DESIGNING A DX CRYSTAL SET

by Mike Tuggle
46-469 Kuneki St.
Kaneohe, HI 96744-3536
E-Mail: tuggle@apacs.com

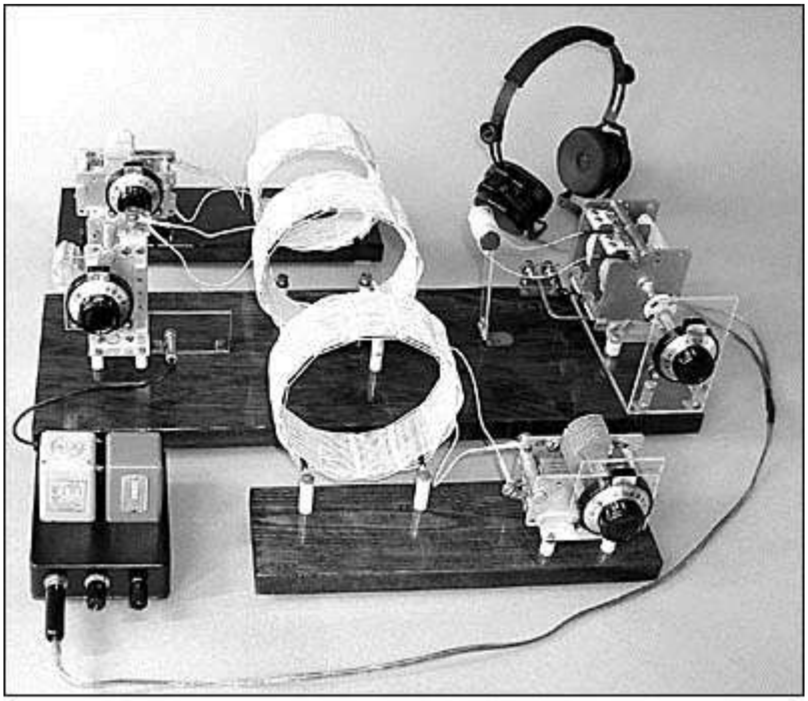

Fig. 1. The 'Lyonodyne-17,' an example of a well-designed DX crystal set.

Long distance reception with crystal radios is once again becoming a serious pursuit among hams and other radio hobbyists. They are discovering that the DX capabilities of these receivers have been greatly underrated. I've been particularly interested in crystal sets since 1959, when I first discovered you could actually DX with them. The Internet has aided crystal set DX activity by making exchange of ideas between like-minded enthusiasts much, much easier. This article only touches the surface from a personal perspective. The reader is encouraged to pursue the online resources, described below, covering all aspects and providing further examples of this fascinating hobby.

In this article I'll cover general design considerations for building DX crystal sets, but will leave the actual construction specifications up to you.

Equipment

Figures 1 and 2 show an example of a DX crystal set. I call it the "Lyonodyne-17." The design evolved from an earlier version described in the November, 1978 OTB. As you can see, this is not your grandfather's crystal set.

Antenna (right) and detector (left) tuners are mounted on the middle board. Wave traps are located fore and aft on separate boards, making it possible to adjust the coupling by moving the boards. The antenna coil (L1) is wound on a short ferrite rod. The matching transformer unit for my RCA "Big Cans" sound powered phones is at front, left.

So, what makes a crystal radio a "DX" set? Well, this one is double-tuned (L1-C1 and L2-C2) for selectivity to tune weak DX stations in the RF jungle we now live in. Some DX sets resort to triple tuning for even more selectivity -- depends on how many hands you have to do the tuning. The wavetraps (L3-C3 and L4-C4) can be tuned to reject strong unwanted stations in the manner of the notch filter on a communications receiver.

