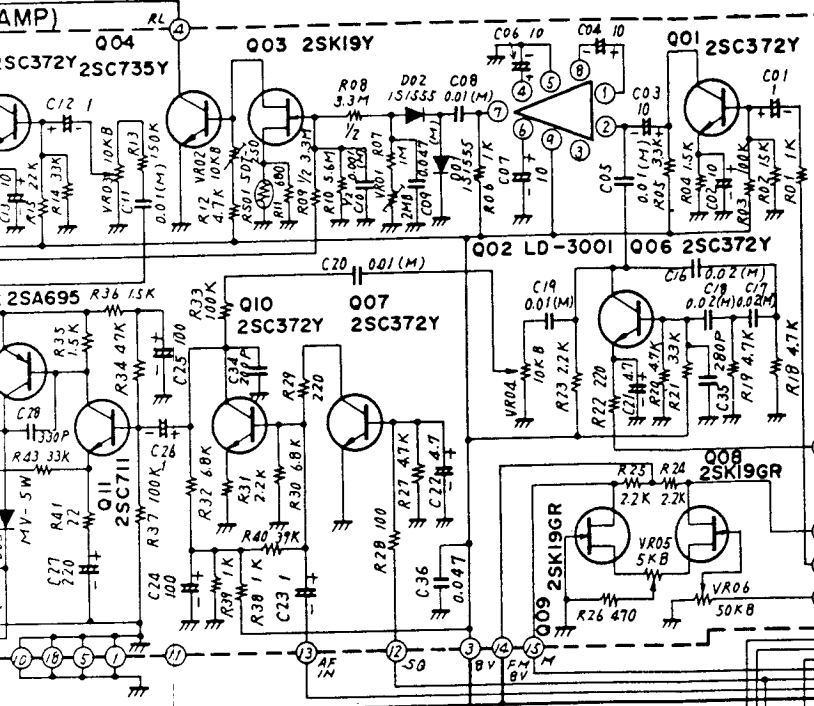
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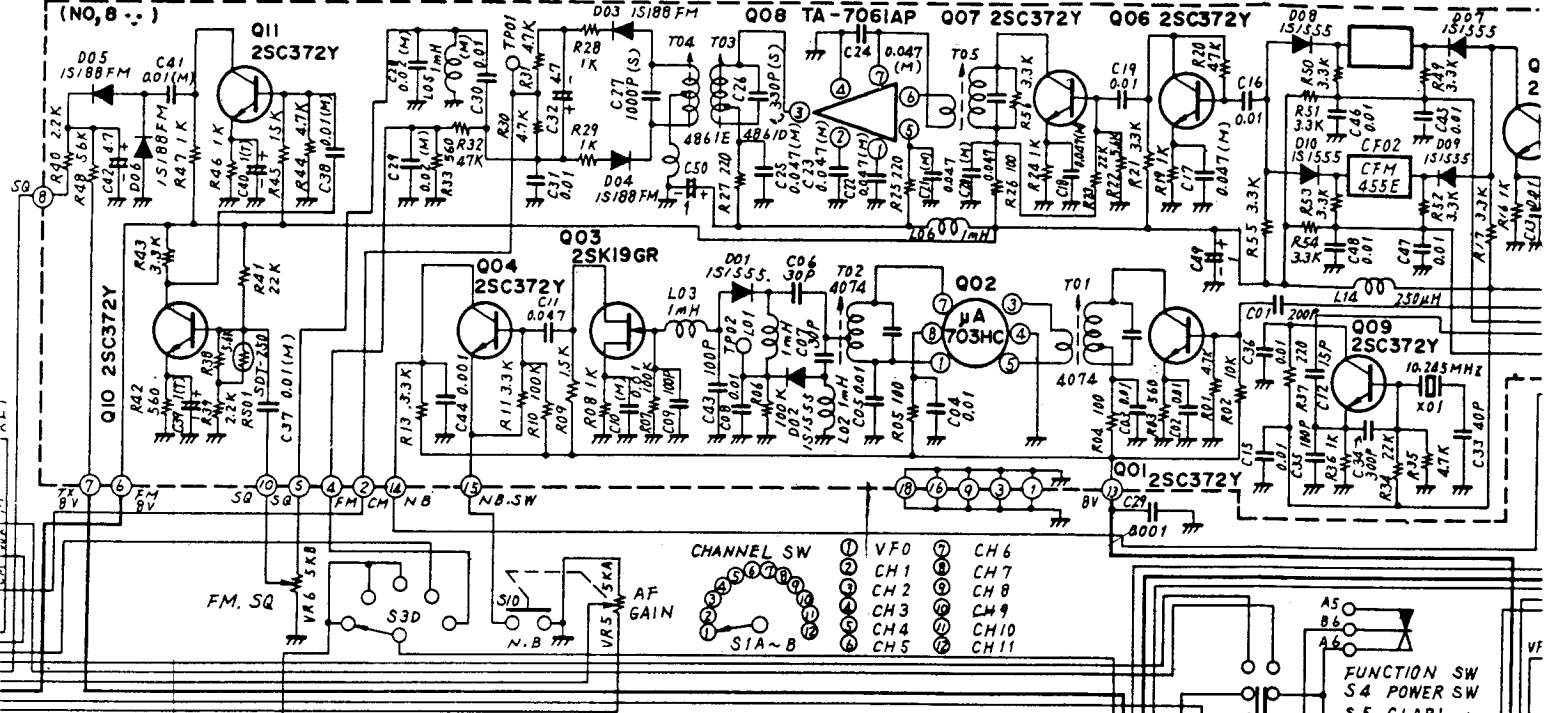
U4 010-11





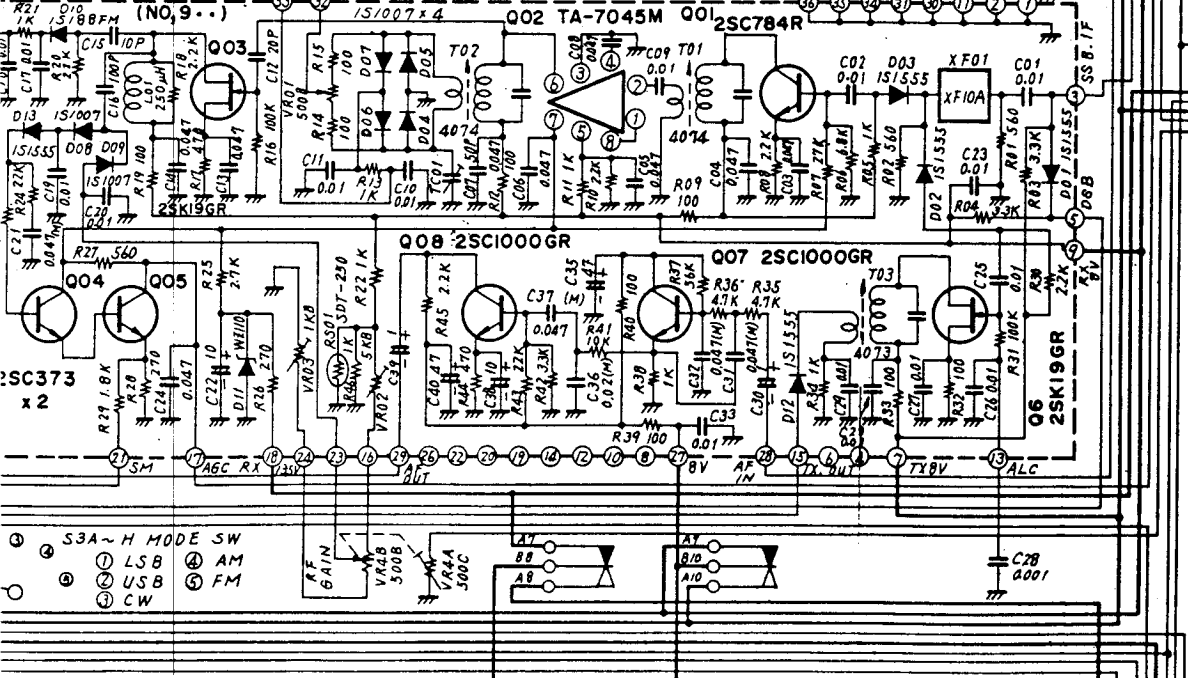
PB-1463 (FM IF)

(NO. 8...)



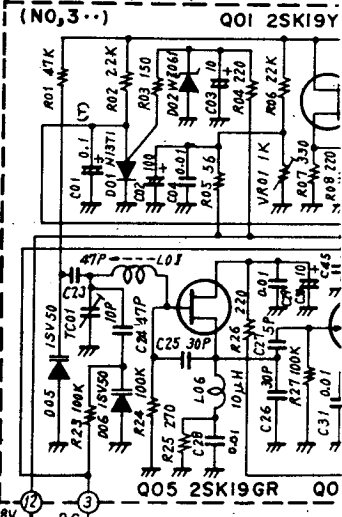
PB-1462 (SSB IF)

(NO. 9...)

