

A Silk Purse ...

Easy upgrades for Heathkit's SB-104 transceiver.

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As a radio amateur on a budget, I always keep my eyes open for bargains—especially “repairman specials”—that may come my way. I came across such a deal when I was offered the chance to buy Heathkit's SB-104 at a low price. The radio was in excellent shape physically, but needed tender loving care to return it to operation.

The quality of used Heathkit gear is dependent upon the person who assembled it. If that person wasn't skilled in the art of soldering, it can be a nightmare. The seller was nice enough to let me “look under the hood,” and I discovered very neat, conscientious assembly work. Sold!

It wasn't long before I dug into the service manuals and had the rig back in working condition. But as I used the radio on the air, I noticed some deficiencies in its performance. The hot rodder/home-brewer in my blood kicked in, and I set about to improve things.

Introduced in the mid-seventies, the SB-104 was Heathkit's first attempt at a fully solid-state HF rig. They made some improvements along the way, which resulted in the SB-104A. The “A” version has several refinements,

notably an entirely new receiver front-end board. The “A” front end uses diode doubly-balanced mixers similar to those used today. Heath offered a retro-kit to update original models to the “A” version. They also offered a kit to add crowbar overvoltage protection to the matching station power supply. Many SB-104 owners became painfully aware of the need for this protective circuit, as I have seen the factory repair stickers labeled “overvoltaged” inside.

Microphone mods

The first modification I performed was to replace the microphone jack on the front of the radio. The original is an oddball two-conductor connector which may be difficult to obtain. I replaced it with a more common four-conductor microphone jack, and used an extra conductor to provide bias for an electret mike cartridge (fed through a 12 k resistor to the 11-volt supply). You can put in any mike jack that will fit, to match whatever microphones you have around. The microphone circuit is originally designed for high impedance microphones, so I improved the input to work better with a low

impedance mike. Simply replace R204 on circuit Board B with a resistor of approximately 50 k ohms.

11-volt regulator

The SB-104 operates on 13.8 volts DC, and a mobile bracket was available, so one could assume it can be run mobile. Well, it can, with two stipulations: I hope you have lots of room in your car (I don't!), and the engine had better be doing something other than idling. I attempted to operate the radio on emergency power (a car battery in my shack) and discovered it started going crazy if the voltage got lower than 12.8 volts. Looking deeper into the problem, the radio's regulated voltage is 11 volts. The 11-volt regulator couldn't maintain below 12.75 volts input, and would upset the biasing of some of the circuits, notably the various oscillators. The pass transistor couldn't turn on “hard enough” to hold the voltage steady.

I redesigned the 11-volt regulator using a P-channel power MOSFET, which has a very low turn-on resistance. On circuit Board B, remove the following components: C203, C226, C227, D207, R254, R255, and the

