World War Wireless

What can you do with a pencil, a razor blade, a paper clip, and a hank of wire? Why, build a radio, of course!

Penn Clower W1BG
459 Lowell Street
Andover MA 01810

Hams with TVI problems often learn the hard way how poor metal connections can generate harmonics. Two conductors making partial contact, in gutters for example, can rectify and re-radiate as harmonics part of the signal from a nearby transmitter. What few newer hams realize is that the same phenomenon was crucial to the operation of one of the cheapest receivers ever designed: the Foxhole radio.

Photos by W1GSL

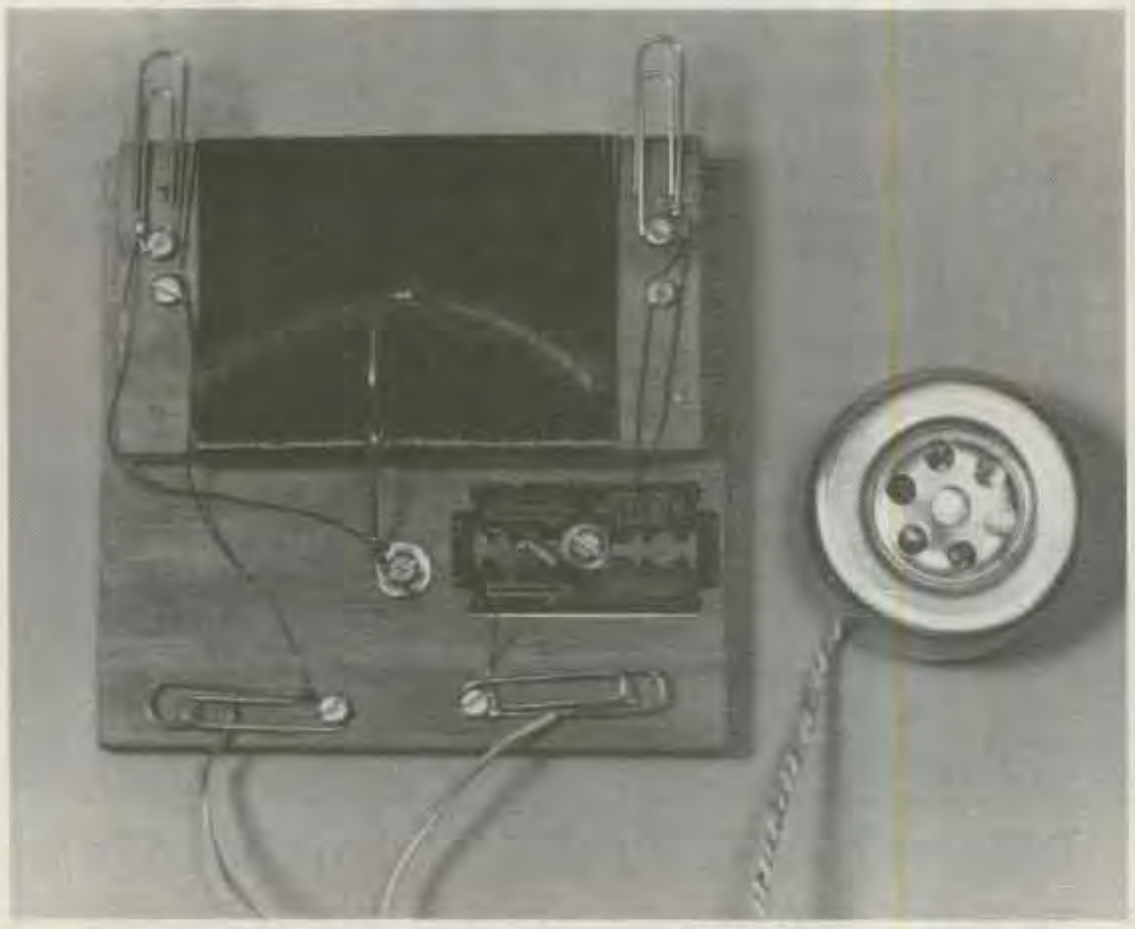

Photo A. A close replica of a set W8EFW described in 1945, this Foxhole radio can be built for pennies and works amazingly well. The razor blade is the diode. The earphone was borrowed from a telephone.

