RADCOM TECHNICAL FEATURE

# More on Short Loop Antennas

**After publication of Roberto Craighero I1ARZ's article on short loop antennas in Radcom, he received several requests for further explanation about this type of aerial, both from the mechanical and electrical point of view. Here are answers to the various questions raised, followed by construction details for a Portable 20m Short Loop.**

THE CIRCULAR LOOP gives a better performance than other shapes because of the higher radiation resistance that such a configuration presents. In fact, radiation resistance is also dependent on the area included in the loop. We know from geometry that a circle is the figure which has the greatest area for a given circumference. The loop, however, can be built with different shapes, but will have lower overall efficiency for the following reasons:

1) The area within the loop is smaller for shapes other than circles, and the resultant radiation resistance is lower.
2) The loop can be built with straight pieces of pipe. This simplifies the construction but increases the ohmic losses due to the welding which joins the various pieces. For example, an octagonal shape loop has (in theory) an efficiency very close to a circular shaped loop but at least seven joints have to be welded to obtain such a configuration. Therefore it is preferable to make the loop circular in a single piece, or if the loop is very large, split it into two semi-circles joined at the base This then requires only one joint to form a large loop.

The square configuration has a lower radiation resistance and represents the worst case in terms of efficiency, but needs only four joints. This solution, despite the previous argument, is a very acceptable compromise between reduced efficiency and easy construction. Maximum care must be exercised in making the four joints (90° copper elbows) to reduce ohmic losses. Such losses can be partly compensated by using a larger diameter conductor. I used this method to build a 40/80m band square loop, having an overall perimeter of 10.70 metres. This used 40mm copper tubing of only 1/2mm thickness, resulting in a very light loop, supported in the middle by a discarded strong fibreglass windsurf mast.

Copper tubing is the preferable conductor for loops but, alternatively, aluminium may be employed. To compensate for the lower conductivity of aluminium compared to copper, the diameter of the tubing must be increased to say 30/32mm. This gives the advantage of having a self supporting loop of aluminium pipe, strong enough to withstand dynamic wind stresses. It should be noted, however, that difficulties arise in the welding operation, as welding aluminium is not an easy task.

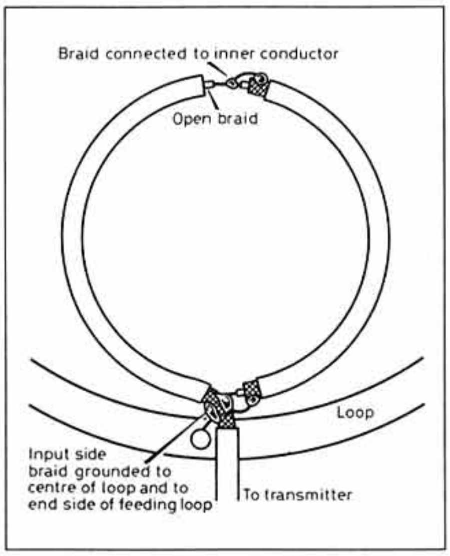



**Fig.1: Details of the coaxial feed loop employed with the loop antenna.**

## EFFICIENCY

WHEN THE CONDUCTOR length approaches 0.25λ the loop achieves its maximum efficiency. This also corresponds to the largest bandwidth, and the lowest voltage across the tuning capacitor, which is important for building a monoband antenna. In this case the capacitance to bring the loop to resonance can be obtained using a fixed capacitor in parallel with a small variable one, sufficient to cover only the desired band. Another simplification is obtained from the relativity large bandwidth which permits faster and less critical tuning. Therefore good quality, wide spaced, silver plated butterfly capacitors for VHF use may be employed since low capacitance values will cover a single band.

The parallel fixed capacitor of appropriate value must be a high quality transmission type ceramic capacitor, with adequate rating to support the high RF voltages existing at that point. The use of a switch to insert various fixed capacitors for different bands is not possible due to the high ohmic losses existing on the contacts of the switch. A simple method of obtaining a good, highly insulated, fixed capacitor, is using a short piece of RG8 coax cable. Bearing in mind that such cable has a capacitance of about 1pF for each centimetre length, you can build your capacitor with length slightly greater than the calculated value of capacitance. With the old 'cut and try' system, you can easily bring the loop to resonance using this method. Maximum input power should not exceed 60-70 watts.

