W5GI “Mystery Antenna”

Steve G0KYA

W5GI's “Mystery Antenna” gets a lot of attention. Possibly because of its daft name.

It looks like a G5RV, but W5GI (now SK) used coax stubs to give what he called “a coaxial colinear array on 20m”. It consists of a half wave length (at 20m) of 300 Ohm ribbon that feeds a dipole centre. Either side of the dipole centre are two pieces of wire 17ft long.These are then each connected to the inner of a 16ft 6in piece of RG58 coax. The outer is left unconnected. The far end of this is then shorted and connected to a further 17ft of wire, giving an antenna with a total span of 101ft.

Update: To save time I have appended the original CW magazine feature at the back of this PDF.

The only difficulties are making sure that the joints are strong enough to support the weight (there are many reports of breakages) and that it is best to use shrink wrap tubing on the joints to waterproof them.

Cutting the ribbon feeder to an exact half wavelength (taking into account the velocity factor of the cable) is a little problematic.

One solution relies on the fact that a true half wavelength of feeder will always replicate the impedance at its far end. So, put a 50 Ohm resistor on the far end of your 300 Ohm ribbon feeder. String it up in clear space and trim the length until you see a 1:1 SWR at 14.175MHz when using an antenna analyser.

Update: Have just built another version of this antenna and the resistor method works a treat. I used 300 Ohm ribbon from Moonraker in the UK and the have wavelength came out at 8.3m (27ft 3in).

It is likely to end up between 8.2 and 10.7m (27-35ft) long.

Now, the “mystery” part of the name refers to the fact that it is supposed to be almost impossible to model as it uses coax stubs.

This is really nonsense, as it seems quite easy in any NEC-based program to model stubs. My results modelling the W5GI in MMANA-GAL seem to agree with Steve G3TXQ's real-life results and VK1OD's modelling.

What we can say is that W5GI said that the stubs caused the antenna to feed the three radiating elements in phase. But all the evidence points to the fact that the antenna does NOT have three in-phase elements on 20m.
The modelling and real-life results show a six-lobed pattern – just what you expect with three half waves fed out of phase.

But the question is, does the antenna “work”? Is it worth making?

I built a W5GI (I refuse to call it a “mystery antenna”) to see how it would compare with other antennas.

Mine is fixed over the roof where I used to have a full-size 80m OCF dipole and I have been able to compare it with an 85ft W3EDP end fed, a 65ft inverted L, a multitude of dipoles and a Western HF10 (see other review) among others.

SWR results
(brackets after trimming – see text)
1.8MHz – SWR >31:1 (>31:1)
3.5MHz – SWR 2.8:1 (2.6:1)
3.8MHz – SWR 8.1:1 (4.2:1)
7MHz – SWR 2.8:1 (3.3:1)
7.1MHz – SWR 3.0:1 (3.0:1)
7.2MHz – SWR 3.6:1 (3.0:1)
10.1MHz – SWR 5.7:1 (5.0:1)
14MHz – SWR 4.1:1 (3.0:1)
14.2MHz – SWR 5.3:1 (3.2:1)
18.1MHz – SWR 5.2:1 (8:1)
18.168MHz – SWR 4.7:1 (8.0:1)
21.2MHz – SWR 6.7:1 (5.7:1)
24.9MHz – SWR 6:1 (3.0:1)
28MHz – SWR 5.7:1 (5.4:1)
28.5MHz – SWR 6.4:1 (5.7:1)
29.7MHz – SWR 3.9:1 (6.2:1)
51MHz – SWR 4.0:1 (4.5:1)

Lowest SWR point on 80m was 3.434 (2.9:1) after trimming it was 3.6MHz (2.4:1).

SWR figures

In the original write up W5GI quoted low SWR figures for the antenna that were mostly below 3:1. Unfortunately he didn't say how much or what type of feeder he used, as put a long enough piece of lossy feeder on and you will end up with a low SWR on ANY antenna.

My own figures (see above), taken when the bottom of the ladder line is fed with 15ft of RG58, showed that it isn't such a good match on all bands.

What I did decide to do was see if I could optimise it for 80m as this is the band I really wanted to use it on for the RSGB 80m Club Championship. As the lowest SWR point was below 80m I decided to shorten the 300 Ohm feeder by about 12 inches and then fold back the ends of the antenna. I ended up with the lowest SWR point at 3.6MHz (2.4:1). This also improved the match on 20m and 40m, but made it worse on others.

But how did it perform on all bands? Here is my analysis:

On–air comparison with loft-mounted multiband dipoles/ Western HF10/ W3EDP 85ft end-fed long wire.

80m

Inter G signals better than W3EDP – up around 10dB. DL 0-5dB better. Better than Western HF10 and 65ft Inverted L on both inter-G and further afield.

Conclusion: The antenna is quite useful on 80m if you can't fit a full-sized dipole in. It works well around the UK and lots of DX has also been heard in the middle of the night. In essence it shouldn't be much better than a G5RV though.

40m
Inter-G 5dB better than indoor dipoles. 10-15dB better than Western HF10. Similar to W3EDP. Germany – similar to W3EDP, sometimes 5dB better. Belgium better by 5dB, Ukraine similar. Better than inverted L by 10-12dB to Germany.

Conclusion: The antenna is quite useful on 40m as well. If you are looking for an 100ft antenna just for 40/80m it is worth considering, along with the G5RV/ZS6BKW and W3DZZ.

30m
Czech rep. – 3S pts better than W3EDP. DL similar to W3EDP or 2S pts down. Noise level 3 S pts better, therefore better S/N ratio. Down 10dB on 65ft inverted L. Similar results to MFJ-1786X magnetic loop.

Conclusion: Not a brilliant match on 30m – will get you going, but you could be better off with a dipole for this band. I did work T32C (East Kiribati) with it, so it can't be too bad!