The phrase "hurry up and wait" probably predates World War II, but its meaning was certainly driven home then to thousands of hams. Often serving long tours of duty in forgettable places, ham GIs gave top priority to receiving news and entertainment from the nearby Armed Forces Radio Station. Of course, in those days radios used tubes, so the bulk and power requirements of typical receivers limited their availability. This was especially true in forward locations where the Army had more important services to provide—things like food and ammunition.

So some genius, and we can only hope he was a ham, invented the Foxhole radio. Made from commonly available components, its chief distinguishing feature was the use of a razor blade for the detector diode. A flat coil of enameled wire and a headset (probably "borrowed" from a field telephone) completed the circuit. While not an outstanding performer, the radio was compact, obtainable, and best of all—it worked! Copies were built and used all over the world.

The original design has several interesting features in addition to the razor-blade detector. Note the absence of a tuning capacitor in Fig. 1(a). The sliding contact on the coil doesn't tune stations so much as it adjusts the match between the antenna and its load. There might be some tuning action if the antenna looks capacitive, but selectivity is sure to be poor. My guess is that it didn't matter because there was probably only one station to listen to anyway.

Puzzled about the wide, flat coil form shown in the photographs? Everyone knows a good efficient inductor is wound as a cylinder no more than two diameters long. The flat coil may be an electrical compromise, but it sure is a lot easier to pack in a knapsack, put in a pocket, or hide in a POW camp.

All in all, the Foxhole receiver is real ham-radio stuff. You scrounge the parts, put them together as

best you can, and the result works!

Building the Foxhole radio today is as easy as it was in WWII. The set shown in Photo A is the real thing—a close copy of the receiver described by W8EFW in the *QST* "Hints and Kinks" column for September, 1945. To improve performance, I also built the several accessories shown in Photo B. The biggest gain came from using a capacitor to resonate the coil. In keeping with the spirit of the project, even that component was homemade—with plates snipped from the side of an old tin can.

A Razor-Sharp Detector

The razor-blade detector is the most interesting part of the receiver. To build it, you first need a Gillette Super Blue Blade. Forget about using anything made of platinum or coated with Teflon™. To simulate wartime conditions, I used my blade for its intended purpose until it hurt—about three weeks. That may not be necessary, but I wanted to do things right and my wife wouldn't let me dig a foxhole in the backyard. Compromises are sometimes unavoidable.

I clamped the used blade to the baseplate with a short woodscrew (W8EFW recommended thumb or carpet tacks). The same mounting screw clamps the contact wire to the blade, so I scraped away some of the bluing to ensure a good contact.

The rectifier contact point is made from a 1" piece of pencil lead. Start by sharpening a pencil, then carefully carve away the wood at the tip. Break off the sharpened length of lead and tightly wrap its blunted end with 8 or 9 turns of fairly stiff wire. Leave a 1" or 2" pigtail of wire to clamp under the "phone jack" terminal screw when you mount the rectifier.

In operation, the point of the lead is moved over the surface of the razor blade until a sensitive spot is found. When that happens, the radio starts to work and the lead is carefully released so that its mounting wire holds it in the correct position. I found rectification was best when the point contact was resting on one of the silver letters etched into the blade. Of course, it goes without saying that the blade is thoroughly cleared of soap or oil before rectification is attempted. This is a crude system and a little tricky to adjust, but once set up, it works surprisingly well.

Scrap Wood Chassis

Construction of the rest of the radio is shown pretty clearly in the photographs. The baseplate is a 4" by 4" square of 3/8" or 1/4" wood. The coil is about 175 turns of #26 enameled wire wound on another scrap of the same wood, this one 2" by 4". Any wire size from 22 to 28 will work as long as the wire is enameled to keep the turns from shorting. The antenna, ground, and headphone terminals are made from paper clips. The sliding coil contact is a paper clip bent and mounted to maintain downward pressure on the coil. I soldered the pivot end of this arm to a washer and fastened that to the board with a screw. W8EFW simply bent the end of the paper clip around a tack. Running the arm back and forth across the coil several times makes enough of a mark to show where the insulation must be scraped away for the arm to make contact. I also soldered all the wire connections to improve reliability. The radio will work without that step, but it does make life a little easier.

