

# Transmitting Ferrite Loop for 80/160

*Thirty years of experimenting ... now it's your turn!*

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Little has been published in the amateur radio press on the subject of ferrite rod transmitting loop antennas. I have been experimenting with these, off and on, for around 30 years.

Here we will look at some earlier background problems, frustrations, and pitfalls first, and then get into a practical 80/160 m design. It is my hope that other amateurs will also experiment along similar lines to produce even better loops, and get some real "on air" activity going. This should more rapidly increase the rate

of practical design progress, in a field which heretofore seems to have been mostly limited to defense development and a few commercial activities.

It was way back around 1960 when I first became interested in the workings of the ferrite rod loop or loopstick. At that time, the usual assembly was an eight-inch-long by three-eighths-inch-diameter ferrite rod, built into a broadcast receiver operating on the medium wave band (and long wave in Europe).

I first wound a coupling coil onto a ferrite loop antenna to enable it to be used as an external antenna coupled to the receiver with coaxial feedline, as in **Fig. 1**. This is now accepted practice.

The next move was to reduce the number of wire turns so that the loop resonated in the 160 and 80 meter bands. The results were encouraging, although progress was slow.

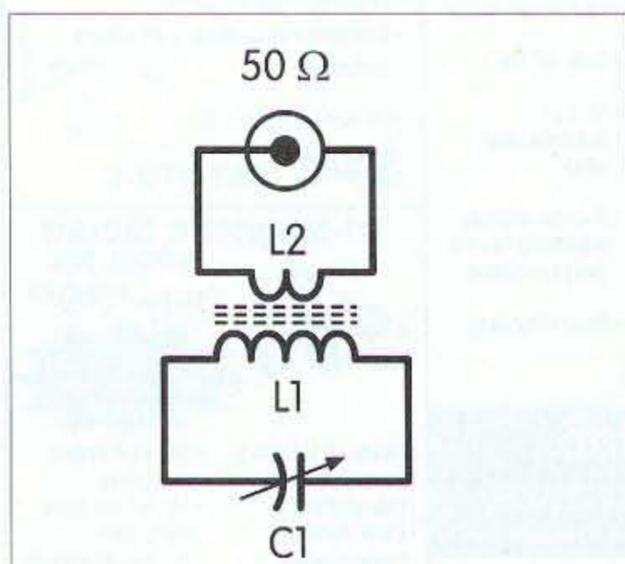
It seemed logical that, using the **Fig. 1** circuit, the process could be reversed—that is, RF fed into the coupling coil via the coaxial feedline—to produce a transmitting loop antenna. My first results were somewhat encouraging, but initial efficiency was very low.

I approached a ferrite rod manufacturer and asked for a quotation for a quantity of six pieces of every eight-inch rod of all available materials, together with materials specifications. The result was a quotation for a minimum order of 5000 pieces in two types of materials—nickel-zinc and magnesium-zinc. Not very helpful!

Later, I inquired as to whether they had any information/experience on the subject of using ferrite rod loops for transmission purposes, or knew where such information might be obtained. The reply was ambiguous (neither yes nor no). In effect, they said they were not prepared to discuss the subject. I took this to indicate that such work was indeed being undertaken, but they could not or would not talk about it.

This only increased my determination to carry on experimenting with ferrite TX loops, with only limited facilities, and without any help or advice from rod manufacturers.

Gradually I gained experience by trial-and-error methods, reaching the conclusion that an effective transmitting ferrite loop antenna could eventually be designed and produced.



**Fig. 1.** The conventional ferrite loop. OK "on receive" only.

In the early 1970s, I moved to Minnesota (USA) to live, work, and operate (G2BZQ/WØ). There, nickel-zinc ferrite rods were readily available, as well as Type 61 material in half-inch-diameter rods. Now I was able to make further progress. The circuit in Fig. 2 gradually took the place of Fig. 1, and I was able to produce a good input-to-output ratio using single rods.

### Design challenges for 80 and 160 meters

- Selection of suitable rod materials and dimensions.
- Difficulty of matching/coupling the loop to the TX.
- Core saturation.
- Producing a radiated signal.

### Core saturation

When RF is applied to a TX ferrite loop antenna, a point is quickly reached, as power is increased, at which core saturation manifests itself. This is accompanied by a sudden increase in core temperature; a sudden decrease in radiated output signal; and general instability and the production of harmonics, especially the third.

