

MORE MICROWAVE TEST EQUIPMENT FOR 10 GHz

The Backfire Antenna/Boomerang

by C.L. Houghton WB6IGP

Microwave enthusiasts may recall my article in the October 1988 issue of 73 (pp. 40-41). In it, I describe how to build a 10 GHz detector mount to use with frequency measuring wavemeters and an amplifier. In this article, I will describe the backfire antenna or boomerang, its construction and operation, and the two meter injector. Both devices use a detector mount—either a commercial unit that accepts a 1N23 type diode, or the home-brew mount described in Part 1.

The Backfire Antenna

Industry has used the backfire antenna for many years. Even some of the early amateur microwave pioneers in the 1940s used them. It's a simple concept and easy to apply—I've wondered why it hasn't surfaced earlier in some of our amateur radio publications.

The backfire, or boomerang, antenna is a waveguide-mounted detector to which a source of RF energy is directly inserted into the 1N23 diode, producing a flow of current. The RF comes from a single-stage 2N2222 transistor oscillator, crystal-controlled at 30 MHz (our IF frequency) for stability. This is all you need, besides a small horn antenna to receive and to act as the transmit antenna for the boomerang. You can build the oscillator or use an International Crystal oscillator board powered by a 9 volt transistor radio battery. See Figure 1 and system photographs.

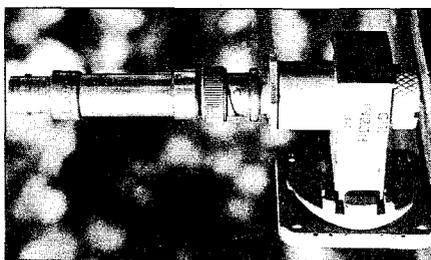


Photo B. Commercial mount with 1N23 type diode now fitted with varactor for connection to a 2-meter HT. Home-brew mount works just as well.

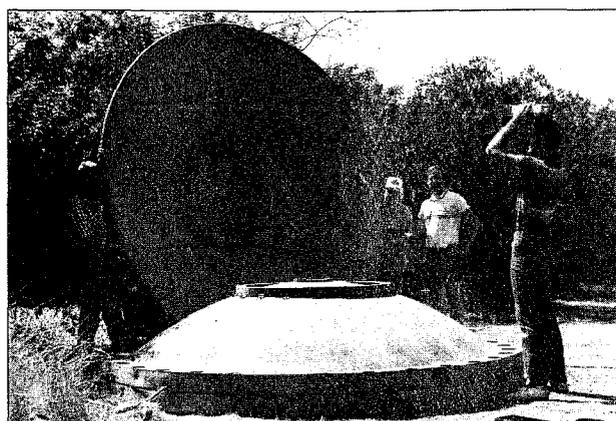


Photo A. Some members of the San Diego Microwave Society having a little fun with ten-foot dishes. Kerry Banke N6IZW with 10 GHz transceiver in hand.

The 30 MHz signal injected into the detector diode mount by itself is not productive, but when it is injected with microwave energy via the horn antenna, it produces upper and lower mixer products detectable by your full-duplex transceiver. Modulation isn't usually detectable unless it is imposed on the 30 MHz oscillator. You will detect a return CW carrier when your antenna is pointed in the direction of the boomerang. You will detect modulation from the source when even when the boomerang is fairly distant from the Gunn oscillator. Signals at this point are very weak and are a result of the time/path differences.

With the microwave injection mixed with the 30 MHz oscillator, it doesn't matter which microwave frequency you use to obtain a return from the boomerang. I tried this same operation at other microwave frequencies, and operation is just as good as it is on 10 GHz. Design is not critical. Just use a resonant waveguide for the frequency and inject your IF frequency into the detector mount.

Ed Munn K6OYJ has even used a tin can fitted with a diode as part of a polaplexer for boomerang operation on our 3 GHz band. See Figure 2. When I finish my 5 GHz Gunn oscillator, I intend to build another boomerang out of some scrap 5 GHz waveguide, or possibly a used Sardine can, just for fun. If you don't play, how can you have any fun with these microwave bands?

IF System Required

The IF system must operate around 30 MHz. If your system uses a different intermediate frequency, change the crystal to match. Operation is the same. There will be some problems if your IF is high, say 100 MHz, because of the input matching and loading of the 1N23 crystal.

