Here are some Heathkit VHF-1 (Seneca) problem solutions and modifications.
I had the good fortune to acquire a Seneca that was originally well built and remained relatively unmolested. The arrangement of items below is in their approximate order of encounter in proceeding through the Testing, Adjustment and Calibration Instructions section of the Heathkit Assembly Manual. With these changes, I have added no new holes, nor done anything else that is irreversible.

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NA7RH 3-18-2009

Contents

VFO Hum, Frequency Shift and Drift when Driver is Keyed

With the high voltage rectifier tube removed, upon keying only the driver, the continuously running VFO would suddenly be modulated by hum and shift several kHz at 2-meters.

Quote from Heath Model VHF-1 product review in QST for January 1961, re. 144 Mc operation: "….and you will see that getting an absolutely stable, buzz free, f.m.-free signal from a conventional tuned-circuit v.f.o. is well-nigh impossible. …"

The likely cause, at least of the hum modulation, seemed to be some RF signal leaking into the VFO. The 300-volt supply voltage was changing from 330 volts to 306 volts with the key down, but the regulated 150 volts to the VFO screen was not changing. Varying the line voltage with the Variac to produce the same 300-volt supply range did not produce the hum modulation or as significant a frequency shift. Only the 2E26 driver stage is keyed, so the likelihood is small that a load change reflected back through two tripler stages could shift the frequency.

The investigation consisted of applying various filters to the VFO supply lines and attempting to confine the 2E26 driver RF to its shielded compartment. Although a supply line filter consisting of a 0.82uH choke and added bypass capacitor greatly reduced the voltage detected with an RF probe at the VFO 300 volt supply terminal, it did not affect the hum modulation and frequency shift.

When the 2E26 driver is doubling to 2-meters, substantial 72 MHz fundamental and harmonic voltages can appear across the plate choke, RFC-5 and RFC-6 in series. These connect from the driver tank coil center-tap to the B+ feed-through, FT-10 on the compartment wall. The thought was that the resulting currents through the feed-through capacitor and chassis walls could induce voltages and cause RF to escape the shielded driver compartment (which is by no means a seamless RF tight box). In the circuit, the 2-meter choke, RFC-5, resonated at 134 MHz and the 6-meter choke resonated at 55 MHz. A Mathcad model of the RFC-5 / RFC-6 combination says that its impedance will be high at 50 and 144 MHz, but will drop to low values in the 70 to 110 MHz range and beyond 210 MHz (3rd harmonic). The model also shows that this behavior is quite sensitive to stray capacitance.

The thought (that 2E26 plate choke circulating currents flowing in the feed-through filter and compartment walls is a major source of the driver RF reaching the VFO) is substantiated by the only modification I found that significantly reduced the effect. There is an unused rotor (ground) lug on the 51pF driver plate tuning capacitor. See Detail 3, page 24 of the assembly manual; the lug is not visible in other views. In an attempt to reduce driver plate circulating currents in the feed-through capacitor and chassis, I added a 220pF Sprague Cera-Mite capacitor between the rotor lug and feed-through FT-10. That reduced the VFO frequency shift to 1-2 kHz at 2-meters and reduced the hum modulation, when keying the driver. The 220pF value was series resonant with its leads near 70 MHz. Addition of a 4700pF Cera-Mite capacitor in parallel with the 220 pF further reduced the frequency shift to a few hundred Hz and the hum modulation was no longer noticeable.

More work needs to be done for a better understanding and further improvements. I do not know whether another Seneca would exhibit this problem of driver RF affecting the VCO, or whether the modification described above would always apply.
I did leave the 300-volt supply filter in place at the VFO since it did significantly attenuate the RF voltages seen on the B+ line. Perhaps it was providing a detectable improvement after reduction of the driver emissions.

Tube Substitutions and Tube Condition

Inappropriate tube substitutions are likely present in a newly acquired Seneca. In place of the original 5R4GY, the 5U4GB rectifier found in my Seneca has a lower voltage rating that could imperil the irreplaceable power transformer, especially at today's higher AC line voltages.
Semiconductor rectifiers, if used, need to have a series resistance comparable to the 5R4. In the Seneca, Standby and PTT operation open the power transformer HV secondary center tap, so the transformer often carries capacitor-charging surges limited only by transformer, choke and rectifier resistances. For 2-meter operation, the higher plate voltage possible with semiconductor rectifiers is inappropriate, since, at 600 volts,

Heathkit has already pushed 25% beyond the 6146A and 6146B ICAS voltage ratings for the frequency.