The external braid must be welded to one loop end and the inner conductor to the other. Also welding must be performed with great accuracy. Another method of building a capacitor with a high insulation factor is by using copper clad printed circuit boards.[1].

A portable loop can be built using only the external copper braid of an RG213 coax cable, as a conductor. Compensation for losses due to the small diameter of the coax is desirable when using the loop for a single band.

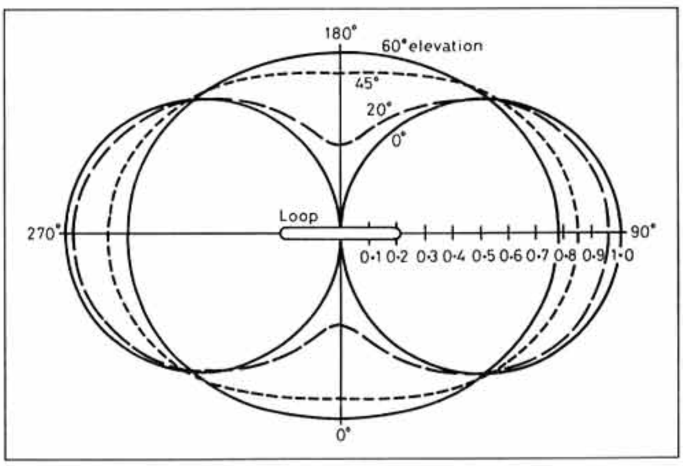


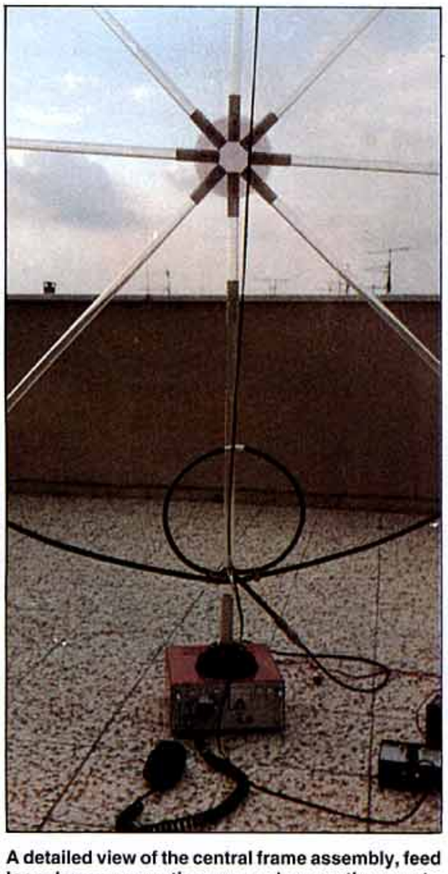

**Fig.2: The interesting radiation pattern of a vertically mounted loop antenna (*QST*, June 1986).**

# A Portable Short Loop Antenna for the 20 Metre Band

AFTER EXPERIMENTING with short loop antennas at my QTH [2], I decided to build a portable antenna of this type to be used for field days or summer holidays.

My first attempt, was a short loop antenna for the 10 and 20 metre bands. It was 80cm in diameter with copper tubing of 22mm outer diameter, and was silver plated to obtain the best RF conductivity. The tuning mechanism had a remotely controlled electronic reduction gear. I fitted a strong magnetic mount to keep the loop standing on the roof of my parked car (see photograph). The antenna worked very well with outstanding results, even using very low power (less than 2W). The car roof acted as an efficient ground plane, providing excellent performance for semi-portable activity. For transportation, the antenna can be stowed in the car boot without difficulty. However for true portable operation, the loop is heavy and cumbersom.

I enjoy hiking and, therefore, decided to build a really portable loop that could be easily assembled and dismantled, was light in weight, and efficient at radiating the signal from my QRP rig.



