MOUNTING THE KV6O DG-5/SB-650 EMULATOR IN HEATHKIT EQUIPMENT

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INTRODUCTION

The Heathkit SB-650 is a nixie frequency display sold in the 1970's for use with the HW and SB line of receivers, transceivers and transmitters. The SB-650 is a relatively large piece of equipment which is housed in a separate cabinet and is typically placed on top of the Heathkit radio.

The Heathkit rigs use the same mixing scheme as the Kenwood TS-520, and so the Kenwood DG-5 has always worked with Heathkit radios.

The Kenwood TS-520 and the Heathkit SB/HW radios also share the same intermediate frequency of 3.395 MHz. This permits interchangeability of other accessories such as crystal filters and noise blankers.

My goal was to put the KV6O emulator inside the radio, as opposed to having an external box. While I am using the KV6O emulator with the nixie tube display program, the following notes should still be of some help to those using the LCD or LED display as far as housing and powering the Arduino and Emulator Shield assembly.

Each of the Heathkit rigs requires a minor modification to work properly with the SB-650. Once the modification is performed, the SB-650, Kenwood DG-5 and KV6O emulator can all be used interchangeably with the Heathkit radios.

At the end of this document are seven pages from the SB-650 assembly manual. These describe the modifications steps needed for each specific Heathkit receiver or transceiver. Note that on the last of these installation pages, directly above Figure 3-14, is a notice that begins with "IMPORTANT: AFTER …" which refers to some "initial tests". This can be ignored since it is referring to the initial tests of the SB-650, which was not yet completed by the builder at this point in the Heathkit assembly manual.

In other words, after performing the described modifications to the Heathkit rig you will be able to use the KV6O emulator without any further adjustment of the emulator or the radio.

HOUSING THE ARDUINO and EMULATOR SHIELD

The Arduino board specified was the Duemilanove. An original Duemilanove board can be hard to find, and is sometimes a bit expensive since it has apparently become something of a collectible for hard core Arduino enthusiasts. There are inexpensive clones, and the one I would recommend is the Duemilanove Plus, illustrated in Figure 1.

I have made a couple of notes on Figure 1. First, keep in mind that the top of the original Duemilanove USB data port almost abuts the DG-5 Emulator shield when they are plugged together. The lower profile USB-C connector of the Duemilanove Plus solves that problem. So far each Duemilanove Plus board I have purchased has come with a cable that goes from the Arduino to a standard computer USB jack.

Second, I recommend removing the power jack. You can either find a lower profile jack or hardwire power directly to the Duemilanove Plus board using a readily available external power cable assembly such as the one illustrated in Figure 2.

These two modifications (power jack and USB jack) permit all of the header pins on the emulator Shield to be trimmed by several millimeters so that the Shield will be as close as possible to the Arduino board.

This slightly more compact assembly will fit within a commercially available aluminum enclosure project box that is 38.4 X 87.9 X 57.2 mm (available on line, just search using those dimensions). The project box is shown in Figure 3.

A photo of the complete assembly is shown in Figure 4; note that the 5 volt regulator is mounted to the back wall of the enclosure which provides an excellent heat sink.

INTERCONNECTING THE EMULATOR SHIELD TO THE NIXIE TUBE DISPLAY

I mounted the nixie tubes using the TaylorEdge 1355 SmartNixie 6 digit backplane (See Figure 5). This eliminates the need for a wiring harness to connect the SmartNixies to the Emulator Shield. The backplane has a socket (bottom view of Figure 5, left side of board) that accepts the TaylorEdge 1364 HVPS Horizontal (low noise) power supply, which provides the 170 volts needed by the nixie tubes.

The backplane accepts 6 of the IN12 (TaylorEdge 1328ST) SmartNixies. There is a 2.1X5.1mm power socket on the backplane if needed. Besides power and ground, only the two data lines are needed to connect the Emulator shield to the backplane. This is a very fast way to get the nixie display operational. Note: There are some protruding switches on the backplane that are not used in this application and can be desoldered or cut off if they are in the way of your particular mounting arrangement.

POWERING THE EMULATOR AND THE TAYLOREDGE BACKPLANE

In my installation I needed 8V for the Arduino and Emulator board as well as the 1355 backplane (the dropout voltage on the 7805 regulator on the Emulator is 7 volts). I also needed 12V for a fan and six green Light Emitting Diodes that I placed behind the nixie tubes.

The combination of the Arduino/Emulator and backplane/nixies consumes 250ma. The fan consumes 40ma and the six LEDs consume 100 ma.

I installed this in a Heathkit SB-303 receiver. The entire radio is powered by a power transformer having a 50VAC secondary with a grounded center tap (See Figure 6). By using each half of the secondary, we need to convert approximately 25V to either 12V or 8V. Note that one half of the secondary has a 50 ohm resistor (R701) in series with three #47 lamps. There is a voltage drop of approximately 7V across R701, leaving a potential difference of approximately 18VAC between ground and the junction of R701 and the lamp P701.

I connected a power supply (available online from various sources) which contains both an LM317 and an LM337 voltage regulator across the 18VAC (see Figure 7). On the "positive" side I connected the Arduino, Shield and Backplane; on the "negative" side I connected a fan and the LEDs. The power supply pictured, along with a 40mm fan, fit entirely within an LMB No. 103 Box Chassis (2.75" X 2.125" X 2.125").

USING A DIFFERENT TYPE OF NIXIE TUBE

The IN-12 nixie tube is fine, and similar tubes have been mounted in an SB-303 cabinet. See Figure 8 (May, 1973 QST cover photo) showing a homebrew SB-303 companion transmitter using the Raytheon 8422 nixie tube. I wanted to use a smaller tube that permitted display of all six digits but that did not overwhelm the front panel. I chose the IN-2 nixie, which fits within a 0.75" hole. In order to use the TaylorEdge backplane I had to create an adapter for each tube, with wires going from the backplane socket to the IN-2 socket. I mounted the sockets on a piece of aluminum and the wires come out the rear to the backplane. No. 18 solid wire is the right diameter for the backplane sockets. Use just one No. 18 wire per tube and you will have enough stiffness to support the whole nixie array. Use a flexible ribbon cable to make the other tube socket to tube socket connections. Figures 9 shows the general interconnection schematic, with some interconnections omitted for clarity. Figure 10 is a photograph of the completed adapter module sitting inside the radio.

DISPLAY ALTERNATIVES

All of the SB series radios use an identical escutcheon that fits into a rectangular cutout in the front panel. In order to view the nixie tubes at least part of the escutcheon must be removed. I wanted to save as much of the original rotating dial window as possible, so I cut the top portion away as seen in Figure 11. I just used a hacksaw and took my time. Since it is plastic, use of a higher speed power tool risks melting the plastic. By removing the top of the escutcheon, this leaves room for four of the six nixies. A hole punch was used to make room for the "tens of Megahertz" and "tenths of Kilohertz" tubes.

A simpler approach is to just display four digits ("hundreds of Kilohertz" through "tenths of Kilohertz"). The four tubes will fit within the existing front panel cutout without the need to deface the panel. The four tube method is more consistent with the amateur equipment of the time (1970 plus or minus a few years), such as the National HRO-600 and the Signal One CX-7. Those radios relied on the operator to observe the band switch position in order to infer the Megahertz digits.

CONNECTING THE EMULATOR TO THE RADIO

The modifications that you have made to the radio for use with the SB-650 provide the signals that you need. Note that Kenwood and Heathkit used different names for the three signals (CAR/BFO, HFO/HET, and VFO/LMO).

Since the KV6O emulator is being mounted within the radio, the connections to the three oscillator signals can be hard wired to the rear of the spare RCA jacks already modified and mounted on the rear panel. The RCA phono plugs going into the emulator enclosure may omitted if desired and the interconnections hardwired to the emulator board.

Figure 12 shows the general arrangement of the emulator box, power supply box and nixie adapter within the radio. Figure 13 shows the radio in operation.