Weak tubes can result in low grid drive through the various multiplier stages, particularly for 2-meter operation. The 6146B suffers low grid drive and neutralization difficulties on 2-meters.

6AQ5 Clamp Tube Oscillation

The clamp tube had an RF oscillation when using every 6AQ5 in my stock.
The symptom was a set of abnormal modes with the key up in CW mode:

CW Key-up Mode	Final Screen V	Plate Current, ma	Grid 3 Current, ma	Calculated Bias V
Normal	16	50	0	0
Squegging	46	<10	1.5	-24
Oscillating	200	100	2.4	-38

The grid and plate currents in the key-up abnormal modes were independent of Driver Plate or Final Tank tuning. Often, when initially switching from Standby to CW, one would see the Squegging (irregular oscillation) mode. Then the continuous Oscillating mode would appear after first key-down and up. When in this mode, a shortwave portable receiver brought near the Seneca detected broadband noise (in the 10 to 20 MHz range, I seem to recall).
By inserting 100-ohm resistors in series with the 6146 screen leads to detect the screen currents, almost all of the ~20ma screen dropping resistor current was found to be going to the 6AQ5 clamp tube plate in the Oscillating mode.
The lead from the un-bypassed 6AQ5 grid pin 1 (Pictorial 19, 6 inches in length) should resonate near 20 MHz with the feed-through capacitor FT13 (which measured about 900 pF).
Solution: Add 1000 pF ceramic bypass capacitor from grid pin 7 to ground on the 6AQ5 clamp tube socket. Only the Normal clamped mode was seen thereafter.
The 6AQ5 grid lead, from the tube socket to feed-thru capacitor FT13 on the final grid compartment wall, apparently has enough inductance to sustain oscillation.

2-meter Neutralization and Screen Lead Inductance

Before neutralization is attempted, the Final Grid Circuit needs to be operating properly, providing 4-5 ma of 2-meter grid drive (without HV applied to the final).

Intermittent Connections
The neutralization procedure provided inconsistent results on 2-meters. The 2-meter feed-through signal in the Final Plate Compartment measured with the grid dip meter was moving around in level with slight mechanical movement of final plate tank connections. Neutralizing wires adjustment locations and the depth of the dip seemed to vary.

Solution: Lightly cleaned surfaces of mechanical RF connections in final tank (using Mother's Mag and Aluminum Polish, applied with a Q-tip and removed with alcohol).

Noalox Anti-Oxidant Joint Compound, applied when re-assembling, seemed to provide the biggest step toward eliminating the intermittent connections. Cleaning continued until no more mechanical sensitivity was evident.

Poor 2-meter Neutralization Dip
2-meter neutralization adjustments did not null the driving signal well in the final tank circuit. (The null on 6-meters was much deeper.)
Similar push-pull 6146 2-meter designs contemporary to the 1958 Seneca, such as Chambers, November 1952 QST, page 11, and De Maw, September 1966 QST, page 11, used series screen-resonating capacitors, or lower value short-leaded screen bypass capacitors and decoupling chokes for a lower screen impedance to ground. On this Seneca, someone before me had replaced wire ground connections on 6146 pins 1, 4, 6, 7 and 8 with 3/16-inch-wide braided straps, which seems to be a step in the right direction. De Maw used ¼-inch wide flashing copper stock. On 2-meters, the 0.001µF screen bypass capacitors of the Seneca are operating well above their self-resonant frequency. The assembly manual calls for 3/8 inch leads on those capacitors, and Pictorial 16 shows a greater than minimum capacitor lead length. With that original capacitor value, the lead inductance series resonates below 6-meters, rather than where neutralization is more demanding.

Solution (In addition to improved 6146 grounds): Add a 150pF disk ceramic capacitor with short leads between screen lug 3 and cathode lug 1 of each 6146 tube socket. This seemed to reduce the amount of signal in the final tank detected by the grid dip meter. The 2-meter neutralizing wires then produced their best dip when located at points further away from the tubes.

