Lets talk about Crystal Sets (Part 2)

Basic Electronics

Last month we introduced you to the basic crystal set and how it worked. This month we have two crystal sets for you, the first an improved version of the one described last month and the second a miniature version which is actually built into a matchbox.

First, let us briefly recap on what we said last month: A basic radio receiver consists of an antenna (and earth) to receive the signals, a tuned circuit to separate the wanted signals from all the other signals in the radio spectrum, a detector to extract the audible signal from the radio signal, and an earphone — to convert the audio signal into sound.

The antenna, detector and headphones were discussed last month. There is not much (at least in this type of receiver) which one can do to improve performance. However, the tuned circuit can take a variety of forms — and it is this with which we are concerned this month.

Last month's basic crystal set was tuned by varying the capacitance. Our first set this month uses the same method, but the other uses variable inductance. We will talk more about this later.

Our first set is similar in some respects to last month's design, but has one vital difference: instead of a single tuned circuit we now have two; two coils and two tuning capacitors.

Why two tuned circuits? A serious limitation with any crystal set is its poor selectivity. The reason is simple; a single tuned circuit just cannot provide sufficient discrimination between the wanted and unwanted signals. This is aggravated by the fact that the single tuned circuit will be loaded by both the antenna and detector circuits connected to it. (More about "loading" in a moment.)

It is for this reason that larger sets use several tuned circuits (plus other tricks) in order to achieve adequate selectivity. If the output of one tuned circuit can be fed into a second one, resonating at the same frequency, the rejection will be greatly improved.

It is a similar process to purifying a liquid. The first process gets rid of most of the impurities, but some are able to sneak through. The second process is able to get rid of most of those missed by the first, but there will still be some which manage to find their way through. This process could go on and on, but there are limitations. At each purifying (as at each tuned circuit) some of the wanted material is lost. Therefore, there is a limit to the number of stages one can have.

Unfortunately, feeding the output of one tuned circuit directly into a second one is the least desirable procedure. If these two circuits are too intimately coupled they cease to function as separate circuits, and behave more like a single circuit. On the other hand, if they are not adequately coupled, there will be a serious loss of signal.

This problem is overcome in larger sets by interposing amplifying stages between the tuned circuits, which also effectively isolate them. Since we have no such stages, we must select a compromise order of coupling.

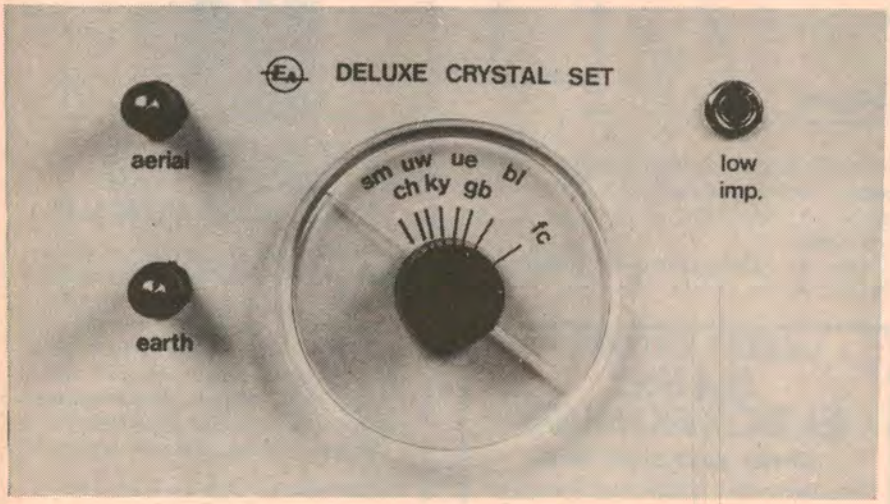
When a tuned circuit is at resonance, the wanted frequency builds up voltage and current to a maximum, while the signals of other stations are largely rejected. Because the voltage and current are changing, a changing electromagnetic field is set up around the coil.

If a conductor is placed in a magnetic field, a current is set up in the conductor. If we place another coil so that it is in the magnetic field, it will have a current set up in it. This is transformer action — it is the same effect which allows a transformer to step voltage or current up or down from another voltage or current.

Maximum transfer from one coil to the other occurs when the coils are oriented in the same direction (either end to end or alongside one another) and are close together. But, as we have seen, it is not always desirable to have maximum coupling between the coils.

