Optimizing the Heathkit HW-101, SB100-102 Transceivers

The Heathkit HW/SB series of transceivers were very popular in the late 60's through 70's and are fairly plentiful on the used market even today, nearly 30 years later. This series of modifications will increase the audio quality of both receive and transmit, improve operation on CW, enhance strong signal handling of the rigs, and make the units useable with the low-Z headphones so often used today. All of these changes require no hole drilling or mechanical changes at all, and the rig can be easily restored to its original configuration at anytime if desired. The text deals with the HW-101, but the changes are applicable to the above mentioned SB-series as well.

Conversion to Low-Z Headphones:

These rigs are designed to be used with Hi-Z headphones, but if low-Z phones are used the outboard speaker will not mute completely with the phones connected. To convert to low-Z phones, make the following wiring changes referring to ***(Figure 1)*** of this document, and pictorial 8-4 (foldout from page 53), and pictorial 8-5 (foldout from page 67) of the HW-101 manual:

1.) Remove the black wire from terminal strip BA lug 2 and reconnect it to lug 3 (ground).
2.) Remove the green wire and the 100Ω resistor from jack AB (speaker).
3.) Connect the green wire to terminal strip BA lug 2.
4.) Connect the 100Ω resistor removed in step 2 to lugs 2 and 3 of terminal strip BA.
5.) Remove the jumper wire from lugs 1 and 2 of headphone jack L.
6.) Run a NEW wire along the wiring harness from speaker jack AB lug 1 to the headphone jack lug 2.

Now the external speaker should mute completely when low-Z phones are used.

