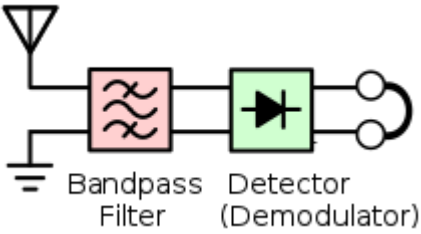
# THE COLLINGWOOD OPEN DAY 2018

## CRYSTAL RADIO SET

aka

# *The Magic Radio*




Brought to you by
The Royal Naval Amateur Radio Society
HQ Shack, Building 512
HMS Collingwood

It is personal, you never have to turn it on or off, it is always there, no batteries, no internet, no “connection” You are connected to the station by....nothing!

Someone talks into a microphone and hundreds of miles away someone else (you!) hears them. How is it possible? By Magic, or as some call it, Physics. Quantum Physics no less

People have always needed to communicate with or talk to each other over longer and longer distances. When shouting and megaphones failed, electricity took over with wire conducting the flow.

First, just switching the flow on and off sent a message but a little later the flow was varied by speech and voice messages could be sent. Wires connected the two ends-Telephony. Imagine a wire connected your telephone in the hall, across the oceans across continents to the other side of the world to your relations in their hall in Australia, a wire all the way!. No wonder it cost a fortune to speak like that but it was done.

The idea of using it for “entertainment” was unthinkable! This

was far too expensive and complicated. But soon there *was* a cheaper way, no wires, Wireless. Using electro-magnetic radiation or “Radio” it starting with on/off sparks, like lightning (or the spark that lights your gas ring) to a varying continuous wave.

The first long range transmission was by Signore Marconi. The spark in Cornwall was detected in Newfoundland across the Atlantic Ocean without wire - Magic!

The first device to detect this spark was crude but worked well enough to be commercial and got developed into voice transmission.

So on the cohere became galena crystals and cats-whisker, valves amplified the radio and the audio  so more than one person could listen without headphones (not a really cool fashion statement even in those days) and it all became cheaper and the crystal set was outmoded, but has never stopped being developed.

Headphone  the first crystal sets were very expensive and valves and batteries that had to be bought ad charged, (HT,

Grid bias, and two accumulator, one in use, the other at the hardware shop being charged. were super expensive so a lot of people had receivers that used neither. This is what we will show today.

The image of the time is of the master of the house operating the crystal set, listening on the headphones, smoking his pipe, then telling his family what the BBC newsreader had said. The ladies of the house sewing or darning. We have come a long way from there. Girls can do Magic as well.

But it needs some source of energy and that comes from the transmitter (the carrier) along with the voice which varies (modulates) the carrier. Sorry if you are disappointed that it is truly free. But Physics/Nature will not be denied. However it does show that if you want more energy out, after you have reduced the losses, then more energy must be put in. Hence a bigger capture device (Antenna) will give louder sounds out.

The radio consists of signal capture (antenna, aerial), single signal selection (tank circuit), modulation extraction (diode), and audio output (buds, headphones, speaker).

Each element can be improved!

But be aware that the whole device is “interlinked” forward and backward, so a change at the output causes a change at the input, and what you think should work better might not! That’s the downside, now the up, It’s a great feeling when something works just as you thought it would.

Each element in a little more detail:

- **Capture**
- **Select**
- **Demodulate**
- **Output**

**CAPTURE**

Aerial + Earth. These are names that were at the beginning of radio communications meaningful but are now just names. Make the aerial wire longer and higher! inside, not so good, outside better. A good one would be from the up stairs window to the tree at the bottom of the garden, (a few twists and turns on the way are OK. The wire can go through the window and the window closed on it again. Not ideal but still OK. The other part, the Earth/ground does not have to be actual earth or actual ground but is the other half of the system. I have used a widow frame as earth, the locking key making the contact with the metal. A common recommendation is using the central heating pipes But modern plumbing has a lot of plastic

in it and might not work as well as you would hope. Or a loop of thin wire round the ceiling of your room (held up with pins). There seems to be a new design every week always something new

**SELECT**

Select- Selectivity/gain trade off

different bands

Types of inductor

Coil construction

Spider, basket coils, Litzwire

Ferrite rods, Ferrite toroids,

Capacitors:

Air-spaced

Polyvaricon

Slow motion drive for easier tuning,,

**DEMODULATE**

The diode characteristics are different for different materials and at different signal levels.

Si,

Ge,

Schottky,

4terminal.