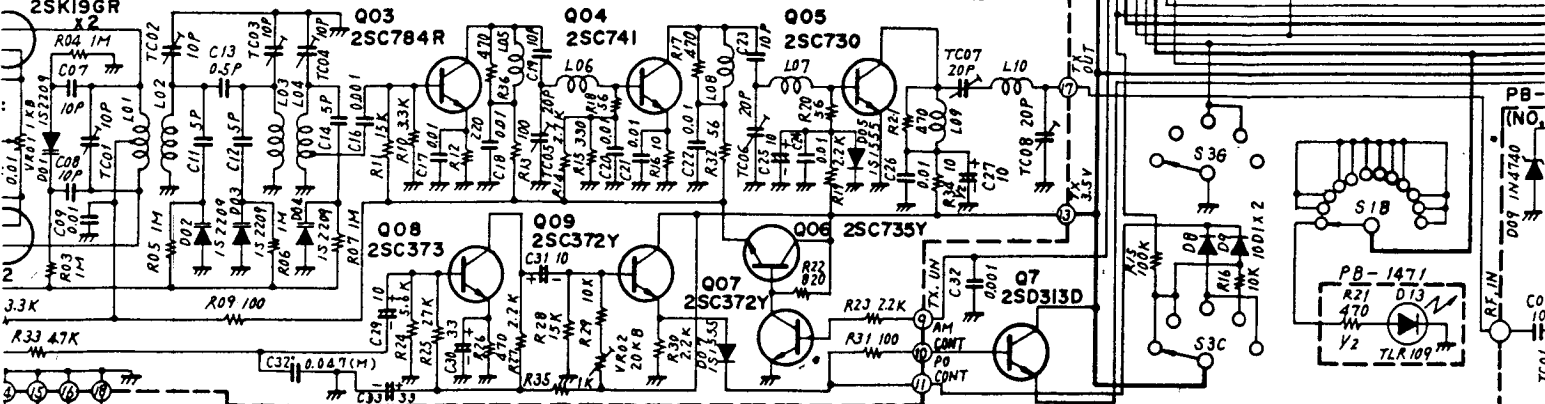


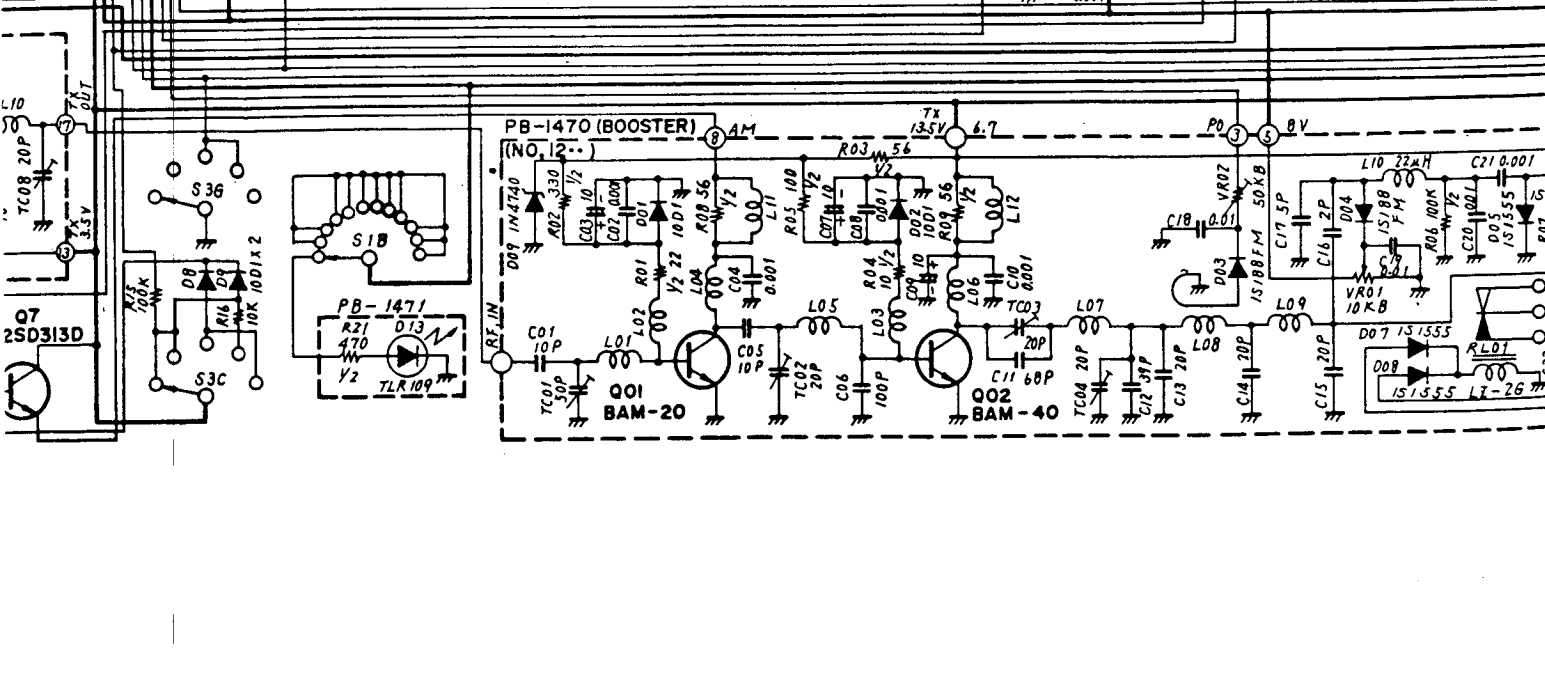
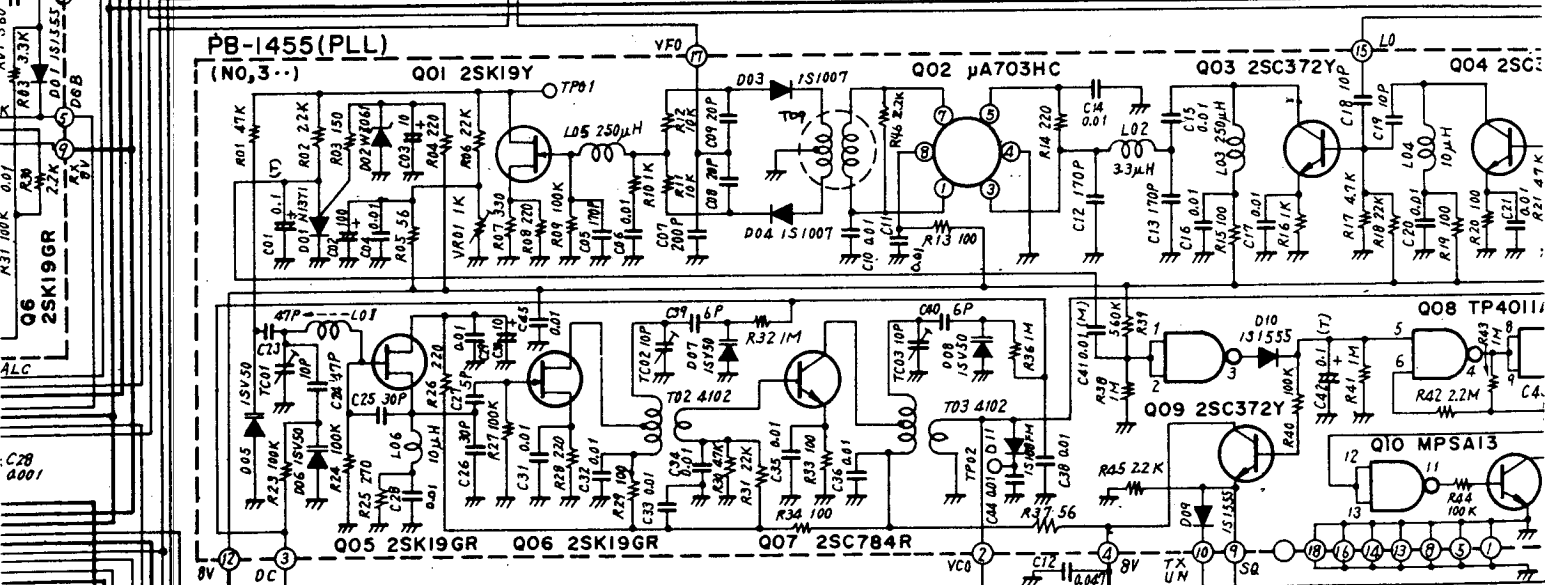
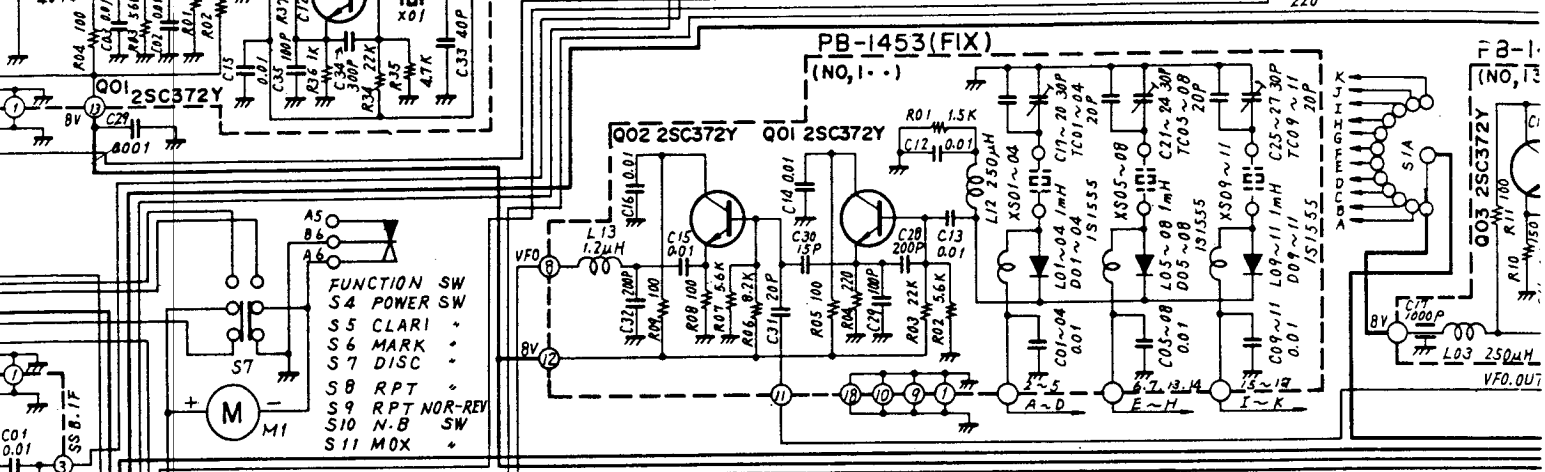
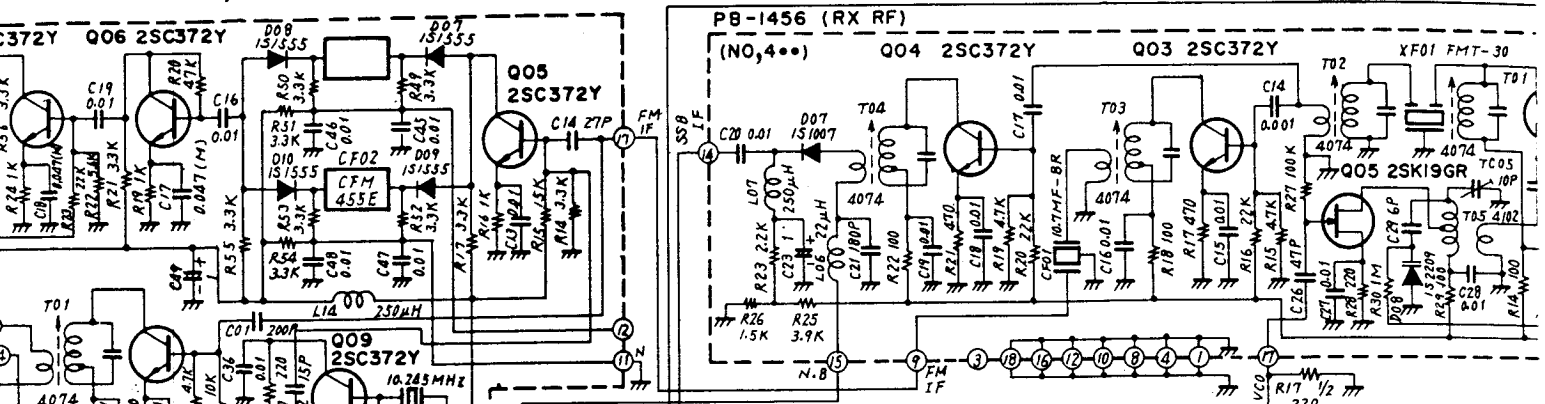
PB-1455 (PLL)

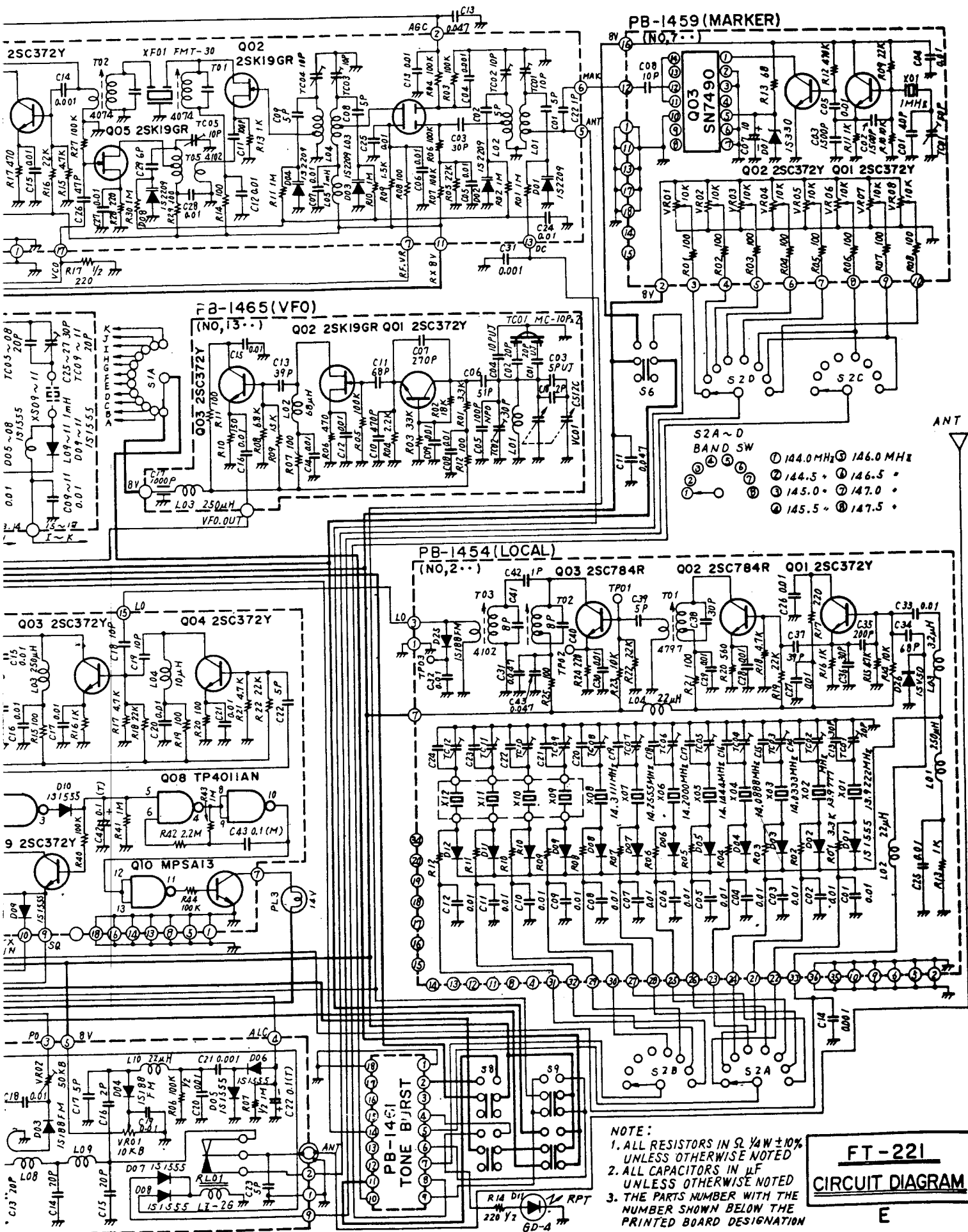
(NO. 3...)