20m
Noise level 3 S pts better than W3EDP. 1 S pt worse than Western HF10. Similar signal strengths to Western HF10. 10-20dB down on dipole to YU1. Croatia similar strengths. Dipole slightly better or equal to Italy, but noise level better. US (Iowa) similar on all antennas. RBN and WSPR tests show HF10 better into Italy, but W5GI better into parts of USA.

Conclusion: Tests show the antenna's multilobe pattern on 20m. This can work in your favour or work against you. There have been many times that I've switched to the W5GI and weak signals have just vanished. At other times signals have occasionally become stronger or are equal to a dipole. This is frustrating as whether you class this as a "good" antenna on 20m depends on whether the station you wish to work is on a lobe or not. I have seen a similar performance on a G5RV and despite claims from reviews on eham.net, I'm not convinced that the W5GI is the stellar performer on 20m that some people think it is.

17m
US (Virginia) similar to dipole. Illinois 3 S pts down compared with HF10. Belarus similar strengths. Sweden better than dipoles/HF10. Ukraine 1 S pt better than HF10, 4S pts worse than dipole.

Conclusion: Altogether, about 2-3 S points down on HF10 and dipoles –

quieter, but not good

15m
Noise level 0-1 S pt better than 40m dipole. Similar to Western HF10. 2 S pts down to Med. 1 S pt better to SV. EA 0-2 S pts better. UA 2 S pts better. 3 S pts better.

Conclusion: Livelier than the Western HF10, but not a very good match.

12M – nothing heard, so no tests.

10m
EA signals 3 S pts down compared with dipole (firing wrong way). 1 S pt down to EA8, RA. 3 S pts down to 9A.
Conclusion: Not a stellar 10m performer. You might be better off with a dipole.

Rig used for tests Icom 756 Pro3
Was the rig's internal ATU able to tune? Yes, on all bands bar 6m.

So only 6m was a problem - if you have a Yaesu rig (in which the internal ATU doesn't seem to like matching much above 3:1) you may have problems.

Overall conclusion
This is a tough one. Overall, I liked the antenna's performance on 80m. It seemed to outperform the 132ft OCF dipole that it replaced. I think this may be due to the fact that the ends are in free space, whereas the ends of the OCF came down to almost ground level – one was wrapped around the back wall of a shed to fit. I think this proximity to an "earthy" object didn't help the OCF's performance, but I did manage to work VP8 The Falklands on it, so it couldn't have been all bad.

Update: I have been using the W5GI in the RSGB's 80m Club Championship and people often remark how loud I am, despite the antenna lying on the roof. Just beat my own personal best score on CW this week so it is working!

It also seems useful for 40m, giving a relatively easy match and good performance. I have broken pile-ups into Europe with it on 40m. Once you climb past 40m it become a little more unpredictable.

This can be a characteristic of "long" antennas, where their multilobe pattern either works for or against you.

In conclusion, I'm not sure that the antenna works any better than a G5RV. In fact, if you are looking for an antenna of roughly the same length, with similar performance, but with a better match check out the ZS6BKW variant.

On the following page are my predicted radiation patterns. Tests are still ongoing see whether these actually equate to reality, and at the moment the jury is out.

I'm trying to work out where exactly the nulls are as this would give a clue as to whether the model is correct or not.

I still need the bands to be in a better shape before I can come up with a definitive answer. Is it a bad antenna? No, I've tested worse – and some that cost a lot more money. Is it a multiband antenna? Well, yes, but it doesn't offer a 1:1 match on all bands. In fact, mine doesn't offer a 1:1 match on any band. But then neither did the original designer's!

For the sake of an afternoon's work, some coax and a piece of ribbon feeder you can build one and try it for yourself.

Overleaf are my modelled radiation patterns. Note that these are for the antenna mounted flat top at about 10m. If you put it up as an inverted V, with the top at 10m and the ends at, say, 3m the whole pattern changes completely (see below).

The lobes virtually disappear and it ends up pretty omnidirectional as you can see below for inverted V plots for 20m and 10m. On 20m you end up with radiation broadside to the wire, just a like a half wave dipole.

Steve G0KYA, September 2011

Postscript - 13th October 2011
Having just worked T32C after a lot of work, I wondered if it would better feeding the W5GI with a 4:1 balun at the point where the 300 Ohm ribbon meets the coax.

The end result was that the SWR figures were even worse as it has quite a low impedance to start with. What I did find was that water had been finding its way into the coax – even with self-amalgamating tape it had been running down the 300 Ohm feeder straight into the connection.

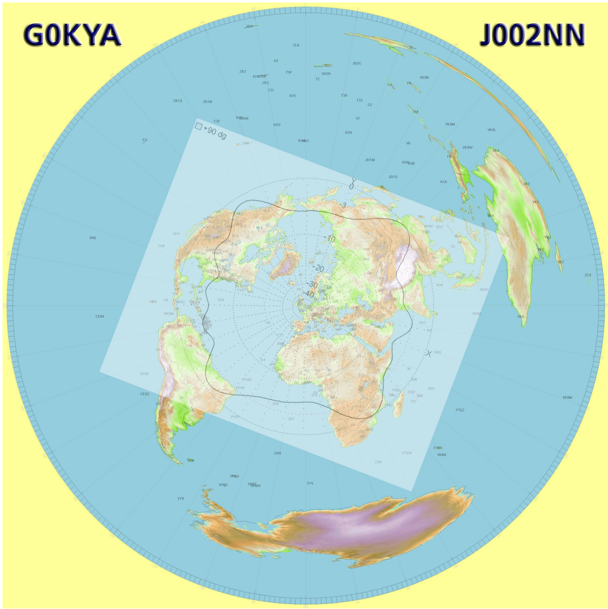
This is because it is hard to get SA tape to completely fill the gap on the 300 Ohm feeder due to its ridges. I have now replaced the coax and used sealing mastic on the joint to stop this happening again.

Conclusion: I don't think feeding it with a balun is a good idea – stick to the ribbon/coax. You can always coil some coax to create a choke balun.