**OUTPUT,**

Ear buds,

Headphones, lo-impedance (loZ), Hi-impedance (hiZ) Transformers,
Amplifier that would need batteries! but you might build a dongle that plugs straight into the amp.

It has all been done before BUT getting the combination and adjustment just right is art as much as science and it is truly magic when it works.

**HOW WE GOT HERE:**

There used to be 14 Semaphore towers between Portsmouth dockyard and the London Admiralty. A message could be sent in seconds. A message warning of an invasion could be sent from Deal to London in under a minute, but what about fog, rain, night time - not so good.

Passing electricity through a coil of wire would make a magnet (lodestone) move. Moving a magnet in a coil of wire would make thin metal move the electroscope. Electricity was made by chemical reactions.
Electricity could be stored in Leyden jars.

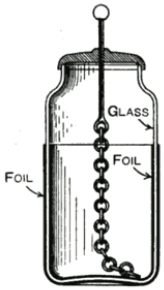



*Figure 1- Early Leyden jar*

Lightning, a natural phenomenon, cats fur standing up and so

on
A spark generated on one side of the lab would induce a spark on the other side with no apparent connection.

All the known effects of electricity - such as sparks, electrostatic attraction, chemical changes, electric shocks, and later electromagnetism - were applied to the problems of detecting controlled transmissions of electricity at various distances.

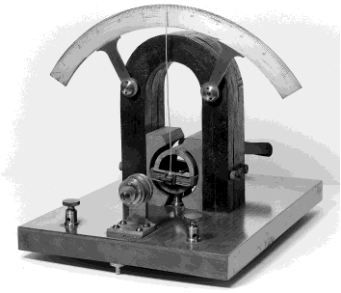


*Figure 2- Galvanometer*

Hans Christian Ørsted discovered in 1820 that an electric current produces a magnetic field which will deflect a compass needle. In the same year Johann Schweigger invented the galvanometer, with a coil of wire around a compass, which could be used as a sensitive indicator for an electric current. In 1821, André-Marie Ampère suggested that telegraphy could be done by a system of galvanometers, with one wire per galvanometer to indicate each letter, and said he had experimented successfully with such a system. In 1824, Peter Barlow said that such a system only worked to a distance of about 200 feet (61 m), and so was impractical [4].
A process of continuous development in Europe, Russia and America produced a system to send coded messages over long distances using a single wire. User emphasis moved from purely military to more commercial uses.

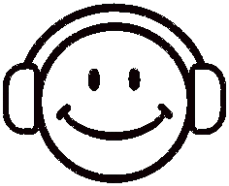
At the same time this was going on a “wire-less” system using

spark induction emulating lightning was being investigated.

Carrier meter deflects on deflection, half waggle at speech can see but not hear, human eye cannot “move” fast enough - wrong sort of detector.

Modulation

But the ear will not detect carrier on/off so cannot hear Morse Code. That needs a little more “magic” (and a battery)



What this set does not do

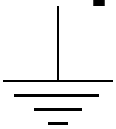
As it stands it only receives local Medium Wave AM (amplitude modulation) stations. Talk Sport, Absolute Radio, 5live.

It will not drive a loud speaker directly

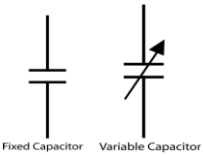
## Appendix1 - The Parts: Symbols, Pictures

