# 9

# Transmission Lines

## Contents

# Easier BNC and Type-N Connector Installation

### *By Zack Lau, KH6CP*

(From *QST*, June 1989)

Getting all the cable-shield wires through the clamp can be difficult during installation of BNC and Type-N connectors; usually, a few braid wires end up getting squashed under the clamp. Solution: Hold the wires down by wrapping them with electrical tape. Don't tape beyond the braid wires onto the coax outer jacket; just tape the braid itself.

# Connectors for 1-Inch Hardline

## *By Ray Benny, N6VR*

(*From* QST, *May 1992*)

This item first appeared in the *National Contest Journal*.

The following is a description of the system I use to install female coax connectors on 1-inch Hardline. The only parts needed are the Hardline (available from many cable-TV companies), a ½-in. male copper pipe adapter, and a standard PL-258 barrel connector that can be disassembled (Amphenol 83-1J is the type I use). Figs 1 and 2 are provided for reference.

1. Make a square cut at one end of the Hardline with a fine-tooth hacksaw.

2. Use either a hacksaw or tubing cutter and cut off 9⁄16 in. of the plastic jacket and aluminum tubing. Do not cut or nick the center conductor. Completely remove the plastic jacket and aluminum outer conductor.

3. Using a sharp knife, remove the foam from the copper center conductor. Use a fine file to deburr the end of the center conductor.

4. Tin the center conductor with a thin film of solder.

5. Cut off evenly about ½ in. of the outside plastic jacket.

6. Disassemble the coax barrel connector by removing the internal snap ring. Note the end of the barrel from which the snap ring came.

7. Apply solder flux to the snap ring end of the barrel and the inside of the male adapter. Place the fluxed end into the ½-inch male adapter. Tap it gently to seat it. Next, place the two pieces upright in a vise. Use a propane torch to solder the pieces together.

8. Slip the barrel center coupler about halfway onto the tinned center conductor of the Hardline. It may take some experimenting to find the best position for proper spacing of this coupler. Solder the coupler onto the center conductor.

9. Apply a small amount of silicone grease (I use the non-hardening type) on the foam, around the center conductor. Apply a small amount of aluminum/copper conductive grease (Noalox, Penetrox or equivalent) to the outside of the Hardline's aluminum jacket.

10. Hold the prepared end of the Hardline pointed upward and slip half of the clear plastic barrel spacer over and onto the barrel center coupler. The end with the outer recess goes upward (the same way it came apart). The second half of the plastic spacer is not used. Place the male adapter/barrel assem-

**Fig 1—At the top, an assembled Hardline connector. At the bottom, the pieces of the barrel connector and the plumbing fitting are lined up, ready for installation on the cable.**

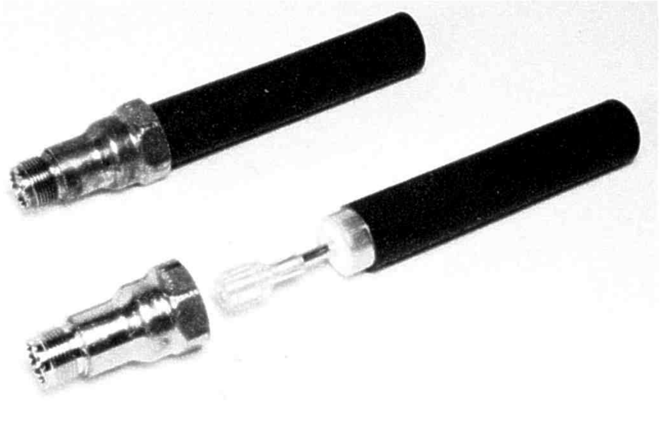

**Fig 2—At the bottom, the PL-258 connector is soldered into the plumbing fitting. Half of the barrel's insulator is installed and the barrel center coupler is soldered to the Hardline center conductor. All that's left to do is screw the connector assembly onto the Hardline and weatherproof the connections.**

bly over the center coupler soldered to the Hardline. Use a large adjustable wrench to screw this assembly onto the aluminum jacket. Screw it on until the plastic barrel center spacer just touches the inner ridge of the barrel.