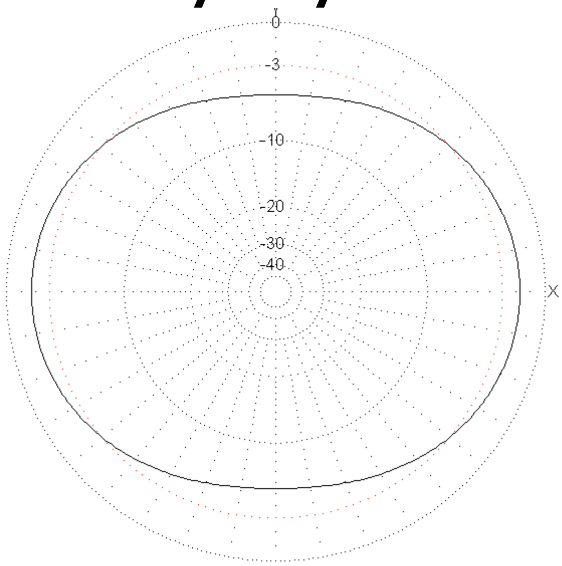
Below: Plots for W5GI raised as an inverted V

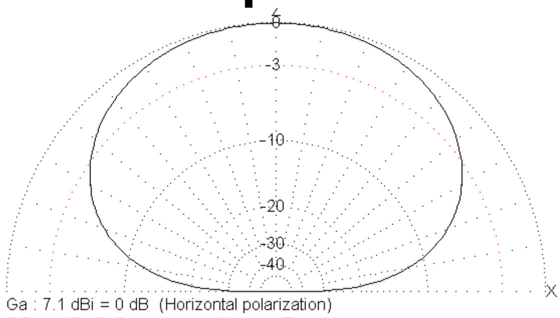
Inverted V 20m

Inverted V 10m

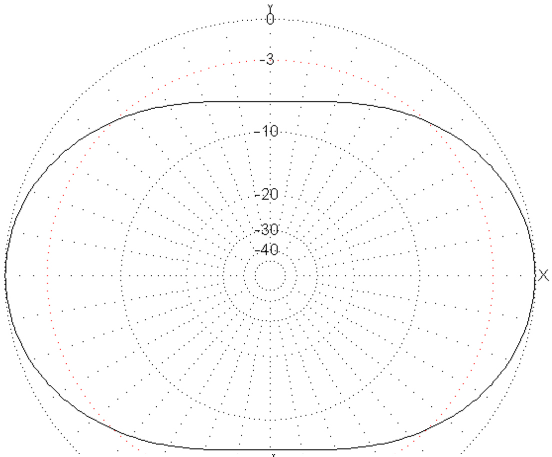


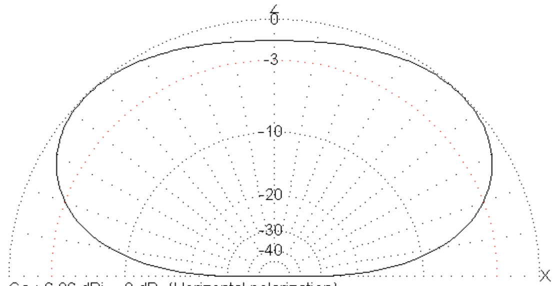
W5GI Mystery Antenna – plots as flat top



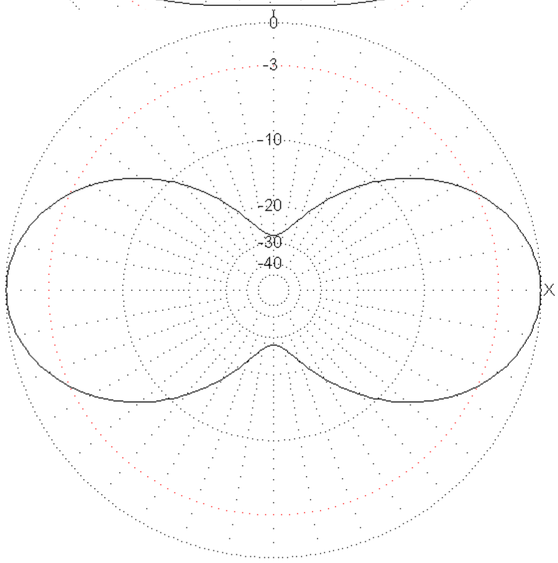


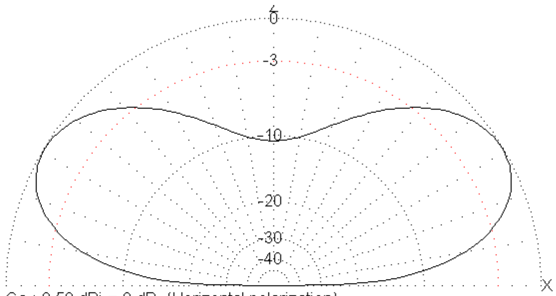
Ga : 7.1 dBi = 0 dB (Horizontal polarization)
F/B: -1.07 dB; Rear: Azim. 120 deg, Elev. 60 deg
Freq: 3.650 MHz
Z: 13.148 - j32.369 Ohm
SWR: 5.5 (50.0 Ohm),
Elev: 90.0 deg (Real GND :3.00 m height)
(For elev. angle 45.0 dg Peak:5.5 dBi)