For this reason we have made the coupling variable, by arranging one coil so that it can slide along a slot cut in the baseboard. This is quite a simple method of altering coupling.

The situation may arise that, no matter how close the coils are placed, there is still not enough coupling for reasonable listening. In this case, a small amount of capacitive coupling may be added by connecting a 4.7pF capacitor between the tuned circuits (see circuit). Note that 4.7pF will be



Front panel of the deluxe crystal set. Note the simple handspan dial with the station markings behind it. The panel was made from stiff card, using Letraset rub-on letters.

about the maximum value — it will probably not require this much.

The coupling is not the only item which needs adjustment. Note the trimmers on top of the tuning capacitor. These are used to adjust the individual tuned circuits so that they both resonate at the same frequency for a given dial setting. Adjustment should be made at the high frequency end of the band (2SM, 3AK, etc).

We used two different types of trimmer, mainly to show what to look for on discarded sets. The first is a compression type, adjusted with a screwdriver, while the other is a concentric type, screwed in by hand. Any other type may be used. Simply solder them between the fixed plates of the capacitor and the frame.

As in last month's crystal set, a high impedance to low impedance speaker transformer is used for the headphones.

Earlier in this discussion we used the term "loading" in regard to the tuned circuits. The selectivity of a tuned circuit is affected quite markedly by the external circuits we connect to it; such as the detector, headphones and the antenna. The more intimately these are coupled to the tuned circuits the more they load it, and the worse the selectivity.

This is the reason for the taps on the coil; they allow us to select the best order of coupling. The tap giving the smallest number of turns produces the lightest loading and the best selectivity, but gives the weakest signal. Conversely, the tap with the largest number of turns gives the strongest signal, but the worst selectivity.

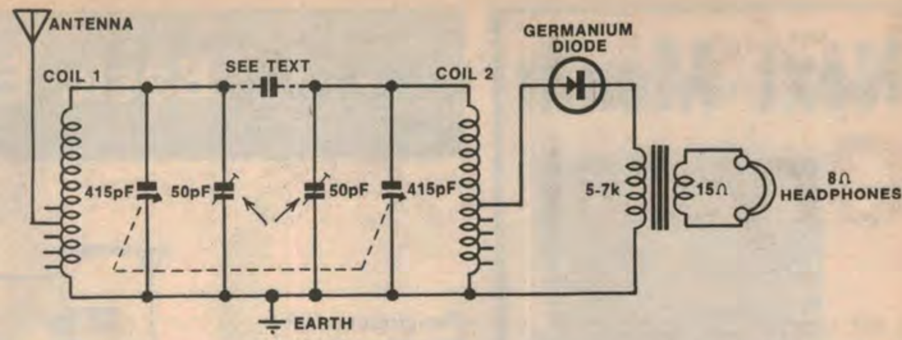
In any given situation the best tap will depend on such factors as the size of the antenna, strength of the signals, number of stations available, etc. Thus the user has to make his own selection, possibly even changing them to receive different stations.

Construction of the set is not too involved — anyone with basic woodworking tools could manage it. In fact, some may like to treat our construction as a starting point, and enclose the crystal set in a wooden case.

We used a plywood base board, measuring 200 x 140mm, with a Masonite front panel measuring 200 x 120mm. The front panel is glued and nailed to the baseboard. Placement of components is not critical, as long as you place both coils in a straight line. The slot for the moving coil is 115mm long, and starts 10mm from the side of the baseboard, 30mm from the back.

Lightly centre punch marks along the slot line every 5mm, and drill them with a 3mm drill. Then elongate each hole so that it meets its neighbour. Finish the slot with a rat tail file.

Both the moving and stationary coils are secured with screws and nuts. (The amount of metal is too small to have



The circuit of the Deluxe Crystal Set, showing the two tuned circuits. The capacitor (dotted) between them may be required only under certain circumstances (see text). The trimmer capacitors are used to align the tuned circuits at the top of the band.

any serious adverse effect.)

When mounting the moving coil leave enough wire to allow it to travel the full length of the slot. Similarly for the lead from the taps.

Longer nuts and screws are needed for the moving coil, as this has two nuts on each screw. Washers are used to stop the heads from coming through the slot, and these must be placed on each screw before insertion. We also used washers between the nuts and cardboard former, to prevent undue stress on the cardboard.