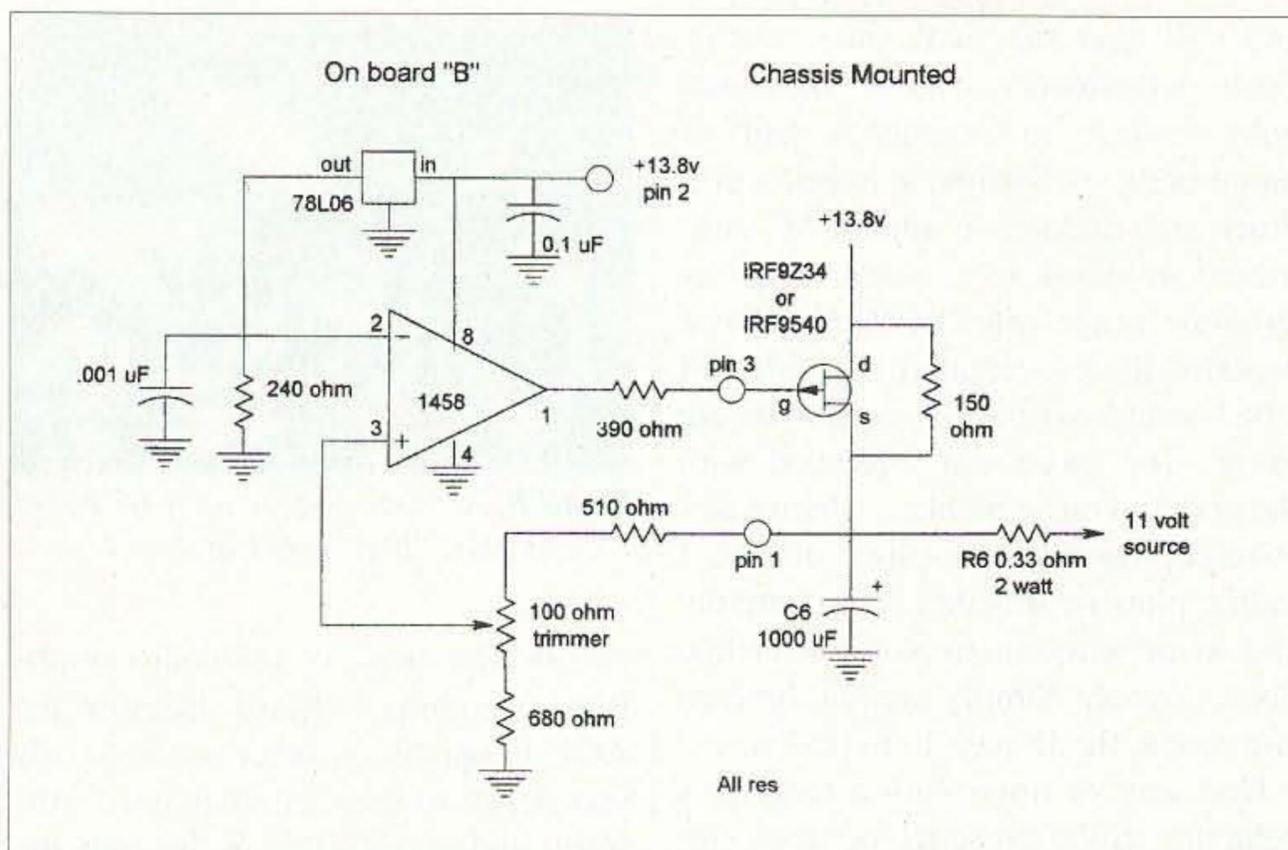


Fig. 1. 11-volt regulator, Heathkit SB-104. All resistors 1/4 W, 5% unless specified.

power transistor Q2 (mounted on the chassis). The power MOSFET transistor should mount in the same socket Q2 was removed from. Be sure to use insulating washers to prevent a short to the chassis. I constructed the remainder of the regulator circuitry (Fig. 1) "dead-bug" style in place of the old circuitry on Board B. The circuit consists of an op-amp referenced to a regulated six volts driving the power transistor. A lower voltage on the output results in turning on the transistor "harder." The small trimmer potentiometer should be adjusted for 11 volts output. After performing this modification, the radio remains stable down to 11.5 volts supplied.

S-meter

In the process of testing the SB-104, I had a calibrated signal generator attached to test the receiver. When I attempted to calibrate the S-meter, I found that it had less than a 20 dB range from S1 to full scale. I tried many different ways of correcting this, and found the best solution to be the simplest. On the receiver IF/audio board (Board F), the S-meter circuit is fed through a zener diode, ZD502, 4.7 V. This voltage drop is too much, delaying the action of the S-meter until

well after the AGC starts functioning. Remove ZD502 and replace it with a pair of silicon switching diodes (1N914 or similar) in series. The series-connected diodes provide a 1.4-volt voltage drop, and should be installed with polarity opposite that of the zener diode. Adjust R534 on the top left corner of Board F to calibrate the S-meter. Use either a calibrated signal generator or off-the-air signals to set it to your liking. This modification greatly increases the range of the meter.

AGC "pop"

I found another design flaw I traced to Board F. When using the radio in a normal discussion with the AGC switch set to "slow," the AGC would "pop" when I unkeyed, and this effectively shut down the receiver until the AGC voltage decayed. I would miss the first few words of reply if my friend was quick on his mike. On the receiver IF/audio board (Board F), capacitor C535 controls the AGC decay. I added a few parts to hold off the charging of this capacitor momentarily when the transmitter unkeys. Just add three parts: a 2N3904 transistor, a 15 kΩ resistor, and a 15 μF tantalum capacitor. I added them dead-bug fashion along the top edge of the board adjacent to R544 (refer to Fig. 2).