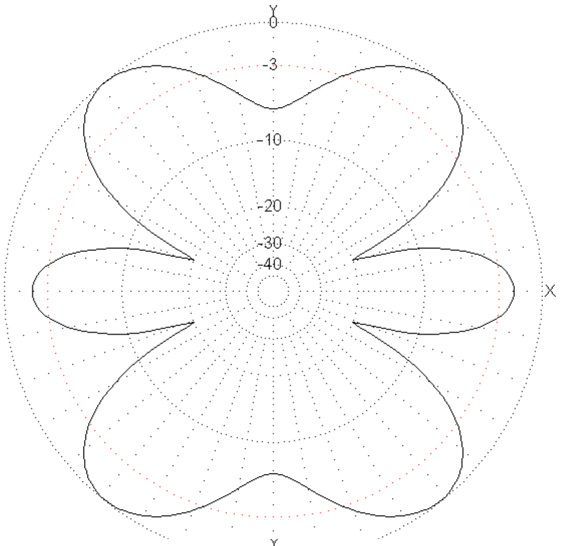


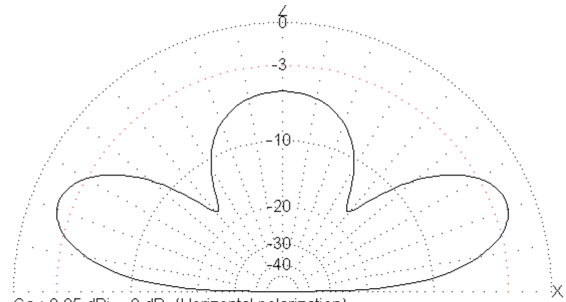
Ga : 6.06 dBi = 0 dB (Horizontal polarization)
F/B: 0.00 dB; Rear: Azim. 120 deg, Elev. 60 deg
Freq: 7.050 MHz
Z: 48.252 - j117.809 Ohm
SWR: 7.6 (50.0 Ohm),
Elev: 45.7 deg (Real GND :3.00 m height)



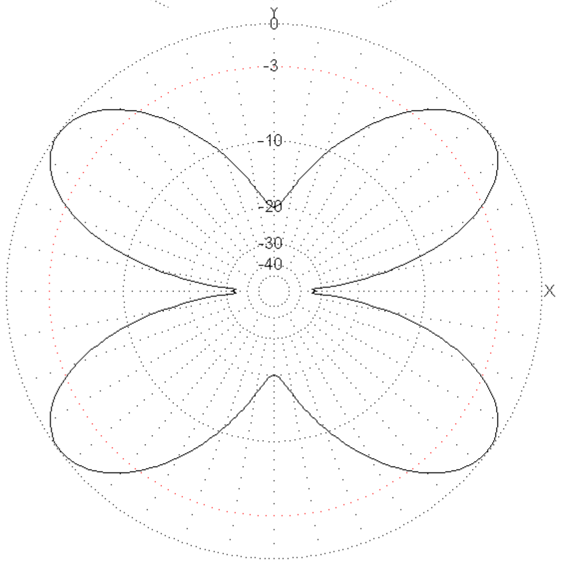


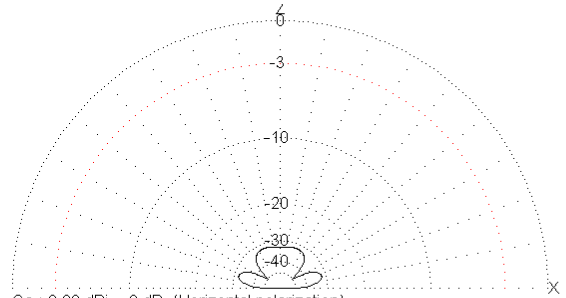
Ga : 8.59 dBi = 0 dB (Horizontal polarization)
F/B: 0.00 dB; Rear: Azim. 120 deg, Elev. 60 deg
Freq: 10.120 MHz
Z: 36.759 + j243.737 Ohm
SWR: 34.4 (50.0 Ohm),
Elev: 30.9 deg (Real GND :3.00 m height)



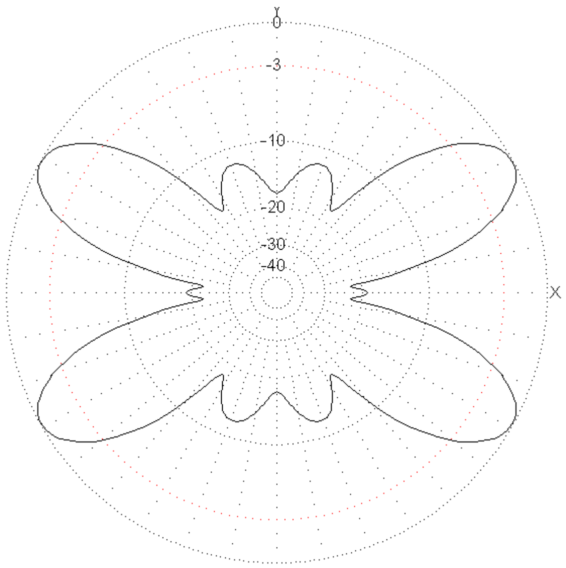


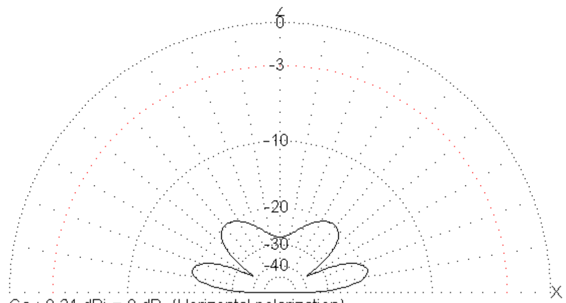
Ga : 8.05 dBi = 0 dB (Horizontal polarization)
F/B: -1.84 dB; Rear: Azim. 120 deg, Elev. 60 deg
Freq: 14.150 MHz
Z: 102.195 - j93.753 Ohm
SWR: 4.0 (50.0 Ohm),
Elev: 22.1 deg (Real GND :3.00 m height)