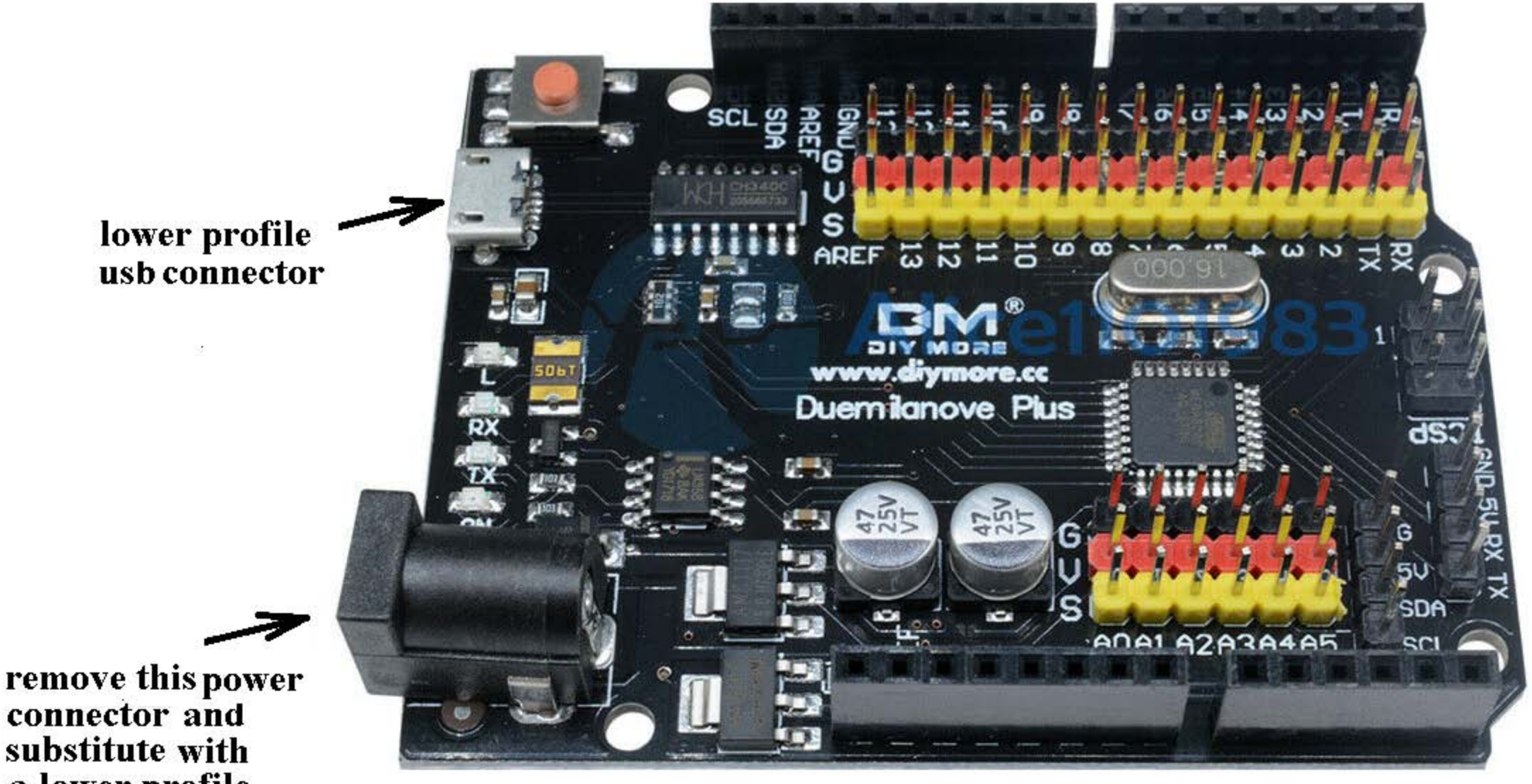

lower profile
usb connector
remove this power
connector and
substitute with
a lower profile
arrangement
SCL
SDA
AREF
GND
13
12
11
10
9
8
7
6
5
4
3
2
1
0
RX
TX
L
RX
TX
ON
BM®
DIY MORE
www.diymore.cc
Duemilanove Plus
47
25V
VT
A0 A1 A2 A3 A4 A5
GND 5V RX TX
SDA
SCL