The ferrite rod transmitting loop is essentially a low-power device. Fortunately, this means you can experiment using small-dimension assemblies along the lines of those from the modelmaking hobby, which can be played with in the comfort of your home, irrespective of the weather outside! The basic equipment you need is a field strength meter, a large neon bulb, and a portable receiver.

### Ferrite rod selection

Ferrite rods can be divided into two main material groups: manganese-zinc and nickel-zinc. You can obtain each in various "mixes," for different applications. Unfortunately, both types are the same in appearance, so you have to be careful in trying to identify surplus rods.

Experimenting in the 80 and 160 meter bands will teach you that a nickel-zinc rod with an initial permeability of between about 126  $\mu$  and 220  $\mu$  will be the best. There is every indication that this permeability changes

considerably under TX loop conditions. Because we will have to use commercially available rods, our choice will have to be restricted to Amidon Type 61 and MMG Type F14 (with permeabilities of 125  $\mu$  and 220  $\mu$ , respectively). Manganese-zinc rods (e.g., Types 33 and 43) appear in quantity on the surplus market at attractive prices, but they should be avoided at all costs. They have an initial permeability of maybe 800/850  $\mu$  and are quite useless for ferrite loops above VLF and LF.

Experience also has taught me that antenna gain and directivity increase as the rod diameter and/or the rod length is increased. The maximum nickel-zinc rod diameter is one-half inch, with lengths of up to eight inches. You can lengthen rods by adhering two or more of them together, end to end, just as you can increase the diameter by affixing two or more together side by side. The spacing between wire turns, and between wire turns and the ferrite core, is critical.

### Some practical TX ferrite loop designs

Over the years I have tried a great many permutations of the ferrite loop antenna for transmitting, with results ranging from quite useless to quite encouraging.

The antenna shown in Fig. 2 produced some interesting and unexpected results. I experimented with variations of this design in the 1970s and 1980s. The input/output power ratio was my best up to that time.

I started with a simple seven-and-one-half-inch-long by one-half-inch-diameter Type 61 rod, which I later lengthened to 15 inches by cementing two of them end to end. The TX power was gradually increased, and saturation set in at about 18 watts on the 3.5 MHz band using CW.

At 18 watts, the core temperature increased on a thermometer bulb cemented to the rod, and the radiated output (on a field strength meter) suddenly fell off. Up to about 15 watts, no significant harmonics were detected.

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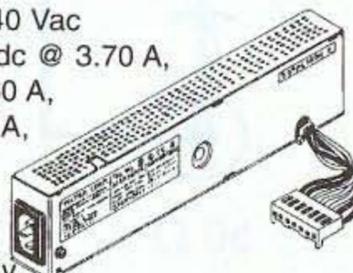
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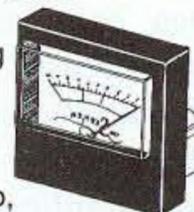
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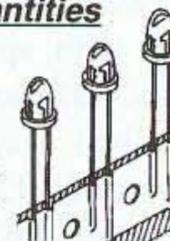
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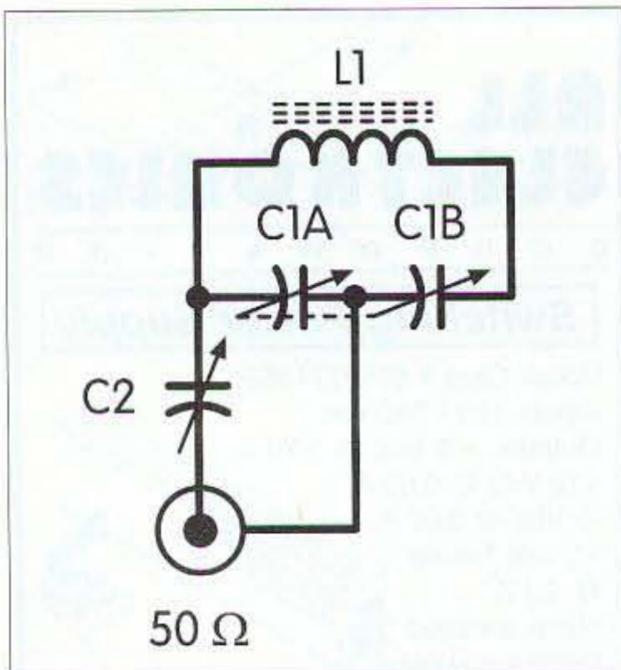


Fig. 2. An earlier TX ferrite loop. Successful, but very difficult to adjust and QSY.

