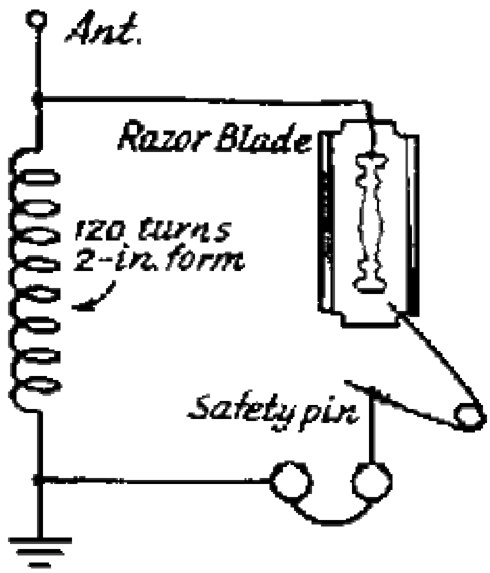
Foxhole Radios AND Crystal Radios

If you appreciate ingenuity, simplicity, and like instant gratification from your radio projects, then you ought to spend a few minutes building your own foxhole radio. Foxhole radios were built by GIs in World War II from materials they had easy access to in the field. They usually consist of just a coil and a detector. They use a point detector, the chief component being an ordinary razor blade.

Here is some more information on the foxhole radio sets used by the boys on the Anzio beachhead. In the daytime they could receive stations from Rome and at night Nazi propaganda "jive" programs from Berlin. Here is the diagram:



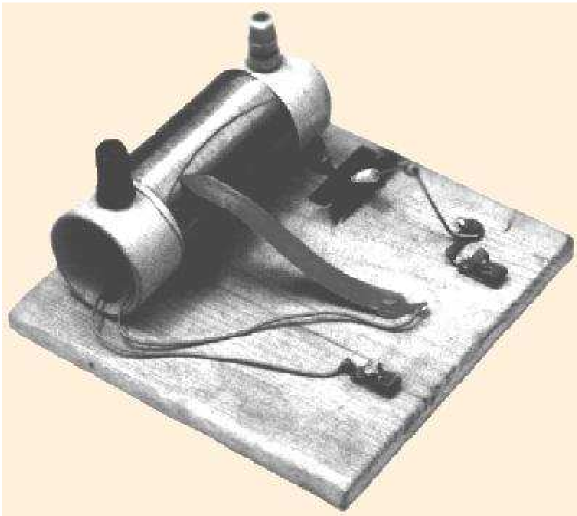
In the "Strays" section of QST for July, 1944, another mention is made of the razor blade foxhole radio:

According to Toivo Kujanpaa, a licensed ham op stationed on the Anzio Beachhead, several of the radio men there rigged up a field version of a "crystal" set using a razor blade for a detector. Their efforts were rewarded by the reception of a "jive" program (along with some German propaganda) aimed at the American forces from an Axis station in Rome.

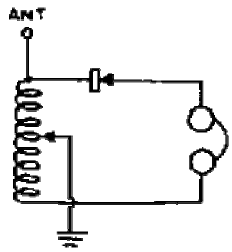
Note the simplicity of the design. Parts were assembled on a piece of wood, usually held in place with thumbtacks. The safety pin is anchored at one end and placed so the point may be moved around on the surface of the razor blade. According to an article in

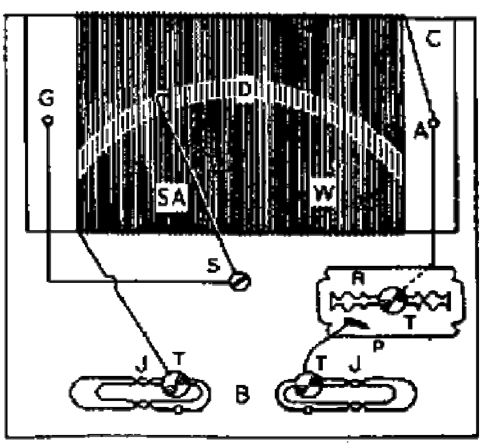
Popular Mechanics of October, 1944, the blued steel surface of the blade gives the rectifying action needed for detection without crystals.

Someone soon figured out a better way to use the razor blade detector: use a pencil lead point on the razor blade. I built a foxhole radio in a few minutes using the previous diagram, but I used a pencil point. I fashioned a safety pin shape out of stiff wire, then tied about an inch of pencil lead to it with finer wire. The radio worked the first time I tried it. Of course, with a fixed coil I received only one station.



The photograph shows a similar radio built by Don Menning; he simply stuck the whole tip of a pencil on the end of the safety pin.





Here is the parts list for the schematic based on Lt. Cornell's submission:

(A) Antenna connection. This nail also fastens the coil form to the baseboard.

(B) Baseboard. 4 inches square, ¼ inch thick.

(C) Coil form. Wood block, 3¾ inches long, 2 inches wide and ¼ inch thick.

(D) Area of coil scraped clean along arc of switch arm.

(G) Ground connection. This nail also fastens coil form to baseboard.

(J) Jacks for 'phones. Paper clips held down by tacks.

(P) Detector. Pencil lead wrapped with copper wire and resting lightly on razor blade. Some adjustment of the location and pressure of the lead on the blade may be required.

(R) Razor blade held down and connected to wire by tack.

(S) Screw or nail for pivot of switch arm.

(SA) Switch arm made from paper clip.

(T) Thumbtack, or any kind of tack.

(W) Coil winding, approximately 175 turns No. 26 insulated wire.