A detailed view of the central frame assembly, feed loop, lower supporting arm and magnetic mount.

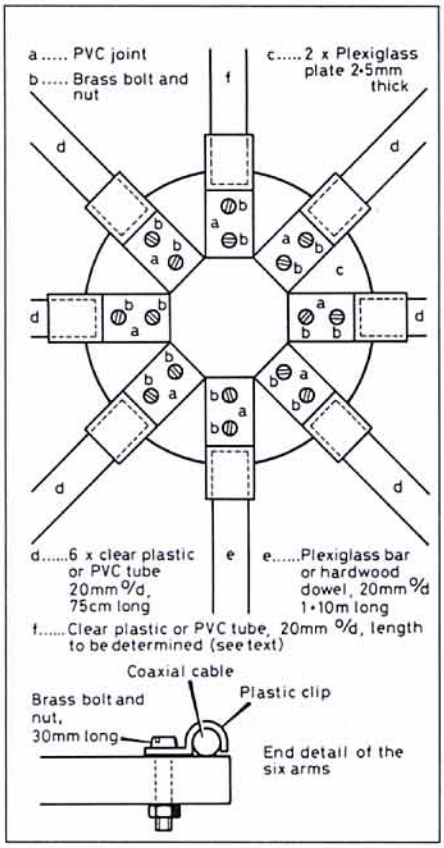



Fig 1: The loop has eight plastic/PVC supports.

## CONSTRUCTION DETAILS

AS MY QRP RIG IS 20 metres, I designed the antenna for this band. I decided to use the external braid of a coaxial cable as the loop conductor, bearing in mind the weight of the whole system and its portability. In fact a length of coaxial cable can easily be coiled for transportation, and I chose RG213 coax, which is excellent for this application.

To obtain the best radiation efficiency the maximum circumference of the loop was slightly less than $\lambda/4$ length (about 5.1 metres) for the required frequency [2]. This length is necessary to compensate for the small diameter of the coax cable braid (about 10mm). The resultant loop diameter is 1.62 metres, and the calculated radiation efficiency about 80%.

Both ends of the coax are terminated with UHF PL259 plugs, and the coax inner conductor has only a mechanical function, not being electrically connected to the respective SO239 sockets. To ensure the best electrical contact and get a better flow of tin over the coax braid, additional holes must be drilled in the PL259 plugs. These joints will introduce radiation losses due to ohmic resistance, and therefore good soldering is essential. Unfortunately it is impossible to avoid the connectors if you wish to obtain a fully collapsible loop.

## THE SUPPORTING FRAME

AN INSULATED SUPPORTING frame is required to keep the coax cable in its correct circular shape.

I then built a light plastic tubular structure which was easy to assemble and carry, but rigid enough to withstand dynamic wind stresses when in operation. The frame had eight arms connected to a central assembly.

This central assembly consisted of eight plastic joints, of a type normally used to

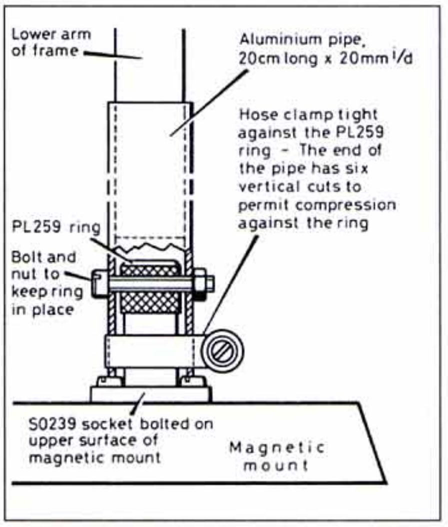



Fig 2: Detail of the magnetic mount assembly.