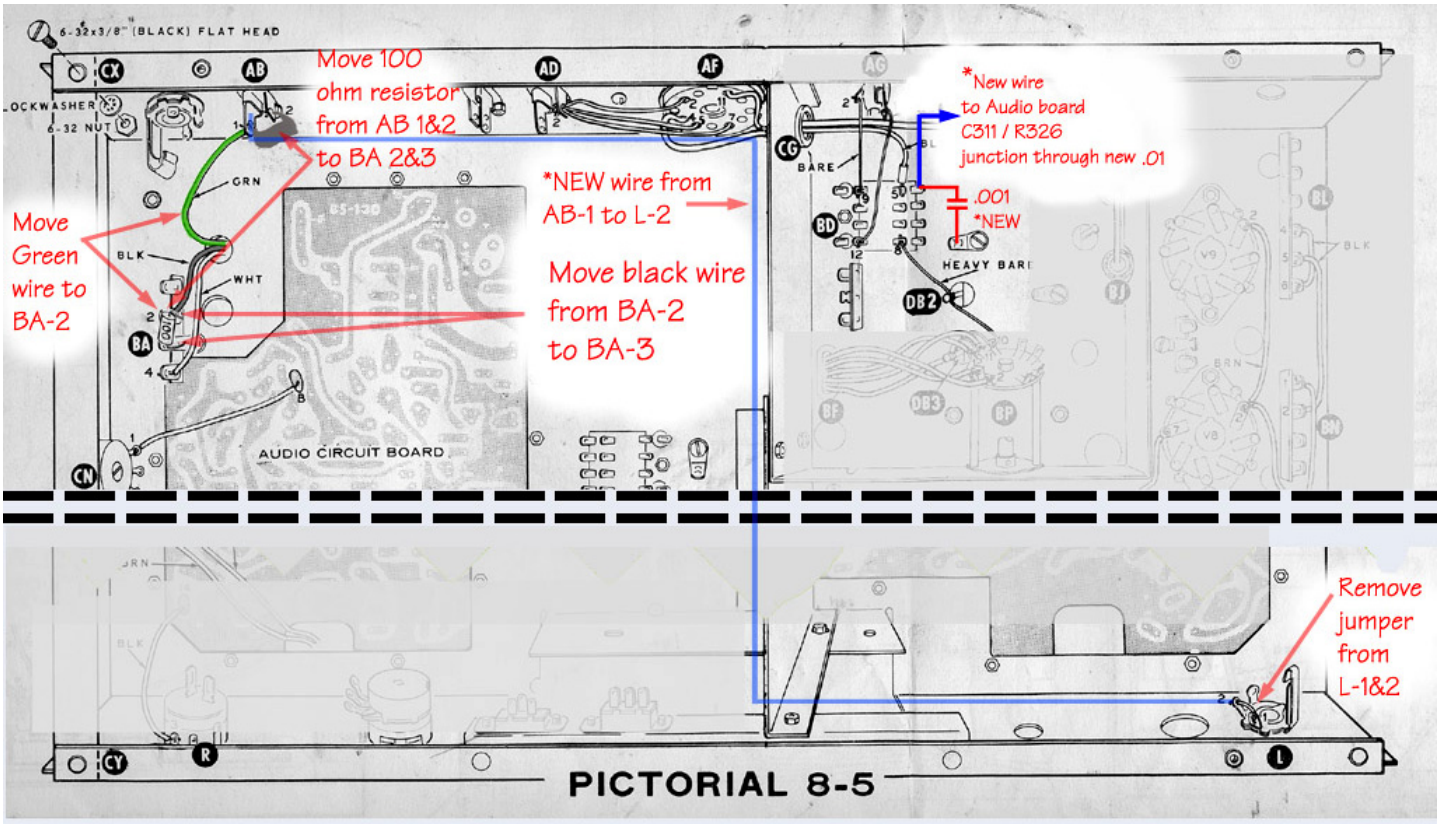

Figure 1

Improved CW Operation:

In the CW mode the rig's relays are energized by the CW sidetone amplifier's sidetone output driving the vox relay amplifier. The audio (sidetone) drive to the vox amp is a bit on the low side for fast relay action, and at speeds approaching 20 wpm the first dot sent is heard in the sidetone but isn't transmitted due to the slow relay response time. Correcting this is a very simple modification – simply replace the 470KΩ resistor R328 on the audio board with a 1KΩ resistor ***(Figure 2)***. This increases the drive to the vox amp enough to cause the relays to pull in quicker. Now the rig will key reliably at 20 wpm. The first dot tends to become shortened at 25 wpm but the rig is useable at this speed.

Another annoying problem with these rigs is the fact the sidetone can be heard when the rig is in the CW mode without the key actually being pressed. Although the sidetone amplifier is in deep cutoff, there is enough coupling through the inter-electrode capacitance of the tube to allow the output of the sidetone oscillator to be heard at a constant low level even when the key isn't being pressed. Fortunately this is also fairly easy to correct:

1) Connect a .001 µfd disk capacitor (DO NOT use a higher value) from relay RL1 pin 1, to ground ***(Figure 1).***
2) Connect a piece of wire about 8" long from pin 1 of RL1 and run this wire through the same opening in the shield as the wiring harness.
3) On the audio circuit board, replace 1MΩ resistor R326 with a 2.2MΩ resistor ***(Figure 2).***
4) At the circuit board junction of R326 and C311, connect one side of a .005 µfd 500v disk capacitor, and connect the other side of this capacitor to the wire from RL1 pin 1.