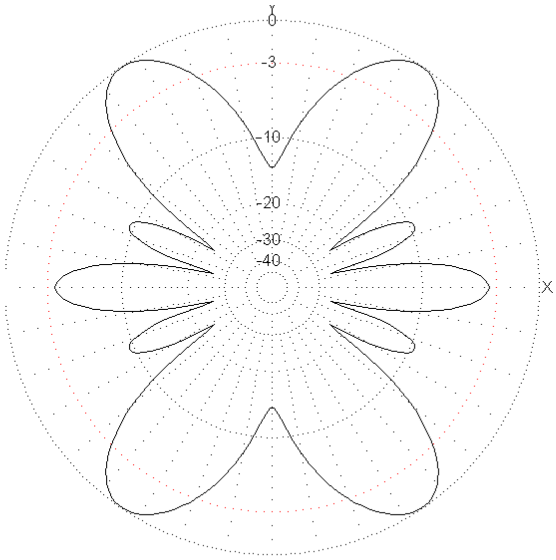


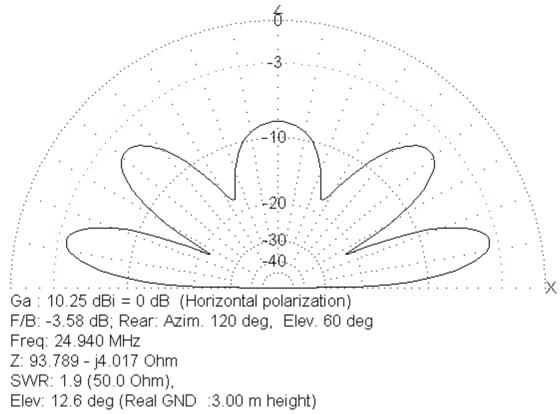
Ga : 8.89 dBi = 0 dB (Horizontal polarization)
F/B: -31.43 dB; Rear: Azim. 120 deg, Elev. 60 deg
Freq: 18.120 MHz
Z: 71.424 - j353.590 Ohm
SWR: 37.1 (50.0 Ohm),
Elev: 17.0 deg (Real GND :3.00 m height)

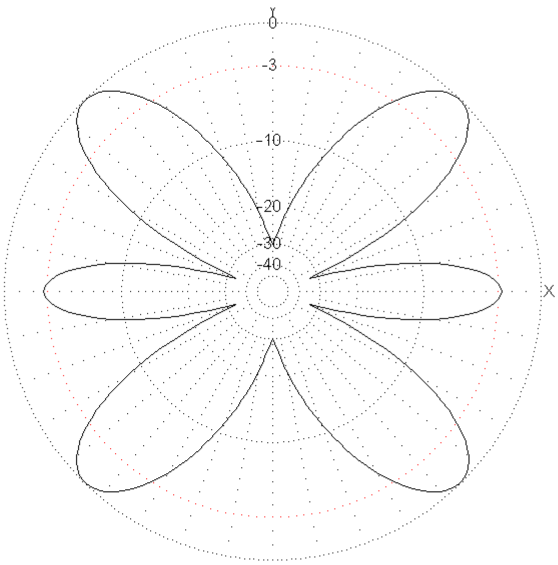


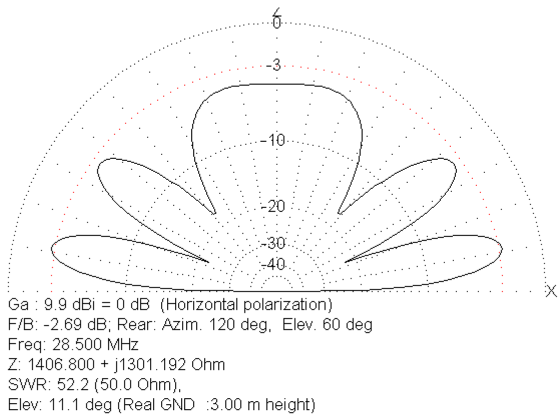


Ga : 9.24 dBi = 0 dB (Horizontal polarization)
F/B: -18.94 dB; Rear: Azim. 120 deg, Elev. 60 deg
Freq: 21.200 MHz
Z: 32.602 + j46.653 Ohm
SWR: 3.2 (50.0 Ohm),
Elev: 14.7 deg (Real GND :3.00 m height)









Based on W5GI Antenna mounted flat-top at 12m. The antenna run is along the Y axis (vertical on the page). Modelled in MMANA-GAL.

(These models are currently experimental and need verification by way of real-life tests)