11. There, done! When this connector is mated with its other half, I wrap it with several layers of black tape to provide a water-tight seal. Another thing that I do is to trim/tune the coax for a multiple of a half wavelength at the operating frequency.

Once tuned, the input impedance present at the coax input will be the same at the output of the coax. (See ON4UN's *80-Meter DX Handbook*, or *Low-Band DXing*,[1] which describe how to use an SWR meter and a dummy antenna to trim the coax line.) I have used this 1-in. CATV Hardline as described on several long runs (200 to 300 feet) in place of standard RG-213 cable. Although I have not measured the losses with a load and wattmeter, I have definitely noticed a difference in both the receive and transmit signals on the higher HF bands. I have also replaced a 60-foot run of RG-213 on 450 MHz with about 50 feet of electrically cut 1-in. Hardline (with RG-213 jumpers on both ends for flexibility) and noticed a much-improved signal. This 1-in. Hardline is very expensive if purchased outright, but my Hardline was free! The trick is to call your local TV cable company and ask them if they would like to unload their "reel ends" (large reels with only 100 to 300 feet remaining). My local company was in the process of cleaning their yard, so I was able to take as much as I wanted. If they are not too happy about giving it away, it may be worthwhile to offer them payment to at least offset the scrap value they could receive from a surplus dealer.

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[1] J. Devoldere, *Antennas and Techniques for Low-Band DXing* (Newington: ARRL, 1994).

# Using Type-N Connectors on Half-Inch Hardline

### *By Dave Mascaro, WA3JUF*

I have used standard Type-N connectors on half-inch aluminum Hardline for over 10 years. Performance and weather resistance is as good as or better than commercial connectors. Most commercial connectors have a push-fit center conductor connection that turns green after six months outside.

This procedure allows the use of ordinary Type-N connectors on half-inch aluminum Hardline with a solid copper center conductor. Refer to Fig 1.

1. Strip off the plastic covering. Be careful not to nick the aluminum.
2. Bore the connector nut to ½-in.
3. Slide the nut onto the Hardline.
4. Slide the ferrule onto the Hardline (see Fig 1). The ferrule is made from a 0.2-in. piece of ½-in. soft copper pipe, split to fit snugly around the aluminum outer conductor.
5. Flare ⅛ in. of the end of the aluminum jacket to form a clamping ring inside the connector housing.
6. Cut the center conductor flush with the end of the outer conductor.

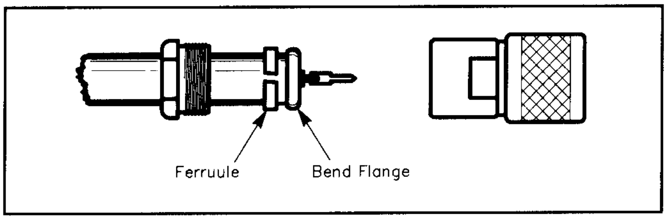


**Fig. 1—Assembling a Type-N connector to ½-in. Hardline.**

7. Drill a hole in the center conductor to accept a piece of 18-gauge wire.
8. Solder the connector center pin and wire to the center conductor.
9. Coat the ferrule-aluminum connection with Oxiban.
10. Assemble the connector. After tightening the nut, the connector housing should not turn. If the connector is loose or the nut bottoms out, use a wider ferrule.
11. Coat the connector with silicone sealant.

# Semi-rigid 0.141-Inch Coax to BNC Adapter

### *By Wes Atchison, WA5TKU*

This approach to fitting a BNC connector to the popular 0.141-inch semi-rigid coax takes advantage of the 0.156-in.-ID of 3/16-in.-OD brass tubing. This technique was developed on UG-88 BNC connectors. The connector dimensions were taken from the Amphenol connector catalog. Other manufacturers' connectors should work as well. In fact, the technique should be adaptable to any connector by simply using the appropriate-sized brass tubing.

The ID of the UG-88 locking nut is a nominal 0.214 in. This results in a difference between the coax OD and the locking nut ID of 0.073 in. This difference is taken up by two pieces of brass tubing (1/32-in. wall thickness). A 1/2-in. and 7/16-in.-long piece of 3/16-in. and 7/32-in.-OD brass tubing (respectively) are slid onto the coax as shown in Fig 1. A trial fit of the 7/32-in.-OD tubing is necessary before assembling the connector, since the nominal dimensions of the locking nut hole and the tubing OD are a 0.004-in. force fit. Depending on the tolerances of your materials, the nut may have to be drilled out with a no. 2 or 7/32-in. drill bit. An alternative method would be to sand down the OD of the brass tubing.