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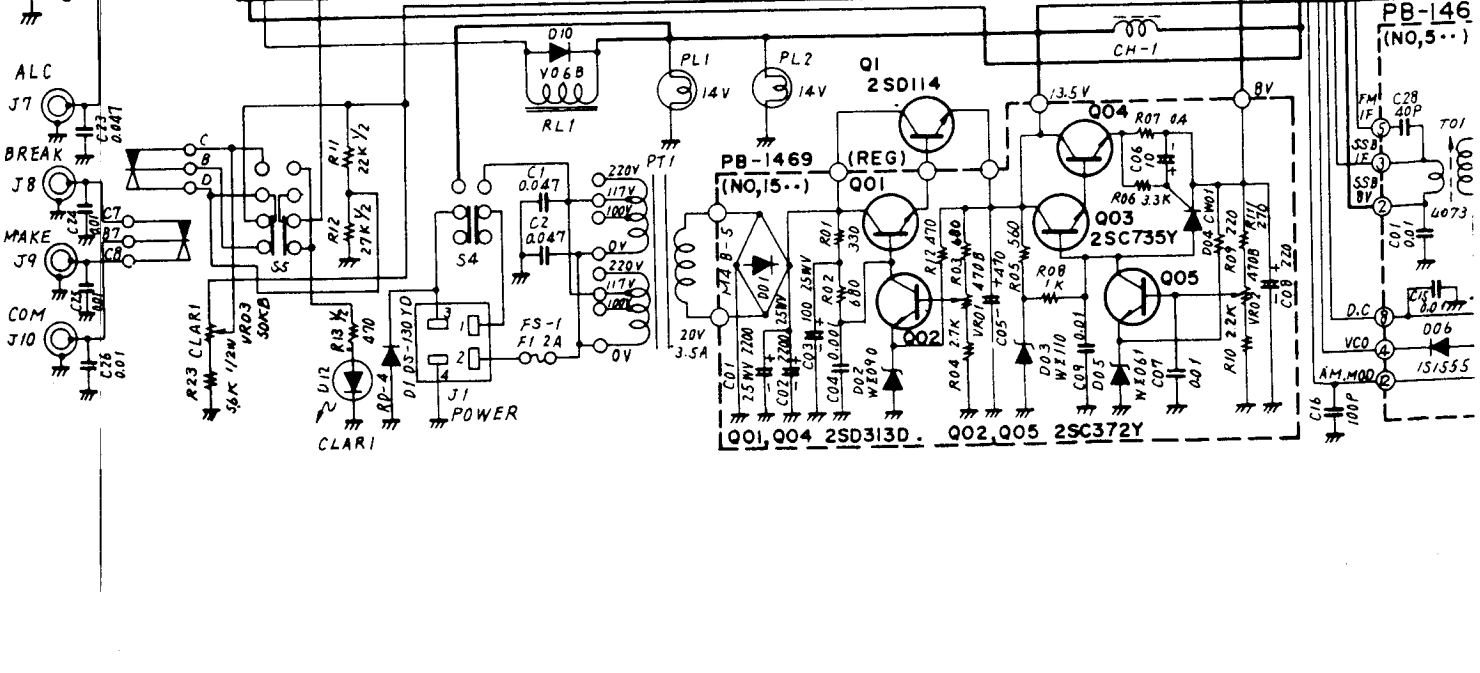
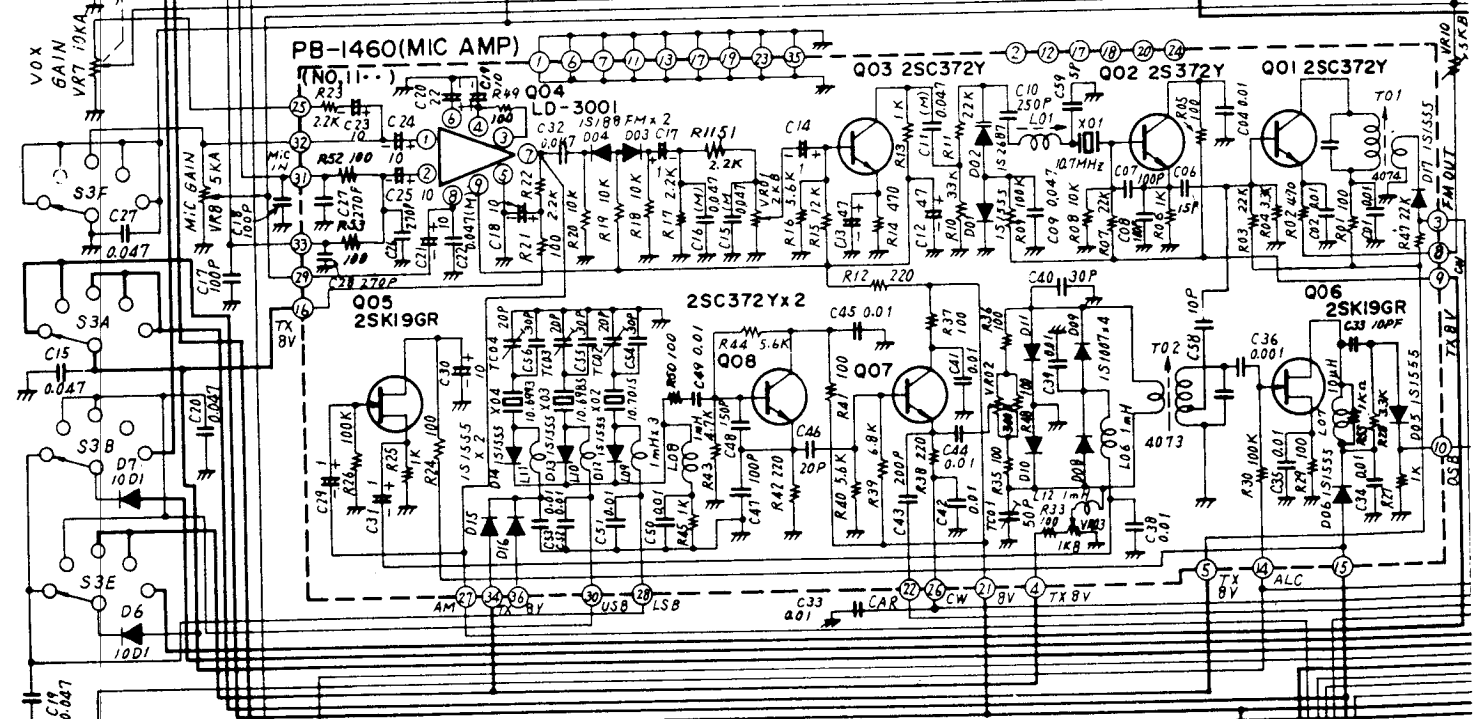
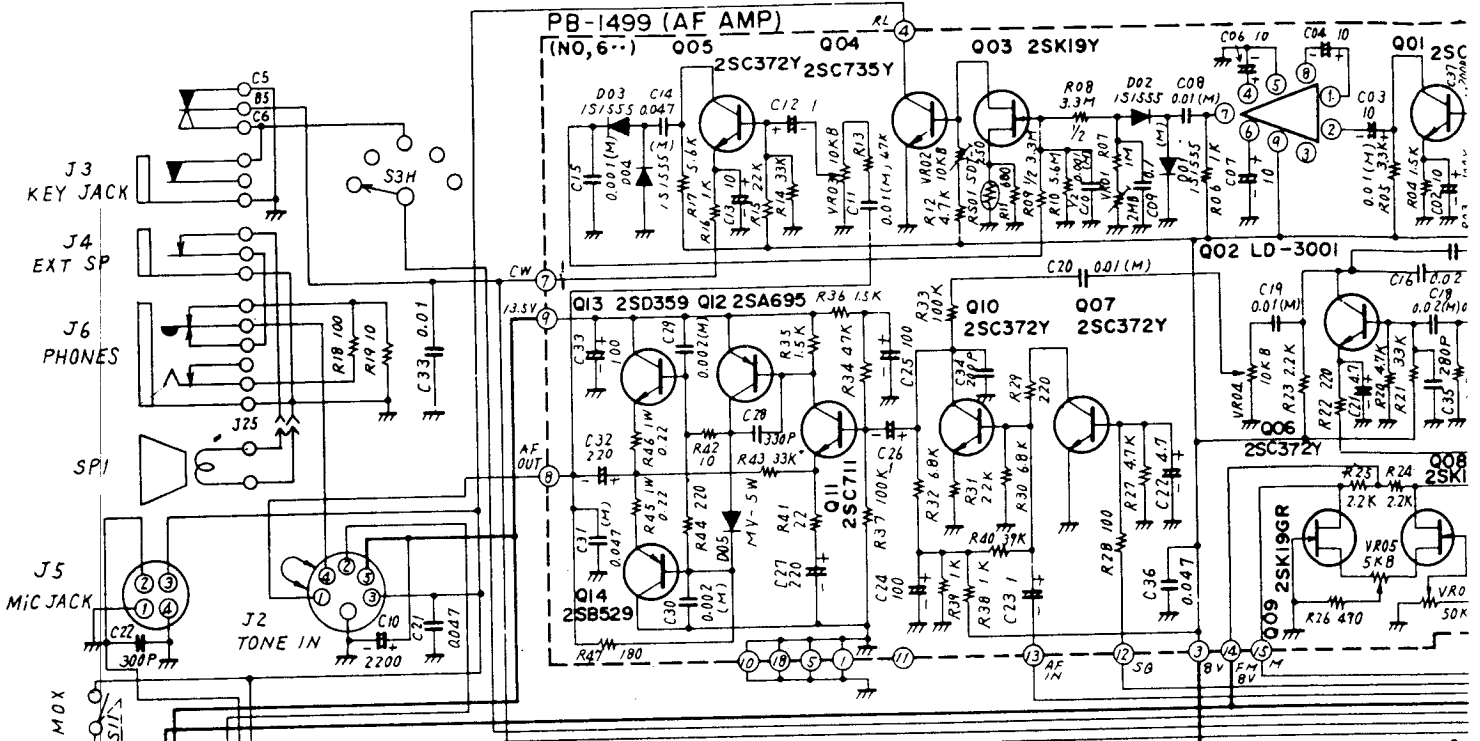
S2A-D
BAND SW

① 144.0 MHz ⑤ 146.0 MHz
 ② 144.5 " ⑥ 146.5 "
 ③ 145.0 " ⑦ 147.0 "
 ④ 145.5 " ⑧ 147.5 "

