W1ICP talks about open-wire and coax, what they can do for you, and what they can do to you. Next month we'll take this information and use it to get open-wire feeders into the shack.

Let's Talk About Wire

Part I—Handling Coax and Open-Wire Feeders

BY LEW McCOY*, W1ICP

I've been writing about open-wire transmission line and coax for many years now, and I still get letters and questions pointing out the reluctance of some amateurs to run open-wire feeders into the shack to get to the Transmatch or tuner. In my own case, I use an insulated type of 450 ohm "ladder" line and have never really been concerned about bringing the line into my shack. However, a happy ham is best defined as, well, a happy ham! This article will show you a couple of ways to bring your transmission line inside your house without coming in with open wire.

I have explained using open-wire feed line with antennas many, many times in the past, but I know it will also help the reader to go over the subject once again so the problems or non-problems can be cleared up.

When one thinks of feeding an antenna, almost without exception the new amateur is led to believe that coaxial line is the only way to go. Coaxial line is normally well insulated and can be run alongside metal or other coaxial lines, through walls, under ground, or even through water (depending on the type of coax).

So why bother with open-wire line? Trust me, there are many excellent reasons for using open-wire line. First, for all intents and purposes it is a lossless line. One thing you should know about any feed line is that the losses in the line increase with the standing wave ratio (SWR). Therefore, if a line is essentially lossless, as with open-wire types, it means that even with high SWR present, the losses are insignificant —not so with coax. Second, open-wire line is considerably less expensive when compared to coax. The type of line I use, 450 ohm "ladder line" (which can handle 1500 watts) is only 14 cents a foot. Third, it can be used with a multiband dipole made only with wire. This can provide the best and most efficient type of multiband dipole.

Because of the potential for high SWR losses with a lossy line, coax should be operated at or near the impedance of the line. The impedance of the line is determined by the size of the conductors and their spacing and the type of material used to hold them apart. Usually we think of coax in terms of 50 ohms impedance, although there are numerous other values of coaxial cable manufactured. To repeat, the primary problem with coax is that the line must be operated at this characteristic impedance, or very close to it, or losses will result.

How lossy is coax? Here is one example, and admittedly it is a bad one. With 100 feet of RG-58/U on 2 meters, almost 80 percent (!) of the power transmitted is lost because of ohmic resistances in the line. To be fair, one would not use (or *should not* use) RG 58/U on 2 meters or even 10 meters. Losses with any type of transmission line increase with frequency, but RG 58/U is particularly bad. So, if more than 25 feet of transmission line must be used, don't choose RG-58.

In the golden days of amateur radio (and don't ask me why they were "golden," except that gold was $32 an ounce), we made our own open wire lines, usually with No. 12 wire that was spaced 2, 4, or 6 inches apart. These days most amateurs use what is *called* open wire line, but in actuality it is a line that is similar to TV twin lead, with the exception that it has openings every few inches to reduce losses. The impedance of this line is about 450 ohms. Keep in mind, though, that like coax, the line is insulated, although as I pointed out, much cheaper per foot.

At this point I would be remiss if I didn't state that one should not use open wire to feed a directional rotary beam—at least not without giving the problem some thought. Any very long runs of coaxial line can produce some bad losses, particularly when one is using a beam to obtain gain. The losses from very long runs of coax can negate the beam gain. However, in some cases, amateurs find it necessary to situate their beams at a considerable distance from the shack, which would result in high losses as mentioned. For runs of over 250 feet I would suggest going to open-wire line to get to the beam, then using one of Jerry Sevick, W2FMI's 9 to 1 balanced to unbalanced transformers (see *Transmission Line Transformers,* by Jerry Sevick, W2FMI, published by the ARRL). This would get you from the 450 ohm impedance of the open-wire to 50 ohms, and then you could feed the beam directly with coax.

I cannot stress enough how important Sevick's book is to amateurs interested in making baluns or transformers to get from one impedance to another. I could cover the construction of a 1 to 9, 50 to 450 ohm transformer/balun in this article, but one would profit more by studying the design in Sevick's book.

In the case of a multiband dipole such as the McCoy dipole (June 1992 *CQ*) or the G5RV type, we would definitely want to use open-wire line. With it we can tolerate extremely high mismatches without loss, which we cannot do with coax. And that leads us up to the discussion of feeding a

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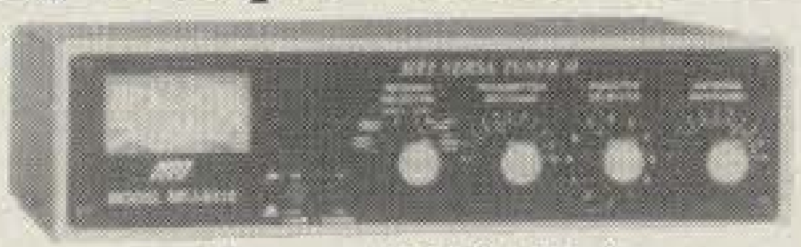

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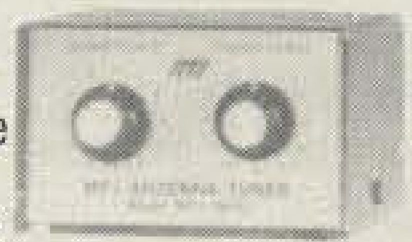

