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HOMING IN

Radio Direction Finding

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Motorized Beams, Santa Barbara Style

One reason that VHF hidden transmitter hunting is a growing activity for ham clubs is that it's inexpensive to get started. You can go on foxhunts or T-hunts (as these events are called) with the 2 meter radio you have now, if it has an S-meter.

A quad, yagi, or other radio direction finding (RDF) antenna is cheap, especially if you make it yourself from PVC pipe and wire or from scrap TV antenna tubing. Add an RF attenuator made from some toggle switches, carbon resistors, and copper-clad board, mount the beam on your car, and you're set. Such a setup is more than adequate to win many hunts, with practice.

However, like participants in any other sport, T-hunters are always looking for an advantage over the competition. Decades ago, they discovered that a polar display of signal strength versus direction gives a much better understanding of signal characteristics than an S-meter alone, particularly when hunting among tall buildings or hills that bounce and scatter 2 meter signals.

"Homing In" covered theory and advantages of polar displays in detail with actual trace photos in October 1992. KK6CU's home-brew mobile implementation of the scheme was featured in the following issue, complete with motorized quad and storage scope indicator. Now two T-hunters from Santa Barbara, California, have found a way for penny-pinching tinkerers to have a polar display and motorized beam without the expense of a storage monitor and the hassle and noise of RF slip rings.

Look! No Slip Rings!

Tom King KA6SOX works in marine electronics at the Santa Barbara harbor. Kerry Provancha KK6OS enjoys mechanical engineering challenges. Together, they created the RADAD, which stands for "RAdio Detection And Direction" (see Figure 1). As passersby admired it at a recent ham radio swap meet, I interviewed them and

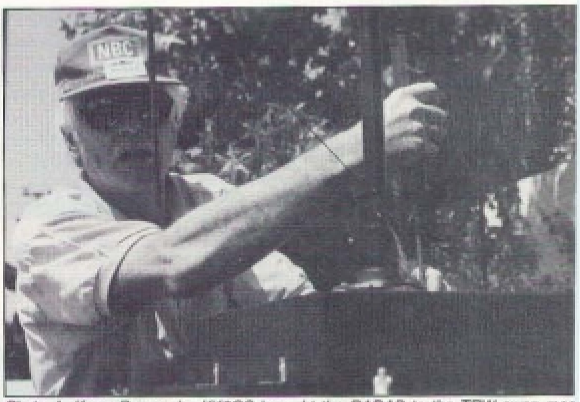

Photo A. Kerry Provancha KK6OS brought the RADAD to the TRW swap mee and unscrewed the covers to reveal the antenna turning mechanism.

they eagerly told me how it came about.

KK6OS: "We were looking for a long persistence phosphor cathode ray tube (CRT) display, rather than a storage scope, because a storage scope needs to be cleared all the time."

KA6SOX: "I happened to get some junk marine radars. The magnetron transmitting tubes had croaked or the high voltage boards had gone up in flames. They're economically unrepairable for marine service because I can't get tubes or power supplies a reasonable cost. Fortunately, thos parts aren't needed for RDF."

KK6OS: "Of course, the microwav transmitter, receiver, and horn antenn were of no use, but we retained th rest of the radar essentially intact. W changed the antenna drive motor be cause we wanted different rotatio speeds (see Photo A)."

KA6SOX: "Sometimes we want t paint the RDF picture slowly an sometimes fast, depending on wha the hider is doing. So we used a 3

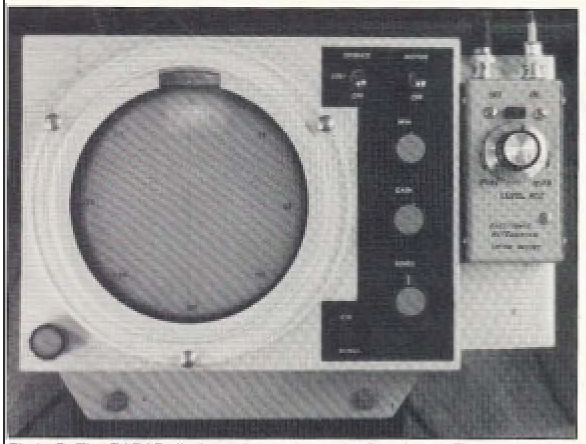

Photo B. The RADAD display unit mounts on the floor hump. Tom made a new front panel and mounted the RF attenuator box on a bracket for easy access.

volt DC motor and built a variable voltage inverter to control speed."