In October of 1962, Popular Mechanics ran a construction article by Joe Tartas which was almost identical to the above design. Mr. Tartas noted that GIs used their bayonets buried to the hilt in moist earth for a ground connection. You probably do not want to use your vintage WWII bayonet in this manner unless you're a stickler for authenticity!

As with any radio of this type, a good ground and a long antenna (50 to 100 feet) will give you best results. Don't expect room-filling sound, but do expect a lot of fun from very little effort!

The only part of a foxhole radio you don't build from scratch is the 'phone. However, if you're really looking for a radio project built entirely from scratch, you could try your hand at building one.

If you take apart a 'phone, you'll notice they're very simple in construction. Basically, there's a coil with a small iron core. Electrical variations in this coil generate a magnetic field used to attract and repel a metal plate. This vibrating plate produces the (faint) sound you hear.

The March 1, 1994 issue of The Xtal Set Society Newsletter carried an article by Nyle Steiner describing how to build your own home-brew 'phone. Nyle used a coil made from 7000 turns of 0.004 inch wire around a ¼ inch rod. For more information, check out this article, or experiment on your own!

Disclaimer: Working with antennas and electrical devices (especially old ones) can be dangerous, and mistakes can be fatal. If you decide to work with such things, it is solely your responsibility to work safely and to know what you're doing. –DJA

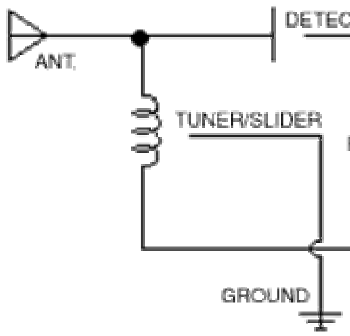
Foxhole - POW built radios

Foxhole and PoW built radios: history and construction

Building a foxhole radio is rewarding and the basic setup is very simple. It is, however, difficult to adjust, and it may take several attempts to find a proper razor blade for the detector. This is a project that requires patience and much trial and error, but it will pay off once it begins to work. It will help to be versed in the construction and operation of crystal sets before building one. It will be especially helpful to read the introductory notes about the coil, detector, antenna, and other components. These sets are extremely simple in construction, but tuning and modification require some basic understanding of theory, as well as practice. All sets presented here are based on old articles, notes, and people's recollections. There are fairly major variations in design and materials among these plans. It must be remembered that these were improvised under often adverse conditions; there was no "standard" design. With this in mind, take this entire article as a whole, and use it a bit here, a bit there, to build towards a design that works best using modern materials.

Set 1

GI's, during World War Two, built these sets which took advantage of (comparatively) readily available materials. The instructions are purposely lacking in detail; these were a project designed with improvisation in mind. It will help if you have had some experience with crystal sets before undertaking this project. It is very tricky to tune and properly set the detector. But once you get it working, you will be amazed that you can actually receive signals through so crude a device. This design has survived mostly thanks to the article *Build a World War II Foxhole Radio* by Lance Borden, as it appeared in the Electronics Handbook vol. XVII, p. 47.



The basic components are:

\Razor blade "PAL Super Single Edge" or a regular rusty one

- Cardboard toilet paper tube
- Wire coat hanger or other handy strip of workable metal
- Headphones or earphone (2 - 4 K ohms)
- Large safety pin
- Lead from a wooden pencil
- #22 AWG (or so) wire
- Something for a base (small scrap of wood)
- Lacquer, glue
- Small tacks or screws for fastening components

Refer to the schematic for wiring and connections. Wind the coil 100 turns around the tube. #22 AWG wire is recommended, but it is likely that whoever was in the field used whatever gauge was in the scrap coil, motor, or transformer they were cannibalizing. Spray / paint the coil with lacquer (or whatever is handy) to set it firmly. Scrape off whatever paint or varnish may be on the wire used for the tuner/slider. Spread the safety pin apart and bend the head 90 degrees to use it as a base for attaching the pin to the base. The pin should stick up from its bent head, then down to its point where the pencil lead is attached with some of the wire left from winding the coil. The sharpened pencil lead is the detector, which touches the razor blade, which is in turn attached to the base at one of its ends (through the hole) with a screw or tack. The tuner should be mounted so that it is free to pivot and slide across the coil (see the crystal radio page for basic construction tips). Use a scrap of paper or cardboard as a template for getting the tuner/slider the correct size. Sand off the varnish on the coil where the slider will touch it. Connect the ground and antenna, hook up the headphones, and through much patient adjustment of the detector and slider, you should eventually be able to pick up broadcasts. A capacitor (.001 - .002 uF) between the earphone terminals improves performance. I have seen more than one example where a cap was improvised from cigarette foil, cut into strips and stacks (the paper backing served as the insulating layers). Simple variable capacitors (condensers) may have also been easily improvised.

A note about the detector

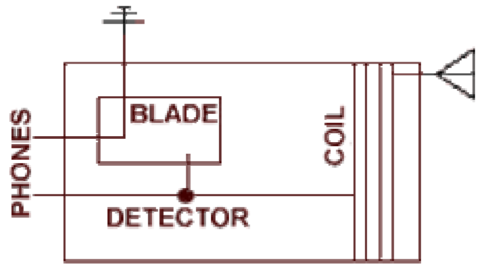
The blade of choice is an old fashioned disposable blue razor blade, which (according to some sources) was coated with a layer of selenium oxide. This formed a point contact diode when coupled with the pencil lead, demodulating the radio signal. A plain rusty razorblade forms a point contact diode with iron oxide which doesn't make as good a detector, but will still work. You will need to try the pencil lead (sharpened) at several different locations (nearest the edge usually works best) to find the most sensitive point. You may need to adjust the contact pressure as well; the lead should touch the blade fairly lightly.