## Ferrite Transmitting Loop for 80/160

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Then harmonics appeared as power was increased.

I adhered a second 15-inch rod alongside the first, and rewound L1. This significantly increased the radiated signal, and the saturation point rose to about 22 watts. As an exercise, an electric blower fan was turned onto the L1/rod assembly, and the saturation point was thus increased to about 25 watts. In all cases, interturn spacing, with spacing between wire and core, was used.

I then tried it on the air, using the regular 10/12 watt CW TX, and an occasional QSO was made. The problem was that when QSYing, to answer a CQ call, the loop had to be carefully readjusted to the other station for maximum received signal, and then C1A and C1B and C2 carefully readjusted on transmit. This operation took between one and two minutes, by

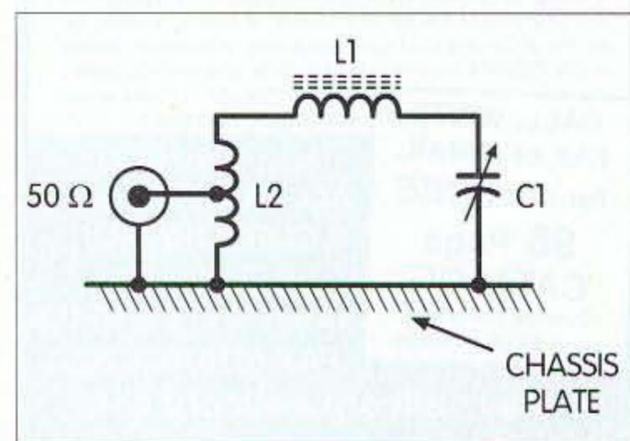


Fig. 3. A successful TX ferrite loop. Much easier to adjust than Fig. 2.

which time the other station was well into a QSO with someone else.

However, early one morning in January 1987, when the band was quiet, a random CQ was sent at 3560 kHz and a reply received from SMØCOX in Stockholm—an estimated 900 miles! It was not a hoax, as he had often been worked regularly on the normal antenna. A careful check was made to ensure that the 54-inch feedline was not accidentally radiating. The only explanation was that it was a case of two stations being on the right frequency at the right time and on the right day. These results were never repeated.

Later, I scrapped the Fig. 2 circuit. I used the rods for the Fig. 3 one. I wound L1 with well-spaced 5 A wire turns, and had it well spaced from the core. L1 was resonated by C1, and the coaxial feedline tapped, for 50 ohms impedance, onto air-cored L2. This could perhaps be described as a helical hairpin matching.

This TX ferrite loop was much more docile than the previous one (Fig. 2), and relatively quick QSYS could be carried out. With limited operating time between 0430 and 0515 hours, using 10/12 watts CW between 3560 and 3580 kHz, I was able to make some occasional QSOs.

More recently, using my substantial (or at least hard-won) background of practical know-how accumulated over many years, I arrived at the following design.

### Ferrite transmitting loop for the 80 and 160 meter bands

This design uses a 12-inch-long by three-quarter-inch-diameter fabricated ferrite rod of either Type 61 or Type F14 material.

The schematic in Fig. 4 shows L1 suspended above a metal base plate, and resonated by variable capacitor C. The 54 inches of RG-58 coaxial feedline is tapped onto the opposite end of L1, for a  $Z = 50$  ohms match. With the specified turns and construction of the loop, it covers both the 80 and 160 meter bands, although I intended it primarily for 80 m CW. Fig. 7 shows the general layout built onto a metal baseplate 13 inches long by six

