ABOVE & BEYOND

VHF And Above Operation

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Filters for 2 Meters

This month I would like to finish up covering filters by offering details for a few different designs for a 2 meter filter. This filter is used to help prevent RF desensitization or RF saturation on your HT or similar transceivers when they operate near commercial high power VHF radio facilities. The design details that I will present are another attempt to construct simple filters out of readily available component parts for home construction. The construction of filters, and for that matter almost any electronic project, can be quite intimidating if you do not have a well-stocked junk box. Most of us, myself included, have spent many hours trying to come up with components to construct a seemingly simple project, only to put it on hold for lack of materials.

Here are a few designs for 2 meters that should be easy to construct. What makes these filters nice is that they can be constructed out of components from your plumbing or hardware store, or even your own kitchen. I have provided several basic designs to simplify the filter's construction. They can be adapted to your HTs as well as mobile rigs to reduce or eliminate desensitization when operating near commercial installations.

2 Meter Filters for HTs

The first filter was actually constructed for a low power 2 meter HT (5 watts) that could be used with a rubber ducky or conventional antenna. It can be used in line with a mobile transceiver but was built to be small and therefore is more suitable for low power HTs. In either case, the filter is used to provide attenuation higher in frequency where the offending signals lie. Operation without this type of filter near high power transmitters could shut off (or bias, active AGC, etc.) the front end RF stage of your receiver. If this is the case, your receiver will be dead when mountaintopping or contesting near high power VHF RF.

For example, during the ARRL 10 GHz microwave contest this year, filters of this type made the difference in being able to communicate from some of the more populated RF microwave mountaintop sites. The filter provides attenuation to signals above 150 MHz and very low loss to signals in the 144 to 148 MHz 2 meter band. This provides the needed filtering and attenuation to make operation quite manageable near high power RF sources. Most newer VHF radios do not have adequate filtering to prevent this type of out-of-band influence.

This first filter, constructed by N6IZW, uses two large ceramic adjustable coil forms half an inch in diameter and about two inches long. A coil is wound on each form with #12 enamel wire, almost filling the entire coil length with about 12 turns. Leave some room for pruning and varying the turn spacing on the form. Initially, the coil is wound tightly and then can be spread out to resonate as needed. The adjustable core makes this much easier. Each coil is taped at exactly one turn above ground, the 50-ohm point of connection. The two coils are positioned half an inch apart adjacent to each other, within a metal box approximately 2-3/4" x 2-1/8" x 1-1/4" (the box size isn't critical). BNC coaxial connectors serve as input/output connections to the taps on each coil on our model, but you can use any connector you desire.

You need some means of injecting a signal through the two coils to determine just where resonance is, pruning, stretching or adjusting the slug-tuned coil form until minimum SWR or resonance is found. One method of adjustment is to couple a low power HT through the filter with an SWR meter coupled to a power meter and adjust for minimum SWR. Loss through the coils runs about 1 dB at 2 meters. Then check where the coil rolls off—it should start to give higher attenuation near 150 MHz and increase rapidly as frequency is increased. This coil and adjustable slug will not take a large amount of power, so limit it to less than 20 watts. Different designs and construction techniques are required for higher power. See Figure 1 for design details.

A variation of the slug-tuned coil design developed by N6IZW is to wind the coils out of #12 wire on a 5/8-inch mandrel and mount them without the coil form. The coils are positioned much the same as with the form but are now suspended in air and rigidly grounded at the bottom of the coil. Adjustment is more critical as we do not have any adjustable core to help in tuning. The coils must be adjusted entirely by stretching and adding or removing turns to bring them to resonance. Note: The metal chassis is the same size as the coil form version.

The coils are placed adjacent to each other, spaced the same half inch apart, and are resonated by the proximity to the metal case and tight coil-to-coil turn spacing and length of each coil. The RF input and output is placed at the one-turn point from the grounded end of each coil. Make this connection as direct as possible to the solder pin on the BNC connector. Excess length at this point will increase loss and reduce efficiency of the filter. See Figure 2 for design details of the air-spaced coil filter.

If your coil section does not resonate at the desired frequency you might have to add a turn or two; however, we have found in our container that 12 turns seems about right. The test results for this filter are as follows: 1 dB insertion loss; 10 dB rolloff frequencies at 119 MHz and 154 MHz. The 20 dB rolloff points are at 110 MHz and 164 MHz. The filter exhibits 1 dB ripple between 130 and 144 MHz. See Figure 6 for the frequency response curve of this filter.