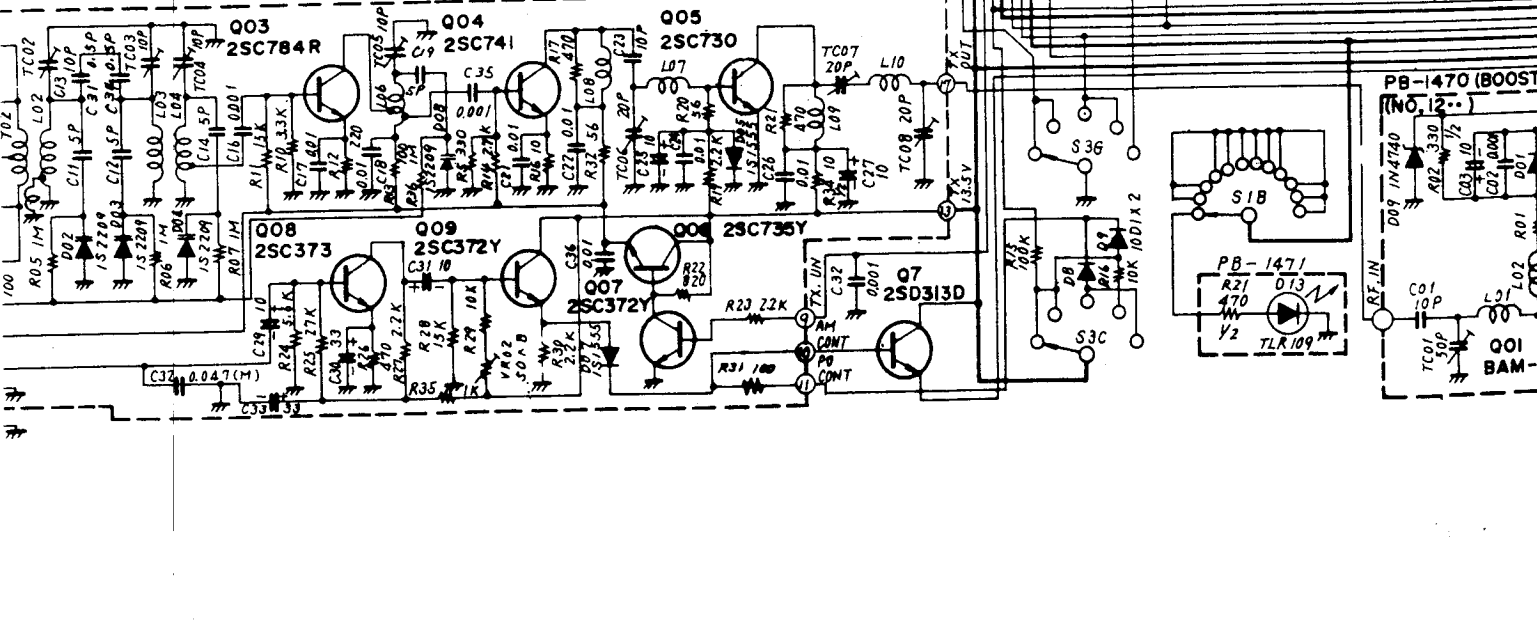
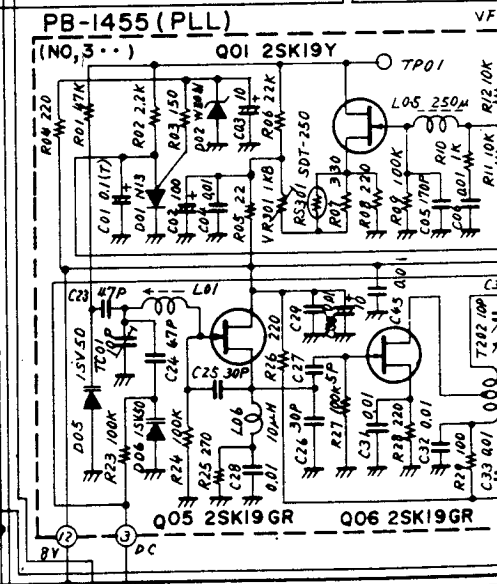
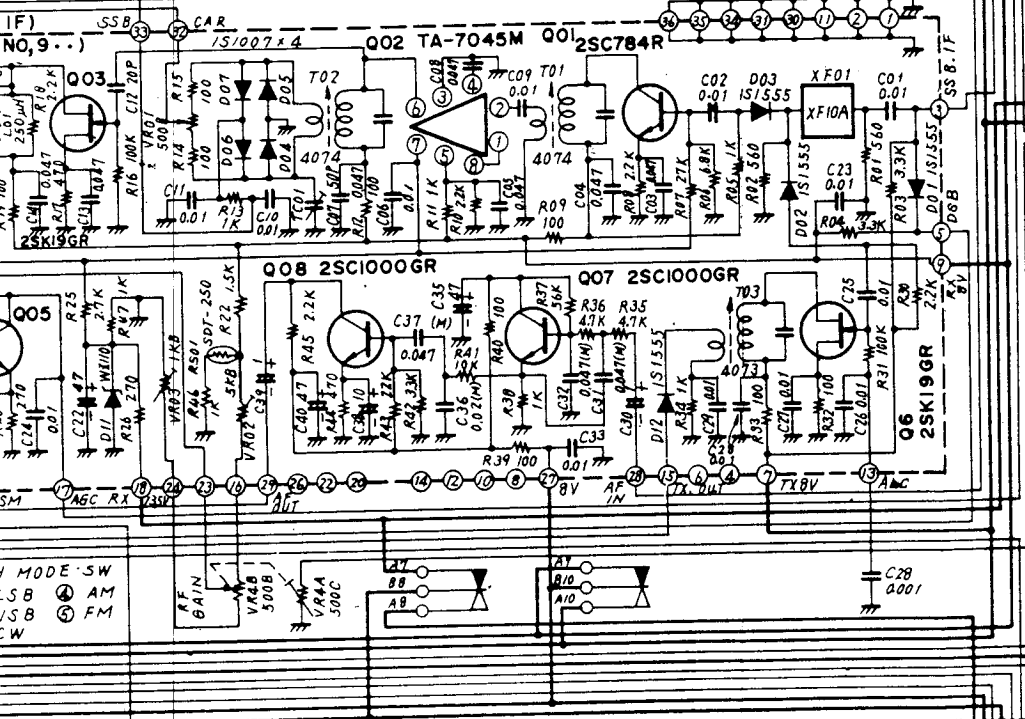
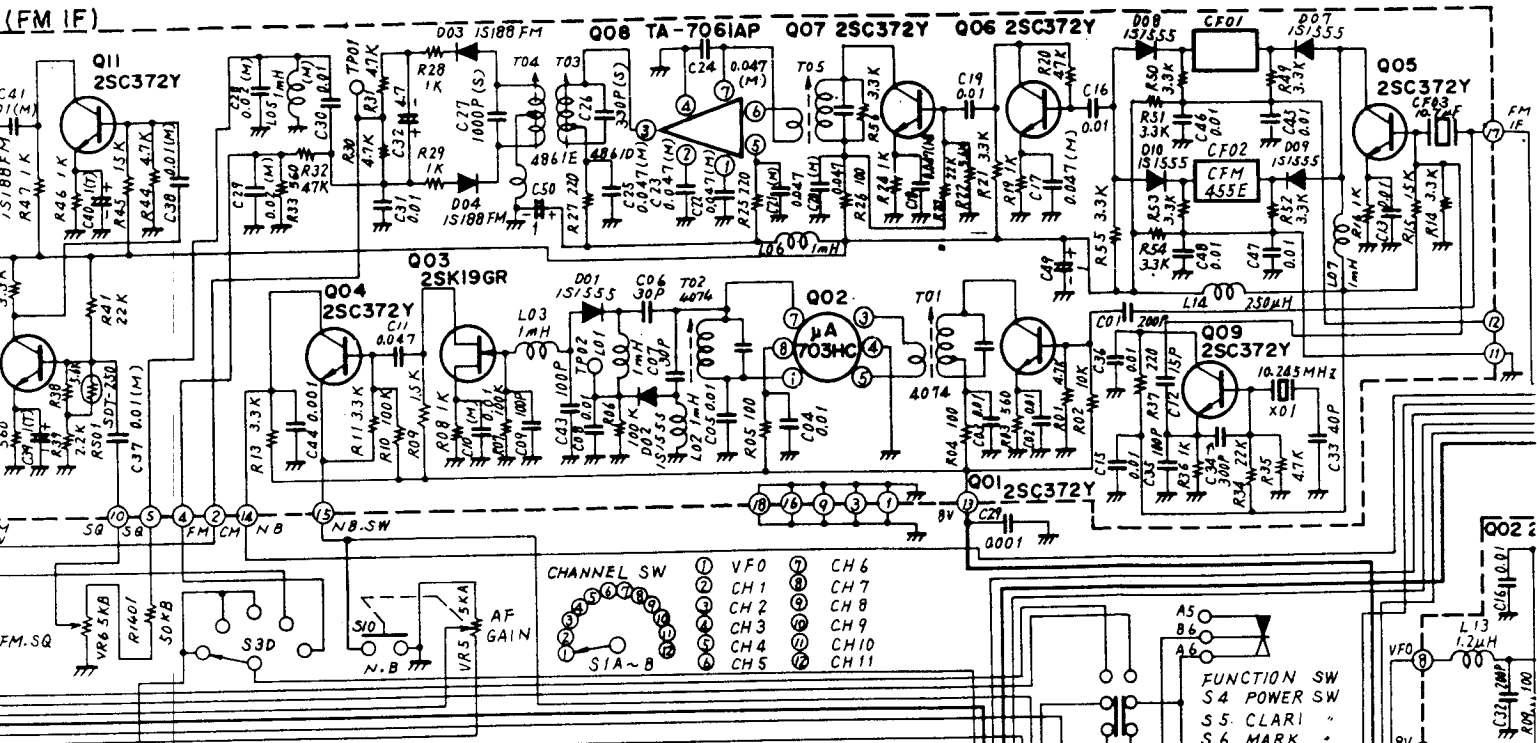
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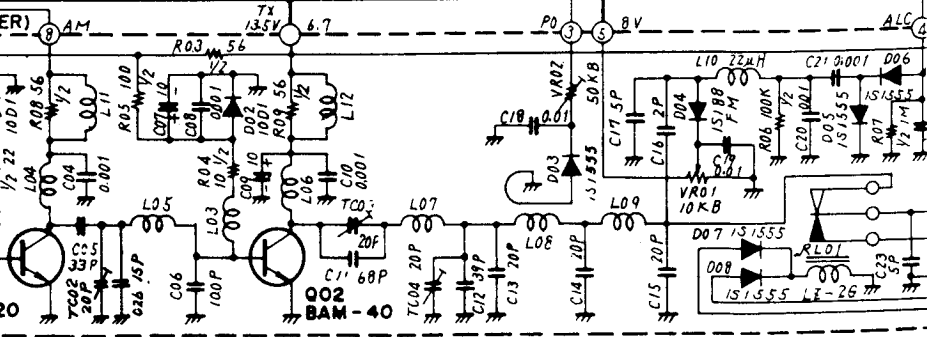
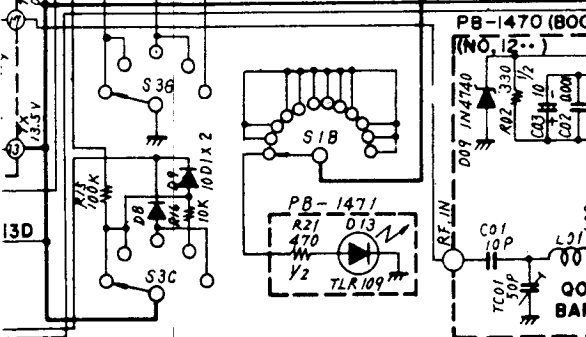
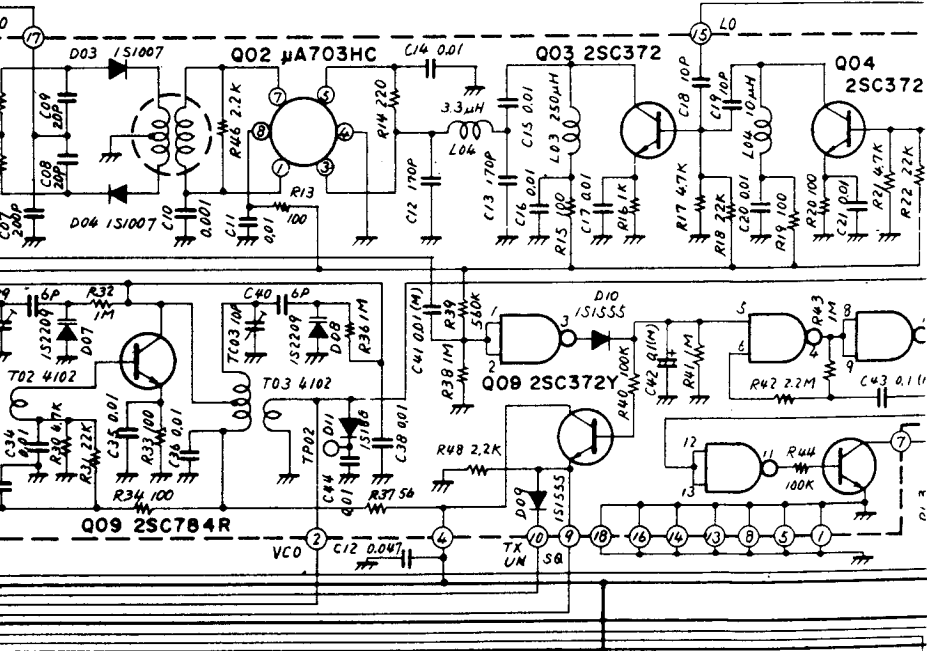
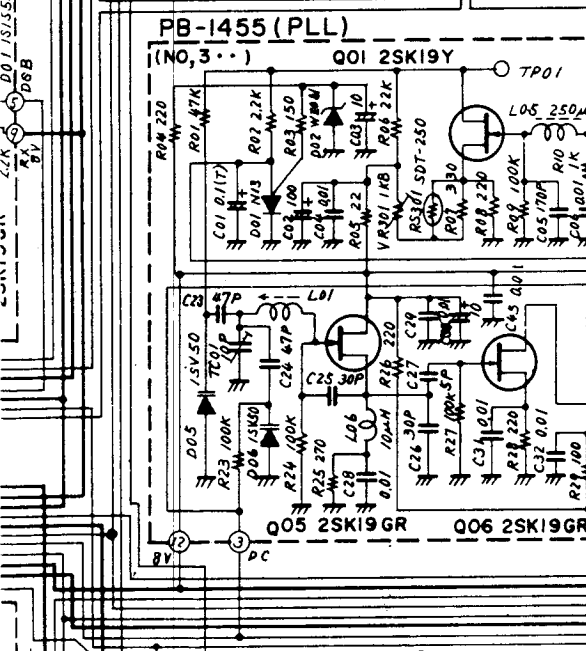
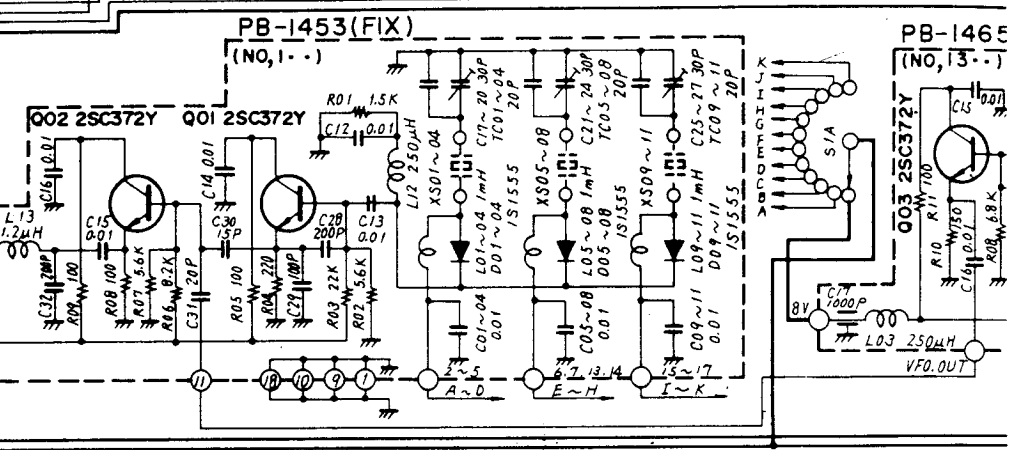
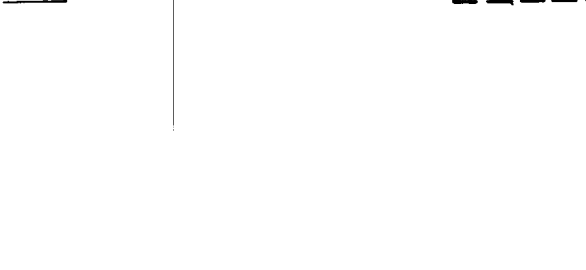
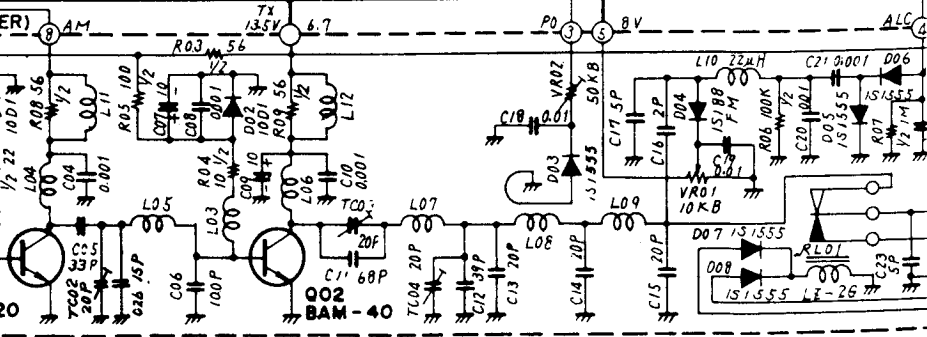
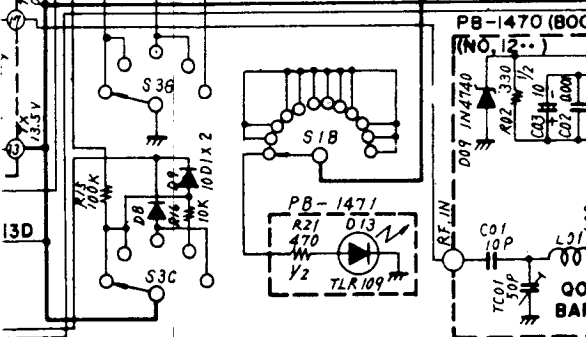
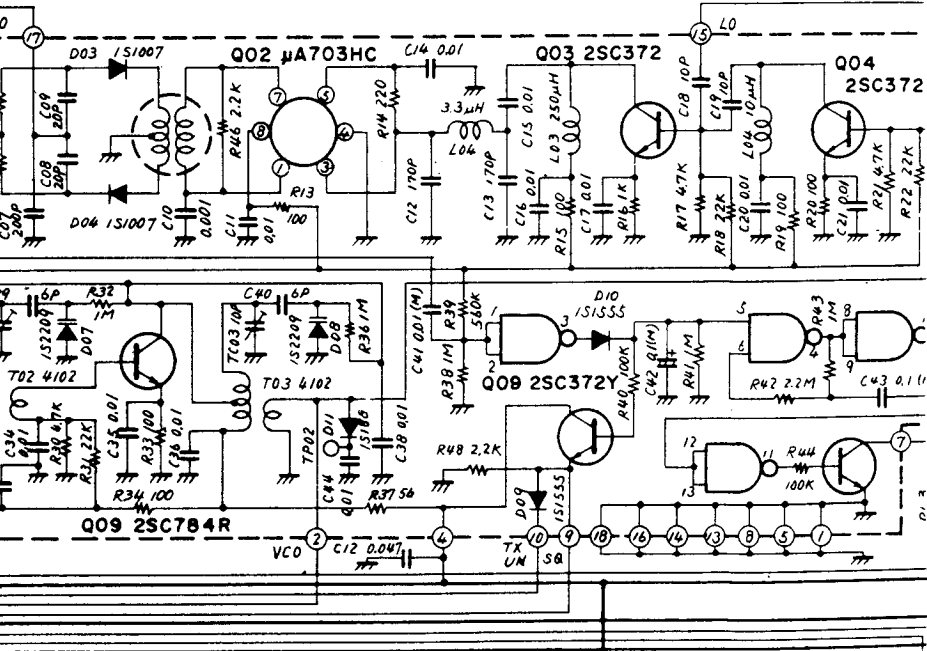
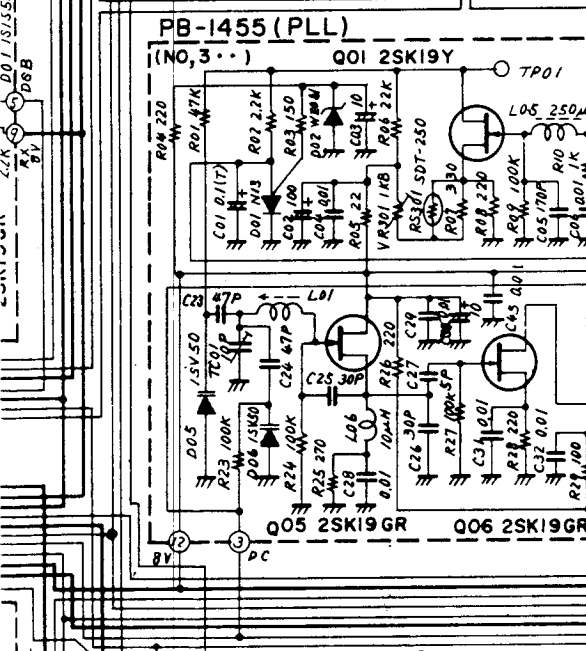
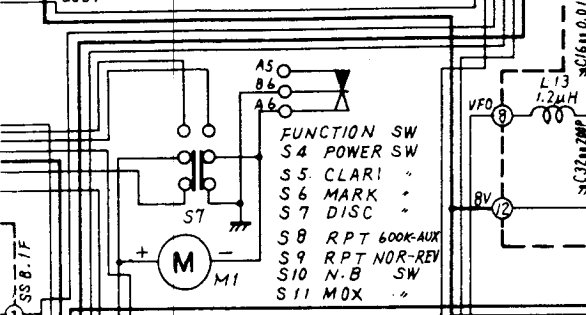
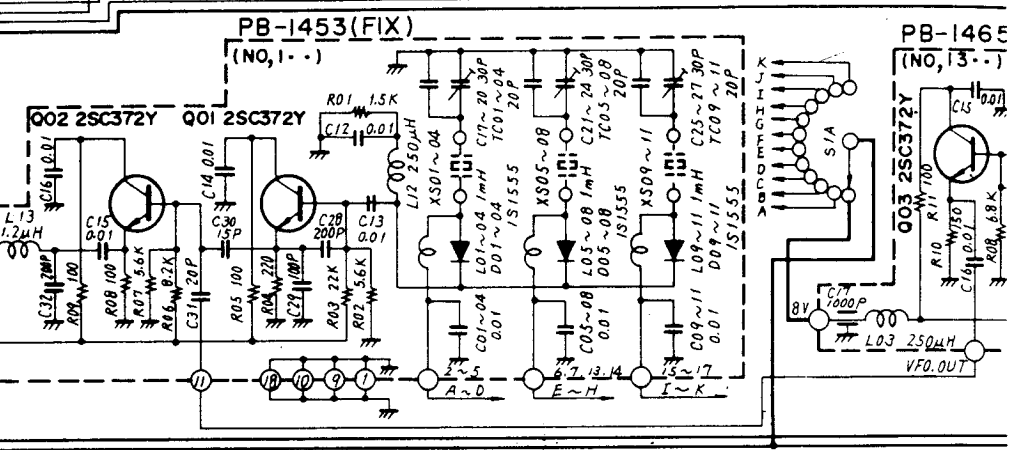
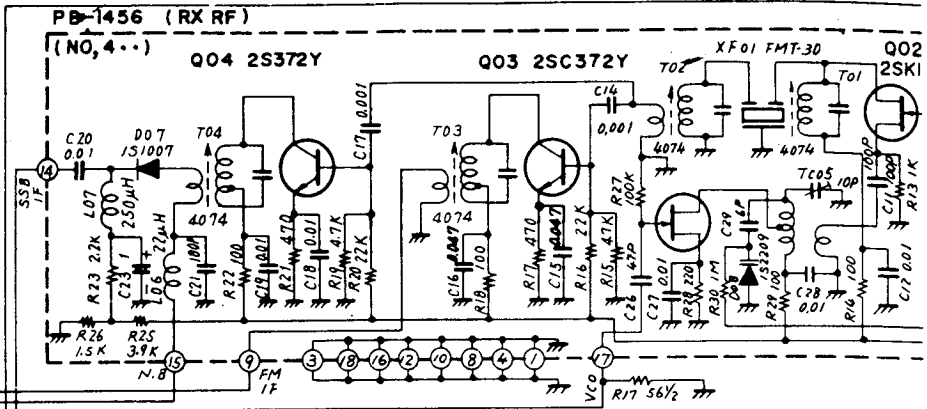
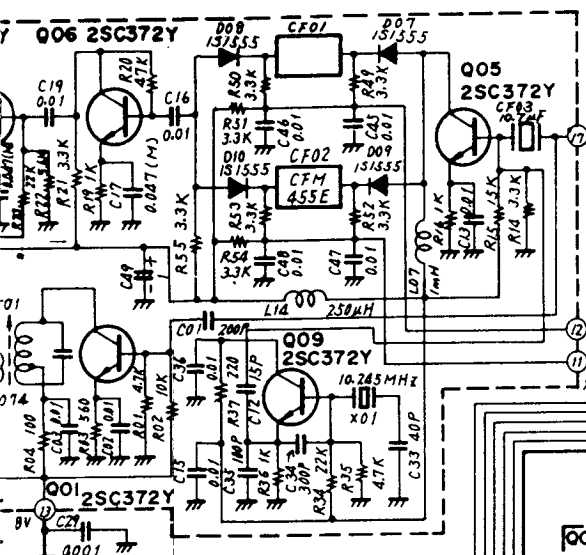
1. ALL RESISTORS IN Ω μ W $\pm 10\%$ UNLESS OTHERWISE NOTED
2. ALL CAPACITORS IN μ F UNLESS OTHERWISE NOTED
3. THE PARTS NUMBER WITH THE NUMBER SHOWN BELOW THE PRINTED BOARD DESIGNATION