Because the screwheads protrude below the bottom of the baseboard, rubber feet are screwed to the four corners to provide clearance.

Other components (gang, transformer) are mounted with No. 4 or 6 self-tapping screws. Watch that the shaft of the tuning capacitor emerges in the middle of the front panel — it would be wise to mark this first. The transformer mounts between the moving coil and the headphone sockets.

A 3 lug tagstrip (1-E-1) is mounted underneath the right hand side screw holding the gang. On this is mounted the detector diode.

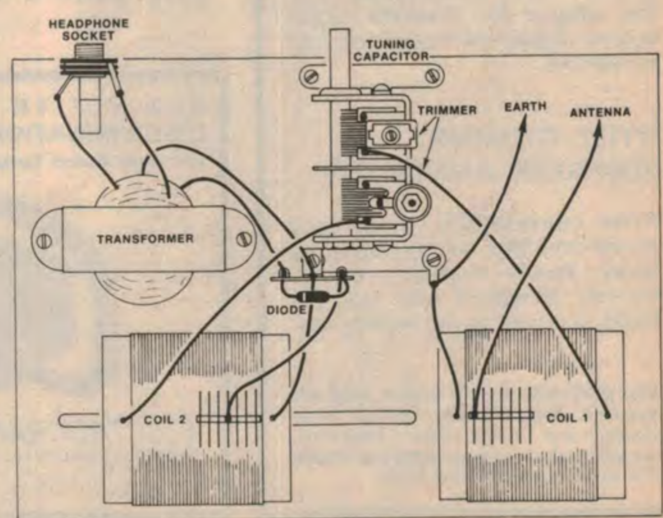
On the front panel, two terminals (red & black) provide the antenna and earth connections, while a socket is provided for a pair of low-impedance headphones. The dial is a push on "handspan" dial suitable for 6mm shafts. As many older tuning capacitors have 9.5mm shafts, an adaptor may be necessary. These should be available from your supplier, along with the handspan dial. If your supplier has difficulty with the dial he should be able to obtain them from Watkin Wynne Pty Ltd, who are the wholesalers. Note that you must obtain one through your normal supplier.

The front panel is made from a piece of thin cardboard, lettered with "Letraset". The cardboard was stuck to the Masonite with "Aquadhere" wood glue.

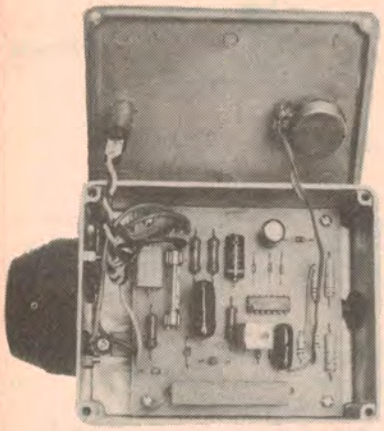
Lettering of the stations is best left until the set is complete. When the wiring is completed, check for errors. If you are sure there are none, connect the antenna and detector leads into the highest tap on their respective coil. This should ensure that at least something will be able to brute-force its way through.

If stations are well separated, leave the taps where they are. But we imagine there will be little or no selectivity on this high tap. Even moving the coils wide apart may not help much. Move the antenna and detector taps to about half way down, and check. Keep moving down until you are able

The layout of the Deluxe Crystal Set is not critical, but that shown here is a logical one. The coil on the left is the movable one, sliding in the slot shown. Refer to the photograph of the front panel for the terminal and jack positions.



Next Month



ZERO VOLTAGE SWITCHING POWER CONTROLLER

Phase-controlled Triac circuits generate considerable radio interference. This "zero voltage switching" power controller generates no interference at all and can be built using off-the-shelf components. Use it to control heating appliances such as radiators, vertical grillers and electric blankets.

TV/CRO ADAPTER

Turn your disused black and white television set into a large-screen oscilloscope with our TV/CRO Adapter. This economical unit can be built for under $30 and has its own modulator for direct connection to the TV antenna terminals. Use the adapter for dramatic large-screen display of frequencies up to 300kHz.