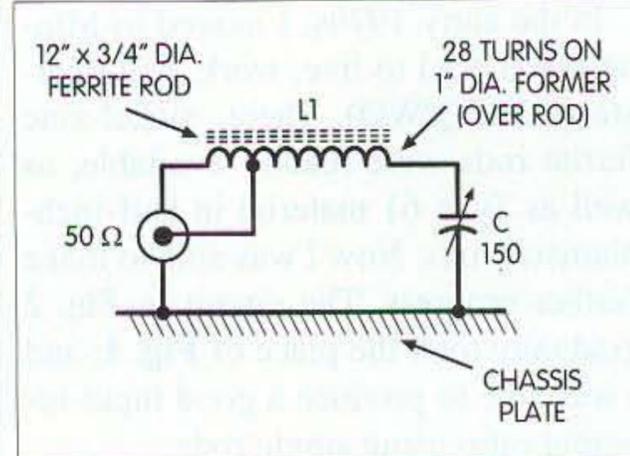


Fig. 4. Schematic of author's 1997 80-160 m ferrite TX loop. L1 = 28 spaced wire turns tapped 2-3/4 turns for  $Z = 50$  ohms. C = 150 pF small, TX-type variable.

inches wide, with an overall height of four and one-quarter inches.

### Construction

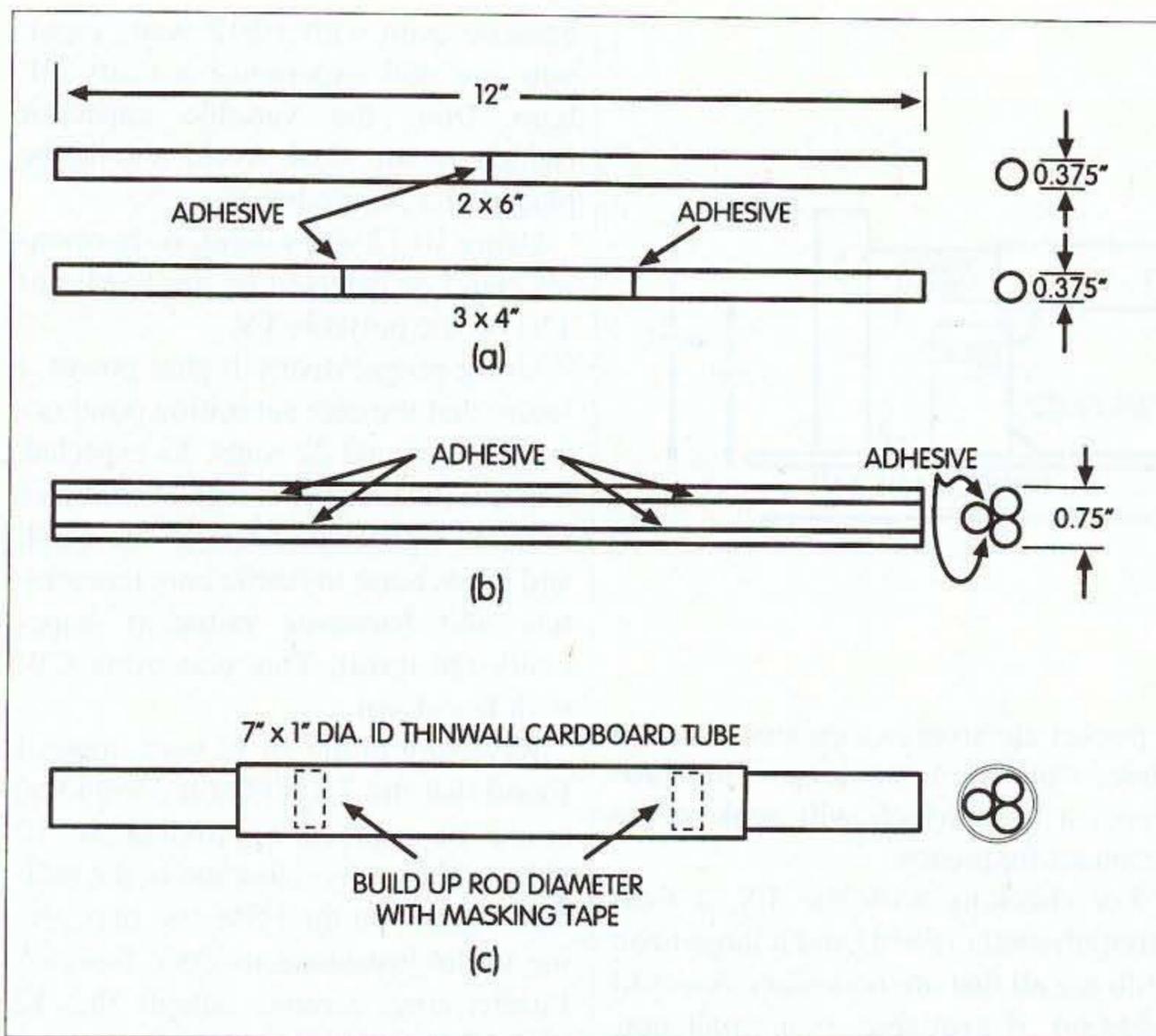
Fig. 4 shows a 12-inch-long by three-quarter-inch-diameter ferrite rod fabricated from three 12-inch-long by three-eighths-inch-diameter rods (Amidon Type 61 or MGM Type F14) cemented side by side.