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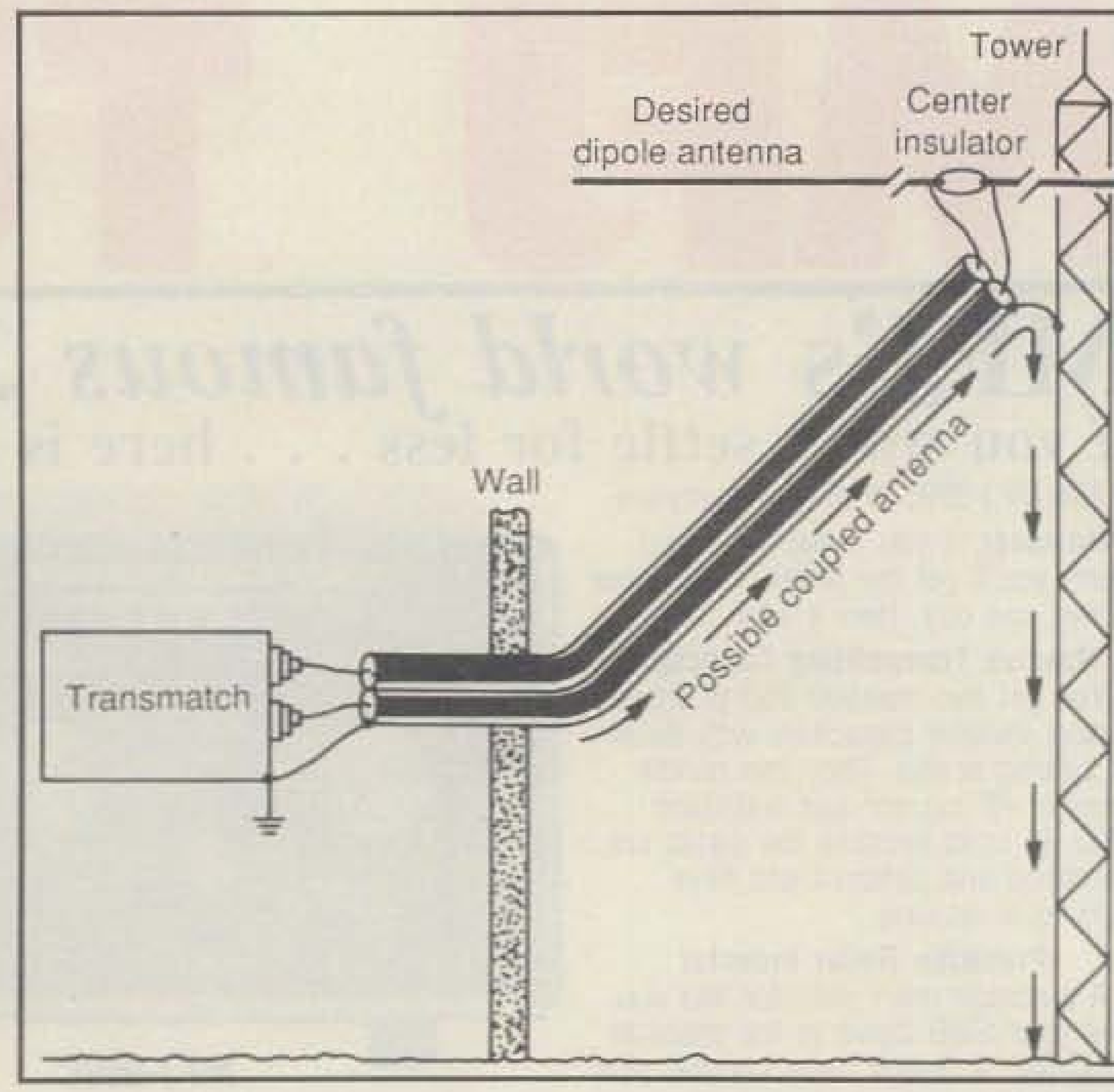
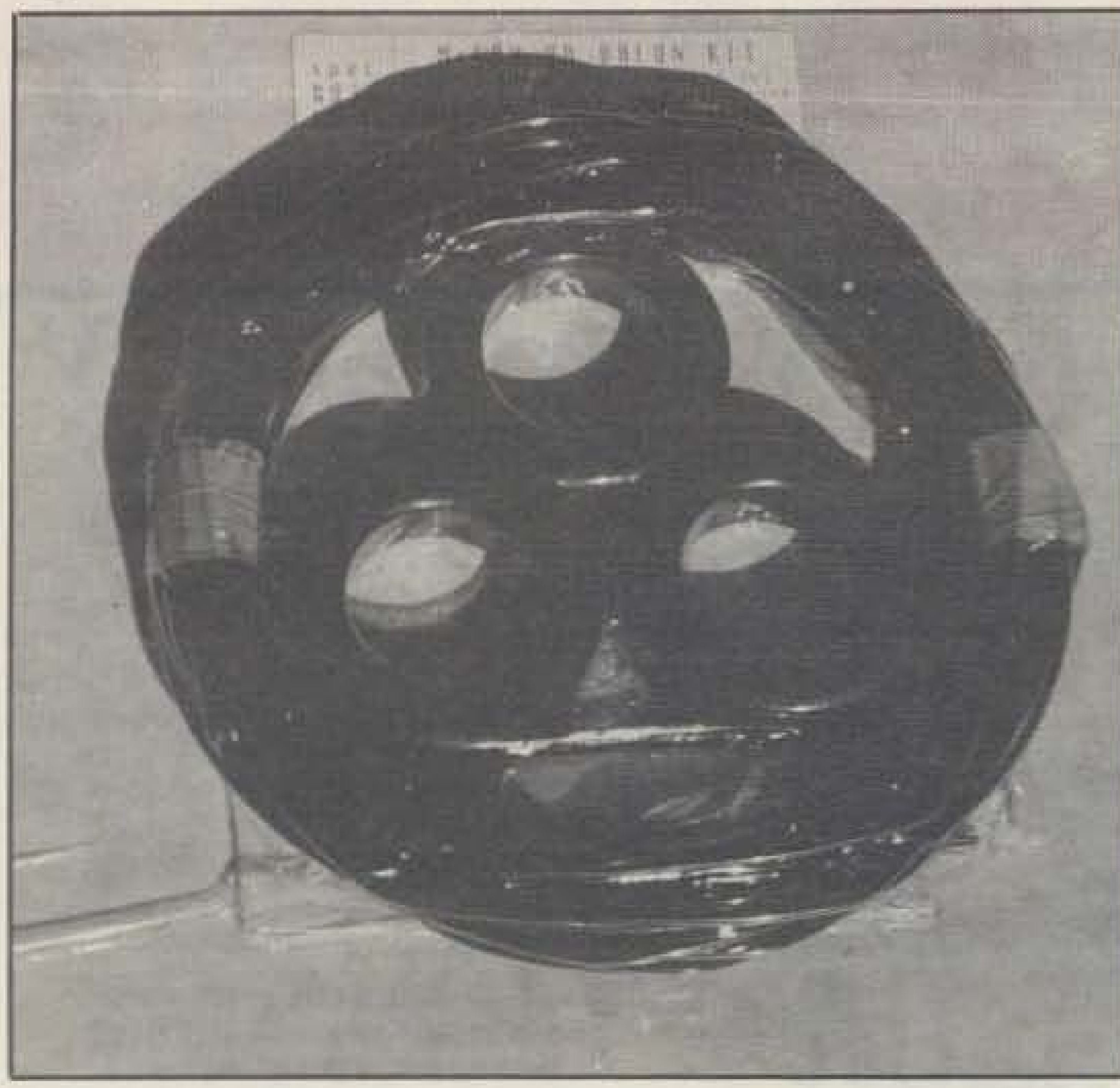


Fig. 1 – A possible "No-No" some amateurs use: dual coax out to a tower to feed a dipole. Frankly, from a technical standpoint this can be rather dumb. The outer shield of the coax, from the rig out to the tower, plus the tower itself and the guy wires can also be an antenna. All this can, or could, upset a beam pattern if there is a beam (and there usually is) on top of the tower. However, I know some readers would swear by such a system, and in that case I state McCoy's rule: "If the darn thing works, leave it alone."



This is the kit of toroids, special 3-M electrical tape, and No. 14 Teflon-covered wire that is sold by The Wireman (see ads in CQ).

multiband dipole with open-wire line. When I say a "multiband" dipole, I mean a wire dipole opened at the center and fed with open-wire line (or it could be an end-fed dipole, but I have never encouraged the use of end-fed antennas). One conductor goes to one side of the dipole and the other conductor to the other side.

