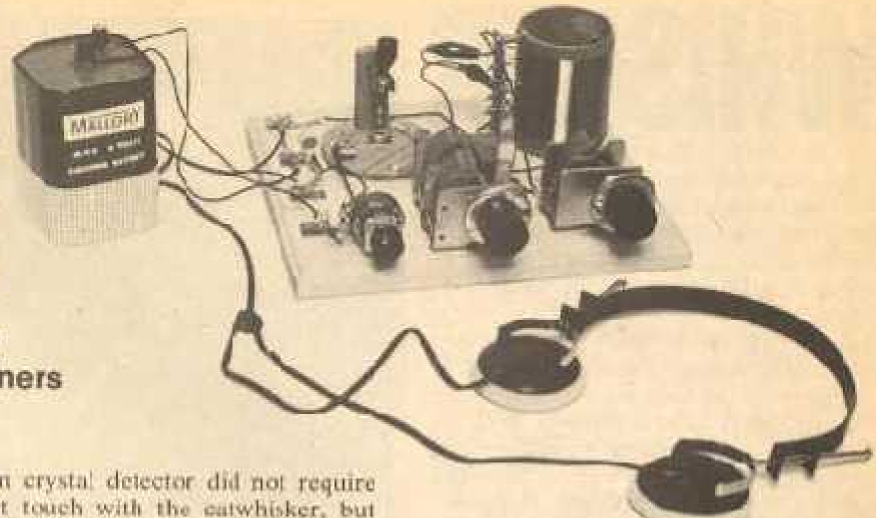
GRANDPA'S WHISKER



Build a carborundum detector from the days of the not-so-ancient mariners

by Charles Green

IN THE BEGINNING OF this century, when radio was still called "wireless," the crystal set was used by most of the early radio pioneers. The simple "catwhisker" touching a piece of galena or silicon crystal, and a coil wound on an oatmeal box, formed a primitive yet effective radio receiver that stayed popular for many years. Even the later development of the vacuum tube could not entirely bury the crystal set; it still remained popular as a first set for many radio experimenters who later went on to more complicated electronic developments. Even today, the simple crystal set is still being built using modern germanium or silicon diodes in place of the moveable catwhisker and crystal.

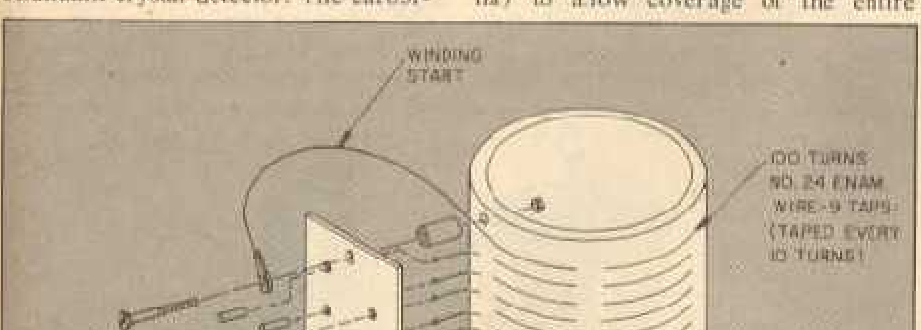
Back in the old days, the popular galena and silicon crystals had a rival for the more specialized ship-to-shore communication work. It was the carborundum crystal detector. The carborundum crystal detector did not require a light touch with the catwhisker, but instead required a heavy contact pressure. This heavy catwhisker pressure was more suitable for the early radio stations on ships. The lesser sensitivity of the carborundum detector was compensated by the crystal's ability to take stronger radio signal energy (such as leakage from nearby spark transmitters) without burning out, then the galena and silicon crystals could. What is *really* different about the carborundum detector, is the requirement for a bias battery. This bias battery is normally not used with galena and silicon crystals.

