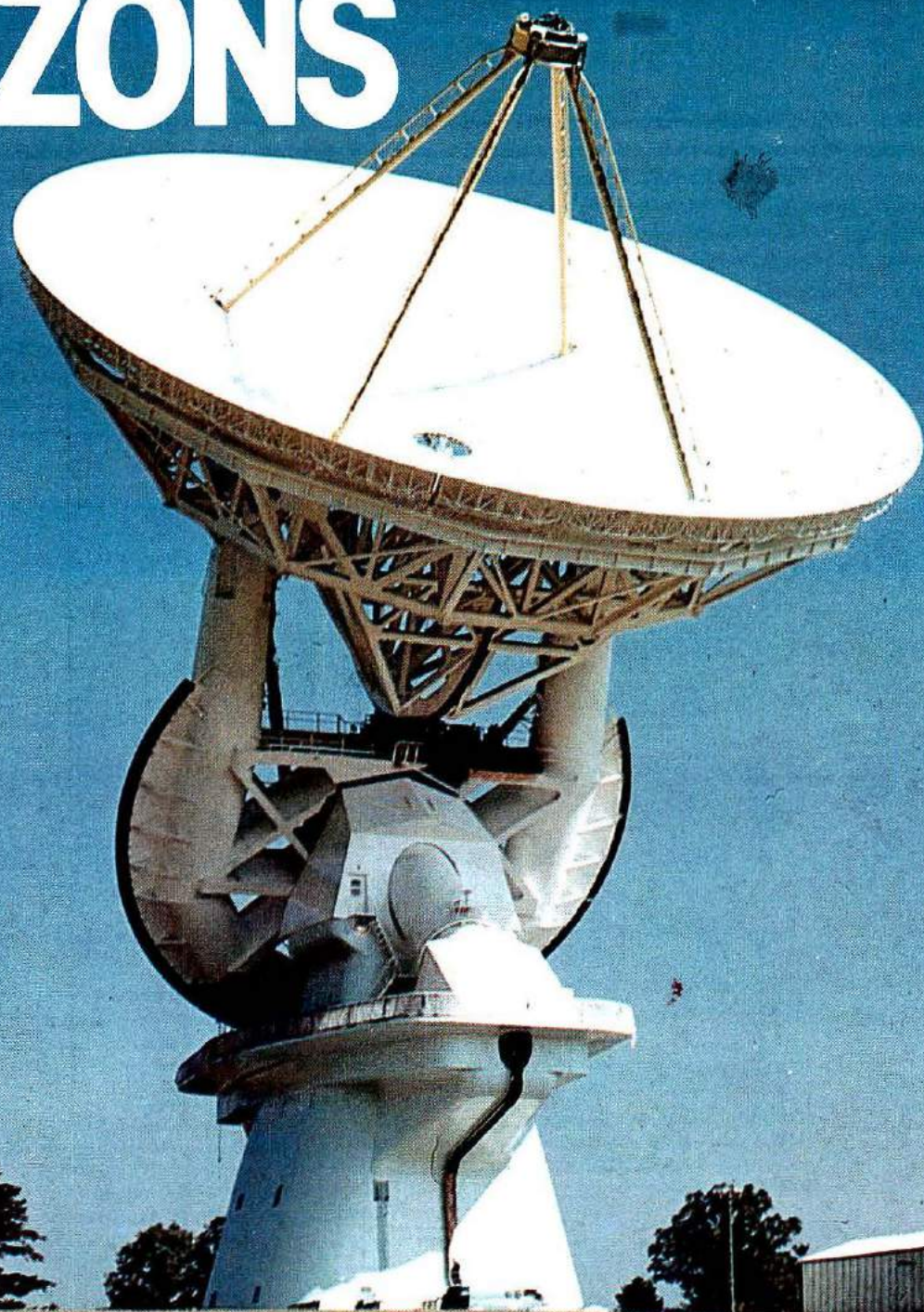


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AM RADIO HORIZONS



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Drake FS-4 Solid State Synthesizer
shown with Drake R-4C, MS-4 and T-4XC

Drake is ready for 1979 TODAY!