As I pointed out in the June 1992 *CQ* article, the dipole length is not really important, but attempt to make it more than a quarter wavelength long at the lowest band used—in other words, at least 60 feet for 80 meter operation. You may hear many discussions about how long the feed line should be, but simply, it should be long enough to reach the shack. A problem arises here in that sometimes we end up with *RF voltages* in the shack, usually indicating the antenna system load may be operating at a very high impedance. The very simple answer to this is to change the feed line length by adding more line. If you are using the type of insulated "open wire" line I mentioned, it is no problem to simply coil up some lengths of the line and insert this new piece in the feed point at the tuner. How much line? A complete change would be a quarter wavelength of line, but the answer is to try different lengths to change the load. You may not need a quarter wavelength.

I have received calls and letters with questions about open-wire feeders that bear answering here. For one thing, some amateurs have had problems of Transmatches not being able to handle the antenna system, and they have experienced arcing or some other weird problem. Simply put, because a 150 watt Transmatch means exactly that—it is capable of handling 150 watts, regardless of the load or system. However, some open-wire-fed dipoles, on some bands, will exhibit high RF voltages, and the capacitors in the specified Transmatch experience RF voltages that can cause arcs or flashover. This really means the doggone thing won't handle the 150 watts! I have just discussed how to change this condition by changing the load impedance by altering the length of feed line.

What about using two lengths of coax and only using the inner conductors to create a "shielded" open-wire line? (See fig. 1.) It is possible to do this, **but** there are several problems which may arise, and I'll attempt to cover them. First, one would assume here that the impedance of the line using two 50 ohm conductors would be 100 ohms. But that is not important—at least if we are going to "tune" the line as we would do with open wire. But let me digress for a moment.

Years ago I wrote an article called "When Is a Feed Line Not a Feed Line?" (Naturally, the answer is when the feed line radiates and becomes an antenna.) This article went into considerable discussion about feed line radiation, and it was based on an event that at first was very baffling.

It seems two amateurs had bought identical beams and towers and had very similar locations. However, the one amateur's antennas had good front-to-back ratios on 10 and 20 meters, while the other's did not. Keep in mind that these stations were identical—almost! They wrote to me and asked why this happened.

At the time I was on a TVI lecture tour and would be in their area, so I agreed to stop by. As I said, upon examination, their antenna installations appeared identical. They had the same beams, they both had baluns installed at the antenna, and the only real difference I could see was the actual length of their respective coaxial feed lines. I reasoned, and as it turned out correctly, that the problem was feed line radiation (parallel standing waves), and this feed line radiation was upsetting the normal beam patterns. We used a grid dip meter and dipped the *outside braid* of the coaxial lines. The station that had the poor front-to-back ratio turned out to show a grid-dip resonance on the outside of the line on both 10 and 20 meters.

Keep in mind that any wire or metal in the vicinity of the antenna *that is resonant to the frequency of the power in the antenna* can couple power from the antenna and reradiate it. We changed the length of his coax to get rid of this resonance and the problem disappeared. His patterns became identical to those of the other station. And one more thing: Both stations had baluns at their antenna, which is supposed to cool off the lines and cure such problems. Naturally, I came to the correct conclusion that a balun may or may not help such a problem.

Getting back to our dual coax, we can connect the inner conductors to the balanced output of the Transmatch in the shack and ground the shields. But what about the shields out at the dipole? Most amateurs who have done this have left the topside shields just "hanging." Similarly, if the center of dipole is suspended from a tower holding a beam or beams, the shield is grounded to the tower. Fig. 1 illustrates such a setup.

In fig. 1 what we have is essentially two antennas—that's right, two antennas. The first antenna is a dipole fed by the inner conductors, and the second is an antenna consisting of the tower, from its ground up to the shields and then the shields back to the Transmatch and its ground. In our world of multiband antennas—from 160 through 10 meters—almost certainly that ground shield antenna is going to be resonant on one of these bands. And if so, it will certainly couple power from whichever antenna is being used. If you have such an installation, grid dip the shields to find the bands it might be resonant on, and change the ground lengths to move that resonance out of the band.

Once again going back to our dual coax, keep in mind we still have relatively lossy feed lines, plus the fact that these losses shoot up dramatically when high SWR conditions exist. SWRs of 20 to 1 or higher are common on tuned lines with multiband use. The real problem here, aside from losses, is the high RF voltages that can develop on the lines, with the likelihood of line destruction. Frankly, such an installation is just not my cup of tea.

In Part II we'll get to decide to bring open-wire line into the shack—or not to.

(To Be Continued)

W1ICP concludes this two-part series by debunking old myths and showing us how easy it is to work with open-wire line.

Let's Talk About Wire—Part II

Getting Open-Wire Feeders Into The Shack

BY LEW McCOY*, W1ICP

Whenever a feed line is resonant on the same band as the antenna in use, it is well nigh impossible to keep the feed line from coupling energy from the antenna and reradiating it. But is this important? The answer is yes and no. If you have a beam and desire a given pattern, then you certainly don't want the feed line radiating and giving you something other than the desired pattern. On the other hand, let's assume you are using a multiband dipole fed with open-wire line. The antenna is going to provide all kinds of patterns, depending on its length, height, band, etc. Feedline radiation in this case *is not lost power*, and it is going to go somewhere and maybe work someone for you. Therefore, such radiation from a multiband dipole feed line just isn't that important.

As I have already stated, I bring my open-wire line directly into the shack. I use a plastic pipe through my wall to bring the open-wire line to my Transmatch. Some amateurs don't want to do this, however. They want coax coming inside. I know of two rather simple methods of meeting this requirement, and they both will work well. In one case a transformer/balun is used to get from the coax to open-wire line. In the other a section of dual coaxial line is used.

A word or two about coax is in order here. A coaxial feed line is supposed to be a two-conductor line. The inner conductor is one lead and the outer braid is the other. Unfortunately, the outer braid can be looked at as two conductors—the *inside* and *outside* of the braid. When you physically attach the outer braid to one side of the antenna, you of course have physically attached both the inside and outside of the braid to the antenna. If the outside of the braid happens to be of a certain impedance value (determined by its electrical length), then you will have a difficult time keeping RF from flowing back down the outside of line, causing parallel standing waves and feeder radiation.