Make sure that your coil structure does not touch the side of its cabinet (chassis) because it may present a problem to your transceiver. This filter can handle quite a good power level (it has been tested to 45 watts in mobile applications). I attribute this to removing the adjustable coil or air variable capacitor found in other designs.

Alternate Designs for 2 Meters

Alternate designs at moderate power levels can be accommodated by small air-variable capacitors and compact coil circuits that are contained in the same metallic enclosure. This enclosure can be as simple as one constructed out of PC board material, or even some suitably-sized chassis or box. When using PC board material be sure to use the double-sided variety. Ground both sides together at several places. I constructed one for 2 meters and had some very funny things happen because one side of the copper foil was not grounded. It gave some weird results—just ground the two sides together for minimum problems.

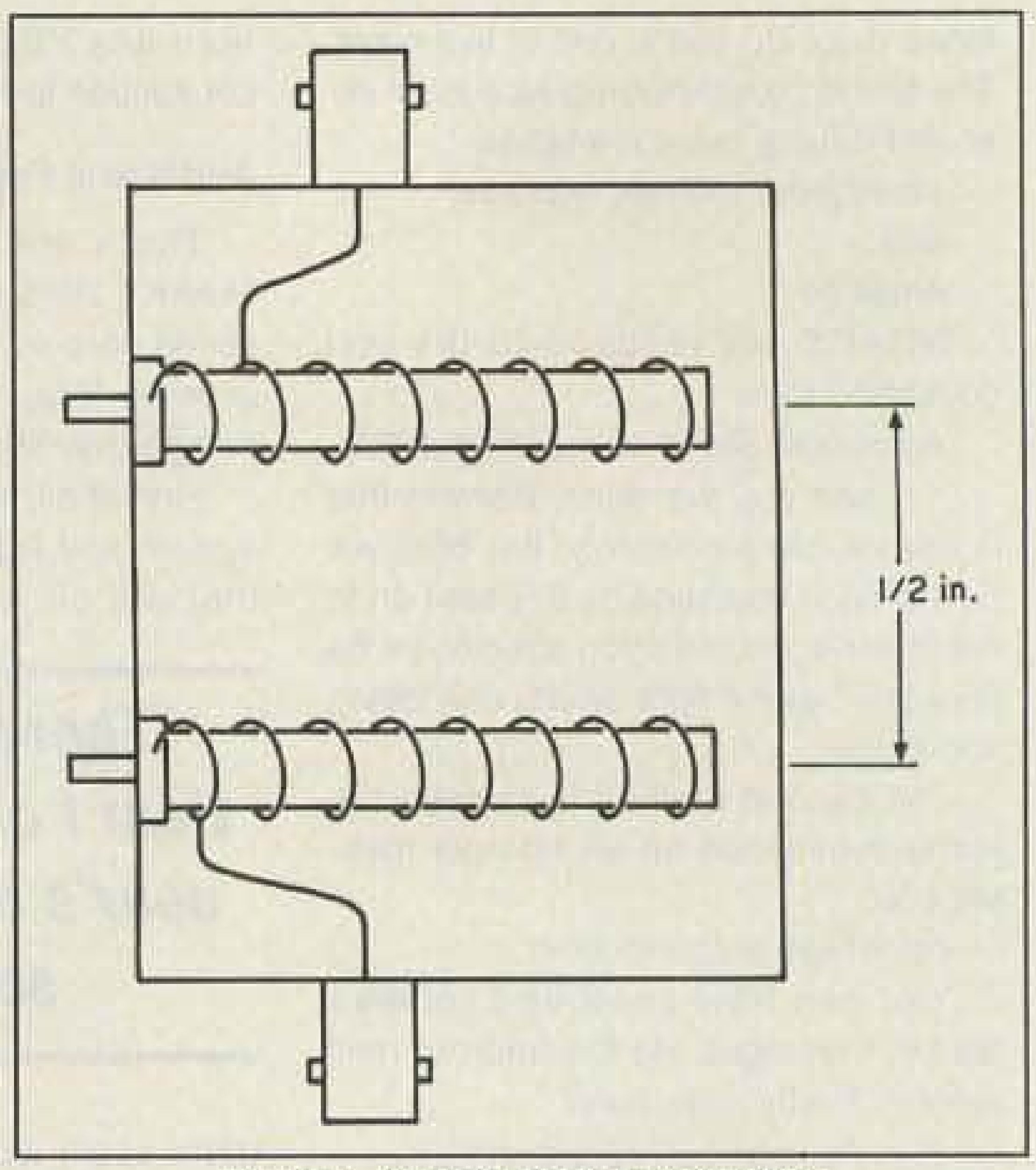

Figure 1. Variable coil 2 meter filter.