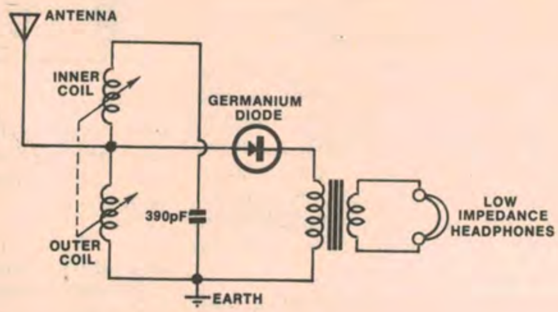
STILL COMING: 200/300W AMPLIFIER

After considerable delay, our power amplifier will be published soon. Really rugged, conservatively designed and easy to build, it is well worth waiting for.

Our planning for this issue is well advanced but circumstances may change the final content. However, we will make every attempt to include the articles mentioned here.

Basic Electronics

The circuit of the Matchbox Crystal Set. Tuning is achieved by varying the coupling between the two coils.



to separate each station well. Then tune to a high frequency station (2SM in Sydney, 3AK Melbourne, etc) and adjust both trimmers for maximum volume. Once the trimmers are peaked, try moving the coil back and forth.

Incidentally, the only way to make sure alignment is correct at the low frequency end (2FC or 3AR) is to ensure that the coils are identical. It is difficult to provide adjustment on either coil to correct this. So take care when winding the coils.

As you learn to use the crystal set, you should find the right combination of taps and coupling to give optimum results from all your favourite stations.

The next set is quite novel — believe it or not, it is built in a matchbox!

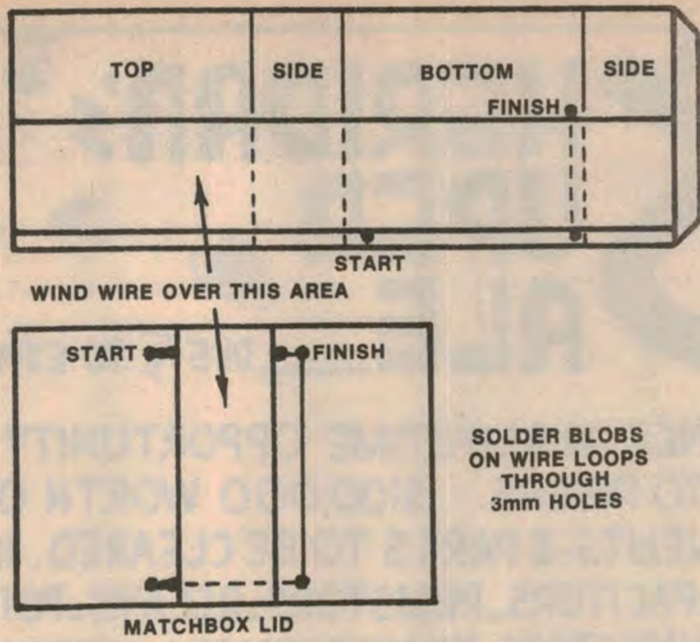
It contains just two commercial components — a diode and a small fixed capacitor. The other two major components are a pair of home-made coils. One coil is mounted inside the matchbox tray and the other is wound over the outer portion of the box. To tune it, all you do is try to get a match out of the box — in other words, move the tray. This tunes in the stations!

Why build a crystal set in a matchbox? Well, why not? Apart from its novelty and simplicity, this little crystal set is capable of a good performance. Connected to a good antenna and earth, it will perform just as well as the "straight" crystal set described last month, and nearly as good as the deluxe model just described.

The operation of this set is based on the fact that the inductance of one coil can be changed by another coil in close proximity. Because the coils are simply connected in series, it might appear that the resonant frequency of the tuned circuit would be governed only by the capacitance across the coils.

This is only part of the story. Because the coils can be moved relative to one another, we have a situation where the inductance of one coil can "buck" or oppose the inductance of the other coil. By the same token, the opposite is true. By physically turning one coil through 180 degrees, the inductances can be made to assist, or add to one another. In practice, more range is obtained by opposition than addition.

By planning the size of the coils, and the amount of fixed capacitance across



These drawings are actual size templates showing where the folds are made, and how the coil is wound.

them, we can make them cover the broadcast band. The natural resonant frequency of the inside coil will be around 750kHz — roughly corresponding to 2BL in Sydney and 3LO in Melbourne. By placing the outer coil on one way, down to 530kHz is covered. Turning this coil around will cover the other end of the band — up to 1600kHz.