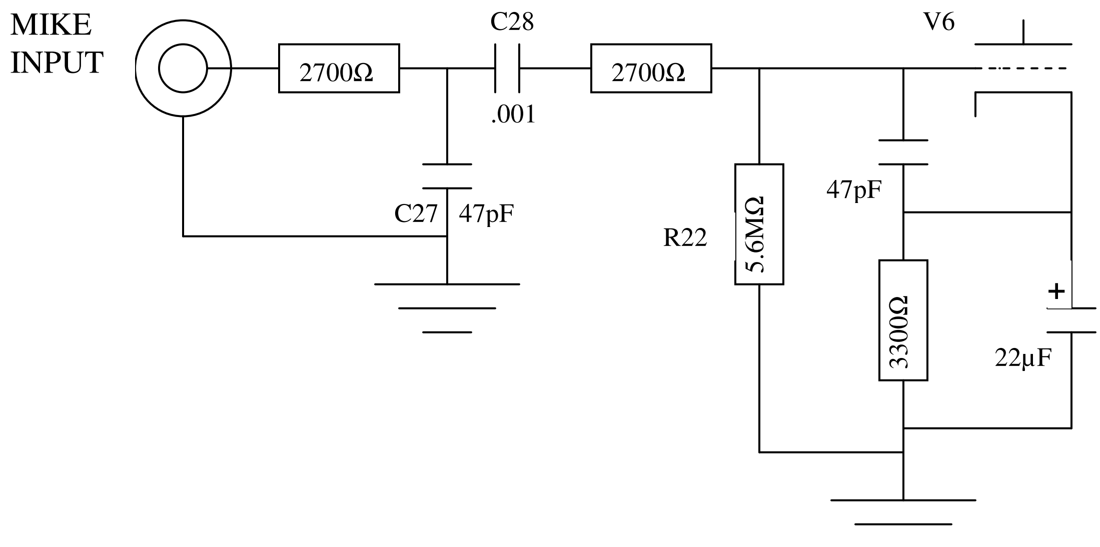
Noise and Hum modulation due to Mike input susceptibility to RF

Initial Problem:
The sensitivity of the mike input to 2-meter RF revealed itself even when using a dummy load, and with all the shielded RF compartment covers installed, but with the VHF-1 out of its outer cabinet. With a 3-foot long, well shielded audio lead terminated in 75 ohms attached at the mike connector, in the Phone mode there was loud hum and noise modulation, and the carrier controlled final plate current rose to as much as 100 ma. The resting plate current returned to the normal level of about 50 ma with the cable disconnected from the mike connector.

Discussion:
At the mike input, the long leads to ground of the 100pF bypass capacitor (C27), shown in Seneca Assembly Manual Pictorial 14, coupled with the low RF impedance through coupling capacitor (C28) to the first grid, do not provide much RF attenuation at 2-meters. The 2-meter RF attenuation is insufficient when the mike cable length resonates near the transmit frequency, and perhaps for a wide range of lengths.
It is seems that the RF emissions creating this sensitivity could have increased from years of aluminum oxidation in metal-to-metal joints or degradation of ceramic feed-thru capacitors into the RF compartments. However, tightening screws of the various shields, covers and sub-chassis did not provide detectable improvement.

Another concern about the mike input circuit is the load presented to a crystal microphone. For a crystal microphone on AM phone, a 1 meg ohm resistor (R21) in parallel with 2.2 meg (R22) is normally too low a load impedance for the desired low frequency response.

Corrective Action for RF Sensitivity & Mike loading:



The first 2700-ohm resistor mounts inside the MIC connector, soldered into the center contact. C27 goes directly from the protruding lead of that resistor to the MIC connector ground lug. The input 1 meg ohm resistor to ground, R21, was removed, but could have been replaced with a 10M ohm resistor. The other 47pF capacitor connects between V6 grid and cathode, soldered to tube socket terminals 7 and 8. On cathode terminal 8 of V6, be certain to disconnect the short wire to ground. Addition of a solder lug under a V6 tube socket mounting screw provided a ground for the added cathode resistor and its bypass capacitor.