FIGURE 1

FIGURE 2

FIGURE 3

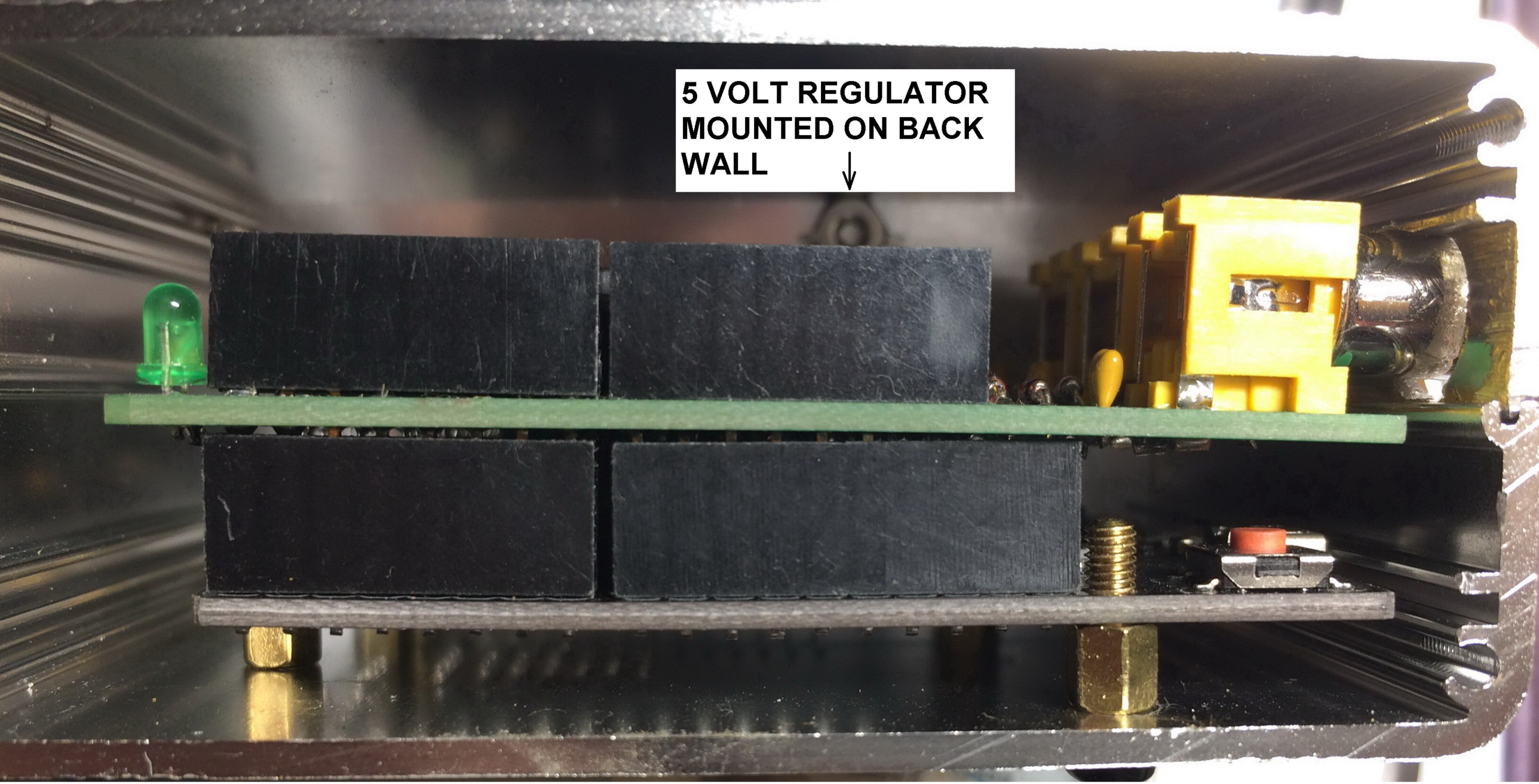


FIGURE 4

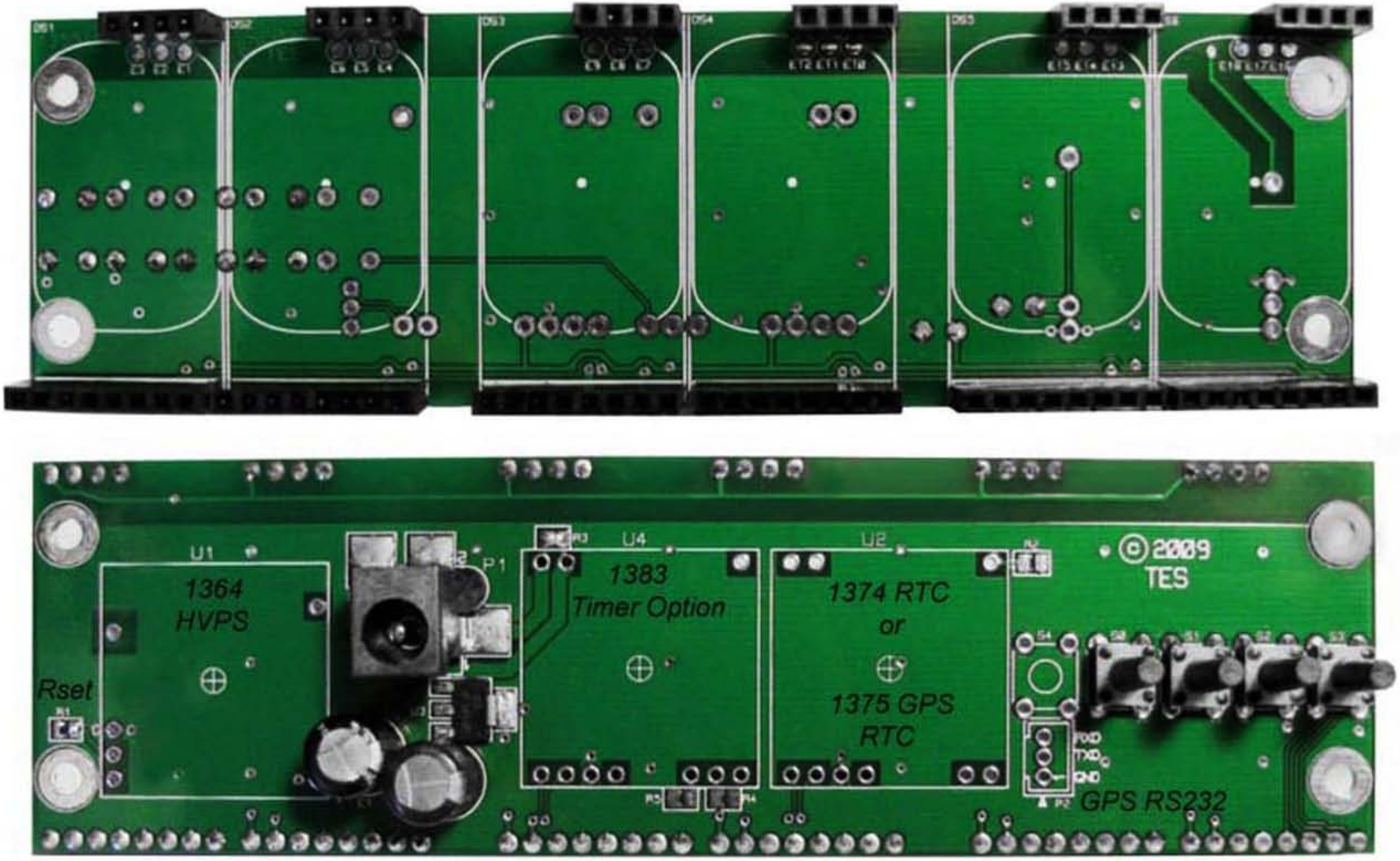
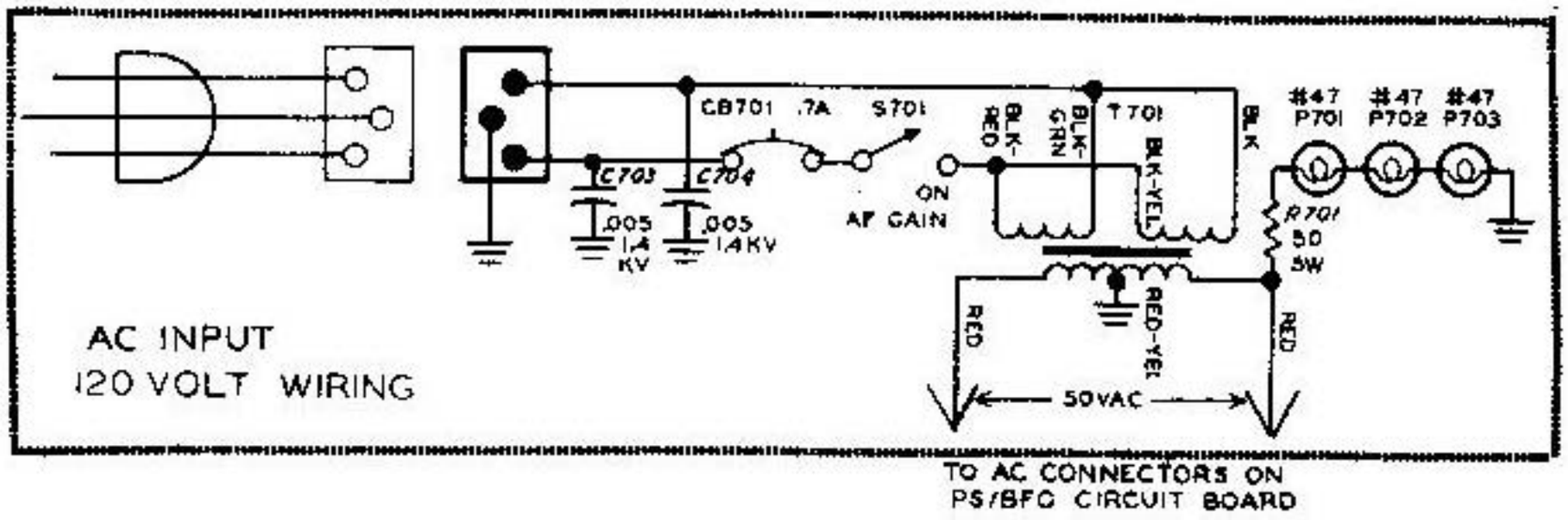

U1
1364
HVPS
Rset
P1
U4
1383
Timer Option
U2
1374 RTC
or
1375 GPS
RTC
2009
TES
GPS RS232

FIGURE 5


CB701 .7A
S701
C703
C704
.005 1.4 KV
.005 1.4KV
ON
AF GAIN
BLK-RED
BLK-GRN
T701
BLK-YEL
BLK
#47 P701
#47 P702
#47 P703
R701 50 5W
RED
RED-YEL
RED
50VAC
AC INPUT
120 VOLT WIRING
TO AC CONNECTORS ON PS/BFO CIRCUIT BOARD

