

# CANNY CAVITIES



By Harry Lythall G4VVJ

**Harry Lythall G4VVJ shows you how to make practical resonant cavity filter. But first you need to get the 'cavity' - so make that coffee, drink up and empty that 'canny can'!**

A few years ago I found myself living in close proximity to another Radio Amateur who was also active on the 144MHz band. If I went on air when he was on, I suffered from his r.f. field (and I'm sure he suffered from mine).

I eventually hit upon the idea of using a narrow-band resonant cavity filter to solve the problem. The filter allowed me to operate at the opposite end of the 144MHz band without any problems, and the interference and receiver de-sensing were effectively eliminated.

The filter is a tuned circuit made in a metal container, with loops to couple radio frequency energy with very low losses, see Fig. 1. The low losses involved, and the way the tuned circuit is made, results in a very high Q and thus a very narrow bandwidth.

Since  $\text{Bandwidth} = F/Q$ , as the Q increases, the bandwidth decreases. The bandwidth of a resonant cavity is therefore much more narrow than that of conventional inductor/capacitor tuned circuits due to the higher Q that can be obtained.

My workshop facilities were limited and funds short, so a large (1.5kg) coffee tin was pressed into service to make the cavity filter. The whole project was thrown together in just over an hour, but, the availability of better tools this time could be dramatically reduced.

A two-port resonant cavity filter placed in the antenna circuit of a receiver, Fig. 2, will effectively pass only the narrow band of frequencies to which it is tuned. A single-port cavity may also be placed in the receiver antenna lead, Fig. 3, in such a manner that it rejects (by absorbing) a narrow band of r.f. signals.

Absorption will only occur at the frequency to which the cavity is tuned. By a combination of band-pass and band-stop filters a nearby transmitter can effectively be 'switched off'.

The band-pass filter can only be used over a limited frequency range without adjustment, so they are normally only found on fixed frequency stations such as repeaters.

The repeater system would use several cavity filters to allow

transmitter power to reach the antenna, without desensing the receiver. The layout of Fig. 4 shows the way duplex operation is possible using a single antenna.

A resonant cavity band-pass filter (at say 100MHz) with a Q of 1000 would have a bandwidth of 100kHz. Cascading two or more filters would give an even narrower bandwidth.

## Some Dimensions

Some dimensions for the construction of amateur band basic cavity filters are given in Table 1. From the drawing of Fig. 1, you'll see the construction is self explanatory, but I'll give assembly tips as I describe each component.

For the centre conductor almost any household plumbing copper pipe or tubing is ideal. I've found tubing with 15-37mm diameters in the local d.i.y. outlets.

The copper tube should, ideally, have an outside diameter of 15-20% of the inside diameter of the metal container used. The smaller diameter pipes are easier to work with, but the overall performance of the filter may suffer a little if it is too small.

The length of the pipe (ideally) should be about 80-90% of the  $\lambda/4$  (free-space) - at the desired frequency. But this length may be reduced if the tuning capacitance is increased. Also, at less than 80% of  $\lambda/4$  there may be a degradation of the overall Q of the cavity.

As an example let's design a stub for 400MHz (it's easier!). The free space wavelength at 400MHz is 750mm. So,  $\lambda/4$  is therefore 187.5mm. Now, take 85% of this value, for the copper tube, which is about 160mm in length.

The frequency coverage of a

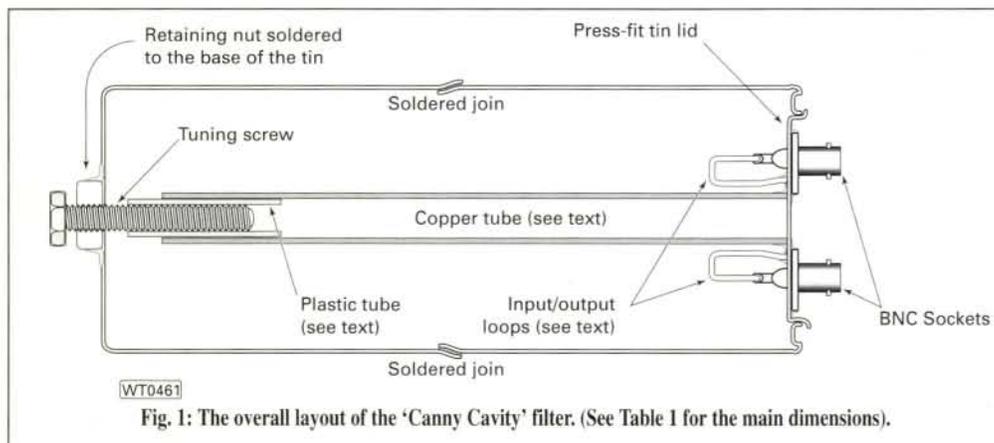


Fig. 1: The overall layout of the 'Canny Cavity' filter. (See Table 1 for the main dimensions).