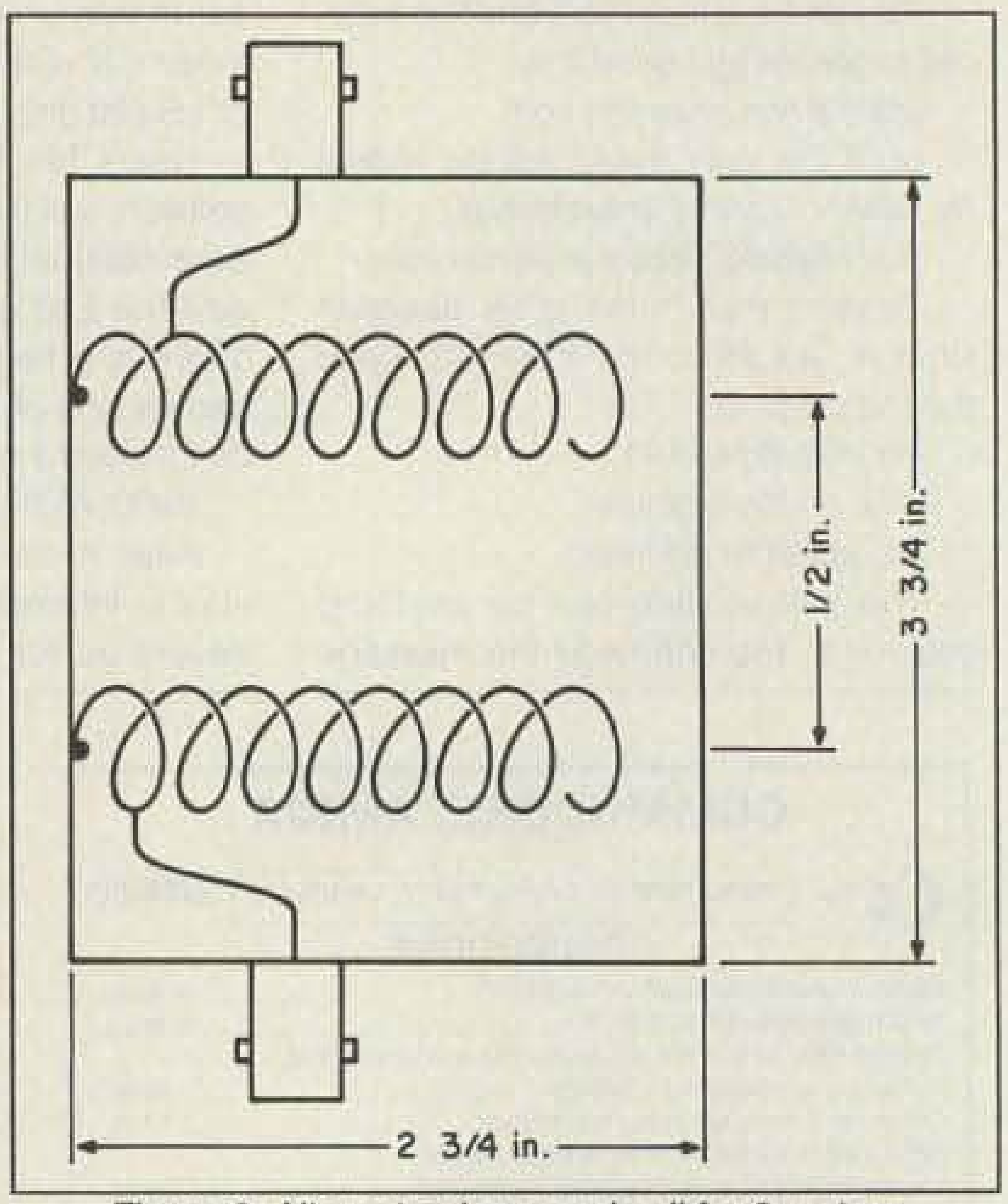

Figure 2. Alternate air-spaced coil for 2 meters.