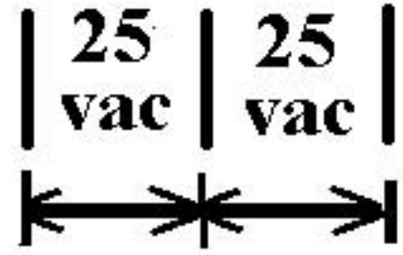

25 vac
25 vac

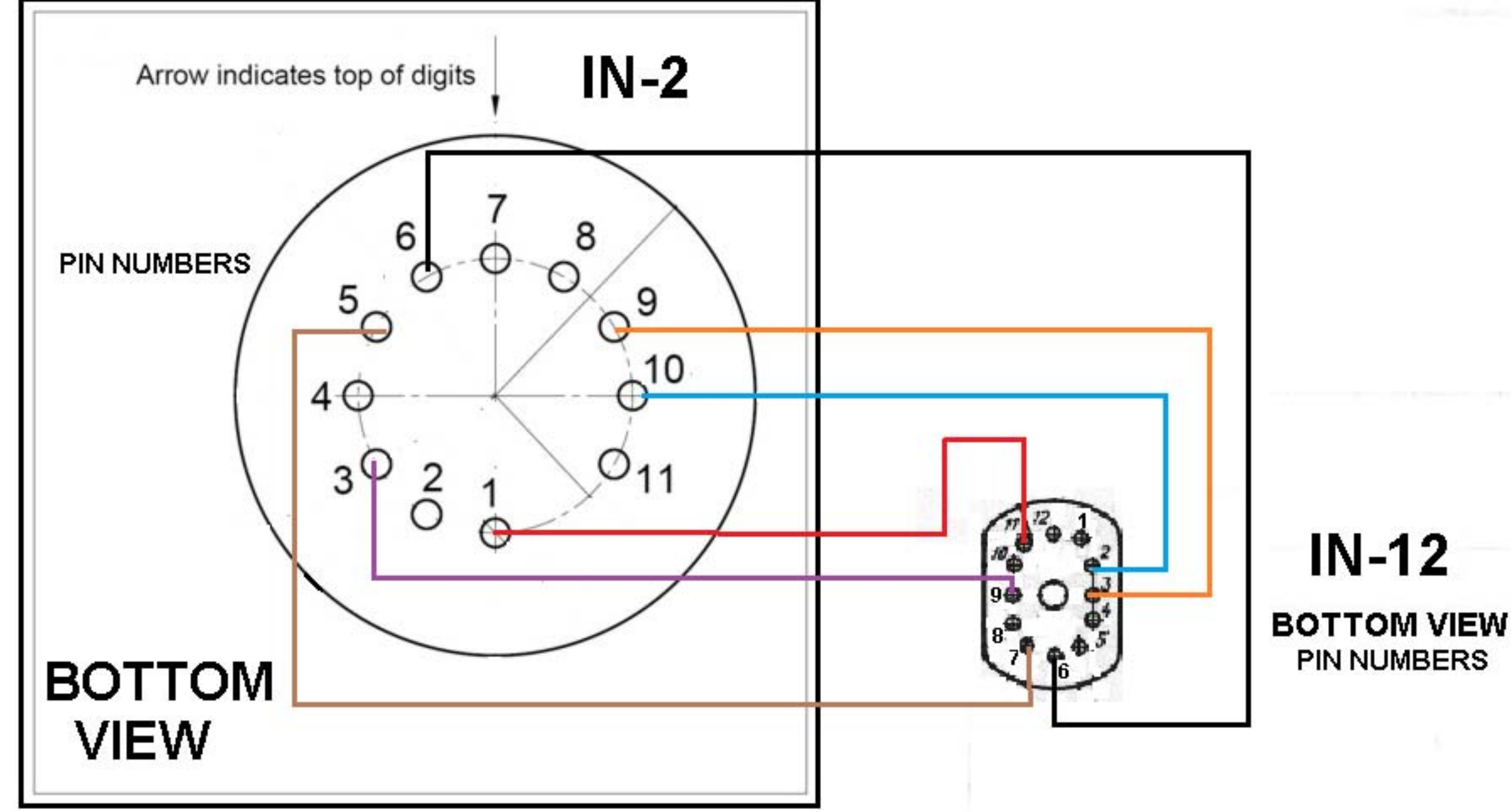
FIGURE 6


AC input
GND
AC input
thanks-4-buy
-VCC negative output
GND
+VCC positive output

FIGURE 7


QST
devoted entirely to
amateur
radio
May 1973
75 Cents
OFFICIAL JOURNAL OF THE ARRL

FIGURE 8



Pin	IN-2 Connection
1	Cathode (1)
2	Cathode (2)
3	Cathode (3)
4	Cathode (4)
5	Cathode (5)
6	Cathode (6)
7	Cathode (7)
8	Cathode (8)
9	Cathode (9)
10	Cathode (10)
11	Anode

PIN NUMBER	IN-12 NUMBER DISPLAYED
1	ANODE
2	CATHODE „0"
3	CATHODE „9"
4	CATHODE „8"
5	CATHODE „7"
6	CATHODE „6"
7	CATHODE „5"
8	CATHODE „4"
9	CATHODE „3"
10	CATHODE „2"
11	CATHODE „1"
12	DECIMAL POINT