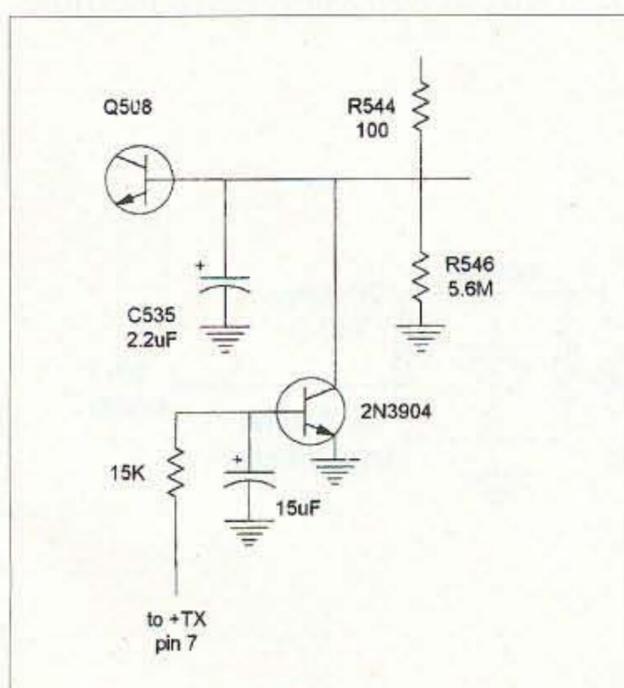


Fig. 2. "Unkey" AGC mod, Heathkit SB-104 Board F.



Photo A. Heathkits such as these once ruled the waves.

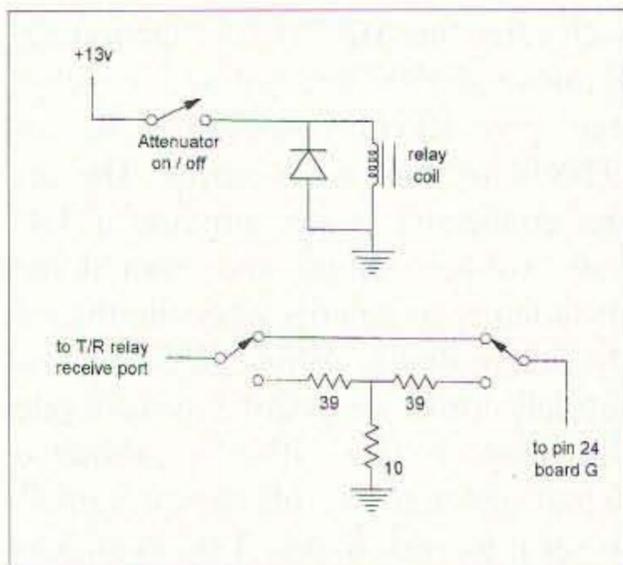


Fig 3. Receive attenuator, Heathkit SB-104.

Display ICs

In the process of my improvements, I picked up a second SB-104 (in horrible shape) as a source of parts, cheap. The frequency display on it had a couple of segments that were blank. The display digits are not LEDs, but a type of flat vacuum tube display. They require 180 volts DC for operation, so be careful when poking around behind the display! I determined the display driver IC was bad, but could not find a replacement for the DD700 chip used by Heathkit. Later I got lucky and a factory-repaired board I found had a more common IC in its place. These numbers are still currently available: SN75480N or ECG2028.

Receiver mods

The remaining modifications were done to improve the receiver's poor performance in the presence of strong signals. The true measure of a good receiver is that it can handle large signals

and still hear the weak ones nearby. Such performance can be measured with modest equipment: A pair of home-brew oscillators, a hybrid combiner, step attenuator, and an AC voltmeter are used to measure receiver dynamic range (the *ARRL Handbook* explains the procedures). The SB-104 I had tested out poorly as to dynamic range. The radio was equipped with the optional noise blanker, which I discovered was a major cause of this. I didn't plan to use this radio mobile, and found it ineffective on power line noise anyway. Simply unplug the card and rewire the IF path to bypass it.

One way of improving a receiver's behavior in the presence of large signals is to attenuate them. Almost all current HF transceivers include an attenuator switch. I added a 20 dB attenuator and a small 12-volt DPDT relay to the underside of the chassis near the antenna jack (see Fig. 3). Put the relay inline between the T/R relay (or the optional RX antenna switch if you have one) and pin 24 of Board G. You can switch it with the now-unused NB switch. When the band is full of "big guns" (like during a contest) you can switch in the attenuator.

