The G3HBN portable magnetic loop

For many years, a portable magnetic loop has been in use at G3HBN for holidays and special events. The design was a simple loop of RG-213 braiding slid over a piece of half-inch water hosepipe and supported by pieces of bamboo which formed a pear-shape. The whole was manually tuned and supported on a photographic tripod. It was time to upgrade this loop. The recent articles in *RadCom* inspired a new design

The requirement was to improve the performance and increase the operating bandwidth, if possible. Looking at some aerial history, the old Cage Dipole came to mind. The Cage Dipole was designed to increase the bandwidth and help with the matching of it for commercial broadcasting purposes. In those stations, very long open-wire feeders from the transmitter to the aerial were customary. Aerial tuning units were not used and the feeder was coupled directly into the transmitter with either a link or a π coupling circuit. Such aerials would have a bandwidth of say 2.5 to 5.0 or 5.0 to 10.0MHz.

THE LOOP

The element of this loop is constructed along the lines of the cage dipole outlined above, but only a single cage element is used. This element consists of 12 cables of stranded plastic-covered hook-up wire connected in parallel. The inner core of wire is about 1mm diameter. The overall diameter of the cage is 50mm. The element, when constructed, is placed on an hexagonal wooden frame. A tuning capacitor of 525 + 525pF with slow-motion drive is used to bring the loop to resonance at the desired frequency. The tuning range is from 6.9 to 32.0MHz. The loop is fed with a Faraday link coupling made with RG-213 coax, the braiding of which is open for 2.5cm at the centre. The photograph shows the completed loop on a tripod mounting. One of the problems of magnetic loops is the very narrow bandwidth. **Table 1** illustrates the comparison between a 1m, 22mm copper tube element and the 1m, 50mm caged element.

A worthwhile bandwidth increase has been achieved. This represents an overall improvement in performance and is reflected in the results. The outer diameter of the loop at the diagonals is about 105cm. When the length of the conducting element becomes greater than λ/4, the loop ceases to operate properly and becomes difficult to couple. It is desirable, therefore, to try to keep the overall conductor length to about 0.24λ or less at the highest frequency of operation. Although the model described here will operate on 29MHz, the element is really just a little too long.

Table 1: Bandwidths of the two designs.

Portable loop 12-wire cage	Centre Frequency	Fixed loop 22m copper tube
21	7015	11
30	10115	16
50	14050	30
75	18100	45
110	21100	60

Notes: All values in kHz.
Measurements were taken at VSWR of 1.3:1 points with a Welz SP-300 VSWR / power meter.
Both loops had a VSWR of 1:1 at the centre frequency.

Table 2: Parts list.

3	old CDs glued together to form the centre core
2	plastic 3cm plumbing nuts glued together
7	plastic till-roll spools or similar rigid plastic tube that fits the dowels
6	dowelling spokes, 12mm, for the hexagon
5	plastic 10mm or 15mm wall-mounting water pipe clips
4	2.5cm (1in) rubber tap washers
5	3 x 40mm bolts with nuts and washers
5	water pipe saddles to strengthen centre mountings
12	55mm plastic discs.
4	packets of 10m of 6A (24/0.2mm) hook-up wire (Maplin)
	Connectors to suit termination to the capacitor
1	525pF + 525pF variable capacitor
1	suitable plastic box or non-metallic container
1	slow motion drive 6 or 7:1 reduction.
1	well-insulated tuning knob, or plastic coupler and knob
1m	RG-213 Coax
5	Terry clips, 10mm
	Portable and rotary mounting

CONSTRUCTION

Most constructors seldom follow exactly what is described in an article but, listed in **Table 2**, are the items that went into making this particular model.

The assembly is fairly obvious from the photographs and **Fig 1**. There are several points that are not so obvious. The overall diagonal measurements from the centre to the outer cables should not be less than about 105cm. If the hexagon is smaller than this, with the cable specified, the loop might not quite tune to 7MHz. With this measurement, the loop should tune from 6960kHz to 32MHz.

The dowelling should be cut into five lengths of 47cm and inserted into rigid plastic tubes (eg till-roll inners) at the centre hub. The sixth length is measured to fit whatever mounting box can be found. The seventh plastic support should be mounted to the tuning box and then the sixth spoke measured and cut. The five white plastic pipe clips are screwed to the ends of the five 47cm spokes.

The spacers are made with the 12 plastic discs cut from about 1mm thick plastic. A 3-litre food container was cut into flat pieces which were scored with 55mm circles. A further circle of 50mm diameter was scored inside each one. Marks should be made every 30° on the 50mm circle for drilling the holes for the cables. A centre hole should be drilled for the fixing bolts and rubber washers.

The capacitor should be mounted and some suitable terminals used. PL-259/-239 plugs and sockets were used in the example, but ordinary spade terminals would be easier and just as good. The capacitor is wired to the connectors and loop using *only the fixed vanes*, the rotor being left unconnected or 'floating'.