FIGURE 9

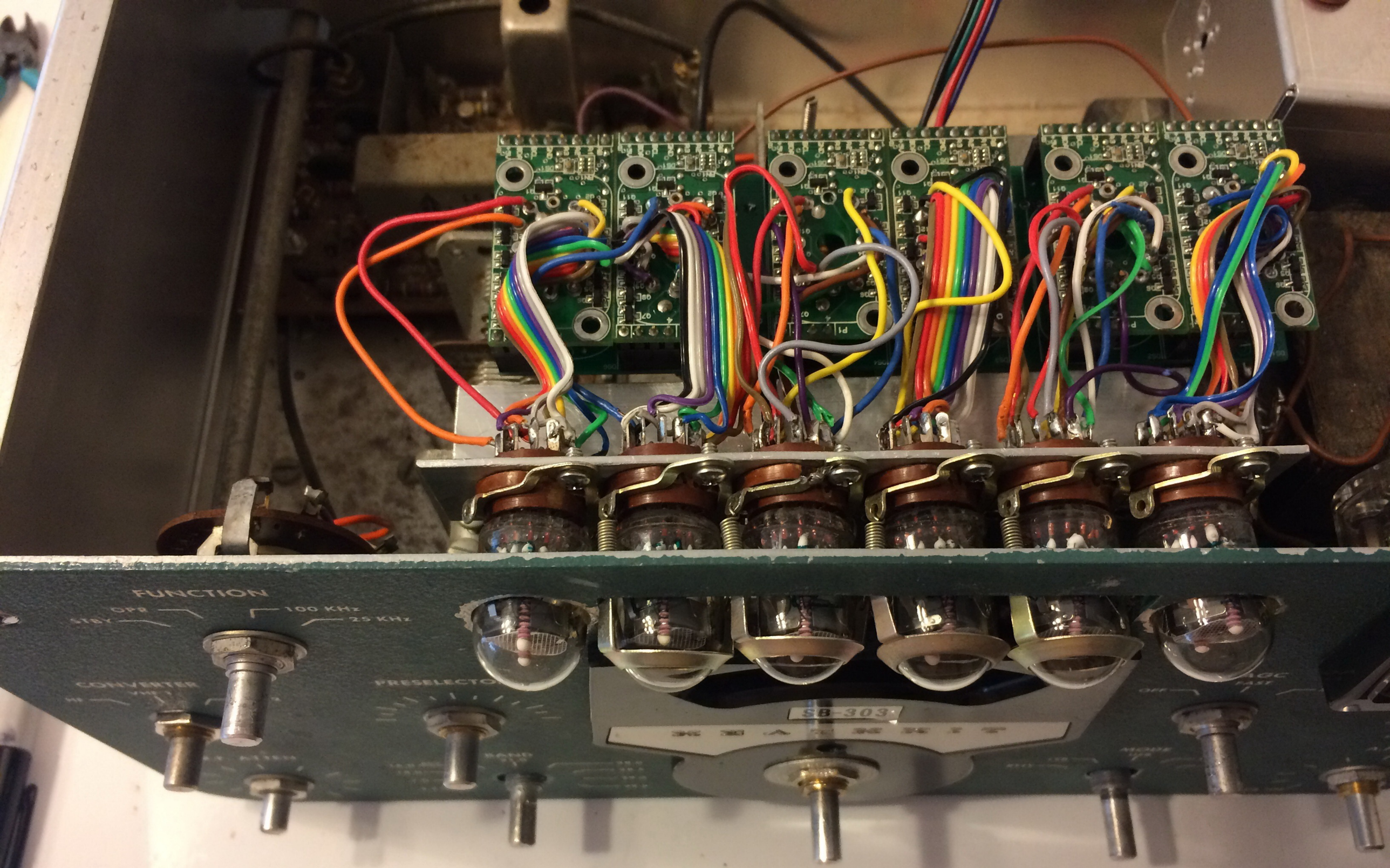

FUNCTION
OFF
STBY
100 KHz
25 KHz
CONVERTER
PRESELECTOR
SB-303
SENATE

FIGURE 10

FIGURE 11

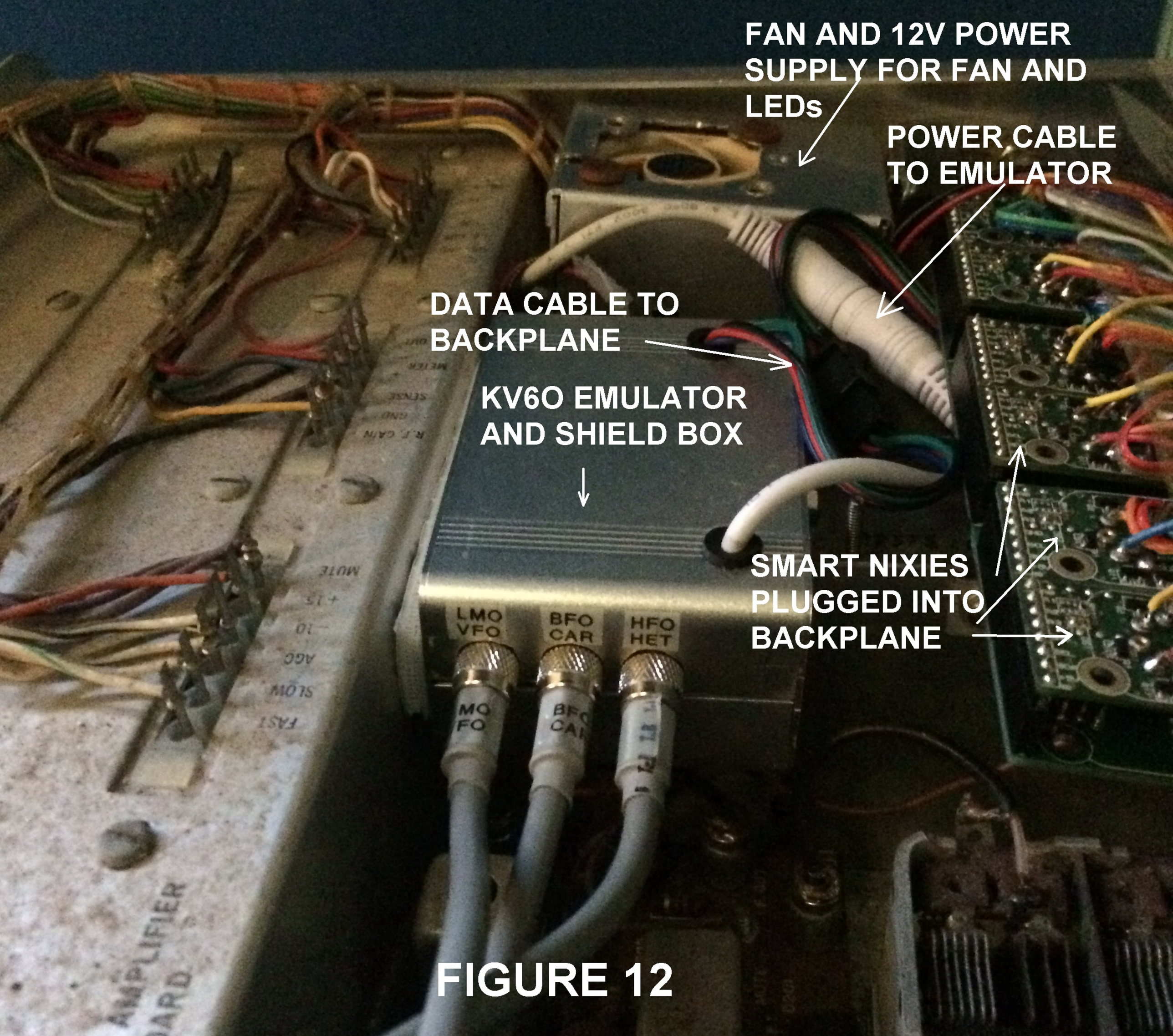

FAN AND 12V POWER SUPPLY FOR FAN AND LEDs
POWER CABLE TO EMULATOR
DATA CABLE TO BACKPLANE
KV6O EMULATOR AND SHIELD BOX
SMART NIXIES PLUGGED INTO BACKPLANE
LMO VFO
BFO CAR
HFO HET

FIGURE 12


FUNCTION
OPR
STBY
100 KHz
25 KHz
DECIBELS
S-UNITS
SB-303
HEATHKIT
CONVERTER
VHF 1
HF
VHF 2
PRESELECTOR
AGC
FAST
OFF
SLOW
R.F. GAIN
SPEAKER DISABLE
R.F. ATTEN
BAND
21.0
15.0
RCV ONLY
14.0
7.0
3.5
28.0
25.5
29.0
29.5
MODE
USB
LSB
CW
RTTY
AM
A.F. GAIN

FIGURE 13

INSTALLATION

The installation of the Frequency Display requires that your equipment (receiver or transceiver) furnishes three signals. These are the outputs of the HFO (high frequency oscillator), LMO/VFO (linear master oscillator/variable frequency oscillator), and BFO (beat frequency oscillator). This section of the manual presents the steps necessary to provide these three signals from Heath 5-band transceivers of the SB and HW (SB-100, HW-100, etc.), series and from amateur receivers of the SB series. No instructions for other makes of equipment are available.

Three unused phono sockets must be available on the rear panel of your receiving equipment. If they are not, they must be installed. Your kit contains three phono sockets (with mounting hardware) for this purpose. Figure 3-1 is the socket mounting detail. DO NOT drill any holes until you have carefully read the "Installation" instructions for your equipment.

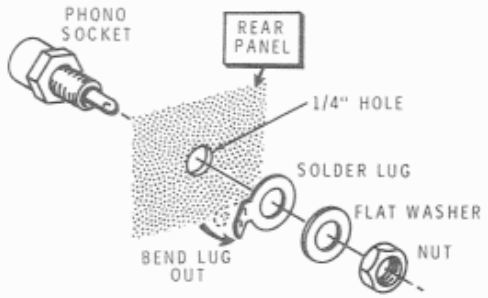


Figure 3-1

Figures 3-2 and 3-3 show two examples of where to locate additional phono sockets. Figure 3-2 shows an SB-102 transceiver. The original two spare phono sockets (spare A and spare B) are used. The ground terminal was moved and its original mounting hole was drilled out to provide a location for the third phono socket. Figure 3-3 shows where three phono sockets were added to an SB-301 receiver.

Before deciding upon the location for the mounting holes, be sure no cabinet lips, interior mounted parts, or other interference will exist. Select the socket locations to retain rear panel symmetry. Use a center punch to mark the centers of the 1/4" holes to be drilled.

Install the required number of phono sockets on the rear panel of your receiver or transceiver. Then select the appropriate following section and perform the indicated steps to connect the three required signals to the sockets. Upon completion, proceed to "Initial Tests" on Page 39.