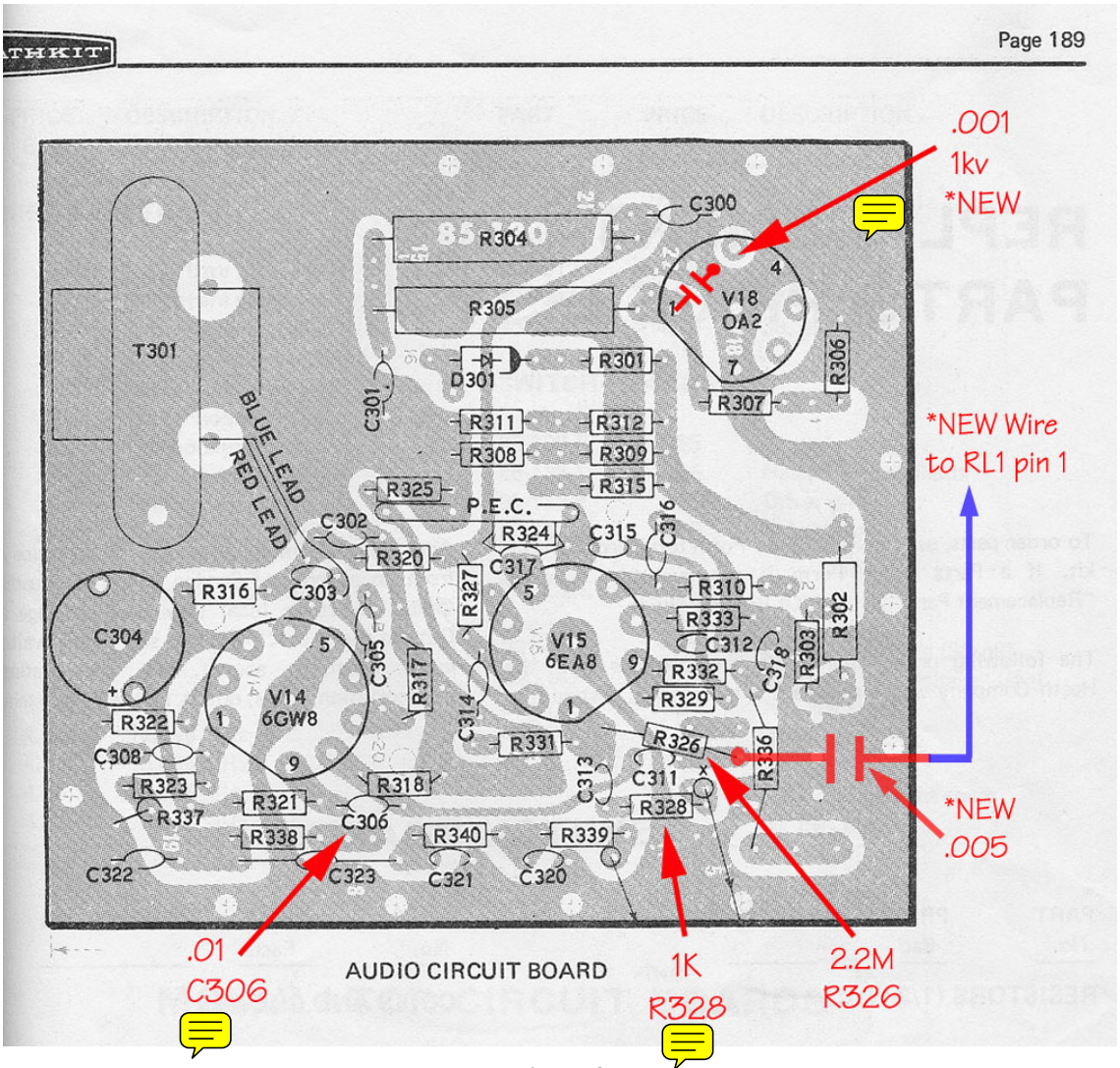

Figure 2

Now during receive, the sidetone will be bypassed to ground by the normally closed contact on RL1. During transmit, RL1 opens and the sidetone works normally.

Transmit Improvements:

The transmitter audio quality can be improved by changing the value of coupling capacitor C11 on the modulator board from .001 µfd to .01 µfd ***(Figure 4)***. This will increase the low frequency response and give the transmit audio a little more "body".

If 10KΩ resistor R202 is present between the I.F. circuit board (L101 pin 4) and the bandpass circuit board (V5 pin 2), remove and replace it with a piece of insulated hook up wire ***(Figure 3)***. This will increase drive to the 1st transmit mixer. This change is already incorporated in later model HW-101s.