If you slowly separate the receiver and the boomerang, you will see a very defined peak, and as you move them further apart still, you will see a null. The phase difference between the 30 MHz signals, which can be used to measure distance, causes this change. You can also change the

frequency of your microwave transmitter in small kHz steps and observe the null and peak at each frequency. You can measure distance from this.

Bore Sight

The boomerang or backfire antenna shines when used as a target for your antenna. With the unit perched at some distance, you can sight down the axis of your antenna and draw a straight line between the two. You can use it for antenna measurements to peak your system. Be sure your transceiver is on the frequency you wish to peak up, as it does not matter to the boomerang. As you increase the



Photo C. Boomerang bottom view showing 30 MHz oscillator (International Crystal) mounted in small LMB box.

distance, you obtain a weaker signal and a much more defined antenna pattern. If the boomerang is moved about the front of your antenna, you will be able to detect the main lobe and the focus of the electrical axis. Moving around the sides, we would expect to see some side lobes, but the null and peak previously mentioned makes these measurements very difficult.

Just for fun, one day members of the San Diego Microwave Group gathered around several large dish antennas located in the backyard of Kerry, one of the members. We speculated on the pattern we would obtain if we tried a new frequency, DC or sound, instead of electronics. We moved our heads into prime focus and whispered to other members about a hundred feet away. Not bad. The gain of the ten-foot dish at audio frequency was very good, in fact. Stepping into the main lobe quite a distance away from the dish, you were soon pelted by very loud, focused sound—*full duplex!* You could whisper so low that a person standing three feet away could not hear you, yet the person at the feedpoint of the dish was copying solid and very loud. Now if we took the boomerang with a 1 kHz audio oscillator and . . . ?

When you know the distance your system will work at with a very narrow antenna beamwidth, try setting your microwave dish in a new spot, and then aim it at the boomerang with the 30 MHz oscillator turned off. When you think you are on target, turn on the boomerang and recheck for maximum signal and antenna orientation. This way you will become more familiar with the aiming characteristics of your antenna. I thought I was pretty good until I tried it, but I had to do some re-evaluating. It is like learning how to hold a camera steady when triggering the shutter. By dry-running the antenna, you improve your accuracy in pointing

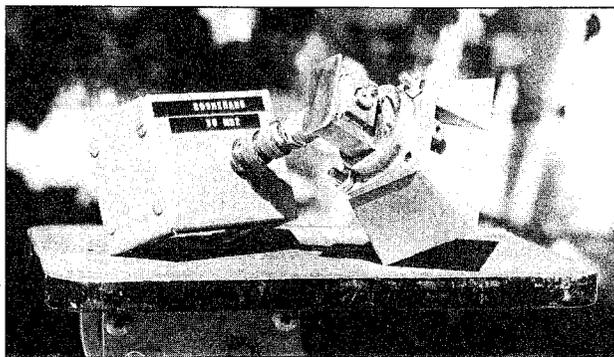


Photo D. Rear view of Boomerang showing back construction used on home-brew detector mount.

your system and make more contacts. One to two degrees beamwidth is not much to play with.

Use a map to point your dish antenna on distant points. Don't get one from your local service station; instead, obtain a quality survey map. US Geological Survey quadrangles describe in detail the topographic areas of interest from small to large. You'll also need

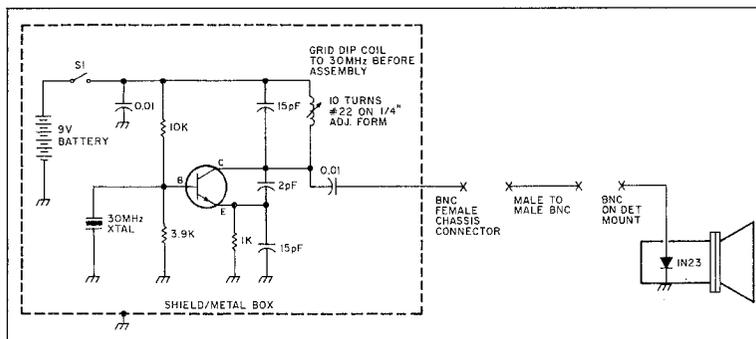


Figure 1. Schematic of oscillator that produces the RF that drives the 1N23 diode in the wave-guide mounted detector.

a good compass. For aiming your antenna, Sears has several levels that will give you an indication of mount positioning and inclination. I found a General bubble bull's-eye level, the size of a quarter, at our local hardware store for \$2.39. It has 45 degree markings and is quite sensitive. It proved useful in adjusting antenna orientation.