Result:
After the above changes were complete, there was no longer speech amplifier sensitivity to RF. The 2-section R-C filter is perhaps overkill, since the calculated attenuation exceeds 75 dB. The intent was to eliminate the RF in the audio fully.

Power Supply 120 Hz Hum in Speech Amplifier

Continuing testing with the mike input loaded with 75 ohms, the remaining hum now had a 120 Hz rectified AC waveform and the level produced about 10 percent modulation. With that load swamping the input, the most likely cause of the hum was inadequate supply filtering. That should come as no surprise after study of the schematic. A triode audio preamplifier stage, of itself, has very little power supply rejection. In this speech amp, we do not see the usual B+ supply R-C filter section that would reduce ripple to the first stage and suppress audio feedback from later stages. In fact, in the VHF-1 300V supply, there is only one 40µF electrolytic capacitor (C43) for ripple and audio frequency filtering. After 50 years, that electrolytic capacitor could be degraded; however, the ripple on the 300V supply measured about as expected, given the 6H choke and 40µF capacitor.

Corrective Action for Supply Induced Hum:
Remove 0.2µF paper tubular capacitor C34, to gain access to terminal strip AA (C34, the only paper tubular in the Seneca, is found in Pictorial 14 floating above terminal strip AA.).
Add a 300V supply line filter for the 12AX7 speech amplifier stages of V6, with the following steps. See the schematic below.
Remove the orange hookup wire between lug 2 (B+ to V6) and lug 4 (B+ to V7) of terminal strip AA. Replace wire with a 15k ohm resistor between lug 2 and lug 4.
Install a 10µF, 450v electrolytic capacitor between lug 2 of terminal strip AA and ground (I used V6 terminal 9 for ground, with sleeved leads, positioning capacitor against chassis). Actually, any capacitor value greater than 2.2 µF should attenuate 120 Hz ripple by >26 dB, reducing hum modulation from 10 percent to less than 1 percent.
Install a new 0.2 or 0.22µF, ≥200v Polypropylene or Polyester Capacitor for C34.

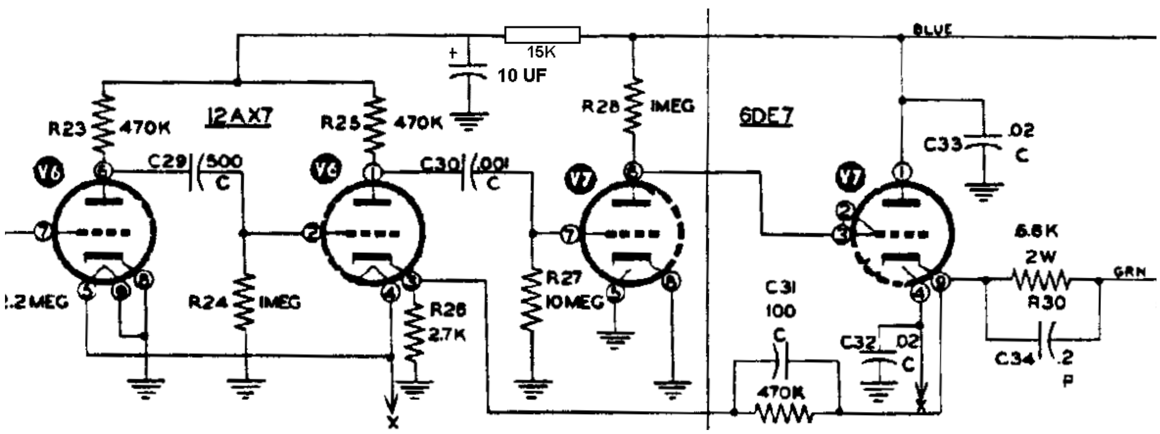


Figure 1, Speech Amp with added Supply Filter

Result:
After adding the supply filtering, and with the mike input still loaded with 75 ohms, the 120 Hz modulation was less than 2 percent, indicating that there was reduced direct ripple contribution from the V6 B+ supply.

Electric Field Induced 120 Hz Hum in Speech Amp Input

However, with the mike input open and unloaded, the 120 Hz hum modulation was again ~10 percent. The open frame 6H filter choke of the 300v supply is very near the speech amplifier and the large AC voltage across it that can create a field to which the high impedance input is sensitive.