You can experiment with the carborundum detector by building our *Grandpa's Whisker*, which is patterned after the early crystal sets. The receiver uses a tapped coil and two variable capacitors (one capacitor tunes the antenna) to allow coverage of the entire broadcast band and for maximum signal coupling to the detector. A separate assembly is provided for the carborundum detector and a control is mounted for convenient adjustment of bias battery voltage for maximum detector sensitivity. The receiver is built "breadboard style" on a 8½-inch by 7¼-inch by ¾-inch wood base which is similar to the style of construction used by early radio experimenters.

The Receiver Circuit. Signals from the antenna are fed through J1 and coupled through C1A-C1B to the parallel tuned circuit of L1-C2. C1A-C1B is in a series tuned circuit with L1, and serves to tune the antenna for maximum RF current flow. The resultant tuned signals are detected by D1 and the audio is fed through the R1 bypass C3 to J5-J6 and external headphones. R1 adjusts the D1 bias voltage from B1 and C4 is the RF bypass for the headphones.

Carborundum. Not a natural mineral like galena or silicon, carborundum is the name given to a compound of silicon carbide by its American inventor Edward Goodrich Acheson (a former assistant of Thomas Edison). Acheson was experimenting with a primitive electric furnace in 1891, when he fused a mixture of clay and powdered carbon. He found that the resultant crystals would cut glass similarly to a diamond (silicon carbide is next to a diamond in hardness), and he called his discovery Carborundum; thinking it was a substance composed of carbon and corundum (a crystalized form of alumina). Scientific analysis later showed it to be silicon carbide, but the designation Carborundum was kept as a trade name. Industrial usage of carborundum is primarily grinding compounds and grinding wheels.

Its use as a detector was discovered by experimenters around the beginning



The tuning coil is wound on a cardboard mailing tube section for 100 turns of #24 enameled wire, tapped every ten turns. The taps should be stripped bare with sandpaper before soldering to the clips which are mounted on a section of perfboard. See the text.

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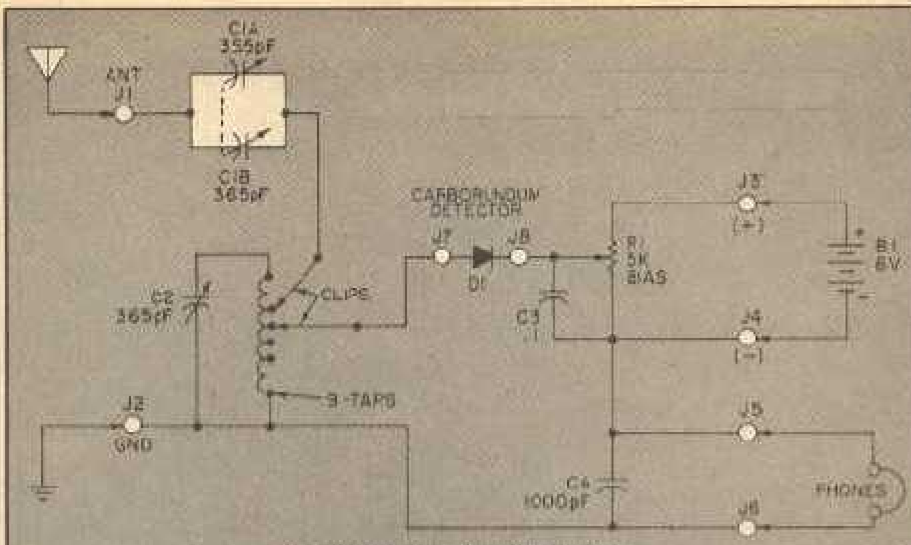
of this century who tried various minerals and substances in their search for better types of radio wave detectors; much as Edison tested many materials in his search for the proper material for his incandescent lamp filament.

A crystal diode has a high current flow with voltage applied so that it conducts in the forward direction (catwhisker to crystal), and a very low current flow in the reverse direction. The amount of current flow in the forward direction depends upon the characteristics of the crystal material and the applied forward voltage. As shown in the Crystal Forward Conduction Curves graph, Germanium minimum voltage is approximately 0.3 V, Silicon is 0.6 V, and Carborundum is 3 V. (The high Carborundum voltage is the reason why a bias battery is necessary to move the threshold down so that the weak RF signal voltages can be detected.)