One determining factor of dynamic range is the quality of the filtering in the receiver. Without adequate crystal filters, a radio will exhibit "mystery S-meter syndrome" when big signals are on the band. The SB-104 has this big time—the S-meter goes up, but you don't hear anything. The nearby loud signals are getting through the crystal filter, operating the AGC, but end up

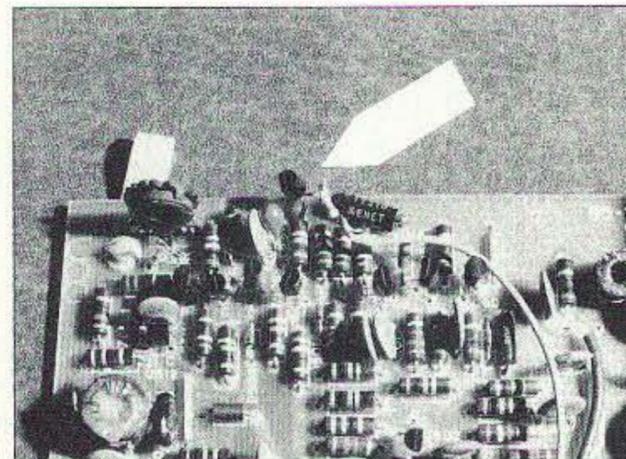


Photo B. A "dead-bug" cluster on Board F cures AGC "pop" (see Fig. 2).

outside the range of the audio amplifier, so nothing is heard. Because the AGC is operating, other weak signals you desire to hear are attenuated. Another undesired effect is hearing the opposite sideband of large signals.

To help correct this problem, I purchased a higher-performance "Fox Tango" crystal filter to replace the stock SSB filter. These are available from International Radio, phone (541) 459-5623, or [http://www.qth.com/INRAD]. This made some improvement, but not nearly enough. This filter is the only narrow bandwidth selective element in the receiver, while most modern HF radios use two sets of filters or more.

An idea came to me as I was cleaning the workbench and found the recently removed Heath crystal filter lying there. Why couldn't I use two crystal filters like the modern radios? I designed a way to add the second filter, adding a small FET amplifier to overcome filter loss. I also used a relay to switch it inline or out. The circuit performs so well I never take it offline.

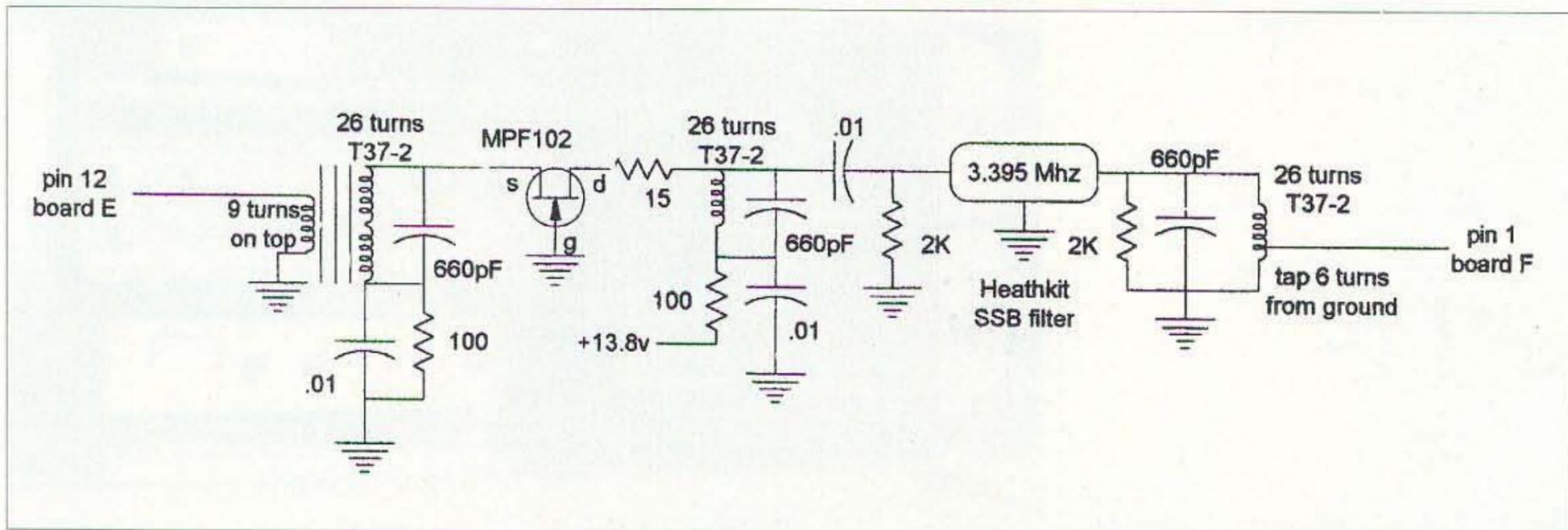


Fig. 4. SB-104PB secondary IF filter.