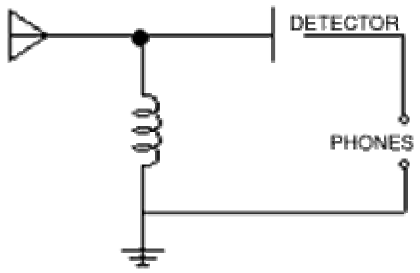
Note: There has been some debate as to what the blue coating actually was. I had heard from one source that it was selenium oxide; a reader, Tom Lee, believed it was carborundum. Tom later wrote back:

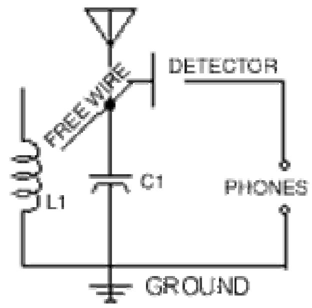
"I actually contacted the Pal Corporation, and they eventually did get back to me with an answer. The blue coating was simply an oxide produced by heat treatment of the blade. No special atoms of any kind. She also said that Gillette and some others produced competitive blue blades that were made in the same way."
Thanks for doing the research, Tom!

Another reader writes that he had success using a blued hacksaw blade (he didn't specify how big of a piece) and a hard drafting lead. These days, a blued hacksaw blade is much easier to find than a blued razor blade!

Set 2







The simplest of these wartime sets didn't include a slider/tuner arm, and were therefor capable of only tuning in one frequency. An article appeared in a 1944 issue of QST, and is faithfully reproduced in the D J Adamson Collection pages, so I won't go into a lot of detail here except to include the schematic. I highly recommend visiting Mr. Adamson's pages if you are interested in old radio (or stereography).

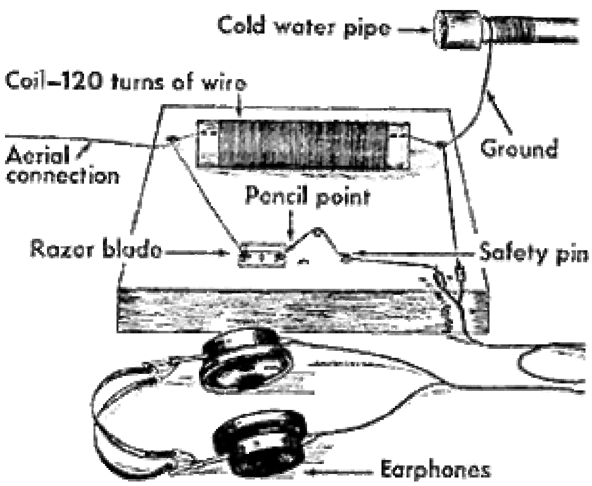
Not much can be said about so simple a design. The coil was 120 turns around a 2" form (toilet paper tube). The whole thing was tacked down to a board. Pencil lead wasn't used at the time, instead the safety pin point directly contacted the blue (or rusty) razorblade. There is no tuner, of course, so only one signal will be received, and only if there is a station broadcasting near the correct frequency!

Set 3

I have been told that often these radios were constructed even more simply. The whole thing would have been built on a small, thin piece of wood or shingle, about 1/8 to 1/4 of an inch (3-6 mm) thick, 1or 2 inches (25-50 mm) wide, and 3 or 4 inches (75-100 mm) long. The coil was wound around one narrow end (I am not certain how many times... start with 100 and experiment). The blue razorblade would have been screwed or tacked down (at one of its ends) at the other end. The safety pin and pencil lead (if there was a pencil lead, which there probably wasn't) would have been rigged up in the same manner as in the above sets.

From what I can tell, there would have been only 3 terminals, one securing the antenna wire and one end of the coil; one with the detector (bent safety pin head) and one of the headphone wires; and one with the razorblade, ground wire and the other headphone lead. I have not built one of these. This is based on a sketch I made which in turn was based on the description of someone I briefly chatted with a long time ago, who himself constructed the thing much earlier. It is possible something was left out, so it may take a lot of tinkering to get it to work (if it works at all). Once I get around to building one of these myself, I will add to this page whatever tips I can (assuming I can get it to work!) I would also enjoy hearing if anyone else completes a working model.

Set 4



I have recently come across a sketch of a set that looked exactly like set 2 on the Crystal radio page, except it had a razorblade/pencil detector where the diode would have gone.

There was no "standard" design. They all used razorblades, usually blue, but the other components and configurations varied greatly. I have even seen a reference to a set that uses two blades, stuck with one business end in the board, and inch or so apart. I don't have any details about the circuit, but wires ran from each blade, presumably either between one of the headphone terminals and the antenna, or between the ground and the antenna. A pencil lead spanned the blades, resting on the sharp edges.

Set 5

This is paraphrased from the article "How to Build a 'Foxhole Radio' ", from*All About Radio and Television*by Jack Gould, Random House, 1958.

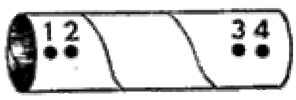
The illustrations are by Bette Davis (a different Bette Davis, I imagine). The book is long since out of print, and too dated for most libraries to hold a copy. It is a simple set, much like Set 2, but curiously it does not include a slider for the coil, even late in the article after the razor blade is dropped for a crystal and a condenser is added.

