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HAM RADIO HORIZONS

ANTENNAS and TOWERS

Drake Accessories

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Drake Directional RF Wattmeters

W-4 1.8-54 MHz **WV-4** 20-200 MHz

Drake directional, through line wattmeters, using printed circuits, toroids, and state of the art techniques, permit versatile performance and unsurpassed accuracy, yet at a lower cost.

In contrast to VSWR measuring devices of the past, Drake wattmeters are frequency insensitive throughout their specified range, requiring no adjustments for power or VSWR measurements.

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High accuracy; ideal as laboratory instruments.
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Specifications	W-4 $72.00	WV-4 $84.00
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Line Impedance	50 ohm resistive	50 ohm resistive
Power Capability	2000 W continuous	1000 W continuous
Jacks, Removable Coupler	Two S0239 input and output connectors	Type N input and output connectors.
Semiconductors	Two 1N295 power meter rectifiers	Two 1N695 power meter rectifiers
Accuracy	± (5% of reading +1% of full scale)	

Drake RCS-4

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- Grounds All Unused Antennas
- Grounds All Antennas in Gnd Position for Lightning Protection
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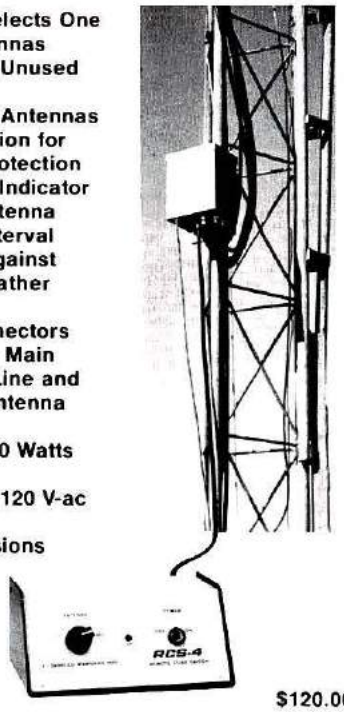
- Handles 2000 Watts PEP
- Available in 120 V-ac or 240 V-ac 50/60Hz Versions

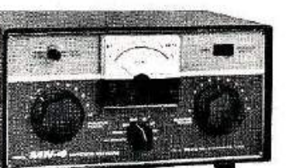


$120.00

• Control unit works on 110/220 V-ac, 50/60 Hz, and supplies necessary voltage to motor. • Excellent for single coax feed to multiband quads or arrays of monobanders. The five positions allow a single coax feed to three beams and two dipoles, or other similar combinations. • Control cable (not supplied) same as for HAM-M rotator. • Selects antennas remotely, grounds all unused antennas. Gnd position grounds all antennas when leaving station. "Rain-Hat" construction shields motor and switches. • Up to 30 MHz, insertion of switch changes VSWR no more than 1.05:1. • From 30 MHz to 150 MHz, insertion changes VSWR no more than 1.5:1. • Motor: 24 V-ac, 2 amp. Lubrication good to −40°F. • Switch Rf Capability: Maximum legal limit.

Drake MN-4 & MN-2000 Matching Networks

- **80-10 Meters**
- **Antenna Selector and By-Pass Switches included**



MN-4 (300 Watts)
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MN-2000 (2000 Watts)
$220.00

A Drake matching network is a worthwhile addition to any amateur station where peak performance is desired. Basically identical, except for power handling capabilities, the MN-4 and MN-2000 enable feedline SWR's of 5:1 to be matched to the transmitter. If input impedance is purely resistive, even higher SWR's can be handled. • Besides presenting a 50 ohm load to the transmitter, the Matching Network's built in rf wattmeter allows accurate and continuous power measurement and VSWR indication. The advanced wattmeter circuitry yields frequency-insensitive readings from 2 to 30 MHz, and accuracy until now obtainable only in expensive wattmeters.

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All prices (suggested amateur net) and specifications subject to change without notice.

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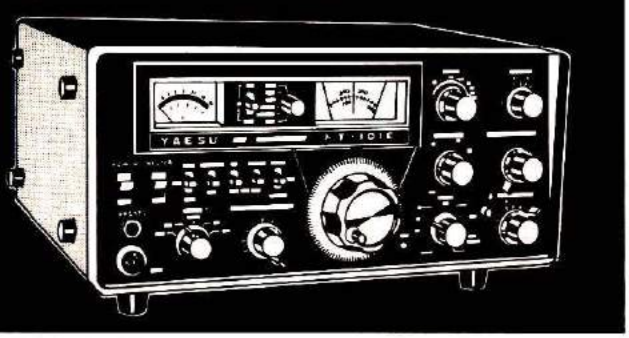

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Yaesu's number one transceiver now available from Long's has these features: • Solid-state • 10m thru 160m coverage • Built-in AC & DC power supplies • Built-in RF-speech processor • 260 watts PEP SSB, 180 Watts CW & 80 Watts AM • Solid-state VFO • Built-in VOX • Auto. break-in CW with side tone • Built-in WWV/JJY reception • Heater switch • Built-in speaker • High-Q, permeability tuned, RF stages • All mode operation: SSB, CW and AM.

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KENWOOD TS-520 SSB transceiver

• Covers 10 thru 160 meters • Solid-state thru-out except for final & drive stages • FET VFO • WWV • Amplified-type AGC circuit • VOX/PTT/MOX circuit • Dual gate type 3SK35 MOS FET

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THIS MONTHS HORIZONS

High-Frequency Antennas

One of the most important things you have to think about when you're putting your amateur station together is what kind of antenna you're going to use. In this article W1HR discusses some of the many types of antenna which are used by amateurs on the high-frequency bands, and some things to think about when you make that all-important decision.

Radio Towers

One very effective way of increasing your communications power is to use a larger antenna. Going from the typical dipole to a beam usually requires some type of supporting tower. K1XX talks about some general, but important, things to consider when selecting a tower and installing it.

Vhf Antennas

Sooner or later you'll start looking at the vhf bands as a place to go for more adventures in communication. Antennas for these higher bands are not greatly different from their high-frequency counterparts, but there are a few pointers to keep in mind. Read up on the subject now and be ready for your station expansion.

The G5RV All-Purpose Antenna

If you have room to put up an 80-meter antenna, then you may want to try the G5RV — a sky wire that can be installed as a flat top or an inverted vee — one that works quite well on the 80- to 10-meter bands with a single feedline and no tuner, and is popular with Amateurs throughout the world.

Field Day

Each June many aluminum-loaded vehicles can be seen heading for the best mountain top around. A few days later many of the occupants of those vehicles return with bloodshot eyes and numerous mosquito bites. An explanation of this June madness is given by WA1ABV and K1XX. Because both of them have coordinated record-setting Field Day efforts, they are well qualified to tell you the what and why of this unforgettable event.

TV DXing

Your own TV set, a good rotatable antenna, the right conditions, and a lot of patience are the only seven-league boots you'll need to go signal-hopping around the country in search of a championship boxing match, a hockey game, or even the local news in East Bias, Ohio. TV DXing is a lot more fun than watching game shows or late, late re-runs, and it's best done when you wouldn't want to be doing something else anyway. Try it and see.

Use A Wavemeter

If you must make waves, be sure they are the kind you want and where you want them. The wavemeter is one of the simplest and earliest-used devices in Amateur Radio stations, and can be built quickly and inexpensively. This one combines the functions of a wavemeter and field-strength meter, making it even more versatile.

The Far Horizon

DXing is as much an art as a science. Your transmitter and receiver are your flying carpet that puts the world at your doorstep; but you have to know how and when to travel. This article tells you why, as well. Join us now on electronic pathways to adventure.

Before Spark

You probably won't find Grakk's name in any of the history books, but way back in 35,000 B.C. he was a big man in inter-cave communication. Later, we find Lethargicus — a Greek, and Lasagne — an Italian, making their contributions to the growing art of radio communication. In fact, it was the latter effort that gave us spaghetti tubing to protect the "insides" of our modern radios. The spread of radio in the middle ages (later known as middle-age spread) is also treated in this treatise: a whimsical glimpse of the past.

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HAM RADIO HORIZONS

June, 1977
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The Cover
Many amateurs dream of an antenna installation like this, but for WØRX it's a reality. The rotary 100-foot (30m) pole supports full-size beams for 40, 20, 15, and 10 meters. For more antenna ideas, see pages 12, 22, 28, and 36. Photograph by William LeBaron, WØMTK.

CONTENTS

THE VIEW FROM HERE

Spring and early summer seems to be the traditional time to install a new antenna (for most sensible people — I always seem to wait until winter's first real blizzard). Magazines often feature antenna articles in the summer, just as we're doing this month, and it's great to get outside and try out new ideas. In the fall, the new antenna is given a final inspection and maintenance is performed to make sure it will withstand the rigors of coming winter storms.

Regardless of when you work on an antenna installation, a very real physical risk is involved. When you climb a tower or a steeply pitched roof, one incautious moment can end in tragedy. The antenna season is upon us, and many amateurs will be thinking about working on their antennas, or installing new ones. If you're going to work on your antenna this summer, I'd like to offer a word of advice: observe safety rules and use the buddy system, even though you may have to climb only fifteen feet.

Here's a true story about a ham in California who was making antenna adjustments alone. The guiding forces that protect drunks and other foolish creatures must have been operating in this instance, because this fellow lucked out. Others may not be as fortunate.

Late one afternoon Bill G. (not his real name, of course) decided to work on his antenna. Coaxial cable needed replacing and some soldering was necessary. Bill started up a ladder laden with 70-feet of coax and a 50-foot extension cord looped around one shoulder. Over this was looped a leather holster full of tools. A bag of hardware was tied to the bottom of the tool holster. Bill climbed over the end of the ladder and started up the steep roof. No problem here; he'd done this many times before. But he didn't account for one important factor. A typical Southern California breeze, about 15 knots, was blowing in from the ocean.

When Bill reached the base of the antenna mast, he was standing on the peak of the roof, which offered very little footing. You can probably guess what happened next. The weight of gear and tools on one side of his body, plus the wind forces, caused him to lose his balance. Friend Bill, tools, cable, and hardware started down the roof toward the ground 30 feet below. Somehow the coax cable wrapped itself around one of the standpipes on the roof, and Bill ended up dangling over the edge of the eves. Thanks to the strength of the cable and short overhang of the eves, Bill managed to reach the ground by going down the side of the house rappel fashion. (Antenna work was suspended for the rest of the day.)

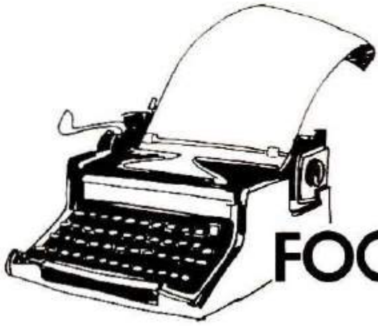
It is easy to overlook safety precautions when you're preoccupied with the problem at hand, when you're in a hurry, or if you're tired. Climbing a tower or roof should never be attempted without another person standing by to give aid or summon help. Professional antenna installers, for example, never work alone. Insurance companies and common sense forbid it.

Overconfidence when working on high structures is probably the greatest cause of accidents. Our California friend had been on his roof many times during the week before the accident. He felt almost as much at home working on his roof as in his workshop. The first time up, he took every possible precaution. But as he became familiar with the situation, he became careless. Result: near disaster.

The consequences of a 30-foot fall can be just as permanent as a jolt from a 3000-volt power supply. When you work on your antenna this summer, remember the tale about our colleague who almost ended up a statistic. Be careful, and use the buddy system.

Jim Fisk, W1HR
editor-in-chief

More details? Ad Check page 78.



FOCUS & COMMENT

Type acceptance — two words that are guaranteed to raise the hackles of almost any amateur or manufacturer of amateur equipment. It is seen by many as an abridgement of the freedom that has been a part of the fun of Amateur Radio for all of its history; the freedom to experiment, change, and innovate. As currently envisioned, the type-acceptance program would apply only to manufactured units and to equipment that is marketed in kit form.

There are worriers among us that foresee, perhaps with good reason, an extension of this program to include home-made equipment for high-frequency bands. Type acceptance would place an intolerable burden on the experimenter, and ultimately suppress that facet of amateur radio to extinction — the testing procedure is lengthy and expensive.

There is no need to let this happen. Amateurs have always been perceptive to the problems that inferior equipment can cause. A recent and shining example is the change that has come about in some of the vhf fm transceivers that are available for the repeater crowd. Early units that were imported (and some that were made in the United States) produced enough spurious signals to key up every repeater in the area, and get into other nearby receivers, no matter what channel they were supposed to be operating on. Many of them did, in fact, do just that. Wise heads could see the commotion and damage that would result if this continued, and made pointed suggestions to the manufacturers about the future of Amateur Radio and their equipment market if changes were not forthcoming. This was not a group of gullible appliance operators, but a service with a good record, operated by people who wanted to keep a clean house. The results are evident in the improved gear that has been marketed more recently.

Unfortunately, Amateurs could do nothing about the abuses of other services, and now type acceptance for all manufactured equipment is very close to reality. We may not be able to turn the tide at this point, but we should start building a breakwater to protect our individual workbenches, soldering irons, and experimenter's curiosity.

It could be that part of the solution lies in making more and better test equipment available. How does the Amateur who is not part of a school, business, or club, where good test facilities are available, know how good (or bad) his rig is? If he waits until he causes a problem on the air, it may be too late, and besides, he is still in the dark as to how effective any cures may be.

What is needed is a sincere effort to develop some simple, reliable, test equipment that can be easily duplicated, or purchased at low cost, which will give meaningful indications of proper or improper operation. To wit: Spectrum analyzers are expensive, but TV sets are not; is there a way to build a "magic box" to hook between your rig and a TV set to display what your transmitter is putting forth? Again: Wavemeters are easy to build, as are field-strength meters. Is there a "gold-plated-cinch" way to build a calibrator so the numbers you obtain in your backyard, reading the strength of harmonics, have some true meaning?

I would like to think so. As long as I have been a member of the Amateur fraternity this type of challenge has been accepted and met by the scientists among us. Where would we be if someone had not wondered, "Is there a way to send pictures within the same bandwidth as voice?" or, "Is it possible to get a satellite on board a rocket as a piggy-back passenger?"

And to think that just the other day I heard someone complaining that "there is nothing left to explore nowadays." Don't you believe it!

Tom McMullen, W1SL
Managing Editor

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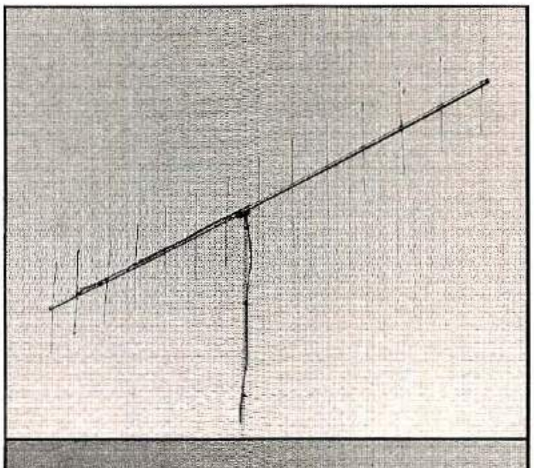

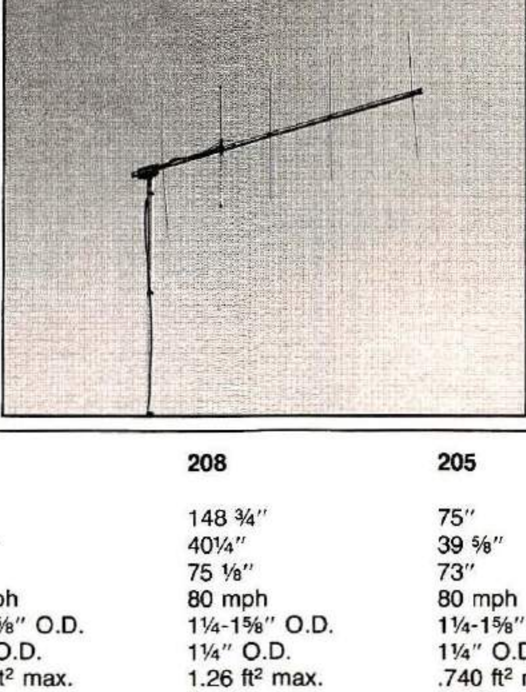

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SPECIFICATIONS	214	208	205	203
Mechanical				
Boom length	186″	148 ¾″	75″	43½″
Longest element	39½″	40¼″	39 ⅝″	40¼″
Turning radius	95″	75 ⅛″	73″	43½″
Wind survival	80 mph	80 mph	80 mph	80 mph
Mast diameter	1¼-1⅝″ O.D.	1¼-1⅝″ O.D.	1¼-1⅝″ O.D.	1¼-1⅝″ O.D.
Boom diameter	1¼″ O.D.	1¼″ O.D.	1¼″ O.D.	1¼″ O.D.
Wind load area	1.65 ft^2 max.	1.26 ft^2 max.	.740 ft^2 max.	.496 ft^2 max.
Net weight	5.5 lbs	4.1 lbs	2.9 lbs	2.2 lbs
Electrical				
Forward gain	13.0 dBd*	11.8 dBd*	9.1 dBd*	6.1 dBd*
Front-to-back ratio	20 dB	20 dB	20 dB	20 dB
Maximum SWR	2:1	2:1	2:1	2:1
Band width	2 MHz	2 MHz	4 MHz	4 MHz
Maximum power	250/500 PEP	250/500 PEP	250/500 PEP	250/500 PEP
Impedance w/balun	52 ohms	52 ohms	52 ohms	52 ohms
½ power beam width	35° vertical	43° vertical	60° vertical	95° vertical
	35° horizontal	36° horizontal	45° horizontal	60° horizontal
Stacking distance	82″ min.	82″ min.	82″ min.	82″ min.

*Hy-Gain antennas are gain rated against a standard dipole antenna (dBd) instead of a theoretical isotropic source (dBi). This is a more honest and realistic means of comparing forward gain.

More details? Ad Check page 78.

More details? Ad Check page 78.

NEWSLINE

A VERY STRONG PRO-AMATEUR RADIO STATEMENT from FCC Chairman Dick Wiley accompanied the release of the Commission's proposals for banning 10-meter linears and type acceptance of Amateur gear (May Newsline). Highpoints of Wiley's comments:

"While I Concur in the Commission's proposals to ban use of linear amplifiers in the 11-meter citizens radio band and to require type acceptance of Amateur equipment, I must admit to doing so with some reservations...My concern is that, in attempting to deal with the rapidly proliferating and sometimes troublesome CB service, we may appear to be penalizing the Amateur community which, in my judgment, is one of the most professional and self-regulated services within the Commission's jurisdiction...

"I Look Forward to a healthy and vigorous discussion on the proceedings the Commission has opened today. Whatever their ultimate outcome, however, I wish to take this opportunity to express my respect and admiration for the Amateur community. I hope and trust that my colleagues will give these Dockets, and the comments filed by the Amateur community (as well as others), careful attention prior to reaching any final conclusion."

A Powerful Endorsement from the FCC's number one man!

ELIMINATION OF AMATEUR SECONDARY STATION licenses proposed by the FCC in March would apply across the board – only individual primary station licenses would be retained. Existing secondary station licenses would remain in force until their expiration date, but could not be renewed. Comments on the proposal, Docket 21135, are due June 2; Reply Comments June 30.

The "Closed Season" on issuance of new secondary station licenses applies only to applications received after March 3. All applications for renewal of existing secondary station licenses will still continue to be processed as before.

"BULK MAILED" NOVICE EXAMS may be discontinued because Gettysburg is having so many problems with vague requests and non-return of unused exams. The net result is proving as heavy a burden on Amateur licensing people as handling Novice exams on a one-to-one basis used to be. There has even been some talk that perhaps the Novice program itself is no longer needed, since Technicians now have all Novice privileges, the material covered in the Novice exam is also in the Technician exam, and CB is doing the basic job of promoting two-way radio as a hobby!

Processing Novice Exams consumes a major portion of the manpower Gettysburg devotes to Amateur licensing, and with Technician ranks growing along with the higher grade licenses it is possible that cutting back or even dropping the Novice program will be proposed. Novice exam requests and scoring at present have number one priority at Gettysburg, however, and current turnaround time for a proper exam request is still 2-3 weeks. Processing time for other routine applications is running 5-6 weeks.

AMATEURS MOVING to a new permanent location now no longer are required to advise the FCC of the change within four months as has been required by Part 97.95(a)(2) of the Rules. In an action adopted March 8, the Commissioners simply deleted that paragraph from the Rules. One caution must be observed, however – be sure mail sent you at the address the FCC does have gets to you, as "failure to reply to official communications" – for example a "pink ticket" – can get you in deep trouble!

ID CARDS FOR CB TRANSMITTERS are no longer required by the Commission – in its release announcing the change the FCC said the cards were little used in enforcement so were being dropped as a deregulatory move.

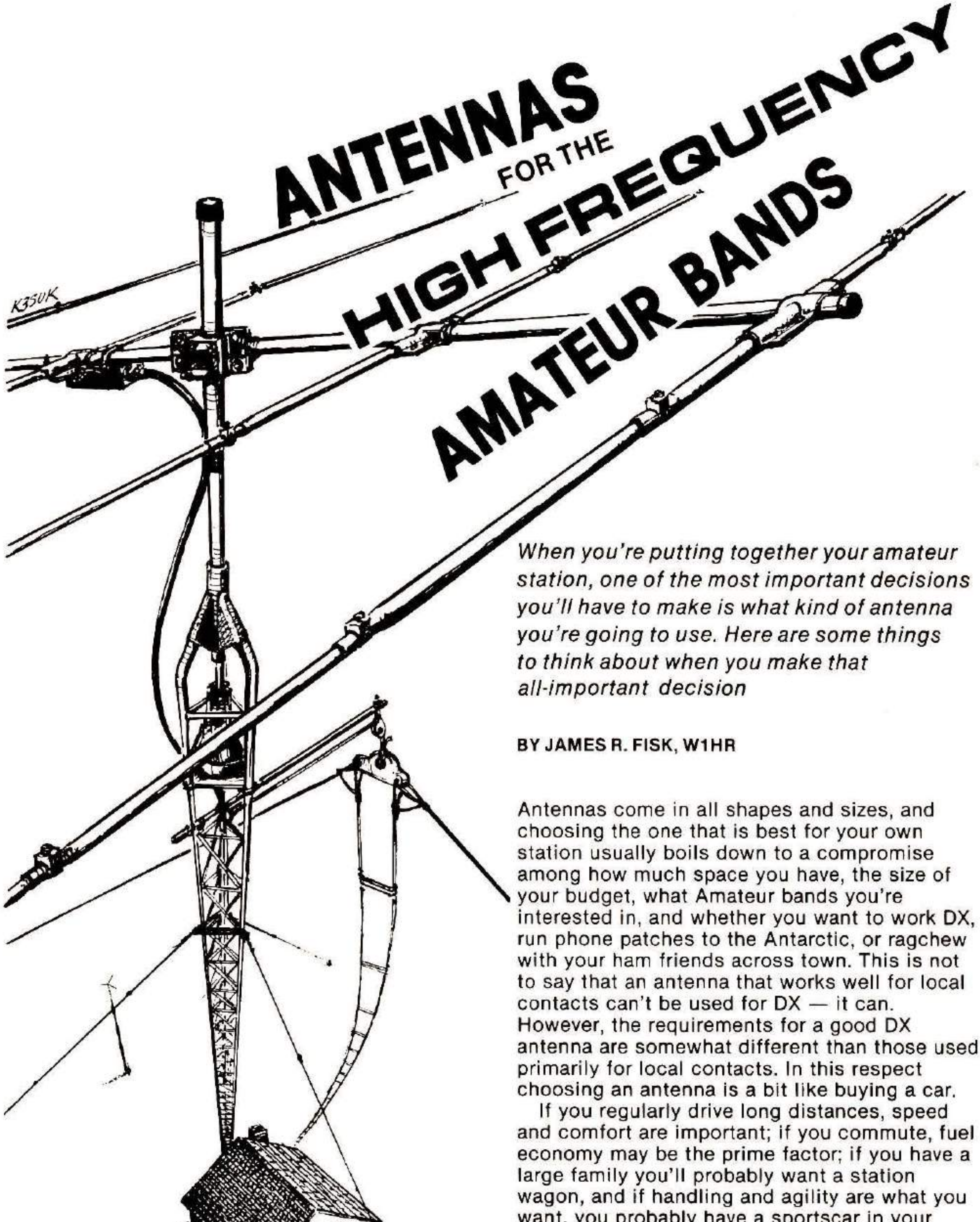
HARMONIC AND SPURIOUS EMISSIONS from all Amateur transmitters will be specifically limited by a first Report and Order on Docket 20777, the bandwidth Docket. The new limits are 40-dB below carrier level under 30 MHz and 60-dB down between 30 and 235 MHz, and apply to all Amateur equipment – homebrew and modified as well as commercial.

FM SIGNALS THROUGH THE OSCARS are becoming more of a problem as crowding above 146 MHz drives simplex activity into the lower band half. FMers are urged to avoid the satellite 145.85-146.0 input band so they won't bother Amateur space communication or when OSCAR 7 is on Mode B (2 meters out) – and vice versa.

OSCAR 7's 435.1-MHz Beacon will be turned on during the first Mode A day of each week as a receiver/antenna checking aid to those preparing to use the AO-D satellite's 2M to 435-MHz transponder when it's launched in November. OSCAR 7's Mode A telemetry on 29502 kHz will indicate the beacon's status (channel 6B). Reports of 435.1 beacon reception are sought by AMSAT.

FOUR SCHOLARSHIPS for the academic year 1977-78 are being offered to licensed Amateurs – General class or higher – by the Foundation for Amateur Radio. Requirements for the scholarships, two for $750 each and the others for $250 each, differ; full details and application forms should be requested from FAR Scholarships, 8101 Hampden Lane, Bethesda, Maryland 20014.

ANTENNAS FOR THE HIGH FREQUENCY AMATEUR BANDS



When you're putting together your amateur station, one of the most important decisions you'll have to make is what kind of antenna you're going to use. Here are some things to think about when you make that all-important decision

BY JAMES R. FISK, W1HR

Antennas come in all shapes and sizes, and choosing the one that is best for your own station usually boils down to a compromise among how much space you have, the size of your budget, what Amateur bands you're interested in, and whether you want to work DX, run phone patches to the Antarctic, or ragchew with your ham friends across town. This is not to say that an antenna that works well for local contacts can't be used for DX — it can. However, the requirements for a good DX antenna are somewhat different than those used primarily for local contacts. In this respect choosing an antenna is a bit like buying a car.

If you regularly drive long distances, speed and comfort are important; if you commute, fuel economy may be the prime factor; if you have a large family you'll probably want a station wagon, and if handling and agility are what you want, you probably have a sportscar in your garage. Any car will get you from point A to point B, but the model you choose depends upon the kind of driving you do. So it is with antennas — the one you choose should be tailored to your own operating habits.

Obviously you want the best antenna you can put up, but before you make that all-important choice, you have to know something about the many types of antennas which are available and why some are more popular and work better than others. In this article we'll describe some of the many types of antennas used by amateurs, give you some hints for putting them up, and tell you how to get the most for your money.

Fortunately, an acceptable antenna is often easier to put up than it is to describe, but we have to start somewhere, and a good starting point is the word antenna itself. The origin of the term is obscure but stems from the Latin word for "sail yard." If that calls to mind pictures of tall ships and lofty sails, you're getting the right impression because your antenna should be as high and as large as possible, within reason. Usually it's not possible to install an ideal antenna, so you have to put up the best possible compromise — and if you look around, you'll find that most hams have compromise antenna installations for one very practical reason: Cost.

The first requirement for a high-frequency antenna is that it must be made from material which is a good conductor of electricity. Wet string, even if it's soaked in salt water, just won't do. There are a number of good electrical conductors with silver about the best, followed by copper, gold, chromium, aluminum, magnesium, beryllium, sodium, molybdenum, rhodium, tungsten, and zinc, in order of increasing resistance. Ruling out the precious metals because they're too expensive, and some of the others because they're difficult to work with (too soft or too brittle), leaves copper, aluminum, and zinc. Phosphor-bronze, a copper-based alloy, is also a good choice.

**Copperweld* is the registered trademark of the Copperweld Corporation of Glassport, Pennsylvania.

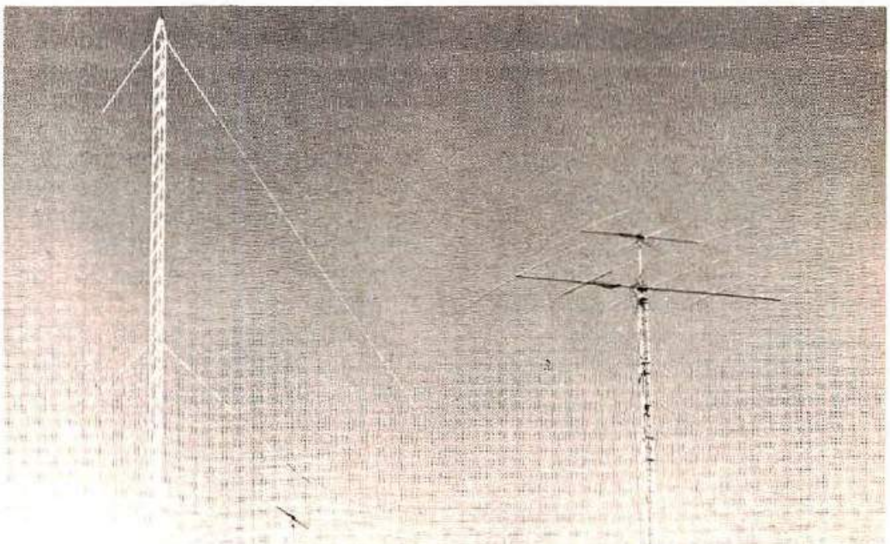
Copper is perhaps the closest to an ideal material from the standpoints of availability, cost, strength, weight, and ease of fabrication including soldering. Aluminum is next best and, for some types of antennas where weight is a major consideration, may be the better selection.

At radio frequencies the current flow tends to be concentrated near the surface of the conductor; this is called "skin effect" and is due to internal effects. Since rf current flow is confined to an area near the surface, the rf resistance is many times the dc resistance and increases at higher frequencies. On 160 meters, for example, most of the rf current flow in a copper wire is within two-thousandths of an inch of the surface (2 mils or 50 microns). This decreases to 0.5 mil (12 microns) at 28 MHz.

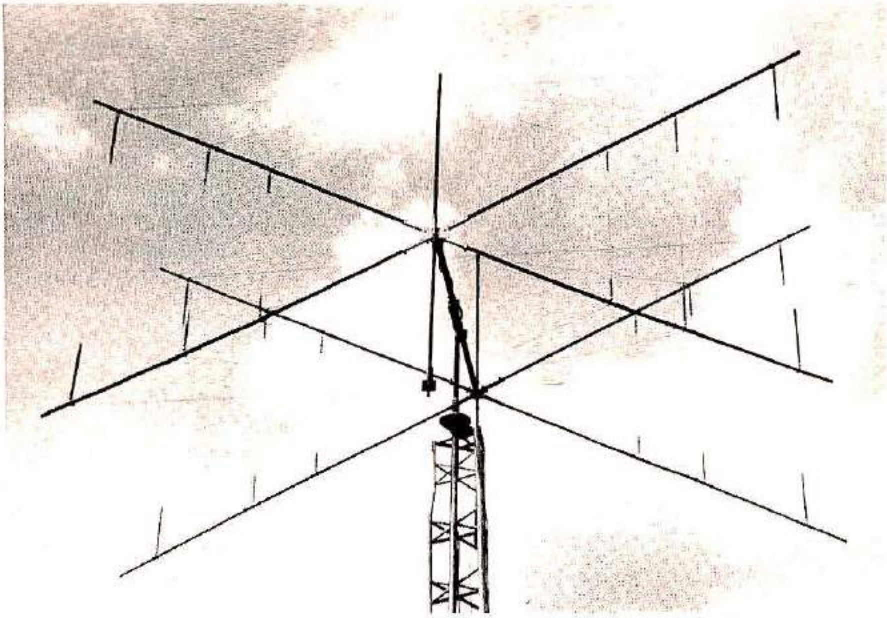
Because of skin effect, a length of copper tubing has exactly the same rf resistance as a solid copper conductor with the same diameter. It also means you don't have to use solid-copper conductors at high frequencies. *Copperweld** antenna wire, which consists of a steel core with a thin copper coating, is often used for antennas because it is much stronger and stretches less than solid copper wire; above 1 MHz its rf resistance is the same as solid copper wire of the same size.

Receiving antennas

If you're only interested in listening, your antenna can be a random length of wire, perhaps 20 to 25 feet (6-8 meters) long, attached to a tree, run under the eaves of your house, or even hung out



The antenna farm at W7IR near Phoenix, Arizona, includes rotating Yagi beams for 20 and 15 meters, right; beams for 40 and 10 meters, center; and a 91-foot (28m) vertical for 80 and 160 meters, left.



This cubical quad built by W1HXU provides high-gain performance on the amateur 10, 15, and 20 meter bands.

the window if you live on the upper floor of an apartment house. Modern receivers are very sensitive, so you can get quite good results with a very simple antenna. If you live in a wooden building, you can even install an antenna in the attic or other convenient place — steel-reinforced concrete is a very effective rf shield, so an outdoor antenna is a must if you live in a modern high-rise. However, there are simple solutions to this problem, as you shall see.

Fortunate indeed is the apartment dweller whose landlord will say, "Sure, go ahead and put your antenna on the roof if you want to." These enlightened souls are few and far between, so if your landlord is one of these, take good care of him.