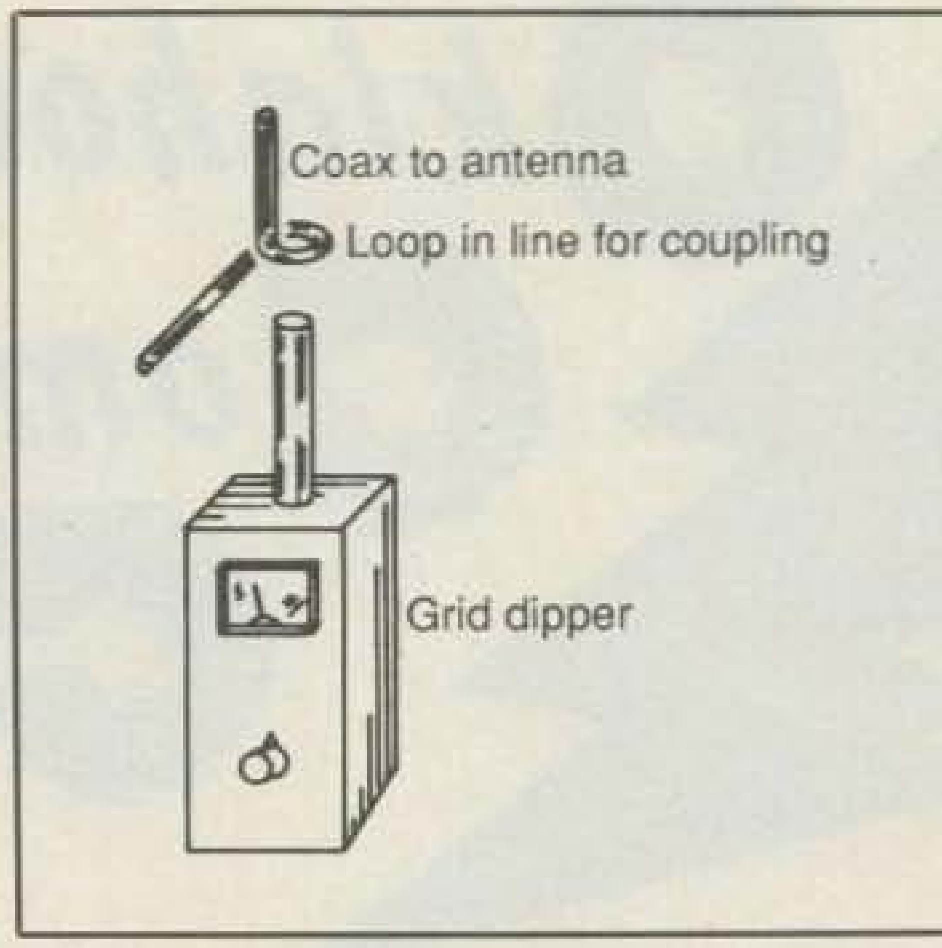


Fig. 1– This shows how I couple the grid dip meter to a loop in the coax. Just laying the grid dip coil alongside the coax does not provide a tight enough coupling. As described in the text, if you find a dip in one of the amateur bands, change the coax length to move the dip out of the band.

You may read or be warned by many "experts" that feed-line radiation can cause TVI or other interference because such radiation is vertically polarized. If they are careful "experts" they will say "can cause" to cover themselves, because quite simply, they could say all vertical antennas "can" cause TVI. In really plain, simple, easy-to-understand language, *any* antenna radiation, horizontal and/or vertical, "can" cause interference. These experts should realize that a TV installation has no respect for vertical *or* horizontal polarization. The real answer to the problem is that any decent television set should have built-in protection or a high-pass filter added to stop *any* amateur RF overload.

The reason I emphasize the above is that recently there has been a flood of praise for what are called "current" choke baluns, which are supposed to stop or prevent feeder radiation. I say "supposed to stop," because in many cases they will do a good job, but they are not a cure-all. *No balun is*. Most of these have been described for use with powers up to 150 watts. I made some tests using coaxial line with the shields resonant, via the grid dip meter method, to a 20 meter dipole. I used a good grade of heavy-duty coax (for high power), and I tried different amounts of large ferrite beads installed over the coax line at the feed point of the antenna. In all cases, running 1500 watts test, key down, the beads got too hot to handle, and in several cases they actually shattered. Please understand, this is a worst-case condition with the coax line braid being resonant at the operating frequency.

I might add that if you grid dip your coax, make a small loop of the coax to fit over the coil of your dipper (see fig. 1). This will provide the necessary coupling. Also, *and most important*, the actual electrical length of the line cannot be measured with a measuring tape. The electrical length is the length from the feed point of the antenna, down to your station, through your equipment, and to the point where the line is returned to real earth ground (and we don't know where that is, but the grid dipper will show the resonance). To move the resonance point, I recommend adding coax or changing the length to ground by using a longer ground lead. (Don't, for gosh sakes, prune your coax; it costs too much!) If your beam is multiband be sure to check the other bands, because it may take several changes in length to get the resonance out of each band. You don't have to move the resonance far, as long as it is out of the band.