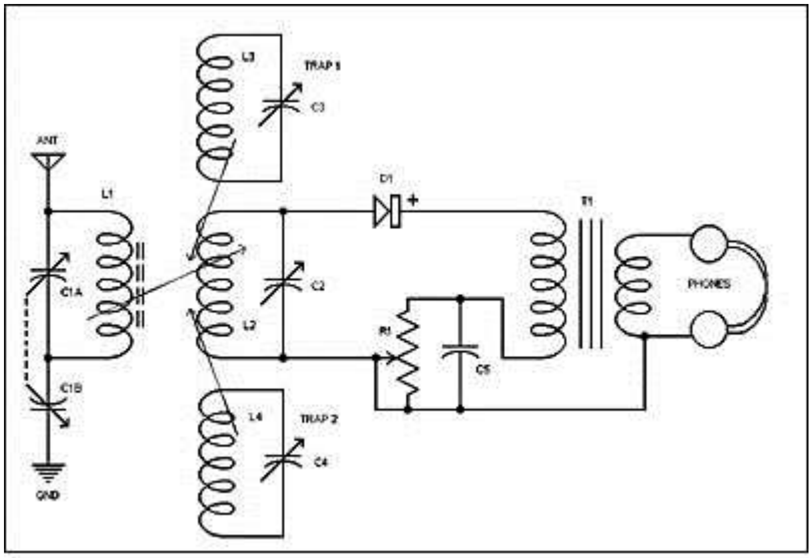

Fig. 2. Schematic of the 'Lyonodyne-17.'

Coils L2 through L4 are basket-wound litz wire for low loss and high Q. Variable capacitors C1 through C4 are highest-quality, silver-plated, ceramic-insulated units--as perhaps only the military could specify. All these components are isolated from the mounting board by ceramic standoff insulators. Overkill maybe, but why take chances?

Design Principles

Two fundamental principles underlie DX crystal set design and construction: use of low-loss components and proper impedance matching between stages.

Avoid the temptation to construct the set with vintage components. The result may be a handsome set that is only a fair performer. I have such sets, and they sit up on the shelf and look nice. However, for ultimate performance, one should rely on top quality (usually modern) components and materials.

This is especially important for tuning capacitors, coil wire and forms, and detector diodes. Layout and construction, particularly in the RF-carrying sections (antenna through detector), should follow good HF practices: short direct leads, careful insulation of components, and avoidance of switches, taps and other trappings in the 'hot', RF-carrying sections.

The crystal set, like any other radio, consists of a series of stages--each with a function, each coupled to the next. The stages of a simplified crystal receiver are diagrammed in Figure 3. The resistances shown are used for detailed circuit analysis that will not discussed here.

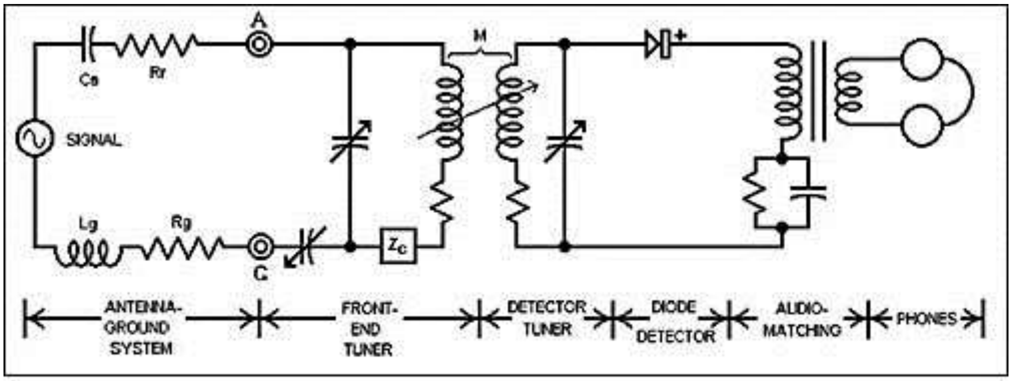

Fig. 3. The stages of a typical DX crystal set (see text).

We have, from left to right: antenna-ground system, front-end (antenna) tuner, secondary (detector) tuner, diode detector, audio matching and finally, phones. Maximum transfer of available signal power from one stage to the next happens when the impedances of these stages are matched to each other--from antenna to phones--and indeed, from phones to one's ears.