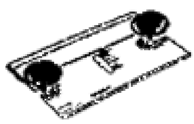
Tools required are:

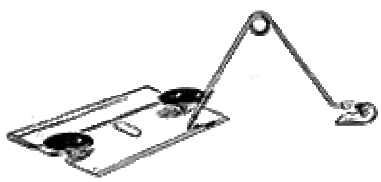
- A hammer
- A pair of pliers
- A pocket knife

Parts

Board, at least 8 inches by 6 inches (200 by 150 mm)







Cardboard tube, 2 inches in diameter
by 6 inches long (50 mm by 150 mm)

Insulated (enameled) copper wire, 28 gauge

Pair of crystal earphones (which in 1959 cost 2-3 dollars U.S.)

3 new nails

4 metal thumbtacks (not plastic push pins)

A used blade that fits a safety razor. A plain white looking blade often works better than "blue" blades (direct quote)

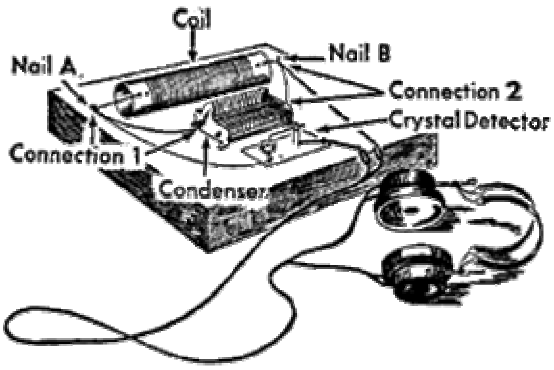
Big safety pin

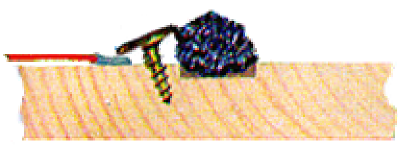
Pencil with a fat lead

Make 4 little holes in the cardboard, 2 at each end, with one of the nails. Push about 6 inches (150 mm) through hole 2, and then pull the wire up through hole 1. Wind the wire around the tube, making sure the turns lie side by side and not on top of one another. Wind for a total of 120 turns. Afterwards measure off 6 more inches of wire at the end and cut. Push the end of the wire down through hole 3 and up through hole 4. Lay the coil on its side at the back of the board. Fasten it to the board with 2 thumbtacks, making sure the thumbtacks do not touch any of the wire.

The razor blade is placed in front of the coil. Lay it on the board, and gently fix it in place with two metal thumbtacks. Do not push the thumbtacks all the way in.

Sharpen the pencil so there is a long piece of lead showing. Break off the lead, and wire it to the tip of the safety pin. Bend the head of the pin back so that it will lie flat on the board. Place the pin to the right of the razor blade. Hammer a nail through the head of the pin until it almost touches the pin.





Remove the insulation from the ends of the wires coming from the coil, as well as from the ends of all wires used to make connections. Hammer a nail just to the left of the coil. Leave it sticking up just a bit. Wrap the bare wire from the end of the coil around this nail.

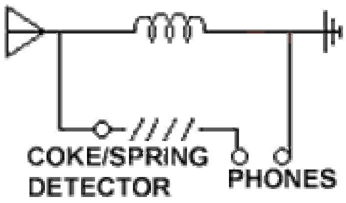
Take another wire and wrap a bare end around the thumbtack holding the left side of the razor. Push the tack all the way down to make contact. Take the other bare end of the same wire and wrap it around the nail.

Hammer a nail to the right of the coil and attach the coil wire as above. Use another wire to connect from this nail to one of the terminals of the earphones. Take another wire and wrap the bare end around the nail holding the safety pin. Hammer this nail in to hold the wire in place, but not so tightly that the pin cannot move a little. The other end of this wire attaches to the other free end of the headphones.

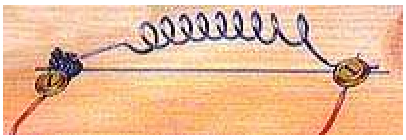
The antenna attaches to the nail that connects with the coil and razor blade (A). The ground wire attaches to the other nail, where the coil connects with the earphones (B). Hook up the headphones, and gently move the pin and pencil lead across the razor blade until you hear a broadcast. Once you hear it, don't move the pin, because you are more than likely going to lose it if you do. If there are more than one stations nearby broadcasting near the same frequency, you are likely to hear overlap. To solve this, you can add a condenser. A variable type can be used, as in the illustration. It is recommended that it have 17, 19, or preferably 21 plates. Or you can use a fixed capacitor of around .002mF, or you can build your own (see the condenser article on the Crystal page). If a variable condenser is used, the post attached to the fixed plates should be connected to the nail that connects the coil to the blade (A). The condenser's other post is attached to the other nail (B). Once a station is found using the pin and blade. The condenser is turned until the signal becomes clearest. Also note that in the illustration a crystal and detector have been substituted for the razorblade. The wire that was attached to the blade is attached to the crystal's post, and the wire that was attached to the pin is attached to the detector's post. A safety pin can still be used instead of the cat whisker (see the introduction of the Crystal page).

POW Radio

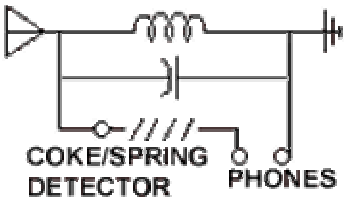
Prisoners of war during WWII had to improvise from whatever bits of junk they could scrounge in order to build a radio. One type of detector used a small piece of coke, which was a derivative of coal often used in heating stoves. The piece of coke used was small, about the size of a pea. A small board was used and a depression was cut into it near one end to hold the coke. A screw and, if available, a screw cup were used to hold the coke in place. A wire lead to the receiver was run from this to the coil/aerial (see Set 5).