The following steps are taken to assemble the connector:

1. Strip the shield and center insulation of the coax back far enough to install the center pin of the connector. Do *not* install the pin.
2. Slide the drilled-out nut onto the coax.
3. Slide the 3/16-in. brass tubing onto the coax.
4. Slide the 7/32-in. brass tubing onto the 3/16-in. tubing.
5. Slide a no. 6 washer onto the coax.
6. Adjust the washer, 3/16-in. tubing, and the 7/32-in. tubing so that the assembly is flush with the end of the coax shield.
7. Solder the washer, 3/16-in. tubing, 7/32-in. tubing and the coax shield as shown in Fig 1.
8. Solder the center pin to the coax center conductor.
9. Slide the connector housing onto the coax.
10. Slide the nut into the housing and tighten.
11. Use an ohmmeter to check for shorts.

Brass tubing can be found in 12-in. lengths at most hobby shops (for about a dollar a piece). The no. 6 washer can be found at your local hardware store for about 15 cents.

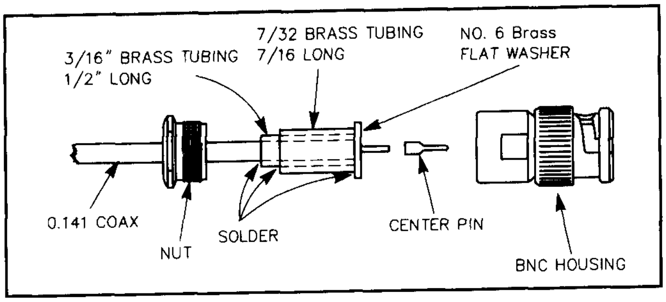


**Fig 1—WA5TKU's method of attaching a BNC connector to 0.141-in. semi-rigid coax. See text for details.**

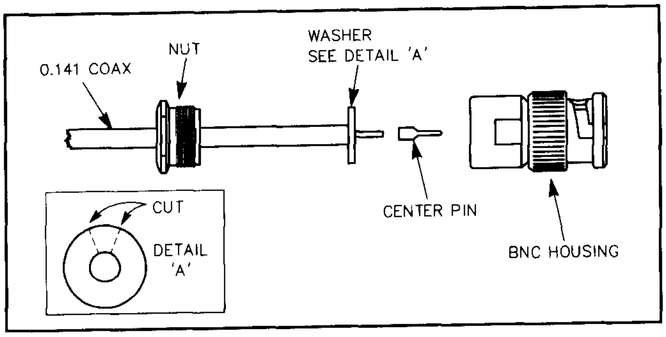


**Fig 2—An alternate method of fitting a BNC connector to 0.141-in. semi-rigid coax. See text and Fig 1.**

Another approach I have developed is shown in Fig 2. This technique is not as "pretty" as the one described above, but it does work. The backing washer used to install the connector on RG-58 coax is cut with a side cutters. The inside diameter is reduced to fit the coax with a pair of pliers. It is necessary to cut the overlapping ends of the washer to fit the assembly inside the connector housing. The washer is soldered to the coax shield after the insulation has been stripped to allow the installation of the center pin. The housing is now installed and the nut tightened.

This technique is not recommended for cables that will be used outside.

I prefer the first method because it supports the coax better and appears to be more professional. I use both methods in my 1296-MHz system.

# Adapting Commercial Circulators and Isolators for Amateur Use

### By Kent Britain, WA5VJB

(From *Proceedings of the Central States VHF Society Conference '91*)

Ah, those little things you see in all the commercial microwave equipment, but almost never in ham gear. I now have over a dozen of these in my stations . . . they solve so many problems!

Think of these ferrite devices as a fluid check valve, or a doggie door that only lets the pooch go out (Fig 1). An isolator will absorb 5 to 10% of the signal going from IN to OUT, but if you send a signal backward through it, 99 to 99.9% of the signal is absorbed. Boy, if you could put one of these in your 20-meter station, the antenna could fall down and the transmitter would never know the difference.