Wire or tubing?

The choice of wire or tubing for your antenna depends largely upon whether your antenna will be vertical or horizontal, and that, in turn, depends upon the available space and what kind of operating you intend to do. On the lower frequency amateur bands, 80 and 40 meters, the physical size of the antenna almost always dictates that it be made of wire and suspended horizontally above the ground. Vertical antennas made from aluminum tubing can also be used to good advantage on these bands, but for maximum performance they require a good ground system (not a ground rod) that is expensive and time consuming to install.

For the higher frequency amateur bands, 20, 15, and 10 meters, the antenna may be a horizontal length of wire, a vertical made from tubing, or two or more sections of aluminum tubing arranged in an array of elements or beam. Without going into a lot of detail at this point, verticals for 10, 15, and 20 meters have one outstanding advantage over other types — they can be put up in very limited space and don't require trees, masts, or chimneys to support the ends. The ground-system requirements at these frequencies are somewhat easier to meet than at the lower frequencies, so a vertical is an excellent choice and often represents the best compromise in many space-limited situations. For the apartment dweller a vertical may provide the *only* antenna solution; they have been attached to porch railings, window sills, flag poles, and even eaves troughs.

Antenna resonance

Although it may not look like it, every antenna is really a complex electronic circuit with resistance, capacitance, and inductance. This is further complicated by the fact that the nature of these components varies with frequency, height above ground, and how close the antenna is to other objects. In fact, there are some antennas which defy analysis, even with modern, high-speed, digital computers. This is one of the reasons why few amateurs design their own antennas — there are any number of proven designs available which are easy to duplicate and give good results.

There are certain frequencies where the effects of inductance and capacitance cancel out, so at this point the antenna is said to be resonant. Below resonance the antenna looks like a capacitance, and above resonance it looks like an inductance. This is important to remember because it can be used to advantage if your space is limited and you have to use an antenna that is "too short."

The shortest antenna that is naturally resonant at a given frequency is one just long enough to permit the rf current to travel from one end to the other and back again during the time of one rf cycle. Radio waves travel through space at the speed of light, approximately 300,000,000 meters per second, so the distance a wave travels is one cycle is equal to this speed divided by the frequency in Hz. This is called the wavelength. At 4 MHz (4-million Hz), for example, the wavelength is 75 meters. Since the wave travels the length of the antenna *twice*

— from one end to the other and back again — an antenna *one-half* wavelength long will allow the rf current to travel one complete wavelength during one rf cycle. Therefore, the shortest resonant antenna is one that is one-half wavelength long.

If you were to use the speed of light as the basis for figuring out the length of your wire antenna, and then installed insulators at each end and suspended it between two masts, you'd find that it would resonate at a slightly lower frequency than you wanted. This is because of the so-called *end effect* which is caused by the small amount of capacitance introduced by the supporting insulators. End effect varies with frequency and with different installations, but up to about 30 MHz experience has shown that the length of a wire antenna is about 5 percent less than the length of a half-wavelength in space. As an average, the following formula can be used to find the physical length of horizontal wire antenna

$$L = \frac{468}{f_{MHz}} \text{ feet}$$

$$L = \frac{142}{f_{MHz}} \text{ meters}$$

where L is the length and f is the frequency in MHz. For example, if you want to operate at 3.725 MHz in the 80-meter Novice band, the length of a half-wavelength antenna is

$$L = \frac{468}{3.725} = 125.64 \text{ feet}$$

or 125 feet, 7-5/8 inches

$$L = \frac{142}{3.725} = 38.1 \text{ meters}$$

Table 1 gives the dimensions for half-wavelength wire antennas for various frequencies in each of the six high-frequency amateur bands from 160 through 10 meters.

Although an antenna is naturally resonant at only one frequency within an amateur band, it can be used quite successfully both above and below resonance. This is because the matching network in your transmitter compensates for non-resonance, within limits. In fact, if you cut your antenna for the center frequency of an amateur band, in most cases it will operate with good efficiency from one end of the band to the other. The 80-meter band is an exception; this is because the output loading circuits built into most transmitters don't have enough tuning range to compensate for the high reactance at the band edges when the antenna is cut for 3.75 MHz. The best bet here is to use an antenna tuner. Some other alternatives will be discussed later.

Table 1. Length of half-wavelength wire antennas for various frequencies in the high-frequency bands.

Band	Frequency (MHz)	Use	Half Wavelength (feet)	Half Wavelength (meters)
160	1.825	General	256.4	77.81
160	1.875	General	249.6	75.73
80	3.725	Novice	125.6	38.12
80	3.750	General	124.8	37.87
80	3.600	CW	130.0	39.44
75	3.800	Phone	123.2	37.37
40	7.175	Novice	65.2	19.79
40	7.150	General	65.5	19.86
40	7.100	CW	65.9	20.00
40	7.250	Phone	64.6	19.59
20	14.150	General	33.1	10.04
20	14.050	CW	33.3	10.11
20	14.275	Phone	32.8	9.95
15	21.175	Novice	22.1	6.71
15	21.225	General	22.0	6.69
15	21.100	CW	22.2	6.73
15	21.350	Phone	21.9	6.65
10	28.150	Novice	16.6	5.04
10	28.050	CW	16.7	5.06
10	28.550	Phone	16.4	4.97
10	29.475	Oscar	15.9	4.82

Radio propagation

It may not be immediately apparent, but radio propagation has a good deal to do with antenna selection and design. You don't have to completely understand *all* the ins and outs of propagation to select an antenna, but a basic understanding will help

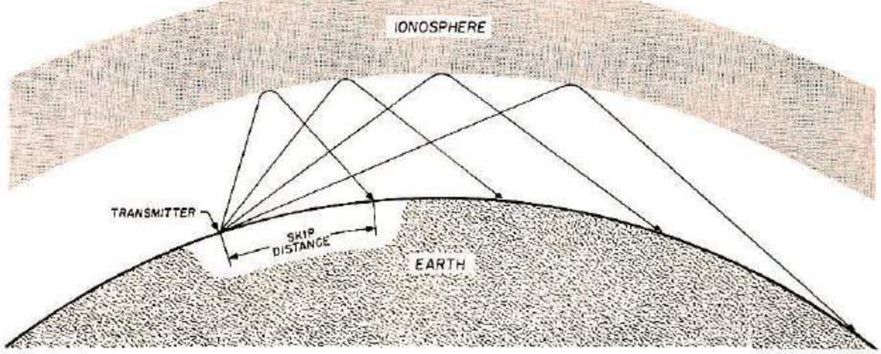


Fig. 1. Radio propagation by sky wave, rf radiation which is reflected by the ionosphere. The skip distance is determined by both the angle at which the rf leaves your antenna, and the height of the ionosphere, which depends upon time of day, season, and latitude among other things. During periods of low sunspot activity, as now, the ionosphere is most effective on 40 and 20 meters. During the next sunspot high in 1981, daily round-the-world propagation on 10 and 15 meters will be common, and there may even be occasional "openings" on 50 MHz!

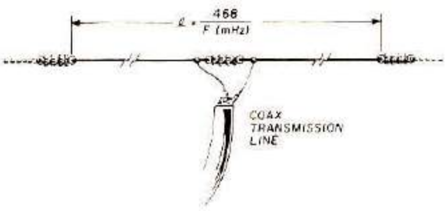


Fig. 2. Dipole or doublet antenna provides a good match to 50- or 75-ohm coaxial transmission lines. Proper length depends on the desired operating frequency as shown in **Table 1**.

you choose an antenna that will do the job you want it to.

Basically, radio waves propagate in three different ways: line of sight, ground wave, and sky wave. For line-of-sight propagation your antenna has to "see" the antenna of the station you want to work. Since high-frequency radio waves are slightly bent by the atmosphere, radio line-of-sight is about 20 per cent greater than the distance you can see on a clear day. If you live in the midwest where the land is flat for miles around, and your antenna is 100 feet (30m) high, maximum radio line-of-sight is about 15 miles (24km).

The ground wave is simply that portion of the radiated energy which moves along the surface of the ground; a certain amount of rf from *all* antennas is radiated in this fashion. On the a-m broadcast band the ground wave accounts for propagation up to 100 miles (160km) or more during the daytime, but range falls off quickly with increasing frequency — on 160 and 80 meters it provides reliable communications only to 50 miles (80km) or so. On the higher frequency bands the energy in the ground wave is quickly dissipated in ground losses so it's useful only for close-in radio communications.

Dentron 80-10AT antenna tuner is designed to load a random length of wire on 80 through 10 meters. It's ideal for portable operation or for apartment dwellers who have limited space. Maximum power rating is 500 watts PEP.

Almost all high-frequency radio propagation is by way of the sky wave, rf energy which is reflected off the ionosphere back to earth as shown in **Fig. 1**. The height of the ionosphere varies with the time of day, season, and latitude among other things, and may be anywhere from 125 to 250 miles (200-400km) above the earth. As can be seen from **Fig. 1**, maximum skip distance occurs when the rf from your antenna is concentrated within a few degrees of the horizon. At higher radiation angles the skip distance is much shorter. This is the reason why most serious DX operators choose antennas which have very low angles of radiation such as multi-element Yagi beams or cubical quads.

Dipole antennas

One of the simplest, most effective antennas for amateur use is the dipole or doublet antenna shown in **Fig. 2**. This is the same type of antenna used by Heinrich Hertz in his first experiments with radio waves back in 1887, so it is sometimes referred to as a *Hertz* antenna. Amateurs usually use dipole antennas which are one-half wavelength long because they're easy to put up and provide a good match to 50- and 75-ohm transmission lines. Longer (or shorter) dipoles can also be used, but if the length is considerably different than one-half wavelength, the antenna will not provide a good match to a coaxial transmission line so an external antenna matching unit will be required.

As I mentioned earlier, the height above ground and the nearness of other objects has an effect on the way the antenna behaves. These things also affect the feedpoint inpedance of the antenna. Out in free space the theoretical input impedance of a half-wave dipole is 72 ohms, but when installed over ground the impedance varies from zero (at ground level) to nearly 100 ohms (about 3/8 wavelength above ground) as shown in **Fig. 3**. Note that this assumes a *perfect* ground, not a lossy, real-life ground.

The ground under your antenna may be very good (if you live in a salt marsh) or very poor (if you live in the desert) but it will never be perfect. Nevertheless, this graph should give you an idea of the range of impedance values provided by a half-wavelength dipole. Many antenna books suggest that the dipole be installed 1/2 wave-length above ground — this isn't always practical, but if you can manage it the feedpoint impedance should be somewhere around 72 ohms.

Radiation resistance

The rf energy supplied to your antenna through the transmission line is dissipated in the form of radio waves and in heat losses in the antenna conductor and the insulators. Since the antenna is made from a good conductor of electricity, heat losses due to

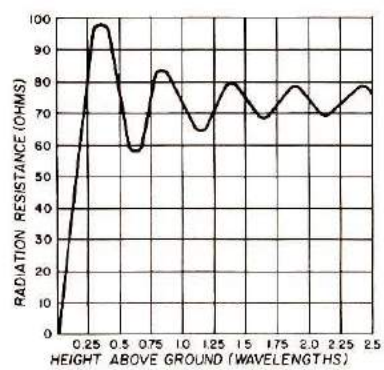


Fig. 3. Radiation resistance of a horizontal half-wavelength dipole varies with height above a perfectly conducting ground. The earth under your antenna is not a perfect conductor, but this graph will give you an idea of the range of feedpoint impedance values to expect.

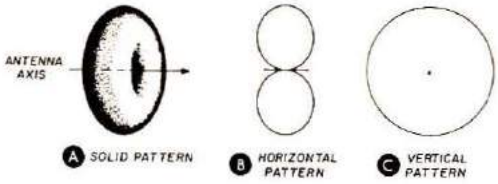
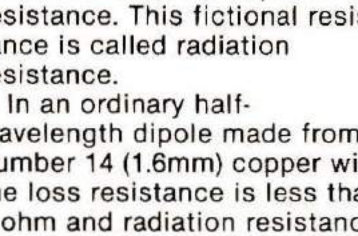


Fig. 4. Radiation pattern of a half-wavelength dipole in free space looks a bit like a doughnut as in **A**. Since the radiation patterns of most antennas aren't as simple as this, it's difficult to present a three-dimensional view, and both horizontal and vertical patterns are used. The horizontal radiation pattern of the free-space dipole, as seen from the top, looks like a figure eight, **B**; the vertical pattern as seen from the end of the antenna looks like a circle, **C**.

the ohmic resistance of the wire are very low. The radiated energy is the useful part and since it, too, is dissipated, — so far as the antenna is concerned the radiated energy *looks* like it was dissipated in a resistance. This fictional resistance is called radiation resistance.

In an ordinary half-wavelength dipole made from number 14 (1.6mm) copper wire, the loss resistance is less than 1 ohm and radiation resistance makes up the rest. The 72-ohm feedpoint impedance of a half-wavelength dipole, for example, consists of about 71 ohms of radiation resistance and 1 ohm of loss resistance. Any energy which is dissipated in the loss resistance is not radiated, so it's important to keep the loss resistance as low as possible. For full-size antennas this is



MFJ antenna tuner can be used to tune your transmitter into a random length of wire on any amateur band between 160 and 10 meters. It's rated at 200 watts, maximum.

forced to use a "short" antenna because of space limitations, you'll find that the feedpoint impedance may be 10 ohms or less; the ohmic resistance will still be on the order of 1 ohm so it represents about 10 per cent loss. In some mobile antennas for 80 and 160 meters the loss resistance may even be greater than the radiation resistance. This dramatically reduces the efficiency of the antenna. Nevertheless, small antennas can provide surprisingly good results.

Radiation patterns

All antennas have a distinctive radiation pattern which shows how well the antenna radiates energy in any given direction. Most simple antennas radiate energy in most all directions, but multi-element arrays concentrate the energy in one direction like a beam of light. The radiation pattern is three dimensional so it's difficult to illustrate it properly on the printed page. Therefore, antenna radiation patterns are usually presented in two views: Horizontal (as seen from a point directly above the antenna) and vertical (a side view from ground level).

A half-wavelength dipole in free space, for example, has a radiation pattern that looks something like a doughnut as shown in **Fig. 4A**. As seen from the top, the horizontal radiation pattern takes the form of a figure 8 (**Fig. 4B**). The vertical radiation pattern, as seen from the side, is a circle as in **Fig. 4C**. Note that this is the radiation pattern of a half-wave dipole out in free space where it's not affected by reflections from the ground.

The antennas that you and I use are not out in free space, so they are subject to the influences of the earth which intercepts the radio waves travelling to and from the antenna, and distorts or absorbs them. If the earth under your antenna is a good conductor (which it usually is

The Universal Radio *Tripole* multiband antenna is designed for use on 80 through 10 meters, and provides a good match to 50-ohm coaxial transmission lines. An optional matching network is available which permits operation on 160 meters as well.

not), the radio waves near the antenna and underneath it are reflected by the earth and bounce back into space, sometimes reinforcing each other and sometimes cancelling one another, or a little of both. The various combinations of reflection, interference, and absorption change the radiation pattern of the dipole. The overall effect depends upon the height above ground as shown in **Fig. 5**.

Experimenters have tried all different heights for their half-wavelength dipoles, and discovered long ago that the

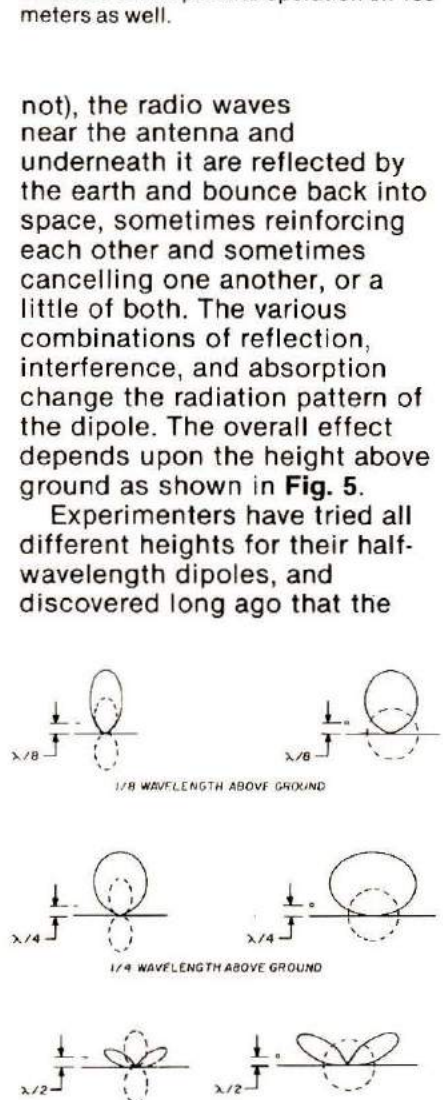


Fig. 5. Horizontal and vertical radiation patterns of a half-wavelength dipole 1/8, 1/4, and 1/2 wavelength above ground. Note that maximum power is concentrated at low vertical angles when the antenna is 1/2 wavelength high — at other heights most of the energy is concentrated in a vertical lobe; this is fine for medium-range communications but not best for long-range DX work.

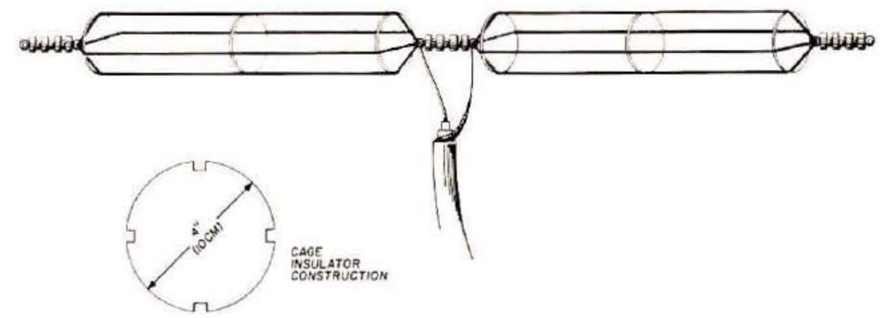


Fig. 6. Operating bandwidth of an 80-meter dipole is limited because the output circuits of modern transmitters aren't designed to cope with the off-resonance effects; the antenna is just as effective at a band edge as it is in the center, but your transmitter is incapable of loading maximum rf power input into it. This can be solved by using a "thick" dipole which is simulated by a cage of wires as shown here.

best height above ground was 1/2 wavelength. As can be seen in **Fig. 5**, when the dipole is 1/2 wavelength above ground, the energy in the vertical pattern is concentrated at an angle of about 30 degrees above the horizon. At 1/8 and 1/4 wavelength above ground most of the rf energy from the dipole is radiated straight upward toward the sky. This is fine for short- and medium-range communications, but not very good for DX work. At greater heights above ground the radiation is again concentrated in a vertical lobe, so a height of 1/2 wavelength is about optimum for good DX operation.

It's not usually possible to place your dipole a half wavelength above ground on 80 and 160 meters, so do the best you can. With antennas, as in life, everything turns out to be a compromise of one kind or another, so put your 80- and 160-meter antenna as far above ground as you can and don't worry about it. On the higher frequency bands a half wavelength becomes smaller and smaller, so at 40 meters it is only 65 feet (20 meters) or so; not easy, but not impossible, either. On 20 meters it's about 34 feet (10 meters), and so on down the scale.

Broadband dipoles

If you want to operate on the 80-meter band and cut your dipole to resonate in the center of the band at 3.75 MHz, if you use a coaxial transmission line you'll probably find that your transmitter won't load properly as you get near the band edges. The antenna itself is just as effective at the band edges as it is at resonance if you can get rf power into it, but the output matching network in your transmitter isn't able to cope with the off-resonance effects caused by operation more than about 2 or 3 per cent away from resonance.

This is not a problem on 40, 20, and 15 meters because the width of these bands is a small percentage of the center frequency. If you use a coaxial-fed dipole on 80 meters, however, the maximum bandwidth you can expect to cover before running into transmitter loading problems is about 200 kHz. Remember that this is not a problem with the antenna — it's a limitation of your transmitter. Fortunately, there are some simple solutions to this problem that will allow you to operate anywhere on 80 meters with a single antenna.

One of the easiest ways to solve the bandwidth problem on 80 meters is to increase the diameter of the dipole. This is because the off-resonance effects are less drastic if you use a "thick" dipole, so the operating bandwidth is increased. Thick dipoles made from aluminum tubing are often used on the vhf bands, but stringing up a 125-foot (38-meter) length of aluminum pipe for 80 meters obviously isn't too practical. However, you can simulate the same thing by using the arrangement shown in **Fig. 6** which is called a cage dipole. This type of construction provides a pretty good match to coaxial cable over the entire 80-meter band.

Another way to simulate a thick dipole is to use the fan arrangement in **Fig. 7**. This type of construction was originally conceived back in the 1930s for wideband TV reception and you can still see it today in many uhf-television "bow-tie" antennas. This antenna will also provide a good match to a coaxial feedline over the entire 80-meter band.

Still another approach to satisfactory operation from one end of the 80-meter band to the other is shown in **Fig. 8** — use open-wire feeders and an antenna matching unit or antenna tuner. You can also use coaxial feedline and an antenna tuner to provide a good match to your transmitter, but losses are considerably lower if you use open-wire feedline. Although this type of antenna requires the use of an additional piece of equipment

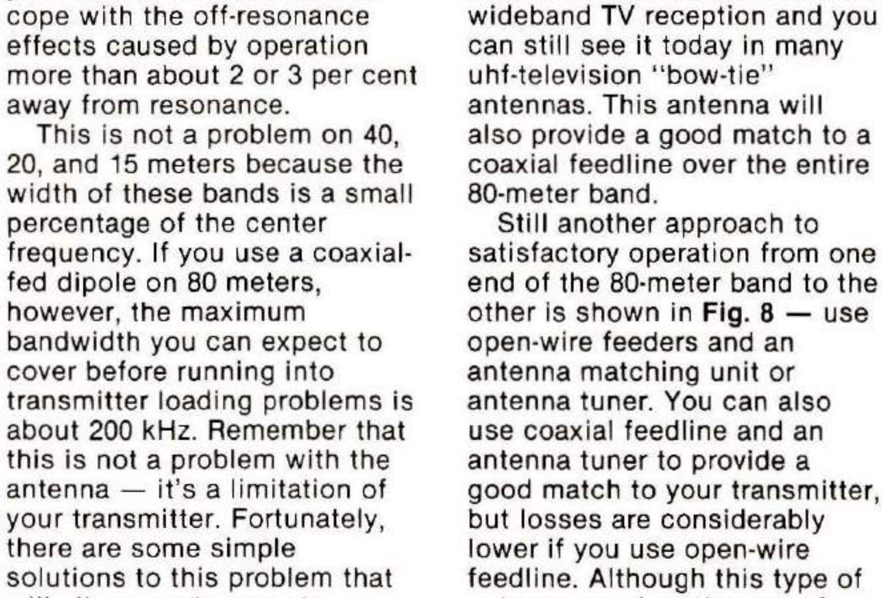


Fig. 7. The fan dipole is another way to increase your operating bandwidth on 80 meters. This arrangement is somewhat easier to build than the cage dipole shown in **Fig. 6**.

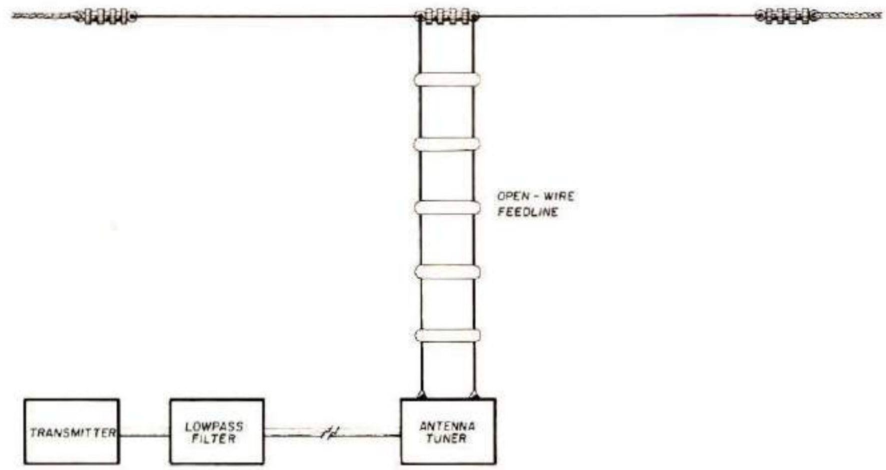


Fig. 8. This antenna system can be used on any of the high-frequency amateur bands with good results. It does require the use of an antenna tuner, but if you have space for only one antenna, this is an excellent choice. The dipole should be 1/2-wavelength long on the lowest amateur band you intend to use (about 125 feet or 38 meters on the 3.5-MHz band).

— the antenna tuner — it has the added advantage that it can be used on *any* of the amateur bands.

If your space is limited so you can only put up one antenna, this is an excellent choice. You do have to readjust the antenna tuner for each band, but that doesn't present much of a problem after you have tuned it correctly the first time; just write down each of the control settings and keep the list nearby — in the future all you have to do is return the antenna tuner to those dial settings, which only takes a few seconds.

The half-wavelength folded dipole shown in **Fig. 9** is yet another way to increase your usable operating bandwidth on 80 meters over that of a single-wire dipole. The feedpoint impedance of the folded dipole is about 300 ohms, so if you want to use a 50-ohm transmission line, you"ll have to install a 4:1 matching transformer which will transform the 300-ohm feedpoint impedance to the 50-ohm impedance of your cable. Years ago, when amateurs regularly used balanced open-wire feedlines or TV twinlead, the folded dipole was very popular, but today it is seldom seen. In most cases, the fan dipole or cage dipole are a better choice if you want to operate from one of the 80-meter bands to the other.

Other dipoles

One of the big disadvantages of the horizontal dipole is that it requires a high mast or tree at each end. If you're fortunate enough to have some high trees in your backyard which are the right distance apart, you're all set, but most amateurs aren't so lucky. One very popular solution to this problem is to elevate the center of the dipole and allow the two halves to slope down toward the ground as shown in **Fig. 10**. This is called an inverted-V. In addition to needing only one high supporting mast, it requires much less horizontal space. Some amateurs have even reported that the inverted-V is more effective than the horizontal dipole on 40 and 80 meters, particularly at heights above ground of 75 feet (23 meters) or less.

Sloping the halves of the dipole down toward ground tends to lower the resonant frequency of the antenna; it also decreases the feedpoint impedance and bandwidth. Therefore, the length of the inverted-V must be shortened somewhat to resonate at the same frequency as a horizontal dipole. Since both resonance and feedpoint impedance are a function of the apex angle (which should not be less than 90 degrees), there's no fixed formula for figuring out the correct length. The best bet is to cut the antenna to the length

The Millen *Transmatch* is designed to match antennas on the 80, 40, 20, 15, and 10 meter bands. The unit has a built-in swr meter and is rated at 2000 watts.

shown in **Table 1** and equally shorten the length of each half until the antenna provides a good match to your 50-ohm coax at the desired operating frequency. As with horizontal dipole antennas, bandwidth can be increased by using a cage of wires similar to that in **Fig. 6**.

Still another variation on the dipole theme is the "sloper" shown in **Fig. 11**. This antenna

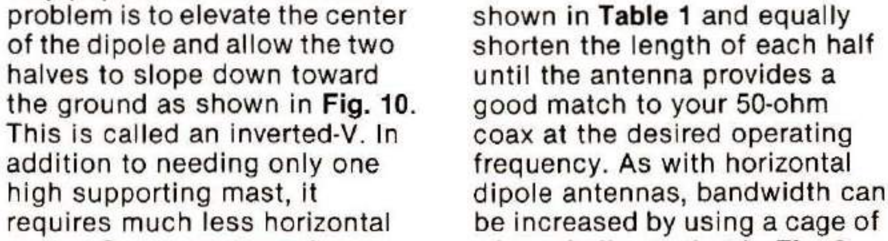


Fig. 9. The folded dipole has somewhat greater bandwidth than a single-wire dipole, but the feedpoint impedance is 300 ohms so you have to install a 4:1 matching transformer if you use 50-ohm coaxial feedline. In general, the cage dipole (**Fig. 6**) or the fan dipole (**Fig. 7**) are a better choice for complete band coverage on 80-meters.

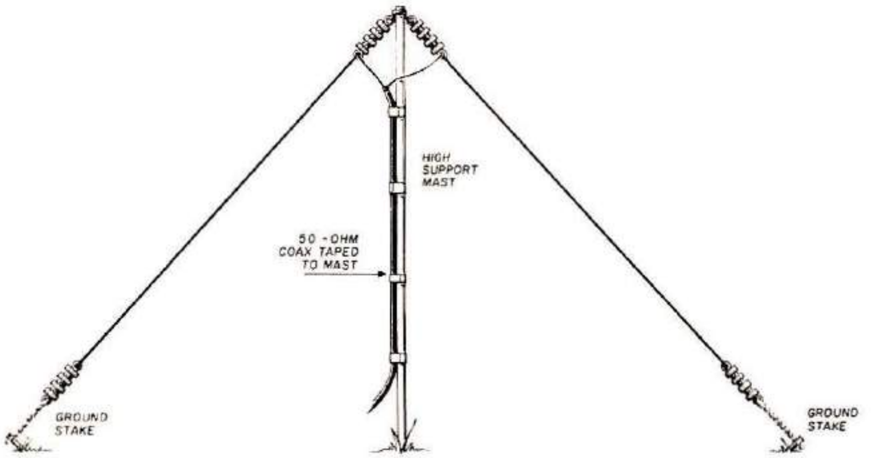
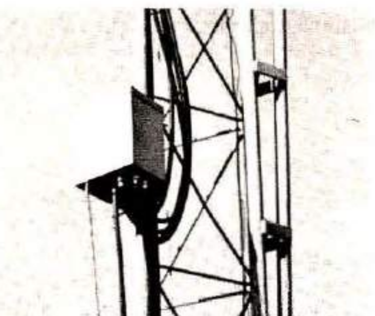


Fig. 10. The popular inverted-V is simply a half-wavelength dipole with the ends sloping down toward the ground. This antenna requires somewhat less space than a horizontal dipole, and needs only one high mast. Resonant frequency depends upon the apex angle and height above ground, so the length of the antenna must be "pruned" to the correct length as discussed in the text.

requires only one high support mast and is very popular for DX work because maximum radiation is at low vertical angles. Some DXers have even installed four sloping dipoles on the same mast, 90 degrees apart, so they can direct their transmissions to different areas of the globe simply by switching the coaxial feedline



The R. L. Drake RCS-4 remote coaxial switch is ideal for switching the various legs of a sloper antenna system. It can also be used for switching your transmission line between other antennas which are located on the same tower.

from one sloper to another. This can be done manually, or with an electrically-driven coaxial switch which is mounted on the support mast and controlled from the shack.

The length of a dipole does not have to be limited to one-half wavelength — lengths much longer (or shorter) can be used, but they don't present good matches to 50- or 75-ohm transmission lines. An exception here is a dipole which is an *odd* multiple of 1/2-wavelength long, such as 3/2 (1-1/2) or 5/2 (2-1/2) wavelengths; the behavior of these dipoles is very similar to that of half-wave antennas and they provide a good match to coaxial transmission lines. This is important because a 1/2-wavelength dipole for 40 meters is 3/2-wavelengths long on 15 — this means that the same antenna can be used on both bands. None of the other high-frequency amateur bands have this relationship.

Dipoles which are an *even* multiple of 1/2-wavelengths long (such as 1, 2, 3, or 4 wavelengths) present a very high feedpoint impedance, so it's not a good idea to use them with coaxial transmission lines. A practical example is a 1/2-wavelength 3.5-MHz dipole which is 1 wavelength long on 7 MHz, 2 wavelengths long on 14 MHz, and 6 wavelengths long on 21 MHz. If you use open-wire feeders and an antenna matching unit (see **Fig. 8**), however, the 80-meter antenna is a very effective radiator on *all* high-frequency bands, even on 160 where it is only 1/4-wave long! Dipoles which are longer than 1/2 wavelength have a slight amount of gain over a half-wave dipole at the same height above ground, but gain is less than 3 dB for dipoles shorter than four wavelengths.

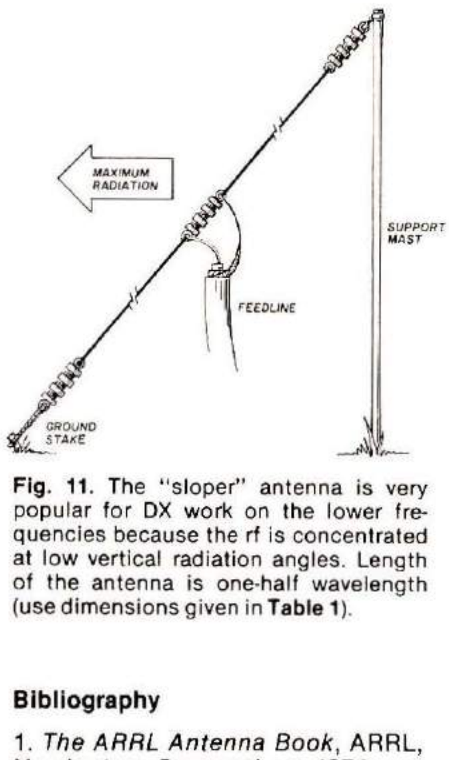


Fig. 11. The "sloper" antenna is very popular for DX work on the lower frequencies because the rf is concentrated at low vertical radiation angles. Length of the antenna is one-half wavelength (use dimensions given in **Table 1**).