A foot or so (30cm) of steel wire (guitar wire, piano wire, etc.) was wound around a pencil, long nail, or similar, leaving about one inch (25 mm) unwound at each end. The wire should be somewhat springy.A second screw and screw cup is set about 3 inches (75 mm) from the first. Attached by this screw are one end of the steel wire spring and a second lead, which is connected to one lead of the headphones or earphones (if anyone has any information on how earphones from these sets may have been improvised, I would like to hear about it). The steel spring wire was then stretched so that it just rested on the coke. After much adjusting of the point of contact on the coke and the tension of the wire, some strong stations would have been received.



If the POW was lucky enough to scrounge a variable capacitor, the set could possibly receive more frequencies.



A POW camp radio's construction described

The Centre for the History of Defence Electronics Museum has posted an amazing interview with Lieutenant Colonel R. G. Wells, who built a rather elaborate set out of scrounged and improvised items while in a POW camp during WWII.

Improvised diode

If you want to try your hand at making your own diode, Allan Charlton, of Sydney, Australia, adds:

"When I was a kid in a small town in Tasmania, Australia, our school was at the base of a hill, and the local radio transmitter was on top of the hill. We had lots of fun with crystal radios.

This is how we made our diodes:
Take a small length of glass or plastic tubing--an inch of the case of a plastic pen works well. Close one end with wax, sealing a wire through the wax. Pour a little copper oxide into the tube: enough to cover the end of the wire. Fill the rest of the tube with copper filings or turnings. Poke a wire into the copper filings or turnings (but don't let it go down to the oxide) and seal the end of the tube with wax.

Can't find copper oxide?
Throw some copper wire into a fire. When it's cool, scrape the oxide off the wire. Yes, there are two oxides of copper, a red oxide and a black oxide, and they both work well. We preferred the red, but I have no idea why."

But what about the earphone?
Richard Lucas, who was a POW in Vietnam, built a radio in camp and was also able to improvise an earphone. He writes:
Four nails were bound together with cloth from our clothes.

Wire was obtained from wire used around the camp which I might add wasn't coated with varnish. It was bare wire, so we wound a layer and, using a candle, we dripped wax over the turns, which were spaced as closed as possible without shorting out (not touching). We repeated this process over and over again until we had about 10 layers of wire, which were insulated from each other layer by a strip of cloth and wax. Then we put this in a piece of bamboo and adjusted it so it was about a 1/32 of an inch from the end.

A tin can lid was positioned over the coil of wire and nails. Then connecting it to our "foxhole radio" (basic design as yours) we could here about three radio stations. Our antenna was the barbwire around the camp and the ground was wire laid along the ground to make up the ground. Best listening was at night and it had to be pretty quiet because the earphone was pretty weak. If we had a magnet to set up a bias on the coil, the volume would have been a lot louder."

And Mike Barnard points out that "the headphones were almost always acquired from a tank crew's radio operator, and often one side of the headphone was cannibalized for wire to wind the tuning coil while the other was used for listening."

A radio constructed in the Milag PoW camp

Gabe Thomas, who is the President of a Merchant Navy POW society, generously donated the following accounts, which occurred at the Milag Nord, the German PoW camp for Allied Merchant seamen:

"As you can imagine, when a ship's company gets captured, there are men with a wide range of skills and interests. Naturally the camp had a fair share of radio operators. The "official" unofficial camp radio used the camp electrical circuit as an antenna after "lights out" when power was switched off. Where this radio came from I do not know, although I do know that trade between POWs and German guards and civilians did bring several radios into camp (cigarettes, coffee and soap from Red X parcels being the medium of exchange.)

I also know that the UK secret service had radio components smuggled into the camp via parcels from families and "well wishers". It appears that the Red X parcels were never used for contraband!

One POW told me that his way of earning "pocket money" from his fellows was to make crystal radios. I asked him where he obtained his crystals and he said that the Germans delivered cart loads of ashes to the camp to surface muddy paths. Graham "Speedy" Spiers made a fine wire sieve and would riddle these ashes to find useable quartz crystals. He reckoned that he would find one every 2 or 3 days.

CLICK FOR LARGER IMAGE

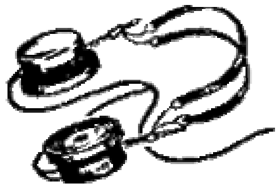
(This is) a radio made/used in Milag Merchant navy PoW camp in Germany in WWII. The radio was made from the bakelite case of a stick of shaving soap. The radio belonged to Edward Roberts and Robert Durant. Shellac covered wire from a stolen guard's bicycle dynamo was wound around the shaving stick case. Insulation was scraped off a portion of the coil for adjustment.

Edward Roberts was an apprentice (officer cadet) on the Delambre (Lamport & Holt Ltd. 7032 tons) which was sunk on the 7/7/40 by the German commerce raider Thor. Between 38 and 44 survived to become prisoners.

Robert Durant was an apprentice (officer cadet) on the Simnia, 6197 tons, owned by the Anglo Saxon Petroleum Co. She was sunk by the German Battleship the Gneisenau on 15/March/41 between 8 & 17 (accounts vary) survivors ended up in MILAG. Also in the camp was Frederick Warner, Radio officer from the ship British Strength. Before capture he had been on Marconi's development staff, experimenting with short wave transmissions. He made numerous radios and before liberation (April 27th 1945) he had made a transmitter. George Waugh, from British Commander, apparently spent most of his waking moments winding coils from wire "acquired" by those on outside working parties. These working parties were always on the look out for useful objects to steal and any telephones or electric bells were fair game for theft. As you say on your site, tank crew headphones were highly prized. The camp electric was switched off at night so the whole circuit became their antenna.