Another filter circuit for 2 meters using air variables can be contained in a box slightly larger than 2" x 4" x 1-1/2". The small size is due to bulk coil and small air variable capacitors in the 10 pF region to resonate the circuit. The ground end of the coil is a straight section of wire about an inch long with an 8- to 10-turn coil (half-inch diameter, spaced one wire turn, #12 wire) to bring the circuit to resonance with the trimmer. Tap the straight section at about the 3/4 to one inch above ground for impedance matching. Mount the coaxial connectors near the tap above ground on both coils. The taps are adjusted for proper match on the straight portion of the coil above the ground end of the coil. See Figure 3 for air space coil construction.

Proper position of the coil taps can be determined by operating the filter in the receive mode and adjusting for best receive performance on both input and output taps. Since you can verify filter operation in this manner, and because of the air variable capacitors, this filter can be used on other nearby frequencies, either higher or lower. This eliminates the need for the test equipment normally required to align the circuit (allowing operation with a scanner, for instance). After this basic alignment, check it out with an SWR meter for final settings.

Normally for 2 meter use we measured 10 dB attenuation at 150 MHz, and at 152 MHz it ran near 20 dB loss. The purpose of the straight portion of the coil circuit near the ground end is to remove the lumped coil circuitry and provide a portion of transmission line length for a short section to facilitate matching and allow room for the coaxial connectors for short connections.

The coil with a section of transmission line attached is similar in construction to a limited-space antenna—for instance, if you constructed a dipole "slinky" antenna by distributing the coil of the slinky out in each direction for the desired dipole length. This type of antenna, constructed entirely out of a coil for its entire length, would not give good performance. Now, if you spread out a few turns of the slinky coil (end section), producing a near straight section on each end of the dipole, the "slinky" antenna will now show better resonances and vastly improved operations vs. a bulk coil design. This is a limited-space antenna; the filter is a limited