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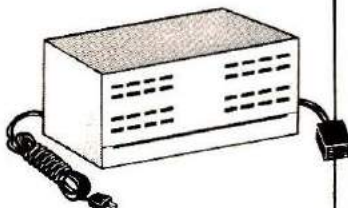


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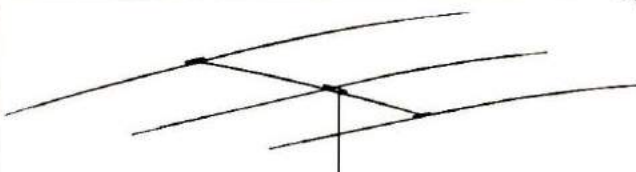
KENWOOD 599D receiver & transmitter

R-599D features: All solid-state - frequency range from 1.8 to 29.7 MHz, WWV & CB band, High stability VFO, 5 fixed channel oscillator, built-in noise-blanker, built-in squelch circuit, built-in crystal filters (SSB/8 pole, CW/8 pole, AM/6 pole), Accurate S meter indication regardless of RF GAIN, 110 AC or 220 AC or 13.8 VDC, 1A. Accessory circuits: AGC (slow/fast/off), CAL (25 kHz), RIT, noise blanker, ANL (AM), Squelch, Monitor, VFO selector, VFO terminal, VFO indicator. Item No. 8505-113

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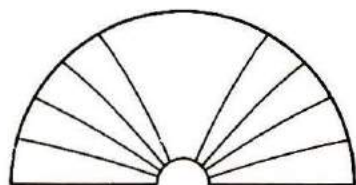


Long's Electronics

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THIS MONTHS



HORIZONS

An Oracle — Radio Astronomy

Radio signals from other planets? From the Milky Way? Yes indeed . . . but don't expect to hear far-out rock groups or the Music of the Singing Spheres. More properly termed "emissions," these signals are indications of the presence of elements and processes that are basic to matter in the universe. Here is a story of the planning and dedication of those who are trying to unravel the puzzle of what's "out there."

A Plan For Morse Code

One of the first steps in reaching for the Amateur Radio Operator's license is learning Morse Code. This article will not only tell you why, but how, and outlines some plans that will make it easier for you. The author speaks from the experience of having conducted many classes in this art.

The Variable Frequency Oscillator

Nowhere are the handicaps of being "bound" to a few fixed and crowded frequencies more evident than in CB operation.

The variable-frequency oscillator (vfo) has liberated today's Radio Amateur from the woe of the rockbound, but it was not always thus. This story of how the U.S. Navy, Howard Hughes, and hams brought the oscillator to where it is makes some very interesting reading.

Your Transmission Line

Like a chain, the performance of your radio station is no better than any of its links — your transmission line is one of those links. Often neglected, sometimes maligned, seldom appreciated, and usually misunderstood, it deserves better. Here are some tips on choosing the right feedline for your station, and how to get the most out of it.

SSB — Transmitter And Speech

Why does speech need processing? What is in a multiband ssb transmitter? What is a "third-method" generator? W1SL tells about these parts of the ssb story in this concluding article of the series.

Instant Phone Patch

A phone patch is a sometimes handy thing when you need an interface between your radio and the telephone system. Here is one that entails just about a minimum of fuss and effort to get going. Further, you can store it out of the way until you need it.

World's Youngest Amateur

Neil "Rusty" Rapp received his first Amateur (Novice Class) license — WN9VPG — at age five! Now WB9VPG, and age

six, Rusty communicates on a daily basis with other Amateurs on the fifteen- and forty-meter bands.

Simple Electronic Keyers

More and more of modern communications circuitry is based on multi-legged integrated circuits which have complete circuits within a single package. Some amateurs shy away from ICs, but like anything, the toughest part is getting started. Here are a couple of simple electronic keyers which will help you get your feet wet with the versatile, low-cost 555 timer IC. Come on in — the water's fine!