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(To Be Continued)


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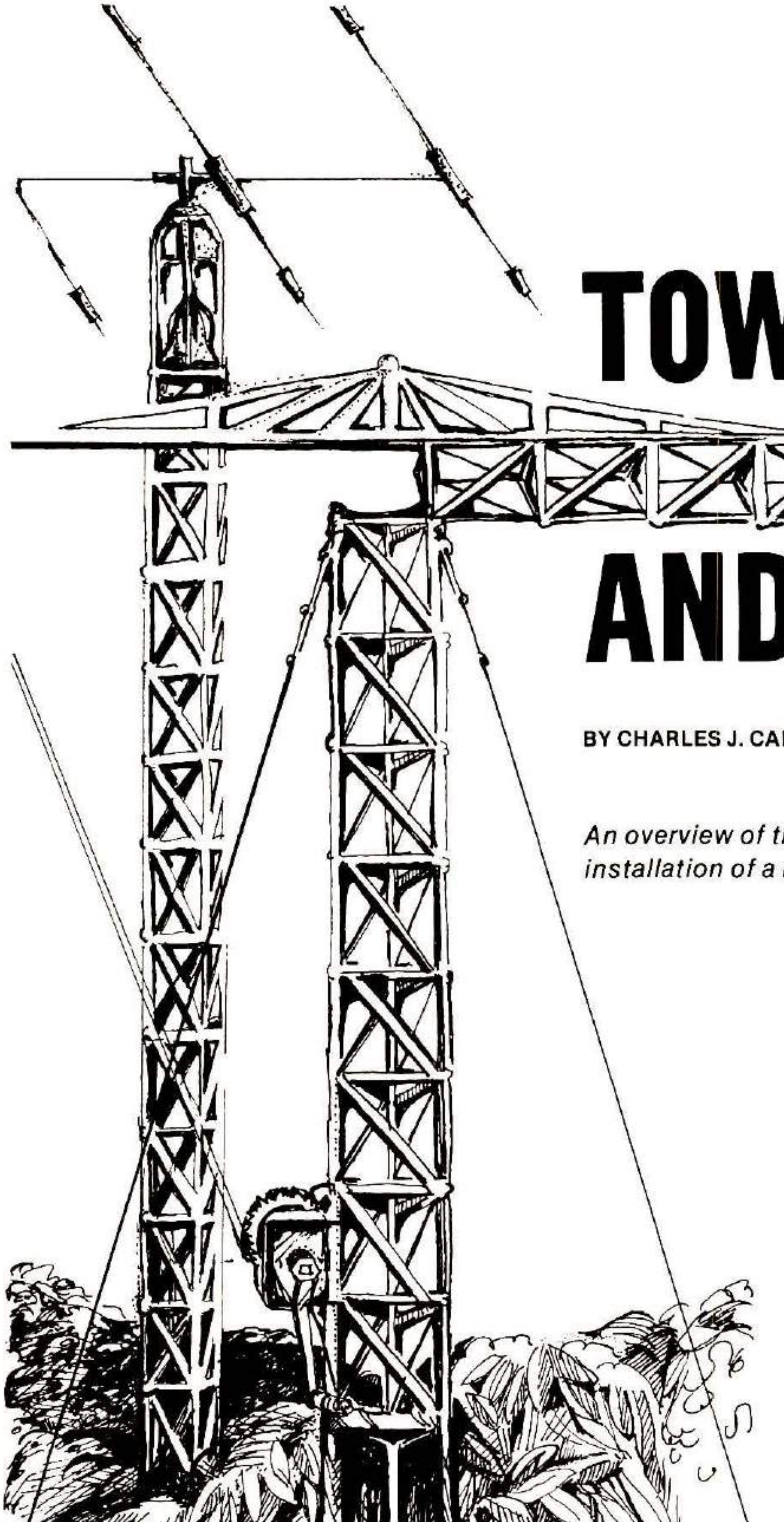


TOWERS UP AND DOWN

BY CHARLES J. CARROLL, K1XX

An overview of the selection and installation of a radio tower

Somewhere in that natural progression from Novice to General, many Amateurs look longingly to the skies, visualizing a beam and the associated tower. With the increased feeling that the old dipole is radiating poorly in all directions, some people seek ways to turn those visions into real steel and aluminum. Usually many hours are spent poring over catalogs and brochures describing the many rotary systems that can be built or purchased. Unfortunately though, an equally important part of the installation is largely overlooked — the tower. Allowable wind loading, maintenance problems, and expandability are a few of the questions that should be considered before any tower installation is undertaken. So spend a little extra time during the selection phase, and consider what your tower will be up against in the coming years. Quite a few days have started off on a sour note when an amateur found his beautiful tower lying in a neighbor's flowerbed.

General considerations

Before laying out a large sum of money, you should look closely at the capabilities of your intended tower. How large an antenna, and with what wind loading, is generally one of the prime considerations. Height, expandability, accessibility, and cost are other factors which should be considered.

Typical specifications might rate the tower at 9 square feet (7.5m^2) of wind load at 40 mph (64km/h). This is a reasonable amount of windloading, unless a blizzard or wind storm comes through your area. A study has shown that the majority of the United States has never experienced winds greater than approximately 85 miles per hour (137 km/hr). Only isolated portions of the country will have the pleasure of experiencing the high winds of a hurricane or other storms. It's best to be sure that your tower is rated for the extreme rather than the normal loading conditions. Check that specification carefully.

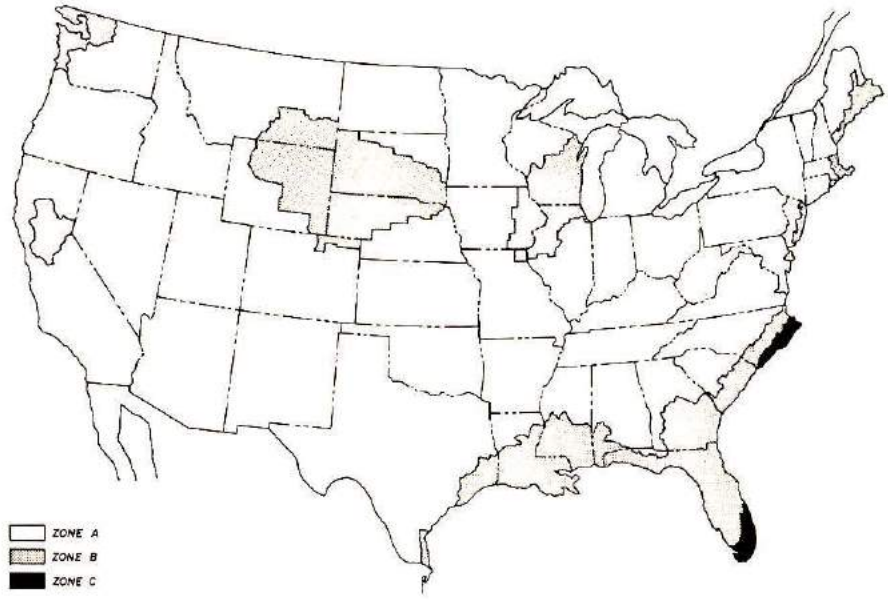


Fig. 1. Expected wind loading areas of the United States from EIA Standard RS-222-B. Zone **A** includes wind velocities to 86.6 mph (139.5 km/h) or 30 pounds per square foot (1.44 kilopascals [kPa]) of impact pressure. Zone **B** is up to 100 mph (161 km/h) or 40 pounds per square foot (1.92 kPa). Zone **C** is rated at 111.8 mph (180 km/h) or 50 pounds per square foot (2.39 kPa). This information is for towers which are less than 300 feet (91m) high.

"I'll go over in a couple of days and see how the beam held up . . ."

Crank-ups

For those people who prefer to do their antenna work with one foot on the ground, the crank-up tower is very popular. Many models are available, ranging from those with small tubular sections to some with large triangular or square sections, each portion telescoping into the next lower one. Though presenting a definite convenience, the crank-up has some limitations. The maximum height cannot be increased, for example. Once a tower of a specific size has been purchased, that is as far as it will go. However, it may be used at less than maximum height if needed. Furthermore, the crank-up models are usually not capable of supporting the large arrays that are more commonly found installed on a sectional type tower. Some companies do have versions that will support large rotary antennas although the price is certainly commensurate with their size.

One very important item surfaces when you use a crank-up tower. Safety is a prime consideration when working near *any* tower, but the hazards increase when using a crank-up. Many stories have been told of people being injured while moving or working on the tower. Unless locks are installed when the tower is extended, the weight of the sections is supported by the winch and cable. A defective cable, poorly maintained winch, or even plain carelessness, can result in a sudden and unexpected lowering of the tower. For anyone standing on a section, the results will be immediately obvious. Crank-up towers have their place, but exercise caution and good judgement when you work on them.

Even though a crank-up tower is usually self-supporting, it can be guyed for additional strength. This is an added measure of safety that may save the tower during an unexpected storm. The relatively small amount of money spent on guying will result in more peaceful sleep at night.

An installed guy anchor prior to attaching the turnbuckles. Each tower will have different anchor requirements. This particular guy anchor is buried approximately four feet (1.2m) into concrete.

Sectional towers

Probably the most versatile is the sectional tower. This type of tower uses identical sections, generally 10 feet (3m) long, that are joined together as the tower is erected. One immediate disadvantage should be apparent: You can't do all your antenna work on the ground! Generally though, once the tower is properly completed, it will survive even the worst of storms. One of the nice advantages of the sectional tower is that it can be increased in height. Raising the height of an antenna from 60 to 120 feet (18 to 36m) only requires the acquisition of 6 more sections, not a complete new tower. Another feature of this tower is that the sections are sometimes light enough that a single person can assemble a complete tower. This may entail tremendous amounts of work and energy for a lone person, but it can be done. The Rohn 25G series (40 pounds or 18kg per section) tower lends itself nicely to this type of installation for those isolated areas like New Hampshire. It's when assembling the larger Rohn 45 (70 pounds or 32kg per section) that the task becomes difficult.

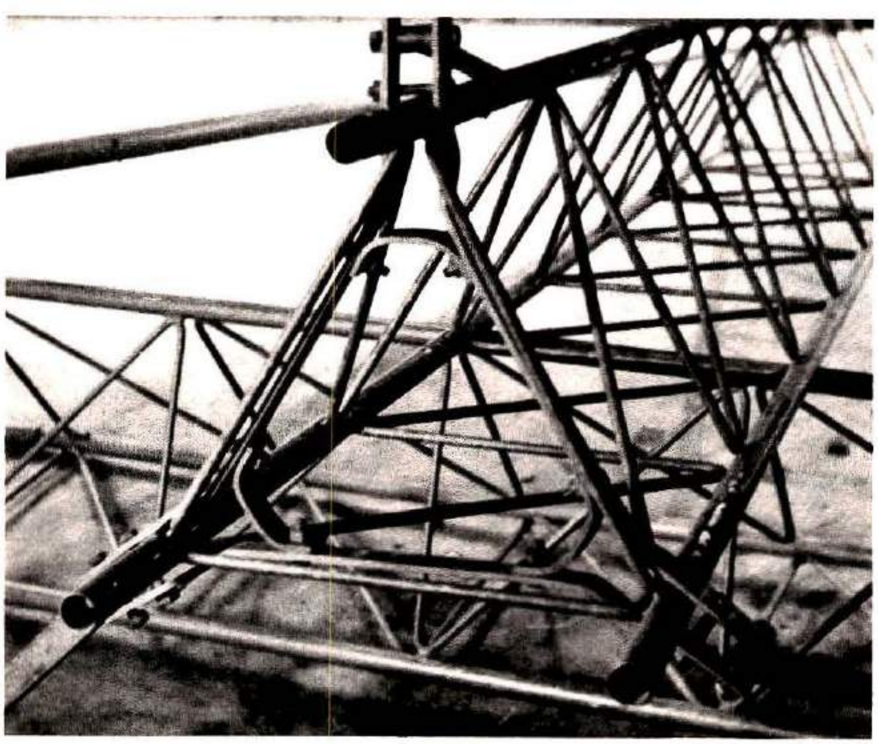
In case you might be wondering about the difficulties of placing an antenna at the top of a non-crank-up tower, rest assured that it can be done. With a little patience even the largest array can be threaded through the guy wires and installed at the top. If this approach is not satisfactory, the antenna can be taken up in pieces and then assembled at the top. Some ingenious people have even made use of the guy wires as a trolley system for raising an array.

Safety

The most important item to consider, for any tower, is safety. Use a lot of good, common sense and judgment, backed up by sound engineering. More and more reports are showing up in the newspapers which talk about people who were electrocuted while installing an antenna and/or tower. Make sure that any erected tower can not fall across nearby power lines. Ground safety is another consideration. Those people who are providing ground support for others on a tower must be conscious of what is occurring. Just being the "strong back and weak mind" is not enough. Thinking is required of everyone. Any object dropped from a tower can instantly become a lethal weapon. So stay away from the base of a tower and, if possible, wear a hard hat at all times. It may seem like a belabored point, but the consequences are very real, especially if you've seen them first hand. Though crank-ups were previously mentioned, the subject is very important; exercise extreme caution when when working with a crank-up tower.

As with most items today, the final selection of a tower largely depends on the size of your pocketbook. A few tips are in order to help defray some of the expenses. Sometimes towers can be obtained by the "take it down and it's yours" routine. Companies or individuals may want a tower removed and very often will let you have the tower simply for removing it. This frequently occurs in areas where a CATV system is being built. Check

Shown are torque bars installed on the tower sections. With guy wires attached to the torque bars, the tower is prevented from twisting either in the wind or as the rotator turns a beam.



with a local tower or antenna company; occasionally they have removed a tower and may be trying to sell it. Surplus or scrap-metal companies may have towers that are available at a reasonable price. With modern galvanizing techniques, it is possible to find older towers in very good condition.

Quite by accident, I discovered that the company doing a local CATV installation was using ¼-inch (6.5mm) EHS (extra high strength) galvanized guy wire for their stringer cable. Any time they didn't have enough cable to reach the next pole, the short portion of cable was discarded as scrap. The thought of the many thousands of feet being discarded still makes me sick. Check with any local CATV companies, their "scrap" is your gold. A typical tower installation would use 3/16 inch (5mm) EHS, so the ¼-inch (6.5mm) size is a little added safety factor.

In the rural areas of the country your local power company may be willing to sell you insulators or guy anchors. As you get nearer the cities, this attitude seems to disappear. At times, some very high-quality materials can be obtained for very reasonable prices.

Regardless of the type of tower you choose, some form of maintenance must be done. The aluminum tower has become quite popular because it is relatively maintenance free. This, though, does not relieve you of all worries. Water can collect inside the legs, later freezing and splitting a leg. Generally, galvanized towers are rust free. A yearly check will show any areas that have broken down and begun to rust. If bolts are used to join the sections together, they should also be a non-rusting type (stainless steel or cadmium-plated steel). If not, some type of preservative should be applied before and after installation. Every few years the bolts may have to be replaced due to rusting of that portion of the bolt which is inside the tower leg. For the crank-up tower, the winch and hoisting cable must be flawlessly maintained. Also, the tower may require lubrication on the travel surfaces.

Installation

With a tower selected, the next major problem will be the installation. Many local ordinances have been enacted that will limit the height or restrict the final site, so if the tower falls, it must fall on your own property. With a quarter-acre lot and such a stipulation you're very restricted as to height and location. Therefore, adequate preparation must be done beforehand to prevent an unhappy visit from the building inspector. If the tower is going to be used to support any type of non-rotating, directive array for the lower frequencies, consideration should be given to the direction of the tower faces, prior to installation.

After making the final decisions about installation,

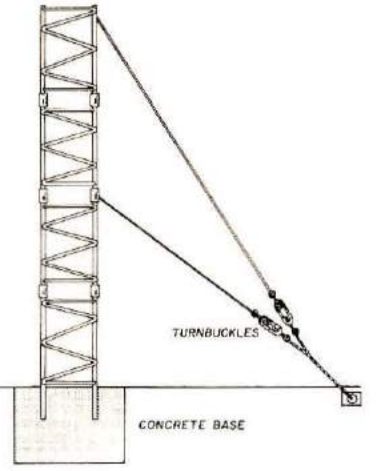
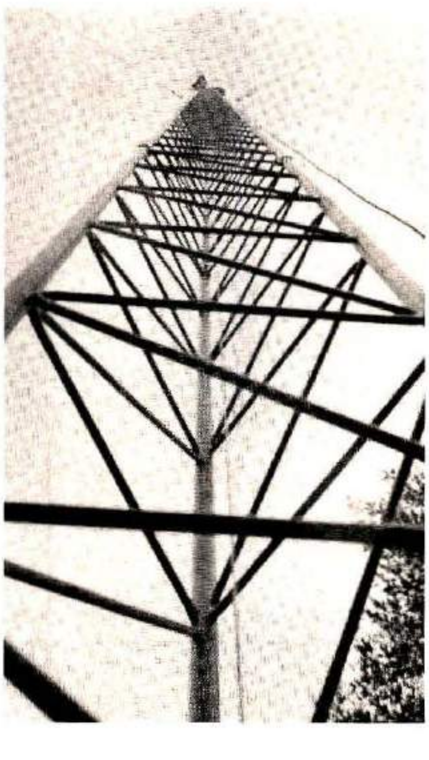


Fig. 2. A typical installation for a sectional tower. The distance from the base of the tower to the guy point should be 80 per cent of the final tower height. The top guy wire may be used to form a trolley system that will allow a large beam to be brought up in a single piece. The amount of concrete in the base is given in the manufacturers specifications.



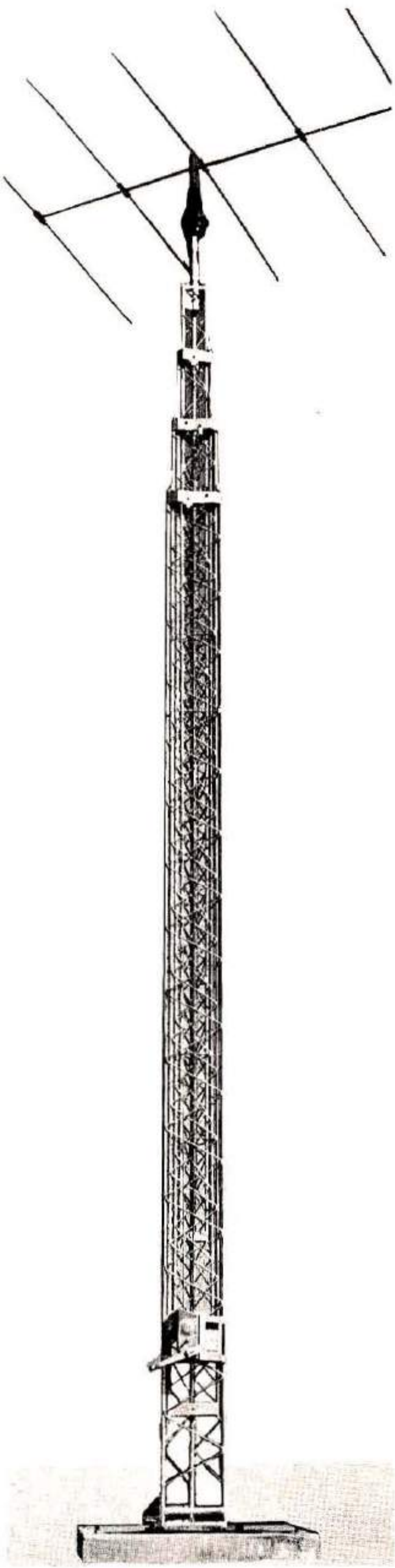
From the bottom looking up. This tower is 120 feet (37m) of Rohn 45 that is installed at the author's QTH in New Hampshire. You can see one of the guy wires being pulled up for installation.

the actual labor can be started. Most towers are supplied with instructions that dictate the type and size of base support. Generally speaking, concrete is poured around a separate base section. It's imperative that the base section be vertical and some method must be used to ensure that it has been set up correctly when the concrete is poured into the hole. With the sectional tower, the first section can be attached and then trued up. For crank-ups, it may be a long process of pouring the concrete and continually checking vertical alignment.

With a properly installed base section, most of the major work is completed for the crank-up tower. If not already done, the hoisting cable must be strung in the tower and the winch attached. At this point the tower can be attached to the base and raised to the vertical. Now a convenient support will enable the attachment of rotor, antenna, and any other hardware. Before installing the antenna, it's a good idea to run the tower up and down several times to make sure everything is working the way it should.

After the concrete at the base section has had time to properly cure, the installation of a sectional tower can begin. The general procedure calls for the people on the tower to guide the joining of the sections while those on the ground provide the heavy work. As each section is installed, the tower workers move upward and make preparations for the next section. When installing a sectional tower, the use of an erection fixture (gin pole) will speed up the process. After each section is installed, the gin pole is moved and used to bring up the next section. It's advisable to check the alignment and even join the sections on the ground. Occasionally drops of the zinc compound used for galvanizing will form on the inside of the legs; their removal will ease the installation. Another tip is to apply a little anti-seize compound on the legs prior to installation. It will not only make the legs go together easier but if extensive assembly or disassembly is anticipated, they will also come apart with little effort.

After a certain amount of tower is erected, a set of guy wires is attached. The spacing between the guys will depend upon the type of tower and installation. Generally it varies from 30 to 40 feet (9-12m) separation. Though not mentioned specifically, the installation of guy anchors is another important point. The anchors will have to bear the stress imposed by the guy wires without pulling from the ground. A typical tower will have the guy points located approximately 80 per cent of the tower's height from the base. Turnbuckles can be used to take up the slack in the guy wire, buy only after the proper tensioning has been done. It is generally thought that the turnbuckles perform the tensioning, but this is not the case. A cable grip is used to hold the guy wire in tension while the cable clamps are installed. The turnbuckle is then used to take up the slack before releasing the cable grip. As the tower is being erected the guy wires are used to make sure the tower remains perfectly vertical. After the installation has been completed and the guys have been properly tensioned, the turnbuckles should be locked in some manner to prevent them from turning and loosening up.



The typical crank-up tower, such as this one by Tri-Ex Tower Corporation, may consist of three or four telescoping sections. Your installation can be strengthened by the use of a house guying bracket for the bottom section.

Conclusion

Throughout this article I've tried to speak only in generalities. The final installation of any tower is dictated by your own requirements. Commercial towers might require the tensioning of each guy wire to 1100 pounds (500kg) and the use of three cable clamps per wire, plus serving the wire ends. However, tower cost may become prohibitive if all the commercial standards are followed; you must judge to what degree your tower will be installed. Excellent results have been obtained in amateur installations using only a portion of the commercial standards. One source of good information is the *Rohn Communications Catalog*. In addition to giving all the specifications for their towers, the book contains some very good engineering information for tower installation.

A very good tower can be obtained and installed for a reasonable price. Don't try to shorten the installation for the sake of a few dollars; use a smaller tower instead. For those unlucky few who do lose a tower in a storm, they'll find that in most cases it is covered in their homeowner's insurance policy. If not, and also for the people who have kind landlords, the additional coverage can be obtained at a very modest price. Locally, the quoted rate is about 50 cents for each 100 dollars of value; certainly a worthwhile investment. **HRH**

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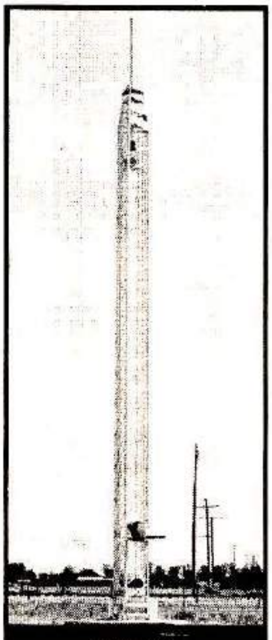

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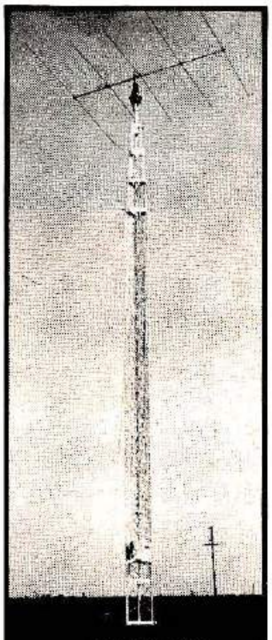

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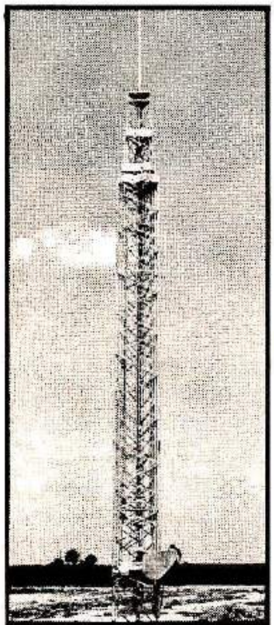

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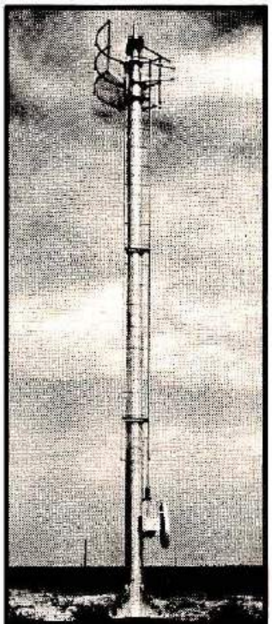
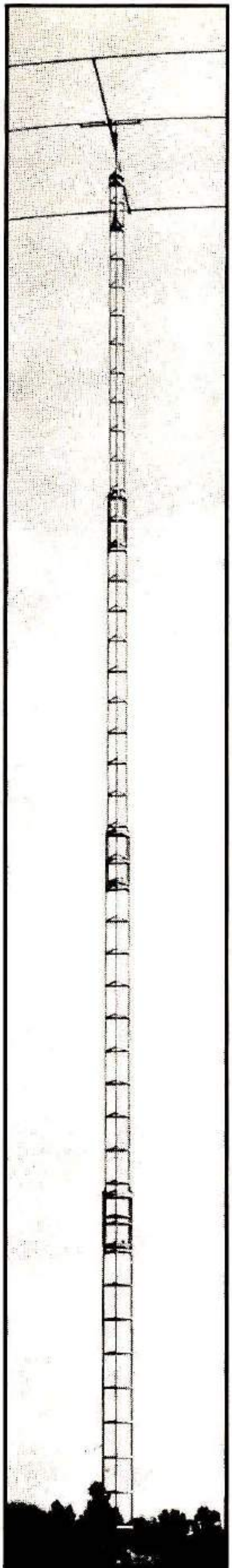


TM-370



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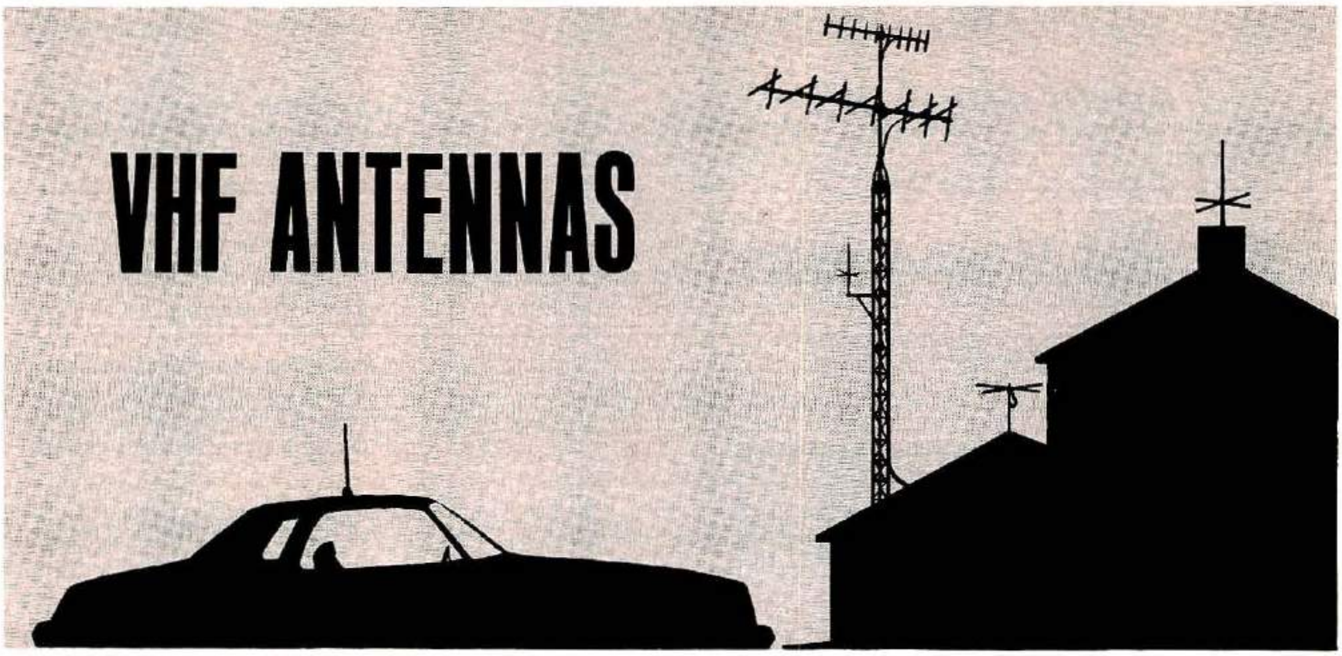
VHF ANTENNAS



BY THOMAS McMULLEN, W1SL

A look at some antennas you can use for most common modes of vhf operation

What kind of antenna do I need to talk through the Oscar satellite? What antenna works best for mobile fm? Umm . . . why do you ask — what do you have in mind? Oh, yes, now I get the picture — you are ready to go for your General or Technician exam, and you're planning ahead for a type of operating that you've never done before. Great! Good thinking.

Well, I could duck out of that question by saying that you can probably get by with what you have been using, but then you would try it and find that your 80-meter inverted-V just wasn't very good at 145 MHz. Oh, yes, it would work to a degree — sometimes.

Vhf antennas are a little bit different, but not enough so to upset any theory you have already learned. The biggest thing to keep in mind is that the losses in the whole system are greater than they were at 80 or 40 meters. And that means the *whole* system; feedline, antenna elements, and the path through the atmosphere. You can take care of the feedline problem by either keeping it as short as possible, or by using the best cable you can afford. Antenna elements should be made of low-loss metal, but unfortunately gold is just slightly more expensive than steak, so we will have to settle for aluminum, and try to keep it free of corrosion by protecting it with a spray-on coating. Yes, copper would be better, but it is heavier and still needs to be protected.

Talking through Oscar

Enough of this discussion of materials; let's look at some other important requirements, like the radiation pattern for instance. Sure, you need to know about that! Otherwise you could waste a lot of time trying to talk through the satellite when your signal was not even getting there. Take a look at **Fig. 1**. Some radiation patterns are shown there, one for a dipole that is one-quarter wavelength above a conducting screen, another for a spacing of three-eighths wavelength. I have also shown the pattern for a medium-sized beam antenna.

When the satellite comes over your horizon, at position A, you can see that it is not yet in the main part of your antenna pattern, so results would be poor. Yeah . . . the beam antenna would take care of that, but it has other problems which I'll get to in a minute. As the satellite gets closer, it starts to enter the pattern from your antenna and it becomes easier to "access" the bird, as the saying goes. That is why the dipole with a spacing of 3/8 wavelength is recommended — it has a useful response area that starts approximately 20 degrees above the horizon. Don't let that little dip between the 50-degree points bother you; by then the satellite is closer to you (at position **B**) and not as much gain (or power) is needed. The pattern for the dipole with 1/4-wavelength spacing is useful for overhead work, but is so poor toward the horizon that I wouldn't consider it. I put it in there just to show what the "incorrect" spacing can do for you. No . . . making the spacing greater than 3/8 wavelength is no good either because the pattern keeps getting a bigger dip in the middle, and finally breaks up into several pieces with even bigger holes in it.

So there you have a pattern

that is generally useful, and you can stick the antenna up on a TV mast or chimney, or even just perch it on a porch rail if you like. Of course the pattern shown was for a single dipole, and the discussion assumes a directly overhead pass of the satellite. However, you can spread the pattern out a bit and do a good job when the satellite is off to one side of you just by putting up another dipole that is at right angles to the first. This is called a turnstile antenna, **Fig. 2.** The turnstile can be mounted above a ground screen very easily (**Fig. 3**). Why do you need the screen? Well . . . it's like this: The screen establishes a definite "reflective" surface under the dipole so that the pattern can be formed by the process of reinforcement. You know — that's like when you put a mirror beside a light bulb. The light rays that would have gone off to the side are now reflected toward you, the light then seems brighter. If there were no conductive surface under the antenna, the pattern would be unpredictable. Another function of the screen is to "shield" the coaxial cable from the antenna and, at the same time, shield the antenna from noisy electrical things below it.