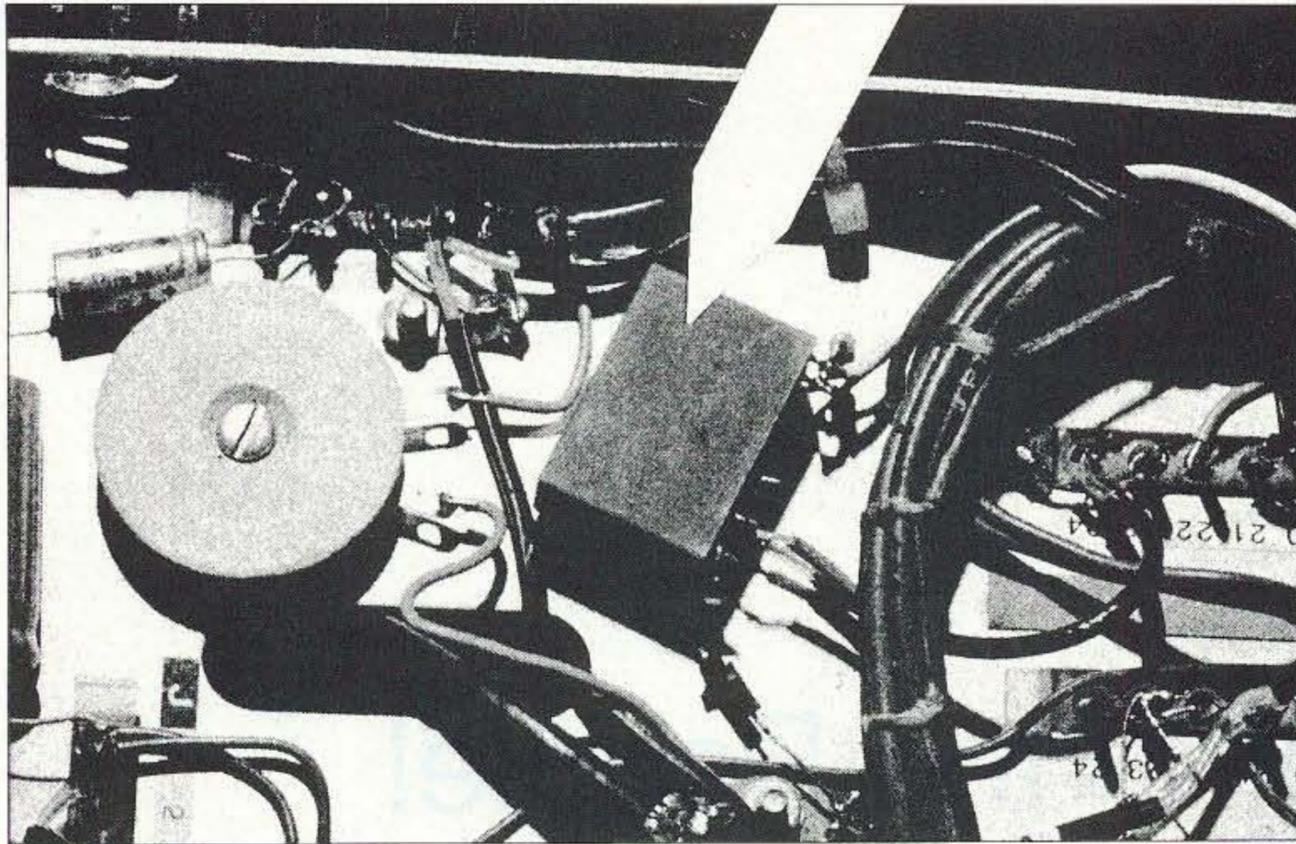


Photo C. The receive attenuator goes under the chassis (see Fig. 3).

No more "mystery S-meter syndrome." I mounted a small piece of circuit board to the filter, and constructed the amplifier and matching circuit right on it (see Fig. 4). The whole assembly then mounts to the chassis above the place the noise blanker used to be. Run some small coax (RG-174) down through the chassis to the IF boards. The input to the second filter comes from Board E pin 12, and the output goes to Board F pin 1. This modification eliminates "filter blow-by" completely.