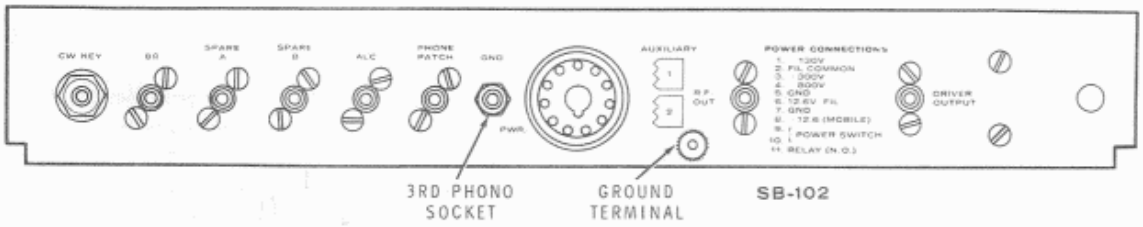


Figure 3-2

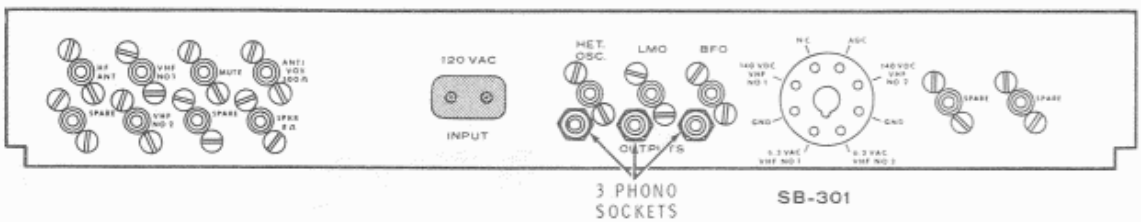


Figure 3-3

TRANSCEIVERS

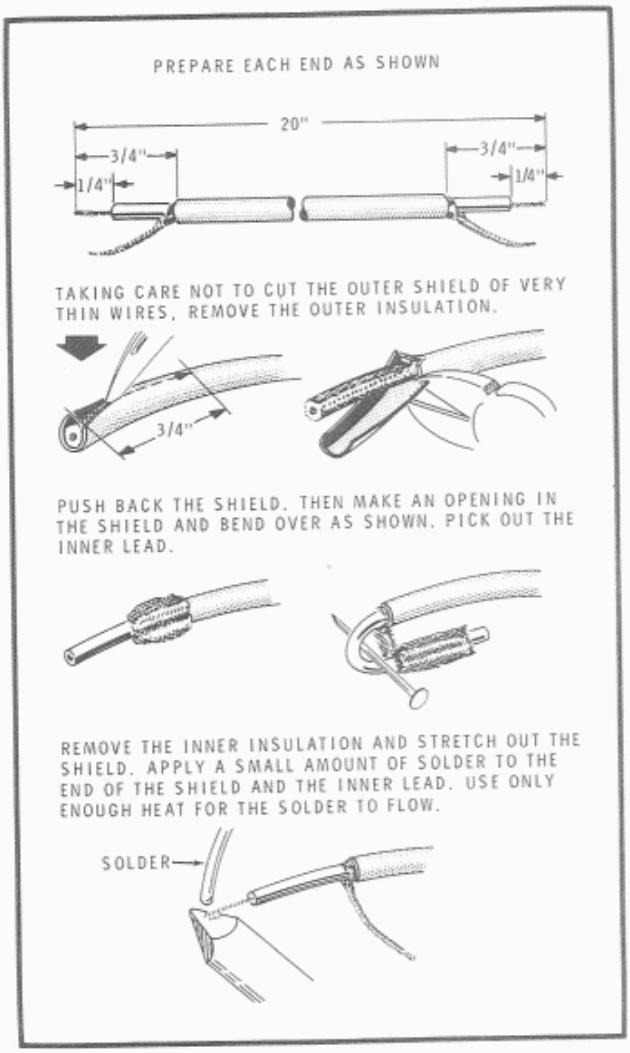


Figure 3-4

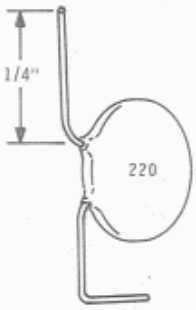


Figure 3-5

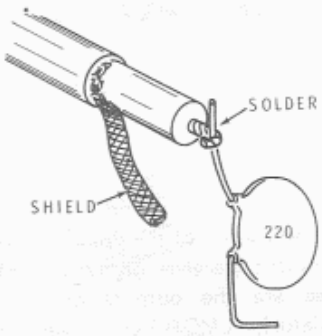


Figure 3-6

BFO MODIFICATION (SB and HW Series)

Refer to Figure 3-4 for the following steps.

( ) Cut a 20" length of RG-174 coaxial cable and remove 3/4" outer insulation from each end.

( ) At each end of the coaxial cable, pull the inner insulation and center conductor from the outer shield.

( ) Remove 1/4" of insulation from the center conductor and trim off any stray strands of wire from the shield braid.

( ) Refer to Figure 3-5 and cut the leads of a 220 pF capacitor to 1/4". Form the leads as shown.

( ) Refer to Figure 3-6 and connect one end of the cable center conductor to the 220 pF capacitor (S-1).

Refer to Figure 3-7 for the following steps:

( ) With the under side of the chassis positioned as shown, push the free end of the coaxial cable under the switch shaft and through grommet CB until about 3" remains over the modulator circuit board.

( ) Connect the foot of the 220 pF capacitor to the foil at point A (S-1).

( ) Connect the shield braid to the foil at Point B (S-1).

( ) Pull any excess cable through grommet CB, but do not place any strain on the capacitor or braid connections.

( ) Position the coaxial cable as shown and connect the center conductor at the free end to the center lug of an unused phono socket (S-1). Connect the braid to the ground lug of the same socket (S-1).

( ) On the outside of the rear panel, mark this socket "BFO."

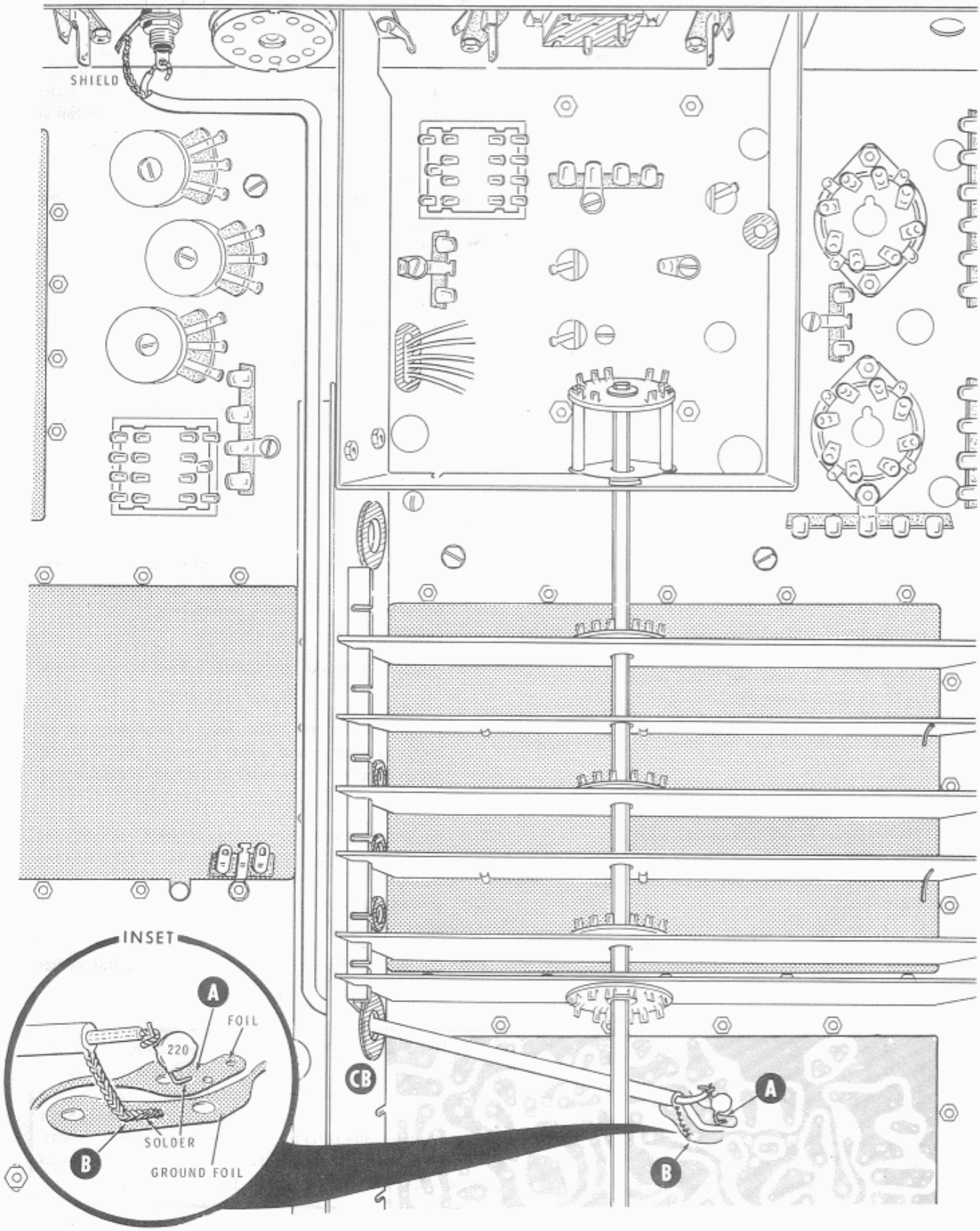


Figure 3-7

HFO MODIFICATIONS (SB and HW Series)

Refer to Figure 3-8 for the following steps (HW-#series illustrated).