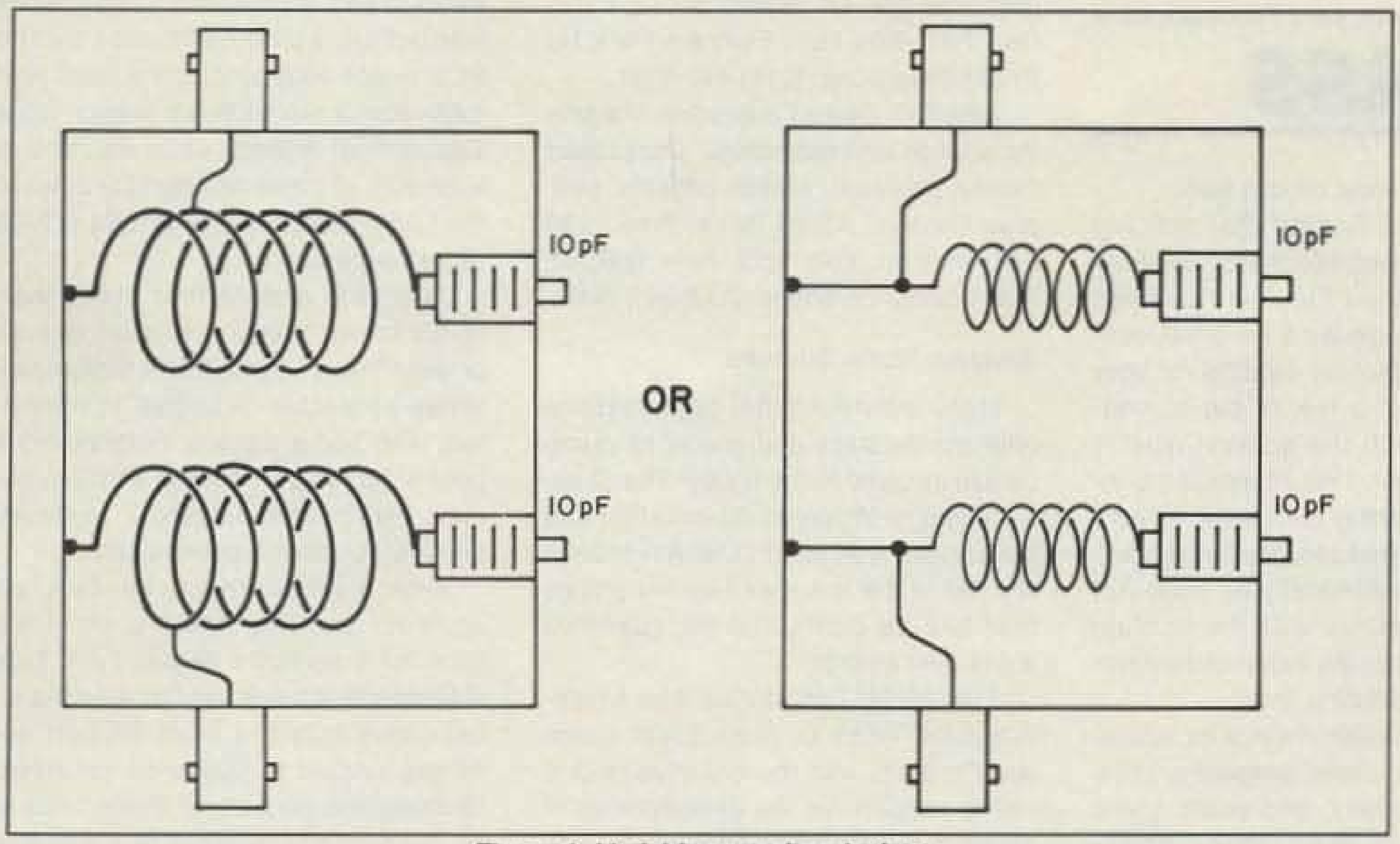

Figure 3. Variable capacitor designs.