Each 12-inch rod is made from two six-inch rods or three four-inch rods, adhered end to end (Fig. 5A). You can cut the rods to length with a small hacksaw. The ends of the rods should be lightly cleaned off with very fine abrasive paper, and cemented end to end using cyanoacrylate adhesive, which is very fast-setting.

The three resulting 12-inch rods are adhered together, side by side, effectively producing one solid rod, as in Fig. 5B. You must carry out this operation with speed, as it takes only a few seconds for the adhesive to set. Wear a pair of plastic/rubber kitchen gloves to avoid a rod securely glued to a finger, and a trip to the emergency room to separate them!

The format of the 12-inch by three-quarter-inch-diameter rod assists with core cooling, as you can see from the obvious vents shown in Figs. 5B and 5C.

I wound L1 onto a seven-inch-long by one-inch-internal-diameter thinwall cardboard tube (ex-household foil). The wire used was PVC-covered 24/0.2 mm copper with an overall diameter of 2.05 mm and a rating of 6 A at 1000 volts RMS. Any similarly rated



**Fig. 5.** Assembly of 3/4" ferrite rod and coil former for L1. (A) Fabrication of 12" x 3/8"-diameter rods. (B) Fabrication of 12" x 3/4"-diameter ferrite rod. (C) Assembly of coil L1 former on "B".

PVC-covered wire would no doubt suffice, providing the overall diameter is the same.

The L1 winding consists of 28 turns of the above wire, wound counterclockwise, evenly spaced approximately one wire diameter between turns (Fig. 4). The right-hand wire drops down to the variable capacitor C (Figs. 4, 6, and 7). The 50-ohm tap is taken from two and three-quarters turns in from the opposite end. Spots of adhesive should hold each turn to the coil tube. The 54 inches of RG-58 coaxial feedline is connected to the tap as shown in Figs. 6 and 7.

L1 is slipped over the center of the ferrite rod as shown in Fig. 5. Two bands of masking tape are built up to hold the coil and rod firmly in position (Fig. 5C).

The 150 pF variable capacitor should be a widely spaced, larger, well-insulated receiving type, or a small TX type. On the prototype, I used a Jackson type E, with mounting feet.

The whole assembly is mounted on an aluminum base plate 18 inches by

six inches (Figs. 6 and 7). Two hardwood pieces one-half inch by one-and-three-quarters inches by four and one-half inches high support the L1/ferrite rod assembly. In each a three-quarter-inch-diameter hole is bored for a one-quarter-inch depth as shown.

The right-hand wood support is mounted with base screws and a small bracket, as shown in Figs. 6 and 7. You then insert the coil rod end into the three-quarter-inch-diameter bored hole; the left-hand wood support is put over the other rod end; and the outline of the support base is marked, with a pencil, on the baseplate. It can now be fitted to the baseplate with base wood screws, and a small bracket (Figs. 6 and 7).