Tuning Coil (L1) Construction. Look at the drawing of the L1 construction details. The tuning coil is wound on a cardboard mailing tube section 2-inches in diameter and 2¼-inches long. Start winding approximately ¼-inch from the form edge with #24 enameled copper wire. Punch a small hole to feed the wire into the cardboard before you start winding, then wrap the wire around the edge of the form to hold it in place while winding; or, a section of plastic tape can be used to keep the wire from moving.

As shown in the drawing, the tuning coil is wound with 100 turns and is tapped every 10 turns. An easy way to make the taps is to twist the wire together for a half-inch and position the free end out. Then, when all of the taps have been made, used sandpaper to take the enamel off the tap-wire ends. At the end of the winding, punch another hole in the coil form and after cutting a three inch lead, thread the free end of the coil wire through the hole and wrap it one turn around the coil form edge (or tape it in place).

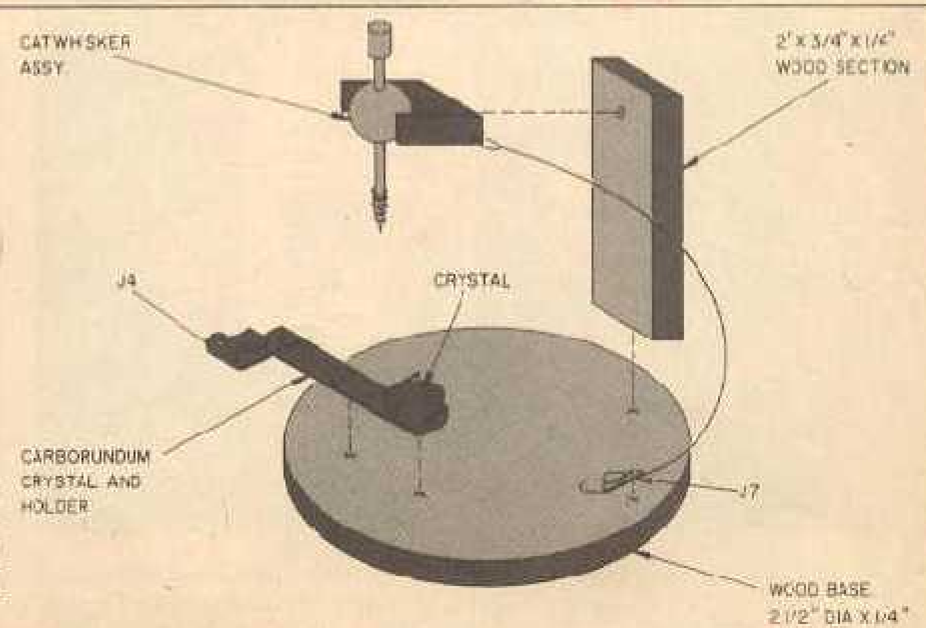
Mount 9 push-in clips in a ½-inch by 2¼-inch perf board section and mount it on the coil form with machine screws and nuts and two ½-inch long spacers (as shown in the drawing). Then solder the coil taps to the push-in clips. Connect the coil start and end wire leads to solder lugs mounted on the perf-board screws. Punch two holes