There was one main radio, a German Peoples Radio, that by decree had only a fixed bandwidth to prevent the German population tuning to Allied propaganda. This radio had been stolen from the local village doctor and with so many radio officers in the camp it didn't take long to modify it. Fortunately the power remained on in the camp theatre hut at night and the radio was in the charge of "Robbo" Robinson, the theatre props manager. A map, updated from the radio reports, showing the progress of the Allied forces after D day was kept pinned behind the door of one room where the German guards never thought to look. All that is except one of the more sympathetic German officers, Henschel, who used to come for a quick look to see how badly Germany was doing!

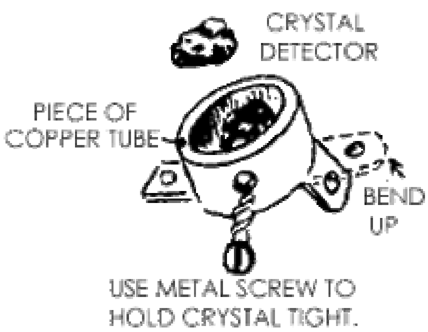
Crystal Radios

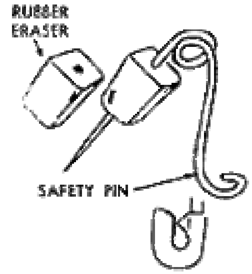


A crystal radio set is able to detect radio signals without a power supply. It works best if there is a transmitter within 25 miles (40 km) of the set. The antenna, a very long wire, picks up the waves and passes them through the set as electronic current, and then down to the ground. The set itself is a tuned circuit that can select a desired frequency from the many that are picked up by the antenna. The electric signals cannot be directly converted into sound because they vibrate back and forth too rapidly. The crystal (or diode) between the tuned circuit and the earphones allows the current to pass through in one direction only. The earphone contains a small solenoid and a thin metal plate. The current passing through the circuit and then through the diode causes the solenoid to move, which in turn moves the metal plate, whose vibrations create (faint) sound waves in the air.

A very simple crystal radio is not very selective, and if there are more than one nearby stations broadcasting near the same frequency, there will more than likely be some overlap, and you will hear two or more broadcasts at once. The solution is to add a tuner and a capacitor to the circuit. The coil length is what determines the frequency the circuit is tuned to. A simple tuner effectively changes the length of the coil by selecting how much of it is in the circuit. A capacitor (condenser) helps refine the tuning further.

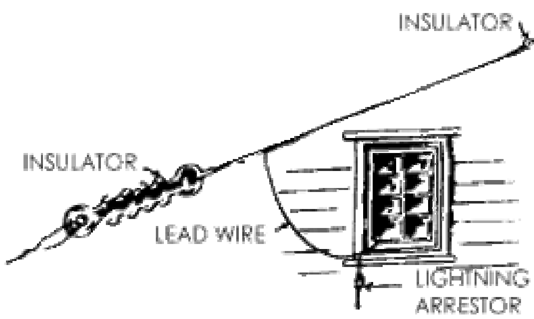
A note about the crystal detector



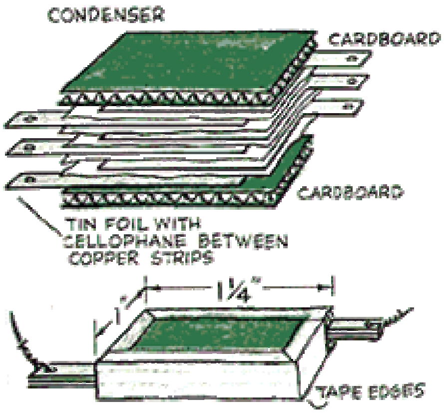


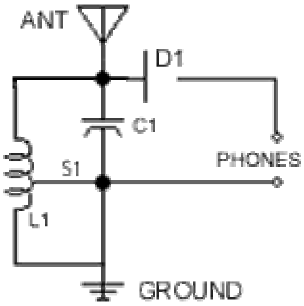
It is a fairly simple process to make a working radio using a modern diode for a detector. However, the reason these are called crystal sets is because the detector was originally a piece of crystal. You can still make your radio the authentic way with a crystal and cat's whisker. Detector stands are still manufactured, one good source being Antique Electronics Supply, 6221 S. Maple, Tempe, AZ 85283-2856 USA (phone 602-820-5411). A crystal detector includes a crystal, a cat's whisker, which is a special thin wire that contacts the crystal, and the stand that holds the components in place. The most common crystal used is a small piece of galena, which is fairly common, and can be found in many rock and hobby shops. The cat's whisker is most often composed of phosphor bronze. Once in circuit, the whisker can be moved about on the crystal's surface to find the most "sensitive" spot. The pressure of the whisker on the crystal is also adjustable. There are some other crystals that will work, so there is much room for experimentation with crystal fragments that you may already have. Also, it is not absolutely necessary to use a detector stand, and the cat's whisker can be improvised with a safety pin. Although it will be less selective and more difficult to adjust, it can be made to work quite satisfactorily. A small piece of rubber pencil eraser impaled on the safety pin helps to insulate it from your fingers while adjusting.

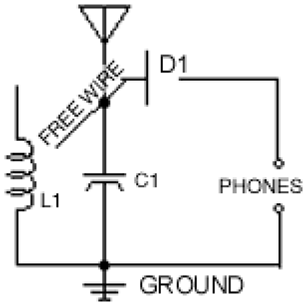
The coil, antenna, ground, and phones



The coils for these sets are typically wound around a 1 1/2 to 2 1/2 inch (38 - 64 mm) diameter core, using 75 to 150 turns of 24 to 20 gauge wire. These are typical numbers, not critical. What is critical is that the individual loops of wire around the coil are wrapped touching the next one over, but that they do not ever overlap. It is also important that whatever attaches the coil to the base can not touch the coil's wire, especially if it is a metal tack or nail. A coat of shellac or varnish helps to keep the coil together. Let it dry thoroughly before using. If a wiper type switch is used, the varnish will need to be scraped away along its path.