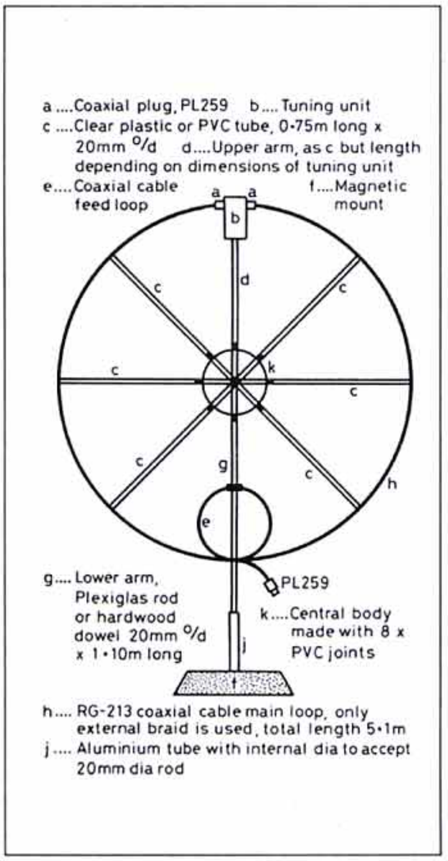



Fig 3: Construction of the 20m Portable Short Loop.

connect two PVC pipes in domestic electrical wiring. Such joints will accept 20mm outer diameter plastic pipes, which are placed in a circle 45° apart. Two round plexiglas plates (2.5mm thick) keep each joint in place by means of two brass nuts and bolts (3mm) - see **Fig 1.** The 8 arms of the structure are clear plastic or PVC pipes with an outer diameter of 20mm. Six of these are 75cm long and have a small plastic clip at one end, kept in place with a brass nut and bolt (2mm). Such clips must be of the correct size for the coax cable.

The whole antenna is supported by the lower vertical arm of the frame. This must be strong, otherwise the structure will be unstable due to the weight of the tuning unit at the top. I used a 20mm OD plexiglas bar, but a hardwood rod of the same diameter could be used instead. The lower vertical arm is also the 'mast' of the antenna and must not be less than 1.1m long. The upper vertical arm is shorter because of the length of the tuning unit at the upper end. For transportation all eight arms can be lashed together and fastened on the side of a rucksack. The coiled coax line and central frame assembly are then stowed in the sack, together with the transceiver and other accessories.

## THE BASE MOUNT

DURING MY TESTS I found that the following method of keeping the antenna in position was both simple and practical.

**The short loop antenna in operation from the Italian Eastern Dolomites at 2250m above sea level. It is light in weight, and easily dismantled for transportation.**

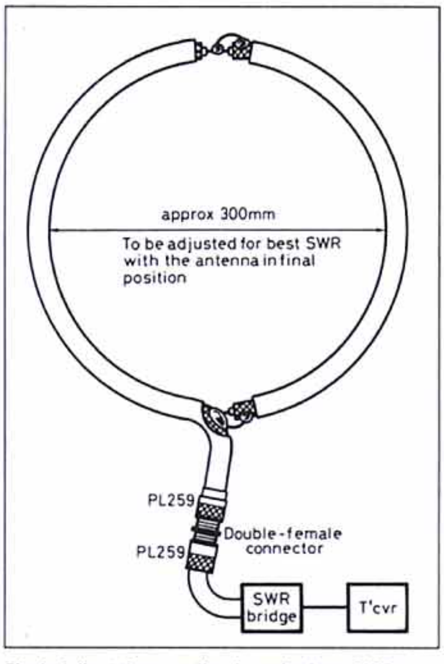



**Fig 4: Adjust the coupling loop for best SWR.**

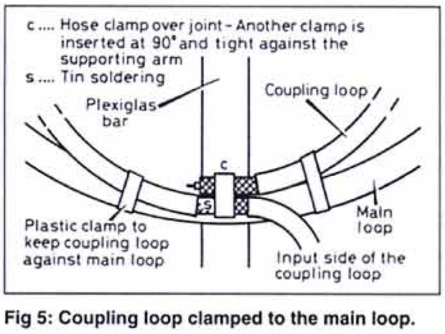



**Fig 5: Coupling loop clamped to the main loop.**

I used a strong magnetic mount originally intended for a CB whip antenna, which was placed on the steel cover of the transceiver. A short piece of aluminium tube was used to connect the frame to the magnetic mount, with an SO239 socket mounted as shown in **Fig 2**. The tube had an internal diameter to suit the 20mm plexiglas bar at the lower end of the supporting frame, and a coupling ring comprising a PL259 connector was bolted inside. It was then possible to screw the short aluminium tube onto the magnetic mount via the SO239 socket, and insert the 'mast' of the supporting frame into the opposite end of the tube. The antenna stayed perfectly upright and rotating the mast by hand gave an indication of the best orientation for transmitting or receiving (See **Fig. 3**).