Corrective Action for AC pickup from 300v supply Filter Choke:
Reposition the V6 mike input components to be closer to the chassis, with leads near parallel ground wires installed from tube socket to mike connector grounds. These steps

made the power supply choke winding less visible, electrically, to the sensitive input. The value of first stage output coupling capacitor C29 was unchanged at 500pF. It provides a low frequency cutoff near 300 Hz helping to reduce first stage hum.

Add Photo of Mike Connector wiring.

Result: With a high impedance microphone connected, 120 Hz ripple was neither visible on the scope (<1 percent modulation), nor heard on the air.

Arcing Relay Contacts at HV Transformer Center Tap

To remove high voltage for Standby, relay contacts open between ground and the center tap of the power transformer high voltage secondary. The under-damped choke input filter of the HV power supply generates a high voltage fly-back and a relay contact arc when switching to Standby. At first, that arc ignited some excess flux on the relay terminals, producing glowing embers and smoke. With the flux removed, the arc became an often-loud audible snap or pop. C41 and R33 (see the schematic below) were obviously intended to do some damping; however, even with low current (100 ma including bleeder, when un-modulated or CW key-up) in the swinging choke there is enough energy stored in the choke (>0.1 joule) to charge the 0.01 µF capacitor to about 4500 volts, ignoring choke losses. The capacitor would need to be increased to 0.2 µF or more, to limit the potential capacitor voltage to 1000 volts (and the voltage across the 10k resistor in series could be an additional 1000 volts).
A 0.2 µF, 1600-volt film or paper capacitor is fairly large and expensive, and in 1958 that was probably the only option to damp the choke fly-back properly.

Solution: Install another terminal strip on the same screw as terminal strip BB in Pictorial 18. On the terminal strip, install a damping network consisting of a 3300-ohm 2-watt flameproof metal film resistor and two 1N4007 rectifiers, all in series with anodes toward ground. The ungrounded end of the network, wired to terminal strip DD lug 5, connects to the rectifier end of the 5-25 H swinging choke and to the 5R4 cathode. The normally reverse biased network absorbs the negative going transient when the relay contacts open. In the event of double diode failure, the 3300-ohm resistor should be large enough to protect the irreplaceable transformer.
Result: Snaps, pops or glowing embers were gone.