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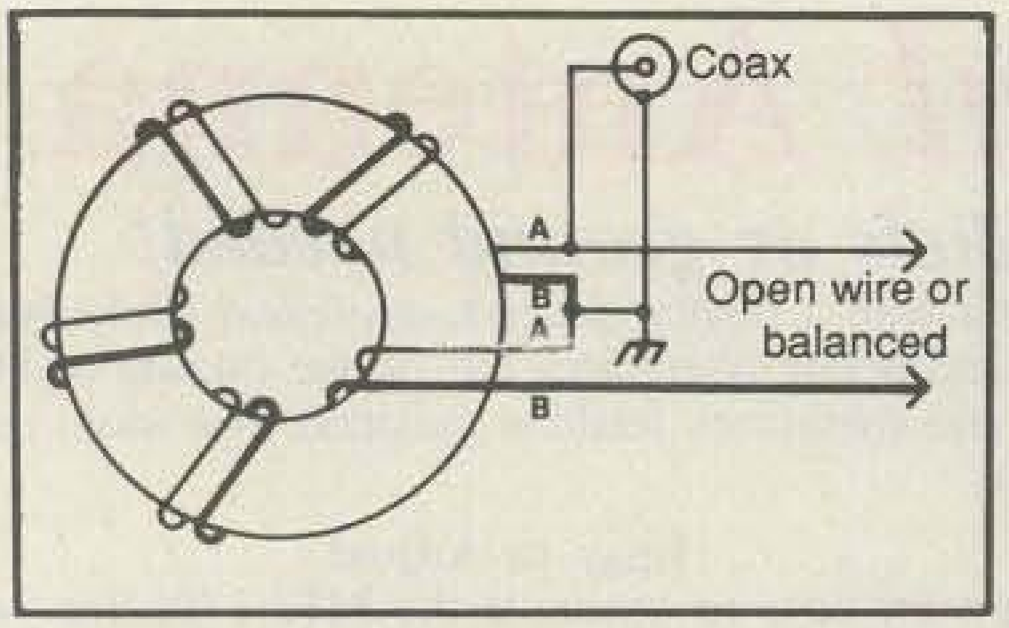
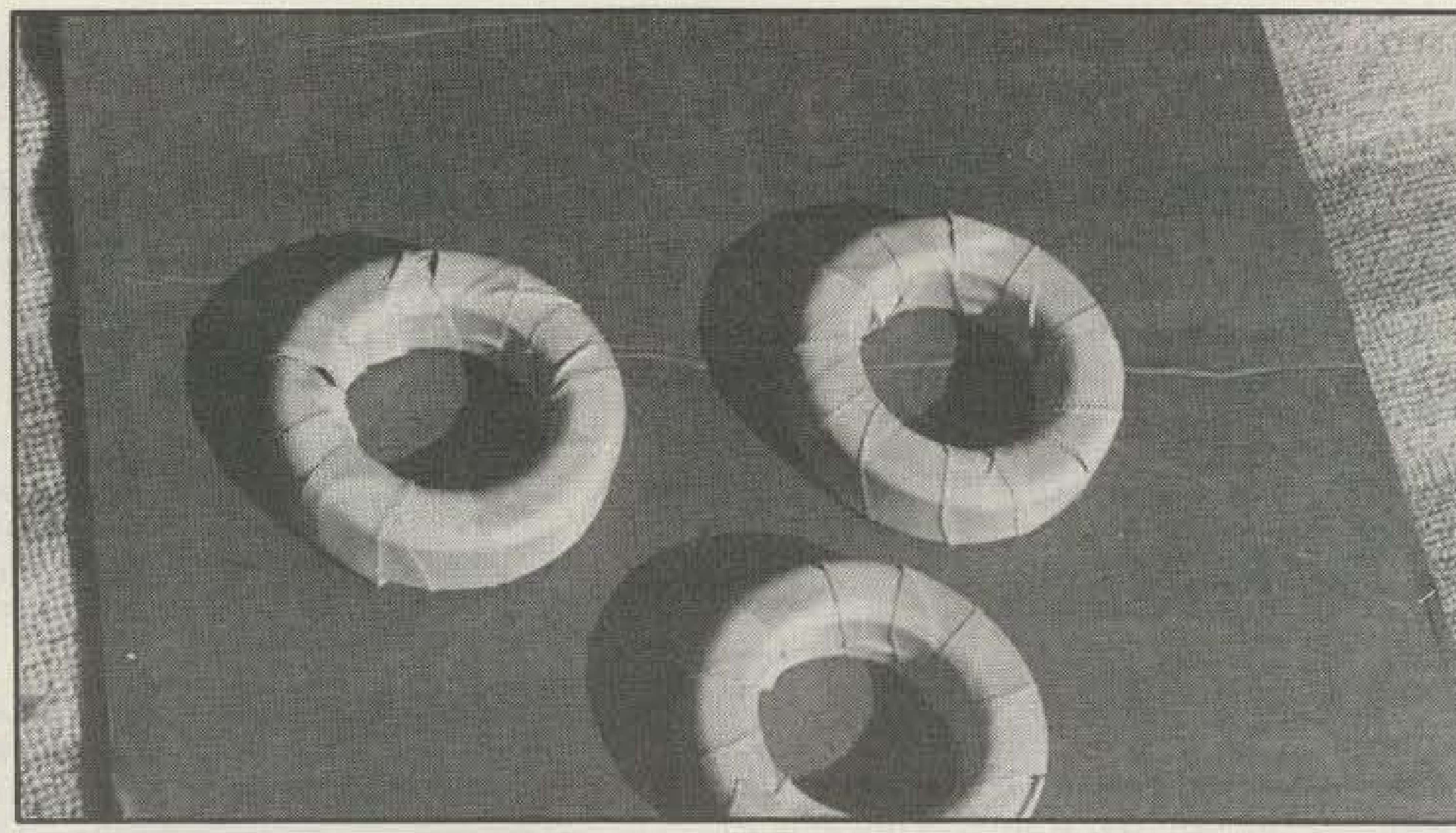
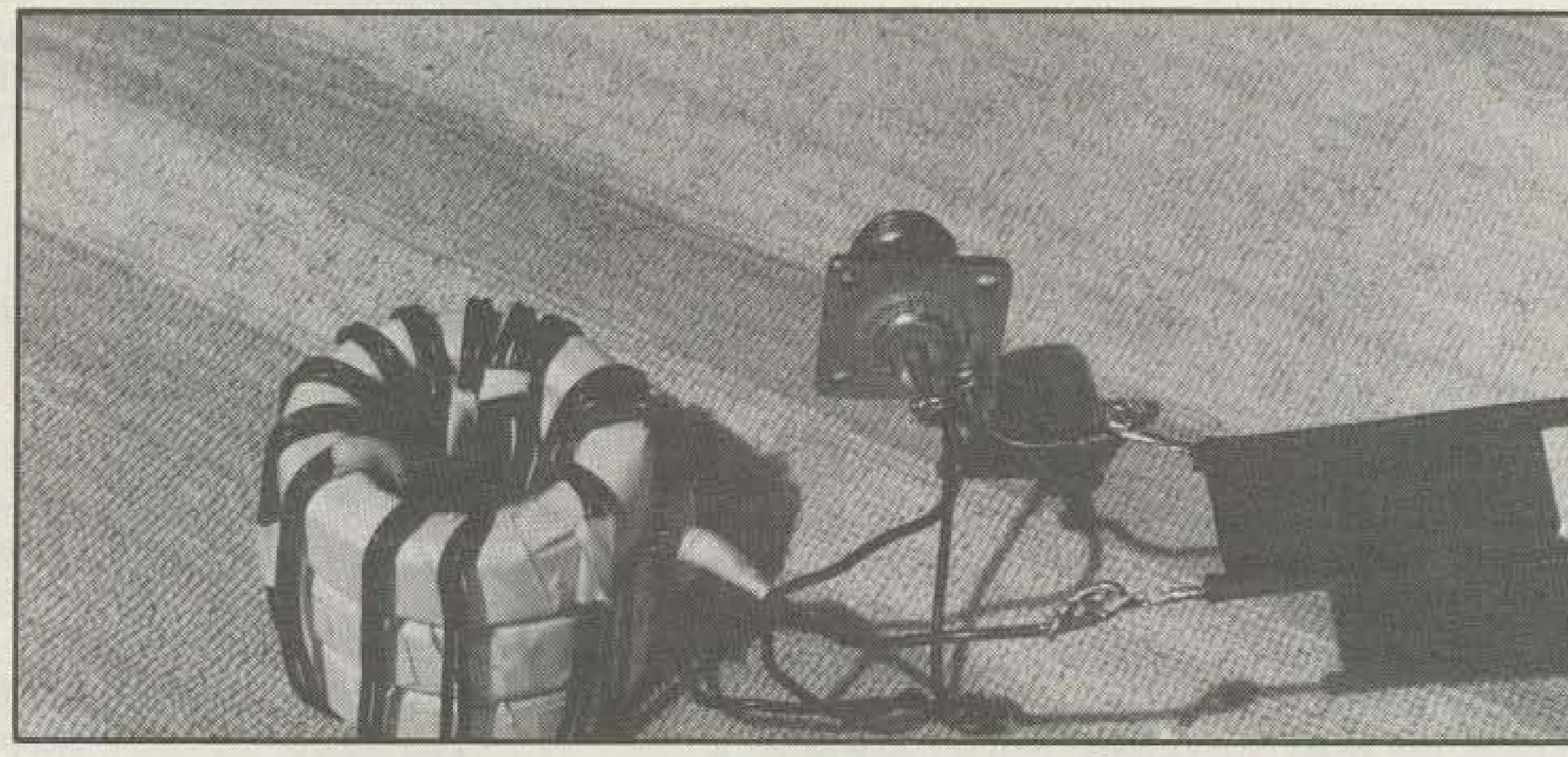


Fig. 2– The 4 to 1 transformer/balun.