cavity with this length of copper tube will be about 220 to 420MHz; the upper frequency limit being determined by the length of copper tube. The lower frequency limit is governed by the maximum tuning capacitance provided by the tuning screw.

### Large Tins

You might have to find some (very) large tins for use at lower v.h.f. Some commercially available cavity filters even use aluminium beer-barrels!

I have successfully used large tins from coffee or other food products. Whatever the source of the tin, it's most important that the lid fits tightly, forming a good seal, otherwise the overall performance of the filter will suffer.

The container must be a little longer than the copper tube, but this can be made up using two (or more) tins soldered together. Prior to soldering, remove the top from one tin and the base of the second (and subsequent) tin.

Then, using an abrasive, carefully clean the new edges well. The tins may be accurately positioned using masking tape which is then removed as the junction is progressively soldered.

Solder and other metal spikes must be avoided. Soldering the copper tube to the cavity lid may be performed by cleaning and pre-tinning both parts well using plenty of solder. The two components may then be mated together whilst the solder is molten, with the copper tube in a vertical position.

Heating is best achieved with a blow-torch, but a gas-cooker has always worked well for me. Allow the joint to cool naturally without movement and a nice uniform joint should be the result. A final cleaning with wire-wool will remove all traces of flux and any other minor irregularities.

### Adjustment Screw

The adjustment screw must be long enough to reach about 20% of the length of the copper tube. Make the hole in the base of the tin before soldering the retaining nut, but take care not to get any solder on the threads of the nut.

For frequencies below 100MHz, the tuning may be carried out with a variable capacitor in order to add the greater capacitance required. The capacitor is connected between the end of the copper pipe and the bottom inside surface of the tin.

Single hole fixing trimmer capacitors are available which will retain the container's r.f. seal. Using this method I've made a small treacle

tin to operate at 144MHz with a very short copper inductor. But the Q wasn't as good as a full sized cavity.

### Plastic Tube

The plastic tube has two uses. It helps prevent the copper tube moving about which would alter the resonant frequency of the filter. (The plastic tube must be a tight fit inside the copper tube).

For the plastic tube's other use, it must also be a very slightly 'friction fit' on the adjustment screw. A tube which does not quite bind the adjustment screw thread may be touched on the inside with a soldering iron tip. This will raise small ridges which will bind in the screw threads, and which also aids frequency stability.

Dents in the side of the tin will have little effect upon the operating frequency of the filter, but the top and bottom of the tin must not be allowed to move. If the screw binds on the nut or plastic tube, then the pressure distorts the tin which modifies the tuning point.

**Warning: do not use black plastic plumbing pipes as some types can be quite conductive at radio frequencies.** The inadvertent use of conductive plastic would introduce massive losses that would render the cavity useless.

### Loops In-Out

For input and output purposes, small coupling loops are used. These loops are formed from 2mm (16s.w.g.) or thicker copper wire (preferably silver plated). The size of the loop is fairly important, but not critical.

Small loops will increase the insertion loss of the cavity filter. Loops that are too big will lower the Q of the filter, as well as allowing the filter frequency to be 'pulled' by an external circuit.

Above 200MHz the loops will normally be about about 15% of the length of the copper tube, and about 7.5% of the width. So at 400MHz this is about 25x12mm. Both loops must be identical if the filter input and output impedances are to be equal. The loops should be positioned 2-3mm from the copper tube resonator as shown.

Table 1, gives the important dimensions of the copper tube centre conductor and the input/output loop sizes. As I've said before the dimensions may vary a little without altering the overall qualities of the filter very much. But, below 50MHz some lengths become a little too large to be practical.