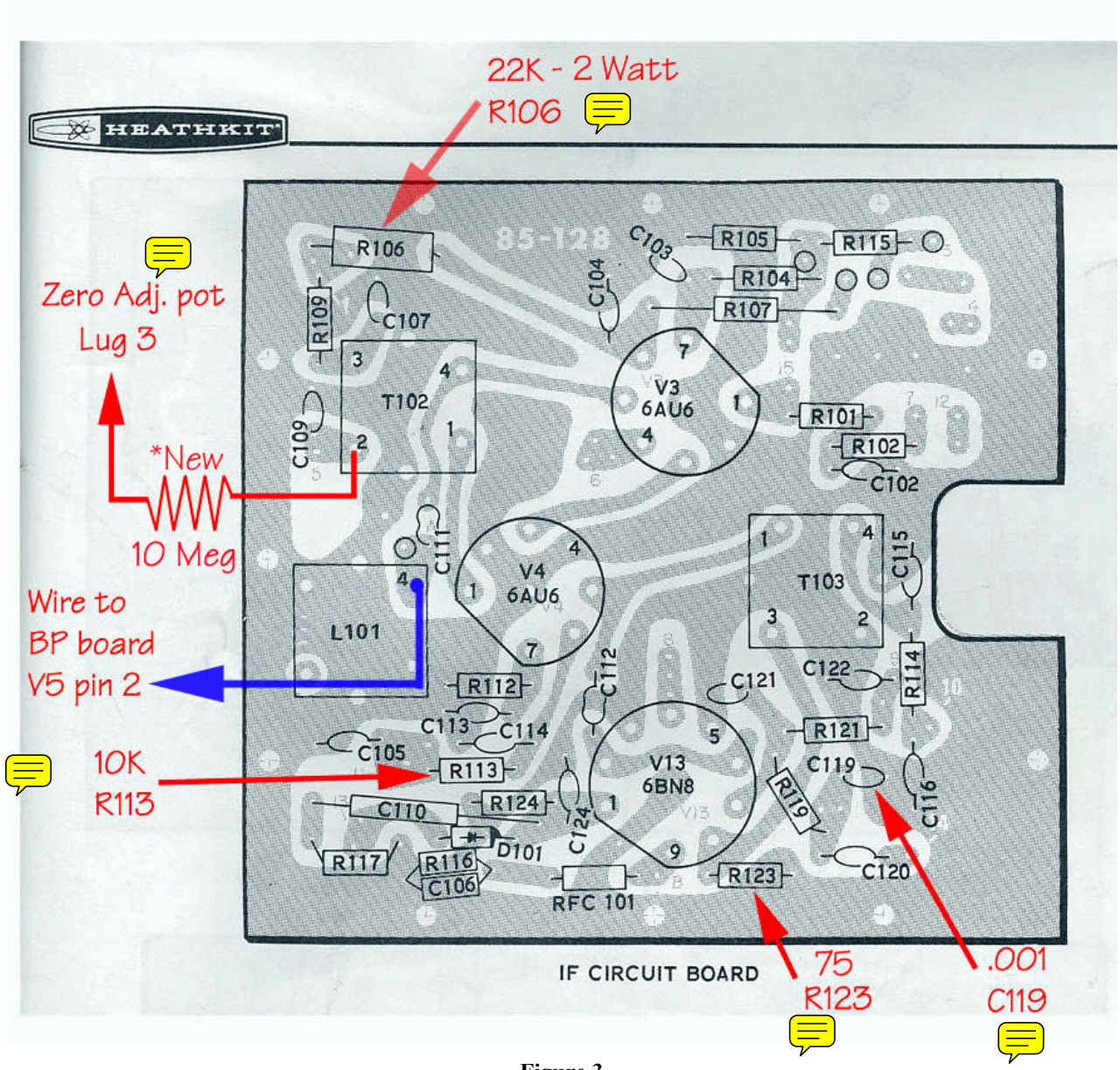

Figure 3

Receive Improvements:

The receiver's strong signal-handling capability and audio quality can be vastly improved by the following changes:

During alignment check to see if, while adjusting T-102 ***(Figure 3)***, there are two points where the transformer can be peaked -- one spot for transmit and a slightly different setting for receive. If so, peak the transformer for maximum transmit drive instead of maximum receive gain. The receiver has an abundance of gain, however the transmitter could use a little extra. This will get rid of some of the receiver gain but WILL NOT affect receiver sensitivity.

Also change the value of the screen dropping resistor R113 in the second I.F. amplifier V4 from 1KΩ to 10KΩ ***(Figure 3)***. This will reduce the gain of this stage a bit and improve gain distribution.

The next step in receive improvements is to increase the BFO drive to the product detector. The BFO (carrier oscillator) injection to the product detector should be about five times the level of the I.F. signal for low distortion. On these rigs, the I.F. signal can equal the BFO injection level under strong signal conditions resulting in a very raspy, distorted audio quality. I have even noted at times some pulling of the BFO oscillator frequency. The major problem is that during receive, the BFO signal is coupled to the product detector cathode through C17, a 12pf silver mica capacitor which is connected to a piece of coax running to the product detector cathode. The capacitance of the coax cable exceeds the value of coupling capacitor C17, and the combination of the two acts as a voltage divider, greatly reducing BFO drive level to the product detector V13C. Correcting this involves increasing BFO drive and decreasing the I.F. drive to V13C.

To increase BFO drive, simply replace coupling capacitor C17 on the modulator board with a 100pf silver mica, and replace the 33KΩ resistors R6 and R7 on the modulator board with 27KΩ resistors ***(Figure 4)***. To reduce I.F. drive, change resistor R123 on the I.F. board from 470Ω to 75Ω ***(Figure 3)***.