Components

A good outside antenna-ground system is essential for DXing. Loop antennas do not have enough pickup to be effective. An inverted L longwire 20 to 30 feet high and 50 feet long is a good start. The one truth to antenna design is, "higher is better." Any effort expended to raise the antenna, even a few feet, will be amply rewarded. In the most recent crystal set DX contest a third design principle emerged: A huge antenna can overcome shortcomings in the first two principles. The winner suspended 140 feet of litz wire near vertically using helium-filled balloons. Another high-scorer just happened to have a 140-foot tall base-insulated tower and four 1000-foot Beverage antennas to complement his junk box set. Most of us have neither the real estate nor the rigging capability to put up one of these 'mega' antennas. So it behooves us to heed principles 1 and 2.

Fig. 4. RCA balanced-armature phones, with matching transformer.

The front-end (antenna tuner) design shown here is one of several that can be used. This particular design tunes a wide variety of antenna-ground systems. Other DX crystal sets use a simple series tuning circuit effectively--especially on long antennas.

The diode detector provokes more mystery, controversy and debate than any other component. Some folks favor low-resistance germanium diodes like the 1N34A or rock stands with galenas. Others swear by high-tech Schottky diodes. The emerging truth is, there is no universally perfect diode.

The 'best' diode depends specifically

upon the set it is used in. Per the second principle, the diode needs to match the tank circuit feeding it and the transformer and phones that it feeds. With some care, a high-Q tank with litz wire coil and a modern, military-grade variable capacitor can attain a resistance of from several hundred kilohms up to a megohm. Only Schottky diodes and a few modern germanium diodes have resistances this high. The old catswhisker-rock stand detectors have far lower resistances.

The most practical approach to selecting the right diode is to apply an A-B listening test to a number of them. Two diodes are mounted in a test stand arranged to quickly switch between them. Using a fairly weak station, one can test a pile of diodes, pair-wise, keeping the winner after each test, until the ultimate one is found. But it's most important to realize that this diode is 'best' for the particular set it was tested in. It may be a quite poor performer in a different set.

Surplus, sound-powered (more properly, balanced-armature) phones have become the industry standard for DX crystal sets. Baldwin Type C's were an early example. Now, post-WWII surplus units made by RCA and US Instruments Corp. (USI) are preferred.

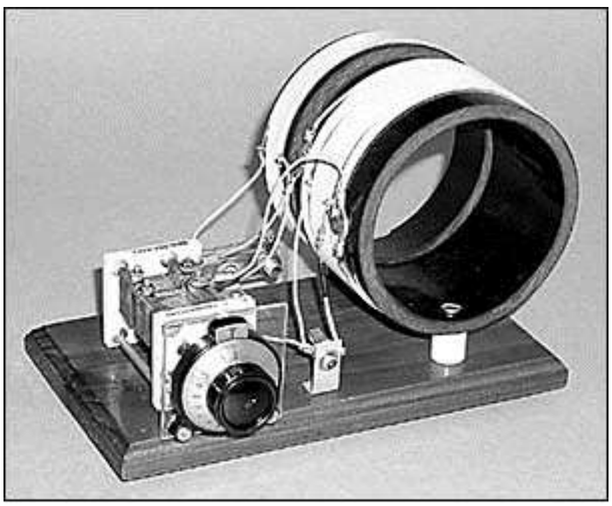

Fig. 5. A '12,000-mile' short-wave receiver.

These phones are low impedance and must be matched to the high-impedance tank (L2-C2) and detector diode by an audio transformer having, typically, 50- to 600-ohm and 50- or 100-kilohm windings (Figure 4). The quality of the transformer is very important, so that its insertion loss is small. UTC input transformers have a good reputation for low loss. The final touch is a comfortable set of headphone cushions for good acoustical coupling to the ears and exclusion of outside noise.

DX Experiences

Under favorable conditions, medium wave or broadcast band DX crystal sets can receive hundreds of stations--some of them thousands of miles distant. In fact, DX crystal set performance is comparable to any other radio (powered or not) short of a full-blown communications receiver with its own outside antenna. The rule of thumb is, if you can hear them on a radio, you can hear them on a crystal set.