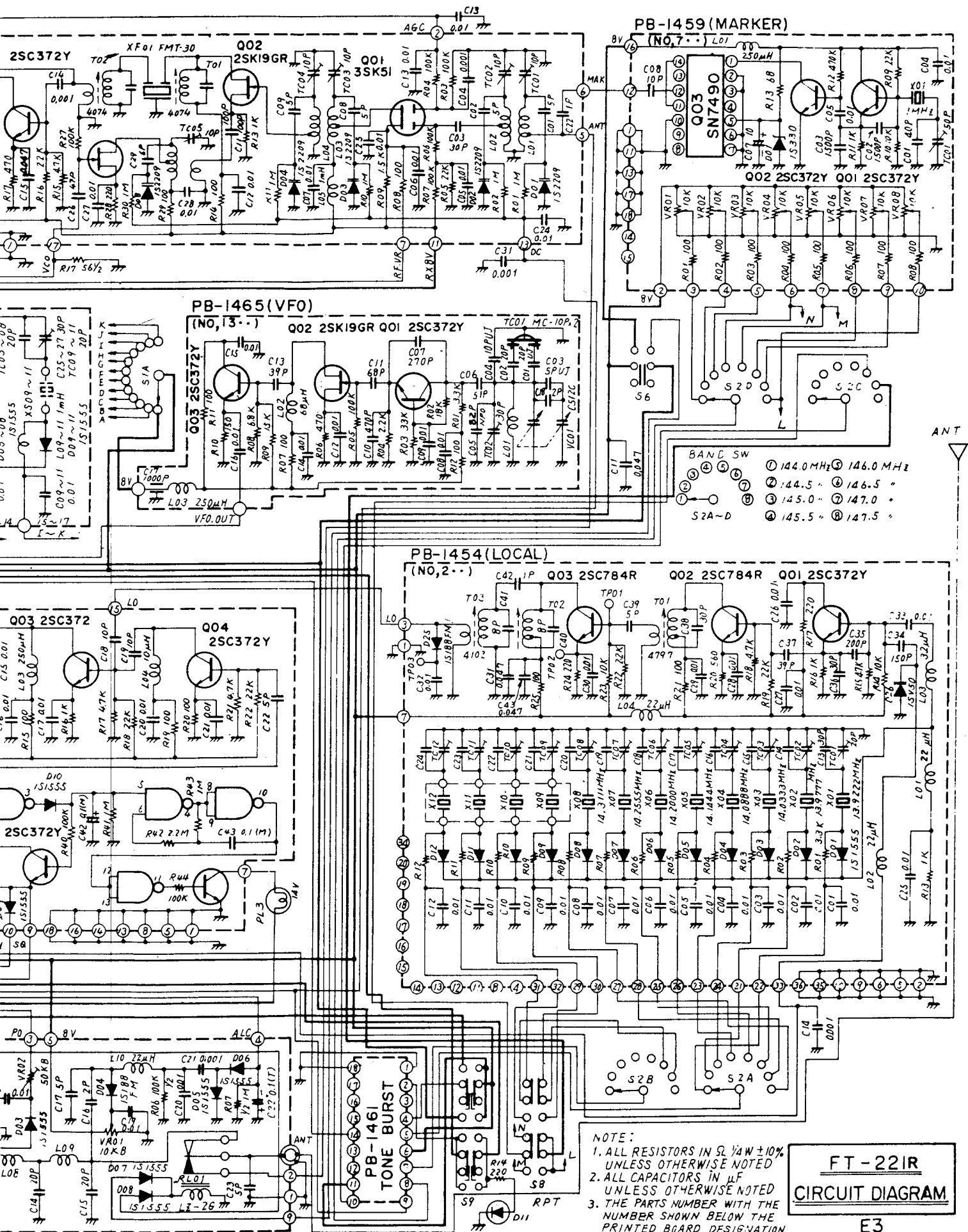
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 E