These work great, Stage 1 never knows Stage 2 exists. You can tweak away without interaction between stages. Unstable stages see a 50-ohm load from dc to the GHz; preamps and LOs are happy. So why don't hams use isolators more often?

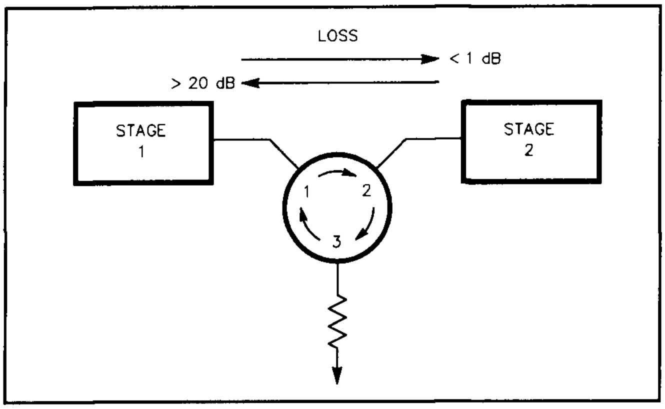


**Fig 1—A circulator isolates Stage 2 from Stage 1 by more than 20 dB, while allowing almost unattenuated signal transfer from Stage 1 to Stage 2.**

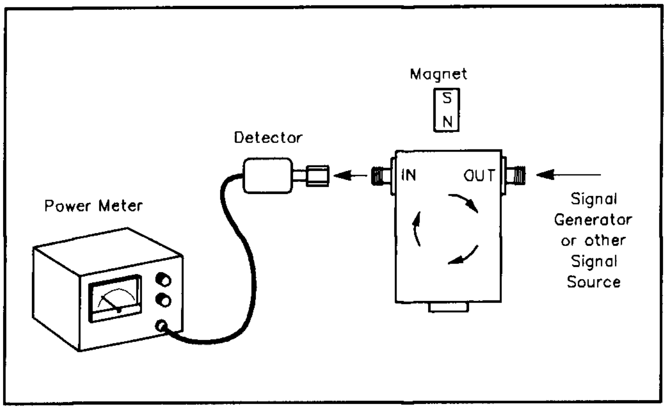


**Fig 2—Using a magnet to tune a circulator. Once the desired isolation is obtained, glue the magnet or magnets in place.**

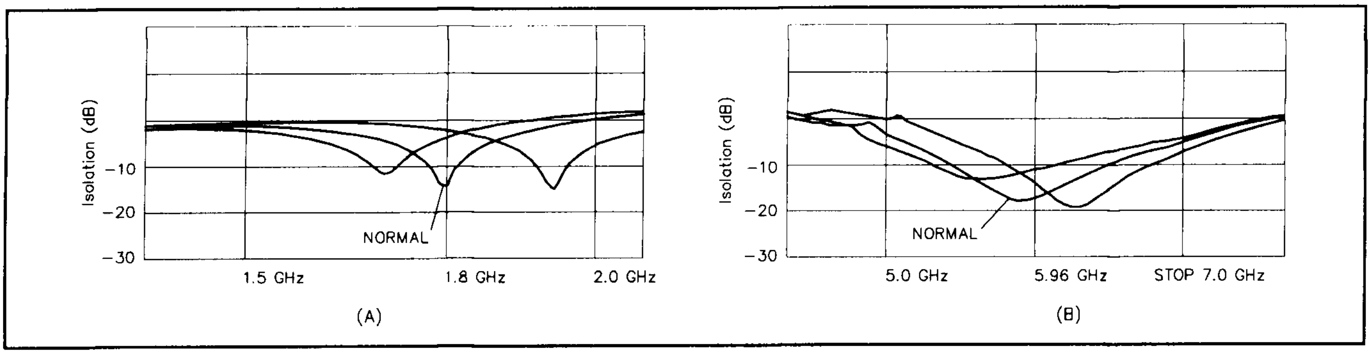


**Fig 3—Plots of two isolators. At A, a 1.8-GHz isolator; at B, a 5.9-GHz isolator. The center plots show the normal plots for the isolators. The left and right plots were obtained when the isolators were approached by the North or South poles of a magnet.**

It is very rare to find a surplus isolator or circulator that is made for one of our ham bands. Fortunately, WA3RMX has shown us that the ferrite devices can be retuned with just a magnet (Fig 2). Just feed a signal backward through the isolator (on the frequency you want!), then move a magnet around on the outside of the isolator. If loss goes down, flip over the magnet. One magnet works well? Try two! Keep experimenting until you get as much loss/isolation as you can, then glue the magnets in place.