In Part I we showed the basic kit available from The Wireman. Here are the three powdered iron cores wound with the 3M insulating tape.



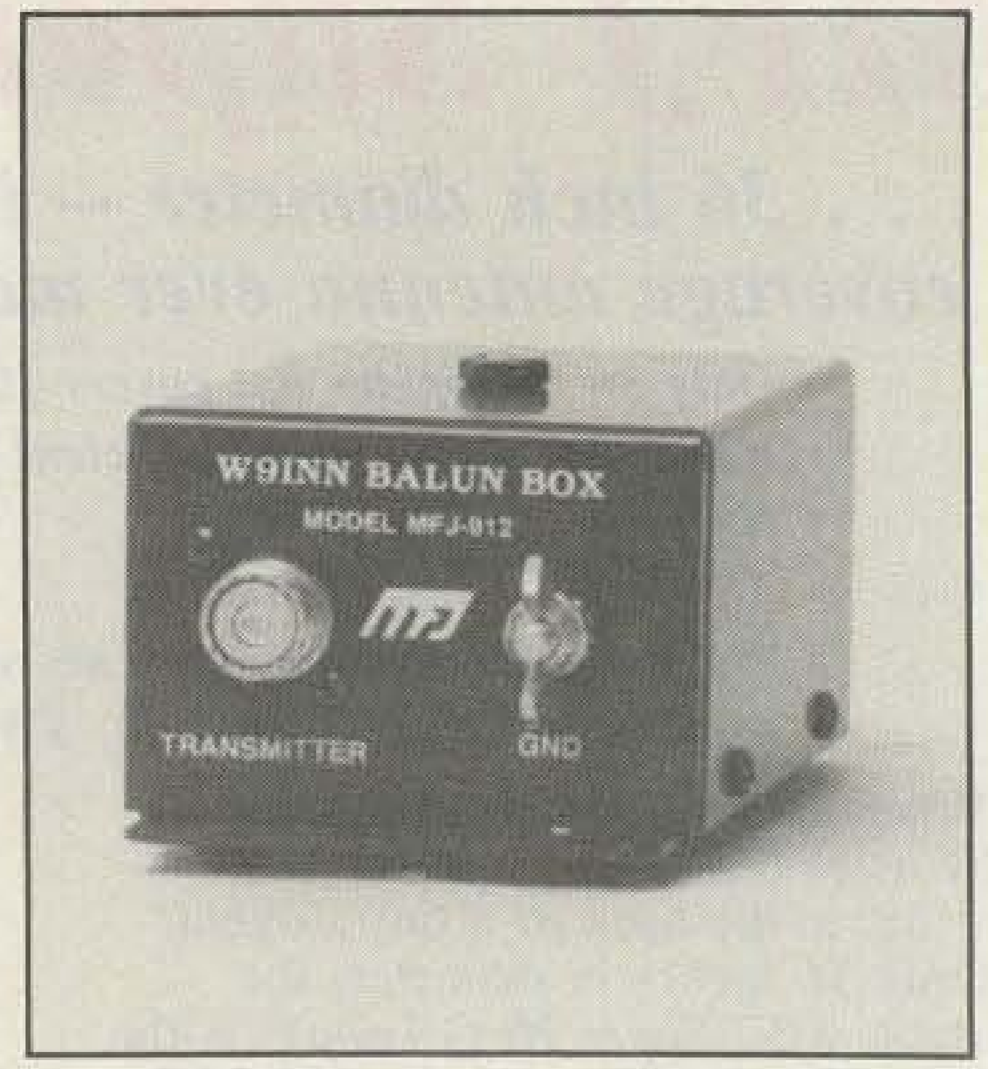
I have deliberately left this "open" type construction to show the bifilar windings and the connections to the coax fitting (SO-239 type) and the other two leads connected to the open-wire line. While electrically this would work well, in actual practice the transformer needs to be mounted in a box or case that is weatherproof.

There are a couple of other points that should be covered before getting down to coax to open-wire feeder connections. Years ago when I first described the Ultimate Transmatch, I had the problem of going from a circuit that was basically single ended, to a balanced output or line (open-wire or twin-lead feeders). The answer boiled down to using a voltage type of balancing transformer. This is important because over the years arguments have erupted about the ratios, standing-wave matching, and other things. Keep in mind this simple fact: All I wanted was a transformer to go from unbalanced to balanced line. SWR had nothing to do with the design for a very good reason. If you take the composite antenna system load, the antenna plus feeders, the load presented at the Transmatch can be almost any value, *as we are not matching that load with the balancing transformer.* We are converting this balanced unknown load through the Transmatch to get the load to convert to the unbalanced 50 ohms, the design type of the transmitter or transceiver. The SWR at the balancing transformer is not important. What is important is that the transformer should be able to handle the mismatched currents or voltages. That is point 1.

One other aside here: I mentioned the heating of the current type of balun. The 4 to 1 voltage balun mentioned above, when properly built as described here, just does not "saturate" or overheat, as some people have said. I first made this type of balun in 1957 and have never had problems, and I run the legal limit. It is true that this balun may not be "flat" from 160 through 10 meters, but *we are not using it as a matching transformer.* Our aim is to get from coax to open-wire line and get as balanced a condition as possible. The cores I used are T-200 type material, and they are not as critical as ferrite, which I would not recommend for this application. Again, I would refer you to Jerry Sevick's excellent book for complete details on these materials and transformers.

Point 2 is how efficient is this type of balancing transformer in providing balanced output to open-wire line? I know I am being redundant here, but the argument that has erupted over current versus voltage baluns leaves one wondering if the whole thing is a tempest in a teapot. In the first place, and I am speaking now about open-wire feed to a multiband antenna, it is well nigh impossible *not* to have some feeder radiation regardless of the type of transformer used. However, it is important to keep in mind that such radiation is not *lost power.* It is going to go somewhere and probably will work someone for you. (Obviously, with the current balun tests I mentioned above, there is power lost as heat.) As long as pattern distortion is not a problem, and it rarely is with wire multiband antennas, then there should be no concern if there is some feeder radiation.

Since the inception of the Ultimate Transmatch some 30 years ago, manufacturers have used the balun/transformer



This is the MFJ-912 four to one open-wire to coax transformer. This is a rugged unit designed to handle big mismatches.

method I described back then in their Transmatch/antenna tuners, and I might add with good success. So since this has worked so well for so many years, I am not about to suggest a change. I am always guilty of using cliches so I have tried to avoid them, but believe me, the old cliche that goes "If it ain't broke, don't fix it" certainly applies here! Fig. 2 is the circuit of this 4 to 1 transformer, and the accompanying photos provide details for constructing the transformer.