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FIG 1 © RADCOM 510

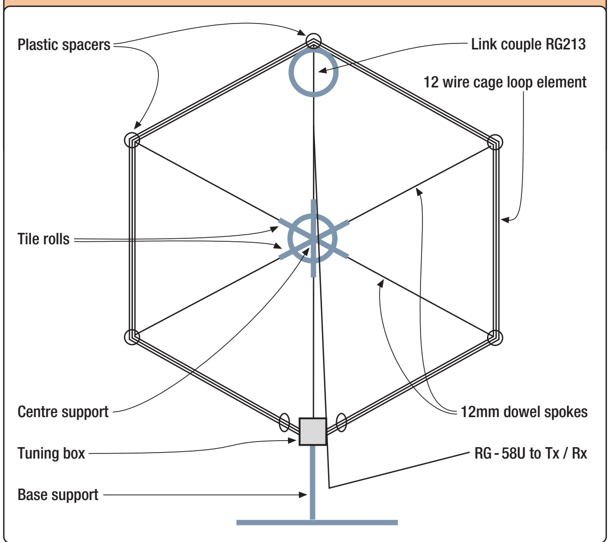


Fig 1
The magnetic loop – for dimensions, see text.

This halves the capacity but doubles the working voltage. Further, it has the advantage of there being no moving contacts involved in the RF path. A well insulated knob, or plastic shaft coupler and knob should be used for tuning.

When the whole framework is assembled, the loop can be wired. Because the conductor is formed in a cage, the cables forming this cage will be of different lengths. Each wire must be threaded through the holes in the plastic spacers *on the frame*. The 12 wires can be cut roughly to length with plenty to spare for termination (coloured wires are a great help here) or from a reel of cable. But, in either case, each wire must be run separately, like stringing a musical instrument. Start with the cables nearest the centre and work outward to the top. Terminate all 12 cables at one end first and solder them to a lug or terminal or PL-259 etc. Connect this end to the tuning box. The other end is more difficult, because the wires need to be reasonably tensioned to form the cage. If they are a little slack, the rubber washers holding the spacers to the spokes provide some adjustment for this purpose. Once the loop element is finished, don't forget to mark which is the top of the cage on the plastic spacers!

Great care must be taken with *all* soldered connections to minimise any DC resistance.

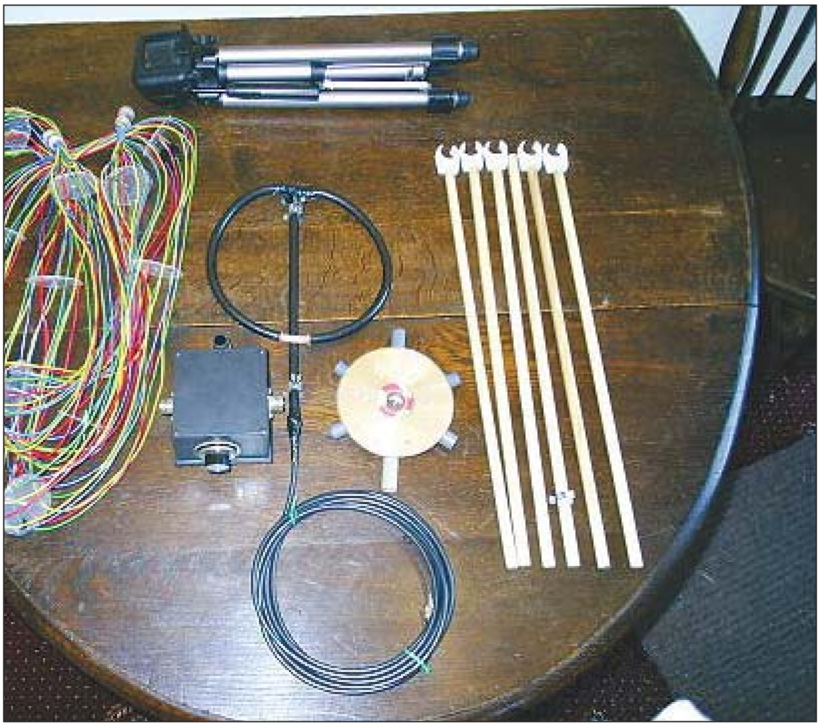
The coupling link is made with RG-213. Many trials were conducted to optimise the coupling but, with the 'fatter' conductor for the loop element, it was found that the coupling link also needed to be 'fatter'. To form the link, strip about 4cm off the cover, expose the inner conductor for 2.5cm and solder the braiding to the inner. From the tip of the join, measure 60cm of cable. Strip about 3cm of cover to expose the braiding and solder the shorted end to the exposed braiding. This will form the coupling link of about 19 to 20cm diameter. At the centre of the link, cut the braiding for about 2.5cm to expose the inner core as illustrated. Bend the remaining coax from the join to run vertically through the centre of the link and join it to the desired length of RG-58U. The mountings for the link are made with two Terry clips bolted back-to-back which clip neatly over the centre spoke and the RG-213.