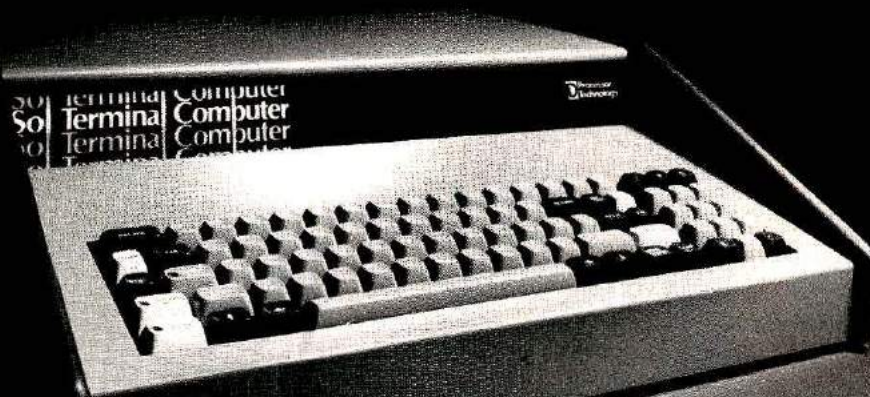
80-Meter Top Hat

A small antenna in a miniscule back yard may not be what you would select for a world-beating installation — but if that is the only choice you have, here is the way to make the best of it. The materials used are commonly available, not too expensive, and the author tells you how to put it all together in a neat and effective package.

HRH Interviews

In the third part of the interview with John Johnston, the discussion includes the Novice drop-out problem, training programs, the code-free license idea, and the scheduling of examinations.

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The Small Computer

Twenty-five years ago a computer as powerful as the new Processor Technology Sol-20 priced out at a cool million.

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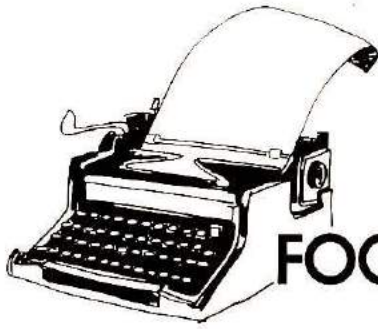
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May, 1977
Volume 1, Number 3

HAM RADIO HORIZONS

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The 140-foot radio telescope at Green Bank, West Virginia, gazes at a distant part of the galaxy. Author Ronan tells us what it's searching for, starting on page 12. Photograph courtesy of NRAO.	Ad Scan	77	Post Box 73
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FOCUS & COMMENT

It has been said that time heals all wounds. It seems that time also can bring about a complete change of attitudes and responses. It was only a short 20 years or so ago that we Amateurs were suffering from the "TVI plague" and, because of the very unfavorable opinions held by most of the viewing public, decided that the less said about our hobby, the better. Inconspicuous was the watchword for antennas and lead-in wire, wherever possible. Equipment was bulky, and the answer to keeping it out of the public view was often a basement or attic hide-away for the shack. Fortunately for us, public opinion has changed, and with it our ability and freedom to "tell and show." To wit:

The clerk who was taking care of my order in a hardware store was nervous and kept looking at the clock. It turned out that he needed to get across town to pick up his car at a repair shop, and the salesman who had promised him a ride was late. The shop was on my way home, so I offered a ride, which was accepted. He spotted the two-meter fm rig immediately, and was just about to ask what my "handle" was when someone came on the repeater and used the autopatch to call the local police to report a minor traffic mishap. Then, the questions started. "Why is it so clear . . . is the telephone bit legal . . . how far can you talk . . . how many stations are on the channel?" The expression on his face was beautiful to behold when I answered the last two questions by picking up the microphone and asking for a demonstration roll-call. It was late afternoon, and the homeward rush had not yet started, but the response of 39 stations, at distances up to almost 65 miles from where we were, was very impressive.

More questions, dozens of them. He knew about CB — he had worked at one time for a local fuel-oil company which had tried CB in their trucks. One line of questioning was about the difficulty of "learning all that stuff." I asked him "How long did it take you to learn how many pipe sizes there were, the names of the fittings, and the difference between the types of copper tubing?" When he replied that it had taken "about a month, maybe a month-and-a-half," I said, "Right! That's about how long it will take you to learn all that stuff about radio to pass the exam." His face brightened — I sensed that the bug had bitten.