It goes without saying that this radio, like its brother, the crystal set, needs a good antenna and ground. The easiest thing to use for a ground is the screw holding the cover plate to a standard ac outlet. If it's available (and made of copper), the house water supply may make a better ground. An acceptable antenna can be made from 50 feet of wire routed out a window and away from the house. Keep the far end as high as possible and use more wire if you can. As far as this radio is concerned, there can never be too much antenna!

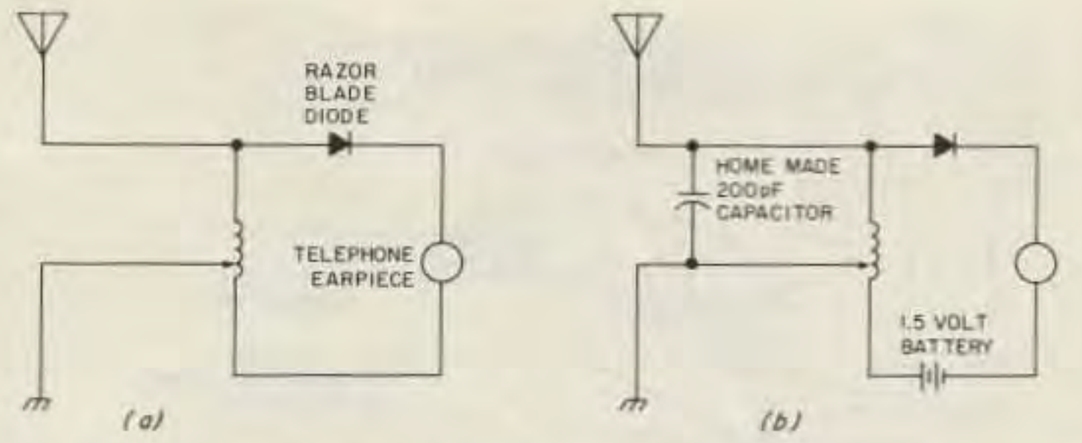

Fig. 1. Complete schematic of the Foxhole radio. The original circuit (a) was built by GIs all over the world during WWII. The addition (b) of a tuning capacitor and a dry cell (to bias the detector) improves reception.

This set works best if the old-style high-impedance headphones are used. The new, low-impedance hi-fi types would work only with a matching transformer. If the proper phones aren't available, you can always do what the GIs probably did—borrow the earpiece from a telephone handset. The Ma Bell earpiece shown in the photographs has a dc resistance of 6 Ohms and an ac impedance of about 150