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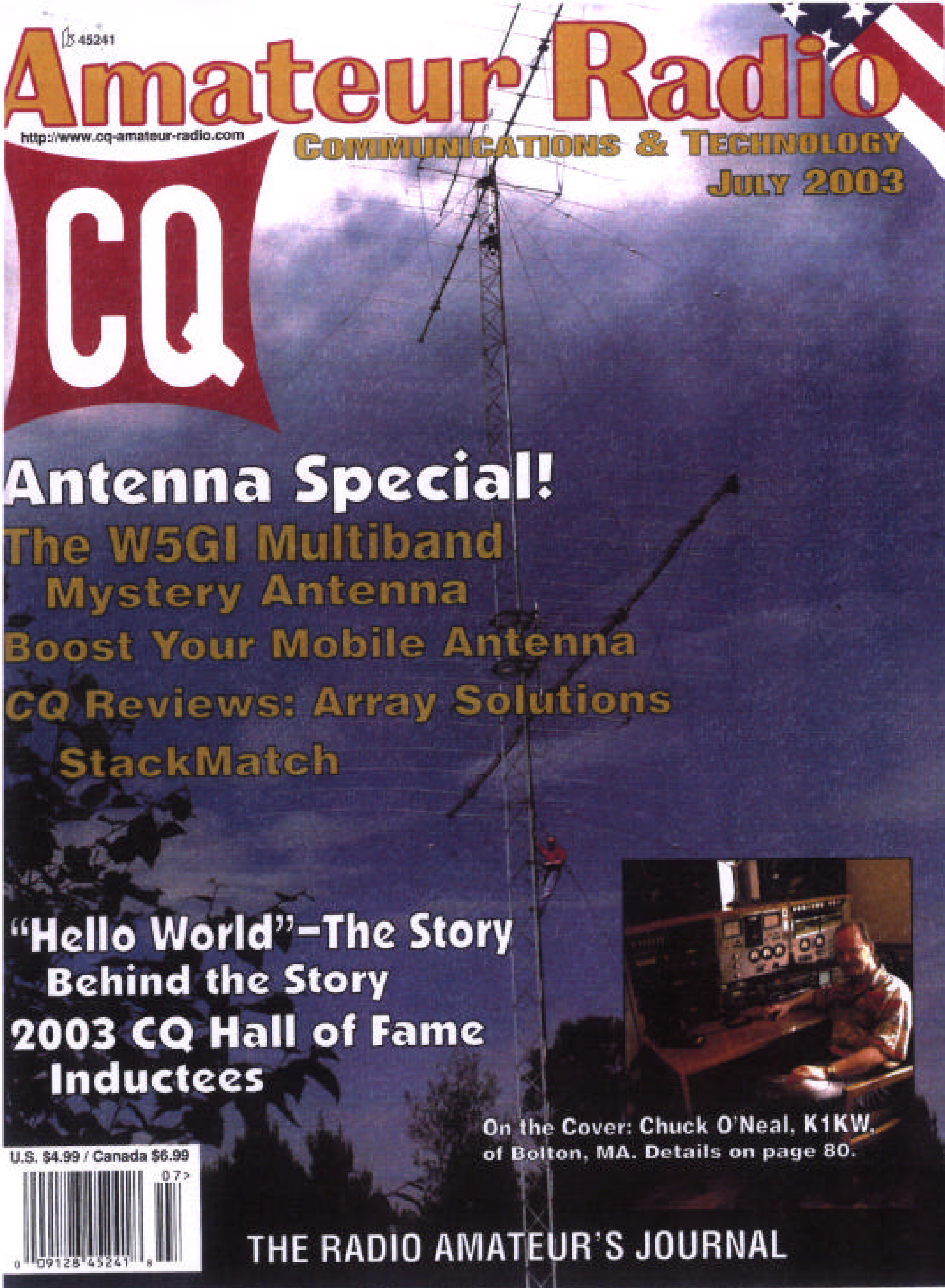

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THE RADIO AMATEUR'S JOURNAL

In the best amateur tradition, W5GI has designed a multiband wire antenna that confounds the antenna modeling software, but passes the most important test of all: It works ... well.

The W5GI Multiband Mystery Antenna

BY JOHN P. BASILOTTO,* W5GI

This article describes an antenna that covers 80 to 6 meters with low feed-point impedance and that will work with most radios, with or without an antenna tuner. It is approximately 100 feet long, can handle the legal limit, and is easy and inexpensive to build. It's similar to a G5RV but a much better performer, especially on 20 meters. During the last two-plus years the antenna described herein was built, installed, and used by amateurs at various heights and configurations in over 300 locations. Feedback from users indicates that the antenna met or exceeded all performance criteria. The "mystery" part of the antenna comes from the fact that it is difficult, if not impossible, to model and explain why the antenna works as well as it does.

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Over two years ago I moved to a new QTH. Like many other amateurs, I succumbed to my wife's demands, which also meant living in a community that prohibits towers and most antennas. Fortunately, the lot we purchased has two large oak trees about 130 ft. apart, which allowed installation of wire antennas at about 25 ft. above ground. I initially installed a G5RV because I work mostly 17, 20, and 40 meters and had good luck with it on these bands at other locations. Although the G5RV worked well, it did not provide the performance I had hoped for.

Over a period of several months I tried a variety of popular antennas —full-size loops for 80 and 40 meters, a commercial multiband dipole, resonant dipoles, a multiband vertical, half square, extended Zepp, and a 130 ft. dipole fed with open-wire line. Each antenna worked reasonably well, but I still wasn't satisfied. In my quest to find a better antenna, I came across an article by James E. Taylor, W2OZH, in which he described a low-profile collinear coaxial array.[1] It was Taylor's article that inspired my design.

The W5GI Multiband Mystery Antenna is fundamentally a collinear antenna comprising three half waves *in-phase* on 20 meters with a half-wave 20 meter line transformer. It may sound like and look like a G5RV, but it is a substantially different antenna on 20 meters. Louis Varney's antenna, although three half waves long, is an *out-of-phase* aerial. Mr. Varney (G5RV) had very specific reasons for selecting a three-half-wave arrangement on 20: He wanted a four-lobe radiation pattern, at least unity gain, and a low feed-point impedance.[2] On the other hand, I wanted a six-lobe pattern on 20 meters, gain broadside to the antenna, and also low feed-point impedance to simplify matching the antenna to the rig. In addi-