I really enjoy operating my SB-104A, and I have relabeled it the "SB-104PB" now that I have personally improved it. The radio is easy to work on, with its modular construction, and they seem to be available for low cost at hamfests and flea markets. There are other improvements to be made, and it's an easy radio to experiment with. I recommend another article about this rig by David Palmer W6PHF (*QST*, March 1982) for those who want to experiment further. 73

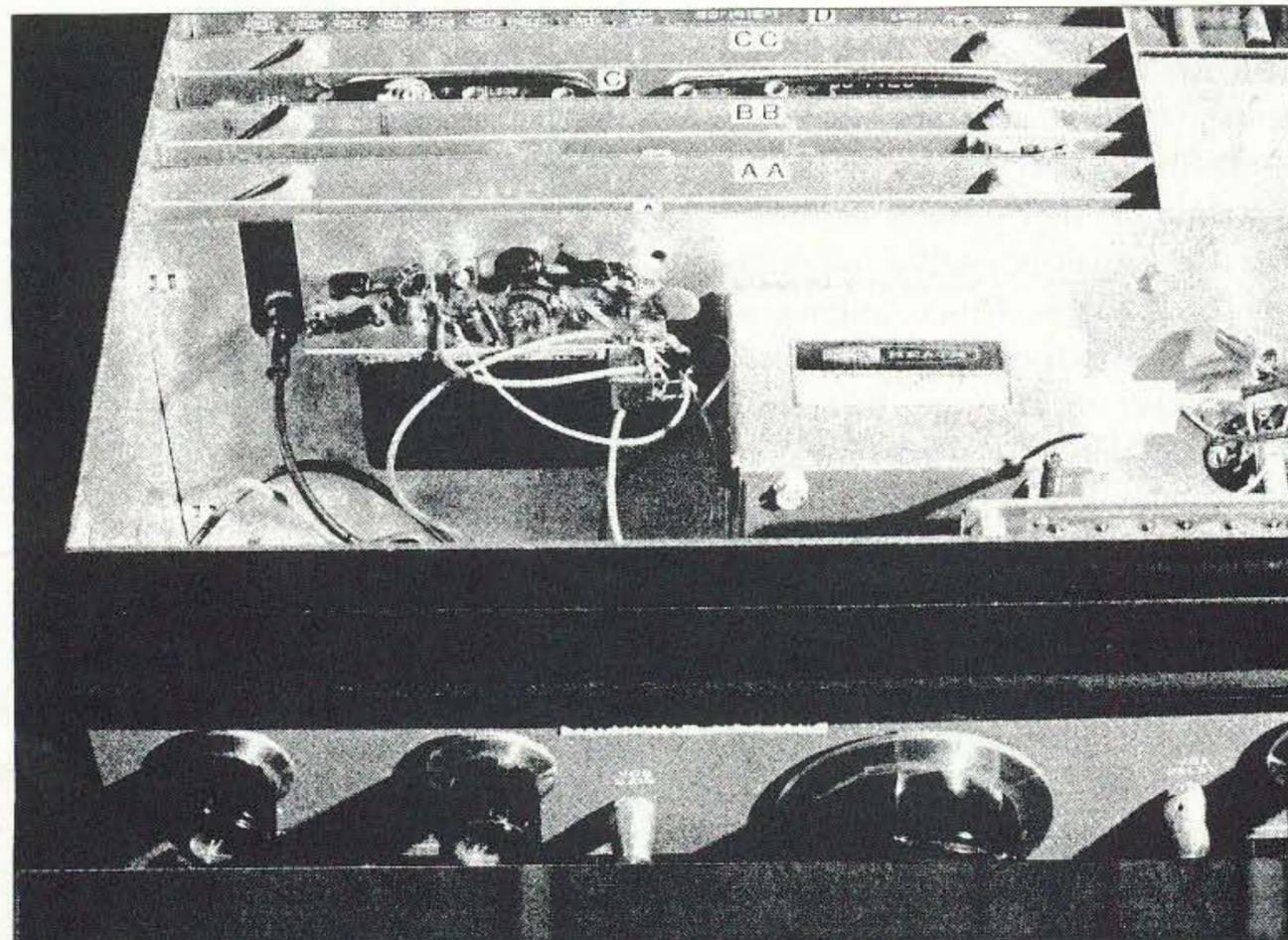


Photo D. A small piece of circuit board hosts the second receive filter (see Fig. 4).

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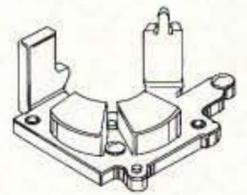


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