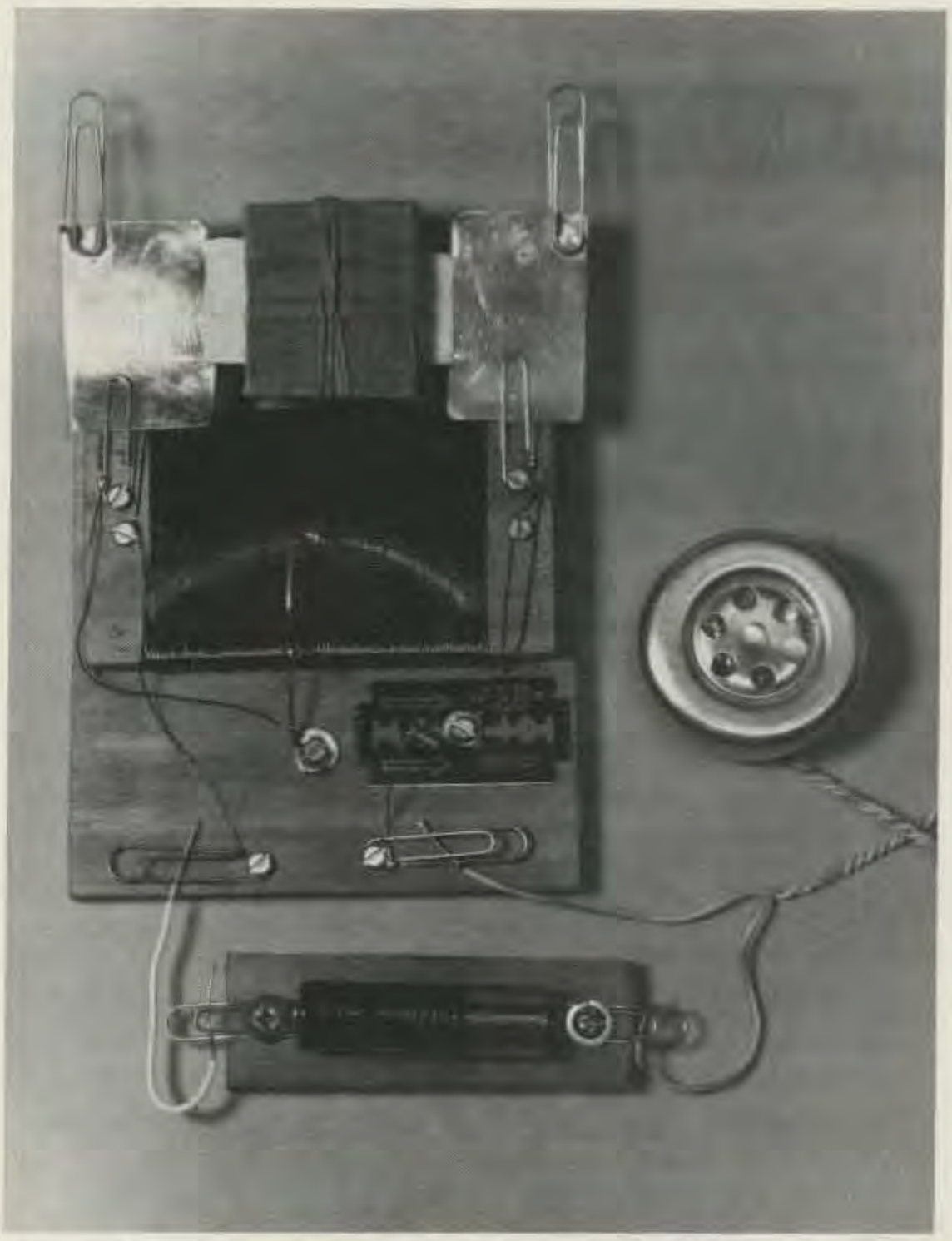

Photo B. Never content to leave well enough alone, the progressive amateur will be looking for high-performance modifications. Here are two: The homemade tuning capacitor and detector bias pack will boost both selectivity and sensitivity.