KK6OS: "It's difficult to find motors with adequate torque over a wide speed range. We use a DC gearhead ype about 5 inches long, about 100 nch-lbs. torque."

KØOV: "How did you make the radar scope show 2 meter bearings?"

KA6SOX: "It was very simple. All he CRT power supply and sweep circuitry is already there (see Photo B)."

KK6OS: "The electronic yoke in the display follows a resolver, which is geared to the antenna (Photo C). Whatever speed the resolver goes, the yoke on the CRT follows exactly. There is no mechanical stuff in the yoke."

KA6SOX: "As the antenna turns, the yoke sweeps the CRT electron beam in a circle. In addition, the radar control head generates a linear voltage ramp that sweeps the beam from screen center toward the edge at about 200,000 times per second."

KK6OS: "We compare receiver S-meter voltage with the ramp voltage. The comparator triggers a one-shot to produce pips, replacing the radar pulse. It pulses the CRT cathode negative for 1.5 microseconds. The S-meter voltage compared against the ramp determines how far out on the screen from the center you get pips. The resolver tells where on the azimuth circle to put the pips."

KØOV: "So at 200,000 pips per second, it looks like a continuous line is being drawn on the screen."

KA6SOX: "Right. Full scale on the S-meter equals maximum deflection to the edge of the screen. The interface was done with one LM339 quad op amp IC."

KØOV: "What about your antenna design?"

KA6SOX: "We went through about a half dozen iterations of the antenna."

KK6OS: "We tried to make one that would fit inside the radar's plastic radome so there would be no windloading. But it was a negative gain antenna without a decent pattern. It would probably work on 450 MHz, but not on 2 meters."

KØOV: "So you made a full-sized 2 meter beam to get good sensitivity?"

KA6SOX: "Yes. We solved the rotary joint problem by using an AEA half-wave whip antenna as the fixed-mounted driven element. The directors and reflectors rotate around it. It gives a beautiful pattern."

KK6OS: "There are no slip rings. The driven element mounts on a BNC that never rotates, so it's noise-free (see Photo D). The coax goes right up through the center of the waveguide where the radar output used to be. The antenna is a three-element yagi, made of a PVC pipe upright and crossbar. Two directors and a trigonal reflector rotate around the driven element. It's all painted stealth black and sits on a rack that bolts to the car-top carrier (see Photo E)."

KØOV: "Was the trigonal reflector used for a better pattern or for mechanical balance?"

KA6SOX: "Both. We had a single reflector at first. When we changed to the trigonal reflector, the lobes on each side dropped by 5 dB and the back lobe completely disappeared. We measured 0.7 dB more gain, too."

KK6OS: "Now the antenna was mechanically balanced almost perfectly."

KA6SOX: "But we discovered that mechanical balance is not the same as windload balance. Even with the triple reflector, when we were going down the road at 40 MPH, it would stall. We then added a small fin on the back. Now we can drive up to 55 MPH with no problems."

KØOV: "How do you shrink the display size as you close in?"

