Science Fair Tips

The Xtal Set Society and its members are happy to provide the information in these pages to parents and teachers. Let's encourage yet another generation to build and experiment with the magic of the crystal radio (and let's include the girls this time!). We have a project on-line, the Quaker Oats box radio. If you are building your own radio from some other plans, many of the hints on these pages should still be of help.

What is a Science Fair Project?
Most school districts have specific directions for students to follow as they try to answer a question. There are several types of projects including
Projects that are experiments where you try to answer questions about how something happens
Projects that use a model to show how something works using more than one condition to compare how this works in different situations
Projects that are collections of items perhaps found in a particular geographic region

What should our hypothesis be for a crystal radio science project?
There are many questions we can ask about crystal radios. Here are just a few ideas:
• How many stations will I hear?
• Will I hear more radio stations during the day or night?
• Do radios with bigger coils work better?
• Do different lengths or kinds of antennas affect the performance?
• Which circuits work best?
• Which kinds of minerals work best as a detector?

What exactly is a crystal radio?
Crystal set radios pick up AM radio broadcasts without batteries or electricity. In the simplest terms, the broadcast station puts out enough power in the form of a radio signal to be picked up by a crystal set. The crystal radio antenna captures this electromagnetic energy, and the signal then passes through the crystal detector. Through a process called "rectification," the detector samples half of the radio wave and transforms the wave into a signal that can produce audio in the earphones. This mysterious process first intrigued great inventors such as Braun, Marconi, and Pickard, and it continues to fascinate electronics buffs, amateur radio operators, and engineers today.

The hobby of building and listening with a crystal radio had its first and biggest craze in the 1920's. Once radio stations began broadcasting all over the country, people began buying and building crystal radio kits. At that time a true mineral crystal was used as the detector. The most popular crystal was galena, and a fine piece of wire called a "cat's whisker" was used to touch the crystal and find the "hot spot" on the rock where a station would come in. These days, many hobbyists use the modern day diode instead of a crystal, but there are still experimenters who strive for the thrill of getting a distant station on a rock.

In the 1950's the hobby enjoyed a revival of sorts; fathers remembered building the sets as kids in the 1920's, and they wanted their sons to build them also. A surprising number of men who grew up in the 1950's built crystal radio sets with their fathers and as Boy Scouts. During the

1950's all sorts of crystal set kits became available, including some on the backs of cereal boxes. Now the hobby is coming of age again as those boys from the 50's have become fathers and want to pass on this radio magic.

The crystal set is the basis for modern day radio and communications equipment; the basics it embodies live on in a wide variety of radio systems. For this reason, a study of crystal sets is a great place to start to build a foundation in radio electronics. You also can learn about natural processes. For example, if you build a short wave (high frequency) AM set, you'll experience firsthand the constantly varying state of the ionosphere. The signals from distant stations will ebb and flow, particularly at night. Similarly, it is possible to build a radio that will detect "whistlers," which are brief radio signals created by lightning strikes around the globe. Many of our members are interested in the crystal set because of its simplicity and complexity; it contains few parts but exhibits many concepts. Crystal sets are a great tool for teaching, and they are a superb hobby.

Quaker Oats Box Radio summary and hints

Our Quaker oats box radio project can be built in a few hours using a round Quaker oats box and parts that you can purchase from the society. A sharp junior high school student may be able to put the radio together all by herself, but grade school students may need adult help and supervision. The directions include soldering the parts together which obviously needs to be done with adult supervision. However, you can use "alligator clips" to clip the wires together instead of soldering. If the child is in late grade school, have them hold the Oats box between their knees to hold it steady while they wrap the wire around it. It is fine to use lots of masking tape to hold the wires and parts in place. By varying the length (inductance) of the coil, this radio can be used to receive either AM stations or shortwave (this is true for any crystal radio).

Getting the radio to work after it is built!

Crystal Radios require special high impedance earplugs; regular stereo earphones will not work. Why? The first crystal radio headphones were different from the modern stereo headphones of today, they usually had input impedances of 2000 ohms or higher. (The input impedance for modern stereo earphones is a small fraction of this value). If you are an electrical techy type you can get a transformer and rig up newer phones to work, but the cost is much more than the inexpensive crystal earplug. (Of course, experimentation with input impedances could be the basis for a more advanced science fair project).

The Quaker Oats box requires that you have a good ground. Clamping or tightly wrapping the ground wire onto a copper, not plastic, cold water pipe works well. The antenna can just be some hook-up wire strung around the room. If you want the best reception, string up a 75 foot horizontal antenna outside.

Setting up your Science Fair Project in the school gym

Many of the school science fairs take place in the gym or in another big meeting room at the school. This isn't the greatest location for crystal radio reception due to all the metal in the frame of the building, but it can be made to work. To improve your chances of getting the crystal radio set to actually work at the display, try to get a spot next to the window and a radiator. You can throw the antenna out the window! Grounding to the base of the cold water pipe coming into a water fountain or nearby restroom sink should work fine (even if the wire leading to the pipe is long). An alternative ground can be fashioned by running a second wire outside but in a different direction.

An option is to build a loop crystal set. Loops will work without a ground or antenna. Although the loop may not work well in the gym, (except perhaps near the window) it can be easily taken outside. When the judges meet with your child for the science fair, he can take them outside to hear the radio. Our book Crystal Set Loopers & More has a number of plans to build crystal set loops of different sizes. Loops are directional; you can point them in the direction of the station you want for optimum performance. The reasons for this are well-understood, but experimentation with this could be the basis for another good science fair project!

Troubleshooting

1. Make sure the plastic cover (insulation) on the coil wire is in good shape, except where it must be removed for electrical contact.

2. Make sure enough insulation has been removed from the wire ends where they need to make contact with wires from other components. This can be done carefully with a pocket knife. Sand paper can be used for removing insulation on enamel coated wire.

3. Make sure the headphones are crystal or high impedance (about 2000 to 4000-ohm) types. If you must use low-impedance phones (most sold with an 1/8 inch--about 3 mm--stereo phone plug are low impedance), then use a matching transformer.

4. The antenna wire needs to be about 45-50 feet long if you're not within a few miles of strong stations. Be sure your antenna wire is well insulated from nearby metal objects. If your antenna passes into the house through anything metallic (aluminum siding, aluminum window frames, etc.), then make sure it's well insulated from the metal objects. You can pass the wire through small-gauge flexible plastic tubing.

5. Be sure you have a good cold water pipe or 4-foot ground rod connection. Remove oxidation from the surface of the pipe or rod with sand paper before making the connection. Don't just tape the wire on and hope for a connection. Use a copper ground clamp from a hardware store. The ground is just as important as the antenna.