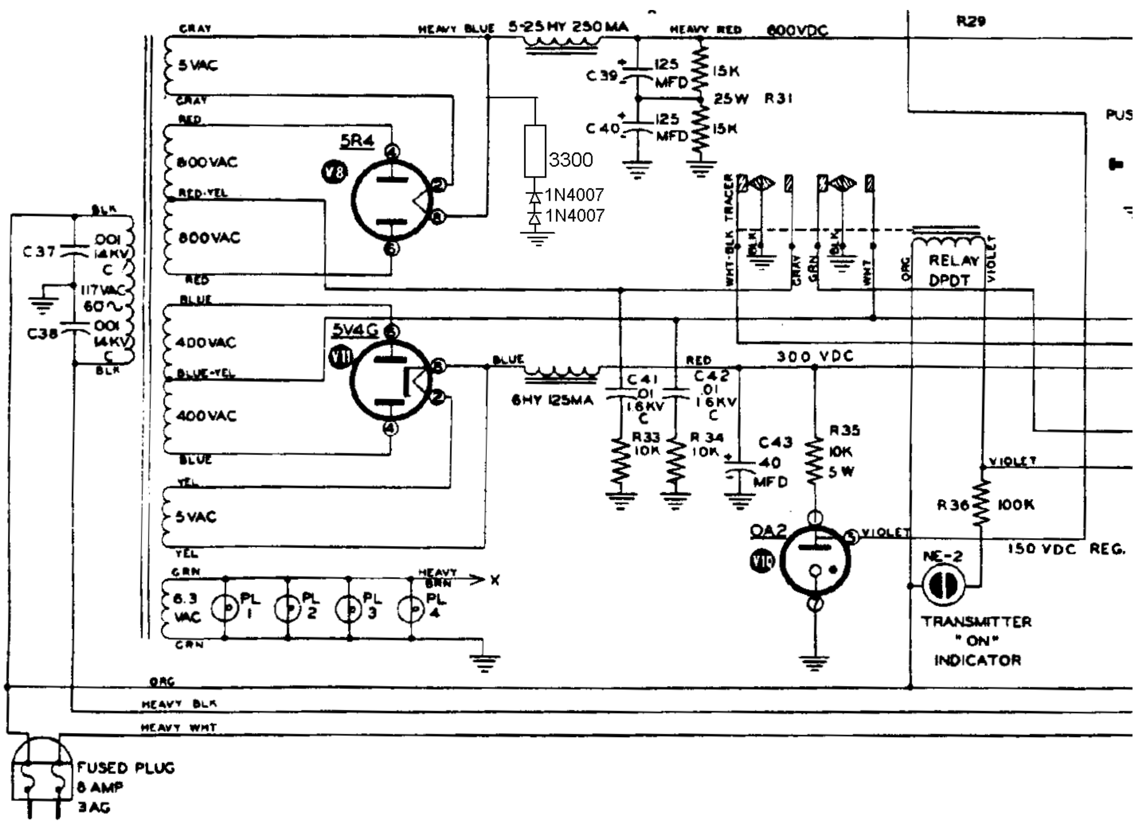


Figure 2 , VHF-1 Power Supply showing Fly-back Damper

Band Switch Mechanism

After cleaning, adjustment and lubrication, the Band Switch can operate easily and smoothly.

Loose Dial Glass

The glue originally holding the dial glass to its frame is likely to have deteriorated. Double bubble epoxy, applied sparingly to the edges with a Q-tip, seemed to work well for reattaching it.

Link Coupling Assembly Error

The adjustable Link Coupling Coil at the Final output was installed upside down.
The Finals would not load to more than 160 ma or produce more than 45 watts of CW output power on 2-meters. After five months of looking at the Seneca and its assembly manual, I finally observed in Pictorial 32 (page 78 and below) and Pictorial 13, that the pictured movable link coupling was different from my unit. The pictured link coupling wires, extending from the spade lugs mounted on the phenolic shaft, cross over the shaft, while in my unit the wires passed under the shaft.
Was this actually an assembly error, or was it a method to obtain greater output loading with 6146Bs on 6-meters?