The first method of using coax to get outside the shack to open wire consists of using such a balancing transformer. We must come out of the transmitter/transceiver using coax to a Transmatch, then additional coax out to the balancing transformer which converts the system from coaxial line to open-wire line. One important point here: The commonly available built-in antenna tuner used in nearly all modern transceivers *will not* do the job. They simply do not have enough matching range to handle the mismatches encountered with a multiband tuned system. For that matter, in many cases they will not handle an 80 meter trap dipole. A Transmatch that has a wide matching range is needed. If you want to build your own, the handbooks are full of them.

I do not recommend using long runs of coax from the Transmatch out to the transformer. Try to keep the coax length under 25 feet, and by all means use an RG 8/U type, not RG 8X or RG 58, even with just 100 watts output. If you run high power, some very high voltages and currents can be developed and the coax must be able to handle them. Therefore, use a good, high-power type of coax.

There are commercial coax to open-wire line transformers available. The MFJ type is one (see photo). This is an excellent transformer and will easily handle 10 to 1 or higher SWR mismatches. However, for

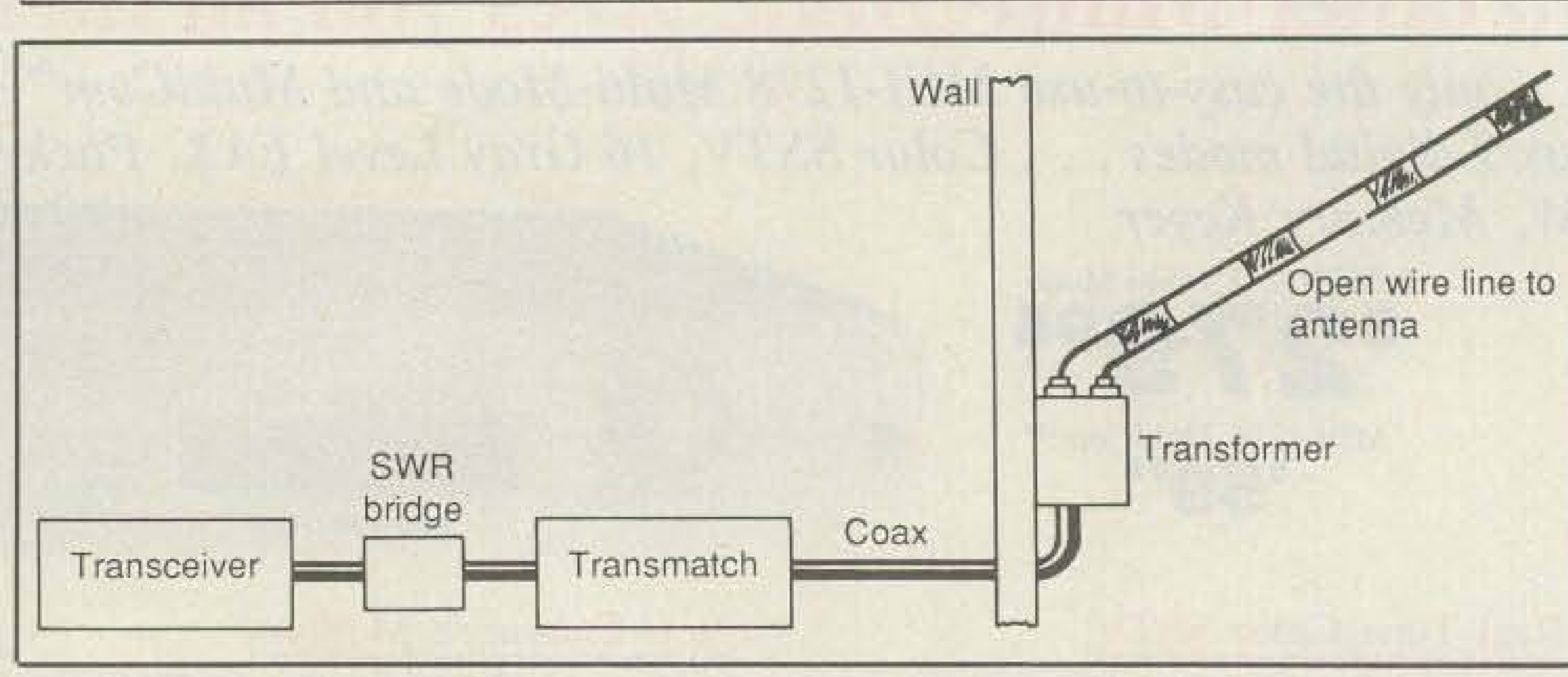


Fig. 3– This shows our goal: to bring the coax through the shack wall (or whatever) out to a transformer and then to the low-loss open-wire line.

those of you who want to roll your own I have shown how to make one in the photos. That way if something goes wrong and you have to blame someone, that someone will be me. The Wireman (see ads in *CQ*) sells a kit of parts for making the transformers. As I said earlier, don't be concerned about the 4 to 1 ratio, as we are not concerned with SWR here—at least not in the sense most amateurs think of SWR, because this is not a matching transformer. The thing to keep in mind is that we have a transmitter or transceiver that must work into a *50 ohm load,* and we must provide this load from an unknown antenna system load. The antenna system load may be very low or very high impedance with lots of reactance, and truly, the balun/transformer is only there to get from an unbalanced to balanced condition; that is all, nothing more. The Transmatch itself will convert the unknown antenna load to 50 ohms.

In fig. 2 a single T-200 core can be used, with Teflon-covered wire for powers up to a couple of hundred watts. For 1500 watts, key down continuous duty, three stacked cores should be used.

Construction of the transformer is relatively simple. The T-200 core/cores are first wrapped with a layer of the special insulating tape. If you are using the three cores, after each one is taped use a couple of strips of tape to tie the three cores together. Next put the two free ends of the Teflon wire in a vise and draw the two wires taut. I would suggest using some strips of the tape to tape the two conductors together, making a two-conductor wire. Next insert this wire "ribbon" through the cores or core and wind until you have at least 10