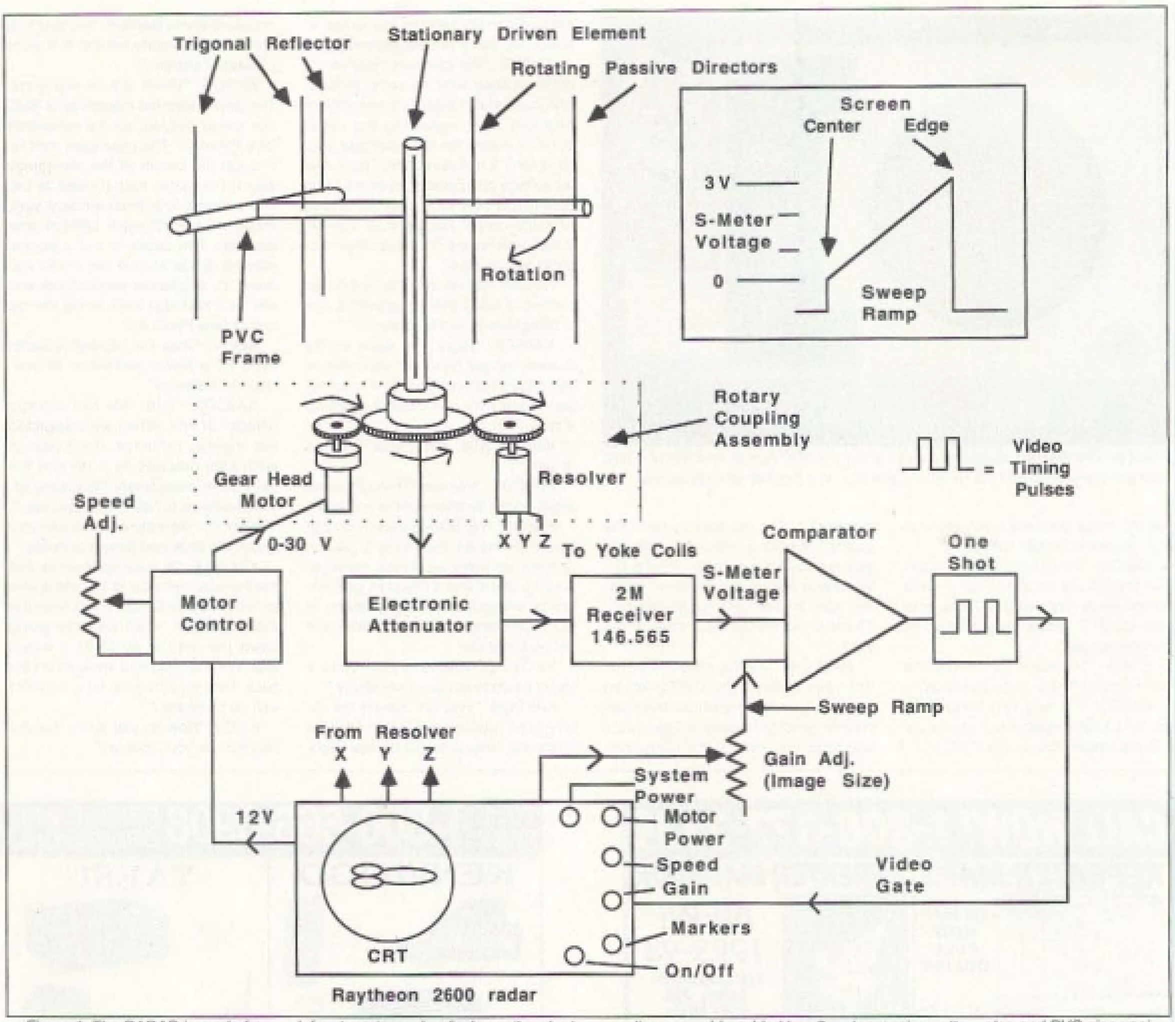

Figure 1. The RADAD is made from a defunct marine radar display unit and rotary coupling assembly, added to a 2 meter receiver, attenuator, and PVC pipe yagi.

KA6SOX: "With an RF attenuator. It's based on the offset attenuator in *QST* for November 1992. We changed the offset to 1 MHz and use a crystal-controlled oscillator, plus better shielding."

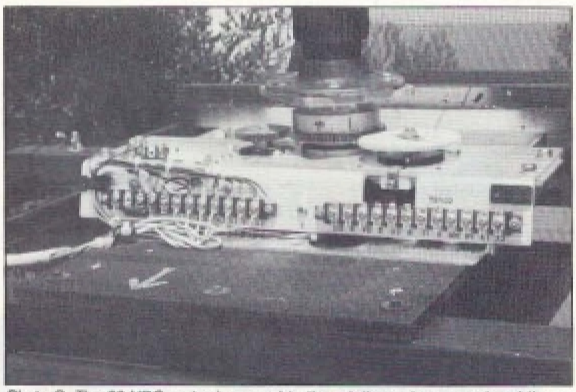

Photo C. The 30 VDC motor is geared to the rotating antenna mast and the resolver. Inside the mast is the old waveguide, which holds a stationary driven element.

