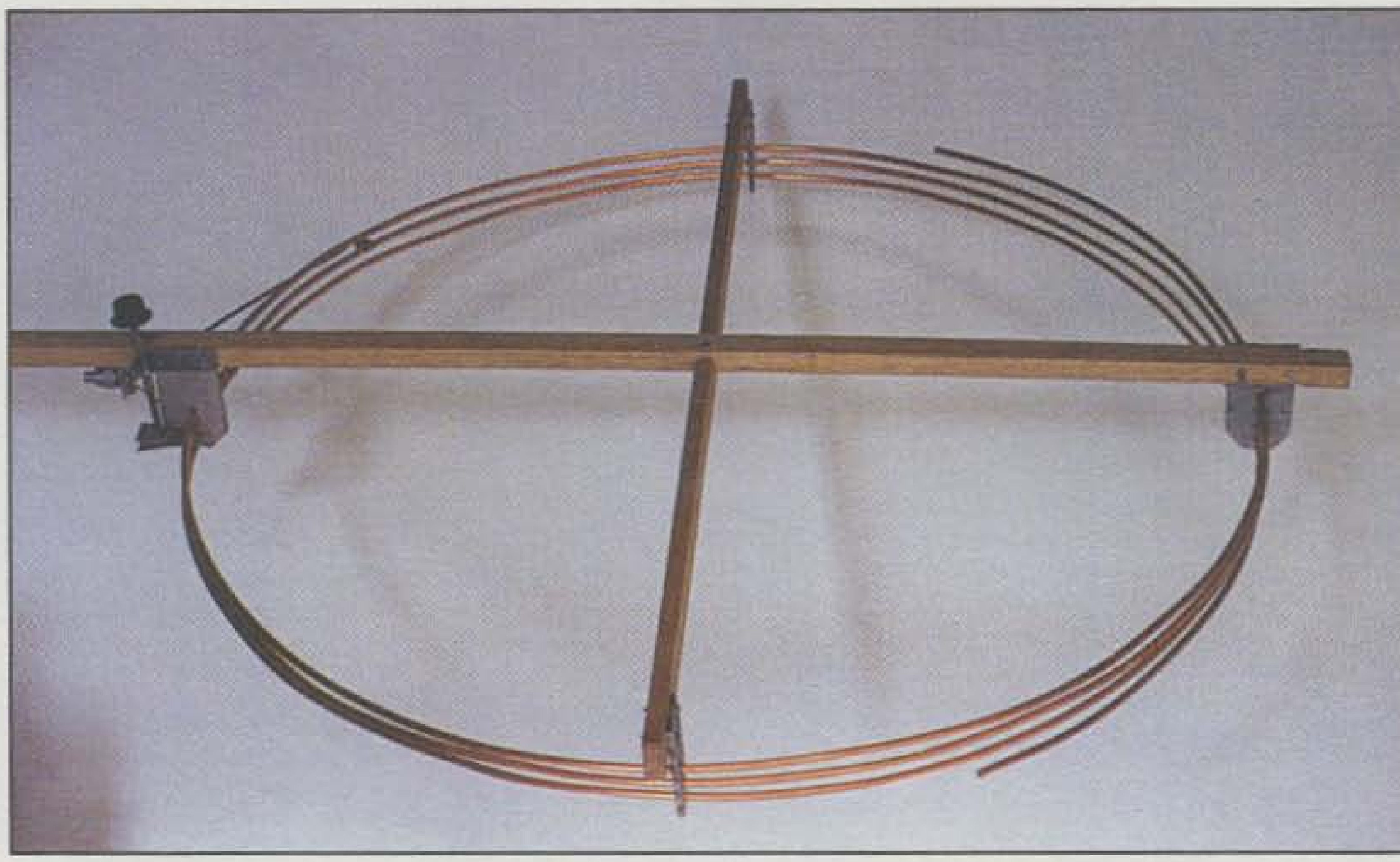
If a single-turn loop antenna is good, are multi-turn loops better? W6HPH says yes, both in theory and in practice. Plus, it can get you on the air on HF from antenna-limited locations.

Multi-Turn Loop Antennas

BY FRED BROWN,* W6HPH



The author's three-turn loop antenna for 40 meters is only 3 feet in diameter, making it ideal for someone operating in limited space.

Transmitting loop antennas have been around for a long time, but they are usually just one-turn affairs. According to Kraus[1], the *radiation resistance* of a loop antenna is proportional to the *square* of the number of turns, whereas the *conductor resistance* is simply proportional to the number of turns.

A three-turn loop, therefore, should have three times the efficiency of a single turn. I constructed an experimental 40 meter model to see what performance can be expected from a three-turn, 3 foot diameter loop.

The principle of the loop antenna can be understood by referring to fig. 1. The loop inductance resonates with the capacitor to the operating frequency; there will always be some point at a distance X from the center where a tap can be placed which will provide a match to 50 ohms. Increasing X will, of course, increase the feed impedance. Therefore, it is very easy to achieve a 1:1 SWR with a loop of any size at its resonant frequency. Usually, however, the loop will need retuning for even a QSY of only a few kHz.