The plots in Fig 3 (made with the help of WB5LUA) show a 1.8-GHz and a 5.9-GHz isolator. As you can see, isolators move up in frequency better than they move down. You also can move isolators about 10% of their frequency. So, a 2.0-GHz isolator can probably be moved up to 2304 MHz, a 6.0-GHz isolator can be moved down to 5760 MHz, a cellular-telephone isolator can be moved to 902 MHz and a 9-GHz or 11-GHz isolator can be moved to 10368 MHz.

# Make Your Own Waveguide Transitions

### *By Kent Britain, WA5VJB*

In putting together several 10-GHz stations out of surplus parts, the first thing you notice is the different sizes of moding, WR-112, WR-90, WR-75, and WR-62. These can be identified by measuring the width of the opening. WR-112 is 1.12 in., WR-90 is 0.9 in., WR-75 is 0.75 in. and, of course, WR-62 is 0.62 in. across.

Well, very quickly you'd like to hook a WR-90 thingamagig, to a WR-75 whatchamacallit. I had two commercial adapters and they had a simple milled step, changing the opening from one waveguide size to another. I contacted our local waveguide expert (K5SXK) and asked Harold what was going on. He explained that the impedance of a waveguide is the ratio of width to height, so if you go from one size to another it's like connecting RG-8 to RG-58.

So, I redrilled some flanges and started making some loss tests. At first I had trouble getting consistent results because of reflections. The isolator/circulators proved to be necessary to get consistent numbers when measuring tenths of a dB. The results are shown in Table 1. Note that these measurements are actually for *two* waveguide size transitions, one on either end.

In short, while I would not claim these numbers as the absolute loss values, they show that simply bolting the different sizes together introduces very little loss. Alignment was also noncritical. Misalignment had to reach a point where one of the openings was being partially blocked before loss rose above a few tenths. Get out your drills and start sticking this stuff together!

**Table 1**

**Measured Loss for Various Waveguide Combinations**

| | *Losses in dB* | | | |
|---|---|---|---|---|
| *Flange* | *Sample* WR-62 | WR-75 | WR-90 | WR-112 |
| WR-62 | >0.1 | 0.3 | 0.3 | 0.4 |
| WR-75 | 0.3 | >0.1 | 0.1 | 0.1 |
| WR-90 | 0.3 | 0.1 | >0.1 | >0.1 |
| WR-112 | 0.4 | 0.2 | 0.1 | >0.1 |

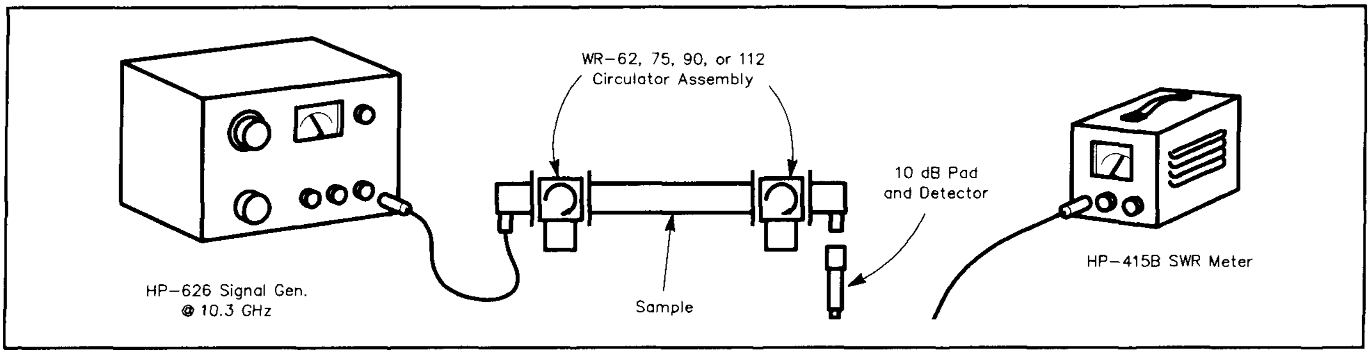


**Fig 1—Test set-up for measuring insertion loss of waveguide transitions.**

# Using WR-62 Waveguide on 10 GHz

## *By Kent Britain, WA5VJB*

(From *Proceedings of Microwave Update '91*)