### Centre Frequency

To carry out the alignment of the centre frequency of the filters, couple a low power transmitter, of the correct frequency, through the filter to a power meter. Then adjust the frequency adjustment screw for maximum power. **But, be sure to use a low power as the filter will cause a very high reflected power until it is correctly aligned.**

Personally, I only construct two-port filters, even when used in a single port configuration. This allows alignment as for band-pass and band-stop (absorption) with the other port un-terminated.

### Insertion Loss

The filter, as described, will have an insertion loss of about 2dB, and a Q of several hundred. But both parameters may be improved with a little care and attention to detail. (The filter must be mechanically symmetrical with positioning and size of the various components).

Losses can be further reduced by silver plating all metal surfaces within the container. However, I have found this to be an unnecessary luxury; I have always achieved the required bandwidth without silver plating.

The cavity described is so cheap

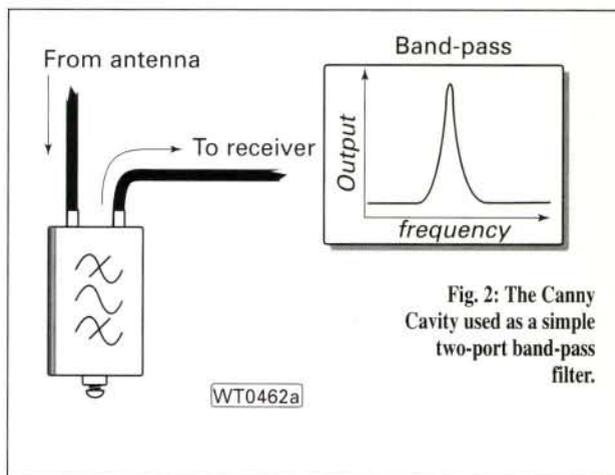


Fig. 2: The Canny Cavity used as a simple two-port band-pass filter.

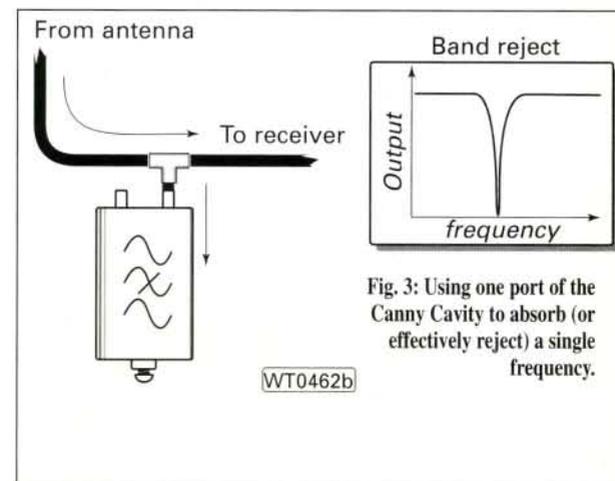


Fig. 3: Using one port of the Canny Cavity to absorb (or effectively reject) a single frequency.

and quick to construct. To obtain a filter Q factors of thousands, two or more cavities may be placed in series.

If you are going to construct a repeater, you may use all-copper or brass construction with internal silver plating. These steps will make the cavity more robust, as well as minimising losses, increasing the Q and aiding long-term stability.

### Unusual Uses

There are some unusual uses for the project! For example: A diode detector on the output of the filter will recover a.m. signals. If the filter is tuned slightly off-frequency f.m. signals are detected due to 'slope detection'.

A simple audio frequency amplifier and speaker connected to the diode detector will reproduce sufficiently strong audio. This could form the basis of a simple a.m./f.m. transmitter monitor or even a local repeater monitor, if you should live sufficiently close to a repeater.

Do not try to fit an r.f. pre-amplifier inside the cavity unless you want to create an oscillator! But you can create a relatively stable signal on the v.h.f. and u.h.f. wavebands. There's plenty of metalwork to dissipate heat, so moderate powers

can be obtained without undue frequency drifting.

Narrow band frequency modulation can be applied by means of variable capacitance diode. No difficulty should be experienced getting an oscillator to oscillate within the cavity.

### Galvanised Dustbin

I've also employed a galvanised steel dustbin and variable capacitor to obtain a filter for 28.05MHz. This enabled me to operate on the c.w. segment of 28MHz and eliminate interference from a close neighbour who was, I think, using a little more than the regulation 4W on Citizens Band!