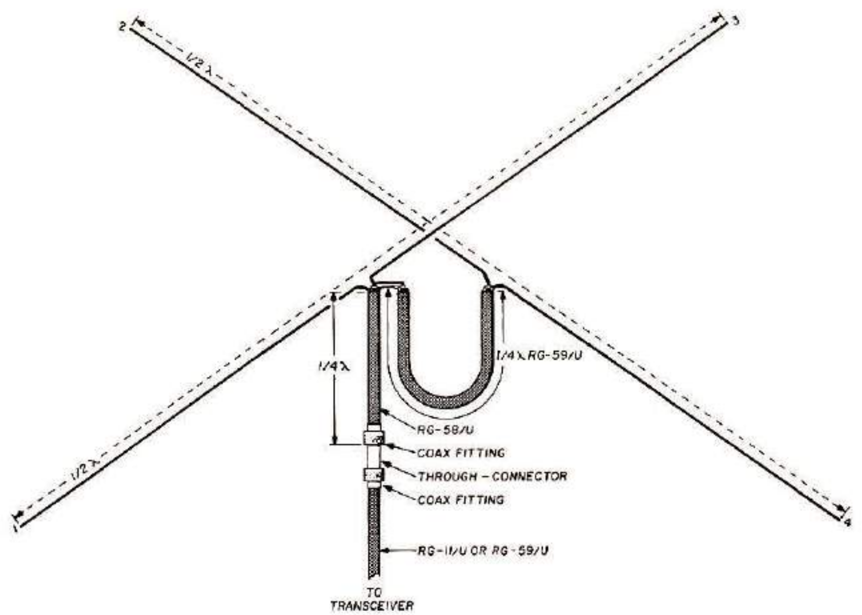


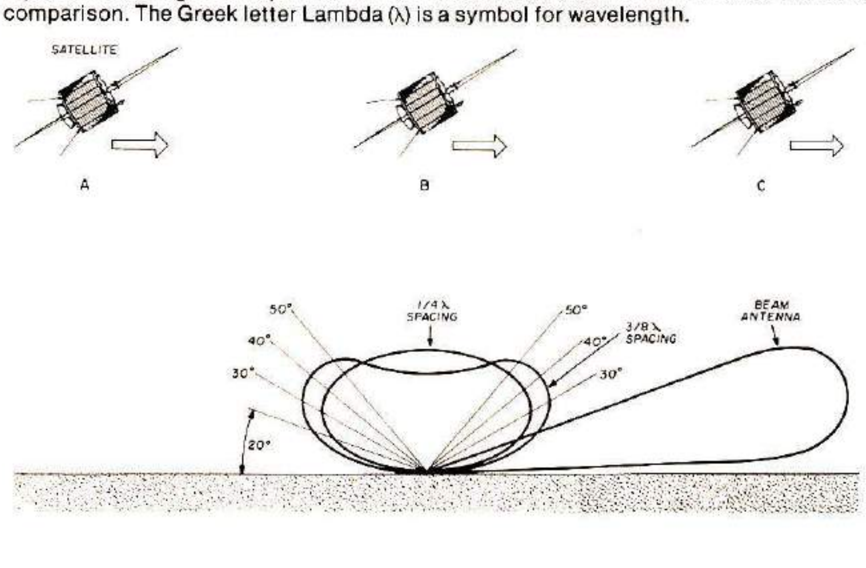
Fig. 2. A turnstile antenna can be made from pieces of brass or copper-clad welding rod for the elements, and coaxial cable for the feedline and phasing loop. When you cut the 1/4-wave sections of cable be sure to allow for the propagation (velocity) factor of the coax you are using. For most common cable, RG-8/U, RG-11/U, RG-58/U, or RG-59/U, it is approximately 0.66. For example, from **Table 1**, 1/4-wave at 146 MHz is 20.2 inches (51.3cm). Multiply this by 0.66 to obtain 13.3 inches (33.9cm), which is the length you should have between the ends of the braid for the pieces of RG-58 and RG-59.

Beam antennas

Okay — let's take a look at what a beam antenna will do for you. As you can see from the radiation pattern, it is a mighty handy thing if you want to catch the satellite at the horizon, and the gain will allow you to use lower power and still talk through Oscar. Sounds great, right? As always, there's a catch. With the antenna pattern only 30 degrees wide, and the satellite moving at a rate of approximately 2.3 degrees per minute, how long is it going to stay in front of your antenna? Right! Thirteen minutes. That means that you'll have to move the beam to keep up with the bird, and you'll have to plot the path pretty well so you know which direction to point the thing.* It could be east of you, west of you, overhead, north, all sorts of combinations are possible, both in height above the horizon (elevation) and direction around the compass (azimuth).

There's nothing wrong with having to move the antenna to chase the satellite — in fact you'll eventually probably want to do just that. However, I would recommend starting with a simple arrangement so you

Fig. 1. Radiation patterns (or signal pick-up area) for horizontal antennas above a ground plane or conducting screen. Two very useful patterns are those of an antenna at 1/4-wavelength and at 3/8-wavelength spacing. Increasing the spacing causes the pattern to break into segments with notches that would cause the signal to disappear. A pattern that might be expected from a modest-sized beam antenna is also shown for comparison. The Greek letter Lambda (λ) is a symbol for wavelength.



*An Oscar-locating aid, called the Satellabe, can be obtained from *ham radio's* Communications Bookstore for $7.95. See page 23 of the March, 1977, issue of *Ham Radio Horizons* for a photograph.

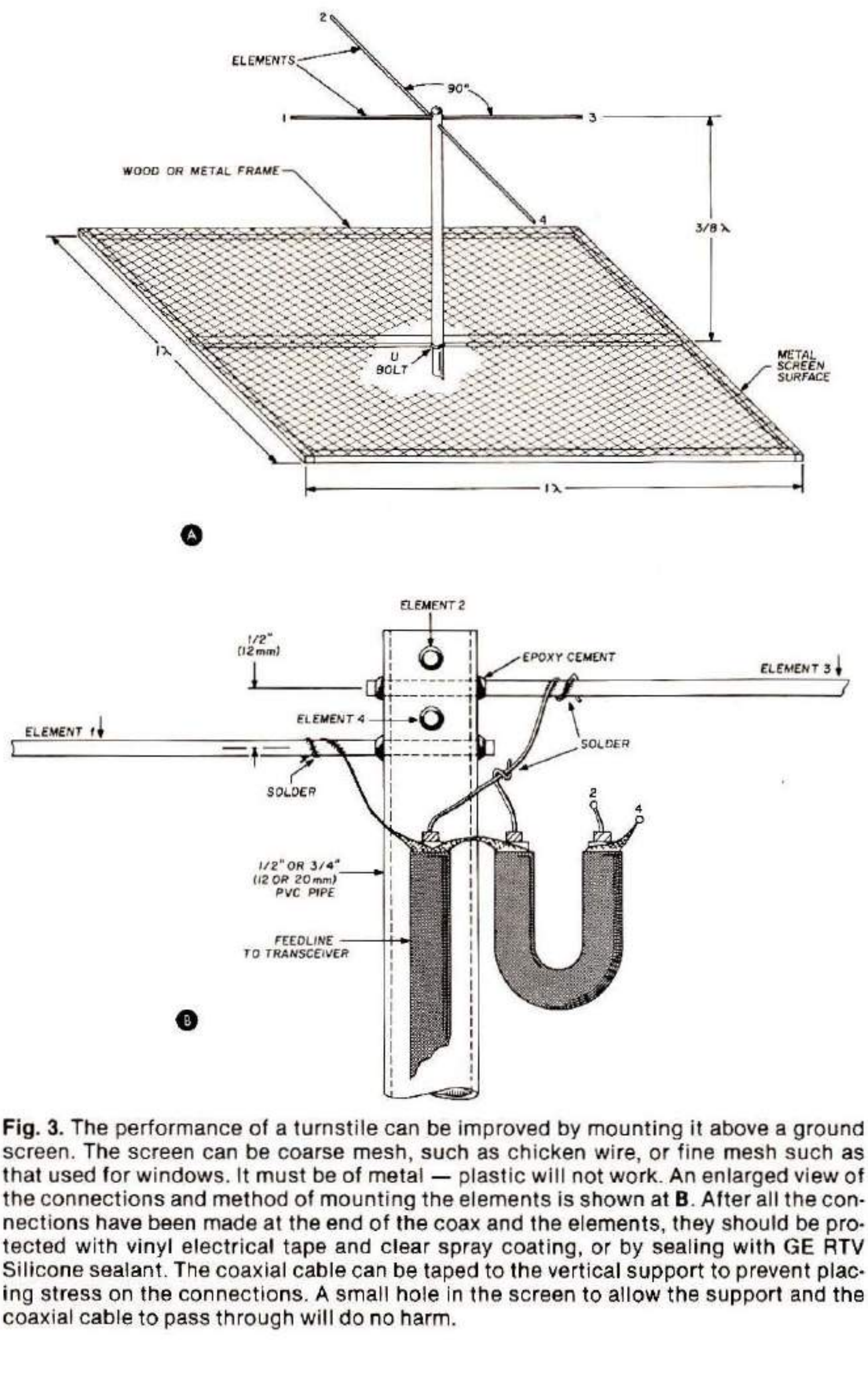


Fig. 3. The performance of a turnstile can be improved by mounting it above a ground screen. The screen can be coarse mesh, such as chicken wire, or fine mesh such as that used for windows. It must be of metal — plastic will not work. An enlarged view of the connections and method of mounting the elements is shown at **B**. After all the connections have been made at the end of the coax and the elements, they should be protected with vinyl electrical tape and clear spray coating, or by sealing with GE RTV Silicone sealant. The coaxial cable can be taped to the vertical support to prevent placing stress on the connections. A small hole in the screen to allow the support and the coaxial cable to pass through will do no harm.

can devote plenty of time to operating and get the hang of it. After you have your timing and procedure all smoothed out, then you can start thinking about a beam to reach really out to the horizon and work the more distant stations.

Beam antennas come in varied sizes and shapes and with gain figures that range from just a couple of dB up to 18 or 20 or more, depending upon how hard you are willing to work at it. The penalty that you pay for higher gain is that the radiation pattern is narrower, and it does not take too long to reach the point where it is so narrow that you cannot keep the antenna pointed at the satellite. A good compromise is an antenna with a gain of approximately 10 dB. It is large enough to make up for some transmission-line loss and allow the use of comparatively low power, but at the same time it is physically easy to handle and install. **Figs. 4** and **5** show an example of what might be typical construction for this type of Yagi antenna. It can be made from parts of an old TV antenna, or from aluminum tubing or wire that can be obtained at your local hardware store.

There are many ways to mount an antenna of this type, and I could not begin to talk about all of them here. A garden-variety TV rotator will handle it with ease, and if you fasten it to the vertical support so that it faces upward at approximately 30 degrees, it will cover the majority of satellite passes for you (**Fig. 6**). If you really want to go all the way, you can use two rotators, one to rotate the antenna horizontally, the other to tip it from the horizon to straight up. Of course, this more flexible system will require two rotator controls, and at least two hands to keep it going in the shack, so better count the number of hands you have before installing such a system.

No, I haven't forgotten your nice new mobile fm rig. I was just about to get to them. Right now it is a toss-up as to just where the most activity is — satellites or repeaters. They are both wonderful areas to explore, so let me tell you about a few antennas you can think over for fm use.

FM antennas

Very simple antennas can be used with your mobile or portable fm transceiver, and a very common type usually turns out to be a 1/4-wave whip. It can be mounted on a car-top or trunk lid, and is often seen sticking out of the top of the various portable units, both hand-held and shoulder-strap types. As a quick and easy antenna to make, it is hard to beat. It will work with common 50-ohm transmission line without a need for a matching transformer; it can be made from almost any chunk of wire that is of the right length; and the radiation pattern is not all that bad (see **Fig. 7A**).

Ideally, this type of radiator should have a ground-plane to help it, for the same reasons that one was so helpful to the dipoles and the turnstile I just told you about. In fact, a quarter-wave vertical radiator, with either radial rods or a screen located at its base, is called a *ground plane antenna*.

There is one minor hitch, however: In amateur work most antennas have gain figures that are referenced to a half-wave dipole. Since the 1/4-wave antenna is smaller than a 1/2-wave one, then it follows that the gain will be less for the smaller antenna. This is an important point to remember when you look at all the gain-claim figures in the advertisements — no one has yet found a way to put 5 pounds of gain in a 1-pound bag! Always try to find out what the reference is when comparing performance claims.

Yes, half-wave antennas can be used above a ground plane too, with the application of a little trickery to keep the coaxial cable happy. Y'see, the impedance at the end of a half-wave radiator is very high, thousands of ohms,* and if you just connected it directly to the end of a piece of 50- or 75-ohm coax, most of your signal would spend its life bouncing back and forth along the cable, looking for a way out. So you have to place a matching network at the end of the antenna, between it and the coax. The term "matching network" is just engineer-type talk for a circuit that acts as a transformer — it helps two widely different impedances get along together. In the case of our half-wave antenna and coax, it can be just an ordinary coil made up of the appropriate number of turns of wire, or it can be a tuned circuit with both the coax and the antenna attached at the proper points (**Fig. 8**).

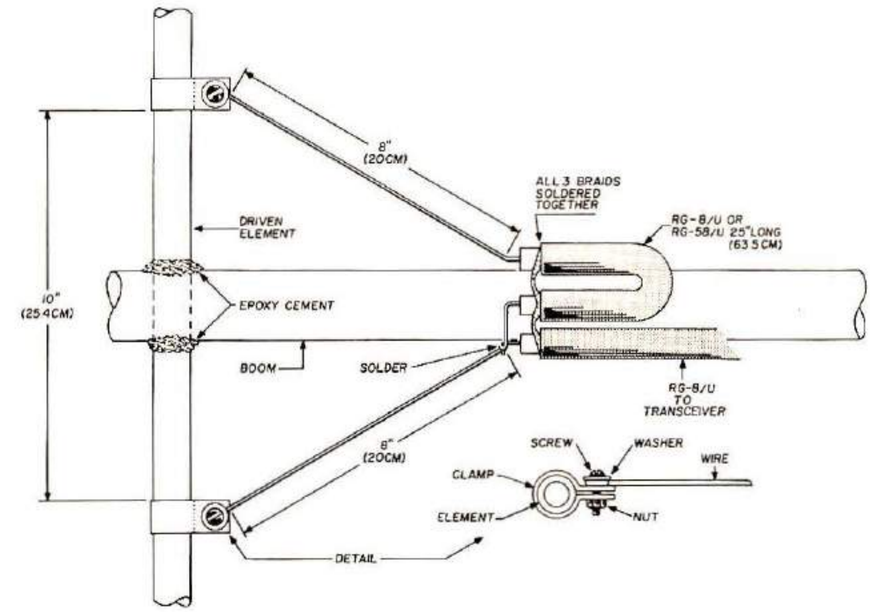
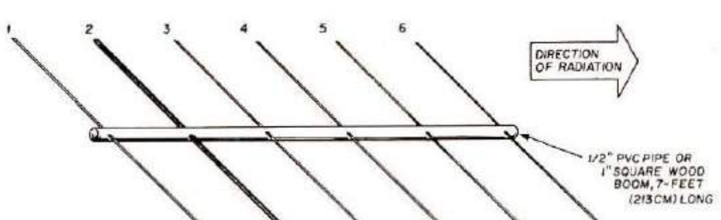


Fig. 5. One method of feeding the driven element of a Yagi antenna is called a "delta" match. A 1/2-wave phasing section made of coaxial cable performs the function of changing the unbalanced transmission-line feed into a balanced feed for the antenna element. The dimensions given are approximate, and should not be critical. If you feel that you need to adjust the feed points for minimum reflected energy, always slide both clamps an equal amount, toward or away from the boom, in small steps — 1/8-inch or so. Do not stand near the antenna or place hands near it when taking a reading on an swr meter. The best position for the antenna when making adjustments is pointing straight up, perhaps on top of a wooden stepladder or a similar non-metallic support. The coaxial cable can be taped to the boom, to hold it in place, and the exposed connections should be covered with electrical tape or with GE RTV Silicone sealant. A clear plastic spray to protect the clamps and that portion of the driven element is a good idea.



ELEMENT		1	2	3	4	5	6
LENGTH	INCHES (CM)	40 (101.6)	37 3/4 (95.9)	36 3/4 (93.3)	36 1/2 (92.7)	36 1/4 (92.1)	36 (91.4)
SPACING FROM ELEMENT 1	INCHES (CM)		16 (41)	27 (68)	43 (109)	63 (160)	83 (211)

Fig. 4. A simple Yagi antenna that will provide improved signals either through the Oscar satellites or for medium-distance contacts at ground level. The construction can be very simple — drill holes that are a snug fit for the elements and epoxy cement them in place. The elements can be stiff aluminum rod or small-diameter tubing. The driven element can be 3/8-inch (95mm) diameter tubing. Elements should be 1/8- to 1/4-inch (30 to 60mm) diameter. Element 1 is called a reflector, element 2 is the driven element; 3, 4, 5, and 6 are directors.

*Impedance, in simple terms, is that quality of a circuit or components that impedes the flow of alternating current. Resistance is its counterpart for dc voltage and current. Because ac current and voltage have a phase (time) relationship with each other, simple resistance theory is not accurate enough for engineering purposes. Impedance theory takes all of the ac factors into account; for the very basic antenna theory that we are discussing here, you can think of impedance as similar to resistance.

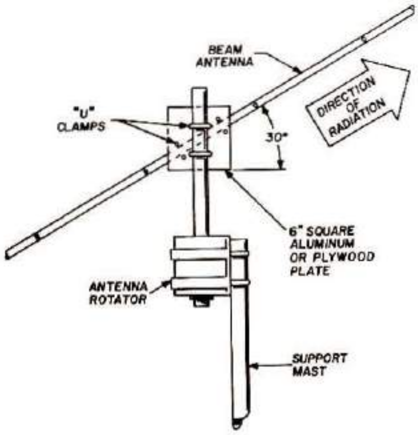


Fig. 6. A simple method of using a Yagi antenna for satellite work is to mount it tilted upward at approximately 30 degrees. This will be effective except when the satellite is directly overhead, but that "zone of silence" will not last long.

Now all of this is fine — your half-wave will have a bit more gain than a quarter-wave, and you can match it to the coax in good shape. But, let's take it just a bit further: Make the antenna approximately 5/8-wavelength long. Now, the impedance at the bottom end of it starts to decrease again, and the matching network has less of a chore to perform. It can still be of the same type, either a coil or a tuned circuit, but it has to act as a peacemaker between 50 and 300 ohms, instead of between 50 and 2000. That is not the only benefit either — since it is slightly larger, the 5/8-wave whip has just a teeny bit more gain than a half-wave, and it is quite a noticeable improvement over quarter-wave. A look at **Fig. 7B** will show another characteristic that is most helpful: The angle of radiation is low, which places your signal down where you want it (unless you like to talk to birds or an occasional aircraft).

So, for mobile use, those are the most common, and easy to make, types of antennas. Yes, there are several antennas marketed that have more elements to them, with neat little plastic sections between, and all that. These antennas have more gain than what I just discussed, but as a beginner on fm you can get excellent results with the more simple units.

Fixed station antennas

Many times you will hear the term "base station" when people are talking about fm and repeaters. This is just a left-over term from the days of commercial two-way radio, when there were two types of units sold on the surplus market: mobile stations and base stations. With a few exceptions, when an Amateur or CBer speaks of a base station, he really is referring to a home-station as compared to the one in his car.

Antennas for fixed-station use can be almost exactly the same as those used for working through satellites, and in fact, many Amateurs do use the same installation for double

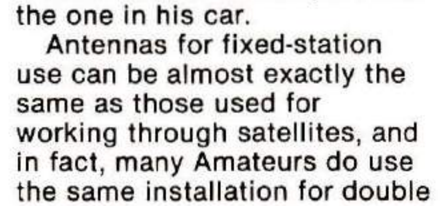


Fig. 8. The matching coil for the bottom of a 5/8-wave radiator can be made of wire, mounted inside a few plastic pipe fittings. In the original description of making this type of device, K6KLO used a telescoping whip as the radiating element. Best results were obtained with the whip extended approximately 48 inches. A variety of fittings can be used at the bottom to make connection to the coil, depending upon the need of the builder. From *ham radio*, July, 1974, pages 40-43.

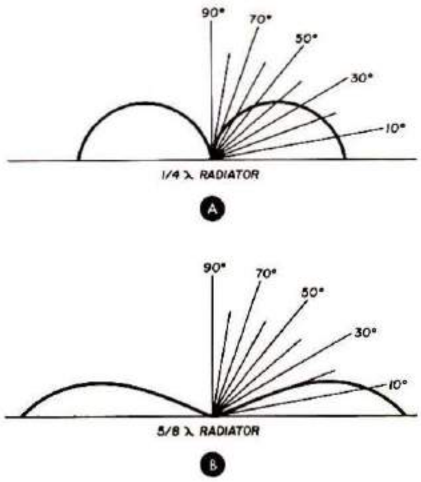


Fig. 7. Radiation patterns for vertical antennas mounted above a ground plane such as a metal screen or a flat portion of a car body. The 1/4-wave whip radiates a large part of its energy upward at angles that do little good. The 5/8-wave antenna brings some of that energy down to add to that at low angles, making it more useful at vhf work.

duty. A good Yagi beam will enable you to reach out over the horizon to talk to another fm station, or even to work ssb or CW, if you are lucky enough to own one of the new all-mode transceivers that are now available. (Your antenna doesn't know the difference between a-m, fm, ssb, or CW; it just passes the signal along.) The only caution I'll give you is to be aware of the polarization differences between the various types of stations, and plan accordingly. Most fm stations, mobile or repeaters, use vertical polarization of their antennas. This is mainly because the vertical whip is much easier to handle in a mobile environment, is essentially non-directional, and is not too bad looking (some of the old horizontal attempts at an all-direction mobile antenna were sure attention getters)! Many amateurs solve the polarization problem by using a pair of Yagis — well, it is actually one supporting boom with two sets of elements attached, one vertically and another horizontally. Thus they can select the polarization that they need at the moment by means of a relay, or by doing some fancy stuff with the coax cable they can feed both at once.

For those of you who would like to stack two Yagis side-by-side, with the elements vertical — yes, that is done too. You do it the same way you would if the elements were horizontal, but just remember to keep the supporting mast near the elements non-metallic. Any nearby metal in the same plane as the elements will distort the pattern and decrease the gain. **Fig. 9** shows one way of making such an array.

While I am talking about stacking antennas let me point out that there is an easy way to estimate the gain improvement when you stack identical antennas: Each time you double the size of the array you increase the gain by 3 dB, theoretically. I add that modifier because there is a small amount of power lost through the feedline harness that you need to combine the two antennas, and the spacing between them must be just right, too. A good rule of thumb is that the spacing should be 1/2 wavelength, or half the boom length, whichever is greater.

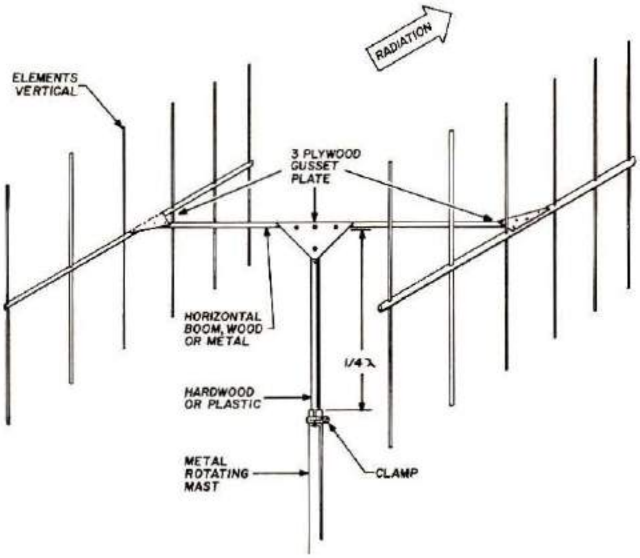


Fig. 9. The use of Yagi antennas to help in working distant fm stations requires that the elements be in a vertical plane. A vertical support, if of metal, would distort the antenna pattern and decrease the effectiveness of the array. You can make the top 1/4 wavelength of the support of hardwood (treated for weather-proofing) or of tough plastic, and avoid the distortion problem. If two Yagis like that shown in **Fig. 4** are used, they should be spaced 42 inches (106cm) apart.

I have been talking mostly about antennas for the 144-MHz band, but everything I've said pertains to all the vhf bands as well. For those of you who would like to experiment with antennas, **Table 1** provides a list of some important dimensions you can use. There are many excellent antenna books and manuals available (see **Bibliography**), and there is a certain amount of satisfaction in being able to turn a few pieces of wire and tubing into something that will help your signal get way, way, out.

For those of you who are not

Table 1. Some useful dimensions for vhf antennas and transmission lines.

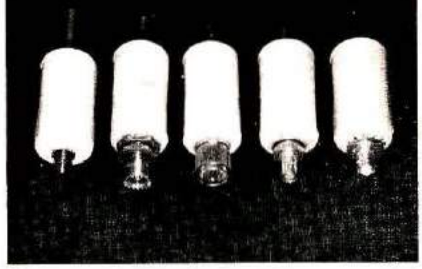
	50 MHz		146 MHz		222 MHz		432 MHz	
Frequency	Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)
1 wavelength [1]	236.2	(600)	80.8	(205.2)	53.2	(135.1)	27.3	(69.4)
5/8 wavelength	147.6	(375)	50.5	(128.4)	33.2	(84.4)	17.1	(43.4)
1/2 wavelength	118.1	(300)	40.4	(102.7)	26.6	(67.5)	13.7	(34.7)
3/8 wavelength	88.6	(225)	30.3	(77.0)	19.9	(50.6)	10.2	(26.0)
1/4 wavelength	59.0	(150)	20.2	(51.3)	13.3	(33.7)	6.8	(17.3)
1/2 wavelength coax [2]	77.9	(198)	26.6	(67.7)	17.5	(44.6)	9.0	(22.9)
1/4 wavelength coax [2]	38.9	(99)	13.3	(33.8)	8.7	(22.1)	4.5	(11.4)
1/2 wavelength twinlead [3]	96.8	(246)	33.1	(84.1)	21.8	(55.4)	11.2	(28.4)
1/4 wavelength twinlead [3]	48.3	(123)	16.5	(40.0)	10.9	(27.7)	5.6	(14.2)
Per cent change each MHz [4]	2		0.6		0.45		0.25	

Notes: (1) Dimensions are based on the wavelength-in-air formula 11810/F(MHz).

(2) Coaxial-cable lengths are based on the velocity factor of RG-8/U or RG-58/U, which is approximately 0.66.

(3) Twinlead lengths are based on the velocity factor of 0.82 for common TV lead-in of parallel wires with flat, solid-dielectric insulation.

(4) The dimensions given are for frequencies in the most-often used part of the bands. The dimensions *increase* as you go lower, and *decrease* as you go higher in frequency. Example: If you want to work at 51 MHz, decrease the dimensions given by 2 per cent; for 145 MHz, increase the dimensions by 0.6 per cent.



Five types of fitting for the bottom of the assembly are shown here. At the left is one with a threaded stud, for mounting on an insulating base. Next is a UHF female fitting, a UHF male, then two types of BNC connector. In the threaded-stud type, the bottom of the coil connects to the stud, and the center conductor of the coaxial feedline should fasten to this same stud after it has been passed through the insulating mount. In all of the coaxial-fitting type of mounts, the coil connects to the center conductor inside the assembly, and the coaxial feedline connects in the normal manner through its fitting. See **Fig. 8**.

inclined, or don't have the time, to experiment and build your own, I hope the discussion and drawings will give you some ideas of what to shop for to get the performance you want at your station for Oscar, repeaters, mobile, or DX work.

Now, go get that General or Technican class license and join the fun!

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2. W. Orr, *Beam Antenna Handbook*, 5th edition, 1976, Radio Publications, Wilton, Connecticut. Available from *ham radio's* Communications Bookstore, order RP-BA, $4.95.

3. *The ARRL Antenna Book*, 13th edition, 1974, American Radio Relay League, Newington, Connecticut 06111. Available from *ham radio's* Communications Bookstore, order AR-AM, $4.00.

HRH

More details? Ad Check page 78.

THE G5RV

an all-purpose antenna

BY JIM GRAY, W2EUQ

No antenna is really all-purpose or all-band, but this one comes close

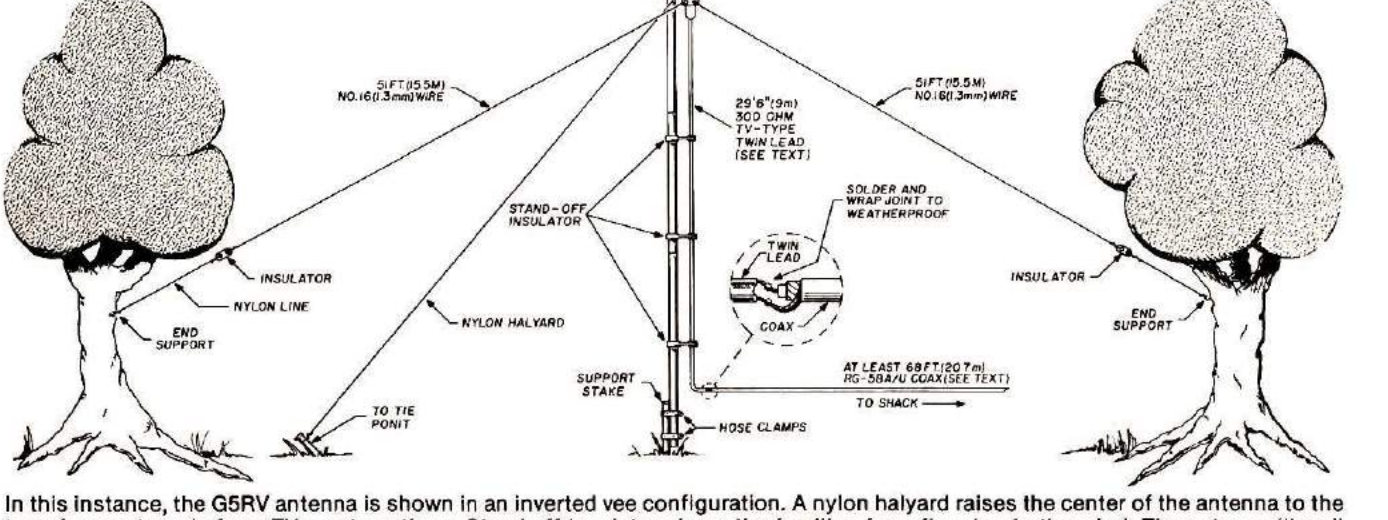
G5RV is the Amateur Radio callsign of R. L. Varney, of Sussex, England. He is credited with having developed and used the antenna that bears his call, although an earlier antenna shown in Collins Radio manuals of the 1930s appears at least similar. It is probably true that the specific antenna known as the G5RV did, however, originate with Mr. Varney — to the delight of Amateur Radio operators everywhere.

The G5RV antenna looks very much like a center-fed Zepp antenna with a flat-top portion and an open-wire feeder portion connected at the center of the flat top. The G5RV, however, lends itself nicely to installation in the popular inverted-vee configuration or, if you have the necessary supports, in the standard dipole or doublet configuration. In any case, the antenna is very simple and unobtrusive — as antennas go.

Dimensions

The flat top can be made from copper antenna wire of no. 14 (1.6 mm) or larger size. The overall length is 102 feet (31.1m) with each leg being half of that. At the center of the flat top, place an insulator or center connector that isolates the two legs of the antenna from each other. Connect an open-wire feedline 35 feet (10.7m) in length at that point, with one wire attached to one leg of the antenna, and the other wire attached to the other leg. If you do not happen to have an open-wire feedline, although it is easy enough to make, just use a length of TV-type, solid dielectric, 300-ohm "twin lead." If you choose the twin lead, use a length of 29.5 feet (9m), a difference in length that takes into consideration the difference between the velocity of propagation of a radio signal along a two-wire "open" line spaced with air dielectric or along a two-wire line spaced with plastic dielectric material.

At the transmitter end of the two-wire feeder, attach a length of 50-ohm coaxial cable, such as RG-58A/U, for example. The center conductor connects to one wire and the shield to the other. If you plan to use a transmitter output power in excess of about two hundred watts, then use the heavier RG-8/U cable. The length of the cable should be at least



In this instance, the G5RV antenna is shown in an inverted vee configuration. A nylon halyard raises the center of the antenna to the top of a mast made from TV mast sections. Stand-off insulators keep the feedline from flapping in the wind. The antenna "legs" serve as guy wires, while the halyard acts as additional support.

68 feet (20.7m), but may be longer if necessary. Attach a PL-259 coaxial connector at the transmitter end of the coax. Solder all connections carefully and weatherproof them by wrapping them with vinyl tape and coating the wrapped portion with silicone caulking material.

Installation

In my own installation, I used several joined sections of TV-type mast tubing as a single support, and hoisted the center of the antenna to the top of the mast with a nylon halyard led through a pulley placed at the top of the mast. I supported the ends of the antenna at a much lower height by tying the end insulators to short lengths of small-diameter nylon line which were attached to the trunks of nearby trees. If I had been blessed with two tall supports, suitably far apart, then the antenna would have been put up as a flat top instead of an inverted vee. In your case, choose the one that is most convenient, or the one you like best. If the inverted-vee configuration is used, the antenna itself acts as two of the guy wires for supporting the mast.

You will find, as I did, that it is desirable to keep the feedline at least several inches (≈10 cm) away from a metal mast or pole. TV-type standoff insulators are good for this. On the other hand, in a flat-top configuration, there is usually no center support, so you don't have to worry; just let the feedline fall vertically away from the antenna at a right angle. As with any antenna, the feedline is preferably led away from the antenna at 90°, and should not lie underneath either of the antenna's legs.

Operation

The first band I tried was 80 meters, and results were fully as good as with my standard 80-meter inverted vee. In fact, I couldn't tell any difference when I switched back and forth. On 40 meters, results were somewhat better than with the trap vertical I had been using, even at long distances, probably due to the lack of a really good ground plane for the vertical. In any case I was pleased. The G5RV really performed well on the 10- 15- and 20-meter bands, and was markedly superior to the vertical at medium distances, although noticeably directional. The apparent pattern at these higher frequencies is a large X whose "legs" form an angle with the wire.