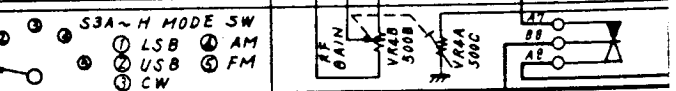
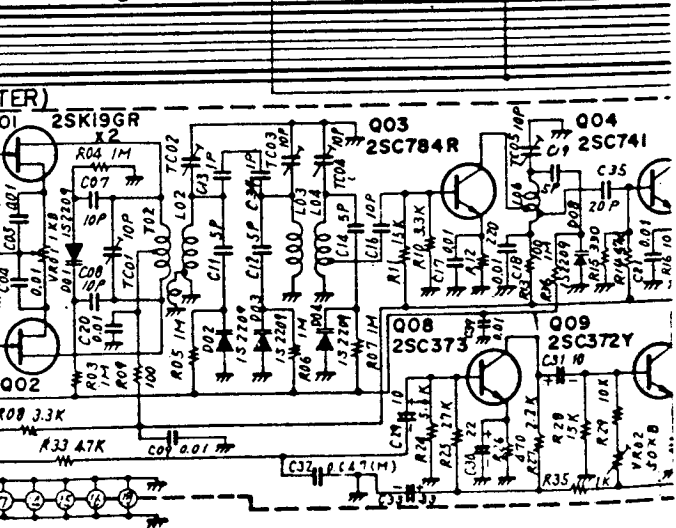
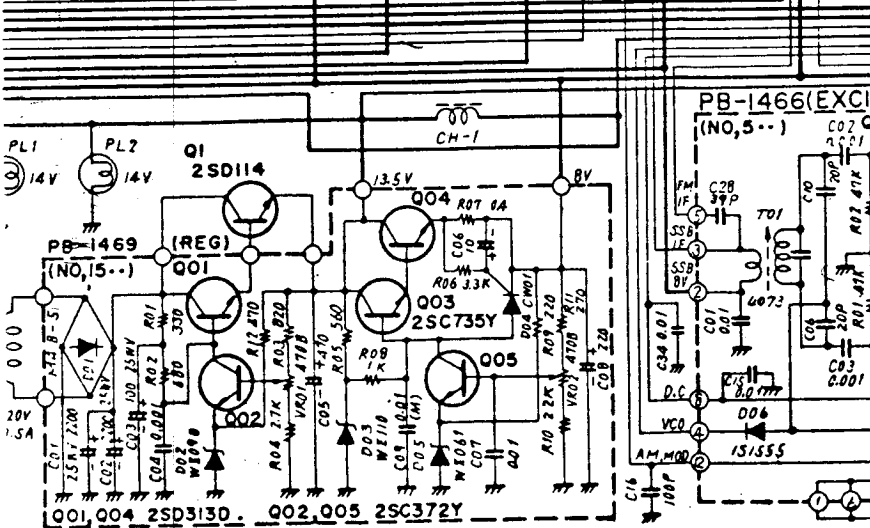
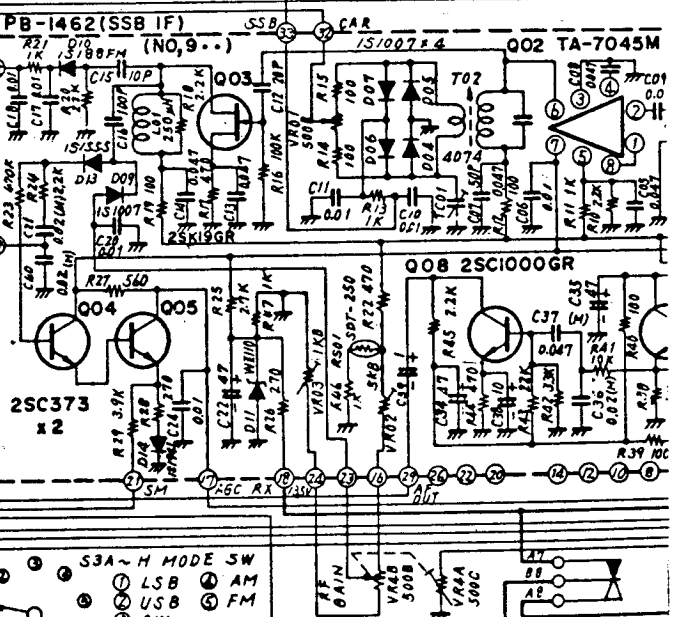
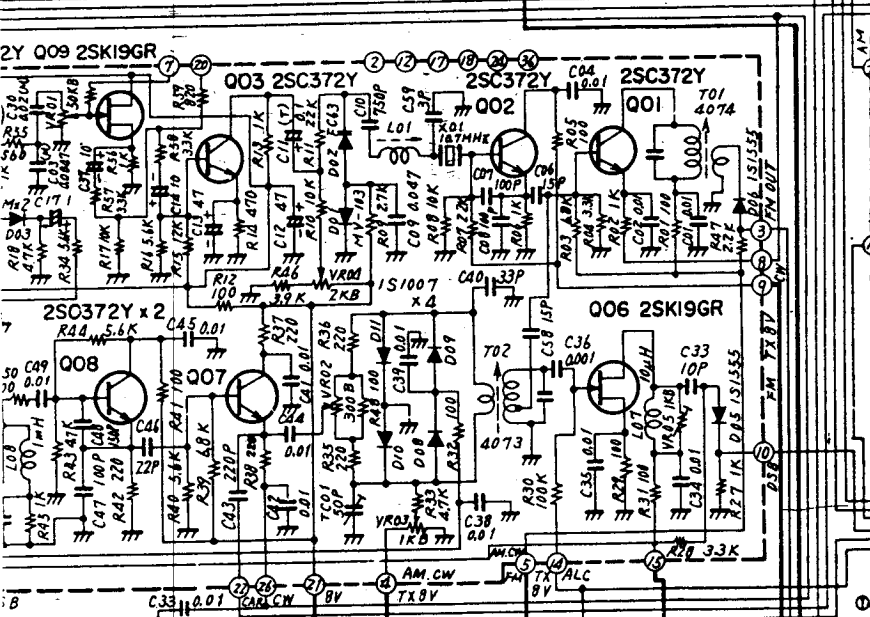
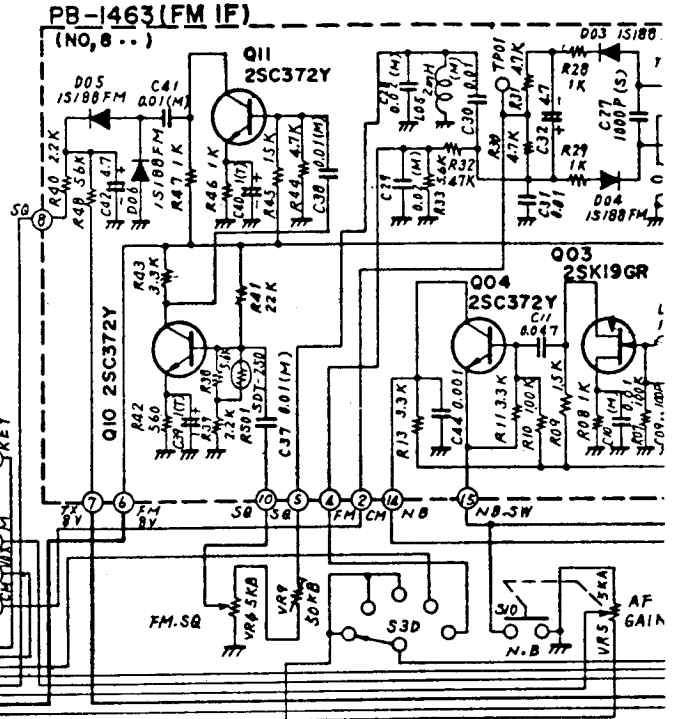
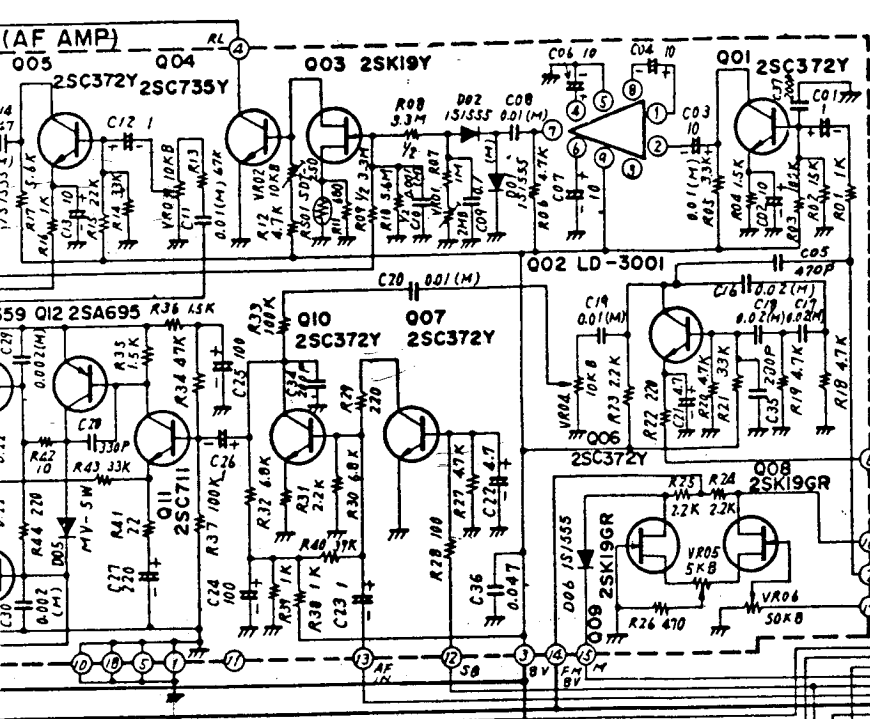