## THE INDUCTIVE COUPLING LOOP

INDUCTIVE COUPLING, in my opinion, is the best method of feeding a short loop antenna. Maximum power transfer is achieved, and it is easy to adjust for minimum SWR over a very large frequency range.

The construction of the coil is straightforward (see **Fig. 4 and 5**). The dimensions are typical, and in practice the coupling loop must be trimmed until an acceptable SWR is achieved. It is best to start with a slightly oversize loop and cut it symmetrically at the ends. Then rejoin it again, until an SWR not exceeding 1.3:1 is reached. An improvement in SWR can also be obtained by slightly deforming the coupling loop, and then fixing it in the best position. All adjustments must be made with the antenna mounted in its final operating position.

The input side of the coupling coil is terminated in a PL259 plug, followed by a double female coax connector and short feed line to the transceiver. An SWR bridge should be used to tune the antenna to resonance.

## REFERENCES

[1] Ted Hart, W5QJR, *QST* June 1986

[2] R Craighero 'Electrically Tuneable HF Loop' *RadCom* February 1989 pp 38-42.

***. . . to be continued***

NEXT MONTH in part 2, I1ARZ gives full constructional details of the tuning unit.

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# More on Short Loop Antennas

**Roberto Craighero, I1ARZ, concludes his discussions of a practical short loop antenna for 14MHz with a description of how to tune it remotely.**

THE LOOP MUST BE remotely tuned; do not try any hand tuning! Apart from the fact that the tuning capacitor is about 2 metres above ground, manual tuning is difficult and not fast enough for normal operation during QSOs.

With a monoband antenna as described, only a small capacitor is needed to resonate the loop, and the capacitor rotation speed is not as critical as for a multiband antenna, due to bandwidth considerations. A VHF capacitor, parallelled with a good quality, fixed, transmission type ceramic capacitor are sufficient to resonate the loop over the whole 20 metre band. In my antenna, I used a split stator (this type of capacitor is essential) VHF variable capacitor. This was a silver plated type, and each section had a value of 10pF. The two sections in series with the loop gave a resultant capacitance of 5pF. I added a ceramic fixed capacitor of 15pF in parallel giving a total capacitance of 20pF. In addition there was the distributed capacitance of the loop, (about 5pF), resulting in a total capacitance of about 25pF. This value was sufficient to resonate the loop over the whole 20 metre band. A suitable split stator capacitor of about 50pF per section will give similar results.

Of course the insulation of the capacitors must be considered, in view of the very high RF voltages existing at this point, especially at higher RF power levels. By calculation, at 100 watts the corresponding RF voltage at the capacitor is about 4kV for a loop of these dimensions. If QRP work is envisaged (most likely for portable operations) the insulation factor is less important, due to the lower RF voltages involved.

The DC tuning motor must not exceed 2RPM. With faster motors an electronic speed control device may be used to reduce the tuning speed, as necessary. [2] Alternatively a mechanical Bulgin type reduction gear should be mounted between motor and tuning capacitor. Each stator section of the variable capacitor should be directly soldered to an SO239 socket or, if this is not possible, a suitable copper bracket should be provided for each socket. Accurate soldering is of paramount importance to reduce the ohmic losses to a minimum. The inner contact of the socket is not used, as the centre conductor of the coax cable is not connected.

The tuning unit is mounted inside a plastic bottle (I used a washing-up liquid bottle !) with a suitable neck diameter, firmly forced inside a PVC joint as shown in **Fig.6.** The bottom of the plastic bottle is cut away and replaced with a circular plexiglas plate (2.5mm thick). The variable capacitor is fixed to the centre of this plate, with the shaft connected to a circular ceramic coupler, followed by another connected to the motor spindle (or mechanical reduction gear, if required).