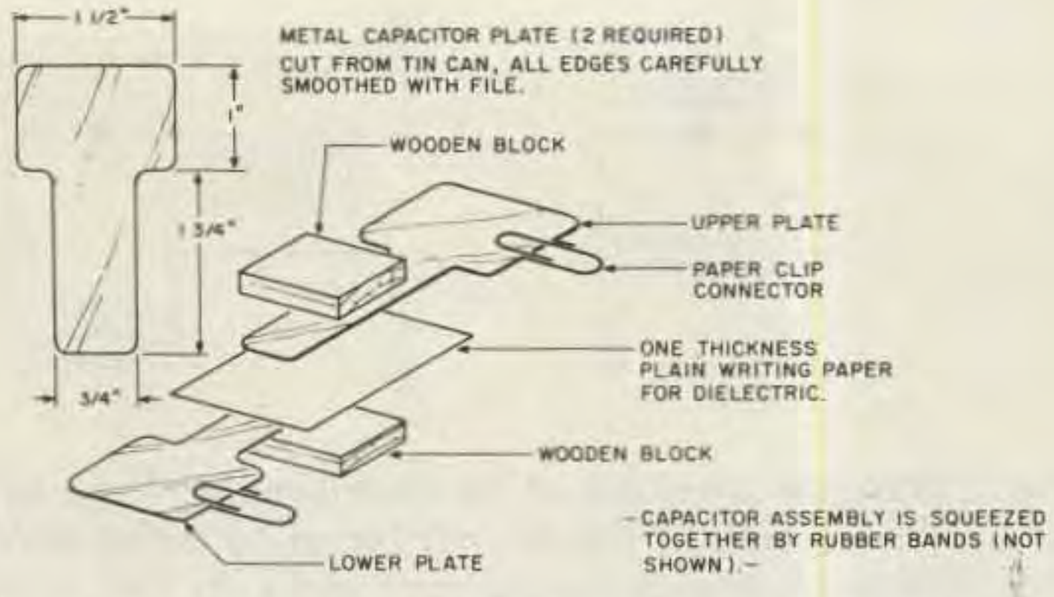

Fig. 2. Home-brew 250-pF (more or less) capacitor.

Ohms. It works almost as well as real headphones.

Operation

There's certainly nothing sophisticated about tuning the Foxhole radio. Check the wiring, hook up the antenna and ground, and connect the earphones. Set the slider to the middle of the coil and start listening. Move the point of the pencil lead slowly across the lettering on the razor blade until you hear a station. Try several different spots because some will work better than others. As a final step, move the slider across the coil until the signal strength is maximized.

The performance of the Foxhole radio will depend on your skill in adjusting the detector and the efficiency of your antenna. W8EFW claimed a range of 25 miles with a good antenna and ground. At my location, two nearby stations (about 5 to 7 miles away) dominate the set so I can't hear anything further away. Those local stations are quite clear, though, and come in with reasonable volume.

DX Accessories

There are several ways to improve the performance of this little radio, and luckily they're both cheap and easy. The first thing to add is a capacitor for resonating the coil, as shown in Fig. 1(b) and Photo B. With my antenna, that gave a noticeable boost to headphone volume and also let me separate the local stations. My friend W1GSL found that at his QTH the capacitor worked best when it was in series with the antenna. The capacitor always improved reception, though, so it's certainly a worthwhile addition.

An old 365-pF broadcast variable is perfect for the job, but you'd be cheating to use one. It's more sporting to make your own capacitor with plates cut from a tin can.

First cut (*very carefully*, those edges are sharp!) a pair of T-shaped plates, as shown in Fig. 2. Smooth the edges with a file and solder on two paper clips as shown. These two plates, separated slightly by an insulator, will be clamped together between wooden blocks to make a fixed 200-pF capacitor. That unit can then ride piggyback on the set, as shown in Photo B.

At first I tried using cellophane tape for the dielectric. That had a lot of dc leakage, so plain writing paper was used in the final version. One layer of paper between the plates makes a nice capacitor and gives about 100 pF per square inch of plate area. Any capacitance value between 150 and 350 pF will work, and the final value can be adjusted if necessary by sliding the plates to change the amount of overlap.

The other circuit improvement is the addition of a 1.5-volt battery to bias the detector further into its nonlinear region. What? A "crystal" set with a battery? The idea may seem strange now, but in the early days of radio that technique was quite common and, in fact, necessary with some of the crystal materials used. Current drain is only one or two mA, so battery life shouldn't be a problem.

The battery holder shown in Photo B matches the style of the rest of the "equipment" and is also easy to make. When using the battery, you may find it easier to adjust the detector first and then add the battery bias for a boost in signal strength. The battery simply goes in series with the headphones. Try flipping the battery polarity several times, as one direction may work better than the other.

Conclusions

The Foxhole radio is cheap to build and fun to operate, but it certainly isn't the world's best "crystal" set and you won't spend hours listening to it. Amazingly, though, it does work, and its story is a truly fascinating bit of radio history. More than just a history lesson, however, this project will also leave you with two long-term benefits.

First, it gives you a perfect way to win "sucker bets" with friends who don't believe you can build a working radio using household materials and no commercial tubes, transistors, or diodes.

Second, you'll have a lot more respect for the rectifying properties of imperfect connections. That's helpful in those cases of harmonic-type TVI which occur despite the use of a properly adjusted transmitter and a good low-pass filter. Rectification generates harmonics, but when searching for the diode, it sure is easy for the inexperienced ham to overlook the rusty joints in his neighbor's TV mast! ■