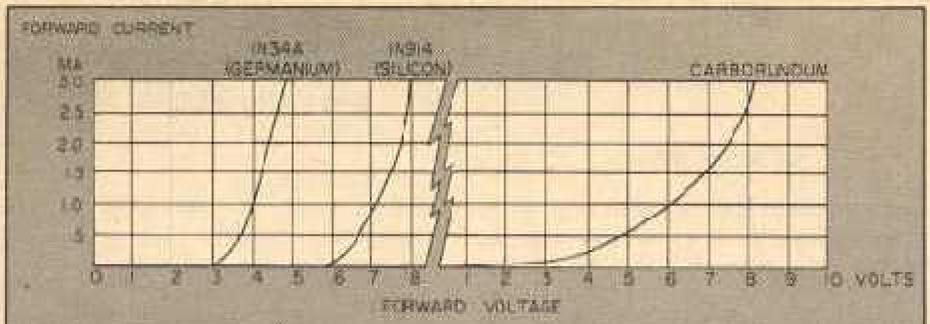


PARTS LIST FOR GRANDPA'S WHISKER

B1—6 V battery
C1A-C1B—Dual 365-pF tuning capacitor (dual gang)
C2—365-pF tuning capacitor (single gang)
C3—0.1 uF capacitor
C4—1000-pF capacitor
D1—Carborundum Crystal (Modern Radio Labs P.O. Box 1477, Garden Grove, CA 92642), and Crystal Detector Assembly (Philmore #7063 open type detector, or equiv.)
J1-J8—Fahnestock Clips
L1—See drawing and text
R1—5,000-ohm potentiometer, (linear taper)
MISC: 2000-ohm earphones 2¼-in. x 2-in. dia. coil form, clips, #24 enam. wire, ½-in. long spacers, perfboard strip, push-in clips, solder lugs, mtg. brackets, wood sections for detector assembly, knobs, 8½-in. x 7¼-in. x ¾-in. wood base, hookup wire, wood screws, headphones (2000-ohms), and a 1N34A germanium diode (or equiv.) for initial adjustment of the receiver.

Most of the crystal detector assemblies you can turn up will be of the horizontal type. You will need a heavier pressure for the carborundum crystal, so convert the assemblage to a vertical format. None of the dimensions shown are all that critical.





As you can see, the minimum forward voltage for carborundum to forward conduct is very nearly ten times that for germanium. This is the reason that our Grandpa's Whisker requires a bias battery. Moving the threshold down allows weak RF signals to be detected.

on opposite sides of the base of the coil form, mount two brackets, and the tuning coil is completed.

Detector Assembly Construction. Most of the crystal detector assemblies available nowadays are of a horizontal type; designed for fine adjustment of a galena crystal. The carborundum crystal requires a heavier catwhisker pressure than the galena crystal, so the detector assembly (as shown in the drawing) is constructed in a vertical configuration.

Begin construction by cutting a 2-inch x ¾-inch x ¼-inch wood section, and then gluing or using wood screws to fasten it to a 2½-inch diameter x ¼-inch high wood base. This wood base is readily available from art, or hobby, supply stores that stock wood plaques. Or, a suitable base can be cut out of a section of plywood. The dimensions of the detector assembly are not critical and should be modified as necessary to fit your particular crystal mount and catwhisker configuration. If necessary, the rivets holding the catwhisker mount to a metal strip can be drilled or ground out, and then reassembled with a solder lug as shown in the drawing.

Mount the crystal holder on the base of the detector as shown in the drawing and photos, and then mount the catwhisker assembly on the vertical section with small wood screws, or machine screws and nuts. Make sure that the crystal holder screws do not protrude below the base bottom. Connect a lead between a solder lug on the catwhisker assembly and a terminal clip mounted on the base. If the crystal cup does not have an attached metal strip and terminal clip as in our model, it will be necessary to mount a solder lug with the cup and connect a lead to a terminal clip mounted on the base.

Receiver Construction. Most of the receiver components are mounted on a 8½-in. x 7¼-in. x ¾-in. wood base. The base dimensions are not critical and any size wood base can be used that will be large enough to mount the components as shown in the photos. The model wood base shown was obtained from an art supply store and was originally intended for use as a wood plaque. Small wood screws were used to hold most of the components on the base, except the variable capacitors C1A-C1B and C2 are mounted with machine screws in countersunk holes drilled through the base bottom. If the particular capacitors in your model do not have tapped bottom holes, metal brackets must be fabricated to fit either front or back capacitor mounting holes. The Bias Adjustment Control R1 is also mounted on the wood base with a metal bracket.