Ideally, the antenna should be 100 feet (30 m) or so long, and strung as high as possible. Insulated or non-insulated wire can be used. Either way, the un-insulated ends should not touch anything that will ground them. It is best if they are tied off to ceramic or plastic insulators, which can in turn be tied off between two high points outdoors, such as a tree limb and your house. Never string an antenna anywhere where it has even the slightest chance of coming into contact with a power line, or in a place where you will need to go near a power line to hook it up. Always take the antenna down if a storm or lightning is predicted. It is safe practice to add a lightning arrestor to you lead wire. You can purchase in many radio and electronic hobby shops antenna kits which include the antenna, insulators, lead wire, and lightning arrestor.

The ground wire can be attached to a metal cold water pipe, or to a metal rod stuck a couple of feet into the earth. Do not attach it to a line carrying gas or electricity.

The headphones (or earphone) need to be high the impedance type designed for crystal sets. They are still available through electronics suppliers and some hobby shops.

The capacitor

The capacitor, or condenser, though not essential for operation of these sets, does help to refine their use when it is added. More complicated sets have a variable capacitor. For the simplest sets, however, a fixed capacitor of around .002 mF or so is sufficient. A capacitor is also very simple to build. The Cub Scouts, being the great caretakers of crystal radio lore that they are, included this picture in the 1954 edition of the Wolf Cub Book. It lacked annotation of any kind other than what is here. The most important thing to know is that all of the tinfoil pieces need to be completely insulated from one another. They cannot touch each other in the least. The whole thing should be bundled tightly with cellophane tape. Also, aluminum foil is more common these days than is tin foil. It will work just as well.

Set one

What is presented here in crude ascii schematic is the simple basis of many simple crystal sets. This is not intended to tell you how to construct a particular set, but it should be enough to get a design started.

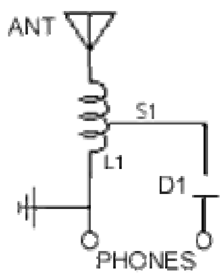
The diode D1, a germanium diode (1N34A or eq. usually recommended), is the detector, and in old sets this would have been the crystal and cat whisker assembly (see "A note about the crystal detector", above). The capacitor can either be a standard mica type of around 0.002 mfd, or a simple variable type, which you can easily build yourself based on a simple design of two metal or metal clad plates, which can be slid apart or together, and which are separated by an insulating material (kraft paper). L1 is the coil. Volumes could be and have been written on coils. A very simple one can be made with a 5 or 6 inch (127 - 152 mm) long, 1 inch (25 mm) diameter plastic pipe, wood dowel, or any fairly sturdy non metallic cylinder that can be easily worked with. Wind using magnet wire (#16 will work). Secure the free ends to the former somehow. The enamel should be sanded off the ends before including them in the circuit. You will have to mount the coil so that it does not contact the base. Sand the side lightly that switch S1 contacts. S1 is a simple piece of metal shaped and fastened so that it may slide across the coil. It is usual practice to attach it to the circuit with a screw or rivet loosely enough so that it can be pivoted to contact most of the coil. The ground can go to a water pipe (not a gas or electric pipe). A steel rod hammered 2 feet into the ground will also work. You can be as elaborate as you wish with the antenna. Don't use during an electrical storm! If you can't get it to work, flip the diode around. This might get things going. If not, check all your connections and make certain there is a good ground connection.

You may also be using the wrong type of headphone. You will need a very high impedence phone. There are phones made specifically for crystal sets.

Set two

This design is a bit different, but mostly in the way the tuner is set up.

The coil for this set should be wound with app. 22-gauge wire, but it isn't critical. The form it is wound around is 1 to 2 inches (25-50 mm) in diameter and 4 inches (10 cm) long. It is wound in pretty much the same manner as the coils in the other projects listed here. A few inches are left loose at one end, the wire is taped down, and winding begins. Every so often, a loop of wire is left out of the winding and twisted together. This loop should be 2 inches (50 mm) or so when stretched out. Try to keep their lengths uniform. They should be closer together near the end of the coil that will connect to the ground connection. The more of these "tails" that are made, the greater the selectivity of the set. Also, as with any of these sets, the more turns in the coil, the greater the range of frequencies that can be received. When the coil is mounted to the base, one end wire is joined to the circuit. The tails are thumb tacked to the base, sticking straight out in front of the coil. The coil's other end wire is tacked to the board along with the tails.



The capacitor is 300 picofarad. The enamel will need to be stripped from the coil's free ends as well as from the tails. The wire that is shown as a "free wire" in the schematic is actually the tuner. It attaches to the coil along it's tails to select frequency.

Set three: bare bones set

A crystal set can be very simple to very complex. If you want to go the complex route, which will produce a much more sensitive and tunable device, I suggest checking out the Xtal Set Society, which produces several fine books on the subject. If you want to construct a very simple one, then the schematic below is about as simple as you can get. It won't produce the easiest set to tune, but it is a great first set, and you will, if you are patient, be able to pick up several stations using it.

Using a toilet paper roll, poke two small holes about a half-inch from each end. Pass about one foot of the free end of a roll of magnet wire (#16 or so) through one of the holes, from the outside of the tube to the inside. Tape it in place. Wind the coil, making sure the adjacent windings touch but do not overlap. It should be wound firmly. When you get near the second hole, roll off another foot or so of the wire and cut it off from the roll. Pass the end through the second hole, and tape in place. Mount the coil on the base, which is a 5 by 7-inch or so piece of wood, corrugated cardboard, or foam core. The coil should be mounted with spacers at each end, under the points of attachment, so that there is open air all around the coil (this is more critical in more sensitive sets, but it is good construction practice always). It can be attached with push pins or small brads.