In the case of impractical sizes, the copper tube inner may be much thinner and coiled into the space available. But I'm not going to go into that now...perhaps another article some time?

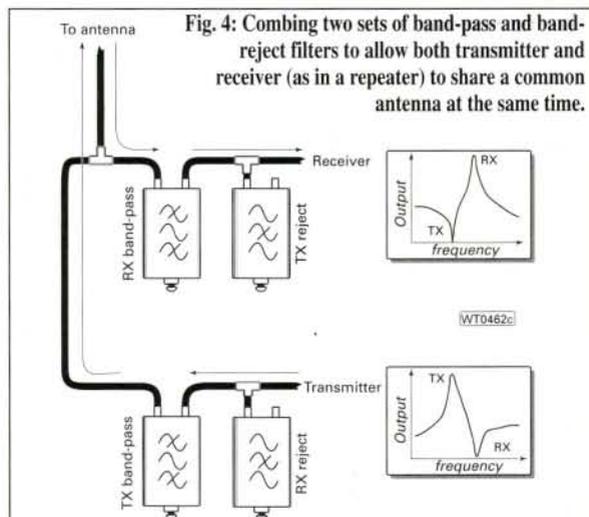
So go on then open up a tin or two and make yourself a 'Canny Cavity' filter. It's easier than you think!

PW

Table 1

Frequency Band(MHz)	Inner length (mm)	Loop Size (mm)
1200 - 1300	51 - 55	10 x 5
420 - 450	120 - 130	5 x 12
140 - 150	350 - 390	60 x 30
70 - 75	700 - 780	100 x 50
50 - 53	1500	120 x 60

Table 1: These are the various dimensions for the 50 to 1200MHz bands. See the text for how to calculate the dimensions for other frequencies.



# RADIO Diary

Compiled by Zoë Crabb

## 1997/8

If you wish to have your Rally featured in Radio Diary, all you have to do is to put together as much information about the Rally as possible, ie. date, location, time, who to contact, etc., and send it to Zoë Crabb at the PW Editorial Office.

\*Practical Wireless & SWM in attendance

**December 14:** The Leeds & District Xmas Radio & Computer Rally is to be held at the Pudsey Civic Centre (Dawsons Corner). All the usual traders will be there, there will also be a talk-in, a licensed bar and disabled facilities, etc. Further information from **John Mortimer** on (01943) 874650 (Bookings Manager), **Gordon Ryder** on 0113-255 0626 (Rally Manager) or from **Malcolm Robertson** on 0113-225 3379 (Club Secretary).

\***December 14:** The Verulam Amateur Radio Club will hold its annual rally at the Watford Leisure Centre, Horseshoe Lane, Garston, Watford, Hertfordshire, from 1000 to 1600. The Leisure Centre is located off the A405 near junction 6 of the M1 and junction 21A of the M25. Attractions will include trade stands, Bring & Buy, grand raffle, cafe, licensed bar and free car parking. Morse tests will be available. For further details call (01923) 262180 or for trade information call (01923) 265572.

### 1998

**January 18:** The Oldham ARC Mobile Rally is to be held at the Queen Elizabeth Hall, Civic Centre, West Street, Oldham,

Lancashire. Doors open at 1100 (1030 for disabled visitors). The event features all the usual traders plus a Bring & Buy stall. Morse tests are available on demand and there is a talk-in on S22 via GB4ORC, commencing at 0730. Mobile Contact prize up to 1400. There will be refreshments and free parking available. (01706) 846143 or 0161-652 4164.

**January 25:** The Lancastrian Rally is to take place at the Lancaster University. Please note that this Rally is now under new management and will be run under the auspices of the Central Lancashire.

Amateur Radio Club. There will be the usual traders, Bring & Buy and ample parking space is available on the campus. Admission is £1.50 and should you require further information, contact **Jim G0GVA** on (01772) 621954.

**February 1:** The 13th South Essex Amateur Radio Society Radio Rally will take place at the Paddocks, Long Road, Canvey Island, Essex. This is one of the biggest and best rallies in Essex, (the Paddocks is situated at the end of the A130). Doors open at 1030. Features include amateur radio, computer and electronic component exhibitors, a Bring & Buy, RSGB Morse testing on demand (two passport photos required), home-made refreshments, free car parking with space outside main doors for any disabled visitors. Admission is £1. **David G4UVJ** on (01268) 697978.