The best times to listen are at sunrise and sunset, when stations are signing on or off, raising or dropping their powers, and changing their antenna patterns. These circumstances make for a jumble of regional stations ripe for the picking. Deep night is usually the best time for flat-out DX.

In 15-year stints at two locations in Maryland, I accumulated logs of over 600 and 400 stations, respectively. The most distant receptions, at 1800 to 2200 miles, were a few powerful stations in the Caribbean area and adjacent South America. I was aided, no doubt, by the largely water path between them and me. The farthest overland station was in Denver at about 1500 miles.

When I moved to Hawaii, I wasn't sure what to expect. The local Honolulu stations were givens. But what about the outer islands? And all-importantly the next stations, mainlanders, the closest some 2400 miles away? As it turns out, Hawaii is an ideal DX location--for distance if not for sheer numbers of stations. With no regional stations, sunrise-sunset activity is non-existent.

West coast 500-watt stations, 2500 miles distant, have been heard here. High-power stations in Cuba (4800 mi.) and the Caicos Islands (5500 mi.) have also been heard, thanks to a mostly water path. Stations from the "interior" also make it over. Last year, it was neat to hear KRVN in snowbound Nebraska (3600 mi.) using a homemade cat's whisker mineral detector. This must be what it was like in the old days.

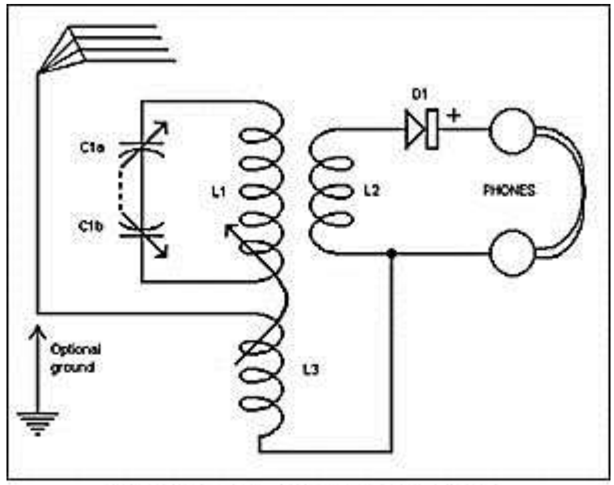

Fig. 6. Schematic of the '12,000 mile-er.'

With low station powers and crowding, medium-wave broadcast band DXing represents the greatest challenge. On short wave there's no limit to the distance--reception is truly worldwide. I occasionally hear the South African broadcasts nearly 12,000 miles away; Johannesburg and Hawaii are nearly at antipodes. From the mainland, Australia (11,000 miles) was a routine catch. Figures 5 and 6 show my "12,000-mile" crystal set.

Crystal Set DX Activities

Crystal set DX activities include discussion forums sharing ideas and results, an annual DX listening contest now into its sixth year, and the occasional set-building contest where some remarkably high-caliber craftsmanship comes to the fore. All of these activities are served up on the Internet.

The following site is a highly recommended grand portal to the wonderful world of crystal set DXing: Owen Pool's Crystal Radio Resources at http://www.thebest.net/wuggy. The comprehensive set of links here covers all aspects of the hobby. This site is headquarters for the annual crystal set DX (XSDX) contests open to everyone. The contest usually takes place in late January. Watch for announcement of specific dates and rules.

My own experiences over the years have led me to shed my skepticism of the incredible DX reports made by old-timers back in the early days. Component technology was not what it is today, but circuit technology was, and the sparsely populated bands back then had to be a lot more DX-friendly. You may want to pull an antique crystal set off the shelf and give it a spin. I'd encourage it.

Some of these old sets are extremely well built. The construction of the military BC-14A/SCR-65 never ceases to amaze me--and others were built just as well. But to start out, I'd recommend conceding to modern technology by using a good, modern diode and sound-powered phones with matching transformer. With just a little luck, prepare to be amazed all over again!