The variable capacitor is secured to the baseplate with base foot brackets or a small metal bracket, depending on the type of variable capacitor used. It should be positioned as shown, so that it is near the coil end. You then fit an insulated extension shaft and a large knob. Secure wiring connections are essential. The RG-58 feedline is connected

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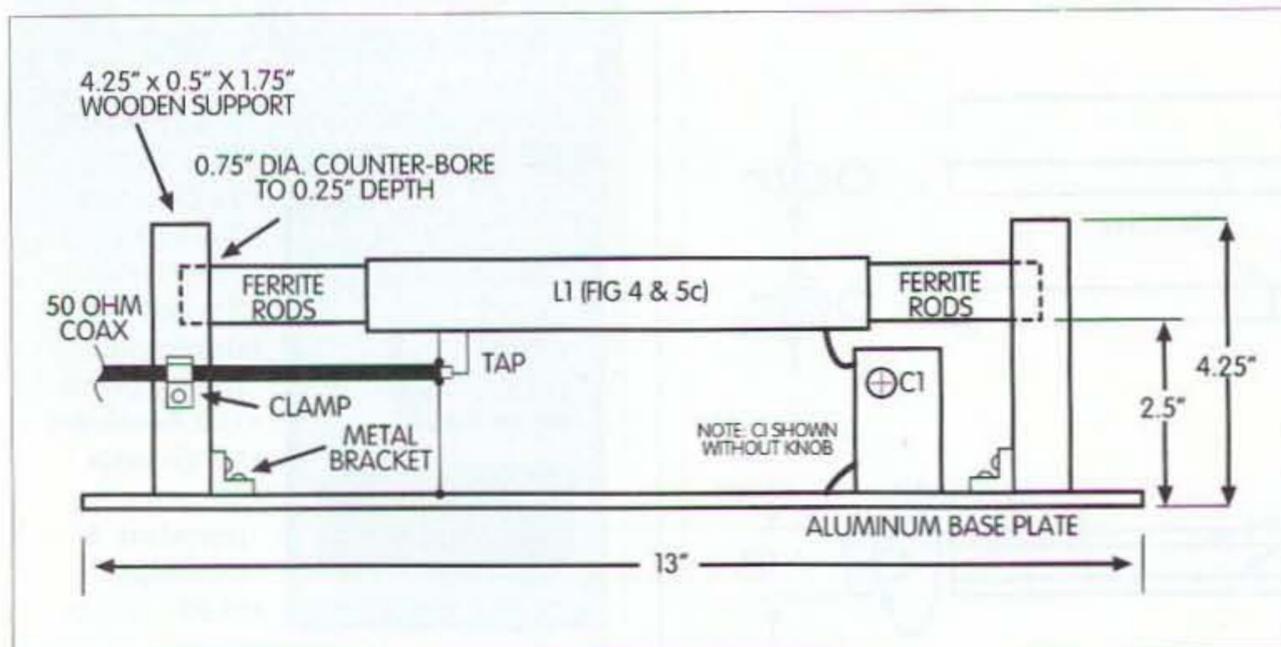


Fig. 6. Assembly, side view.

as shown. The drop down wire, from the coil end, should be rigid 16-gauge tinned copper wire.

### Testing and operation

The prototype covered from 1800 kHz to 4000 kHz, with a small overlap at either end. So it covers both the 80-meter and 160-meter bands, though all "on air" tests were between 3550 and 3580 kHz, using CW.

The loop should be connected to the TX and RX combo, with a short length of coaxial feedline. A 54-inch section was used on the prototype, just long enough for the loop to rest on a small table alongside the operating position. Grounding is at the TX/RX, and not at the loop.

The frequency range of the loop should be checked against a calibrated receiver. In the absence of signals at the time, a noise signal can be generated by

a pocket electronic calculator placed a short way from the loop. This produces a hash which will peak at the resonant frequency.

For checking with the TX, a field strength meter (FSM) and a large neon bulb are all that are necessary. A useful addition, if available, is a small portable TV nearby, as a back-up check for TVI.

On the prototype, both the RX and TX were tuned to 3560 kHz. The loop was first resonated with the RX. The TX tuned up on a dummy load, and then connected to the loop, and 10/12 watts fed into it. This produced a reading on the FSM placed nearby. Only a minor adjustment was needed on the loop resonating capacitor to peak the FSM reading.

Placing the neon near the loop coil showed, as expected, a high RF voltage at the variable capacitor end—and zero at the feedline end. Note: Take care,

because even with 10/12 watts input, you can still experience a nasty RF burn from the variable capacitor (which in an ideal world should be placed in a plastic box).

Using 10/12 watts input, no harmonics could be detected on the FSM, nor TVI on the portable TV.