KK6OS: "The continuously variable electronic attenuator has been the biggest single improvement to the whole system. It makes it easy to keep the display on screen. Before that, we used a switchable resistive attenuator, which was hard to use because of the large step sizes."

KØOV: "Tell me about hunts in Santa Barbara."

KK6OS: "We have all kinds, including mileage hunts (lowest odometer miles wins), time hunts (first finder wins), and combination time/mileage hunts. The hider decides. Most are time-only. We hunt on the fourth Saturday night of the month on 146.565 MHz."

KA6SOX: "A few months ago, the hiders wove the antenna inside a volleyball net at the beach. They used RG-174 coax, painted the color of the volleyball tape along the bottom. It was then painted yellow along the pole all the way down into the sand, where the transmitter was buried, running about 50 watts. I'm pretty sure the vertical pole was a non-tuned reflector. We found the general area easily, and the hiders were sitting right there roasting wieners. The big problem was finding the antenna and the radio."

KA6SOX: "Some T-hunts in Santa Barbara have become absolutely insane. They're not like Los Angeles All-Day hunts, where the T is miles and miles away. But dirty tricks by the hiders are allowed. They do all kinds of weird things, like swinging beams and hiding multiple T's."

KK6OS: "I started it, I guess. On one hunt, we synchronized two transmitters. When one came on, the other one went off, and so on. They were on two different mountaintops. We were trying to screw up the Doppler users so they would get an indication that went this way, then that way. My former T-hunt partner has the control box for the synchronized T's and he likes to use it. Other hams have come up with their own schemes for doing it too."

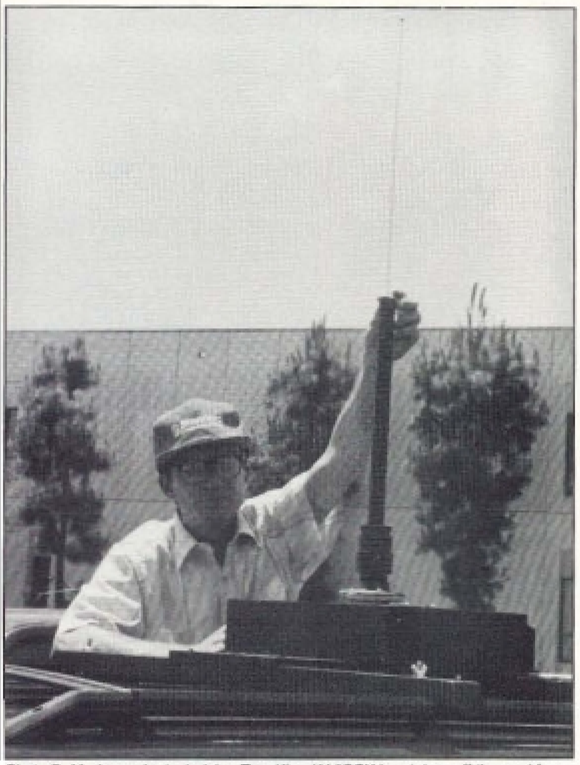

Photo D. Marine radar technician Tom King KA6SOX has taken off the yagi frame with parasitic elements and is holding the top of the driven element whip.