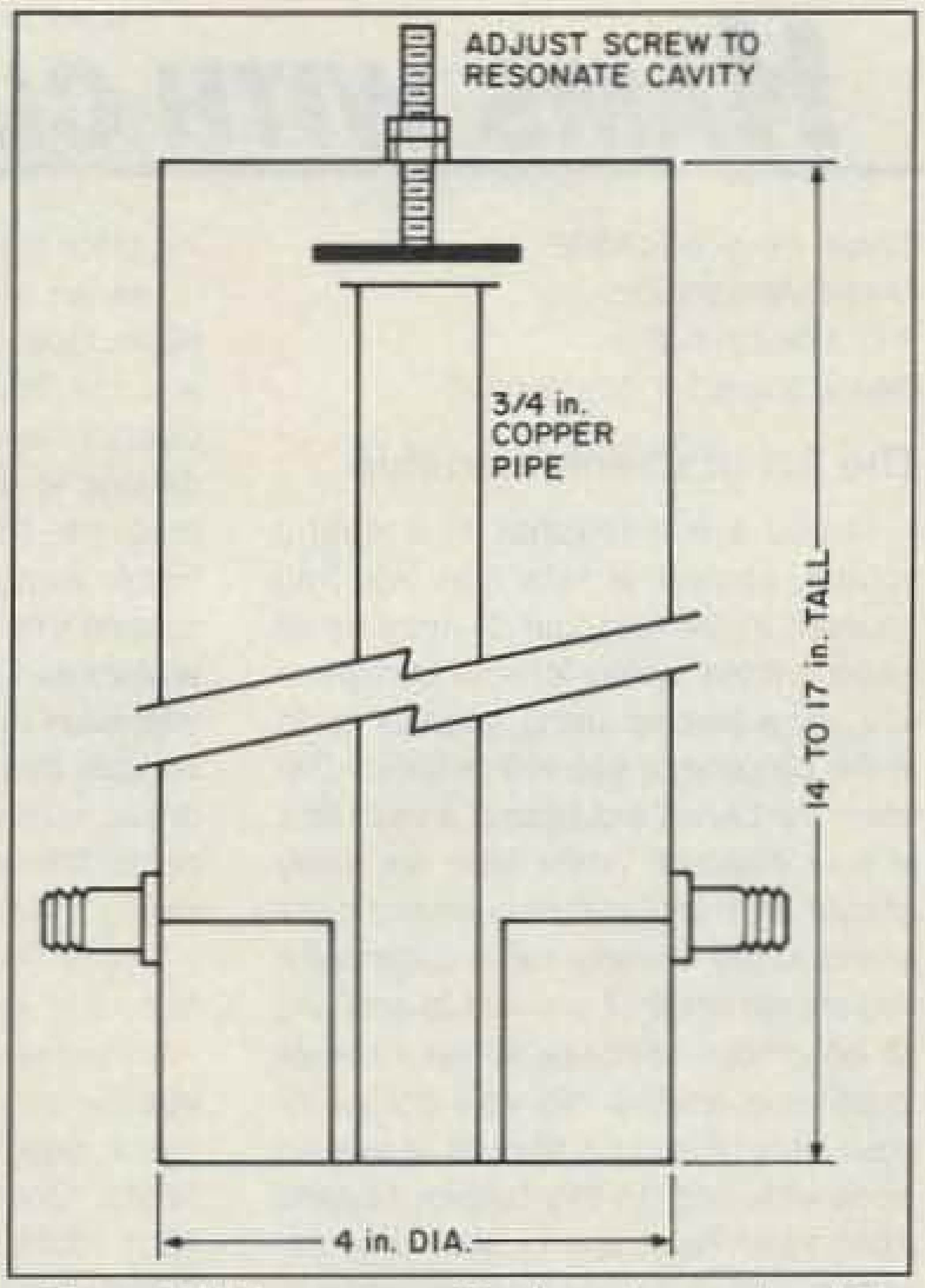

Figure 4. High power cavities (quarter wavelength).