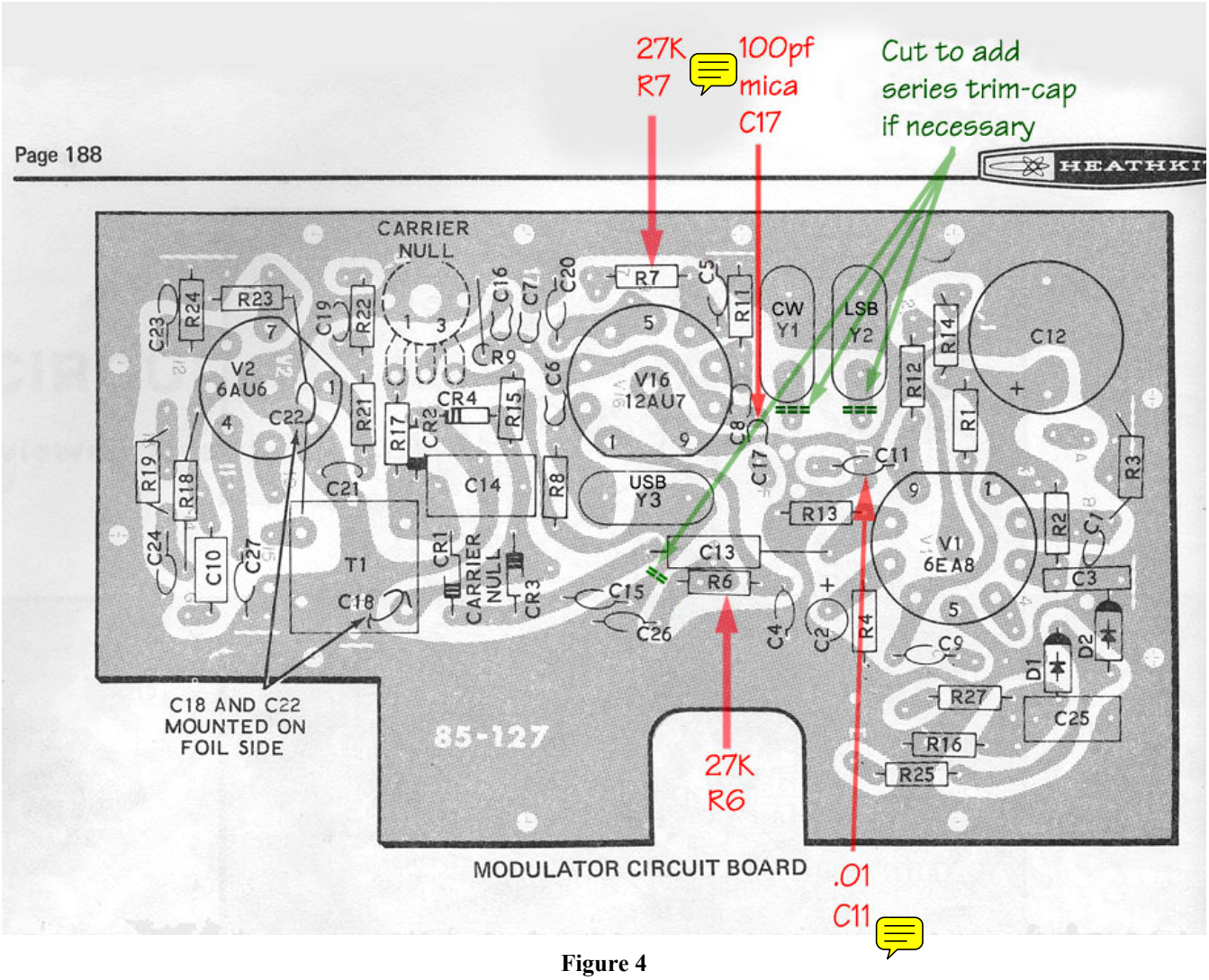

Figure 4

Additional rolloff of the high frequency response will remove the raspy nature of the receive audio, and this is accomplished by changing the value of capacitor C119 on the I.F. board from 500pf to .001 µfd ***(Figure 3)***. The low-end audio response of the audio amplifier increases slightly by replacing coupling capacitor C306 on the audio board with a .01 µfd disk capacitor ***(Figure 2)***.

Any possibility of voltage regulator hash being generated by V18 is reduced by connecting a .001 µfd 500V disk capacitor from V18 pin 1 to the ground foil on the audio board.

Some of the 'birdies' and other internally-generated signals heard in the tuning range of the receiver are reduced considerably by bypassing the filament string to ground with a .01 µfd capacitor connected from the common filament point on the bandpass circuit board to ground. This is the point where the four brown wires connect about an inch below pin 1 of V19 ***(Figure 5)***.