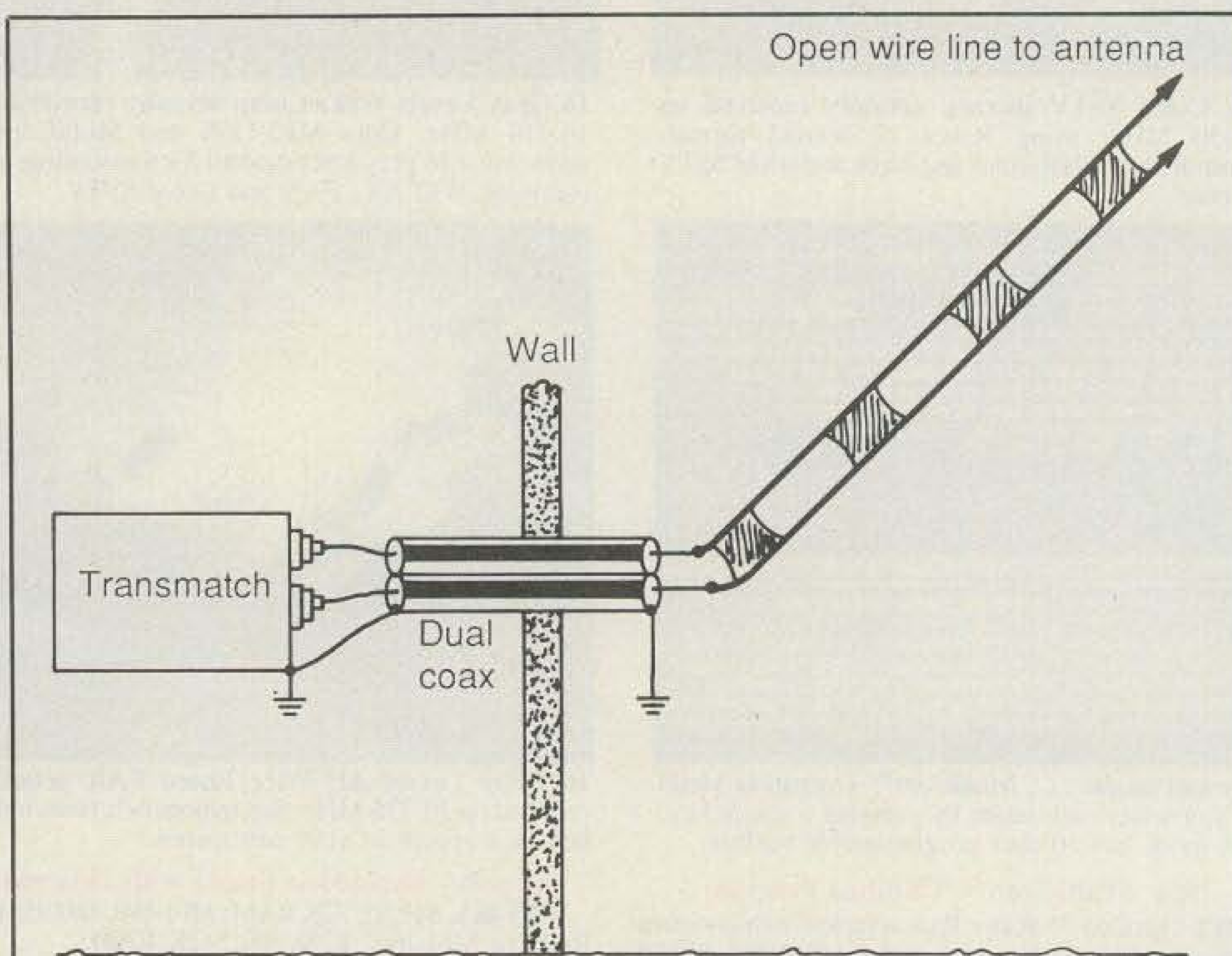


Fig. 4– Here is the second method of using short lengths of coax to get outside the shack. The dual lengths of parallel coax are brought from the balanced output of the Transmatch, out through the wall. At that point, we convert to open-wire line.

turns (10 to 12 turns are okay). You now have your transformer. It can be mounted on a metal plate or U, with a coax fitting on one side and two terminals on the other side (for the open-wire line). The entire unit can then be mounted on an outside wall, post, or whatever (see fig. 3). When mounted outside, cover the assembly with a plastic freezer box to keep out the rain and snow. The Wireman tells me that they can supply two different kits—high or low power.

As I noted earlier, there are a couple of commercial units sold in which the transformer is already mounted in a case. One in particular is the MFJ-912 W9INN remote transformer, which is identical in circuit to the transformer I described above. This unit uses two cores, but they are larger than the three I specified in the home-built version. They will handle at least 2 kilowatts with mismatches that are very high —10 to 1 or greater. This unit is already in a weatherproof box with mounting screws and terminals.

Remember, it is important that the coax from the Transmatch in the shack out to the transformer be a high-quality line, RG-8/U type, that will handle 4000 to 5000 RF volts. To repeat: The reason for caution here is that a high SWR can exist on this line between the transformer and Transmatch. A high SWR can cause high voltage or high current to be present, which could cause damage to the coax line. For this reason it is best to keep this coax line as short as possible.

I realize I didn't use a specific number here, but short as possible means just that. I know of some amateurs who have used as much as 50 feet of coax, but I think this is begging for trouble. Keep in mind that a high SWR is likely to exist on this coax into the Transmatch. For example, an 80 meter dipole, 130 feet long, center fed with open-wire line, is likely to have an SWR of 10 to 1 or higher appearing on the line. This mismatch also appears across the transformer and then goes on to the 50 ohm coax. The Transmatch in the station converts the mismatch to a pure 50 ohm match, but there still can be high voltages and currents on this coax, so keep it as short as possible.

Tune up is simple. With the system all connected and an SWR indicator in the line between the transmitter and Transmatch, apply enough power to obtain a reflected reading on the SWR bridge. Next adjust the Transmatch for a null or match as indicated by the SWR bridge. You can then bring up your power to the desired level.

The second system does not require an external balun/transformer at all. Use the one that is built into the Transmatch. Use two equal lengths of coax to get from the balanced line output of the Transmatch, to a point outside the house, to the open-wire line (see fig. 4). The coax is run together and the two inner conductors will be your section of feed line. The coax shield is connected together at each end (soldered). The coax feeders at the Transmatch end are connected to the balanced output terminals on the Transmatch. (In this case, the balun/transformer is already built into your Transmatch; just about all commercial units have them.) The coax leads at the outside point are connected (soldered) to the open-wire conductors, and the shields are connected to earth ground.

Wait! I know what you are going to say. What about the impedance of the open-wire feeders (450 ohms) being connected to the parallel coaxial feeders (100 ohms)? Isn't this a bad mismatch? It is a mismatch, but *it is of no importance in this case.* The coaxial section is a balanced line, and there can be no radiation from it (not only that, it is shielded). The difference in line impedance does not matter, because we are matching or adjusting a *complete* and complex antenna system load via the Transmatch.

We could, if we wanted to, make a transmission line of combination impedances —say, 300 ohm line, 450 ohm line, 600 ohm line, etc.—as long as both conductors in each line are perfectly equal in length. In theory, the radiation from one conductor cancels the radiation from the other, so the line doesn't radiate. If that is true, our only problem is one of matching this completely unknown load back to 50 ohms at the transmitter—and that is what we do. We adjust the Transmatch as described earlier. Remember, though, as I mentioned earlier, to keep the dual coax lines as short as possible. The same or similar high voltages/currents we mentioned earlier can exist here.

While I have written this article telling you what you can do, it is not what I do. I don't care if the open-wire line comes into the shack. Although I have thoroughly tested both methods, as I stated at the outset, I bring my open-wire line in along with several coax lines through a section of PVC pipe and then up to the Transmatch. Sometimes, however, amateurs like the idea of bringing coax all the way in (also it may keep their wives happy), so be my guest!