In no instance did I use a tuner or any other matching device until, one day, I became curious about vswr. I put my swr bridge in the line and was horrified to find the vswr over 3:1 on certain frequencies. Up until then the transmitter — and even the stations I worked — didn't seem to know or care what the swr was. Thereafter, I used my line matcher to make the transmitter "see" the magic, non-reactive 50-ohm termination, but you know what? The matcher didn't make a bit of difference! As long as the transmitter tunes and loads to its rated plate current without difficulty, then it is happy. With the G5RV antenna, your transmitter will tune and load well, even if you don't use a tuner or matcher.

Comments

No antenna is supposed to do everything well, and this one is no exception. It does, however, represent a nice compromise between cost, space, and performance as attested to by numerous stations around the world who say: *ANT HR OM G5RV*. The real advantage of this simple, low-cost antenna lies in the fact that you can use it on all bands, CW and phone, from 3.5 MHz to 29.7 MHz, without a tuner! **HRH**

CQ FIELD DAY
CQ FIELD DAY
CQ FIELD DAY
CQ FIELD DAY
CQ FIELD DAY

BY MARK PRIDE, WA1ABV/K1RX AND CHARLES CARROLL, K1XX

A brief look at Field Day; what you can do to participate in the many different facets of this summertime fun

CQ Field Day, CQ Field Day. With these words begins one of the most memorable operating events for many an Amateur. Whether young or old, beginner or experienced operator, the "June madness" strikes almost everyone, sooner or later. With all the plans and equipment prepared months, or maybe just days, ago, hundreds of groups literally "head for the hills." The main watchword is preparation, not only for the equipment but for the operators, too. Bugs, floods, and even hayfever are but a few of the many interesting obstacles encountered during that fateful weekend in June. Many people moan "never again," but, like the seven-year itch, they'll be back.

Officially it's called Field Day. Others call it a training exercise, contest, or even a picnic. But, essentially it's plain fun. Where else can you find the elder statesman of your ham club climbing a tree or cooking hamburgers? Field Day is one type of club activity that brings everyone together, and no one has to be left out. Kids can run through the fields and wives can sit and talk, or knit, or sunbathe, while the operators struggle for the right band and a good score. From the large 15-transmitter set-ups to the 5-watt battery-operated rigs, there's a place for everyone on Field Day.

Why Field day?

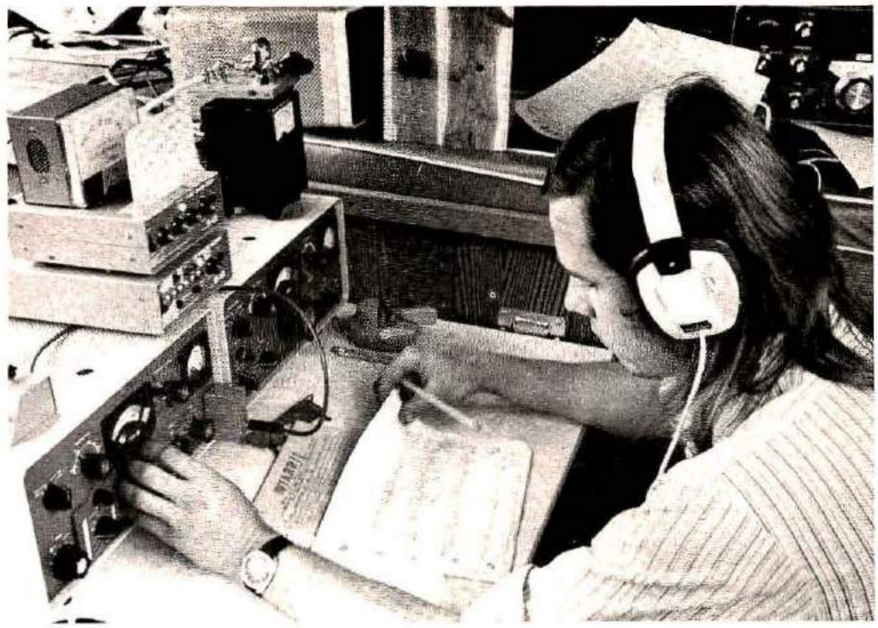
The word *service* plays a key role in the existence of Amateur Radio. Our short history is filled with service-oriented events that have served to strengthen the Amateurs' importance to the community. What better way to fulfill this aspect of the hobby than by participating in the

ARRL Field Day? It's a terrific opportunity to meet old or new friends and work together for a common cause.

The basic intent of Field Day is to give groups a chance to participate in a test of their emergency preparedness. How fast can your radio club organize communications in the field? Certainly, in an actual emergency, the problems would be difficult to overcome. The experience gained through these "simulated" conditions could prove invaluable whenever community hardships arise. This is an excellent time to demonstrate to the public how important the Radio Amateur is, and the ARRL encourages public relations work by rewarding the clubs with bonus points for making the public aware of what's happening. Newspaper, or even television, coverage is very desirable in that the publicity will enhance the Amateurs' image and at the same time attract new members to your club. Some Field Day operations are large, with many participating members, and others are small, but the educational value is the same. Each person comes away with a bit more insight into the idea of improving one's communications capability. The trick is to have the most "on-the-air" effectiveness, without your equipment being overly complicated.

Rules and regulations

As with all operating events or contests, there are several different categories for the participants. Even people who must remain at home are included; they can participate in class D competition. Field Day starts the fourth Saturday in June, and continues for a period of 27 hours. Normal operation is for any consecutive 24-hour period during the 27 total hours. Those groups that do not start setting up their equipment until the beginning of the event are eligible to operate for the entire



The 40-meter CW position has most of the comforts of home in a camper. An electronic keyer with a programmable memory aids WB2DRW while he checks for duplicate contacts.

With the new multiplier for exotic power sources come many different ideas. A typical hillside location not only provides a good antenna location but also an unlimited supply of wind for this generator.

Operating and logging duties on 40-meter ssb are shared by WA1JZC and WA1ABV. Headphones are important to have during the event, especially if other stations are nearby.

27-hour period. This provides a little more emphasis on the fast action that would be typical of an emergency situation.

Some skill and experience is required to select the right transmitter class. With choices ranging from one to fifteen or more transmitters, you're limited only by the resources that you have at hand. Some of the most interesting competition takes place in the one, two, and three transmitter classes. Although the behemoth 15-transmitter operations may seem like overdoing things, just the logistics of handling that many stations make it difficult. Set your own goals and then pick the right transmitter class for your type of competition.

A new factor has been entered into the Field Day rules: Normal scoring now includes 2 points for each CW contact made. You'll have to decide when to stop the 150 word-per-minute ssb QSOs and start the 2-point CW contacts. Otherwise, scoring is straightforward: One point for the ssb contacts and two points for CW contacts. A power multiplier is included, allowing you to take advantage of unique power sources (see **Table 1**).

Table 1. Field Day scoring and basic transmitter classes.

Class

- **A.** Three or more using power independent from the commercial sources.
- **B.** No more than two people in a group. Otherwise operated as Class **A.**
- **C.** Stations normally installed in motor vehicles, including antennas.
- **D.** A normal home station operating from commercial mains.
- **E.** A home station operated from emergency power.

Power Multiplier

Less than 200 watts per transmitter.	*x2*
200 to 1000 watts per transmitter.	*x1*

Power Source Multiplier

Less than 10 watts and all power provided by other than commercial or motor-generator sources.	*x5*

All ssb contacts count for 1 point and each CW contact counts for 2 points.

henry radio a name that says it all

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ICOM's new fully synthesized 4 MHz FM, USB, LSB, CW 2 meter transceiver. 100 Hz or 5 KHz steps, with dual tracking, optically coupled VFO's displayed by seven-segment LED readouts. Features new styling, new versatility and a new approach to the integration of functions. A compact "do everything" radio for 2-meters. The IC-211 . . . . $749.00

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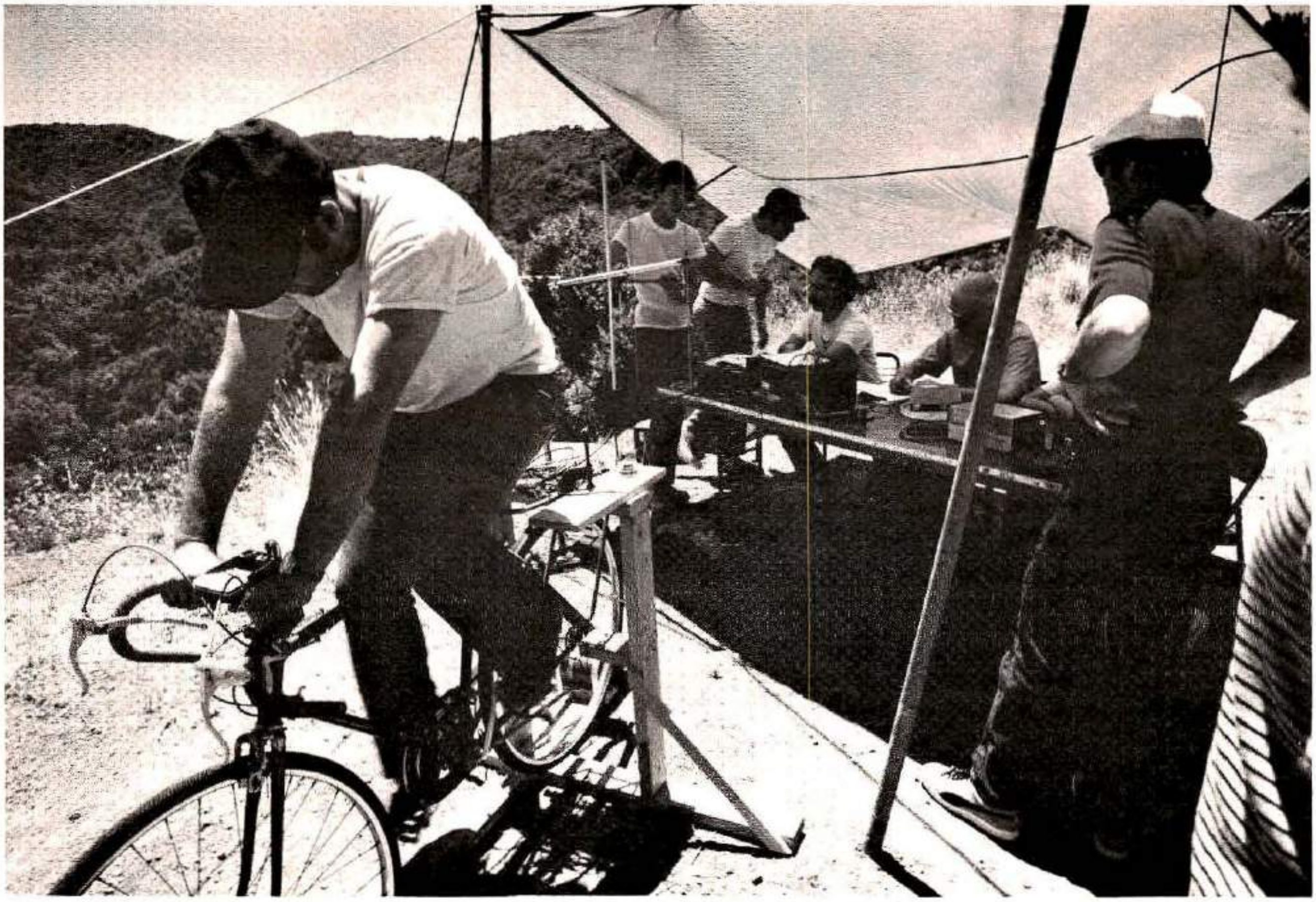
More details? Ad Check page 78.



Instead of watching the speedometer, it's now a voltmeter. This Field Day group is using a bicycle powered generator to run their equipment.

The subject of bonus points was briefly mentioned. Unusual and difficult modes of operation benefit by receiving bonus points. Any contacts made through Oscar satellites are duly rewarded. As many people know, working through Oscar can be a challenge at home, and even more so on the side or top of a mountain. Public relations effort is also justly rewarded with points for any mention of your exercise by the newspapers, TV, or radio. Finally we come to the main purpose of Field Day: Relaying messages. Though it cuts down the number of contacts, you can make extra points by taking the time to relay messages. A complete set of rules is normally published in *QST* prior to Field Day.

Field Day is really a multi-faceted training exercise, and an excellent time to sharpen your own operating skills or pick up some tips from the more experienced operators. Among the crowd, there's always at least one experienced operator from whom new operating tricks or techniques can be learned. If you have never attempted a contest before, prepare for a fun education. Listen to the way an operator attracts new contacts or searches for others calling CQ Field Day. He'll make the exchanges quickly and accurately. This point is of prime concern, especially since it could be emergency traffic the next time. By studying the technique of a well-seasoned contest operator, you too can master the rules of the game.

Newcomers as well as old timers learn and have fun working together. You might even have a chance to try that new transceiver you've seen advertised. Also, you can acquire many new ideas for antennas, carrying them home to be tried in your own backyard. Seemingly, the experimenter in all of us comes to the surface. Every combination, from beam to rhombic, is tried, with each operator always hoping to be louder than the next guy on 40 meters. However, many old-time Field Day enthusiasts agree that the simplest techniques often work the best. Any time new equipment and unproven antennas are combined, there are bound to be problems. Hence the justification for Field Day: Learning what works together and what doesn't.

Most clubs divide their membership into committees

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Automatic search lets you scan any given range of frequencies of your choice within a band. Push-button lockout permits you to selectively skip frequencies not of current interest. The decimal display with its exclusive "rolling zeros" tells you which channels you're monitoring. When the *Bearcat* 210 locks in on an active frequency the decimal display shows the channel and frequency being monitored.

With the patented track-tuning system, the Bearcat 210 automatically aligns itself so that circuits are always "peaked" for any broadcast. Most competitive models peak only at the center of each band, missing the frequencies at the extreme ends of the band.

The Bearcat 210's electronically switched antenna eliminates the need for the long low band antenna. And a quartz crystal filter rejects adjacent stations as well as noise interference.

Call toll-free 800-521-4414 now to place a BankAmericard or Master-charge order. This is our 24 hour phone to our order department and only orders may be processed on this line. To order in Michigan or outside of the U.S. dial 313-994-4441.

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Bearcat® 210 Features

- **Crystal-less**—Without ever buying a crystal you can select from all local frequencies by simply pushing a few buttons.
- **Decimal Display**—See frequency and channel number—no guessing who's on the air
- **5-Band Coverage**—Includes Low, High, UHF and UHF "T" public service bands, the 2-meter amateur (Ham) band, plus other UHF frequencies.
- **Deluxe Keyboard**—Makes frequency selection as easy as using a push-button phone. Lets you enter and change frequencies easily . . . try everything there is to hear.
- **Patented Track Tuning**—Receive frequencies across the full band without adjustment. Circuitry is automatically aligned to each frequency monitored.
- **Automatic Search**—Seek and find new, exciting frequencies.
- **Selective Scan Delay**—Adds a two second delay to prevent missing transmissions when "calls" and "answers" are on the same frequency.
- **Automatic Lock-Out**—Locks out channels and "skips" frequencies not of current interest.
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- **Space Age Circuitry**—Custom integrated circuits . . . a *Bearcat* tradition.
- **UL Listed/FCC Certified**—Assures quality design and manufacture.
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- **Tone By-Pass**—Scanning is not interrupted by mobile telephone tone signal.
- **Manual Scan Control**—Scan all 10 channels at your own pace.
- **3-Inch Speaker**—Front mounted speaker for more sound with less distortion.
- **Squelch**—Allows user to effectively block out unwanted noise.
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Bearcat® 210 Specifications

Frequency Reception Range

Low Band	32—50 MHz
"Ham" Band	146—148 MHz
High Band	148—174 MHz
UHF Band	450—470 MHz
"T" Band	470—512 MHz

*Also receives UHF from 416—450 MHz

Size
10⅝" W x 3" H x 7⅝" D

Weight
4 lbs. 8 oz.

Power Requirements
117V ac, 11W; 13.8 Vdc, 6W

Audio Output
2W rms

Antenna
Telescoping (supplied)

Sensitivity
0.6μv for 12 dB SINAD on L & H bands
U bands slightly less

Selectivity
Better than −60 dB @ ± 25 KHz

Scan Rate
20 channels per second

Connectors
External antenna and speaker; AC & DC power

Accessories
Mounting bracket and hardware
DC cord

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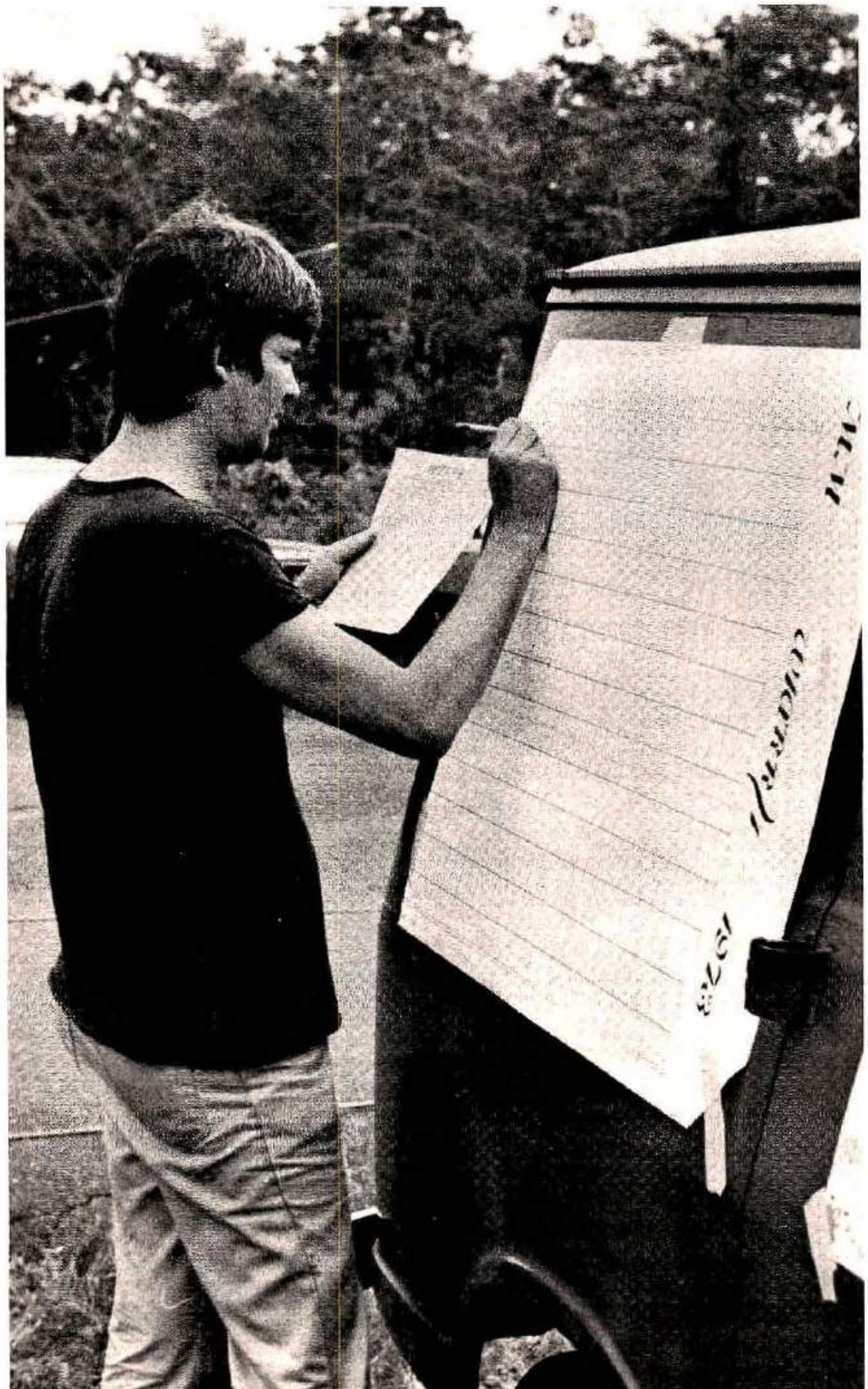
to handle the countless tasks involved in this kind of activity. The greater the number of participants, the easier each item can be handled and with less chance of error. No aspect should be overlooked. It takes a good leader to spearhead any Field Day group. Every job, however large or small, will benefit the club's total effort.

Goals

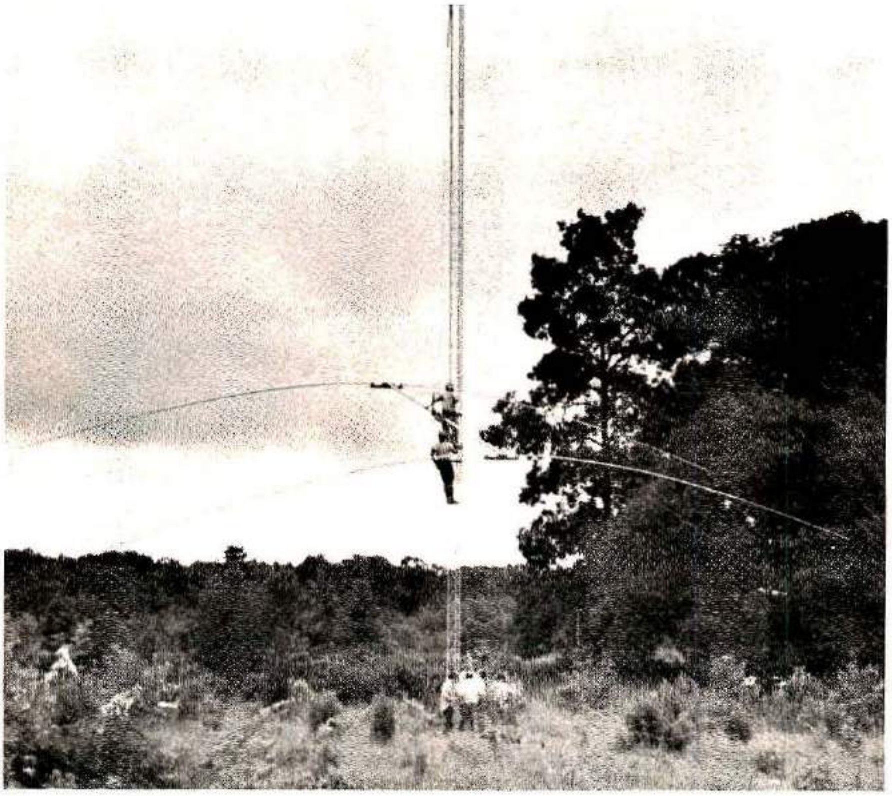
Field Day has its challenges for everyone. Your group or organization must set its own goals: Finishing high in the nationwide competition can be one, or recruiting new members another. The natural hand-in-hand relationship between Field Day and public relations provides a convenient way to increase a club's membership. Many clubs are very service oriented, aiding the community in various ways. Field Day provides a means of announcing, through the media, that you are there to serve the community. Whether a repeater group or contest club, the general public can be shown Amateur Radio through your Field Day efforts.

Many groups combine family activities with Field Day. Often, the balmy June weather permits bringing the other members of families together as a social event. Sometimes the party and picnic atmosphere eclipses the main event.

As in any competitive event, there are winners and losers. Taking top honors in your class can be reward enough. In the strictest terms, Field Day is an exercise in emergency preparedness, and at times it is difficult to separate this aspect from the contest atmosphere. What may seem nonsensical to you may be a type of fierce competition between rival groups.



W1ARR updates the hourly progress chart of the Field Day operation. Comparisons are made frequently to last year's performance and game plan changes are implemented to maximize the groups' effectiveness.



With a little coordination, even the largest of antennas can be installed for Field Day. W1FBY and WA2CLQ are shown guiding a 2-element full size 40-meter beam up the tower.

Serious advice

Many established groups have plans drawn up for using the same site each year. Make sure that your club is flexible enough to change plans on short notice if another group has already appropriated "your" spot.

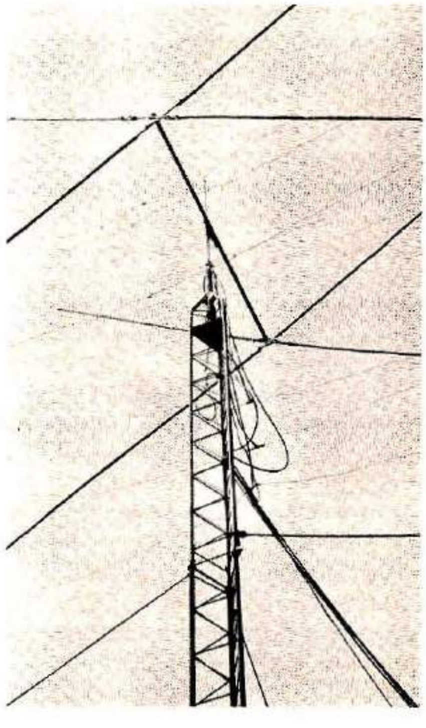
There's a large amount of knowledge that's basic to any Field Day operation. Taking into consideration a few simple hints will produce a competitive effort from any location. The key consideration should be organization and coordination *before* and *during* the weekend. The authors, having been involved in large and small efforts, find the most enjoyable times happen during a tightly run operation. Generally, three operators per transmitter is a good guide to follow. Selecting the right band takes a little experience, but 20 and 40 meters will be the big scorers during the day. At night, 80 and 40 meters will produce the big contact totals. Also, point your antennas at the large population centers. Very seldom will clubs stray that far from home. It may seem complicated, but that's half the fun.

You don't have to get very fancy with towers and rotators, either. Essentially the East Coast people point west, and vice versa. Anywhere from 40 to 70 feet (12-21m) is sufficient tower height. Going higher becomes more difficult and time consuming. A recent record-setting effort by a contest club produced over 10,000 QSOs, with all the antennas 70 feet (21m) or below! By analyzing each variable, and working to solve the problems beforehand, your club's performance in the field will get better every year. A gradual growing process is recommended for any serious Field Day contenders.

Getting involved

Now that we've gotten your attention, how do you find a club to participate with? Start checking into the local repeaters or club nets. Many times Field Day coordination will be conducted over the air. Also, check the local newspapers. Those PR notices were sent out for just that reason. Field Day is such a large and well-attended event that someone can direct you to the nearest site. If all else fails, go out early on the fourth Saturday in June and follow the car with all the aluminum on the top. **HRH**

Field Day antennas come in all shapes and sizes. Making maximum and total use of them can save time and trouble. This 2-element tri-band cubical quad was used on 20-, 15-, and 10-meter CW, simultaneously.



a primer for TV DXing

BY THOMAS R. SUNDSTROM, WB2AYA

There's a "private eye" in your living room! Don't believe it? Let a TV DXer tell you why — and how to turn your own TV set into a window on the world

As a reader of *Ham Radio Horizons* you are already aware that long-distance (DX, in radio amateur terms) reception is a regular event on the shortwave bands. Sure, conditions of the atmosphere and the level of solar activity will affect the signals bouncing around the ionosphere, but some level of DX activity can always be found somewhere on the bands.

Although it seems astounding that TV pictures can be seen from hundreds or thousands of miles away, many of the factors affecting short-wave reception also affect TV signals . . . far more frequently than you think. "Sure," you say, "how can I see TV pictures from far-distant stations when there are 15 local ones?" It's a fact that most people are skeptical, because few have seldom, if ever, turned to the unused channels on the television dial.

A knowledge of the world of frequencies above the usual upper limit of most general coverage receivers can be helpful when you are looking for TV DX.

Vhf signals in the lower TV channels, up to channel 6, can bounce around the ionosphere, and the "traffic" on CB gives a good clue as to where the skip is coming from. I find the easiest way to check things out is by tuning the unofficial national ssb CB frequency of 27.155 MHz, known as channel 16. When *Rubber Duck* calls in from Arkansas on the "lower side," and *Two Ton Tommy* from the "Sunshine State" shouts "that's a big 10-4" on the "upper-side," I've a quick diagnosis as to where TV skip signals might be coming from.

If you have a tunable 30-to-50 MHz receiver, the paging services around 36 MHz and the various state police services around 42 MHz are also useful clues as to what's going on. Certainly, six-meter band Amateurs will be active if there are signals bouncing in. But, for sheer numbers, it's hard to pass up the CB frequencies for a quick diagnosis of conditions.

A synopsis of band conditions on the upper TV channels can also be obtained easily if you have a scanner or portable receiver covering the *NOAA* (National Oceanographic and Atmospheric Administration) weather stations. These continuously-broadcasting stations identify every few minutes, and provide a check of how signals are travelling along the ground. For example, in the Delaware Valley (New Jersey), I normally hear New York City on 162.55 MHz and Atlantic City on 162.40 MHz, but when the Baltimore (Maryland) and Washington, DC, *NOAA* stations dominate, I know something's going on that ought to be looked into.

Obviously, if you are licensed to operate in the vhf amateur bands, you can make the same kind of check by monitoring a far-distant 2-meter or 1¼-meter fm repeater. As the signal approaches full quieting, you will have a clue to unusual conditions that warrant a look-see.

Propagation

TV DXing primarily depends upon two types of propagation: *Tropospheric* and *sporadic E* skip. I've already given clues on how to spot these types of propagation, so let's just hang some descriptions on these words.

If you live near a major population center, odds are that the lower vhf channels will be fully occupied, but there is usually a lot of open space on the uhf dial. Tropospheric propagation most often affects uhf signals, and vhf channels 7-13. *Tropo* (or trops) reception is usually caused by large, slow moving weather systems or large changes in temperature, pressure, or humidity. As a result the signals never leave the troposphere, which extends to a height of six miles (10 kilometers) or so. Signals can travel along the "boundary" of these weather systems to distances of 300, 600 or even, in rare cases, 1,000 miles (500 to 1,600 kilometers).

Temperature inversions caused by cool nights and warm days in the spring and fall often yield the best tropo conditions, particularly in the hours just after sunrise and just after sunset when the temperature changes most rapidly as the atmosphere heats and cools. Nights of fog and misty rain, particularly if a weather front is in the area, portend good tropo conditions.

On the TV screen, signs of tropo reception can be recognized when fringe stations become strong, and stations not normallly seen start to appear. For example, I normally can see almost all of the New York stations here, but WNET-13 is usually poor because of a strong local signal from Philadelphia on channel 12. Signs of improving DX conditions will be a good picture on WNET-13, at 75 miles (120 kilometers), and then very good pictures from WJZ-13, Baltimore, and WDCA-20, Washington, both over 130 miles (210 kilometers) to the southwest.

Whereas tropospheric reception *could* be a daily occurrence, sporadic E skip (*Es*) is not so frequent. *Es* is an exciting happening and fairly easy to spot. It affects primarily those frequencies below 108 MHz (see **Table 1**) but there were several dates during the summer of 1976 when *Es* made it up to 148 MHz and possibly beyond.

WCVE-23 Richmond, Virginia, was photographed during a tropo opening on June 1, 1971, at 11:45 PM EDT, a distance of 235 miles (378 kilometers).

Sporadic E skip is caused by temporary ionization of patches in the E layer of the ionosphere, about 60 miles (95 kilometers) up. Despite studies going back many years, including an exhaustive study during the International Geophysical Year of 1957-58, the cause of *Es* is not precisely known.

Sporadic E is most likely to occur during the summer months, especially June and July, but there is also a minor peak of activity in December and January. The phenomenon can, however, occur on any day of the year.

Sporadic E invariably affects the lower frequencies first and, as the E-layer "thickens," higher frequencies will bounce. This is why the monitoring of class D CB frequencies in the 27-MHz band provides such a useful clue. When the action really gets "hot and heavy," check the first open vhf channel you have, starting with channel 2. I've seen numerous occasions when the *Es* is so strong that local KYW-3 is unwatchable due to skywave interference; another clue that the open channels probably have some good DX on them.

When *Es* occurs, the one-hop bounce is usually in the area of 1,000 miles (1,600 kilometers) plus or minus 200 miles (320 kilometers). Double-hop *Es* can occur, but usually requires that there be no station on the same channel in the vicinity of the intermediate reflection point.

A strong "opening" can result in *Es* up through channel 6, and monitoring the educational fm broadcasting

Table 1. Vhf and uhf allocations

MHz	Assigned to:
30 - 50	Public Safety
50 - 54	Amateur radio (6 meters)
54 - 72	Vhf TV channels 2, 3, and 4
72 - 73	Hobbyist radio remote control
76 - 88	Vhf TV channels 5 and 6
88 - 108	Fm broadcast band (88-92 educational, 92-108 commercial)
108 - 136	Aeronautical
144 - 148	Amateur radio (2 meters)
152 - 174	Public Safety, Mobile telephone, Industrial, Marine navigation, *NOAA* weather stations (162.40, 162.475, and 162.55 MHz)
174 - 216	Vhf TV channels 7 - 13
220 - 225	Amateur radio
420 - 450	Amateur radio
450 - 460	Public Safety
460 - 470	Citizens Radio Service (class A)
470 - 890	Uhf TV channels 14-83
890 - 942	U.S. Government

stations between 88 and 92 MHz can be quite a lot of fun. By the way, this discussion of propagation is not only valid for fm but also for the vhf amateur bands.

There are some other modes of propagation, but these are of little value to the beginning TV DXer. Some readers may be in outlying areas, far from population centers, and may encounter meteor scatter and aurora conditions more frequently than those living in suburban or urban areas.

Meteor scatter depends upon signals reflecting, however briefly, from ionization trails of meteors. Because there are many meteor showers per year (your local library has astronomy magazines that will provide dates and times of meteor showers) the best time to catch meteors is after midnight when the earth is turning into the shower. You might also be fortunate enough to catch a test pattern during the early morning hours, prior to the commencing of regular broadcast activities.

Aurora reception is more likely to occur in the northern latitudes than in the south, and depends upon signals bouncing off a constantly-moving "curtain" commonly known as the *northern lights*. Signals constantly flutter, making it very hard to identify received stations, but the high solar activity which generates auroral activity may also trigger sporadic E skip.