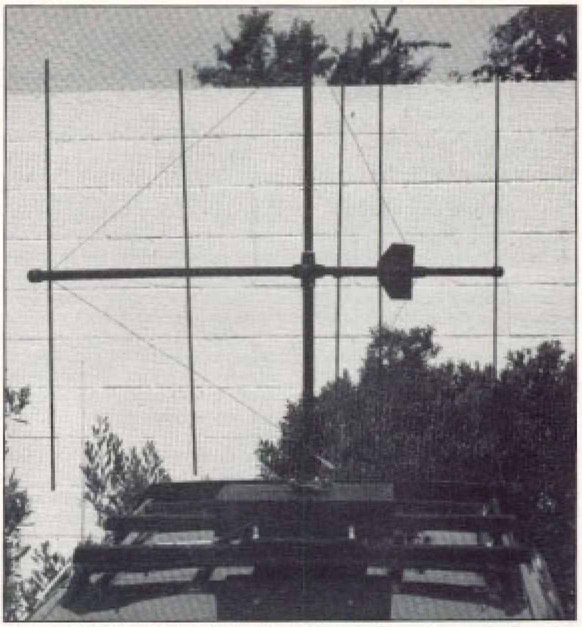

Photo E. This lightweight vertical yagi with trigonal reflector has good gain and an excellent pattern, yet spins up to 140 RPM while the car moves at 55 MPH.

KØOV: "Have you won any hunts with the RADAD?"

KK6OS: "I won with it in June, so I hid in July. When I hid, I used the spinning RADAD antenna in a parking garage downtown. I set the antenna unit on the floor at a middle level of the garage, rotating at 20 RPM. I transmitted 5 watts SSB modulated with a pulsed 500 Hz tone, a quarter second on, then a half second off. I was trying to make the Doppler RDFs go wacky. It didn't do that, because one guy found us in 15 minutes. But another hunter ended up dozens of miles away in the wrong direction from the start, and three teams gave up without finding it."

KØOV: "So your system does a great job finding tough T's, right?"

KA6SOX: "It's still experimental. We don't consider it to be a breakthrough, but it's quite a step forward in distinguishing what is a signal reflection and what is not, which the Doppler cannot do when the two are equal in level. However, it requires a skilled operator to interpret it."

KK6OS: "Up here in Santa Barbara, hunters often pulse the signal. If they picked just the right pulse rate and our antenna was going at just the wrong speed, the CRT screen became useless. On a couple of hunts, I was pulling my hair out. I could not get a bearing, because they were pulsing exactly three times for every rotation of the unit. Since then, we changed the motor control to cover 0 to 140 RPM. With the long persistence P7 CRT at night, you can see 15 to 20 traces superimposed at 140 RPM."

KØOV: "What radar models do you recommend for readers who want to make their own RADAD?"

KA6SOX: "Models 2600 and 2800 are the best. Raytheon designed and imported them, but they were made by Japan Radio Corporation. They're also known as the Mariner's Pathfinder. They were produced between 1970 and 1976. Raytheon sold 35,000 of the 2600s worldwide, and around 8,000 of the 2800s.

KØOV: "Are these radars available?"

KA6SOX: "Sure, but who knows how many are still in service and how many are at the bottom of the ocean! They have longer service life than most radars of the '70's because they don't have a rotating yoke assembly to fail. There are probably 35 or 40 still in use on the thousand or so boats in Santa Barbara harbor. I saw a used one being installed on a boat about three weeks ago."

Let's Try It

After the swap meet, I rode along as Tom and Kerry demonstrated the RADAD on a beginners' hunt sponsored by the TRW Amateur Radio Club. The system worked smoothly and quietly, giving excellent scope patterns. In just a few minutes, we arrived at a parking lot where the hidden signal was super-strong.

None of us had brought "sniffing" equipment, so I tuned to the third harmonic of the hidden T signal with my dual-band handheld, got a bearing by body shielding, and started walking. Five minutes later, I tracked down the antenna 15 feet up in a tree.

Tom and Kerry have found a simple, yet elegant scheme for feeding a continuously rotating beam. Waterproofing is easy and there are no slip rings to make noise or cause losses. The main disadvantage is that only vertically polarized yagis can be fed in this manner, a problem in areas where hiders are allowed to use horizontal polarization.

You can't buy a RADAD, but if you're a knowledgeable builder, you can assemble a similar system. With careful scrounging, you'll preserve your T-hunting gasoline fund. It's time to hit the swap meets and make friends with your local marine electronics tech! 73