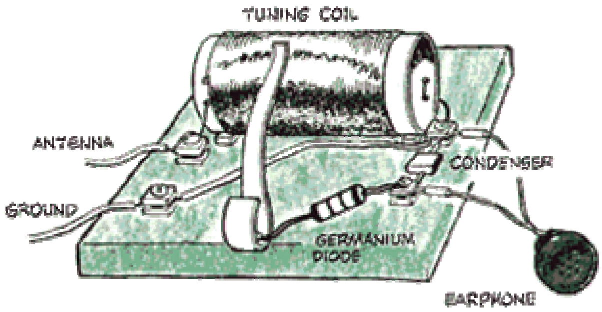
The tuning switch (S1) is a piece of copper strip, which is mounted to the base at one end with a screw or rivet so that it may turn freely. The metal is lifted (not sharply bent) so that it sits on top of the coil, making good but gentle contact across the entire range. It should be positioned so that the mounted end is 2 or three inches from the coil, and centered with the coil (long ways). It is 1/4 to 1/2 inch or so wide, and long enough to cover the entire range of the coil. There should be no sharp edges, as this will wear out the coil.

You will need to add 3 terminals, two on one end of the base, and one on the other (at opposite ends of the coil). Small nails or pins work well. Sand off the enamel from the free ends of the coil's wire. Attach the wires to one of the terminals on each side. Lightly sand off the enamel under the path where the switch swipes the coil. A diode (1N34A or eq.) is attached between the attachment point of the switch and whichever of the 3 terminals is not attached to the coil. The banded side of the diode faces away from the switch.

The antenna wire attaches from the side of the coil that is opposite the diode (the side with only one terminal). It should be as long as is practically possible. Attach the ground to the terminal on the opposite side that is attached to the coil (not to the diode). The ground wire is then attached to a cold water (not gas!) pipe. High ohm headphones (the type designed for crystal sets) or an appropriate earphone is attached to the two terminals between the diode and the coil. A .001 - .002 uF capacitor can be added across the earphone terminals (not necessarily essential).

The switch needs to make good contact with the coil. If necessary, bend the end somewhat in its middle, long ways, to refine contact. Or else, solder a short piece of heavy wire to the bottom of the contact point.

How to make a simple CRYSTAL RECEIVER



A-Dry a cardboard mailing tube in the oven, then paint with a coat of shellac. The tube should be about 6 or 7 inches long and 2 1/2 inches in diameter. Buy one pound of 26-gage (B. & S.) single cotton covered wire. Start and finish winding one half inch from ends of tube. Then shellac all over again. When dry, fasten down to a baseboard at each end, with a screw and washer to prevent it from touching at any point.

B-Cut a strip of cardboard as a test place for selector. When length has been determined, cut a brass strip the same size. Screw this down at a slight angle and mark on coil just where it touches. Fold a piece of sandpaper and with the folded edge remove the shellac and covering from wire on coil. This will leave an arc the bras strip will touch. In fastening on brass selector, use two fibre washers.
C-One end of wire from coil should go to "ground" clamp. Wire from selector should go to "antenna" clamp. Other end of coil wire should go to crystal detector. Run a wire from "ground" clamp back to one phone binding post. From other binding post, run wire to crystal. Between the phone posts, connect an .001 or .002 microfarad receiving-type fixed condenser, which costs very little.
This type of receiver works best when within 25 miles of a broadcast transmitter. Antenna and ground connections should always be tight.

By the 1950's, the basic set changed only slightly, and has remained pretty much the same up to current Cub Scout manuals.

Final notes

This page is intended to get you started on a simple set, as well as to introduce a bit of theory to assist in constructing more complex sets. Crystal radios can be refined and precise pieces of equipment with careful design and construction. There is room for experimentation in every aspect: basic design, the coil, rheostats, the antenna, traps for the antenna (which help to filter the signal before it reaches the set), and so on. Changes in these areas can effect the sets sensitivity, range, accuracy, and even volume. Most of this is beyond the scope of this page. If you want to pursue crystal sets further, a good place to start is the Xtal Set Society. Also, you will find out a great deal on your own by experimentation.

Crystal radio lore

Gordon Johnstone writes:

"My grandfather was one of the first electric torpedo men on the Royal Navy ships during the first World War. He built one of the early crystal radios for my grandmother, but was annoyed at only one person being able to hear at any time. So he took a large pudding basin, and mounted the headset a little up from the base inside. Voila, early parabolic loudspeaker system."

Construction of a diode

If you want to try your hand at making your own diode, Allan Charlton, of Sydney, Australia, adds:

"When I was a kid in a small town in Tasmania, Australia, our school was at the base of a hill, and the local radio transmitter was on top of the hill. We had lots of fun with crystal radios.

This is how we made our diodes:

Take a small length of glass or plastic tubing--an inch of the case of a plastic pen works well. Close one end with wax, sealing a wire through the wax. Pour a little copper oxide into the tube: enough to cover the end of the wire. Fill the rest of the tube with copper filings or turnings. Poke a wire into the copper filings or turnings (but don't let it go down to the oxide) and seal the end of the tube with wax.

Can't find copper oxide?

Throw some copper wire into a fire. When it's cool, scrape the oxide off the wire. Yes, there are two oxides of copper, a red oxide and a black oxide, and they both work well. We preferred the red, but I have no idea why."