Begin construction by locating the component mounting holes on the wood base, and then mounting the parts as shown in the photos. Install solder lugs on all of the terminals J1 to J6 and also on the metal frames (rotors) of the variable capacitors C1A-C1B and C2. Install the detector assembly with three wood screws to the wood base and then install L1 positioned as shown in the photos (with the taps facing the detector assembly).

Wire the components as shown in the schematic diagram and position the wiring for short, direct connections. Install a clip on the lead to C1A-C1B and also on a lead to J7 of the Detector Assembly (the connection to the catwhisker). These clips will be connected to the coil taps during operation of the receiver. Install knobs on the variable capacitors and also on the Bias Adjustment Control, then mark the terminals with rub-on lettering or with small slips of typed, paper designations cemented on to the board.

Operation. All types of crystal set receivers require a good, outside antenna and a good ground for best results. If you are located near a high-power radio station, an inside antenna and a waterpipe ground will probably work. For distant stations, an outside antenna, 50 to 100 feet long will be necessary. Check the mail order houses for supplies and antenna kits.

The taps on L1 are provided to compensate for antenna loading as well as for the loading effect of the carborundum detector. The position of the clip leads on the coil taps must be determined by experiment as they will vary according to the length (loading) of your antenna and the frequency of the radio station being received. Inasmuch as the carborundum detector also requires adjustment (both in determining a sensitive crystal point and in the proper bias voltage adjustment), a saving in initial L1 tap set-up time can be achieved with the use of a fixed crystal diode (1N34A, or equivalent germanium type).

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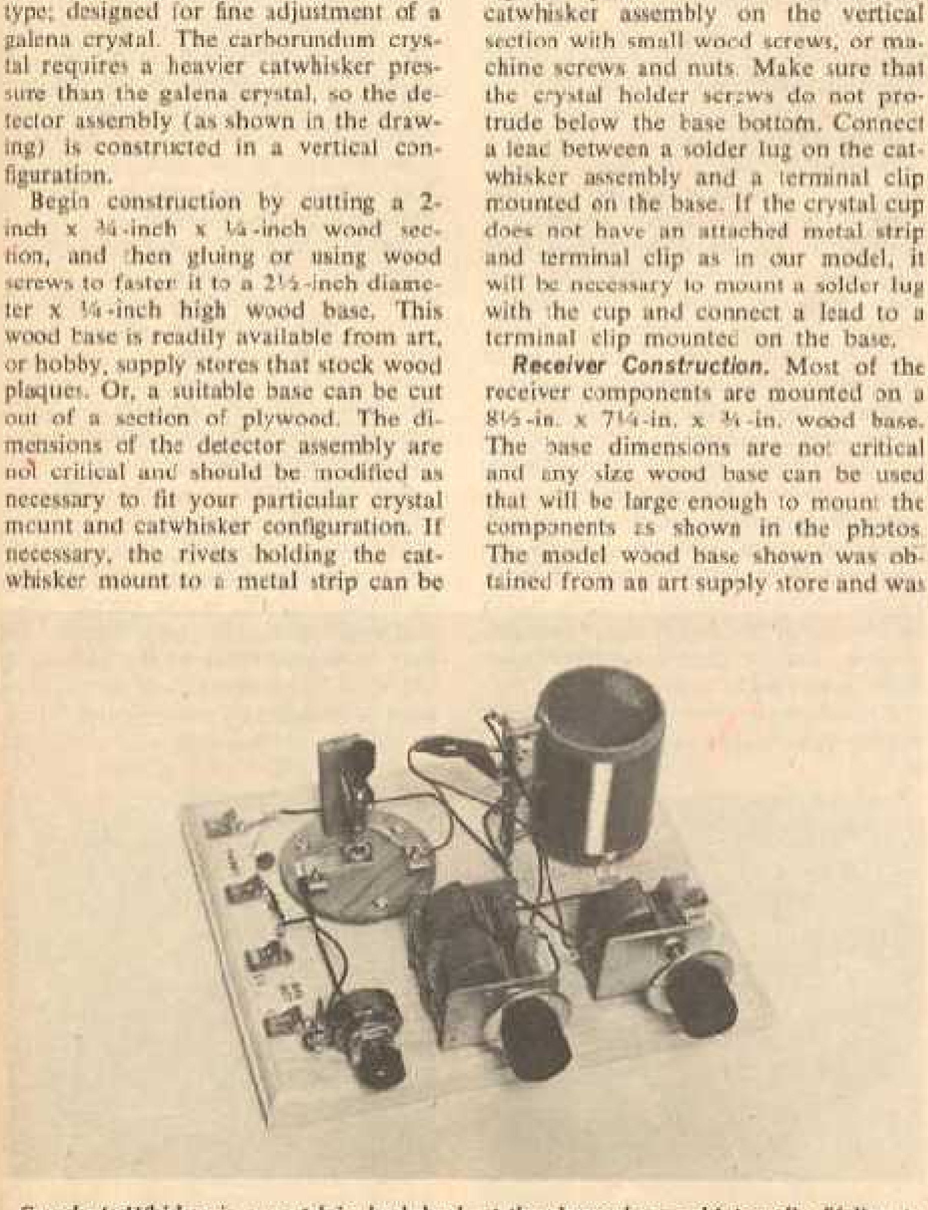