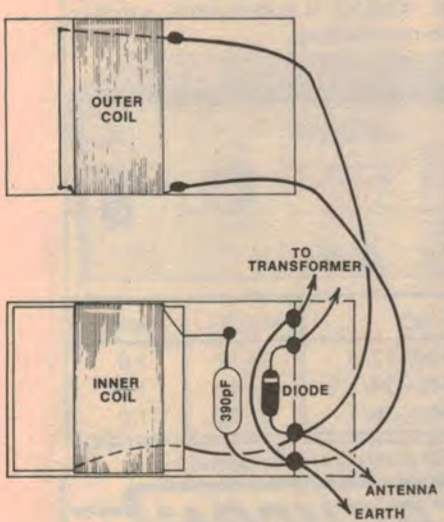
Construction of the matchbox crystal set could hardly be simpler. No woodwork, very little soldering and a few components. You will need an ordinary matchbox (try to get one as new and strong as possible) some thin cardboard, some good paper or cardboard glue, a germanium diode, a 390pF polyester, mica or ceramic capacitor and around ten metres of 30 B&S insulated copper wire.

The first step is to construct the cardboard former for the inner coil. Using the pattern given as a template, cut a thin cardboard piece the same size, and bend where shown. Glue this and leave to set. While it is setting, you can wind the outer coil on the matchbox cover.

Where shown, drill two holes 3mm apart. Scrape the enamel off 50mm of wire and pass the end of this wire through the hole closest to the centre of the box. Pass it back out the other hole, and continue to loop it in this fashion four or five times. This will securely anchor the wire. Cut off any excess wire.

Now wind on the turns. These should be as tight and neat as possible. They should not be able to move when the job is completed. Wind on 39 turns and, when these are completed, drill another two holes similar to the first pair, as close to the last turn as possible.

Cut the wire 50mm from the hole, and scrape the enamel off this. Loop through the holes in the same way as before, and cut off any excess.



Layout of the Matchbox Crystal Set is simple, with the antenna, earth and transformer connections mounted on the end of the matchbox tray.

With a hot, clean iron, place a blob of solder over each of the loops. You will use these as anchorage points later.

The inner coil is wound on the former which we described earlier, the former then being glued inside the tray. The coil is wound in much the same manner as the outer one. The ends are terminated in a similar way, by passing them through pairs of holes sevral times, but the wire is not trimmed close. Leave about 30mm of flying lead. This coil is slightly larger, requiring 48 turns.

Before glueing the former into the tray, you must perform minor surgery. If you look closely at a matchbox tray, you will see the end is made by folding the two sideflaps in and the bottom up and over these sideflaps. The bottom flap must be unfolded — this is used to pull the tray in and out — while the side flaps must remain in position as the anchorage points for all connecting leads.

Because unfolding the bottom flap reduces the strength, it is a good idea to give all flaps a liberal coating of glue before going any further. At the same time, another piece of cardboard, the same size as the extended flap, can be glued over this to give added strength.

Now the former can be glued in place. A glue such as "Tarzan's Grip" is very good for this purpose. The former is glued as close as possible to the end of the tray opposite to the end we have been working on. When the glue is dry, you can prepare the components for soldering.

We have evolved a rather novel way to make connections and hold the components in place. In the end of the tray, we made four small holes. As you can see from the drawing, these are for the antenna, earth, and transformer connections. Through the "earth" hole, we passed one end of the capacitor lead, bent it 90 degrees vertically, then bent it again 180 degrees over the top of the tray and back down the inside. This was then squeezed hard with a pair of pliers to hold it in place.

The other three terminals were treated similarly. Where possible, component pigtails were used as the bend-over terminals. For the "earthy" transformer terminal, a piece of tinned copper wire was bent over the flap, then along the bottom of the box to the earth terminal.

Connections to the terminals were made by drilling four holes through the tray underneath the wire terminals. Thin leads pass up through these holes and solder onto the wires. The advantage of the crimped wire terminal may now be seen. If we relied on solder connections alone inside the matchbox, when we soldered the wires to the terminals, the solder inside might come unstuck. By mechanically holding the components in place, soldering can be carried on without this risk.

The outer coil is connected by means of flying leads to the antenna and earth terminals. These flying leads are cut from thin hookup wire and soldered to the "solder blobs" on the matchbox lid

You may note that after we soldered the leads to the outer coil, we wrapped a piece of insulation tape around the box. This is to prevent undue stress on the solder joints.

Using this set is child's play — simply move the inner tray in relation to the outer cover, and you should find station coming and going!