WR-62 is perhaps the most readily available surplus waveguide. Designed for 12 to 18 GHz, it is almost never seen on 10 GHz. With care, it can be used in the upper portion of our 3-cm band. Figs 1 and 2 compare WR-62 and WR-90 waveguide.

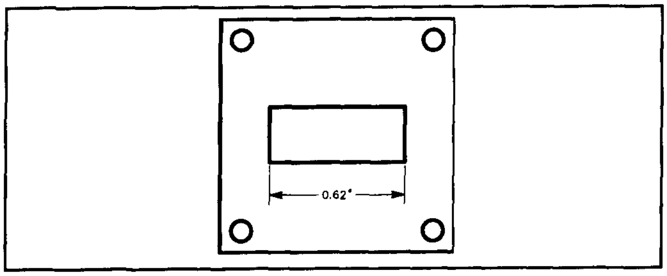


**Fig 1—WR-62 waveguide dimensions.**

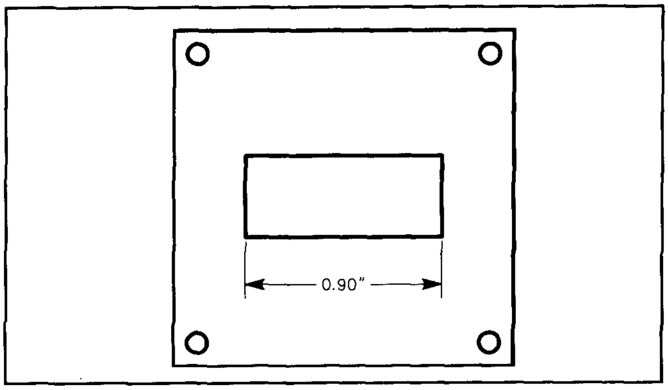
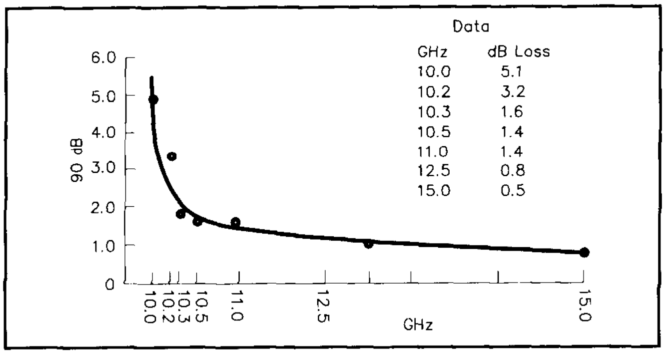


**Fig 2—WR-90 waveguide dimensions.**

The textbook says WR-62 has an ultimate cut-off at 9.5 GHz. I took a large pile of WR-62 and started bolting it together. I ended up with 8 ft. of waveguide containing 18 flanges and 21 bends. The graph in Fig 3 shows how much loss I had through 39 bends and flanges.

As the textbooks say, WR-62 really doesn't work at 10 GHz, but it works just fine at 10.368 GHz! On average, this means a foot of WR-62 with a few bends and flanges has only 0.2-dB loss. The only problem seems to be the WR-62 to-coax transitions. These are usually centered in the middle of the 12-18 GHz band. Several had about 0.5-dB loss, due to mismatch at 10.368 GHz. A three-screw tuner easily matched a transition.

WR-62 really works: I heard my first 10-GHz signals off the moon through a WR-62 Waveguide Switch.