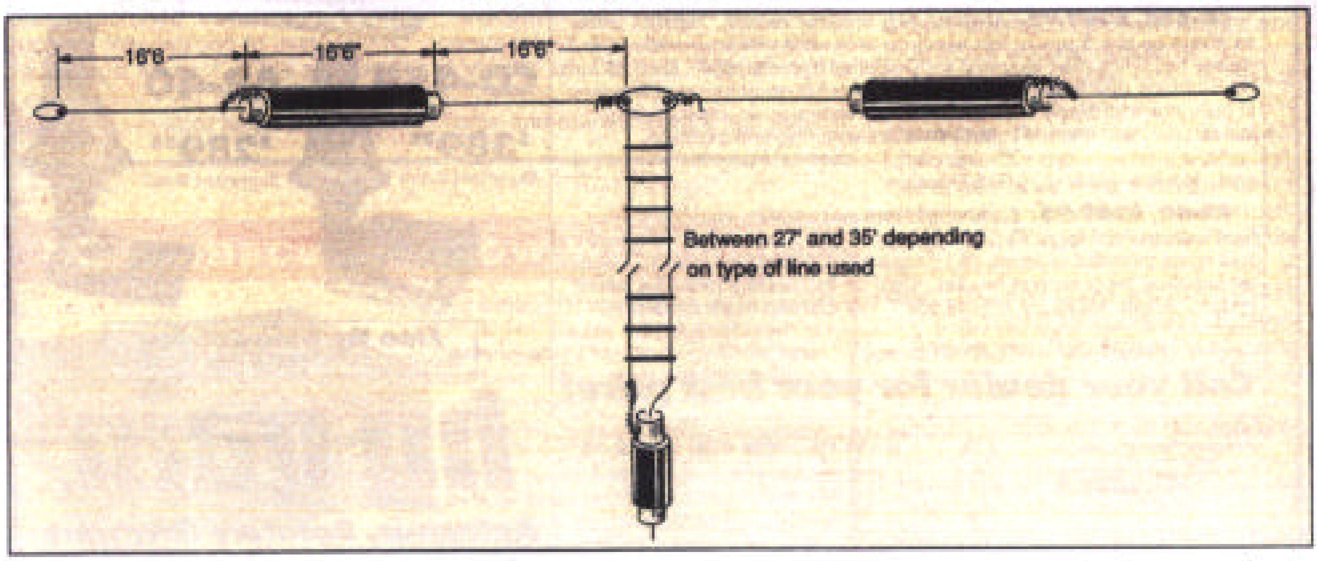

Fig. 1– Schematic drawing of the W5GI Multiband Mystery Antenna. See text for details on connection of coax sections in center of antenna legs and on length of twinlead stub.

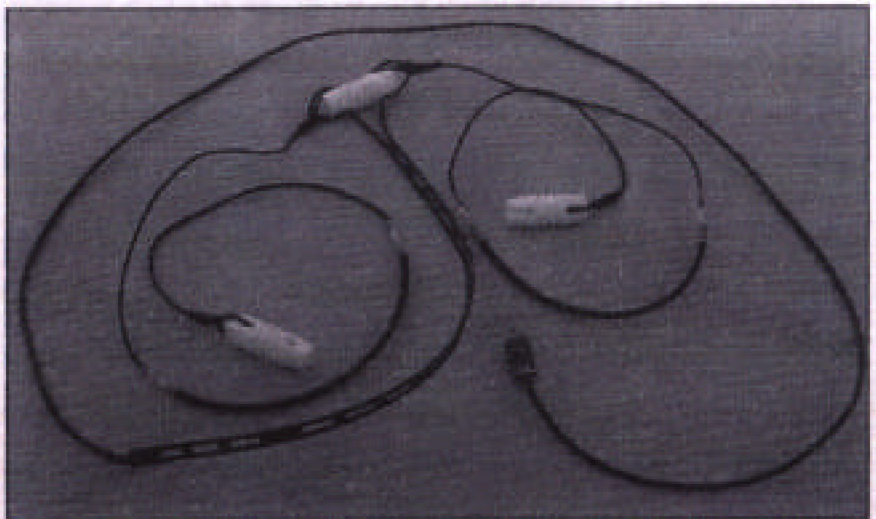

Photo A– Full view of the W5GI Multiband Mystery Antenna, with all sections shortened considerably for illustration.

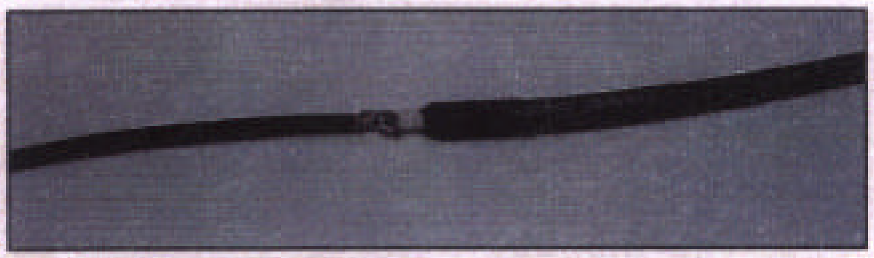

Photo B– Connection of inner end of coax section (closer to center). Note that only the center conductor is connected to the wire.

Installation data

wire:	14 AWG
coax:	Mini 8X
Ladder-line:	Cut to half wave length at 20 meters using appropriate velocity factor

Performance (measurements taken with MFJ 259 Analyzer)

Freq.	SWR	R	X
3550	1.5	42	34
3650	2.5	98	61
3850	3.5	48	61
3950	4	22	36
7000	1.9	95	12
7200	3	22	25
10.1	5.2	22	50
14	1.7	37	19
14.2	1.5	42	18
14.3	1.6	43	22
18.15	1.9	93	13
21.3	2.9	120	46
24.9	1.9	35	23
27.8	2.1	26	16
28.35	1.8	33	20
29.5	2.6	53	55
50.11	2.3	51	37
52.5	1.2	57	7

Table I– Measured performance of the W5GI Multiband Mystery Antenna at various frequencies. Columns list frequency, SWR (all as a ratio to 1), Resistance (R) in ohms, and Reactance (X) in ohms.

tion, the antenna had to be usable as a G5RV and work at least as well on the other HF bands. The answer to my needs was a skywire that incorporated the advantages of a 3-element collinear and the G5RV antenna.

In its standard configuration, a collinear antenna uses phase reversing stubs added at the ends of a center-fed dipole. These stubs put the instantaneous RF current in the end elements in phase with that in the center element. You can make these phase-reversing stubs from open-wire line or coaxial cable. Normally, a shorted quarter-wave stub is used, but an open-ended half-wave stub would also work. The problem is that the dangling stubs are unwieldy and/or unsightly.

In his article Taylor described a low-profile collinear coaxial array. According to Taylor, when you apply an RF voltage to the center conductor at the open end, the stub causes a voltage phase lag of 180 degrees at the adjacent coax shield. This happens because the RF is delayed by one quarter-cycle as it passes from left to right, inside the coax to the shorted (opposite) end. There's another quarter-cycle delay as the wave passes back from right to left inside the coax and emerges on the shield at the open end. Add up the delays and you get a total time delay of one-half cycle, or 180 degrees. In essence, the coax section serves two purposes: It provides the necessary delay and provides part of the radiating element in a collinear array.