Grandpa's Whisker is a nostalgic look back at the days when a ship's radio lifeline to shore was dependent on no more than a coil, a battery, a catwhisker, and carborundum.

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CAUTION. *Make sure that the battery is disconnected for this initial adjustment.*

Connect an antenna to J1, a ground to J2, and a pair of high-impedance headphones to J5 and J6. A pair of 2000-ohm phones was used with our model; do not use low impedance headphones (8 or 16 ohm stereo types). Do not connect the 6-volt battery at this time.

Make sure that the catwhisker is not touching the crystal or the crystal cup (open circuit to the carborundum crystal), and then connect the crystal diode across J7 and J8 (the polarity is not important; it will work either way). Connect both of the clip leads (lead to J8 and lead to C1A-C1B) to L1 coil taps; any of the mid-coil taps will do for an initial start. Set C1A-C1B to mid-capacity range and then tune C2 until you hear a radio station in the headphones. Readjust the setting of C1A-C1B for best headphone volume. Then readjust each one of the clip leads for best headphone volume of the received radio station. All of the adjustments and coil tap settings will interact, and will require careful retuning of both C1A-C1B and C2 for best results.

When a radio station is tuned in for best headphone volume, carefully disconnect the germanium crystal diode from J7 and J8 without disturbing the tuning capacitor settings or the positions of the L1 tap connections. Then place a carborundum crystal in the detector assembly and connect the 6-volt battery to J4 (negative lead) and J3 (positive lead). Adjust the catwhisker until it touches the carborundum surface and then set the bias control R1 to mid-range.

Carefully adjust the catwhisker for a sensitive spot on the crystal surface at the same time adjusting R1 for best volume of received signal. If this seems like a lot of trouble to hear a radio station, remember the radio pioneers around the turn of the century would spend considerable time with equipment even cruder than Grandpa's Whisker in order to capture the elusive wireless signals. After a station is found with the carborundum detector, it may be possible to achieve a bit more received volume by readjusting the coil taps and tuning capacitors.

You can experiment with different types of silicon and germanium crystals as well as other materials with this circuit; but remember, do not use the battery unless it is with a carborundum crystal. The battery will burn out the more conventional germanium and silicone crystals. You can also try chips of carborundum broken off of sharpening stones, etc. and held with melted solder or lead. Or you can also try packing the crystals with sections of crumpled aluminum or lead foil in place of the melted lead bodies. The received crystal set volume will vary according to the type of crystal used; generally germanium will be loudest, and silicon a bit less, and the carborundum crystal will usually be lower in volume. ■