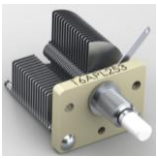
Antenna / aerial

Ground / earth

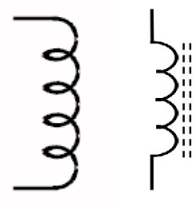


Capacitor

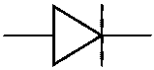


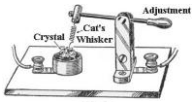



Inductor

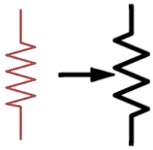


Detector / diode / cat's whisker

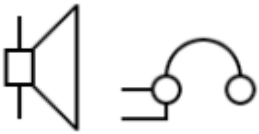





Resistor

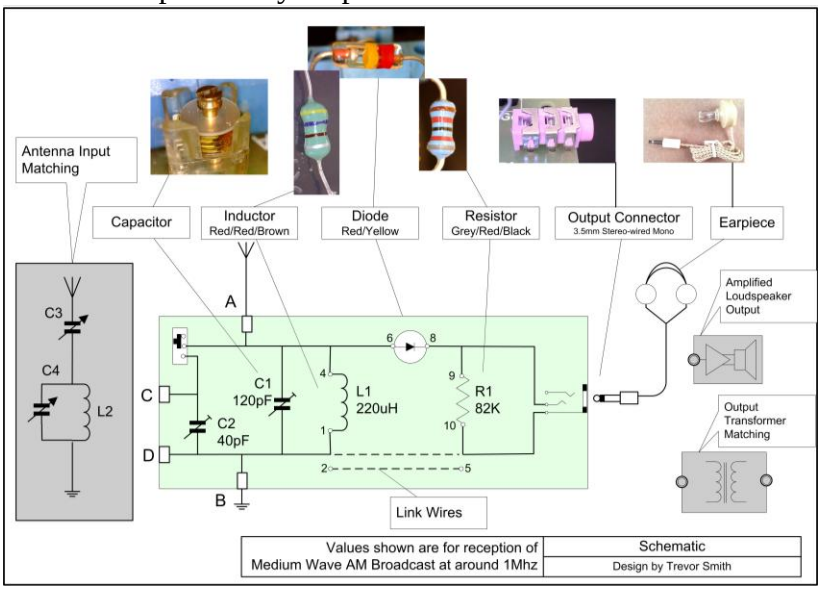


Output

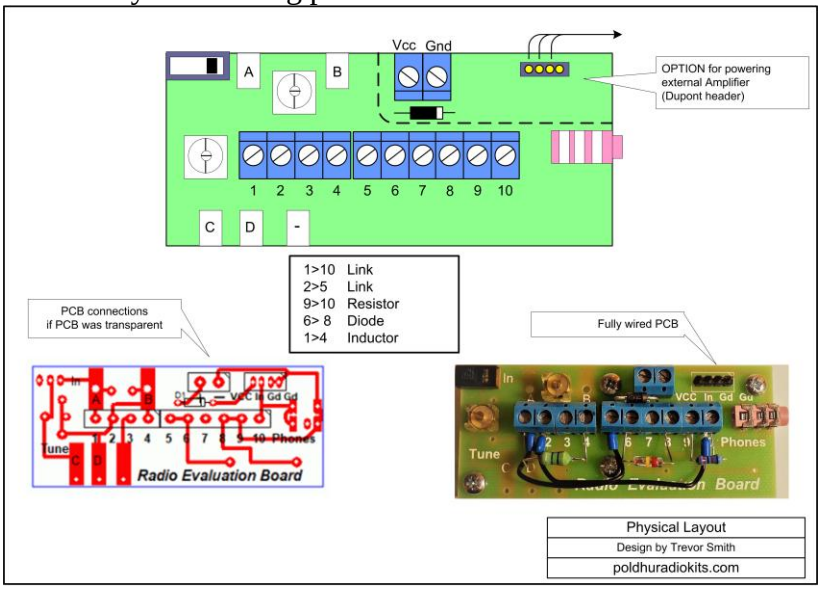


## Appendix2 - TheBuild

### Component layout picture




### Physical Wiring picture



Appendix3
All around us:

Very Low Frequencies: Naturally created lightning, whistlers within our audio range but too weak for us to hear without amplification
http://naturalradiolab.com

Radio Frequency Spectrum

| Frequency | Wavelength | Designation | Abbreviation |
|---|---|---|---|
| 3–30Hz | $10^5$–$10^4$ km | Extremely low frequency | ELF |
| 30–300Hz | $10^4$–$10^3$km | Super low frequency | SLF |
| 300–3000Hz | $10^3$–100km | Ultra low frequency | ULF |
| 3–30kHz | 100–10km | Very low frequency | VLF |
| 30–300kHz | 10–1km | Low frequency | LF |
| 300kHz – 3MHz | 1km – 100 m | Medium frequency / Medium wave | MF |
| 3–30MHz | 100–10 m | High frequency / Short wave | HF |
| 30–300MHz | 10–1 m | Very high frequency | VHF |
| 300MHz – 3GHz | 1 m – 10cm | Ultra high frequency | UHF |
| 3–30GHz | 10–1cm | Super high frequency | SHF |
| 30–300GHz | 1cm – 1mm | Extremely high frequency | EHF |

https://en.wikipedia.org/wiki/Radio_frequency

## The Magic Radio

This set;

We hope to receive BBC Radio Solent, Five Live, Absolute and possibly TalkSport
The transmitters are 3Km away at the Tichfield Gyratory road system on the A27, Grid reference: SU546058. They are all low powered at 1KW
Frequencies:

| | |
|---|---|
| 5Live | 909 Khz, |
| Solent | 999 Khz, |
| Talksport | 1107 Khz, |
| Absolute | 1215 Khz. |

We are listening in daytime so it will be the ground wave that we will hear.
At night the upward wave will be reflected from the ionosphere and the station can be heard much further away. But there will be areas that the wave "skips" over. Propagation is sooo interesting!