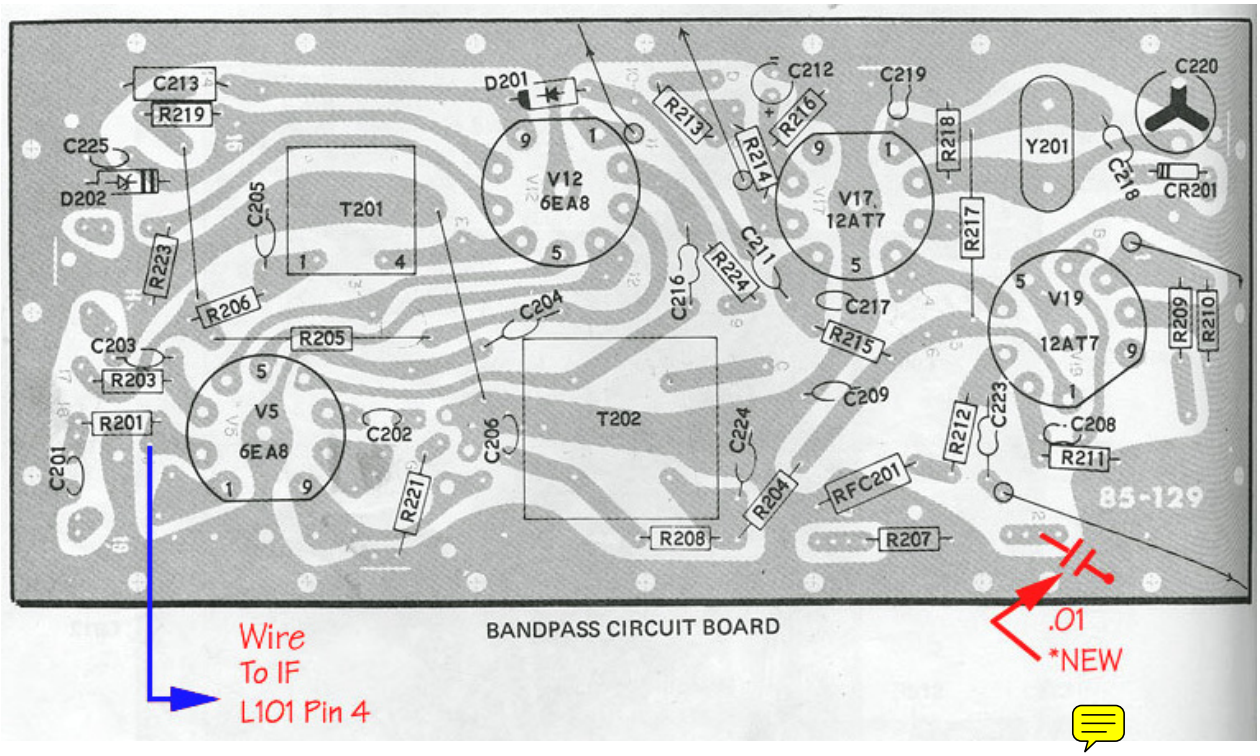

Figure 5

I.F. Filter Passband Improvements:

I believe the crystals that Heath supplied for the carrier oscillator were of fairly wide tolerance, thus the frequencies of the LSB/USB/CW carrier injection may not be properly positioned on the slope of the I.F. filter. This can affect both the receive and transmit audio response to a great degree. Telltale signs of this are not having the same audio response on USB and LSB, and reduced CW power output when using the CW filter.

It is relatively easy to tell if the USB/LSB carrier insertion points aren't placed equidistant from the center of the I.F. filter passband. After the rig reaches a stable operating temperature (1/2 hour) disconnect any antenna and peak the preselector for maximum receiver gain. Next turn up the volume control to a slightly higher than normal level and listen closely to the hiss coming from the speaker. Then switch to the opposite sideband. The pitch of the receiver background noise should be the same if the USB & LSB carriers are both placed equidistant from the filter center frequency.

If the carrier oscillator frequency is placed too far from the filter passband, the receive and transmit signals will lack "lows" but the opposite sideband rejection will be high. If the carrier oscillator frequency is placed too close to the filter center frequency, the receive and transmit signals will have excessive "lows" and the opposite sideband rejection and carrier suppression will suffer. Balance is the key.

On my particular HW-101, the actual measured carrier oscillator frequencies were 3393.8 kHz LSB, 3395.9 kHz USB, and 3395.17 kHz for CW. This resulted in a "tinny" sounding audio response in LSB compared to USB, and a very "bassy" sounding USB. The CW power output while using the SSB filter was 110 watts, but since the CW carrier oscillator injection was so far from the CW filter center-frequency of 3395.4 kHz, the CW power output was 50 watts while using the CW filter!