Frankly, in twenty years of DXing from my home, located between New York and Philadephia, I've never seen TV DX as a result of meteor scatter or aurora. Consequently, you'll probably find tropo and *Es* much more productive. However, all four modes of propagation do exist and have been documented.

Equipment

The most desirable characteristics of a TV receiver are good sensitivity and selectivity. You want to be able to pull in weak signals with a minimum of adjacent channel interference, and it is important to have good *sync* stability in order to lock in the picture both vertically and horizontally.

Infortunately, most of us cannot make a good judgment as to what kind of receiver would be best for TV DXing, nor do many of us have the finances for a special DX-only TV set.

If you are fortunate enough to be able to get some detailed TV set specifications, you can make some comparisons of tuner and i-f specs. The tuner should be mechanically durable, and feel solid to you. I've operated some that felt as if I could snap the shaft in two.

Most of today's top-line sets from the major manufacturers, including the kits, are pretty good. If you plan to buy a new set, do some research in the various consumer service magazines. If buying a used set, even a black-and-white, be prepared for new tubes and an alignment but, above all, make sure the tuner is sturdy.

By the way, don't pick up an old set that uses a 27 MHz i-f. You won't get any DX on that one, because of the many CB signals that can leak through. For the top DXers, antennas are an art in themselves. All-channel antennas, with or without fm, are "no-nos" in their books. Use a log periodic, a narrow-band Yagi, or a good 2-13 channel antenna. For uhf, serious DXers use a 6- or 7-foot dish mounted well away from a 2-13 vhf array.

The antennas should be mounted as high as possible using good, sturdy, rotors. If possible, use a run of cable, preferably shielded 300-ohm or 75-ohm types.

Top DXers will also tell you that preamplifiers are not generally used, especially the commonly marketed broadband types. These tend to contribute to receive frontend overload. If preamplifiers are used at all, they are usually homebuilt with bandpass filters included to select just a single channel.

Have I discouraged you? I didn't mean to, but this is what serious TV DXers will say you need for maximum results. Do I do this? No, because I don't have the room; I'd have to take down my 2-meter antennas.

I violate all the rules by using a 2-83-plus-fm antenna, a 4-set booster, and 300-ohm cable, yet I've logged 66 stations in approximately 15 states; channels 2 and 4 have yielded *Es* from Arkansas, Florida, Iowa, Missouri, Mississippi, and Louisiana in just two years. Tropo reception here has ranged from central Virginia to Massachusetts.

The point of all this is to use the equipment and antennas you have. DX is possible on almost anything that works, and when the band is open it makes little difference whether or not top-quality, DX-oriented, equipment is used. Weak-signal DX-ing does require specialization, but knowing your equipment thoroughly is an advantage that shouldn't be overlooked.

Identifying stations

As I've mentioned, knowing what general region of the country the signals are coming from is relatively easy, whether it be listening to CB or surveying a weather map.

A second tool of the DXer is a knowledge of the "offsets" used. The FCC occasionally requires certain TV stations to use a plus-10 kHz or a minus-10 kHz carrier-frequency offset to eliminate co-channel interference (*FCC Rules and Regulations*, Volume 3, Part 73.606).

If there are only a few horizontal "beat" bars on the screen, the two stations are on the same frequency. If there are about a dozen bars, the two stations are 10 kHz apart, and if there are many bars the two stations are 20 kHz apart.

By knowing the local station's offset or the DX station's offset, it is possible to eliminate two-thirds of the possibilities.

Offset assignments are available in commercial publications, or in the *FCC Rules and Regulations*, Volume 3, available from the U.S. Government Printing Office, Washington, DC 20402. Write for prices.

Logging stations

Shortwave listeners often log broadcast, utility, and amateur stations, and send reception reports to them to get verifications (sometimes called QSLs). Well, TV DXers do the same thing. A report addressed to the Chief Engineer at the station, with the city and state of license, will usually reach the proper person. Make sure the reader knows it is a *TV reception report*; some stations have sent out verifications of their AM outlet, not realizing that TV signals can bounce too.

The reception report should contain verifiable material, excluding virtually *all* network programming, unless a specific station announcement is made that it was being shown on delay. Some good material to prove reception would be local broadcasts or commercials, local "tags" on network announcements, a sketch of the call slide, or the layout of the newsroom.

Be sure to enclose return postage and, above all, do not *demand* a verification. The station is performing a courtesy, and couldn't care less about being viewed outside its normal coverage area.

Photographs

Pictures of the TV DX may be sent to the station along with your reception reports. Some examples accompany the text. Try color slides if you DX on a color set; soon, you will have a colorful collection from both tropo and *Es* reception.

High Speed Ektachrome (ASA 160) exposed at 1/30 second (no faster!) and about an f/2 or f/1.8 lens opening will normally produce very decent color pictures. Make sure the TV set contrast is increased to produce a vivid picture.

A faster black and white film, such as Tri-X (ASA 400), should be exposed at 1/30 second and about f/5.6. If your camera has a built-in exposure meter, use it. Watch the light glare on the tube face, and take steps to eliminate it. The use of a polarizing filter or even movement of a reflecting lamp will be of great help.

If you have one of the new sets with the automatic color/contrast control as the room lighting changes, you might consider "fooling" the cell to make the pictures bright and contrasty. A piece of black tape placed over the cell ought to do it.

To continue, make sure the camera is steady and consider the use of a tripod and cable release. I am assuming that you will use a single lens reflex (SLR) camera in all of this, but

WESH-2 Daytona Beach, Florida, was logged during a week of openings when this station was seen daily. This shot of the forecast was taken during their local 6 PM newscast, on June 6, 1973. WESH is about 825 miles (1327 kilometers) distant.

if you have a camera that does not view through the lens, don't forget to adjust for parallax at the short distance between the camera and TV screen.*

Incidentally, if you try to take pictures at a shutter speed faster than 1/30 second, you'll get some black bars because the horizontal scanning doesn't have a chance to "paint" an entire picture on the tube.

Publications

Although a few TV station lists appear in "White's Log" in the semi-annual *Communications World* and in the Vance A. Jones *Radio-TV Station Guide*, these listings are not particularly designed for DXers. Better alternatives are the *TV Station Guide*, containing maps and station data (including offsets) by TV channels, for North and Central America; *VHF-UHF Digest*, a monthly magazine providing TV, FM, and utilities listings; and *Beyond Shortwave*, an introduction to DXing above 30 MHz; all published by the Worldwide TV-FM DX Association. The association also publishes a brochure explaining the functions of WTFDA that will be sent upon receipt of a self-addressed, stamped no. 10 envelope. A copy of the Digest and an 8-page listing of reprinted articles will be sent free to new DXers who send WTFDA a self-addressed no. 10 envelope with 24¢ postage affixed. Mention *Ham Radio Horizons* when you write.

Another good, but more expensive alternative is the annual *Broadcasting Yearbook* from Broadcasting Publications. This publication is an outgrowth of the weekly trade journal *Broadcasting*, and both can be found at most broadcasting stations or in larger public libraries. The information contained in the *Yearbook* is outstanding in detail and quantity, and is worth scouting around to find a copy to look at.*

Closing remarks

TV DXing can have other side benefits too. A few years ago, I found a good clear picture from WSBK-38, Boston, with a Boston-Montreal Stanley Cup playoff game in progress. A neighbor and I are hockey fans, and we watched the entire game before the tropo opening folded. WSBK is 255 miles (410 kilometers) northeast of here, and was the only TV station carrying the game.

Check the empty spaces on your TV dial; you'll never know what you might find. I'll be happy to try to answer any questions upon receipt of a no. 10 self-addressed stamped envelope.

*With rangefinder-type cameras focused at close distances, there is usually a difference between the image seen in the viewfinder and that "seen" by the lens. If your camera has parallax correction marks in the viewfinder, use them. If not, you'll have to measure.

***Publishers' Addresses**

Communications World, Davis Publications, Inc., 229 Park Avenue, New York 10003.

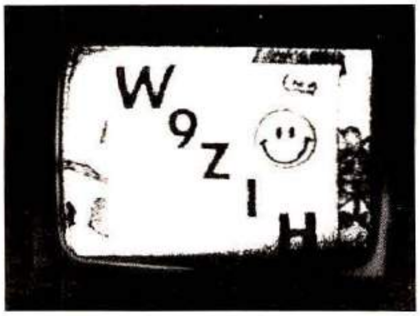
Radio-TV Station Guide, Howard W. Sams & Company, Inc., 4300 West 62nd Street, Indianapolis 46206; $4.95.

TV Station Guide, $5 annually; *VHF-UHF Digest*-sample copy 75¢; *Beyond Shortwave*, $1.25; all available from The Worldwide TV-FM DX Association, Box 163, Deerfield, Illinois 60015.

Broadcasting Yearbook, Broadcasting Publications, Inc., 1735 DeSales Street, NW, Washington, DC 20036; $23 annually.

439-MHz television DXing

There's a fascinating sequel to TV DXing provided by Arthur Towslee, WA8RMC, 180 Fairdale Avenue, Westerville, Ohio 43081. Radio Amateurs are permitted to transmit *slow scan* television signals on hf Amateur bands where frequency crowding limits bandwidth, and *fast scan* television signals on uhf Amateur bands where there is little activity and where great bandwidth is available. Here is a glimpse of *ATV*, Amateur Television, DXing in which



television signals were sent and received over long distances; much farther, in fact, than their commercial counterparts. Art reports:

"I am writing to you in the interest of fast scan Amateur television activity. The following is an amazing bit of atmospheric phenomena that resulted in what I believe to be an ATV distance record. Hopefully, this bit of news will find a place in your magazine and will stir reader interest in this fascinating derivative of Amateur Radio.

"It started when Dale Ulmer, WA9ZIG, moved to Columbus (Ohio) from the Milwaukee, Wisconsin area and set up his ATV activity here. Communicating regularly with Ronald Stefanskie, W9ZIH, in Chicago on 40-meter ssb, the two amateurs decided to set up an ATV (fast scan) schedule on 439 MHz, and try to establish contact with each other. They believed that a two-way contact over the 300-plus mile (500 kilometer) distance would be nearly impossible, but decided to keep the schedule anyway. They picked, at random, Sunday morning, October 3, 1976, from 9 to 9:30 AM local time, for their first attempt. It was agreed that W9ZIH would transmit video between 9:00 and 9:15, and WA9ZIG/8 would transmit video between 9:15 and 9:30. In the course of events, Dale told me and a few others of his upcoming schedule with Ron, but due to the fact that an antenna party among the local ATV enthusiasts was also scheduled for the same time, Bill Parker, W8DMR, and I were the only ones home. (We planned to go to the party later).

"I turned the rig on just before 9:00 AM to check in, and at 9:00 sharp there was nothing but snow visible on the screen. No sign of W9ZIH was observed. At exactly 9:15, WA9ZIG/8's video appeared, so I called him on the 2-meter band to ask him whether he would object to me transmitting video before 9:30 to see if W9ZIH could copy my signal. With that, W9ZIH answered me on 2-meter single sideband (signal strength over S-9) and told me to turn on my video on the 439-MHz frequency. As I did, W9ZIH immediately responded: 'I copy your video fine . . . about 5 per cent snow.' At first, I couldn't believe this report, but an accurate description of my test pattern confirmed it. After that initial exchange, he sent video which I copied with about 5-10 per cent snow (P4) and which was received about the same at WA9ZIG/8's QTH.

"Meanwhile, W8DMR had turned on his equipment and immediately saw W9ZIH's video, but because Ron's callsign wasn't displayed at the time, Bill didn't know where the 'unknown' signal was coming from. It peaked with Bill's beam pointed northwest, but no one he knew was broadcasting ATV from that direction. When W9ZIH displayed his test pattern, you can bet that W8DMR's video recorder began moving!

"The video activity between Chicago and Columbus continued until about 10:30 AM, by which time conditions had somewhat deteriorated, so we signed off. W8DMR, WA9ZIG/8 and I were the only stations from the Columbus area to

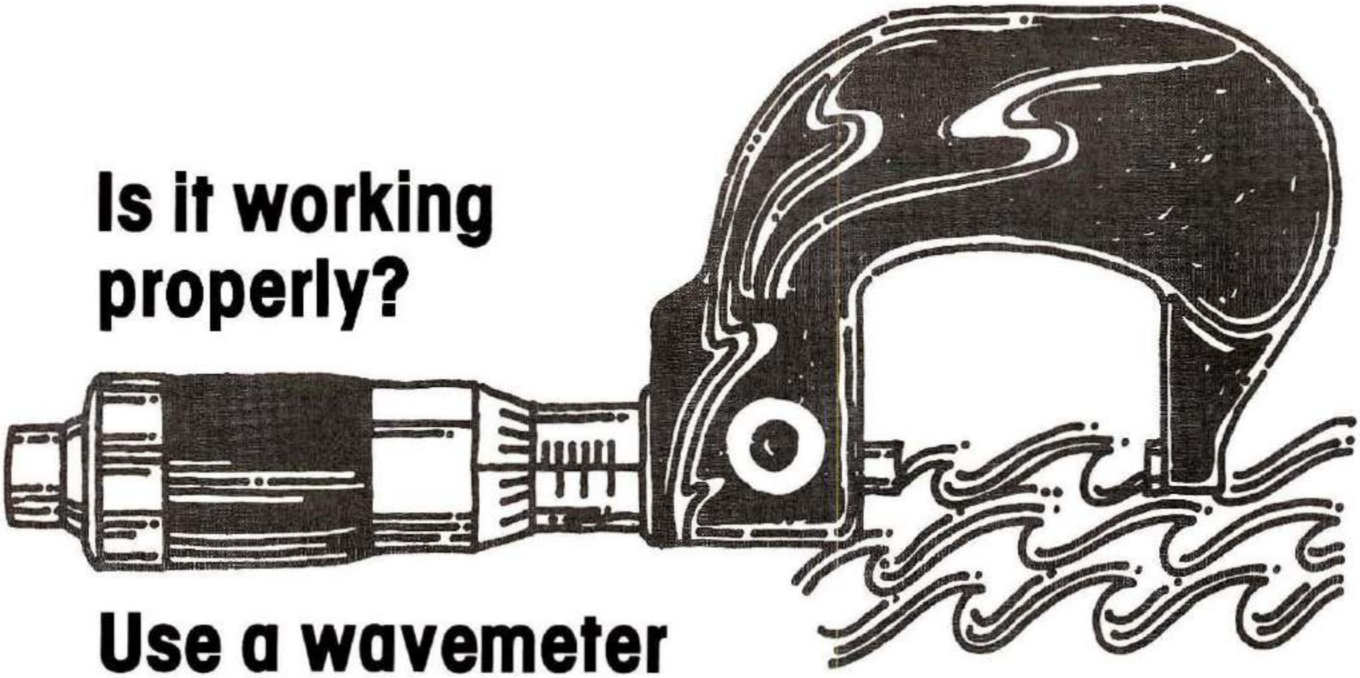
work W9ZIH. We did manage to work another station, WA9SRR, Bob Rosasco, from Winthrop Harbor, Illinois, but with less success (P2). After we signed, WA8TLZ, Dave Wagner, in the Toledo, Ohio, area managed to work W9ZIH with similar signal reports to those we had obtained, but the band 'folded' at approximately 11:30 AM EDT.

"The remarkable thing is that a random schedule was made, not knowing what the band conditions would be, and that we were home at the time the antenna party was in progress. (We arrived at the party late, with some terrific tales to tell!)

"To our knowledge, this is an ATV record distance contact for 439 MHz. I believe W8DMR had a previous contact with K4EJQ in Bristol, Tennessee, but our contact exceeded that one by approximately 50 miles! If anyone knows of a greater distance contact on 439 MHz ATV, we would like to know."

HRH

Is it working properly?



Use a wavemeter to find out.

BY DOUGLAS A. BLAKESLEE, W1KLK

How do you know that your antenna is working? You have just called a station two or three times and he answered someone else — and this is not the first time it has happened this evening. Your transmitter seems to be working okay, at least the meter readings are close to where they should be. That nagging suspicion about the antenna persists. Wouldn't it be nice to have a little box that said "yep, your antenna is well and radiating."

Did that last trip through the car-wash do something to your 2-meter fm or CB antenna? Again, a little box that provided a reassuring meter reading would be real neat, right? Right!

That little transmitter project that you just finished — the one that you painstakingly acquired the parts for, and were ever so careful to follow the instructions to the letter with — is it oscillating, and if so, where? Ah, yes, that handy little box again. It's a wavemeter — a device to check the frequency and relative strength of radio-frequency energy. While not a laboratory standard by any means, it is so useful in hundreds of ways that an ancient version of it was referred to as a "little gem" back in the golden days of radio construction. Let's take a look at what goes into a modern wavemeter that you can build in an evening or two, and then give you a couple of examples of how to use it.

In the early days of radio, the sound of a rotary spark gap or the color of a vacuum tube would indicate trouble. Today, transistors and tubes are hidden behind layers of protective shielding where there is rarely an audible or visual indication when something goes amiss. Nevertheless, every Amateur needs a way to check his equipment (and CB rigs can be checked, too). Otherwise, harmonics could result in a violation notice from a Federal Communications Commission monitoring station, or a vhf parasitic could produce an unannounced visit from the Saturday afternoon beer-and-football bunch. Some specific examples of ways to prevent such troubles follow.

A simple way to check approximate frequency and strength of radio-frequency (rf) signals is with an absorption wavemeter. It's called an absorption device because a small portion of the rf energy is absorbed by its circuit and used to drive an indicator — a meter, in most cases. The basic circuit for the wavemeter (**Fig. 1A**) consists of a tuned circuit (coil and capacitor) to set the frequency, a diode to detect the rf signal and convert it into direct current, and a meter to respond to the dc and indicate the relative strength of the detected signal. The meter can be replaced or supplemented by high-impedance headphones if you wish to monitor the modulation of an amplitude-modulated (a-m) signal.

The field-strength

meter is a cousin of the wavemeter and provides an indication of relative signal strength. The field-strength meter (**Fig. 1B**) consists of an antenna connected to a diode detector, which drives a meter. Obviously, if a way could be found to connect an antenna to the wavemeter, the functions of the two instruments could be combined.

Circuit description

The circuit diagram of a combined wavemeter/field-strength meter covering 1.7 to 200 MHz is shown in **Fig. 2**. As with all simple instruments, the primary design task is to find optimum or near-optimum components for a given circuit configuration. To provide discrimination among adjacent rf signals and to achieve an accurate frequency readout, a highly selective tuned circuit is needed. The measure of tuned-circuit selectivity is *Q*. To confuse things a bit, there are two types of *Q*. First, there is the *Q* of the coil itself, which is a function of size, shape factor and wire resistance. In this wavemeter the *Q* of the coils I used, as measured on a Boonton 195A *Q* meter, is given with **Fig. 2**. The *Q* of an operating circuit is a function of its inductance/capacitance ratio and the load impedance. In the circuit shown, a link input for the antenna was chosen; the transformer action of the coil and link assure that a low-impedance antenna will not unduly degrade circuit operating *Q*.

The sensitivity of the circuit is affected by the forward-voltage drop of the diode and the sensitivity of the meter. Semiconductor diodes exhibit the phenomenon of forward-voltage drop (V_f) and, before more than negligible current can flow through the diode, a voltage threshold (which is a built-in characteristic of the device) must be exceeded. Once above the threshold voltage, current flow increases rapidly with increased voltage. The threshold voltage for germanium diodes is 0.2 to 0.3 volt, while silicon units have a threshold of 0.5 to 0.7 volt. Obviously, for best sensitivity, the diode with the lowest threshold voltage is the choice. Any common germanium diode — 1N34A, 1N67A, 1N270 — is suitable for CR1. Capacitor C2 is included at the output of CR1 to filter out unwanted rf energy.

Output from the rf rectifier is fed to an amplifier whose purpose is to amplify the dc signal to a level sufficient to drive a milliammeter and to provide adjustable gain.

Op Amps

The device used is a 741 operational amplifier, commonly called an *op amp*. During World War II analog devices were designed which would perform mathematical functions such as summation, differentiation, integration, logs, antilogs, and so on. Because this family of devices grew out of *operations research*, John Ragazzini, in 1947, coined the name *operational amplifier*. Today

Glossary of Terms

Forward voltage drop — refers to the drop, or decrease, in voltage measured at one end of a rectifier, compared to the voltage measured at the other end, when current flows through the rectifier in a "forward" direction.

Threshold voltage — the value of input voltage to a device that will cause the device to begin operating or to conduct current.

Bus wire — a name given to a common ground conductor or any other electrical conductor, usually of large diameter, to which other wires and circuits are attached. The bus wire — or bus bar, as it is sometimes known, is often uninsulated, usually made from copper or other material having high electrical conductivity. The origin of the word is obscure, but probably stems from *omnibus*, a carrier of all things.

Parasitic Oscillation — an unwanted or spurious oscillation that may occur in tuned radio-frequency circuits, but at a frequency usually not related to the tuned-circuit frequency. Such oscillations are producers of rf energy that can cause interference to other electronic devices and can create power loss in an amplifier stage, or an oscillator stage. Like most parasites, these oscillations must be removed or, better still, prevented from occurring in the first place by proper design of the circuit and choice of components.

Semiconductor — a material that is neither a conductor (such as copper) nor an insulator (such as ceramic). Most common semiconductor devices — transistors, diodes, integrated circuits — are made from either the element germanium or silicon that have had a precise amount of impurities (other elements) added in order to obtain a specific degree of performance.

Analog — a term stemming from the word analogous (similar to). Often used to compare with digital. Examples are a digital meter that provides a reading in precise numbers, vs an analog meter that has a moving pointer and a calibrated scale; a digital watch vs an analog one with moving hands.

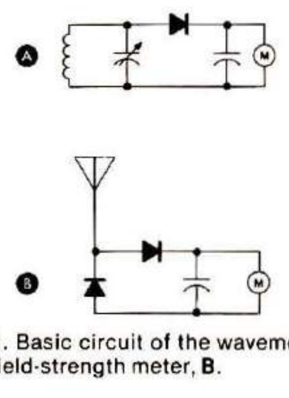


Fig. 1. Basic circuit of the wavemeter, **A**, and field-strength meter, **B**.

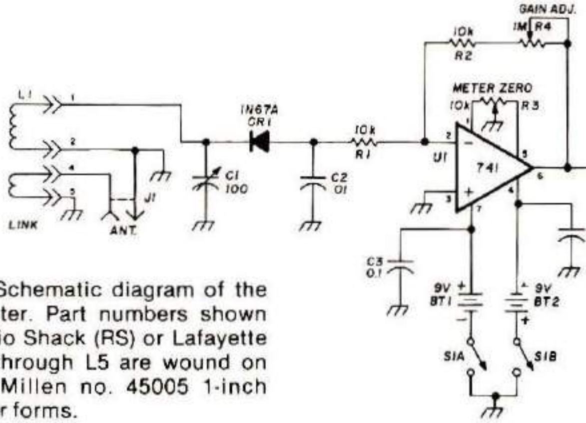


Fig. 2. Schematic diagram of the wavemeter. Part numbers shown are Radio Shack (RS) or Lafayette (L). L1 through L5 are wound on James Millen no. 45005 1-inch diameter forms.

- **BT1,BT2** Transistor radio battery, 9-volt (RS 23-151)
- **C1** 100-pF air variable, panel mount (see footnote).
- **C2,C3,C4** Disc ceramic (RS 272-120 series).
- **CR1** Germanium diode, 1N34A, 1N67A, 1N270 (L 32PO8774V).
- **J1** Phono type jack (RS 274-346).
- **L1** 63 turns, no. 32 (0.2mm) enamel wire, close-spaced; 1050 μH, Q = 80 at 2.5 MHz. Frequency range 1.7 to 4 MHz. Link 15 turns.
- **L2** 28 turns, no. 32 (0.2mm) enamel wire, close-spaced; 28μH, Q = 95 at 5 MHz. Frequency range 3 to 8 MHz. Link 15 turns.
- **L3** 13 turns, no. 22 (0.6mm) enamel wire, close-spaced; 5.1μH, Q = 130 at 10 MHz. Frequency range 7 to 20 MHz. Link 3 turns.
- **L4** 4 turns, no. 22 (0.6mm) enamel wire, close-spaced; 0.82μH, Q = 100 at 25 MHz. Frequency range 17 to 55 MHz. Link 1 turn.
- **L5** 2 turns, no. 22 (0.6mm) enamel wire, 1/4-inch diameter, mounted inside a 1-inch (2.5cm) coil form; 0.12μH. Frequency range 60 to 150 MHz. Link 2-inch (5cm) long by 1/2-inch (1.3cm) wide loop.
- **L6** Loop of no. 8 (3.3mm) wire, 2 inches (5cm) high, 1/4-inch (0.65cm) spacing; flared at the bottom to fit socket. Frequency range 80 to 200 MHz.
- **M1** 0 to 500 μA or 0 to 1 mA meter (L 99P51070V), or any small meter with a case size of 1-1/2 to 2-1/2 inches (3.8 to 6.4cm).
- **R1,R2,R5** 1/4- or 1/2-watt composition (RS 271-1300 or 271-000).
- **R3** PC-mount control, linear taper (RS 271-218).
- **R4** Panel-mount control, linear taper (RS 271-211).
- **S1** Spdt toggle switch (RS 275-326).
- **U1** Op-amp IC, 741 or equivalent (RS 276-007 or 276-010).

hundreds of op amps have been designed using tubes and discrete transistors, but, because of simplicity and size advantage, the most popular devices are in integrated-circuit form. An integrated circuit is a group of transistors, diodes, resistors, and capacitors formed on a single piece of semiconductor crystal and interconnected to form a circuit for a given function. The first op amps were used almost exclusively in analog computers, but now, a book is available that describes some of the many op-amp applications.[1]

An integrated-circuit op amp such as the 741 usually consists of three sections, as shown in **Fig. 3**. The first stage has two inputs, one of which is the inverse of the other. This stage is called a differential amplifier because it amplifies only the difference in current at the two input terminals, which are called positive (non-inverting) and negative (inverting), and marked on a schematic diagram with plus and minus signs, respectively. The terminal names describe what happens if a small positive current is applied. Assuming the op amp is employed as an amplifier, a positive current applied to the positive terminal will result in non-inverted output. But a positive current applied to the negative terminal results in an inverted output. (The output current would be the input multiplied by the gain of the amplifier).

The second stage of the op amp acts as a buffer, usually with a gain of one to ten. The output stage provides moderate current (enough to drive loads of 1 to 10 kilohms) and bipolar (plus or minus) operation.

An ideal op amp will have infinite input impedance, infinite gain, and low output impedance; practical devices come close to these goals. Voltage gains of 100,000 or more can be achieved while drawing unmeasurably low current at the input, but one problem exists in all op amps: If the inverting and non-inverting terminals are connected together at zero potential, the output should always be zero. Unfortunately, this is not the case; and output that occurs under these conditions is called *offset*. The higher the gain of the op amp circuit, the more troublesome

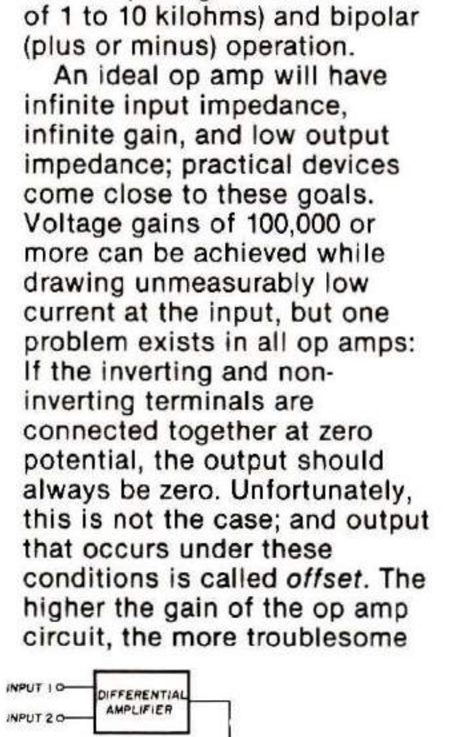


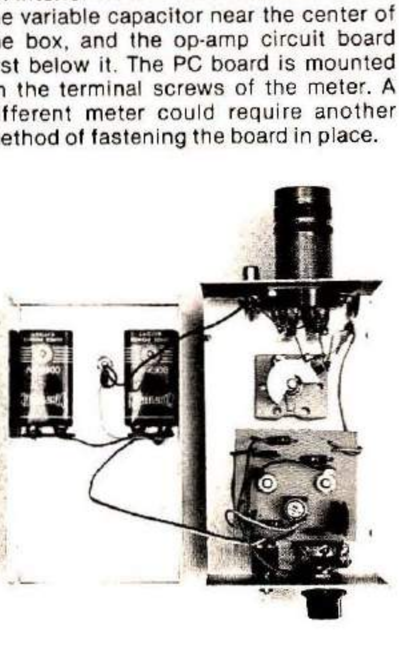
Fig. 3. Block diagram of an operational amplifier.

offset becomes, because the error current is amplified along with the input signal. So, you'll find included in the circuit a control, R3, to null the effect of any *offset error*.

For wavemeter/field-strength meter applications the op amp has too much amplification. A resistive divider network connected from the output to the input (R4, R2, and R1) provides feedback which sets the gain of the circuit. R4 controls the amount of feedback and, thus, the gain. Because of the high gain of the 741, some precautions are necessary to assure stable operation. The op amp contains an internal capacitor which reduces its gain at higher frequencies to prevent oscillation caused by phase shift. Leads to the op amp inputs should be kept short. Both supply voltages should be bypassed by 0.1 μF capacitors *at the op amp* (if more than one op amp is employed, each unit should have its own set of bypass capacitors).

Output from the op amp is a voltage that may swing from 0 to approximately 9 volts. The meter, M1, is arranged to read this voltage. By adding a resistor (R5), which has a much higher resistance than the

An interior view of the wavemeter shows the variable capacitor near the center of the box, and the op-amp circuit board just below it. The PC board is mounted on the terminal screws of the meter. A different meter could require another method of fastening the board in place.



The wavemeter could be one of the most useful items around your radio room. Here one coil is plugged into the socket at the top of the meter box. The "bare" coil form shown to the left has the 60 to 130-MHz coil inside it. A hairpin loop for the highest-frequency range is shown in **Fig. 8.**

meter itself, the milliammeter is converted to a voltmeter. Of course, a 0-1 or 0-10 voltmeter could be used in place of the milliammeter.

Construction details

The wavemeter is housed in a 5-1/2 x 3 x 2-1/8-inch (12.7x7.6x5.4cm) aluminum box (Radio Shack 270-238). This particular size was chosen because it fits well in the hand. Lafayette 12P83738 is a suitable alternative. The coil socket and antenna jack are mounted at the top of the box. A 2-lug terminal strip (Radio Shack 274-688 with 3 lugs removed) mounted at the coil socket holds CR1 and C2. It is important that lead lengths in the rf section of the unit be kept as short as possible.

Coils are wound on 1-inch (2.5cm) diameter forms (Millen 45005, see footnote).* The specifications for the number of turns and wire size are given in **Fig. 2.** These instructions should be followed carefully if the calibration dial of **Fig. 4** is to be correct. The antenna-link input windings can be made from whatever wire you have available. No. 26 (0.4mm) wire was used for all of the coils in the instruments shown, because it was handy. The sixth coil is a piece of *bus* wire bent to shape and covered with heat-shrinkable tubing. No antenna-input provision has been made for this coil: If one is desired, it could be mounted in a Millen form along with the sixth coil.

The circuit board should be assembled next. See **Fig. 5** for the PC pattern and parts layout. Check to see that the foil pattern on the board is clean and shiny, but, if not, touch it up with fine steel wool. Mount the components a few at a time, bending leads slightly to hold the parts in place. Then, using a 20- or 40-watt soldering iron, heat the lead and the foil for a second and apply a small amount of rosin-core solder. The small-diameter solder (often called instrument solder)

*A kit of hard-to-find parts, including the circuit board, five Millen coil forms, the air-variable capacitor, and the 5-pin socket for the coil form, is available from G. R. Whitehouse & Co., 15 Newbury Drive, Amherst, New Hampshire 03031 for $16.25 postpaid. The circuit board alone is $3.00 postpaid.

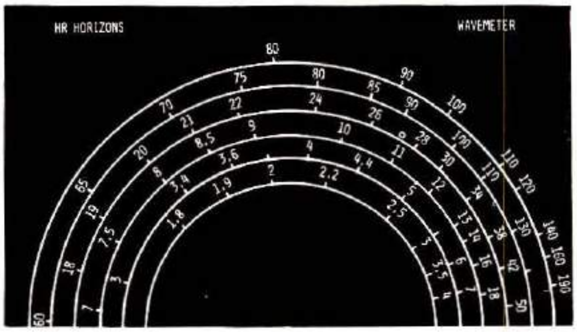


Fig. 4. The calibration dial for the wavemeter. This full size drawing can be cut out or photocopied and glued directly to the wavemeter enclosure.

is easiest to use. Two assembly techniques will be of help if troubleshooting is necessary. First, use a socket for the 741, which will make it easy to substitute another op amp. Second, make all leads from the board to external components long enough so that the unit can be operated with the board dismounted. Troubleshooting a mounted circuit board is often difficult. If you choose to solder the IC in place, invest in a solder-removal tool. Trying to replace an integrated circuit without such a tool can result in damage to the device or the board, or both. My board was designed for a 741 in the 8-lead DIP package. The "can" type may be substituted by bending its lead into the DIP pattern.