(FM IF)



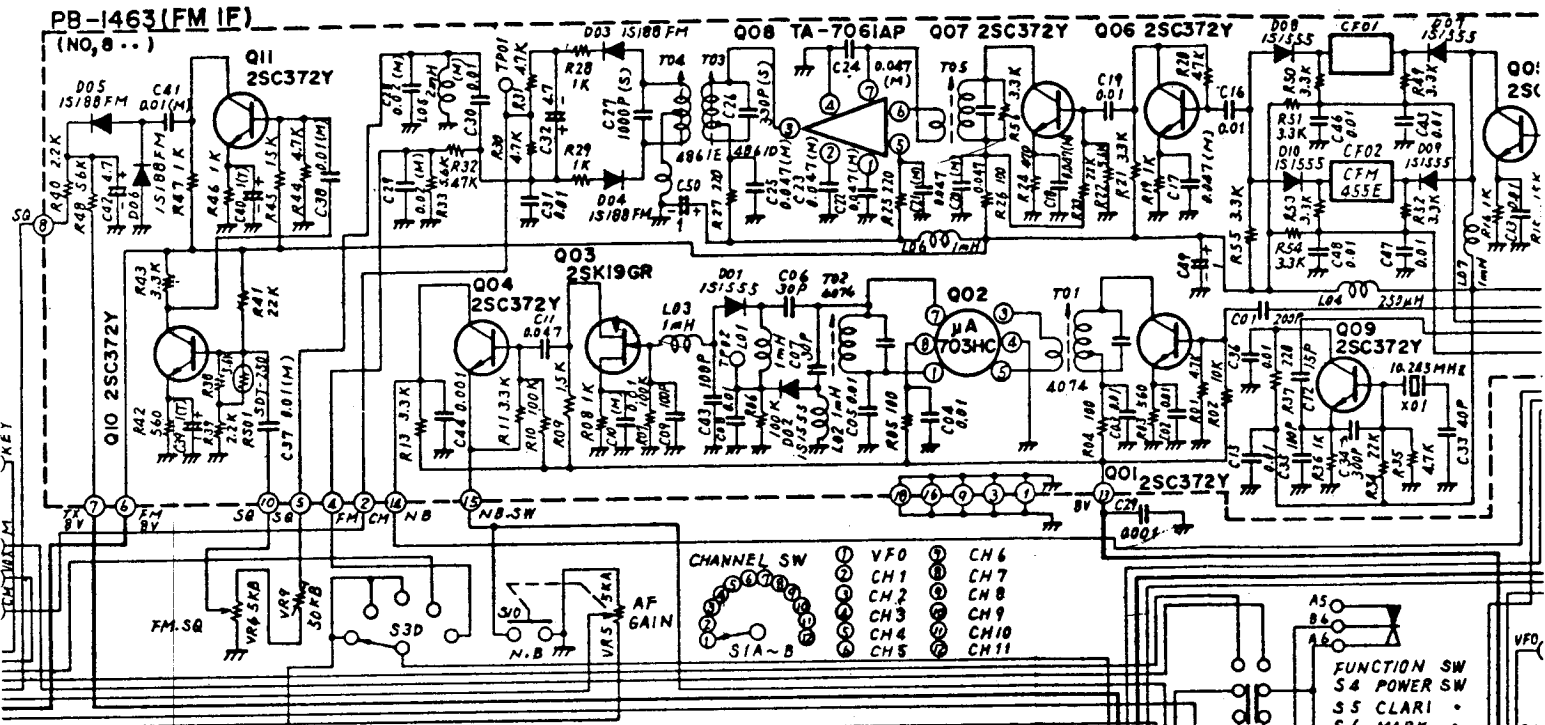






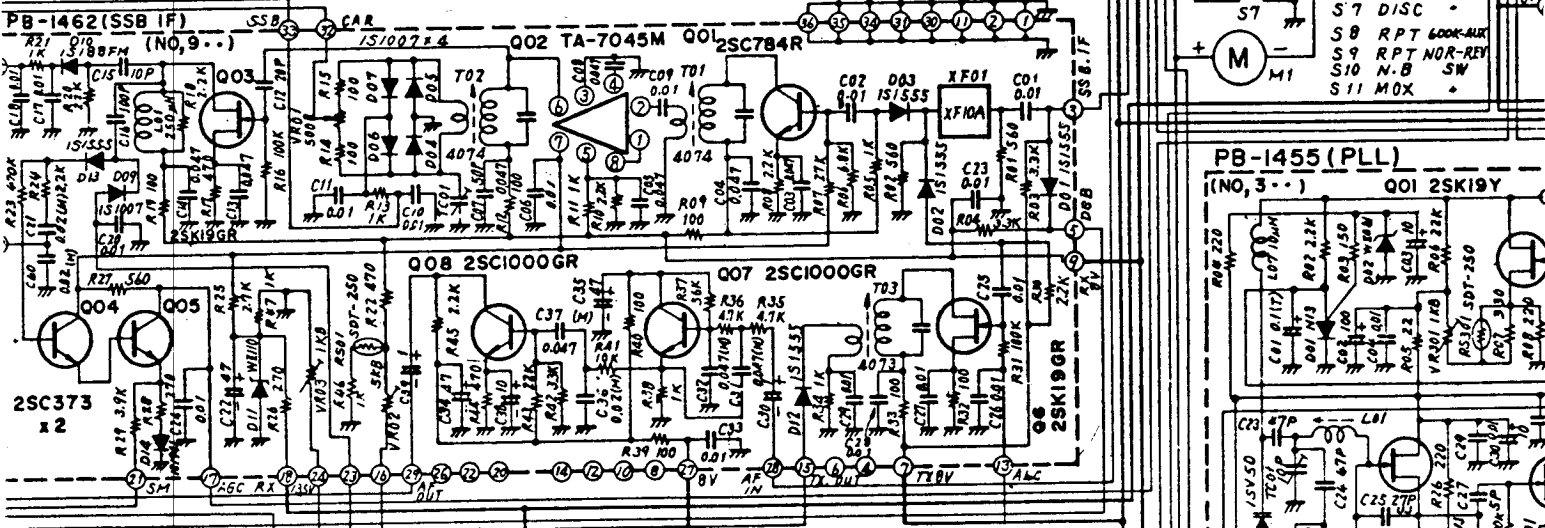
PB-1463 (FM IF)

(NO. 8...)



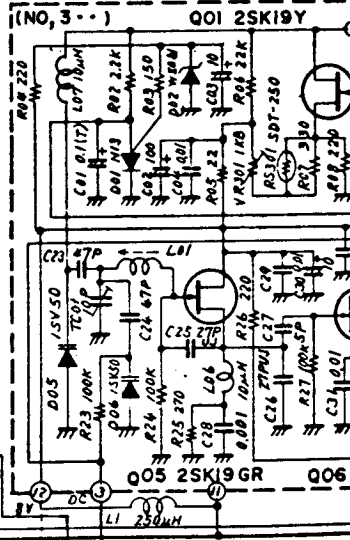
PB-1462 (SSB IF)

(NO. 9...)



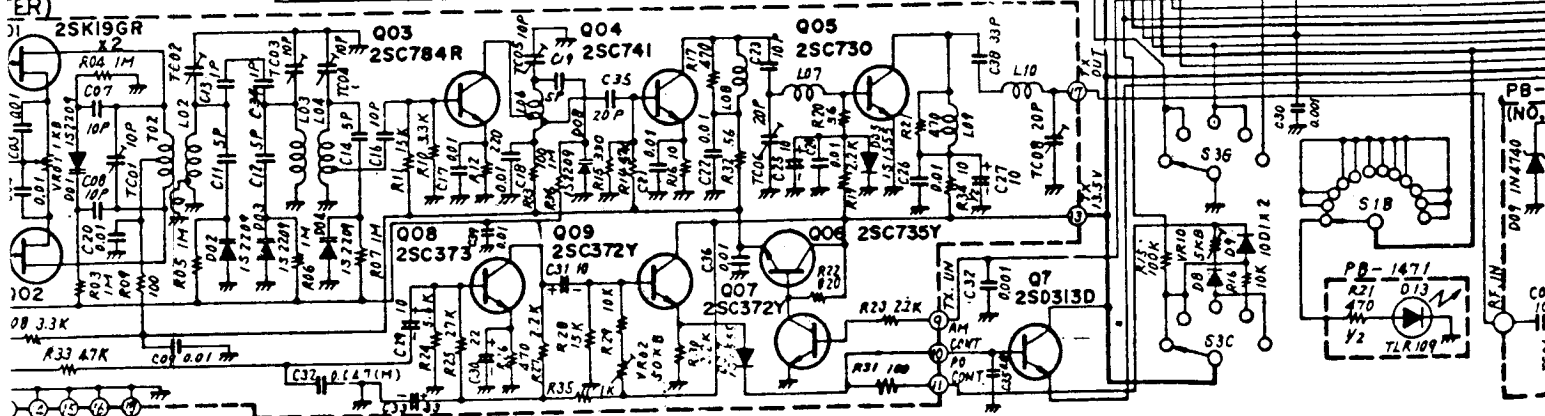
PB-1455 (PLL)