The unit is then fitted inside the bottle which is partially filled with well compressed rubber foam. A small opening for the motor must be cut into the bottle wall and the motor body securely glued in position. Also, the circumference of the plexiglas plate carrying the capacitor must be glued and forced into the base of the bottle. The motor terminals are then connected and by-passed by two 10nF disk capacitors. The motor feed cable must be made with screened twin leads (eg Hi-Fi type), and the braids connected to the motor body and by-pass capacitors. This cable runs along the vertical arms of the supporting frame in the centre of the loop, and it must be possible to disconnect it for transportation. A small plastic base with a brass nut and bolt is fitted to the joint connecting the bottle neck to the supporting frame. This plastic base has two RCA phono sockets connected to the motor. The motor feed line is terminated with the relevant RCA plugs, and connected to the respective sockets on the electronic control box (or to the reversing polarity switch of the motor supply) [2].

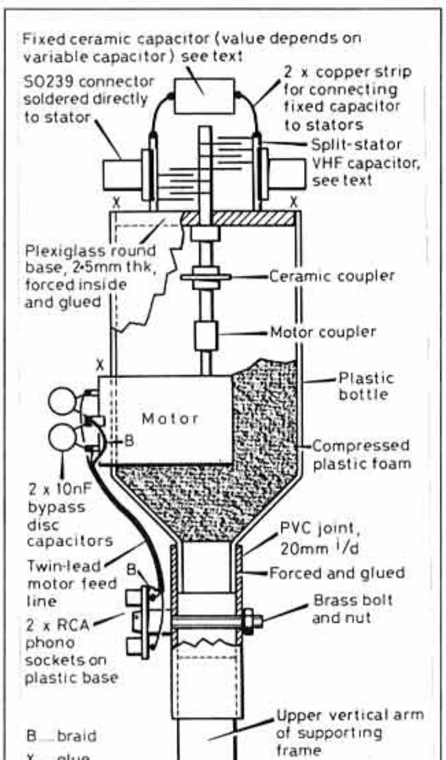


Fig 6: Detail of remote tuning unit.

The length of the upper vertical arm of the supporting frame may be calculated, taking into account the loop circumference, and the position of the capacitor and SO239 sockets.

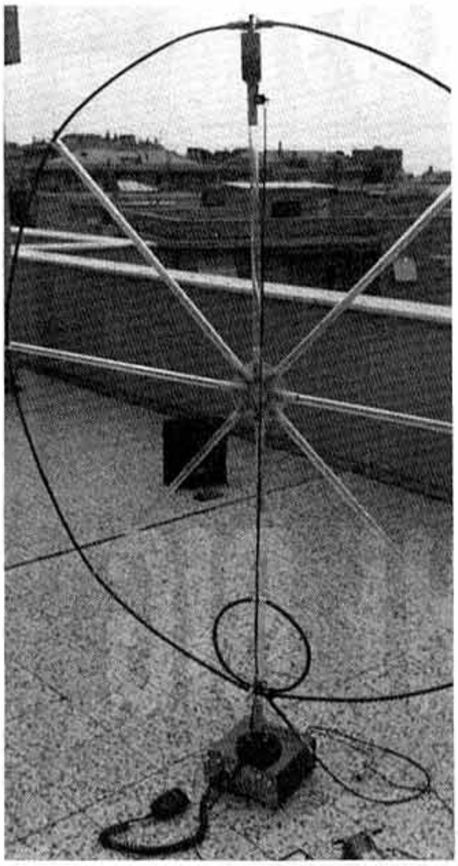
The tuning unit is attached to the top end of the upper vertical arm, and for transportation may be disconnected and kept in a safe place to avoid damage. To assemble the antenna, first insert the eight arms into the central assembly with the frame lying on the ground. Then the coax line is connected into the sockets on the capacitor, and also clipped to the end of each arm. Also, the motor feed line must be connected into the RCA sockets. It is now possible to raise the frame vertically and insert the 'mast' into the tube of the magnetic mount placed on the transceiver cover. The coupling loop can now be fitted in place, and the hose clamp tightened on the plexiglas bar. The lower side of the coupling loop must be adjacent to the inner side of the main loop. Two plastic clamps should be placed symmetrically on each side of the hose clamp fixing point. **See Fig.2.** An SWR bridge and short feed line should now be connected to the output socket of the transceiver.