Data

| GHz | dB Loss |
|---|---|
| 10.0 | 5.1 |
| 10.2 | 3.2 |
| 10.3 | 1.6 |
| 10.5 | 1.4 |
| 11.0 | 1.4 |
| 12.5 | 0.8 |
| 15.0 | 0.5 |

**Fig 3—Plot of insertion loss for an 8-foot length of WR-62 waveguide sections having 18 flanges and 21 bends!**

# A Simple Rectangular/Circular Waveguide Transition for 10 GHz

*By Sam Popkin, K2DNR, and Kent Britain, WA5VJB*

(From *Proceedings of Microwave Update '89*)

## Introduction

Sam noticed that if you squeeze ¾-in. copper water pipe into a rectangular shape it's the same size as a WR-90 waveguide. Sam built several samples and sent them to Kent for loss measurements and other tests. The results were very encouraging!

## Theory

What Sam has come up with is a TE-10 to TE-11 or a rectangular or circular waveguide transition. Even constructed with simple tools, the test section only had about 2% loss due to reflections and mismatches. The inch or so of bent pipe between the rectangular flange and the circular pipe forms a tapered transition section with excellent matching.

## Construction

Just start out by squeezing the end of the ¾-in. copper pipe in a bench vise down to a 0.4-in. opening. Then rotate the pipe 90° and squeeze the other side to a 0.9-in. opening. Back and forth, back and forth, until you form a 0.4- × 0.9-in. rectangular opening. A pair of large pliers or Visegrips can be very useful in forming the corners. Sam prefers to make his own WR-90 flanges out of sheet copper, while Kent likes to reuse old flanges from various pieces of junk. These flanges are then soldered onto the formed end of the copper water pipe. A few quick strokes with a file on the insides and you have WR-90 flanges on a circular waveguide. When you mount the second flange on the other end, be very careful to align the flanges with each other. There should be zero rotation misalignment.

## Use

Circular waveguide has less loss than rectangular waveguide. Copper is an excellent conductor, so loss should be about 2 or 3 dB per 100 feet for your home-built circular waveguide.

There is one big limitation of using circular waveguide: Any protrusion, bend, or discontinuity will cause the wave to rotate. There just isn't anything to keep the E and H field aligned with the walls. Running the signals around a 45° plumbing bend rotated the polarization 20-30°. A 90° bend rotated the polarization about 90°, and with both samples the amount of polarization twist varied with frequency.

Simply use your homebrew waveguide for straight runs then transition back to regular WR-90 for any twists or bends.

One 40-in. section of this homebrew waveguide is even in use in WB5LUA's 10-GHz EME station.

# A Quick Reference Guide for Circular Waveguide

### *Ron Neyens, N0CIH*

(From *Proceedings of the Central States VHF Society Conference '91*)

| *Amateur Band* | *EIA Type Designation* | *Inside Diameter in Inches (Centimeters)* | *Useful Upper and Lower Frequency Range in GHz* | |
|---|---|---|---|---|
| 902 MHz | WC 992 | 9.915 (25.184) | 0.800 | 1.100 |
| 1296 MHz | WC 724 | 7.235 (18.377) | 1.100 | 1.510 |
| | WC 618 | 6.181 (15.700) | 1.290 | 1.760 |
| 2304 MHz | WC 451 | 4.511 (11.458) | 1.760 | 2.420 |
| | WC 385 | 3.853 (9.7870) | 2.070 | 2.830 |
| 3456 MHz | WC 281 | 2.812 (7.1420) | 2.830 | 3.880 |
| | WC 240 | 2.403 (6.1040) | 3.310 | 4.540 |
| 5760 MHz | WC 175 | 1.750 (4.4450) | 4.540 | 6.230 |
| | WC 150 | 1.500 (3.8100) | 5.300 | 7.270 |
| 10 GHz | WC 94 | 0.938 (2.3830) | 8.490 | 11.600 |
| | WC 80 | 0.797 (2.0240) | 9.970 | 13.700 |
| 24 GHz | WC 44 | 0.438 (1.1130) | 18.200 | 24.900 |
| | WC 38 | 0.375 (0.9530) | 21.200 | 29.100 |
| | WC 33 | 0.328 (0.8330) | 24.300 | 33.200 |
| 48 GHz | WC 22 | 0.219 (0.5560) | 36.400 | 49.800 |
| | WC 19 | 0.188 (0.4780) | 42.400 | 58.100 |
| | WC 17 | 0.172 (0.4370) | 46.300 | 63.500 |