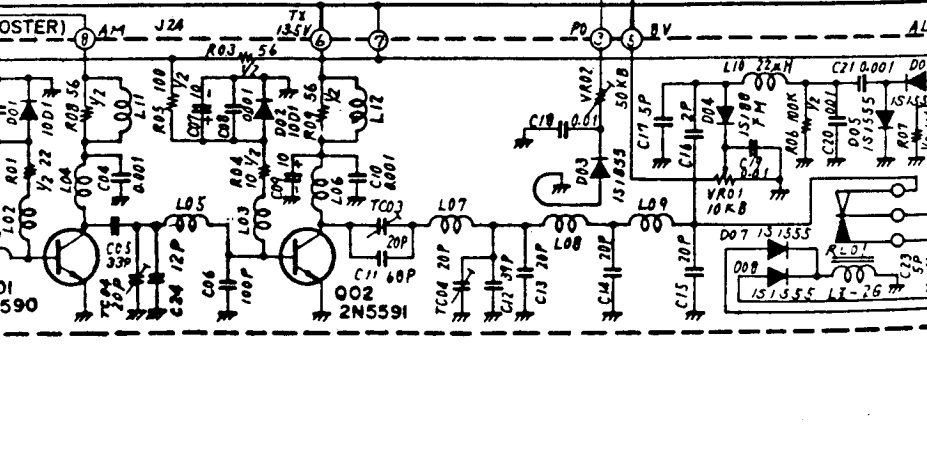
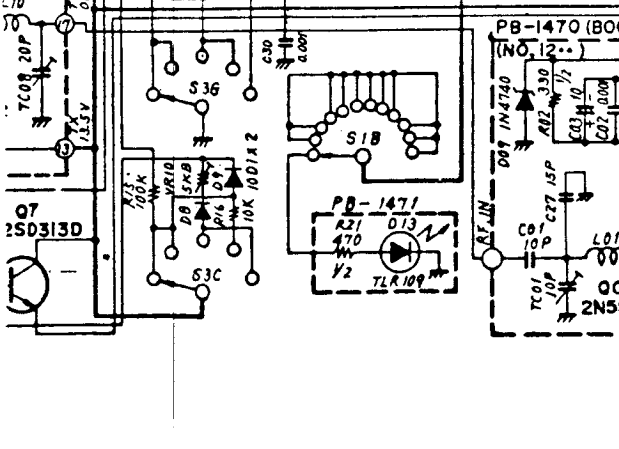
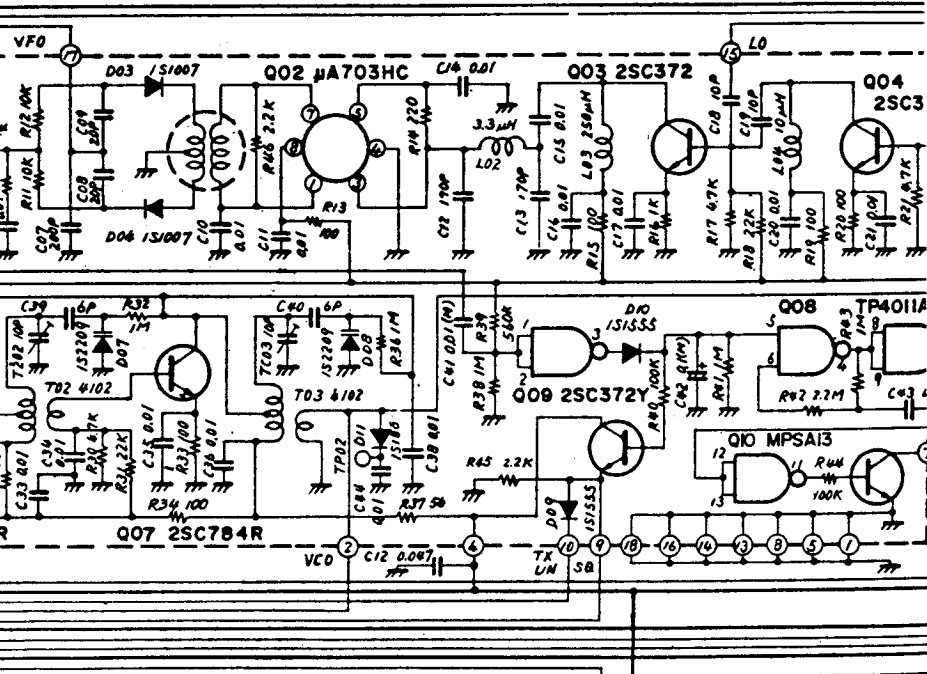
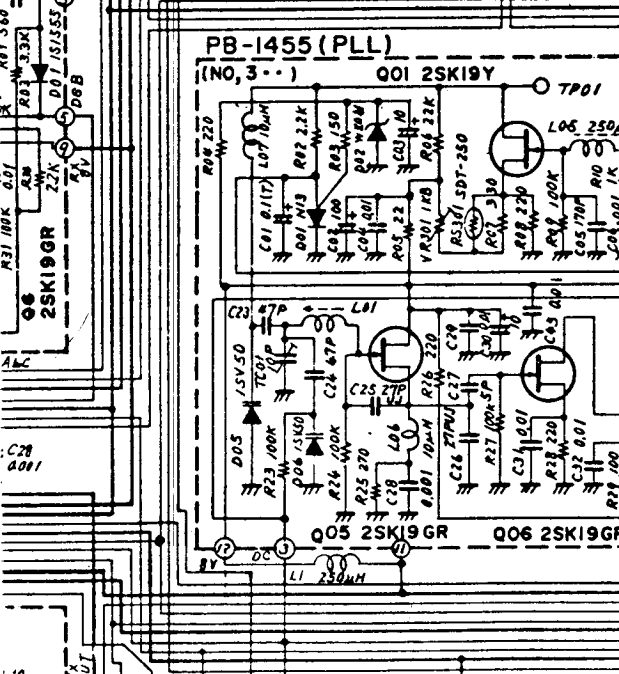
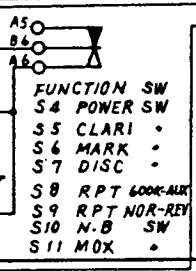
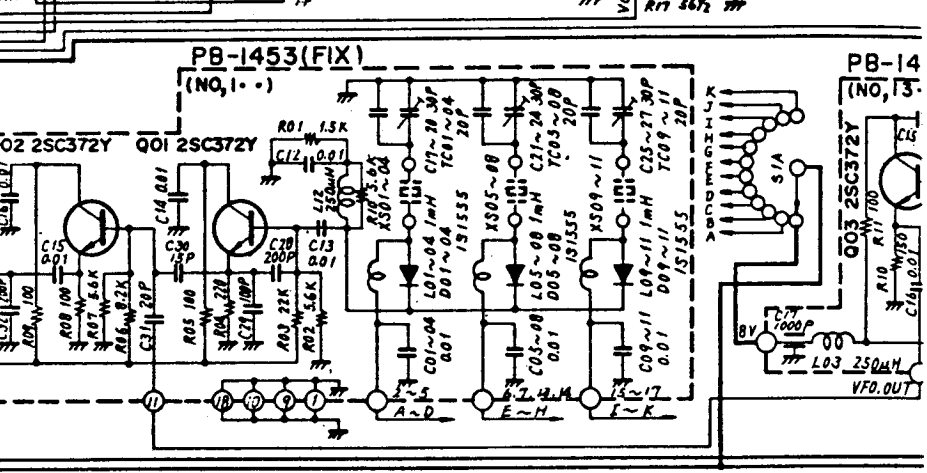
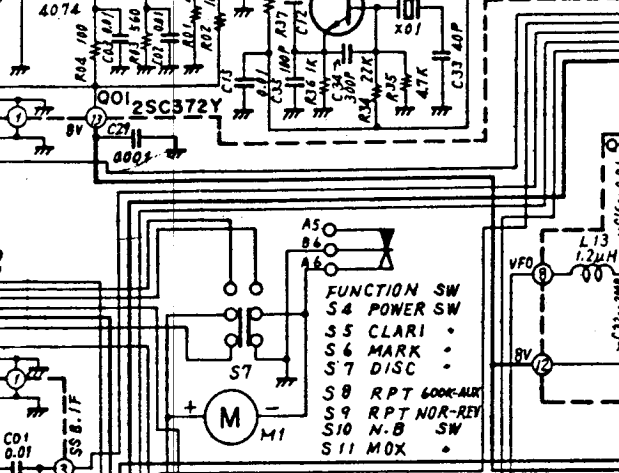
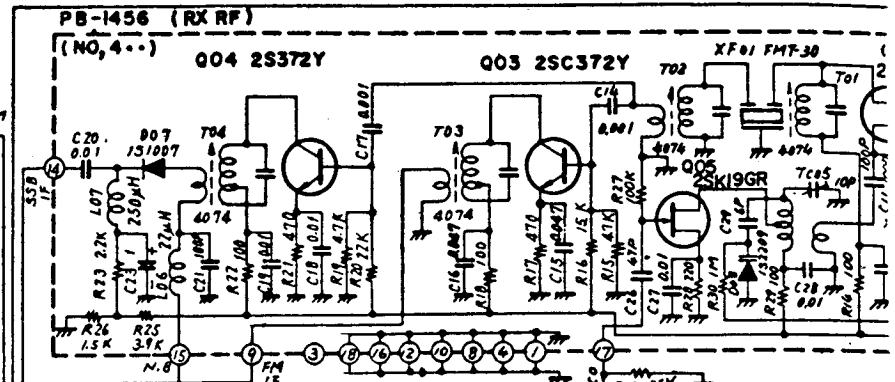
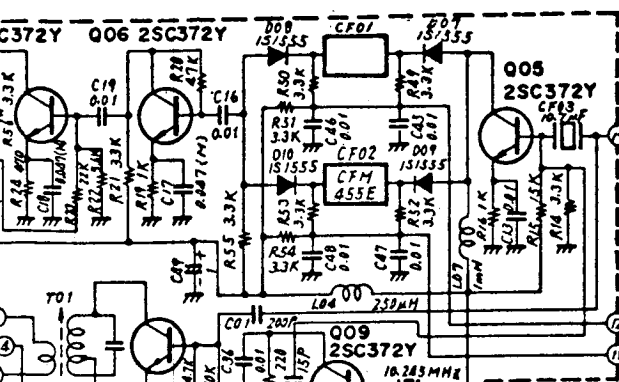
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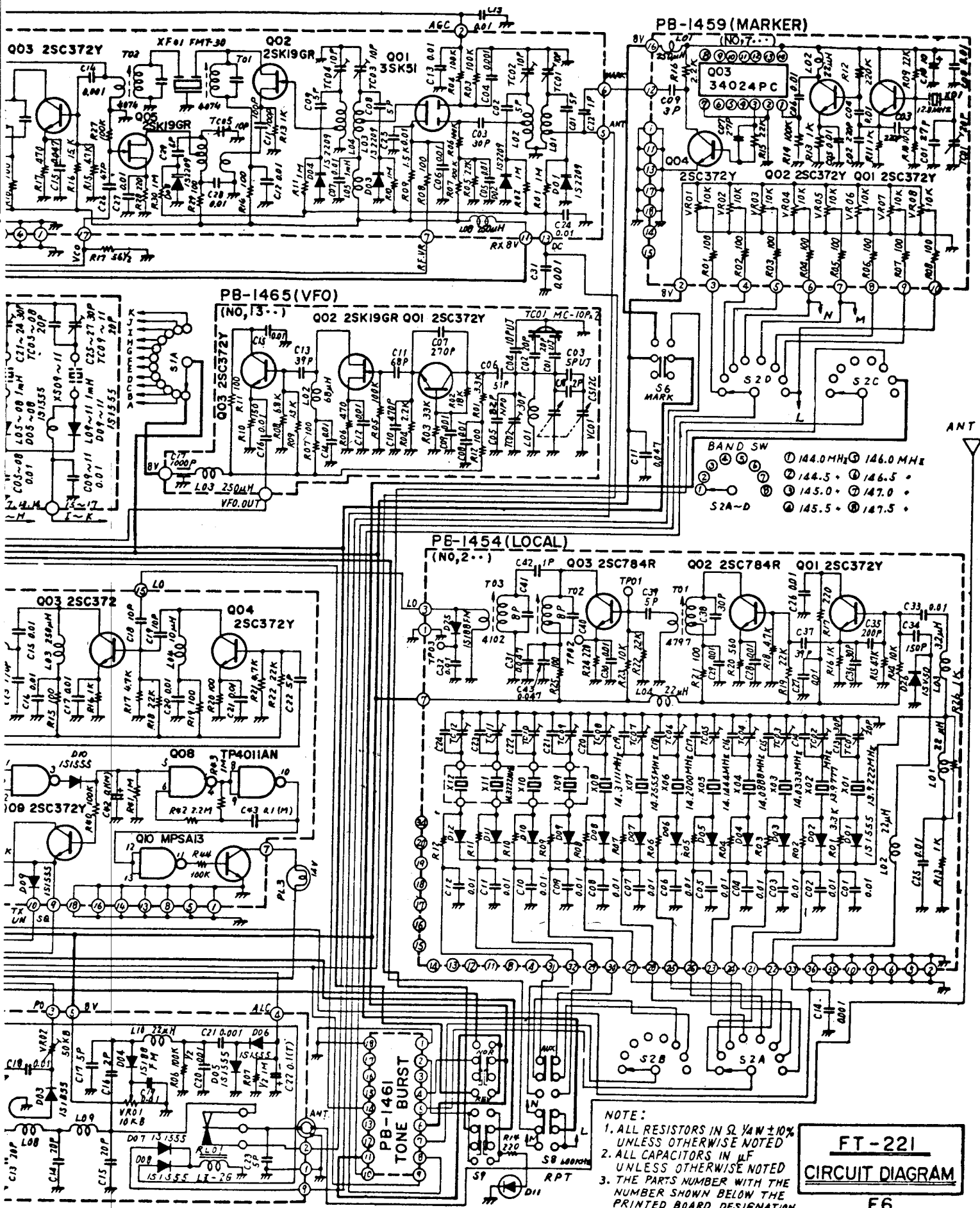


PB-1471 (FM IF)

(NO. 10...)







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E6