The antenna is now complete and takes less than five minutes to assemble or dismantle.

## CONCLUSIONS

THIS ANTENNA CAN easily be adapted for multiband use. With a larger capacitance value it is possible to resonate it for the 20 and 40 metre bands. However best efficiency is obtained only on the higher frequency band where the loop conductor is about $\lambda/_4$ long. If you wish to work on other bands it is easy to modify the loop dimensions accordingly. Remember that with the BASIC computer program published in my previous article [1], it is possible to quickly calculate all the main parameters of a short loop antenna. For more theory on loop antennas I suggest a rereading of my previous articles [2] and [3].

The results obtained with this portable loop



I1ARZ's 20m loop antenna and remote tuner on the roof of his apartment.

were outstanding. With about 1.5 Watts PEP reports from across Europe reached S9 on several occasions with the loop mounted at ground level. This confirms once more the excellent characteristics of the short loop antenna, provided care is exercised during construction and good materials are employed.

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This type of antenna is now becoming more and more popular, and represents an efficient solution for those radio amateurs unable the erect beams or large wire aerials.


### REFERENCES

[1] Ted Hart, W5QJR, *QST* June 1986

[2] R Craighero 'Electrically Tuneable HF Loop' *RadCom* February 1989 pp 38-42.

[3] R Craighero 'A Magnetic Loop Antenna for the Low Bands' *RadCom* February 1991 pp 38-40.

[4] 'Technical Topics' *RadCom* November 1989 pp 37.


### COMPUTER BASIC PROGRAM FOR LOOP CALCULATIONS

```
5   CLS
10  PRINT "CALCULATION OF MAIN PARAMETERS
    OF A COPPER TUBING"
20  PRINT CIRCULAR SHAPED SHORT LOOP ANTENNA"
30  PRINT
40  PRINT
50  PRINT "Conductor Length          METERS:";: INPUT SS
60  S=SS*3·281
70  PRINT
80  PRINT "Conductor Diameter   MILLIMETERS:";: INPUT DD
90  D=DD*.03937
100 PRINT
110 PRINT "Frequency                    MHz:";: INPUT F
120 PRINT
130 PRINT "Power                       WATT:";: INPUT P
140 PRINT
150 CLS
160 A=7·900001E-02*S^2
170 PRINT "LOOP AREA            SQ. METERS:";: B=A*·0929:
    PRINT B
180 PRINT
190 RR=3·38 *10^-8*F^4*Â2
200 PRINT "Radiation Resistance        OHMS:";RR
210 RL=9·96*10^-4*SQR(F)*(S/D)
220 PRINT "Conductor Loss              OHMS:";RL
230 E=RR/(RR+RL)*100
240 PRINT "Efficiency in percentage       %:";E
250 DB=LOG(E/100)/LOG(10)*10
260 PRINT "Efficiency in dB              dB:";DB
270 L=1·9*10^-8*S*(7·353*LOG(96*S/3·1418/D)/LOG(10)-6·386)
280 PRINT "Loop Inductance            HENRY:";L
290 XL=2*3·1418*F*L*10^6
300 PRINT "Inductive Reactance         OHMS:";XL
310 Q=XL/(RR+RL)/2
320 PRINT "Quality Factor                 Q:";Q
330 DF=2*(RR+RL)/XL*F*1000
340 PRINT "Bandwidth                    KHz:";DF
360 VC=SQR (P*XL*Q)
365 PRINT "Capacitor Voltage          VOLTS:";VC
370 CT=1/(2*3·1418*F*XL)*10^6
380 PRINT "Tuning Capacitor             PFd:";CT
```

Fig 7: This computer program can be adapted for most versions of BASIC.