Next, do the required "metal bashing" on the cabinet. A metal enclosure is desirable because of its shielding properties which limit rf pickup to the coil and the antenna jack. Do a trial layout of components to avoid drilling holes in the wrong places. Mark holes to be drilled first in pencil, and then with a center punch. The large holes can present a problem in a home workshop equipped with only a hand drill. *Greenlee* chassis punches are available for large-diameter holes, and they are convenient and easy to use. Another technique is to drill a round pattern of small, closely-spaced holes slightly less in diameter than the desired hole, and then use a half-round file to finish the hole to the desired size.

After the holes have been drilled, remove all burrs with a jackknife. A few coats of spray paint in your favorite color can be applied to the cabinet, if desired. Then, mount the components. The circuit board is mounted on the meter bolts and circuit connection to the meter is made with solder lugs. If you use a meter with lug spacing different than that of the PC board, use just one lug for mounting. Wire all remaining connections. Note that a ground lead is used between the two sections of the enclosure to assure a low-resistance connection. The final assembly step is to identify controls with *Dymo* or press-on labels and to attach the calibration scale with rubber cement or double-sided tape.

Calibration

Set R3, the offset-null control, to approximately mid-range and R4, the gain control, to minimum (fully counterclockwise). Turn the power on and adjust R3 for a zero meter reading. Then advance R4 to maximum (fully clockwise) which will probably cause the meter pointer to move up or down. Re-adjust R3 for a zero indication.

If the capacitor specified has been used, and if the coils have been carefully wound, the calibration scales should be very close to correct. Calibration can be checked by using any known source of rf energy such as a transmitter, rf signal generator, or grid-dip meter. Many dip meters are not very accurately calibrated, so the dipper frequency should be checked with a receiver. A receiver can also be employed as a calibration instrument by wrapping the antenna wire (not coaxial cable) to the receiver several times around the wavemeter coil. Then, tune in a signal. As the wavemeter is tuned through the frequency of the signal, a slight *dip* in signal strength will be noted. One frequency (usually the center frequency) on each band should be checked. If necessary, add or remove coil turns until the calibration scale indication matches the frequency of the known signal.

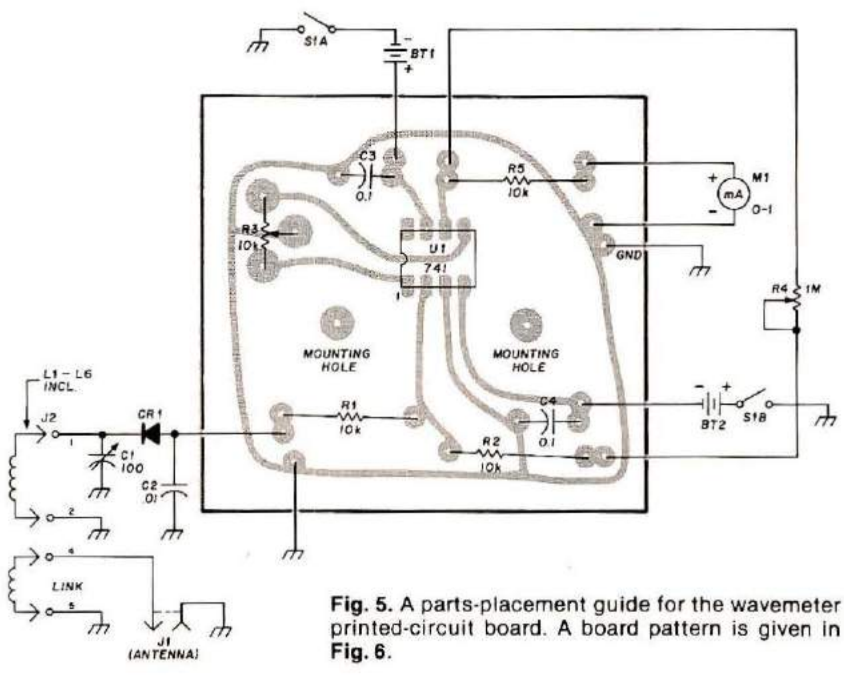


Fig. 5. A parts-placement guide for the wavemeter printed-circuit board. A board pattern is given in Fig. 6.

More details? Ad Check page 78.

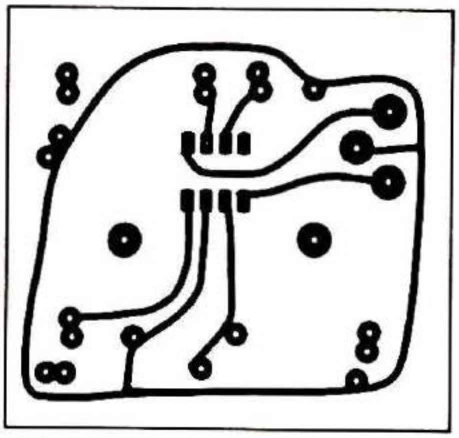


Fig. 6. Full-size circuit-board pattern, foil side. A parts-placement guide is shown in **Fig. 5**.

Using the wavemeter

Use your wavemeter anytime you want to sense the presence of rf energy and to determine its approximate frequency. Whenever you work on a receiver or transmitter, remember the safety rules because high voltages are often present. Even transistor equipment develops enough power to produce a nasty rf or heat burn. When you bring the wavemeter close to an operating circuit, **think safety**.

A few examples will demonstrate the versatility of this simple instrument:

1. As a Novice, you want to check your transmitter to assure that when you are operating on 80 meters, you don't have a second harmonic outside the 40-meter band or have unwanted radiation in any of the TV channels. A pickup loop similar to that shown in **Fig. 6** is built from a piece of RG-8A/U cable. Remove a section of the outer insulation and a rectangular portion of the braid. Using a soldering iron, heat a piece of bus wire and sink it into the insulation which surrounds the inner conductor. Form a loop 1-1/4 inches (3.2cm) in diameter in the bus wire to allow coupling to the wavemeter. With the loop section of coaxial cable connected between the transmitter and the antenna, the wavemeter is used to check for rf energy. If appreciable levels are found on other than the operating frequency, high-frequency harmonic problems can be cured with a *Transmatch* or half-wave filter connected between the transmitter and the antenna. A lowpass filter connected between the output antenna terminal of the transmitter and the antenna will reduce harmonic energy in the TV channels.

2. Suppose you want to check your recently-completed kilowatt amplifier to assure yourself that no parasitic oscillation (an oscillation unrelated to the operating frequency, usually in the vhf region) is present. Reduce the amplifier plate voltage so that if oscillation occurs, the plate dissipation of the tube will not be exceeded. With the amplifier on, tune the wavemeter from 30 to 200 MHz. When the parasitic frequency is found, construct a trap for that frequency and, after all voltage is removed from the transmitter, insert the trap into the plate circuit. Then, rerun the test to make sure that the parasitic has been removed.

3. You're a mobile operator and want to monitor the output of your rig by having some sort of continuous indication that everything is operating correctly. Use your wavemeter as a field-strength meter by

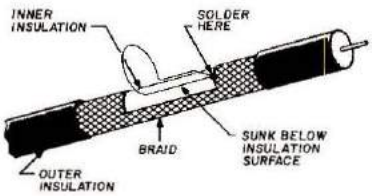


Fig. 7. The pickup loop is constructed from RG-8A/U coaxial cable. The outer insulation has been removed for a length of 3 inches (7.6cm). Then a rectangular section of the shield braid has been cut away. The loop section, made of bare wire, was heated with a soldering iron and sunk into the insulation just far enough to provide some support and coupling to the center conductor. Both ends of the wire forming the loop are soldered to the braid at one point to obtain a ground reference.

Fig. 8. The "coil" for the highest-frequency range could be described as a hairpin. It can be made to the correct size by comparing it to the rule. Bare ends of the heavy wire plug directly into the socket on the wavemeter.

attaching a small antenna to it, and place it on the dashboard of your car in a position for convenient viewing. One enterprising amateur in England insulated his rear-view mirror and used it as an antenna for his field-strength meter. After you have tuned your rig and observed the normal field-strength indication, any sudden drop on the meter indicates trouble with your transmitter or antenna.

4. As an antenna experimenter you're building a quad beam for 6 meters. To check your experiments, locate a *reference dipole* several wavelengths away from the quad, and connect it to the wavemeter by coaxial cable. Then proceed with various tuning and spacing adjustments to produce maximum forward gain, (or maximum front-to-back ratio), as indicated by the wavemeter.

Although details of filters, parasitic traps and antenna tuning are beyond the scope of this article, information can be found in publications such as ARRL's *The Radio Amateur's Handbook*, *Antenna Book*, and *Understanding Amateur Radio*, which are available from *ham radio*'s Communications Bookstore, Greenville, New Hampshire 03048.

Reference

1. Graeme, Tobey and Huelsman, *Operational Amplifiers — Design and Applications*, McGraw-Hill, 1971.

HRH

More details? Ad Check page 78.

THE FAR HORIZON

Long Path, Short Path, Any Path At All

BY BOB LOCHER, W9KNI

It's a Tuesday in late April. I've had a long but fairly satisfactory day at work, dinner's finished, my wife is at a meeting, and my homework's done — now for a little DXing!

Late April and early May are intriguing months for the DXer. The winter doldrums are past, the long-haul paths are opening more reliably now, longer both in time and in length. At this time of year, the northwest path for 20 meters is queen; Guam, Okinawa, Japan, Formosa, Korea, Hong Kong, Macau, and someday — perhaps — China.

The periods around the equinoxes — March 21 and September 21 — are of special interest to the DXer. The sun is directly over the equator, and all parts of the world receive an equal amount of sunshine. While some paths are best in the dead of winter or in mid-summer, many of the important paths are at their best near the equinoctial period.

I settle the earphones on my head, adjusting the band for maximum comfort. The receiver is warm and I begin tuning; the mosaic that is a DX band begins to unfold. I hear Siberians, Japanese — many of them — I hear Guam. There's Minami Torishima, a remote island with a weather station in the North Pacific. Off the back of my antenna I hear Bolivia, all — of course — with Americans and Canadians well mixed in.

I love tuning an open band; the world is calling and I must listen. I conjure up a vision of the Japanese weather station operator on Minami Torishima — off duty and doing a little operating. Weather conditions there are relatively stable right now, but in a few months conditions will change for the worse, with Minami Torishima located right smack in the middle of the so-called "Typhoon Alley" area of the North Pacific.

I think of the Bolivian station as I cross his frequency again — I listen:

QTH HR LA PAZ LA PAZ

Location here is La Paz.

La Paz, high in the Andes mountains, near Lake Titicaca and neighboring Peru. Spring is here in the States, but there the fall season is in the air. I hear him turn it over to a VE3 in Ontario, I go on. There's a weak signal:

WB8EUN DE YBØABT R TNX QSO
UR RST 569 569 HR NR JAKARTA
JAKARTA ON SUNDA STRAIT

WB8EUN from YBØABT, roger, thank you for the contact, your signals are clear and good copy here near Jakarta on Sunda Strait.

Sunda Strait, the watery path that so many ships of all nations traverse.

WX HR 76 76 F ES RAIN

Weather here is 76 degrees Fahrenheit and raining.

I think that 76 degrees is pretty cool for there, then I remember that it's early morning in Indonesia.

This fellow ought to be creating a lot of interest — Indonesia is always a good catch. I hear WB8EUN answering on backscatter. I'm going to listen to a bit of this. As EUN signs clear, several stations try "tail end" calls. The YBØ comes back to WB8EUN and signs clear. Pandemonium! Sure glad I don't need it. The S-meter just stands steady at 20 over S-9 for almost a minute, then drops as stations complete their calls. There's no sign of the YBØ coming back yet. Then a strong

DE K5FVA K5FVA K

Hey — its Louie! He must have been lying in the weeds 'til the pileup died down, because I didn't hear him before.

And, son of a gun, look at that:

K5FVA DE YBØABT

The delayed-call trick worked again. Its one of the more effective tricks in an open pileup. It requires iron discipline and nerves of steel to sit there listening to the pileup, and, as it dies down, slipping your vfo into a clear hole and getting in that one clear call; but it often works.

I move on up the band. Its not wise to listen too long to a huge pileup when the band is open if you don't need that station, because a rare one that you do need may be lurking just up the band. I remember one night a couple of years ago when there was an enormous pileup on a KG6 station who had a 20 over S-9 signal; yet less than 10 kHz higher was the super-rare XU1AA in Cambodia begging for calls.

A call from the past

DE JA1ADN K

It brings back a flood of memories. I was fifteen years old, and been a Novice for only four months. My call was KNØHGB, and I lived in Iowa. Those were the days of 75 watts and crystal-control for Novices. I had just built a new 75-watt rig from a kit; up from 25 watts with the old rig.

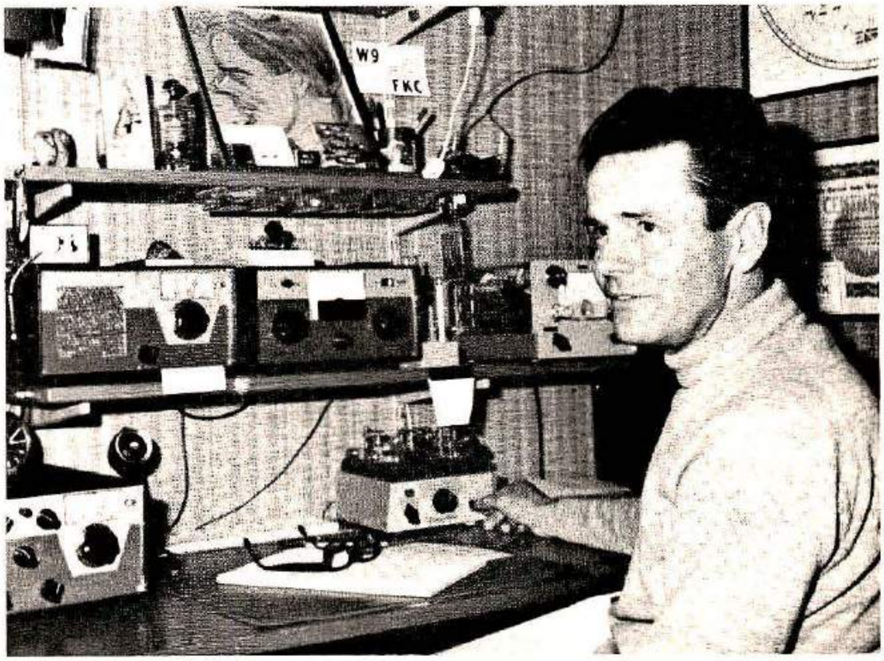
But there was another difference — the new rig should work on 15 meters, but it didn't — something was wrong! A friendly ham in the neighborhood agreed to assist, so one night he arrived with some test gear. The long and short of the problem was too much inductance in the driver grid coil — we removed two turns and I was in business on 15 meters!

We hooked up the 40-meter dipole, my only antenna, realizing that 40-meter dipoles work fairly well on 15 meters. I had one crystal that put me "dead on" 21, 120 kHz. We tuned up the rig, and all seemed well. Now maybe I could catch an elusive W6 — the only call area I lacked. We began tuning near my crystal frequency.

There was a station calling CQ — it was JA1ADN! He signed and I called, very nervously. He came back — to someone else. I was in despair, but my friend told me to wait and listen. I did. The JA finished the contact. I called him again and he came back — to me! Was I excited! It still sends shivers up and down my spine to think of it. And there — right there — I was irretrievably hooked on DX.

Frankly, I was so elated at

SMØFY seems to be enjoying a CW contact with the aid of his keyer. A part of a DXCC certificate is visible behind him, possibly earned through his use of the Drake equipment evident in this neat arrangement.



The station of JA1KSO has the capability to reach out for the rare ones, as indicated by the certificates and endorsements on the wall behind this well-equipped operating desk. One of the DXCC certificates sports a sticker for 300 and another has one for 310 different countries!

that point that the few operating skills I had virtually collapsed. My friend had to help me copy, but I completed the contact okay, and a few weeks later I received my QSL.

Now, twenty years later, JA1ADN is still active, and so am I. We still meet on the DX bands occasionally and, whenever I hear him, I recall my first DX QSO.

Would you believe it was two more weeks before I worked my first W6?

A new part of the world

I glance at the clock — 0155Z (GMT), which is 8:55 PM CDST. I have a note penciled into the margin of my log. Earlier I had heard LU2AFH mention to a W4 that LU1ZA, on the South Orkney Islands in the Antarctic, would be on 14065 kHz most Wednesdays at 0200Z, which translates to 9PM CDST. Now I hit the antenna rotor, and start my beam around to 159° — the bearing for the South Orkneys. I move the receiver to 14065 and I hear a CQ with just the faintest trace of a chirp — a nice fist, too.

CQ CQ DE LU1ZA LU1ZA CQ

Wow — there he is already. Good thing I came early. He's getting stronger, too, as my antenna comes around to his direction. Quickly, I bring my transmitter vfo to a "dead zero" with his signal just as he signs. I listen for a moment — dead silence. I call him:

LU1ZA DE W9KNI W9KNI AR

A brief call because I don't want to attract attention if no one else is calling him. Then,

W9KNI DE LU1ZA

Hot Dog! A new country!

GE OM TNX QSO RST 579 579
QTH ISLAS ORCADOS ISLAS
ORCADOS BT
NAME LUIS LUIS BT
QSL LU2AFH LU2AFH
HW CPY? W9KNI DE LU1ZA K

Good evening old man, thanks for the contact, your signals are strong and clear here at my location on Islas Orcados — my name is Luis — send confirmation card to LU2AFH — how well do you receive my signals? W9KNI from LU1ZA, go ahead.

I go back,

LU1ZA DE W9KNI R TNX QSO
DR LUIS BT
UR RST 579 579 QTH NR CHICAGO
NAME BOB QSL LU2AFH OK
LU1ZA DE W9KNI AR KN

LU1ZA from W9KNI, roger, thank you for the contact dear Luis, your signals are also strong and clear here near Chicago — my name is Bob, I will send the confirmation card to LU2AFH okay. LU1ZA this is W9KNI, go ahead.

R OK BOB TNX 73 W9KNI
DE LU1ZA SK QRZ DE LU1ZA K

Roger, okay Bob, thank you and best regards to you, W9KNI this is LU1ZA, end of contact. What station was calling me? This is is LU1ZA, go ahead.

Wow! Instant pileup! Guess there must be thirty stations calling in there. While I listen to the madhouse, I fill out the QSL. I get out my *DX Callbook*, and find LU2AFH, Luis' QSL manager. I address one of my special blue overseas airmail envelopes — they are very light, to reduce postage expense, and very opaque, so that the contents cannot easily be identified. I look in the front of the *Callbook* and find the table of International Postal Rates. I find Argentina, and the table indicates three International Reply Coupons — IRCs — are needed for airmail return postage.

These IRCs are really nice — you buy them at the Post Office for 42¢ each. Then you mail them to the DX station with your QSL. The DX station takes the IRCs to his post office. If he gives the clerk one IRC, he will receive in return enough postage to send you a QSL via first class surface mail. More IRCs can be exchanged for enough postage for an airmail response — the number needed for an air response

Alf, LA4LL, chases DX from a compact but functional corner setup, proving that you can have a lot of fun without installing a super station.

being listed in the International Postage Rates table in the *DX Callbook*. In this case, the table shows that Argentina needs 3 IRCs for Airmail postage.

I take another blue airmail envelope, and address it to myself, remembering to include "USA" on the bottom line. I fold it, and enclose it in the envelope to LU2AFH, along with the QSL and the three IRCs. Tomorrow I'll take it to the Post Office and send it off. With luck, I may have my QSL from LU1ZA in two or three weeks.

The IRCs are expensive; 42¢ each. Obviously, three cost $1.26, but sometimes an opportunity may arise to purchase them from a DX station or a QSL manager for the approximate "cash-in" value. Such sources are not common, but it does happen, and the DXer should be alert to the opportunity.

Now, I've finished the QSL for the LU1ZA QSO, and I turn my attention again to the pileup. It is huge now, people calling LU1ZA frantically, but he seems to have gone — probably scared off by the size of the pileup. Sure glad I snuck through a QSO before everyone found him!

Which way did he go?

I continue to tune the band, listening to the grunts, the chirps, the whispers calling. I come across a loud, beautiful fist:

P29EJ P29EJ DE W4BW W4BW K.

H'm, it's Prose, calling New Guinea; think I'll take a look. I turn the antenna toward New Guinea — a little north of straight west.

It sure makes a difference using a great circle map. I used to reason that since New Guinea was near Australia, I should point my antenna southwest like it shows on the National Geographic maps. But when I pointed my antenna that way, I could barely hear the DX station. That was a real disappointment. I had put up a two-element tri-band beam, so that I could work DX better, but often I could hear the DX louder on my dipole.

Well, one of the old timers took pity on me when I asked for advice, and dug out a dusty globe. He showed me how Great Circle routes work, and I remembered that name from grade-school geography, along with Bunga of Malaya. Then, he pointed out that radio signals, like transoceanic pilots, travel the globe in the shortest direction — a great circle path.

Then, the "OT" pulled out his *Antenna Manual* and showed me that Great Circle map. All of a sudden I began to understand! I had wondered what that silly map was for. Yup, it tells where to point your beam antenna. There are some real nice Great Circle maps in color, available from *ham radio*,* that you can hang on the wall of your station; they're a great help to any DXer.

To use the map, all you do is find the station you want to work on the map, and mentally draw a line from the center of the map through the DX station to the edge of the map. On the edge you read the direction to point your antenna. With two exceptions, which we'll cover shortly, that's all there is to it. And don't worry about the exact degree reading — being within ten degrees will be fine, and makes no difference. So, for New Guinea, we point the antenna a bit north of straight west, not southwest; and yes, there he is, talking with W4BW.

Radio Amateur's Great Circle Chart of the World plotted from the center of the United States and showing Great Circle bearings in degrees to other areas of the world. The Chart also includes a list of bearings from six major U.S. cities to the most important cities of the world. In full color, 30 x 25 inches (76x64cm), Order No. CB-GCC from *ham radio*'s Communications Bookstore, Greenville, New Hampshire 03048; price $1.25 postpaid.

Comparatively rare Turkey is sometimes represented on the ham bands by TA1MB. Again, the emphasis is on a simple and inexpensive station.

Now, the exceptions. One is one of the more exciting aspects of DXing — Long Paths, something many newer DXers aren't really aware of.

If we consider the ease, given good conditions, that we can work stations ten thousand miles away — stations nearly half way round the world from us — then what happens to our signals when they reach the opposite point of the globe? Do they quit and fall over the edge? Of course not, they keep right on going as far as propagation conditions will carry them. So, beaming our signals down a good propagation path, it is often possible to work a station by sending our signals more than 12,500 miles. Sometimes, this long path approach is more reliable than the shorter direct one.

For example, from the midwest USA in the summer months, the most reliable path into South Africa on twenty meters is the long path. We

The shack of Pete, SM2CEW, has a look of convenience and effectiveness about it. His location (Lulea, Sweden) near the Arctic circle has not hampered collecting QSL cards for the wall.

point our antennas straight west in the hours after sunrise, and there they are, South Africans. It's exciting, really, to think of the signal heading out over the Pacific, over Australia, into and across the Indian Ocean and its trackless surface, and into South Africa — Long Path indeed!

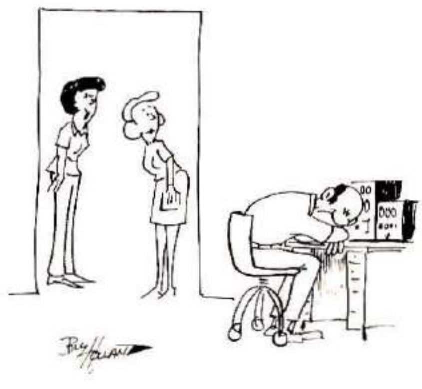
On 40 and 20 meters other reliable long paths exist: The Mid-East and Eastern Europe, beaming straight southwest in mid-winter; Australia, beaming ENE in winter; and India, straight south in winter.

Aiming your antenna is easy: You determine the short path bearing on the Great Circle map, and point your antenna in exactly the opposite direction. The trick is in knowing when to look for a long path opening. Really, experience is the best teacher, but the above information on paths will be a helpful start. Also, if you hear people calling a DX station and you can't hear him on the short path, or can only barely hear him, try pointing your antenna down the long path. Or, if you are listening to a weakish DX station, and he has a bit of echo on his signal, definitely try a "look" in the other direction.

Sometimes, you will even find a situation where both the long path and the short path are open. Then you try both paths, and pick the one offering best copy. This doesn't necessarily mean the strongest signal, but the one most free of echoes caused by the signal on the opposite path.

The other exception to normal-bearing short paths is the so-called "crooked" path. This condition defies conventional logic, and is difficult to forecast. It manifests itself when you hear a DX signal from an unusual direction. You turn your antenna toward him, and he drops out. Then you try long path, with similar results. The condition is due to a scattering effect, which we won't cover here. Usually, crooked-path signals show up on a path that is open to somewhere else. For example, you might hear Japanese stations out of the southwest when the band is open to the South Pacific, or you might hear Europeans on a band open to Central Africa, with no normal opening to Europe. All you can do to work these stations is turn your antenna until the signals peak, no matter what direction.

So, listen carefully, and good DX. **HRH**

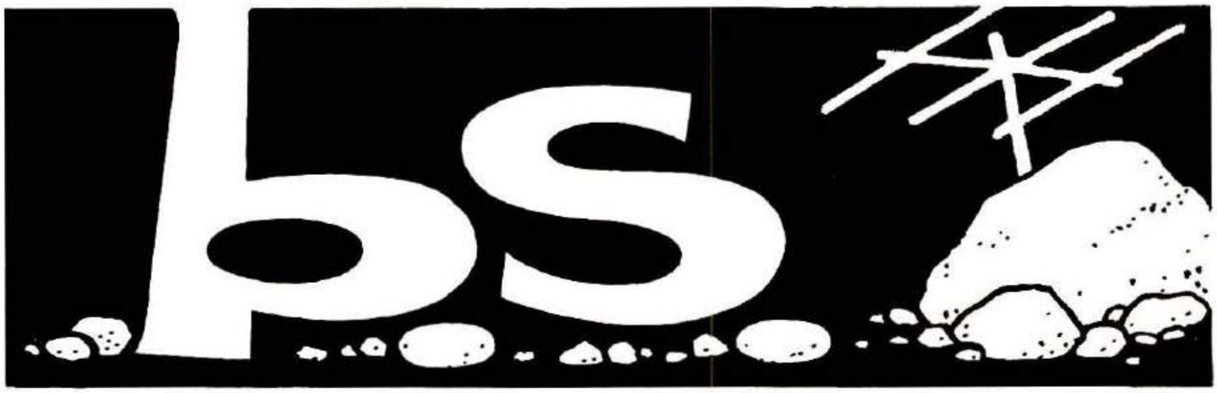


"Nothing serious. Little Mary Jane Hicks next door scooped him on working the DXpedition to Okino Tori-Shima."

More details? Ad Check page 78.

those days before spark...

a look at b.s.



A fascinating chapter in the hitherto unpublished history of hamming is revealed in all its exciting detail. The tragedy, pathos, unsung heroism, and — yes — laughter, are all here, just for you

BY LAURA SARGENT, WA7YUA

Radio meetings were invented in 35,000 B.C. by Grakk — who was looking for a way to get out of the cave a couple of evenings a month. Unfortunately, before he was able to patent the idea, his wife invented the big club and the concussion. (Mrs. Grakk later invented ladies' bridge parties — which didn't become really popular until 1183 when successful playing cards were invented.)*

Although radio itself was not invented until much later in history, there were some early unsuccessful attempts. For instance, one primitive tribe on the coast of France tied long twigs to seashells and tried, in vain, to get a different station (the noise-level was too high).

The first real breakthrough came about 50 B.C. in Greece. Lethargicus, temporarily out of work, was looking around for something to do. While toying with a knife and a piece of wood, he realized excitedly that he had carved a tuning knob. Unfortunately, before he got any further, he received news of the invention of unemployment compensation and went off to stand in line.

Lethargicus' knob somehow turned up in Europe several years later when a German (name unknown) got the idea of attaching it to a box. The story is that he spent the rest of his life carrying the box from one mountain-top to another — trying to get the best reception.

The next important development came centuries later. About 1220 an Italian scientist named Lasagne heard about the early Greek and German work and decided to continue the research himself. He locked himself up in his lab for three years and finally emerged with a working model containing something which he referred to mysteriously as the "insides." Unfortunately, Lasagne's radio could receive only one local rock station.

Another Italian, Fettucini, devoted his life to making a radio (based on the Lasagne "insides" theory) that would send and receive on all frequencies. In 1327 he was finally successful. Unfortunately, the Fettucini all-frequency radio received all the frequencies at once. (Some people liked to dance to it, but most thought it could be improved.)

The next advance after that was made by Linguini. In 1481 he built a radio that could be tuned to send and receive on individual frequencies. Soon after the completion of the first set he was astonished to hear a faint signal coming from another station — in Boston, Massachusetts. This was very interesting to Christopher Columbus (who happened to be visiting that day). He immediately began looking for ways to get across the ocean and exchange QSL cards.

Columbus missed Boston by a few miles, but the Pilgrims eventually landed near there.

*Note: our files for this period indicate that at least two early attempts to popularize playing cards were made, but failed — ostensibly because of the difficulty in shuffling decks of stone tablets. **Editor**

They were met by a small band of Indians who owned little except for the plastic Radio Tepee hand-helds they had been given for Christmas one year. The Pilgrims soon found out that the Indians were not much interested in trading for beads but would do almost anything for a Once-A-Month Free Battery card.

The Indians were very happy with their hand-helds and supply of fresh batteries. They especially liked to use them when they were surrounding the Pilgrims' village prior to an attack. One Indian would hoot like an owl into his radio and another would hear and hoot back. Fortunately for the Pilgrims, the Indians usually got so involved with their hooting that they forgot to fire any arrows.

Radio became very important to the further settling of this country. The westward push was in fact sponsored by the FCC — which had a lot of 6 and 7 calls that weren't being used.

Yes — radio has played an important and interesting role in the history of this country and the world. The next time you squeeze a mike, maybe you'll give thanks to some of the unsung heroes who labored to provide you with such a fun way to spend your time and money. **HRH**

More details? Ad Check page 78.

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10. **THE SPIKE JONES SHOW** (1949), **& VIC & SADE** (1946)
15. **THE ALDRICH FAMILY** (1939), **& LIFE WITH LUIGI** (1948).
16. **INNER SANCTUM** (1949), **& THE HERMIT'S CAVE** (1939)
20. **THE GREAT GILDERSLEEVE** (1948) **& OUR MISS BROOKS** (1949).
27. **LIGHTS OUT** (1943). **& THE WITCH'S TALE** (1939).
28. **GEORGE BURNS & GRACIE ALLEN** (1948)
32. **GUNSMOKE** (1952). **& THE ROY ROGERS SHOW** (1945)
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More details? Ad Check page 78.

DX forecaster

June, 1977

Keep an ear open for unusual weather and ionosphere conditions during the first week of the month, particularly around June 4th and 5th, and again between the 19th and 23rd, with maximum activity surrounding the summer solstice on the 21st.

Band outlook

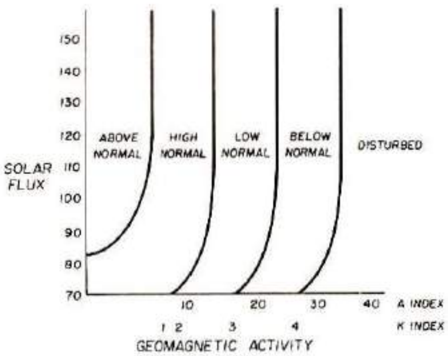
Twenty meters will provide the best DX, with a short early morning spurt, followed by prolonged late afternoon and evening activity. During the heat of the day, look for short skip out to 1000 miles (1600 kilometers) or so.

Fifteen meters will be open occasionally, mostly to South and Central America, although it will be worthwhile to look for activity to other areas between 0700 and 0800, and again between noon and 1800 hours, local time. Until sunspot activity really begins to climb, fifteen will not be much of a summer-time band. Short skip, however, out to about 1200 miles (1900 kilometers) will be prevalent.

Ten meter DX opportunities will be scarce, but on many days you will be able to make good use of short-skip conditions out to about 1300 miles (2000 kilometers) during the day.

Eighty and forty meters will open up during the darkness hours to many areas of the world — from the standpoint of signals being there. *Hearing* those signals will be a problem, however, because of thunderstorm activity. Short skip of up to 300 miles (500 kilometers) during the day and 800 miles (1200 kilometers) at night will be plentiful on 80 meters. On 40 meters, you can plan for good signals out to a maximum of 700 miles (1100 kilometers) during the day and 1000 miles (1600 kilometers) or more after dark.

Sporadic E activity during June should gladden the hearts of all high-frequency and very-high-frequency operators, with frequent openings on *6 meters* out to about 1200 miles (1900 kilometers), and less-frequent (but still good) *2-meter* openings out to about 1400 miles (2200 kilometers). The times to look will be an hour or so before and after local noontime, and again for an hour or so on either side of sunset. Don't forget *10 meters*, either!



This chart shows how the interaction between solar flux and the geomagnetic activity (*A* or *K* index) influences propagation conditions for the hf bands.

Using WWV's propagation information

WWV gives much information of value to the DXer at 18 minutes after each hour, on all of the frequencies they use: 2.5, 5.0, 10.0, and 15.0 MHz. The information consists of *Solar Flux* data plus *Geomagnetic Activity*, using the *A* and *K* Indexes. The following chart was published by the International Shortwave Listeners magazine, *Monitor*.* By transferring the WWV information to the chart, you can quickly plot the crossover point and directly "read" the condition of the ionosphere. Conditions from *low normal* through *above normal* are the ones to use for your forays into the DX jungle. Good hunting!