**February 1:** The Harwell Amateur Radio Society will be holding its second indoor Radio & Computing Rally at the Harwell International Business Centre, 1 mile west of the A34, between Oxford and Newbury. Talk-in on S22. Doors open at 1030 (1015 for any disabled visitors). There will be trade stands, special interest groups, Bring & Buy, craft exhibitors, bar and refreshments and

ample car parking with spaces for disabled visitors. Admission is £1, children free. **Arthur G0KOC** on (01235) 815399.

**February 8:** The Kidderminster Radio & Electronics Fair is taking place at the Kidderminster College, Hoo Road, Kidderminster, Worcs. Doors open 1000 to 1500 and admission is £1.50. There will be all the usual traders, plus a Bring & Buy, Flea Market, Food and Drinks and a talk-in on 145.550MHz. **John G8MGK** on (01527) 545823 or mobile on (0860) 147954 or **Tony G4ALT** on (01562) 69652 or mobile on (0860) 902165.

**February 15:** Northern Cross Rally to be held at Thorns Park Athletics Stadium, Wakefield, South Yorkshire, just out of town on the Horbury Road. Easy access from M1 junctions 39 & 40. The event is well signposted and talk-in will be on 144 and 430MHz. Doors open at 1100 (1030 for disabled visitors and Bring & Buy). Details from **Peter G0BQB** on (01924) 379680 or mobile on (0976) 834938. Internet on rally@waveg.demon.co.uk Web page at http://www.waveg.demon.co.uk/rally/

\***March 7/8:** The London Amateur Radio & Computer Show will be held at Lee Valley Leisure Centre, Picketts Lock Lane, Edmonton, London, N9. Doors open 10am to 5pm each day. There will be trade stands with over 100 exhibitors, a Bring & Buy, RSGB committee and book stands, on-demand Morse tests, talk-in on 2m and 70cm, Special Interest Groups, disabled facilities, bars, catering, ample free parking and lectures. Adults £3, pensioners/under 14s, £2. (01923) 893929.

**March 8:** The Wythall Radio Club are holding their 13th Annual Radio Club Rally at Wythall Park, Silver Street, Wythall, near Birmingham on the A435, just two miles from junction 3 of the M42. Doors open from 10am to 4pm and admission is just £1. There will be the usual traders in three halls and a large marquee, bar and refreshment facilities on site plus a Bring & Buy stand. Talk-in on S22. Contact **Chris G0EYO** on 0121-246 7267 evenings and weekends,

FAX on 0121-247 7268 or E-mail at g0eyo@compuserve.com

**March 15:** The 'Norbreck' Amateur Radio, Electronics and Computing Exhibition by the Northern Amateur Radio Societies Association is to be held at Norbreck Castle Hotel, Exhibition Centre, Queens Promenade, North Shore, Blackpool. Doors open at 1100 (disabled access from 1045). There will be over 100 trade stands, club stands, Bring & Buy, RSGB stand and book stall, construction competition, amateur computer stands and free car parking at the hotel, bus from extra car park. There is also wheelchair access to all the exhibitor stands. Radio talk-in on S22. Admission is £2, OAPs £1 and under 14s free. **Peter Denton G6CGF** on 0151-630 5790.

**March 29:** The Pontefract & District Amateur Radio Society Component Fair is to be held at Carlton High School. The venue is 300 yards from the Carlton Community Centre. Car parking will be at the school as usual. The venue will be signposted from the major roads. There will be a talk-in on 2m. For unlicensed visitors, **Nigel Ferguson G0BPK** can be contacted 0900 to 1400 on (mobile) (0411) 420409 for directions. Doors to the fair open at 1100 (disabled visitors will be admitted at 1030). Once again all traders will be on the ground floor. The bar and tea room (tea room open for early visitors) will be on the first floor. Morse tests will be conducted. Admission will be by prize programme. Contact **Nigel G0BPK** on (01977) 616935 in the evening or on (01977) 606345 during the day, or E-mail at g0bpbk@aol.com Traders please contact **Colin G0NQE** on (01977) 677006.

If you're travelling a long distance to a rally, it could be worth phoning the contact number to check all is well, before setting off.

The Editorial staff of PW cannot be held responsible for information on Rallies, as this is supplied by the organisers and is published in good faith as a service to readers. If you have any queries about a particular event, please contact the organisers direct. Editor