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Neglecting the capacitor loss, the radiation *efficiency* will be the ratio of the radiation resistance to the RF conductor resistance and normally will be quite small. The radiation resistance is proportional to the *fourth* power of the loop diameter, whereas the conductor resistance is simply proportional to the diameter. Therefore, doubling the diameter will raise the efficiency eight-fold.

Originally, this antenna was three turns with a tuning capacitor at the top. The capacitor is a split-stator type, because in this way the loss resistance of a wiping contact can be avoided. Even with a wide-spaced capacitor, however, there was flashover at a power level of only 10 watts. Accordingly, I built my own capacitor and placed it across two turns at the *bottom* of the loop. I considered a high-voltage fixed capacitor at the top, but decided it would be better to just extend the tubing to re-establish resonance. Thus, the loop ended up with a total of 3.36 turns, or 380 inches total conductor length.

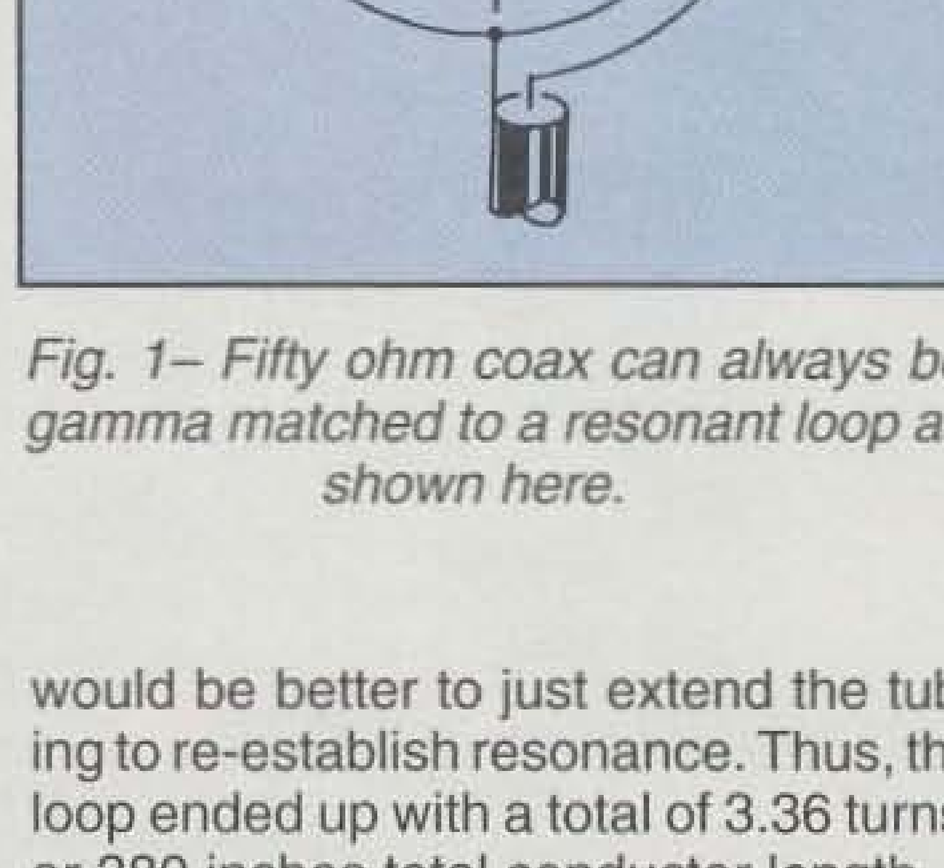

Fig. 1– Fifty ohm coax can always be gamma matched to a resonant loop as shown here.

Construction details should be clear from fig. 2 and the photo. The loop is made from standard 1/4 inch copper tubing readily available from building supply stores. The copper tubing is held by fiberglass supports on a hardwood frame. The "flapper" capacitor plates are cut from flashing copper and covered with Teflon™ tape. This is not the kind of Teflon tape used by plumbers; it is 5 mils thick and sticky on one side, like Scotch™ tape. It should be bent over the edge of the flashing copper and stuck to the outside of the plate so as to reduce the possibility of flashover.

Results

On-the-air tests show that with 100 watts PEP, the loop easily can work stations within the usual 400-mile range of daylight operation on 40 meters. A more quantitative test was made by comparing the loop with a full-wave doublet at 40 feet. This comparison showed the loop to be consistently 10 dB inferior to the doublet, both receiving and transmitting. However, since the loop was only 8 feet above the ground, at least some of that 10 dB can be accounted for by the difference in height. SWR bandwidth (below 2:1) is only 10 kHz, indicating a Q of 550. Still, it can be an attractive option for someone who is unable to put up a full-size antenna for 40 meters.