The other advantage of the boomerang is that it will tell you quickly when your transmitting Gunn oscillator is putting out microwave energy. It does not care what frequency you are on. It will return a CW signal, which tells you that your receiver is operating and gives a quick reference for system evaluation.

Two-Meter Injector

The 2-meter injector is a detector mount that uses a varactor or step-recovery diode as the driven element. We have used an input pad to limit the RF drive from our two-meter HT which, on low power, puts out 200 mW. Pad values were 10 dB to limit the drive to about 10 mW, and 3 dB for 100 mW of drive to the SRD diode. See Figure 3. The diode is rated at 1 watt dissipation. The pad also serves as a DC return for the SRD diode in the detector mount. The best mount possible for

the SRD diode would be a commercial unit, as I am not crazy about threading the tip of a somewhat expensive diode. You might want to construct the second version (with the brass tubing on top) with the BNC connector. Either mount will work well, and each has advantages over the other. One offers ease of construction, while the other requires more soldering expertise. Details on both mounts were described in Part 1 of this article. See Photo B, a surplus mount with 3 dB pad, and Photo C, my second version with a BNC connector.

Ed Munn K6OYJ, a member of our San Diego Microwave Group, provided the diode I used. It worked quite well. We knew it was a varactor with a reverse breakdown of 42 volts at 10 micro amps and a junction capacity of 2.31 pF at 6 volts (1 MHz test frequency) and the same case style as a 1N23. The closest commercial diode that I find listed is the Microwave Associates MA-44641D Step Recovery Varactor. I'm currently trying to find one of these devices to test in the mount. Check your local surplus dealers and put that old scrounging effort to work. See Photo B, varactor mount.

I will make available high power Gunn diodes, case style 118 with silver plated brass rivets, for modifying Solfan type cavities operating on 10 GHz. These devices have power outputs from 50 to approximately 100 mW (+15 to +20 dB) for \$5 each, postpaid continental US. Some select higher power devices for 6 GHz, 10 GHz, and 18 GHz. Output power varies from cavity to cavity and post mounting arrangements, but all devices are tested prior to shipping for RF. I would be happy to answer any questions regarding this or any other microwave related project. Please contact me at 6345 Badger Lake, San Diego, CA 92119. **73**

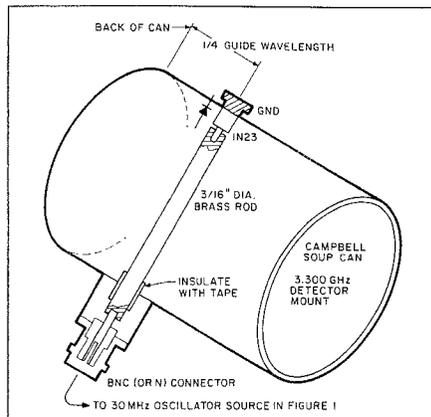


Figure 2. A tin can fitted with a diode as part of a plaplexer for boomerang operation on the amateur 3 GHz band.

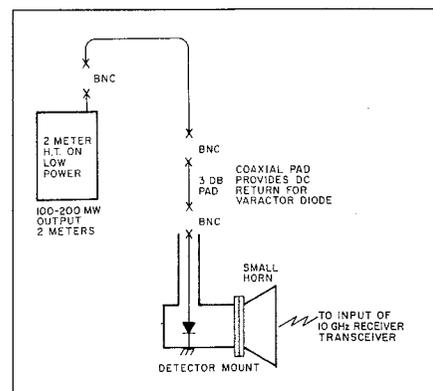


Figure 3. Diagram for the 2-meter injector system. It loads a step-recovery diode (in the detector mount), which generates many harmonics. The 70th harmonic of 146 MHz is 10.220 GHz.