We arrived at his destination before I could finish answering the many questions, so I gave him the location of the next radio club meeting, and invited him to come visit. He did, and I am happy to relate that he is now more than half-way through a license class that was formed shortly afterward.

The point of all of this is that it is truly great to be able to explain what your equipment is and how it is used without fear of being classified as "one of those radio nuts who ruins my ballgame."

There are obviously many similar opportunities to explain our hobby, and the public is more receptive than ever because they are now aware of communications as a part of life. Let's ride this wave of favorable reaction for all it's worth. You no longer need be afraid to answer questions. And, if someone asks one that you cannot answer — don't worry about it. Tell him "I know someone in my club who can answer that for you." When he meets all those friendly people at your next meeting, who are so glad to help him toward getting his Amateur license, a lot of his misapprehension will turn into enthusiasm. And you can wear a big smile if someone asks what you have done lately to help your hobby.

Thomas McMullen, W1SL
Managing Editor

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Begin with the Best

As you develop your skills, increase your participation in Ham Radio activities, and add hardware for ever-increasing flexibility of operations, you'll come to know ICOM. Just ask any old Ham. ICOM is the quality name in VHF/UHF Amateur Radio equipment because it is simply the best. ICOM is the line you'll want to move up to for unequaled quality and features.

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Clockwise from lower left: IC-211 4MHz, 2 meter, All Mode Transceiver; IC-245 Mobile 2 meter Transceiver; IC-22S Mobile VHF FM Transceiver; IC-502 Portable 50 MHz SSB Transceiver; IC-215 Portable 2 meter FM Transceiver; IC-30A Mobile UHF FM Transceiver.

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PERSPECTIVE

Several years ago we heard a lot about an unpopular fellow who was supposed to be a typical representative of the United States abroad. You and I know that his false description was no more appropriate than any other generalization, and we also know that there are ugly as well as beautiful people in all countries of the world; but what if people *think* it's true? "Aye, there's the rub . . .," as Shakespeare said. To be *thought* ugly is as bad as *being* ugly.

We Americans like to think of ourselves as popular because, after all, we should be popular shouldn't we? We've done more than most to help our fellow man, haven't we? It hurts our pride — and vanity — to be seen in an unfavorable light, and to be tagged with such an unfortunate name.

America is physically represented abroad by ambassadors, businessmen, servicemen, missionaries, Peace Corps volunteers, medical personnel, and workers of all kinds who live in various countries and meet people face-to-face every day. Is this enough to create a false impression? Perhaps not.

America is also represented abroad by its newspapers, magazines, television shows, and movies — in short, the communications media. Is *that* where a foreigner's impression of us as a nation comes from? Perhaps it is, in part, but consider something for a minute: You and I represent the largest and most comprehensive communications medium that ever existed on the face of the earth — Amateur Radio.

As Amateurs, we have the power to do more good than almost any other "representative" of our country, because our type of communication provides a very close person-to-person link with another "ham," a contact that can be heard by thousands of shortwave listeners, as well. The normal barriers of time and distance disappear and, in fact, permit us to be "present" in the shack of every foreign Amateur we talk to. What better opportunity could we possibly have to represent our country and ourselves? There are more than 280,000 licensed Radio Amateurs in the United States and, even if only one-in-a-hundred of us contacts a foreign Amateur, we still have nearly 3000 "representatives" abroad!

Do you wonder what this has to do with you? I'm sure that the answer is already apparent. By our conduct in everyday conversations with each other, our courtesy, interest, sympathy, and understanding, we convey impressions to foreign Amateurs; we *are* what they *hear*! How do we sound?

Think about this when you make your next contact, and when you talk to a DX station. Think about it when you are tempted to "wash dirty linen" in public because, in reality, you are the Voice of America. You are judged more often by your operating habits and by what you say than by what equipment you use or the height of your antenna.

So, the next time you go on the air, remember that you hold in your hands the means and opportunity to represent American Radio Amateurs as you'd like them to be represented. You have the power to erase the image of the "ugly" American. What you do with that opportunity is important to all of us.

Jim Gray, W2EUQ



Since 1969, the year in which TEN-TEC introduced the first solid-state HF transceiver, progress has been rapid. It was in this year that we produced the POWER-MITE which triggered the booming QRPP activity. Two years later, the ARGONAUT followed, demonstrating that Ham Radio can be more than just push-button communication.