Using progressively higher power, I found that the core saturation point occurred at around 22 watts. As expected, this was indicated by a dramatic drop in radiated signal indicated on the FSM, and an increase in ferrite core temperature and harmonic radiation (especially the third). This was using CW with key-down.

Reverting to the 10/12 watts input, I found that the TX VFO (at 3560 kHz) could be retuned approximately 12 kHz, without any reduction in the radiated signals on the FSM and thus giving useful instantaneous QSY facilities. Furthermore, a move outside this 12 kHz "bandwidth" required only a quickly executed minor adjustment to the loop tuning capacitor. This removed all the previously described operating difficulties experienced with the circuit in Fig. 2.

Remember, it is essential to be able to rotate the directional loop towards the other station, as indicated by maximum signal on the receiver.

On-air activity for me at this QTH is normally limited to 30 to 60 minutes on 80 m CW four or five days per week, terminating with a short regular QSO at about 0510 GMT with a friend in Stuttgart, Germany, maybe about 250 miles distant. On some mornings, in good conditions, I have been able to use this ferrite loop for this QSO.

### Conclusions

I hope that some other amateurs will take up my challenge, make up this ferrite TX loop antenna, and then proceed to improve it. I also hope that someone can try it outdoors or in the attic, with remote tuning and rotation facilities.

We all know that it will only be by many more amateurs experimenting with such ferrite transmitting loops that their true potential will ever be realized.

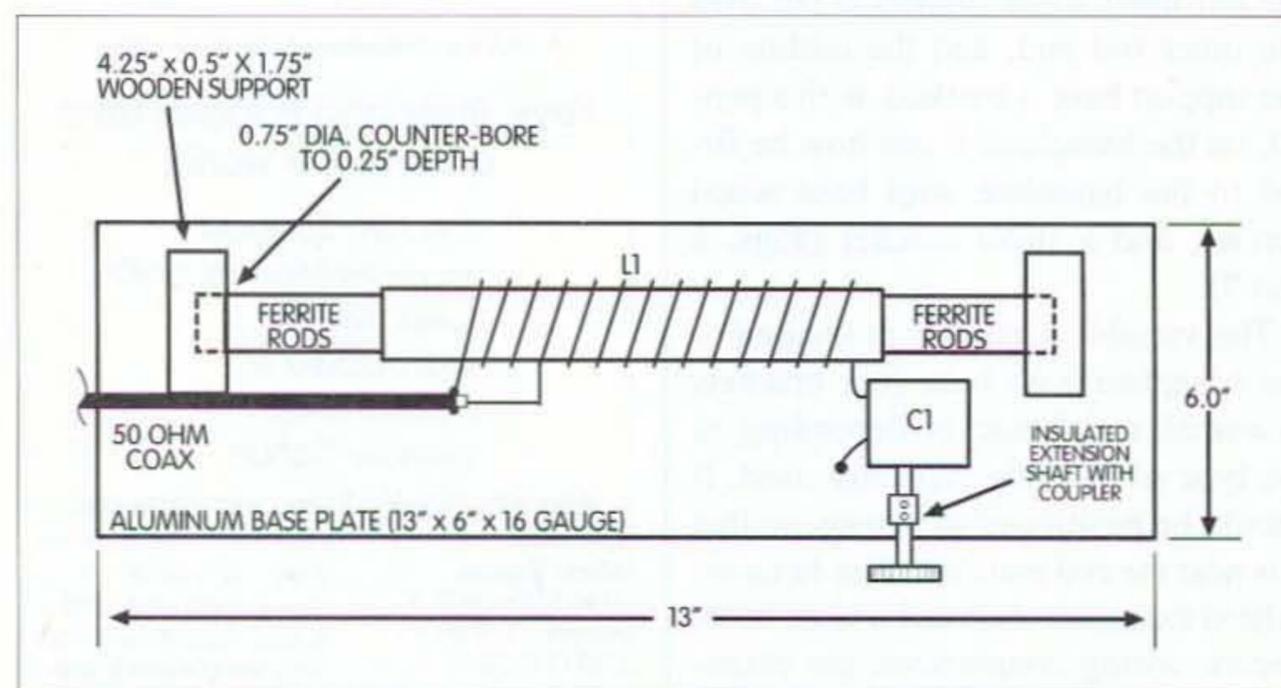


Fig. 7. Assembly, top view.