OPERATION

The first step in tuning the loop is to peak it for maximum aerial noise and/or signal strength on a receiver. If an aerial analyser is available, a quick check can be made for all the bands to observe the VSWR. A 1:1 VSWR should be obtainable on all bands from 7 to 29MHz. If 1:1 cannot be achieved, the aerial should be rotated, observing the VSWR at the same time. Adjacent objects in a room can unbalance the loop and, under these circumstances, it might not be possible to obtain the necessary VSWR. A VSWR/power meter is

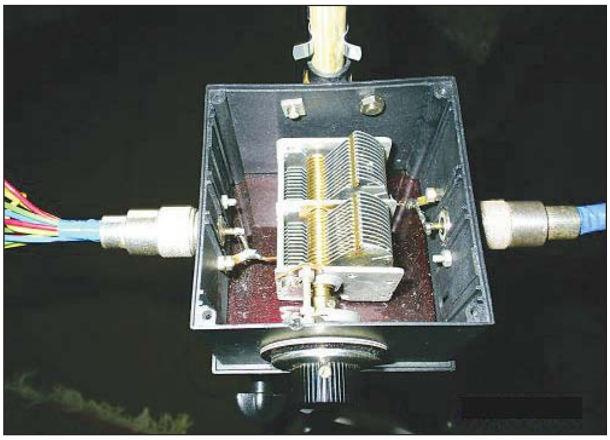
The loop in use at G3HBN.

Detail of the loop centre and link.



Left
Ready for packing.

Below
The tuning box.



an asset, but the loop can be tuned with a simple field strength meter, tuning for maximum signal. Remember that maximum field strength radiation will be in the plane of the loop. On receive, this will be quite marked and a null will be obtained when the aerial is broadside to the signal. However, this does not always seem to be the case. Often very strong signals are received broadside to the loop and the same signal path seems to be effective for both transmission and reception. This may be due to building reflections, another illustration of where the loop needs to be easily and quickly rotated. This is particularly useful when operating low power (QRP).

At the lower frequencies, the tuning of the loop is very sharp and it is essential to have a slow-motion drive fitted to the tuning capacitor. On the higher bands, the tuning is not quite so sharp, but it is still beneficial to tune the loop 'on the nose'. Hand-capacity has not proved to be a problem with this design. On the lower frequencies, the tuning capacitor is large and therefore any hand-capacity is insignificant. On the higher frequency bands, where hand-capacity is noticeable, it is still not too serious a problem because, at those frequencies, the usable bandwidth is much greater. There is, of course, absolutely no requirement for an ATU, if one is fitted to the equipment it should be either de-selected or tuned to a 50Ω load before using the loop.

This model is not built for high power, but it will comfortably handle 20 – 25W. Normally, any indoor aerial used in a built-up area should not really be used for high power, since the problems of RFI (Radio Frequency Interference) can become critical. The loop should be placed as far away from the operator as is practicable.

RESULTS

Tests were carried out in CW (Morse) from the location pictured, in London, and a seaside cottage in Folkestone, with power levels of 5W and 20W. The majority of contacts made were at the 5W level. The overall feel of the aerial was quite amazing, with signals over two S-units stronger than with the original 80cm loop, particularly on the lower-frequency bands. Comparison tests were made between the portable loop and the octagonal loop of 1m diameter on the roof. The roof aerial was, in the main, about 1 S-unit better, but the reports were that QSB (fading) was more prevalent with the indoor loop. Signal reports received varied with conditions, but reports of RST 579 and 589 were not unusual. Throughout the three-month trial period, frequent contacts were made with most European countries, Asia and North America. With 20W, the reply rate to stations called was between 70 and 80%; with 5W it was about 60 to 70% This is about the norm for QRP operation. Calling CQ was not very profitable and seldom is with QRP. Many two-way QRP contacts were also made, one notably on 30m with GM3OXX (1W RST 579), G3HBN being in Folkestone (5W RST 599), the loop being at ground level in the sitting room, about 20m above sea level. This was a very long ragchew. Conditions throughout the test period have been at an all-time low and extremely difficult for making reliable evaluations. However, several DX stations were worked with QRP and that in itself was most gratifying. No tests were made for RF feedback when using a microphone.

CONCLUSIONS

The object of improving the original loop has been achieved with greater success than expected. It seems the application of a multi-cable radiating element for the loop has brought with it more benefits than originally anticipated. The increased bandwidth is far greater than expectations and the improved overall performance in the liveliness of the aerial was a pleasant surprise. The next move is to replace the octagonal loop on the roof with a weather-proofed multi-conductor version. The results obtained here also open the door for further development in the general approach to the magnetic loop as an aerial in its own right, not necessarily to be compared with other aerial types. It is a radiator that has many characteristics that would seem not yet to have been fully exploited. ♦