( ) Use a knife with a sharp point to break the foil near pin 8 of V19. A narrow strip of foil 1/32" to 1/16" wide should be cut and removed.

( ) Cut the leads of a 51 Ω, 5% resistor (green, brown, black, gold) resistor to 3/8" and form them as shown in the inset drawing.

( ) Solder the foot of one resistor lead to the foil at point C. Solder the other foot to the ground foil at point D.

( ) Cut a length of RG-174 coaxial cable (small) long enough to reach from point C in the preceding step to an unused phono socket, plus 1" (so the connections will not be under stress).

( ) Remove 3/4" of outer insulation from each end of the cable, pull the inner conductor out of the shield as before and remove 1/4" of insulation from the ends of the center conductor.

( ) At one end of the cable, connect the center conductor to point C (S-1) and the shield braid to point D (S-1).

( ) At the other end of the cable, connect the center conductor to the center lug of the selected phono socket (S-1). Connect the shield braid to the ground lug of the same socket (S-1).

( ) On the outside of the rear panel, mark this socket "HFO."

LMO MODIFICATION (SB Series Only).

Refer to Figure 3-9 (fold-out from Page 35) for the following steps.

( ) Cut a length of RG-174 coaxial cable (small which will reach from foil pad H on the bandpass circuit board to an unused phono socket, plus 1".

( ) Prepare the ends of the cable as before. See Figure 3-4.

( ) At one end of the cable, bend a small foot on the center conductor and solder it to foil pad H. Solder the shield braid of the cable to the hole in the foil at point E.

( ) At the free end of the coaxial cable, connect the center conductor to the center lug of the selected phono socket (S-1). Connect the shield braid to the ground lug of the same socket (S-1).

( ) On the outside of the rear panel, mark this socket "LMO."

VFO MODIFICATION (HW Series 5-Band Transceivers Only)

Refer to Figure 3-10 (fold-out from Page 35) for the following steps.

( ) Cut a length of RG-174 coaxial cable (small) which will reach from foil pad G on the bandpass circuit board to an unused phono socket, plus 1".

( ) Prepare the ends of the cable as before. See Figure 3-4.

( ) At one end of the cable, bend a small foot on the center conductor and solder it to foil pad G. Solder the shield braid of the cable to the hole in the foil at J.

( ) At the free end of the coaxial cable, connect the center conductor to the center lug of the selected phono socket (S-1). Connect the shield braid to the ground lug of the same socket (S-1).

( ) On the outside of the rear panel, mark this socket "LMO."

IMPORTANT: AFTER you have completed the modification of your equipment for the Frequency Display, and BEFORE you start the "Initial Tests," refer to the manual for your equipment and perform the alignment instructions for the HFO (high frequency oscillator) circuits. Also, be sure your equipment is operating normally on all bands before starting the "Initial Tests."

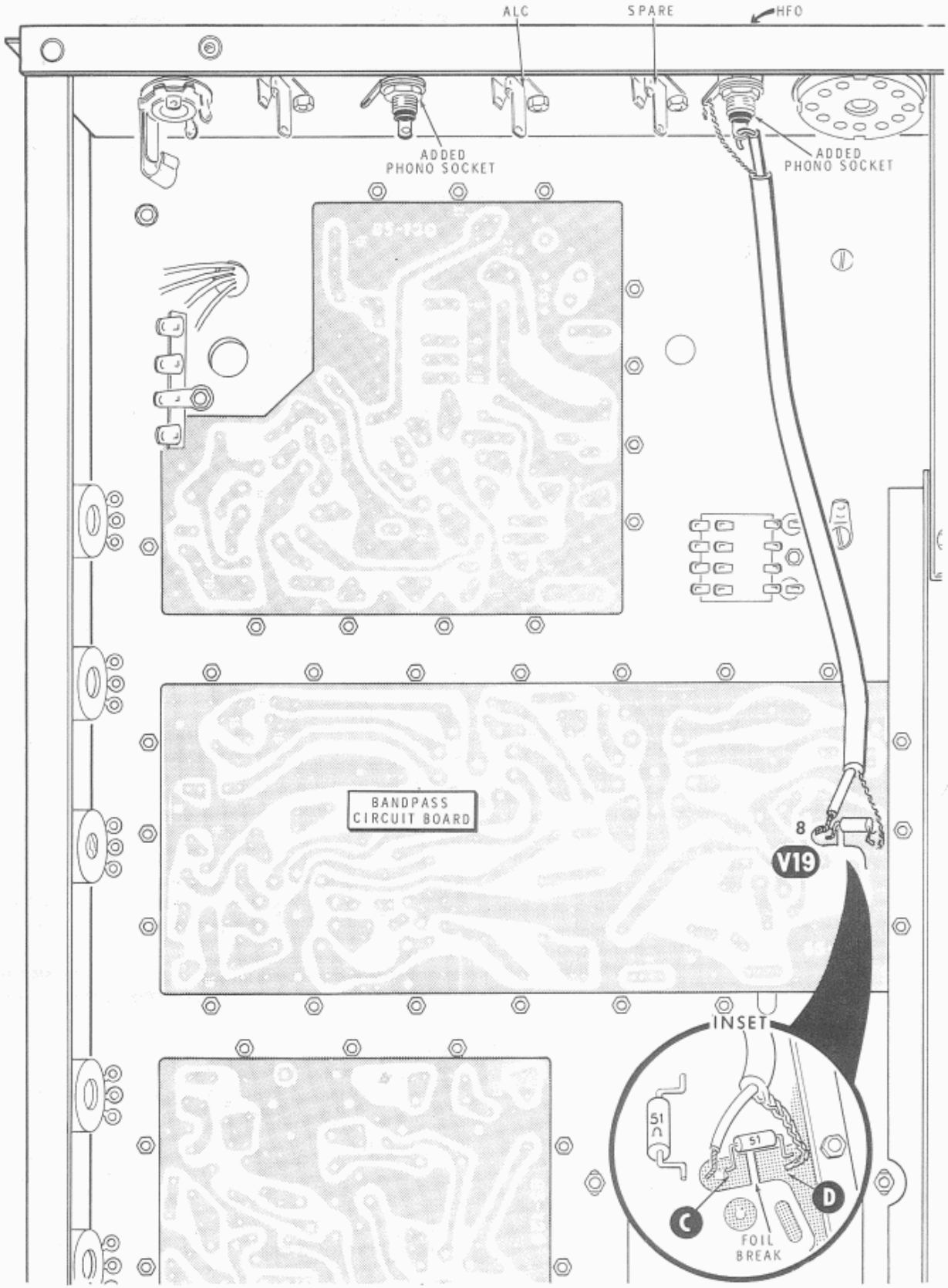


Figure 3-8

(HW-SERIES)