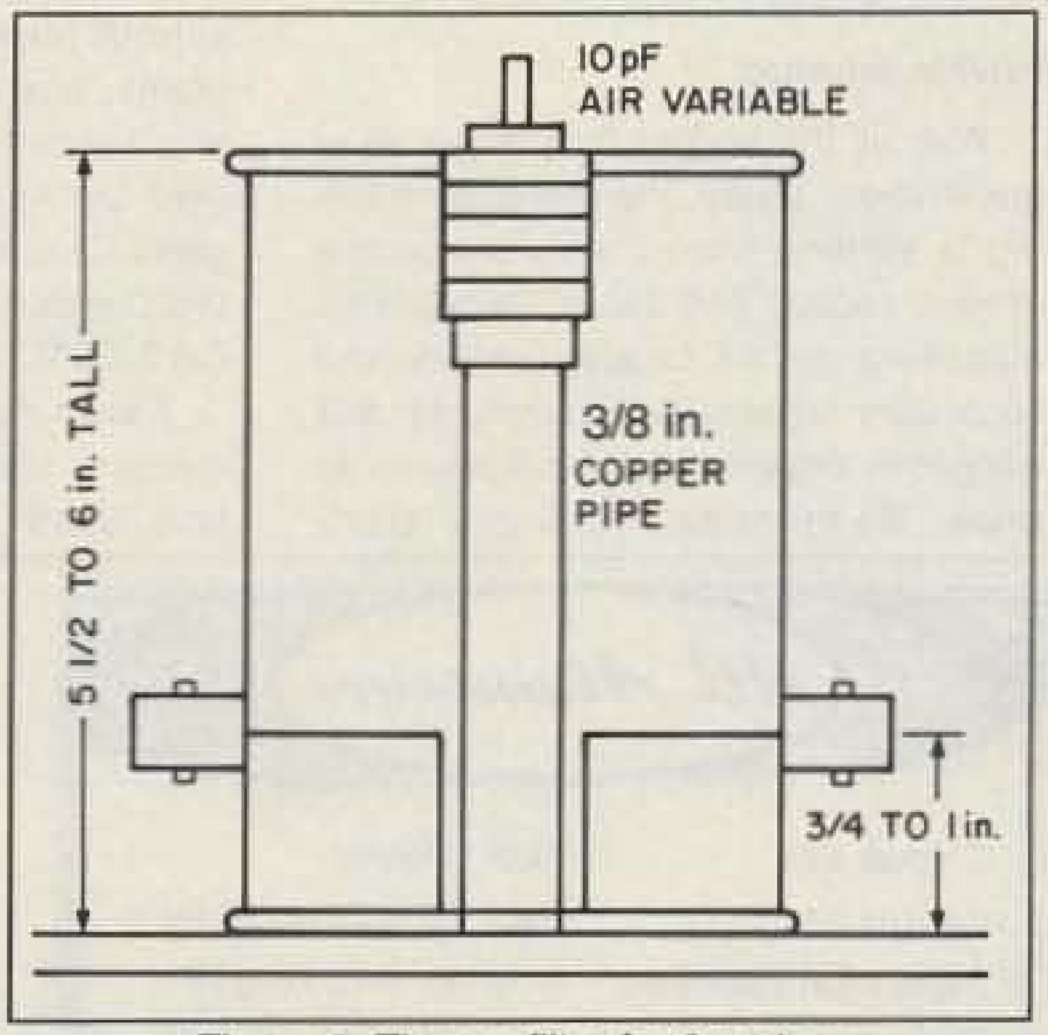

Figure 5. Tin can filter for 2 meters.

space coil—the principle is nearly the same.

Component RF Heating

If you think component heating due to RF is not much of a concern, let me tell you about a 6 meter amplifier I built. This amplifier depicts heating to an extreme. The circuit was a single-stage amplifier using a half-turn input and output inductor for the tank circuit. Initial tests showed very low output power. I made adjustments but there wasn't any particular improvement.

Soon I realized where my errors were. Due to long key up, the output coupling capacitors were squirming about the PC board in a pool of molten solder! The capacitors were dissipating so much RF current they conducted heat to their leads and melted the solder. The trouble turned out to be that the half-turn inductor was just too short. The cure was simple: increasing the inductance a small amount. I changed the total length by adding 1/8 inch of #12 wire, making the total inductor length now 3/4 inch long for its half-turn loop.

Testing after this change produced output power of 80 watts with little trouble. Now it would have worked at the 45-watt level, but for how long? Check out RF heating of the components—it is very important to remain within good engineering ratings.

High Power Cavities

Designs for higher power levels require a more traditional cavity design, allowing very high RF currents to flow through large conductor surfaces. The air-spaced multi-rotor capacitor is replaced by a single top-loading capacitor, or changed by adjusting the center element length along with cavity length to make it resonant. This tends to make the size large because the center element must be very near 1/4 wavelength to be resonant, either by minimum capacitance or by element length, making circuit "Q" quit high. A cavity for 2 meters will be quite large, something very near four inches in diameter and between 16 and 20 inches long.

The top of the cavity usually consists of a single capacitor hat to bring the cavity to resonance. Several cavities can be grouped together to form a diplexer. The cavities in a diplexer configuration will isolate receive and transmit frequencies from a repeater, connecting them both to a common antenna. Diplexers usually consist of four to six cavities for a single pair of frequencies. There are two sides to any diplexer, with half the cavities split between receive and transmit.

As shown previously, simpler cavities can be constructed more compactly by replacing the end element with an adjustable capacitor fixed between the end element and ground. You just have to remember that the capacitor is the power-limiting component here. See Figure 4 for a single cavity for high power use. Additional multiple matching lines and cavities can be used to construct a diplexer that is not unlike most repeater diplexers in use today.

As shown in Figures 1, 2 and 3, the length of a cavity/tuned circuit can be reduced by using bulk components. This allows small tuned circuits to act as filters, with the limitation of lower power operation. Use small 1 to 10 pF variable capacitors. I limit this type of design to the 10-watt level just for a component rating margin. You can push it but be cautious—don't worry about your capacitor, worry about the failure the short will do to your solid-state power amp in your rig.

The Tin Can Filter

The simplest filter to construct is the Tin Can Filter. For this filter all you need to do is to punch a hole in the top of a can (a little longer than a soup can) and add a variable capacitor, soldered to a central copper rod or pipe. Ground the bottom end of the pipe to a plate that connects common to the end of the open can. Taps for the input/output are constructed out of #12 buss wire one inch high and placed in close proximity to, then routed directly to, ground, next to but not touching the central element. The two connections or loops are placed 180 degrees apart. Adjustment is also simple: Connect to an existing system and adjust for maximum signal strength through the filter. Please note that this is a sharp bandpass filter and will be limited to a couple of hundred kHz. This type of filter is intended for spot frequencies only. See Figure 5 for details. It is a very non-critical filter to construct. Adjust all filters on receive for best performance and then test on low power with an SWR meter to find the best match.

Next month I plan to describe a noise generator that you can use to check out your receive systems for best performance. It's quite a simple project, with the noise head having less that five parts.