Maybe your grand-dad remembers Radio Luxembourg on 1440 Khz, (208Metres) that covered Luxembourg and a lot of Germany in daylight but was not heard in the UK. In the evening we heard it although it faded in and out as the ionosphere changed under the influence of the sun.

There is a list of past and present Medium Wave, Amplitude Modulated Stations, attached.

It will not receive FM or DAB. They are on much higher frequencies (VHF) and use a more complex form of modulation. Some people *have* made successful VHF FM crystal Radios,

Appendix4:
Making your CRYSTAL SET "better":

Why would you want to experiment/improve it? So many stations out there, different countries, the whole world to listen to and to be entertained by. A basic receiver is a little "deaf" and hears only local transmitters. But with some different arrangement and experiments, much, much more can be heard on long, medium and short waves. Some Amateur operators use AM for local chat. Aircraft communication in the air is AM. So there is plenty to search for and hear.

Areas to experiment in (in which to experiment ;)
Google can be your friend but also sometimes not a good friend. Too may times will you see the same error repeated without thought. And hear "it works great" Maybe it did for those particular conditions but will not work with yours. But despair not, the basic physics/magic does work.

I am sure you will want to find out more about how to make all this magic work for you.
There is a lot of information on the internet, some good, some not so good and some downright wrong!

The set itself looks so simple, but as you have already found while getting it to work and it is this simplicity that can work against you. Everything affects everything else. Change one thing and the result my or may not be what you expect. Beware of "It works great" Can you repeat the results? Maybe, Probably not.

I think that all the "improvements" are aimed at reducing losses. The only device that has fundamentally changed is the detector. It has been analysed and its operation and limitations

more understood and new materials and construction introduced. The cat's whisker still works well but modern devices are better and easier to use.

It is good to think of making each part work better with its neighbour, matching characteristics, for a better overall result.

Here are a few sites that will start your quest for knowledge
http://theradioboard.com/rb/viewforum.php?f=2&sid=a36c5e4194c393a48fd1979a68a8e15d
http://billydiy.blogspot.co.uk/2016/04/my-crystal-radio-shows.html
http://www.talkingelectronics.com/projects/CrystalSetRadio/CrystalSet.html

There are contests for crystal receivers reception in the US and some of those sets look beautiful and work well. Often they look complicated but the principles are still the same.
Warning: Winding coils can become addictive.
http://www.crystalradio.net/

Here are some mathematical analyses of this humble device.
http://theradioboard.com/best-of-the-best/xtal-radio-spice.htm
http://kearman.com/bentongue/xtalset/6XlStSPS/6XlStSPS.html
http://www.welt-der-alten-radios.de/files/analysis.pdf
https://nebula.wsimg.com/27b567be00193712c2034ad852795d68?AccessKeyId=DC6D26377EE4A5C03247&disposition=0&alloworigin=1

Any Radio, I repeat Any Radio, has all the stages of your Crystal radio. There is added amplification in front and behind. The detector is different only in order to demodulate the different types of information FM, CW, SSB, Data Modes

Appendix5 - List of MW AM stations

A full list (a very long list)can be found at

http://www.mediumwaveradio.com/uk.php

This is a sample of some of the local Medium Wave stations.

| Frequency | Station Name | Transmitter Site | Power (Watts) | Grid Reference |
|---|---|---|---|---|
| 693 | Radio 5 Live | Southwick, Brighton | 1000 | TQ234051 |
| 909 | Radio 5 Live | Fareham | 1000 | SU546058 |
| 1107 | Talk Sport | Fareham | 1000 | SU546058 |
| 1134 | BFBS Gurkha Radio | Royal Military Academy, Nepal Lines, Sandhurst | 1 | SU863612 |
| 1161 | Classic Gold 1161 | Blunsdon | 160 | SU143900 |
| 1170 | Capital Gold | Farlington Marshes | 120 | SU688052 |
| 1215 | Virgin AM | Fareham | 1000 | SU546058 |
| 1287 | Surge | Southampton | 1 | SU421164 |