Heath's intended frequencies for the carrier oscillator were 3393.6 kHz LSB, 3396.6 kHz USB, and 3395.4 kHz for CW. With the specified filter center-frequency of 3395.0 kHz the USB & LSB carrier positions would be 1.6 kHz each side of the filter center-frequency. Unfortunately, the filter center-frequency may not be exactly 3395.0 kHz, so simply placing the carrier injection points equally-spaced from 3395 kHz may not have the intended result. In order to determine the filter center-frequency one must balance the audio response between both sidebands, measure the USB and LSB carrier frequencies, and finally subtract ½ the difference between the USB & LSB frequencies from the USB carrier frequency. The result will be the I.F. filter center-frequency as it exists within your particular rig. For example, if the audio response is exactly the same between USB/LSB, and the measured USB carrier frequency is 3396.31 kHz while the LSB carrier frequency measures 3393.51 kHz, then the difference is 3396.31 - 3393.51 = 2.8 kHz. One-half the difference is 2.8 ÷ 2, or 1.4 kHz. Then the USB frequency of 3396.31 kHz - 1.4 kHz = 3394.91 kHz, which in this example is the actual SSB filter center frequency.

I like audio with a tad bit more bottom end response, so I placed my carrier points just a little closer to the filter center frequency than the Heath spec., i.e., rather than 1.6 kHz off center I went with 1.4 kHz. The frequency of the oscillator is lowered by placing a small amount of capacitance in parallel with the crystal, and the frequency is raised by putting capacitance in series with the crystal. To put a capacitor in series with the crystal simply cut one circuit board trace just before the crystal pin as indicated, and solder the capacitor across the opened trace ***(Figure 4)***. A 100 pf capacitor in series will move the crystal frequency up about 100 Hz, but the same frequency change in the downward direction would only require about 10 pf connected in parallel with the crystal.

On my HW-101 I put the capacitors (silver mica's) directly on the circuit board foils. I got one sideband to sound the way I liked, and then simply adjusted the other sideband to match it in audio response. I wound up using a 10 pf cap in parallel with the LSB crystal, 100 pf in series with the USB crystal, and 80 pf in series with the CW carrier crystal. Following these changes, the new carrier oscillator frequencies for my rig are 3393.51 kHz LSB, 3396.31 kHz USB, and 3395.38 for CW. The audio is perfectly balanced when switching between sidebands, indicating a true I.F. filter center frequency of

3394.91 kHz. The CW power output while using the CW filter went from 50 watts to 110 watts. I also soldered a short loop of wire to the center lug of the carrier null pot to serve as a test point to measure the carrier oscillator frequency. Be sure that once you have determined the filter center-frequency, you place the oscillator frequencies no closer than about 1.4 kHz and no further than 1.6 kHz from the filter center-frequency.

To recap, we are actually matching the response between USB & LSB by ear, then verifying with a frequency counter that the carriers are no closer to the filter passband than 1.4 kHz, and no further than 1.6 kHz. Even though we can match the pitch between USB and LSB with our ear, we can't tell exactly WHERE they are -- only that they are at the same point on the filter slope.

When the carrier oscillator frequencies are changed, the signal level of the oscillator outputs may consequently change and therefore should be adjusted to be equal. Connect a scope or RF probe to the carrier null pot center lug test point and switch between sideband modes, checking for equality in level. If need be, adjust the value of R6 or R7 to achieve equality. The level should be at least 1 volt RMS, or 3 volts P-P.

Stabilizing Meter Zero Settings:

S-meter zero setting instability is mainly caused by heat-related resistance changes in the R106 22KΩ 1-watt resistor on the I.F. board. Replace R106 with a 22KΩ 2-watt wirewound ***(Figure 3)***.

The problem of the meter reading below zero during transmit while in the ALC position is corrected by connecting a 10MΩ resistor from the meter Zero-Adjust pot pin 3, to pin 2 of T-102 on the I.F. board (hints from N4NRW).

After all the above mentioned changes are made, give the rig a touch up alignment and enjoy a much improved vintage rig!

Many thanks to Lenny WB8JCJ for his help in editing, image scanning, input, and implementation of these changes into his HW-101. His help was indispensable.