Calculations show the loop should be only 2% efficient. The actual performance substantially surpasses this figure, which I attribute to the non-uniform current distribution on the loop. The theory is based on the assumption of uniform current.

To understand this, remember that currents on diametrically opposite sides of the loop flow in opposite directions. Radiation from these two currents would cancel completely if it were not for the small spatial separation. This is the reason for the low radiation resistance of the loop antenna.

If the two currents are not exactly equal, however, cancellation will be incomplete and radiation resistance therefore will be enhanced. Since the loop has a total conductor length that is an appreciable fraction of a wavelength (actually 0.23 wavelength), a non-uniform current distribution can be assumed. For instance, current at the conductor ends obviously must be zero.

Don't be surprised if you see a commercial version of this antenna come onto the market. Just remember you saw it first in *CQ*! ■

Reference

1. Kraus, *Antennas, First Ed.*, McGraw-Hill, page 167.

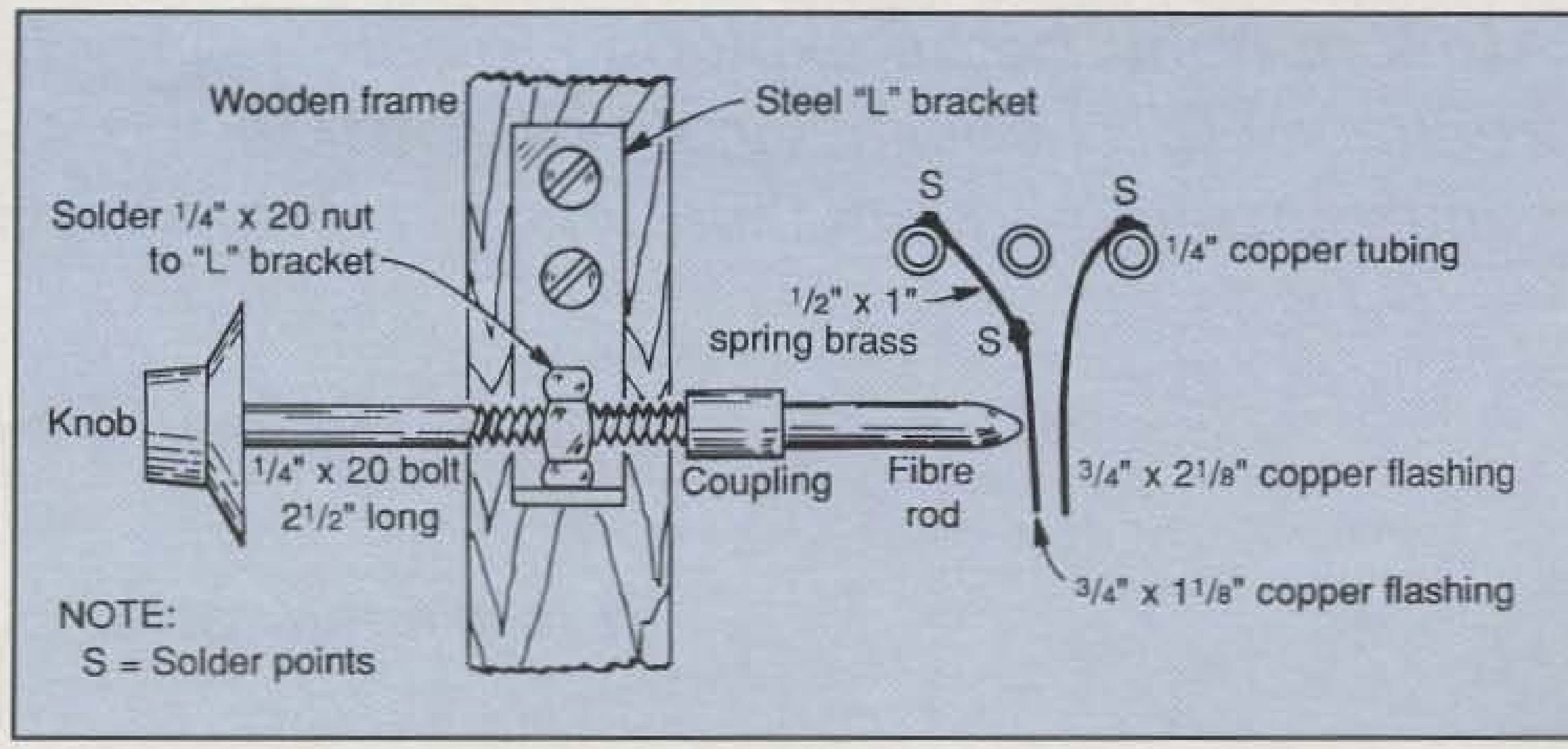

Fig. 2– Construction details of the flapper capacitor. The coax fitting (not shown) is connected to the middle turn of the loop. The outer conductor is connected to the center as in fig. 1, and the distance X is 12 1/2 inches for a match to 50 ohms.

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