My initial version of the antenna used the Taylor formulas, cutting the wires to a quarter wave length using 234/f(MHz) and cutting the coax sections using the same formula, but adjusting the lengths to compensate for the velocity factor of the specific cable used. The first version of my antenna worked well on 20 meters but failed as a multi-band antenna.

I built a second antenna, but this time I cut the coax to the same length as the wire. My reasoning was that perhaps the coax didn't behave like coax and therefore the velocity factor wasn't applicable. To my amazement, the new antenna performed exceptionally well on 20 meters, had low SWR, and performed just as well as my G5RV reference antenna on the other HF bands and 6 meters.

Step-by-Step Construction

The *W5GI Multi-band Mystery Antenna* looks like a plain dipole (fig. 1 and photo A) and is very simple to build. You will need three wish-bone insulators, about 70 ft. of wire (14-gauge household electrical wire works well), enough twin lead or open wire to make a half-wave section on 20 meters (I found that window-type, 18-gauge, 300 ohm ribbon works best[3]), 34 ft. of RG-8X mini-coax, an electrical connector[4] to connect the twin lead and coax, and shrink tubing to cover the exposed coax joints. The antenna can be built in less than an hour when you have the above materials.

Photo C– Connection of outer end of coax section (farther from center). Note that both center conductor and shield are connected to the wire.

Photo D. Connection of twinlead to inner antenna wires at center of antenna.

When you're ready to proceed, do the following:

• Cut the electrical wire into four equal lengths of 17 ft.

• Cut the two lengths of coax to 16 ft. 6 in. each.

• Cut a 20 meter half-wave section of twin lead. This piece needs to be adjusted by its velocity factor. I used 300 ohm window-type line with a VF of .91, for a total length of 30 ft. 450 ohm, solid 300 ohm, or homemade open-wire line can be used provided the electrical length is one-half wave at 20 meters. Actual length obviously will vary, typically between 27 and 35 ft., depending on type and velocity factor.

• Trim 2 in. of braid from one end of both lengths of coax (item A).

• Trim 1 in. of braid *and* center insulator from the opposite end of both coax sections (item B).

• Build a 20 meter dipole without end insulators.

The next two steps of the construction process involve connecting only the "inner" end section of the coax section to one end of the dipole; the shield is not connected to anything here. At the other end of the coax section both the coax shield and second wire section are connected to the coax center conductor.

• Connect one end of the dipole to the center conductor of the coax (item A) and cover with shrink tubing (photo B).

• Connect the opposite end of the coax (item B) to braid *and* quarter-wave wire section, cover with shrink tubing, and connect to end insulator (photo C).

• Install the twin lead through the holes of the center insulator (you may have to enlarge the holes) and solder to antenna wire (photo D).

• Connect the opposite side of the twin lead to the coax (photo E). Almost any type of connection will work, provided the connection is stable and sealed properly. The coax length in the photo is for illustration only. It should be long enough to reach your radio!

• Install the antenna with the center conductor at least 25 ft. high. Mine is installed in a horizontal plane; however, others have installed the 'GI antenna as an inverted-Vee and are getting excellent results. Table I shows the typical SWR results for this antenna.

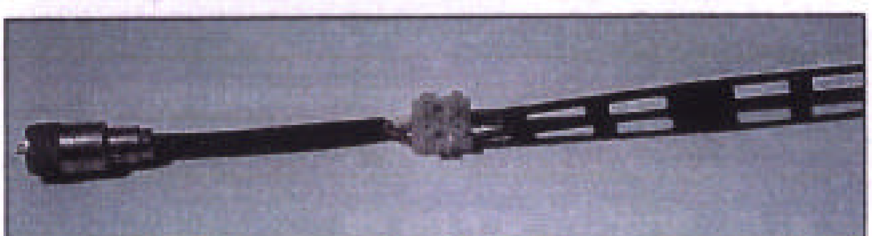

Photo E– Connection of twinlead to coax. Short length of coax section is for illustration only. All connections should be weatherproofed with shrink-tubing, CoaxSeal®, or similar.

On-The-Air Performance

On 20 meters you should expect 3–6 dB gain over a dipole and a six-lobe radiation pattern with an elongated figure-8 pattern perpendicular to the plane of the antenna. This is typical of a 3-element collinear array.[5] On all other bands the antenna performs like a G5RV, which is really a random-length dipole on all but 20 meters. M. Walter Maxwell, in *Reflections II, Transmission Lines and Antennas*, aptly describes this phenomenon. Several users report it is possible to use the antenna on 160 meters, but you will need to connect the twin lead together at the point where it connects to the coax. On 160 the antenna performs like a Marconi. Those who have used the antenna on 160 say the "GI Mystery Antenna" is a quieter receiving antenna compared to other 160 meter antennas.

As for the theory of operation, it remains a mystery. At least three "experts" tried computer modeling the antenna. All three rendered completely different findings. I hope to have more sophisticated findings at a later date. In the meantime, enjoy what for many has been a fun project and an excellent performer.

In conclusion, I would like to thank the many amateurs who have built and used this antenna during the last couple of months, especially Dean, N9ZLS, who personally built over a dozen GI Mystery Antennas and whose feedback has been invaluable; Rod, WA9GQT, who uses the antenna in QRP operation with impressive results, for his feedback regarding 160 meters; and last, but not least, my wife, who provided the opportunity and encouragement to build the *W5GI Multi-band Mystery Antenna*.

Notes

1. James E. Taylor, "COCOA-A Collinear Coaxial Array," *73 Amateur Radio*, August 1989: 24.
2. M. Walter Maxwell, *Reflections II Transmission Lines and Antennas*, Worldradio Books 2001: 20-10.
3. Available from the Wireman and other sources.
4. Available from most electrical parts outlets.
5. For a simple explanation of collinear arrays, read *Troubleshooting Antennas and Feedlines* by Ralph Tyrrell, W1TF. ■