Well that's it for this month. I hope you and yours have a very merry Christmas and a happy New Year. As always, I will be glad to answer questions concerning filters and other related VHF/UHF matters. Please send an SASE for a prompt reply. 73 Chuck WB6IGP.

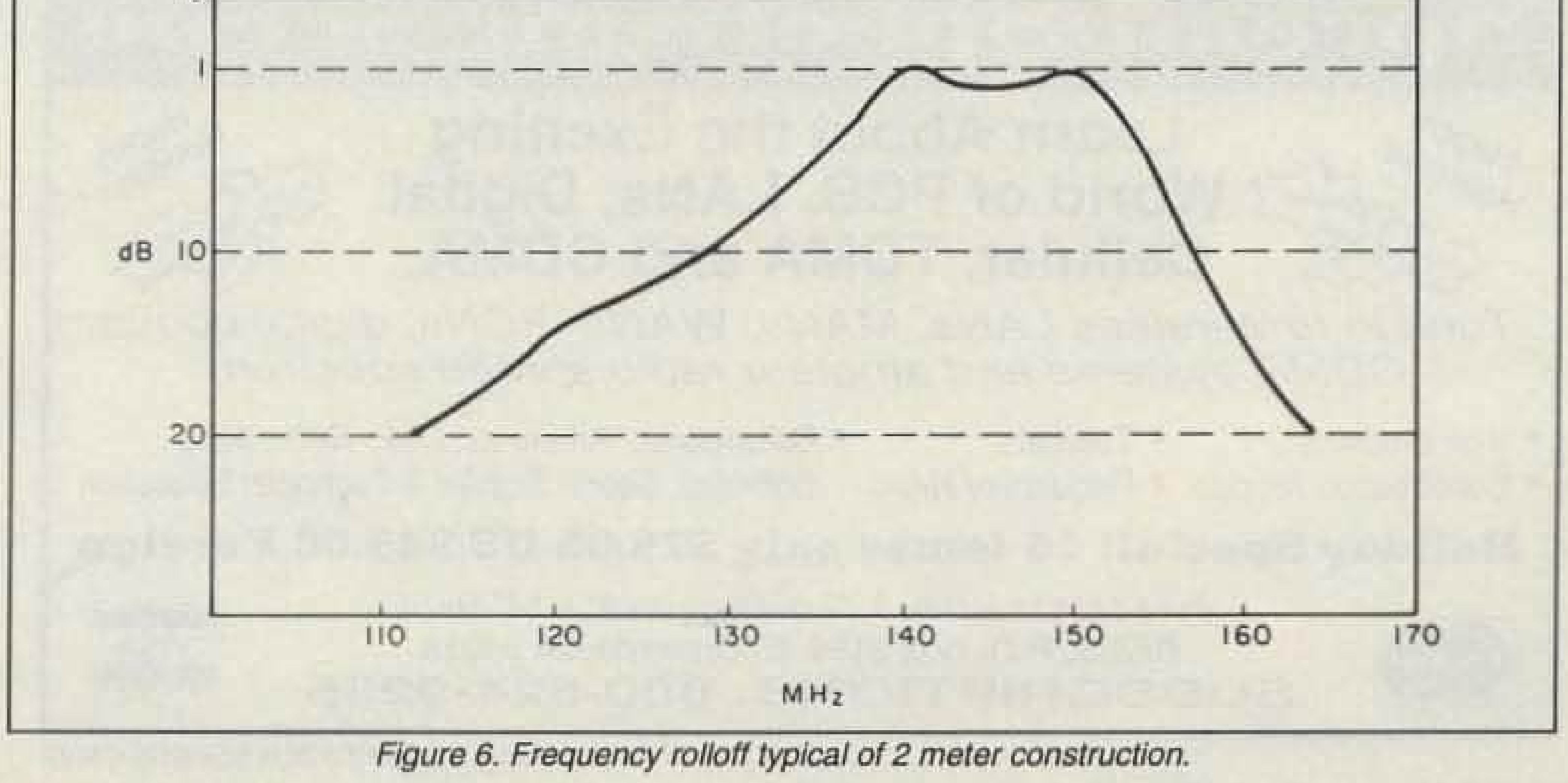

Figure 6. Frequency rolloff typical of 2 meter construction.