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RECEIVERS

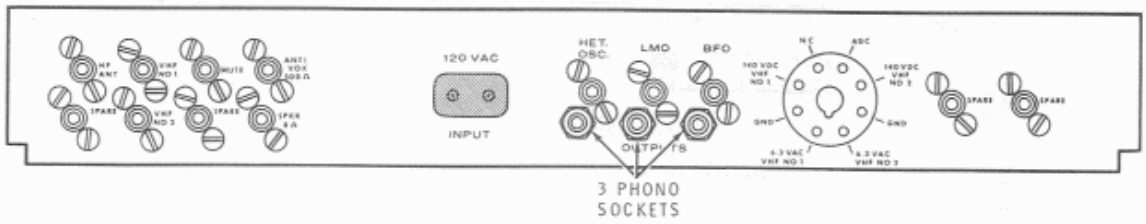


Figure 3-11

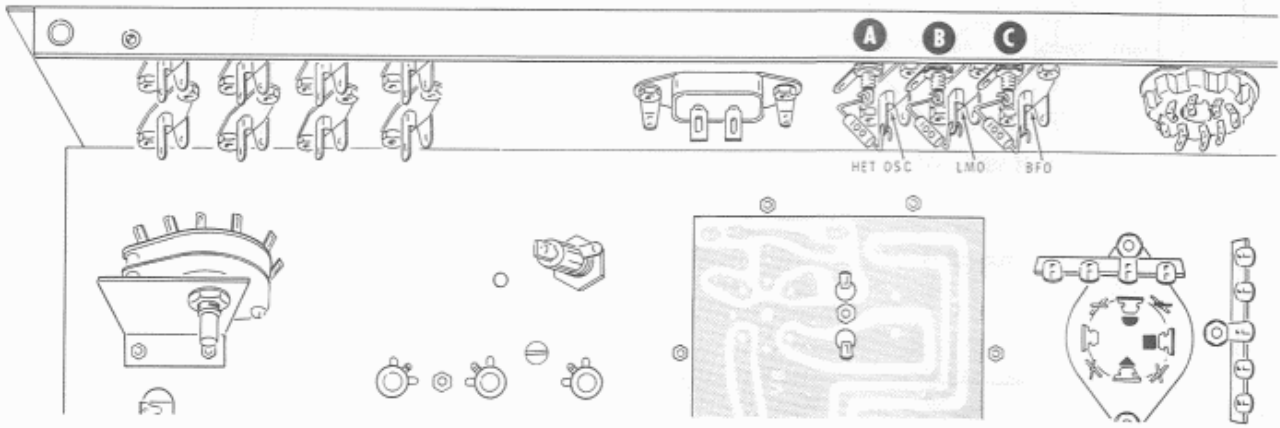


Figure 3-12

NOTE: If the following Receivers (SB-300, SB-301, SB-303) are used in the transceive mode with the SB-400 or SB-401 Transmitters, the RF choke furnished must be installed in the transmitter. Refer to Figure 3-13 (Pictorial 10 in the SB-400 Manual, or Pictorial 4-2 in the SB-401 Manual).

( ) Bend each lead of an RF choke (#45-76) toward the slot in the choke winding form.

( ) Connect the RF choke between lugs 1 and 2 of the terminal strip (S-2). It may be necessary to melt the existing solder in the lugs before the choke leads can be inserted.

( ) Cut off the excess lead lengths, and check carefully to see that all connections to lugs 1 and 2 remain well soldered.

SB-300 AND SB-301

( ) Refer to Figure 3-11 and install three phono sockets at the locations shown. Refer to Figure 3-1 for the hardware mounting detail.

( ) On the inside of the rear panel, refer to Figure 3-12 and connect a 100 Ω (brown-black-brown) resistor from the center lug of the HET OSC socket (S-1) to the center lug of socket A (S-1).

( ) Connect a 100 Ω (brown-black-brown) resistor from the center lug of the LMO socket (S-1) to the center lug of socket B (S-1).

( ) Connect a 100 Ω (brown-black-brown) resistor from the center lug of the BFO socket (S-1) to the center lug of socket C (S-1).

IMPORTANT: AFTER you have completed the modification of your equipment for the Frequency Display, and BEFORE you start the "Initial Tests," refer to the manual for your equipment and perform the alignment instructions for the HFO (high frequency oscillator) circuits. Also, be sure your equipment is operating normally on all bands before starting the "Initial Tests."

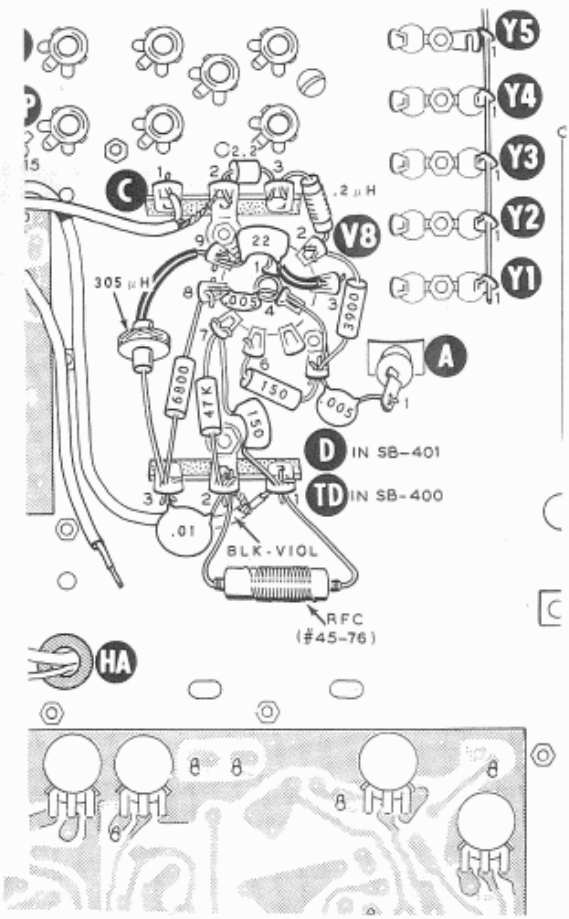


Figure 3-13

SB-303

Refer to Figure 3-14 for the following steps.

NOTE: A coaxial cable has previously been soldered to the back of each of the following three phono sockets. When you connect a resistor to one of these sockets, be sure to solder both the cable and the resistor leads to the lug.

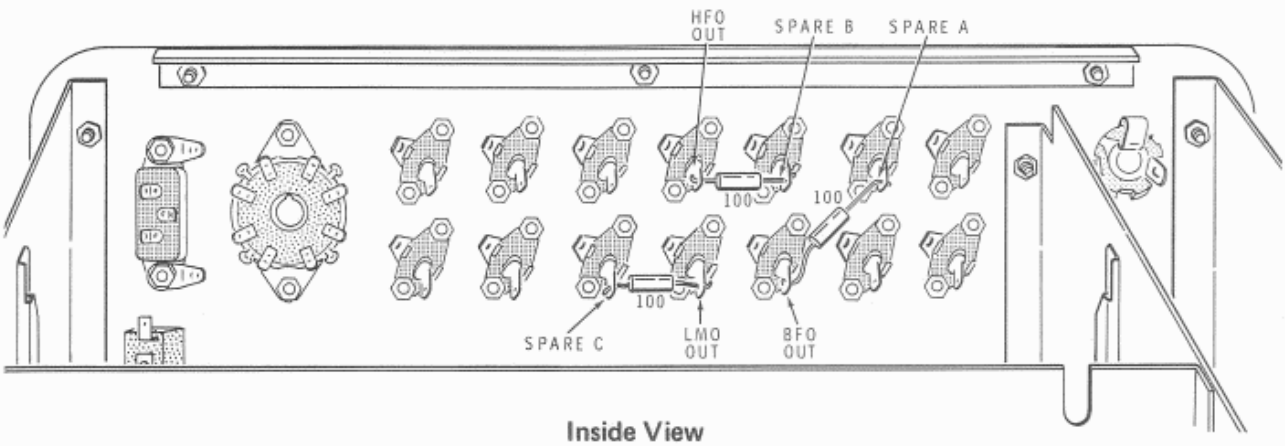
( ) Solder one lead of a 100 Ω (brown-black-brown) resistor to the center lug of the HFO socket. Solder the other lead to the center conductor of the Spare B socket.

( ) Solder one lead of a 100 Ω (brown-black-brown) resistor to the center lug of the BFO OUT socket. Solder the other lead to the center lug of the Spare A socket.

( ) Solder one lead of a 100 Ω (brown-black-brown) resistor to the center lug of the LMO OUT socket. Solder the other lead to the center lug of the Spare C socket.

( ) On the outside of the rear panel, mark HFO, BFO and LMO on the corresponding Spare A, B, and C sockets. Then proceed to "Initial Tests."

IMPORTANT: AFTER you have completed the modification of your equipment for the Frequency Display, and BEFORE you start the "Initial Tests," refer to the manual for your equipment and perform the alignment instructions for the HFO (high frequency oscillator) circuits. Also, be sure your equipment is operating normally on all bands before starting the "Initial Tests."



Inside View
Figure 3-14