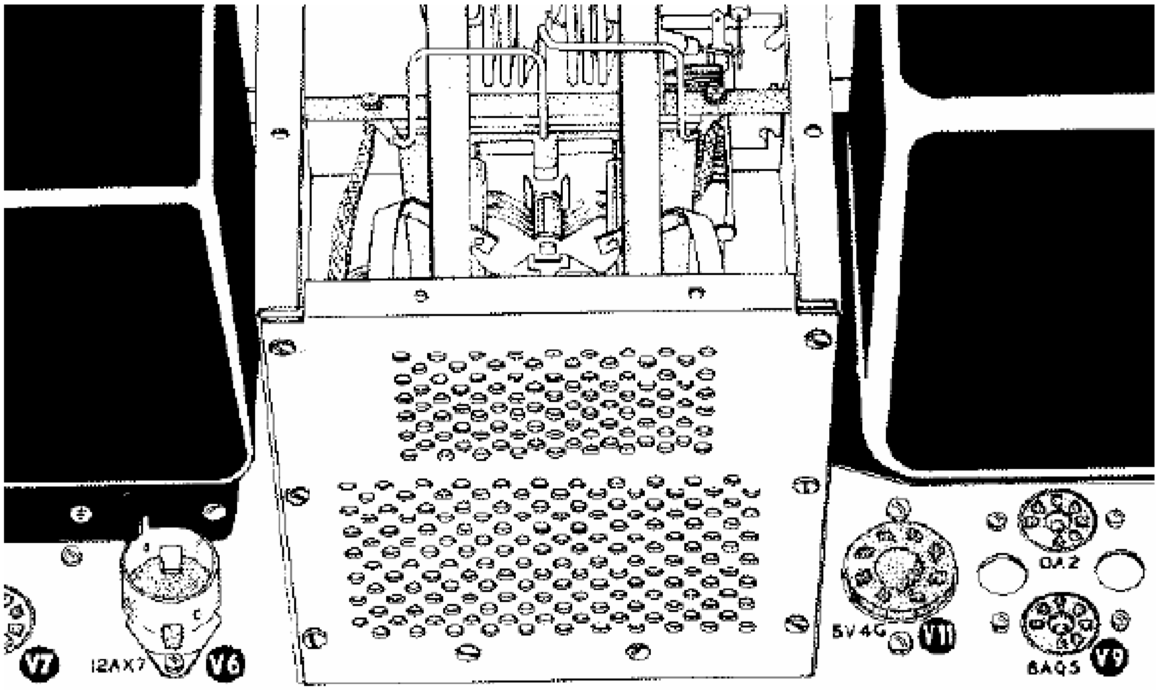


Figure 3, Part of Pictorial 32 showing Link Coupling Coil

Solution: Install the Link Coupling Coil per Assembly Manual. The Finals will now load to more than 200 ma and produce more than 55 watts of CW output power on 2-meters with the AC line at 117 volts.

Unresolved Issues with the Seneca:

VFO Instability on 2-meters / post-warm-up drift

The Seneca VFO is very similar to the series-tuned Colpitts (Clapp) 6AU6 oscillators in the Heathkit VF-1 VFO and the Apache and DX-100 Transmitters. Recommendations found for improving the stability of the VF-1, etc., should apply to the Seneca. The first change to make, as recommended by Glen Zook, K9STH, is to replace the 6AU6 with a pin-compatible 6AH6. This was apparently a change made by Heathkit in the late production Apache, and it requires only slight retuning. The 6485 is a longer emission-life industrial version of the 6AH6.

After 30 minutes of filament warm up, then 20 minutes of operation, a Mullard 6AU6 was still drifting down in frequency, at a rate of 525 Hz per minute at 2-meters.

After substituting a 6485, the downward drift slowed to about 250 Hz per minute after 30 minutes, then reversed and drifted upward at a rate of less than160 Hz per minute.

Several days later, another test from a cold start with the 6485, showed a drift of about 300 Hz per minute after 40 minutes. These drift numbers are for a continuously keyed oscillator. When switching from Standby to CW, which applies B+ to the oscillator, there is a more significant drift. On a sample of a few tubes, the substitution by 6AH6 / 6485 appears to provide an improvement.

Other changes recommended to reduce post warm-up drift include reducing the oscillator screen voltage from 150 to 108 volts and reducing the plate voltage from 300 to 150 volts. I have not yet tried these changes.
The Seneca VFO drift rate is still not satisfactory for comfortable 2-meter phone or CW operation.
Another possible solution to VFO drift is provided by "New Life for the Heath VF-1, VFO", in QST for December 1972. The VFO 6AU6 is replaced by two MPF102 FETs.

Final Tank Link Coupler is not resonant on 2-meters
(- within the adjustment range the series "Loading" capacitor)
The minimum capacitance setting does provide delivery of the expected output power. Another Seneca owner indicated that his unit worked the same way, with the Loading capacitor set at minimum capacitance on 2-meters. However, a transmitter output reactive source impedance would make the final tank tuning and coupling adjustments overly sensitive to antenna switching and transmission line length.

Screen current imbalance between the two 6146 finals
(Indicative of poor drive balance; I have not yet measured the imbalance in the current configuration)

Final Spares Usability
The 6146A spares that I ordered do not seem to work as well as the pair now installed (They do not develop as much 2-meter grid drive). The ones that work well came from an old Heathkit SB100. The grid circuit adjustments were done with the SB100 tubes installed, so use of spares on 2-meters may require future adjustments.

Heathkit Fused AC Plug
There is no place on chassis to put an accessible fuse holder in order to eliminate the Heathkit fused AC line plug and install a 3-conductor cord. For safety, the unmodified Seneca must always have a ground wire connected from chassis to the AC outlet ground screw. A marked original fused plug, with a white stripe on the side of the AC line that goes un-switched to the power transformer primary, allows plug insertion connecting that side to neutral. That way, a transformer short will not make the chassis hot, even with a faulty ground. See Electric Radio for February 2008 for suggestions including putting fuses in an external ABS plastic fuse box. A note at the end of the article points out that the pictured external fuse box with two fuses is not per the NEC code since it again puts a fuse in the neutral line.