HRH

**Monitor* (England), December, 1976.

Glossary of Terms

Sporadic E is a little-understood phenomenon that affects the lower (E) level of the ionosphere and results in strong short-skip propagation. Highly ionized "clouds" seem to appear in the E layer, remaining in place for minutes, or even hours, producing strong but relatively "local" conditions of good propagation — particularly at the upper end of the hf spectrum and lower end of the vhf spectrum. Quite unpredictable, hence the term "sporadic."

Solar Flux is a measurement of radiation from the sun at 2800 MHz and is used to determine solar flux. Values from about 70-150 are chosen to represent the flux level. In general, the higher the solar flux, the higher the degree of ionization. Essentially a product of ultraviolet radiation.

Geomagnetic Activity. Solar particle radiation from the sun directly affects the earth's magnetic field, and can cause the ionospheric activity to weaken or disappear entirely. It is responsible for fading, flutter, and increased noise levels. The **A Index** is the daily (planetary) *average* of measurements taken at all participating observatories worldwide and, hence, is about 24 hours late when reported. The **K Index** is related to the **A Index**, but consists of measurements taken at the Fredricksburg, Virginia, observatory, and reported every three hours. In general, the lower the **A** and **K Indexes**, the better the ionosphere for radio propagation.

JUNE

WESTERN USA

GMT	PDT	N (CENTRAL ASIA)	NE (EUROPE)	E (S. AFRICA)	SE (S. AMERICA)	S (ANTARCTICA)	SW (NEW ZEALAND)	W (W. AUSTRALIA OCEANIA)	NW (FAR EAST)
0000	5:00	—	20	20	15	15	15	20	—
0100	6:00	—	—	—	15	15	15	20	—
0200	7:00	—	—	20	15	—	15	15	—
0300	8:00	—	—	20	15	—	15	15	—
0400	9:00	20	40	20	20	20	15	15	—
0500	10:00	20	40	40	20	20	20	15	—
0600	11:00	20	40	40*	20	20	20	20	20
0700	12:00	—	—	40*	20	20	20	20	20
0800	1:00	—	—	40*	40	—	20	20	20
0900	2:00	—	—	—	40	—	20	20	20
1000	3:00	—	—	—	80*	—	20	20	20
1100	4:00	—	—	—	80*	40	40	40	20
1200	5:00	—	—	—	—	40	40	40	20
1300	6:00	—	—	—	—	40	40	80*	40
1400	7:00	—	—	—	—	—	40	80*	40
1500	8:00	20	20	—	20	—	20	20	20
1600	9:00	20	20	—	20	—	20	20	—
1700	10:00	20	20	—	20	—	20	—	—
1800	11:00	20	—	—	20	—	—	—	—
1900	12:00	20	—	—	20	—	—	—	—
2000	1:00	—	—	—	20	—	—	—	—
2100	2:00	—	—	20	15	—	—	20	—
2200	3:00	—	20	20	15	—	20	20	—
2300	4:00	—	20	20	15	—	15	20	20

MID USA

GMT	MDT	N (CENTRAL ASIA)	NE (EUROPE)	E (S. AFRICA)	SE (S. AMERICA)	S (ANTARCTICA)	SW (NEW ZEALAND)	W (AUSTRALIA)	NW (FAR EAST)	CDT
0000	6:00	—	20	20	15	—	—	15	—	7:00
0100	7:00	—	—	20	15	—	—	15	—	8:00
0200	8:00	—	20	20	20	—	15	—	—	9:00
0300	9:00	20	20	—	20	20	15	20	20*	10:00
0400	10:00	20	20	—	20	20	15	20	20*	11:00
0500	11:00	20	40*	—	20	20	20*	20	20	12:00
0600	12:00	20	40	—	40	20	20*	20	20	1:00
0700	1:00	—	40	—	40	20	20	20	20	2:00
0800	2:00	—	40	—	40	—	20	20	—	3:00
0900	3:00	—	—	—	40	—	20	20	—	4:00
1000	4:00	—	—	—	40	40	40	40	—	5:00
1100	5:00	—	—	—	40	40	80*	40	—	6:00
1200	6:00	—	—	—	40	80	80*	40	—	7:00
1300	7:00	—	—	—	—	40	40	40	—	8:00
1400	8:00	—	20	—	20	40	40	20	20	9:00
1500	9:00	—	20	—	20	—	—	20	20	10:00
1600	10:00	—	20	—	20	—	—	20	20	11:00
1700	11:00	—	—	15	20	—	—	—	20	12:00
1800	12:00	—	—	15	20	—	—	—	20	1:00
1900	1:00	—	—	—	20	—	—	—	—	2:00
2000	2:00	—	—	—	15	—	—	—	—	3:00
2100	3:00	—	20	20	15	—	—	—	—	4:00
2200	4:00	—	20	20	15	—	—	—	—	5:00
2300	5:00	—	20	20	15	—	—	15	—	6:00

EASTERN USA

GMT	EDT	N (FAR EAST)	NE (EUROPE)	E (CENTRAL AFRICA)	SE (S. AFRICA)	S (S. AMERICA)	SW (OCEANIA)	W (W. AUSTRALIA NEW ZEALAND)	NW (AUSTRALIA)
0000	8:00	—	20	20	20	20	15	—	—
0100	9:00	—	20	20	—	20	15	—	—
0200	10:00	—	40	20	40	20	20	20	15
0300	11:00	—	80*	40*	40	20	20	20	15
0400	12:00	—	80*	40*	40	40*	20	20	20*
0500	1:00	—	80*	40*	40	40*	20	20	20
0600	2:00	—	40	40	40	40*	20	20	20
0700	3:00	—	—	—	—	40	40	40	20
0800	4:00	—	—	—	—	40	40	40*	40
0900	5:00	40	—	—	—	40	40	40*	40*
1000	6:00	40	—	—	—	—	40	40*	40
1100	7:00	40	—	20	—	—	40	40	40
1200	8:00	20	20	20	—	20	20	20	20
1300	9:00	20	20	—	—	20	20	20*	20
1400	10:00	20	20	—	—	20	20	20*	20
1500	11:00	20	—	—	—	20	20	20	20
1600	12:00	20	—	—	15	20	—	—	—
1700	1:00	—	—	—	15	20	—	—	—
1800	2:00	—	—	—	—	20	—	—	—
1900	3:00	—	20	15	—	20	—	—	—
2000	4:00	—	20	15	20	15*	—	—	—
2100	5:00	—	20	20*	20	15*	—	—	—
2200	6:00	—	20	20*	20	15*	—	—	—
2300	7:00	—	20	20	20	20	—	—	—

HAM CALENDAR

June 1977

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
*All international events such as contests are shown on the GMT days on which they take place even though they may actually begin on the evening of the preceding day in North America	Digital Electronics for Automation Workshop — Two-day workshop based on the small scale and medium scale TTL integrated circuits. Many hours of laboratory time with individual breadboarding stations will be provided along with indepth lectures — Info: Dr. Norris Bell, VPI & SU Continuing Education Center, Blacksburg, VA 24601 (703) 951-6328 — 7-8 June		Westcoast Qualifying Run 1	2	ARRL National Convention by the Scarborough ARC, The Sheraton Centre, Toronto, Ontario, Canada 3-5 3	Minnesota State QSO Party — By the Heartland ARC — 1800Z 5/4 — 2359Z 6/5 — Excellent warm-up for Field Day and excellent contest for Techs and Novices to get involved in — Tech and Novice frequencies 3725, 7125, 21125, 28125 — Info: Ham Radio Horizons, Greenville, NH 03048 4
Arrow Repeater Hamfest — Chelsea Fairgrounds — I-94 at exit 159 — Ann Arbor, MI Manassas Hamfest — By the "Ole Virginia Hams" ARC, Prince William County Fairgrounds — 1/2 mile S. of Masassas, VA on Rt. 234 — WA4RVN Perkiomen Valley ARC Hamfest — Perkiomenville Sale & Auction Ground, Rt. 29 — Perkiomenville, PA — WA3EBX Rome Ham Family Day — The Beeches, Rt. 26 — Rome, NY Starved Rock RC Hamfest — Bureau County Fairgrounds, Princeton, IL — W9MKS/WR9AFG Tri State ARA W8VA Hamfest — Camden Park, Rt. West — Huntington, WV 5	6	AMSAT Eastcoast Net 3850 kHz 9PM EDST (0100Z Wednesday Morning) AMSAT Mid-Continent Net 3850 kHz 9PM CDST (0200Z Wednesday Morning) AMSAT Westcoast Net 3850 kHz 8PM PDST (0300Z Wednesday Morning) 7	8	Microcomputer Interfacing Workshop — Three-day workshop based on the popular 8080 Microprocessor. Over 20 operating 8080 computers available for participant use. Info: Dr. Norris Bell, VPI & SU Continuing Education Center, Blacksburg, VA 24061 (703) 951-6328 — 9-11 9	10	ARRL VHF QSO Party — 11-12 Bermuda Field Day — 11-12 Tri-State Amateur Hamfest — By the Chickasaw ARA, National Guard Armory — Hernando, MS — 11-12 11
Hall of Science ARC Fleamarket/Hamvention The Egyptian RC Hamfest — Club Grounds — Granite City, IL 12	13	AMSAT Eastcoast Net 3850 kHz 9PM EDST (0100Z Wednesday Morning) AMSAT Mid Continent Net 3850 kHz 9PM CDST (0200Z Wednesday Morning) AMSAT Westcoast Net 3850 kHz 8PM PDST (0300Z Wednesday Morning) W1AW Qualifying Run (+40 wpm) 14	15	16	17	All Asian DX Contest — Phone — 1000Z 6/18 — 1600Z 6/19 ARRL Georgia State Convention — Atlanta, GA — 18-19 Medicine Butte RA and Rosebud ARC South Dakota Hamvention, Chamberlain, SD — 18-19 West Virginia QSO Party — 18-19 18
Amateur Radio Week — 19-25 Santa Maria Amateur Radio Picnic/Swapfest — By the Satellite ARC — Newlove — Union Oil Picnic Grounds on Orcutt Hill — Santa Maria, CA 19	20	AMSAT Eastcoast Net 3850 kHz 9PM EDST (0100Z Wednesday Morning) AMSAT Mid-Continent Net 3850 kHz 9PM CDST (0200Z Wednesday Morning) AMSAT Westcoast Net 3850 kHz 8PM PDST (0300Z Wednesday Morning) 21	W1AW Morning Qualifying Run 22	23	24	ARRL FIELD DAY — 25-26  CQ FIELD DAY CQ FIELD DAY CQ FIELD DAY 25
26	27	AMSAT Eastcoast Net 3850 kHz 9PM EDST (0100Z Wednesday Morning) AMSAT Mid-Continent Net 3850 kHz 9PM CDST (0200Z Wednesday Morning) AMSAT Westcoast Net 3850 kHz 8PM PDST (0300Z Wednesday Morning) 28	29	Mobile Amateur Radio Awards Club County Hunters Convention — Rochester, MN — 6/30-7/3 30		

Dear Horizons:

Rundlett, K4ZA, just phoned me the good news about the new *Ham Radio Horizons* magazine, and read me the prospectus.

I hasten to write to congratulate you and the staff who conceived this magazine, which will be a welcome addition to the ham media and which should fulfill a long present void!

As you well know I have been a booster of *ham radio* for some time, the entire life of the magazine in fact! And I wish to become a steady contributor to the new *Horizons* . . .

A. David Middelton, W7ZC
Springdale, Utah

Dear Horizons:

"I want to be a Ham."

After reading the March, 1977, issue of *Ham Radio Horizons*, I am convinced that ham radio is for me.

I am currently operating a CB mobile and base station (license KBD 0878). I have become discouraged at times trying to talk on a much congested system.

Please send me a catalog and suggested study material for becoming a ham.

Jerry E. Teter
Tamaqua, Pennsylvania

Dear Horizons:

I am writing to tell you how well I am pleased with your magazine *Ham Radio Horizons*. I find your magazine down to earth, interesting, and informative. I was especially pleased with your article "The call from Cedro Canyon" by A. David Middelton, W7ZC.

For years I really enjoyed hamming when I had a house with an outdoor antenna on 80, 40, and 15 meters, but since moving to an apartment house, steel structured, and with restrictions on outdoor antennas, I have to operate with an indoor L-shaped antenna which limits my enjoyment. Is there anyway to enjoy hamming under these restrictions? I would like to see articles, if possible, on apartment operating. Perhaps others have found a way.

Thanking you again for a very interesting magazine.

Max Mendelson
Bayside New York

We have an article in the works at this moment that may help you out, Max. It is called "Antennas for Tiny Yards," and will appear in Horizons *soon. It addresses the problem of limited-space antennas and there are a couple of ideas that will help the apartment dweller. Perhaps one of the antennas presented will do the job for you. If not, there'll be more antenna articles later.* **Editor**

Dear Horizons:

I have just read *Ham Radio Horizons* and I believe it's the best publication for beginners I've seen for some time. I have been interested in becoming a ham, and now seems to be the time. Thanks for the push.

Bruce H. Hanson, KWF 7342
Alamogordo, New Mexico

Dear Horizons:

I had been an inactive radio amateur for approximately seven years until I read the first issue of *Ham Radio Horizons*. This new magazine has since inspired me to once again become active in Amateur radio, with a fervor that I haven't had since I first received my Novice license in 1960.

It is truly a pleasure to find a ham magazine with articles of general interest, rather than solely of a technical nature. Truly, I found each article interesting and informative.

Robert S. Andrews, K1TJE
Brookfield Center, Connecticut

Dear Horizons:

I am 12 years old and about to get my Novice license. I really enjoy your magazine and the two articles on how to get on the air. The only disappointment I found was on page 28 of your first issue. It would be greatly appreciated if you could send me the circuit (or tell me how to get it) for the receiver and QRP transmitter.

Paul Drexler
Wycombe, Pennsylvania

Dear Horizons:

I love your new magazine! I was given a copy at Universal Service, the local ham store here in Columbus. I was previously licensed (K8GMS), but let my license lapse several years ago. I just purchased a Sony ICF-5900W receiver (portable), which brings me to the subject of this letter. The QRP transmitter pictured on page 28 of the March issue is just what I have been looking for to go with the Sony!

I wonder if it would be possible for you to tell me where I can get details on the construction of this unit.

Thank you very much for your attention — I hope to regain my call soon and get back on the air "QRP."

William L. Morrow
Columbus, Ohio

In response to the many similar requests for more information about the Novice receiver and the low-power transmitter that were mentioned in March issue of Horizons, *we are going to reprint the material from* ham radio *magazine, where they first appeared. You'll be seeing them described fully in* Horizons *before long.* **Editor**

Dear Horizons:

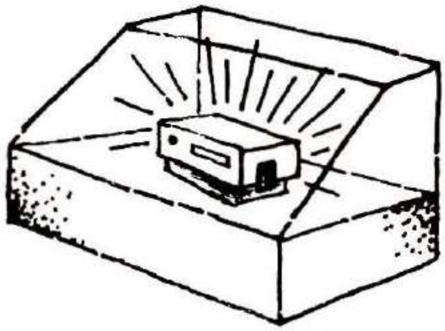
I just received your April, 1977, issue. I feel compelled to object to the so called "Zero Bandwidth SSB" by Agyle Karryer. Could he be the same WIOU who writes for another magazine?

If you must be funny, please issue comic magazines and leave Amateur radio alone. Any more such articles will lead to my cancellation!

Donald E. Thomas
Millville, New Jersey

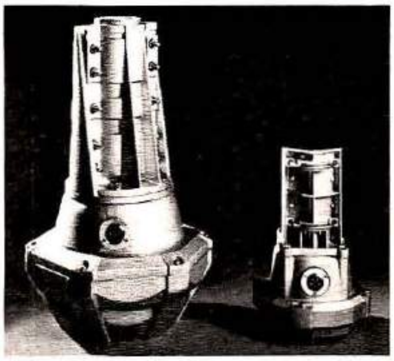
Prof. Karryer replies: "No I don't write for other magazines, and I am sorry if my sense of humor offends Mr. Thomas. I didn't realize that the world was so grim." **Editor**

PRODUCT



SHOWCASE

New Rotor Line Available from Wilson



The rotor everyone has been waiting for will be available in early 1977 from Wilson Electronics Corp., Las Vegas, Nevada. The Model WR1000 Rotor has been designed to handle the largest antenna arrays up to 25 square feet (2.3m²) of wind loading. A stainless steel spur ring gear design is superior to prop pitch models, and provides a full 4,000 inch-pounds (450N-m) of turning torque. The solenoid controlled wedge-type braking system requires 12,000 inch-pounds (1355N-m) before over-riding. The WR1000 Rotor weighs 60 pounds (27kgm), is 11 x 19 inches high, and features 116 steel ball bearings, and can handle over one *ton* of balanced weight.

Also being introduced is the Model WR500 Rotor, considered mechanically superior to other rotors presently being marketed, with 780 inch pounds of turning torque before stalling, a special disc type built-in braking system requiring 1300 inch pounds of torque before windmilling which is twice that of other comparably priced rotors on the market.

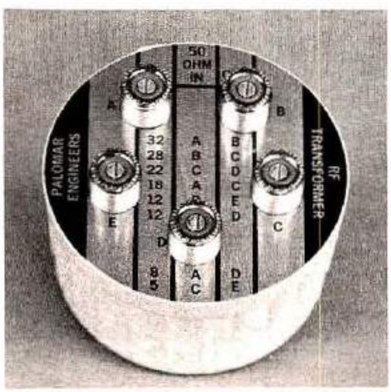
The WR500 has a 98 steel ball bearing raceway capable of handling 750 pounds balanced weight, and assures elimination of side torque jamming when rotor is mounted in line with the mast.

The suggested list price on the new Wilson Rotors will be $429.00 for the WR1000, and $119.95 for the WR500.

RF Transformer Matches Vertical Antennas

Palomar Engineers has introduced a wideband rf transformer rated at 5 kW PEP (2 kW CW, ccs) from 1-30 MHz. Taps are provided to match 50-ohm coaxial cable to 32, 28, 22, 18, 12, 8, or 5-ohm antennas. The transformer is *unbalanced-to-unbalanced* for use with short vertical and whip antennas.

Quarter-wave antennas, or short verticals that have been resonated with loading coils, can be matched to 50-ohm coaxial cable by selecting the proper tap on the rf transformer. In many cases the transformer can be used instead of an antenna tuner. It is much smaller than a tuner of equivalent power handling capability, is less expensive, and is more efficient. It has

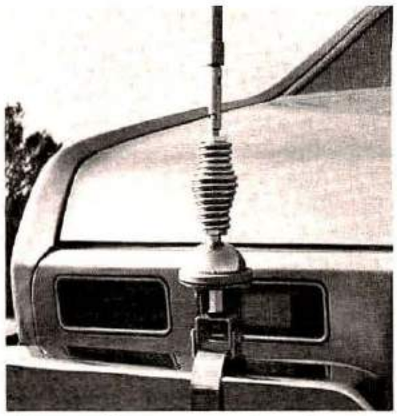


particular application to phased vertical directional arrays.

The transformer is wound with teflon-insulated wire on an rf ferrite toroid core, has uhf (SO-239) connectors, and is epoxy-encapsulated in a white PVC case so that it can be used in any climate. Loss through the transformer is less than 0.1 dB. Size is 3½" (89mm) diameter and 2½" (64mm) high. Price is $42.50, postpaid, in the United States and Canada.

For additional information, write to Palomar Engineers, Box 455, Escondido, California 92025.

Deluxe Mobile Antennas



Swan Electronics has just announced a new series of mobile antennas and antenna accessories for frequencies between 3.5 and 30 MHz. The *Model 45* is rated at 1000 watts peak envelope power, and may be manually switched to any one of five bands: 10, 15, 20, 40, and 75 meters.

Swan antenna accessories include the *SWR-1A* relative power meter, the *WM-1500* in-line wattmeter, the KDS heavy-duty spring for mobile antennas, the ABM mobile antenna ball mount, and the stainless-steel strap bumper antenna mount.

The *Model 45* five-band antenna, including base section, coil, and top section lists for $119.95. The HDS spring retails for $15, the ABM ball mount lists for $15, and the strap bumper mount is priced at $17.

For additional information, write Swan Electronics, 305 Airport Road, Oceanside, California 92054.

More details? Ad Check page 78.

HORIZONS ad-scan

RATES Regular classified is available at 50¢ per word. Display classified (1 inch deep x 2¼ inches wide) is $50, or at the 12x rate is $35. All Ad Scan payable in advance. No cash discounts or agency commissions allowed.

HAMFESTS Sponsored by non-profit organizations receive one free regular classified ad (subject to our editing). Repeat insertions of hamfest ads pay the standard rate.

COPY No special layout or arrangements available. Material should be typewritten or clearly printed (not all capitals) and must include full name and address. We reserve the right to reject unsuitable copy. **Ham Radio** cannot check each advertiser and thus cannot be held responsible for claims made. Liability for correctness of material limited to corrected ad in next available issue.

DEADLINE 15th of fourth preceding month.

SEND MATERIAL TO: Ad Scan, Horizons, Greenville, N. H. 03048.

THE FIRST WEST COAST COMPUTER FAIRE. A conference & exposition on personal & home computers is being held at the San Francisco Civic Center, April 15. Over 200 exhibits and 100 conference sessions on Saturday and Sunday, April 16-17. $9 at the door for two days — preregistration is less. Contact: The Computer Faire, Box 1579, Palo Alto, CA 94302.

ATTENTION MICHIGAN HAMS! See us for Collins, Drake and Ten-Tec gear. W8RP, WB8UXO, WB8VGR. Purchase Radio Supply, 327 E. Hoover Ave., Ann Arbor, MI 48104. Ph. 313-668-8696.

QSL's with class! Unbeatable quality — reasonable price. Samples. QSL's Unlimited, Box 27553, Atlanta, GA 30327.

WYOMING

Ranch land. Antelope, deer, elk, wild horses — Your "Antenna Ranch." 10 Acres $35 down, $35 month. FREE info — maps — photos. Owner.

Dr. Michael Gauthier, K6ICS
9550HH Gallatin Rd., Downey, CA 90240

26th DAYTON HAMVENTION at Hara Arena, April 29, 30, May 1, 1977. Technical forums, exhibits, and huge flea market. Program brochures mailed March 7th, to those registered within past three years. For accommodations or advance flyer, write Hamvention, P.O. Box 44, Dayton, Ohio 45401.

MOBILE IGNITION SHIELDING provides more range with no noise. Bonding strap sale less than 50¢ each. Literature. Estes Engineering, 930 Marine Drive, Port Angeles, Wash. 98362.

ILLINOIS Egyptian Radio Club, W9AIU, Annual Hamfest June 12, 1977 at Granite City, Ill. Club House. Talk in 146.6/76, food available, games for children, activities for ladies, swap row, main prizes (tickets at parking lot), attendance prizes for OM and XYL's.

CODE PRACTICE OSCILLATORS, hand keys, electronic keyers, other products. Free catalogs. GLOBALMAN PRODUCTS, Box 246, El Toro, Calif. 92630. 714/533-4400.

VACATIONLAND HAMFEST: Enjoy a family outing at Sandusky, Ohio, Sunday, May 22, 1977. Cedar Point Amusement Park only 5 minutes away. Lodging, camping and picnic facilities nearby. Indoor-outdoor flea market area, room for all — rain or shine. Info and reservations — WB8LLY, P.O. Box 2037, Sandusky, Ohio 44870.

FREE CATALOG. Unique Components, Kits, Calculators, Digital Thermometers, Ultrasonics, Strobes, Ni-cads, Leds, Transistors, IC's, Chaney's, Box 27038, Denver, Colo. 80227.

SECOND ANNUAL KEY WEST CONCH—FEST May 8-9 $12.00 includes one dinner and admission to many attractions in the Key West area. Door prizes will be awarded. Reservations and room information available from Dennis Farr, 1831 Harris Ave., Key West, Fl. 33040.

NEED HELP For your novice or general ticket? Complete audio-visual theory instruction. Easy, no electronic background necessary. Write for free information: Amateur license instruction, P.O. Box 6015, Norfolk, Virginia 23508.

UR TRIPOLE MULTI-BAND

All-band antenna. Guaranteed. 80 to 6 Meters plus 160' 5 SWL Bands. Built-in balun. 2 KW PEP rating. No retuning, tap or trap changes. 80 to 120 ft inverted-V or horizontal. Available in kit form or assembled.
Kit T80-K . . . . $54.95 cash PPD in USA

Texas residents add 5% sales tax. Send postal card for information on TRIPOLE antennas and feedline kits.

Universal Radio Co. Dept. H3
Box 26041 El Paso, TX 79926
Telephone (915) 592-1910

DIPOLE ANTENNA CONNECTOR

HYE-QUE (HQ-1) dipole connector has coax SO-239 socket molded into glass filled plastic body to accept coax PL-259 plug on feedline. Drip-cap keeps coax fittings dry. Instructions included. Guaranteed. At your dealers or **$3.95 postpaid.** Companion insulators **2/$.99.**

BUDWIG MFG. Co. PO Box 97H, Ramona, CA 92065

RADIO EXPO, CHICAGO. September 17, 18, at Lake County Illinois fairgrounds. Manufacturers' exhibits, flea market, seminars, and door prizes. 4000 attended last year! Exhibitors are urged to reserve booth space now — call Doug Thornton workdays at (312) 595-0020.

IF YOU'RE LOOKING here for used ham gear, there's at least one other place you should be looking: Buyers & Sellers weekly equipment list. Each list (updated every week) contains hundreds of pieces of gear, currently available all over the United States, organized into SSB transmitters, 5 band transceivers, linears, etc. all having our mail purchase guarantee. A sample copy is FREE by sending a Self Addressed Stamped Envelope to: Buyers & Sellers — Dept. ZC, P.O. Box 73, Kenmore Station, Boston, Mass. 02215

MULTI-BAND DIPOLE TRAPS. PACE-TRAPS are the key devices required to build the All-Band dipole depicted in the ARRL Handbook. Two models available. NG-Series (novice gallon) — $14.95 pr. FG-Series (full-gallon) $16.95 pr. Shipped postpaid in USA, Conn. residents add 7% tax. Check or M.O. to Pace-Traps, Upland Rd., Middlebury, CT 06762.

MASSACHUSETTS. NOBARC, Northern Berkshire Amateur Radio Club Hamfest, July 9 & 10 at Cummington Fair Grounds, Cummington, Mass. Details from Hildy Sheerin, WA1ZNE.

NEW HAMPSHIRE. Hosstraders Annual Tailgate Swapfest, Saturday, May 7, all day, at the Deerfield, NH fairgrounds. Admission 75¢. Dealers welcome. Excess revenue to benefit Shriners Hospital for Crippled Children in Boston. SASE for details to Norm, WA1IVB, Box 32, Cornish, ME 04020 or Joe, K1RQG, Star Rt., Box 56, Bucksport, ME 04416.

MANASSAS HAMFEST Prince William County Fairgrounds — ½ mile south of Manassas, Va. on Rt. 234 Info: Send large S.A.S.E. to: Bill Turner WA4RVN, 312 E. Brunswick St., Sterling, Va. 22170.

SPOKANE ARC HAMFEST — Pence Union Bldg. at Eastern Wash. State College. Sat. & Sunday July 16th & 17th. Info WA7BWO, Drawer "A", Cheney, Wash. 99004, or WA7IKZ.

K1FCO, members of the 143 Communications Flight (Spt), Rhode Island Air National Guard, plan to be operating on Armed Forces Day, May 21, 1977. Anyone working our club station, K1FCO, will receive a commemorative certificate from our unit provided a S.A.S.E. and QSL card are sent to us. Our mailing address is; K1FCO, 143 Communications Flight, Rhode Island Air National Guard, T. F. Green Airport, Warwick, R. I. 02886. We will be operating on the following frequencies; 21.385 MHz 1400Z to 1800Z, 14.330 MHz 1400Z to 1800Z, 7.280 MHz 1400Z to 1800Z, 50.700 MHz 1400Z to 1800Z.

SST T-1 RANDOM WIRE ANTENNA TUNER

All band operation (160-10 meters) with most any random length wire. 200 watt output power capability. Ideal for portable or home operation. Toroid inductor for small size: 3 x 4-1/4 x 2-3/8. Built-in neon tune-up indicator. SO-239 coax connector. Guaranteed for 1 yr., 10 day trial. Compact — easy to use. . .only $29.95 postpaid. (Add Sales Tax in Calif.) (213) 376-5887

SST ELECTRONICS, P.O. BOX 1, LAWNDALE, CA. 90260

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Limit 15 inquiries per request.

JUNE, 1977

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Ham Radio UK
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Holland Radio, 143 Greenway
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More details? Ad Check page 78.

More details? Ad Check page 78.

TS-820

The ultimate transceiver . . . Kenwood's TS-820. No matter what you own now, a move to the TS-820 is your best move. It offers a degree of quality and dependability second to none, and as the owner of this superb unit, you will have at your fingertips the combination of controls and features that, even under the toughest operating conditions, make the TS-820 the *Pacesetter* that it is.

Features

Following are a few of the TS-820's many exciting features.

SPEECH PROCESSER • An HF circut provides quick time constant compression using a true RF compressor as opposed to an IF clipper. Amount of compression is adjustable to the desired level by a convenient front panel control.

IF SHIFT • The IF SHIFT control varies the IF passband without changing the receive frequency. Enables the operator to eliminate unwanted signals by moving them out of the passband of the receiver. This feature alone makes the TS-820 a pacesetter.

TV-506 TV-502 VFO-820 TS-820 SP-520

PLL • The TS-820 employs the latest phase lock loop circuitry. The single conversion receiver section performance offers superb protection against unwanted cross-modulation. And now, PLL allows the frequency to remain the same when switching sidebands (USB, LSB, CW) and eliminates having to recalibrate each time.

DIGITAL READOUT DG-1 • (optional) A digital counter display can be employed as an intergral part of the VFO readout system. Counter mixes the carrier, VFO, and first heterodyne frequencies to give *exact* frequency. Figures the frequency down to 10 Hz and digital display reads out to 100 Hz. Both receive and transmit frequencies are displayed in easy to read, Kenwood Blue digits.

Specifications

FREQUENCY RANGE: 1.8-29.7 MHz (160 - 10 meters)
MODES: USB, LSB, CW, FSK
INPUT POWER: 200W PEP on SSB
160 W DC on CW
100 W DC on FSK
ANTENNA IMPEDANCE: 50-75 ohms, unbalanced
CARRIER SUPPRESSION: Better than 40 dB
SIDEBAND SUPPRESSION: Better than 50 dB
SPURIOUS RADIATION: Greater than -60 dB (Harmonics more than -40 dB)
RECEIVER SENSITIVITY: Better than 0.25uV
RECEIVER SELECTIVITY:
SSB 2.4 kHz (-6 dB)
4.4 kHz (-60 dB)
CW* 0.5 kHz (-6 dB)
1.8 kHz (-60 dB)
*(with optional CW filter installed)
IMAGE RATIO: 160-15 meters: Better than 60 dB
10 meters: Better than 50 dB
IF REJECTION: Better than 80 dB
POWER REQUIREMENTS: 120/220 VAC, 50/60 Hz, 13.8 VDC (with optional DS-1A DC-DC converter)
POWER CONSUMPTION: Transmit: 280 Watts
Receive: 26 Watts (heaters off)
DIMENSIONS: 13-1/8" W x 6" H x 13-3/16" D
WEIGHT: 35.2 lbs (16 kg)

VFO-820
Function switch provides any combination of transmit/receive/transceive with the TS-820. Both are equipped with VFO indicators showing which VFO is in use.

SP-520
Although the TS-820 has a built-in speaker, the addition of the SP-520 provides improved tonal quality. A perfect match in both design and performance.

TV-502
The TV-502 transverter puts you on 2-meters the easy way. Operates in the 144.0-145.7 MHz frequency range with a 145.0-146.0 MHz option. Completely compatible with the TS-820, the TS-520 and most any HF transceiver.

TV-506
Similar to the TV-502 except that it opens up the 6-meter band (50.0-54.0 MHz) to your HF rig.

TRIO-KENWOOD COMMUNICATIONS INC. 116 EAST ALONDRA/GARDENA, CA 90248

KENWOOD
...pacesetter in amateur radio

- 100% solid state SSB/CW Transceiver.
- Full coverage of 10-160 meter bands.
- 350 watts P.E.P. or CW input.
- Digital Dial Frequency Readout (Optional).
- Plug-in auxiliary VFO or crystal oscillator (Optional).

The transceiver that has everything you'll ever need!

The 350-XL was designed to fill all the operating requirements of the ham operator. Whether you operate fixed, portable, or mobile, SSB, CW, RTTY, or SSTV, the 350-XL is the perfect rig. It has the performance, versatility, and power to give you everything you need all in a single, compact, high quality transceiver.

We deliberately made many of our special features such as the auxiliary VFO and the Digital Dial Frequency Readout optional so that every feature you could possibly want is available, but you only pay for those that you use. We even made our programmable selectivity filter an option, enabling us to lower the base price of the 350-XL to $895.

The Atlas 350-XL is the State of the Art in Amateur Radio Transceivers for the Next Decade, but available today at your ham dealer.

Atlas 350-XL (less options)	$895.
Model DD6-XL Digital Dial Readout	$195.
Model 305 Plug-in Auxiliary VFO	$155.
Model 311 Plug-in Auxiliary Crystal Oscillator	$135.
Model 350-PS Matching AC Supply	$195.
Mobile Mounting Bracket	$ 65.

Other optional features to be announced.

THE ATLAS 350-XL

ATLAS RADIO INC.

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