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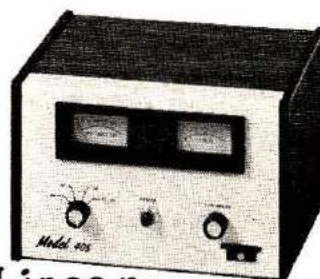
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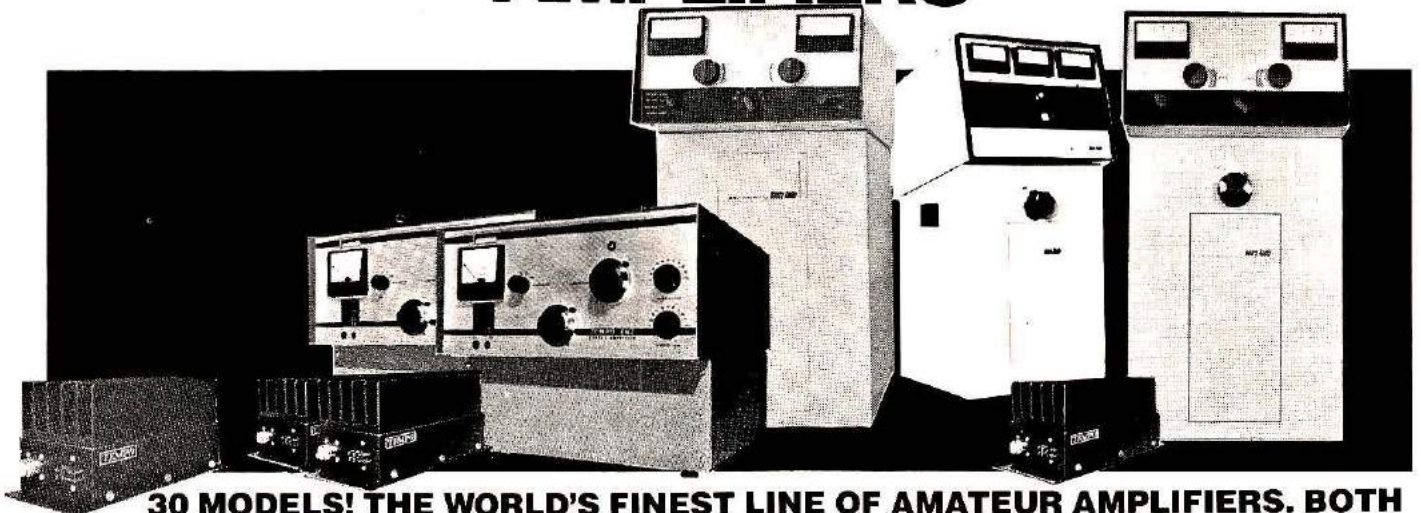
Triton IV

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Tempo 100C02	2W	100W	\$179.				
HIGH BAND VHF AMPLIFIERS (135 to 175 MHz)							
Tempo 130A30	30W	130W	\$189.	Tempo 80A02	2W	80W	\$159.
Tempo 130A10	10W	130W	\$179.	Tempo 50A10	10W	50W	\$ 99.
Tempo 130A02	2W	130W	\$199.	Tempo 50A02	2W	50W	\$119.
Tempo 80A30	30W	80W	\$149.	Tempo 30A10	10W	30W	\$ 69.
Tempo 80A10	10W	80W	\$139.	Tempo 30A02	2W	30W	\$ 89.
UHF AMPLIFIERS (400 to 512 MHz)							
Tempo 70D30	30W	70W	\$210.	Tempo 40D01	1W	40W	\$185.
Tempo 70D10	10W	70W	\$240.	Tempo 25D02	2W	25W	\$125.
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Tempo 40D10	10W	40W	\$145.	Tempo 10D01	1W	10W	\$125.
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NEWSLINE

10 METER LINEAR AMPLIFIER coverage would be prohibited and type acceptance of commercially manufactured Amateur Radio equipment would be required under the terms of two new Notices of Proposed Rule Making adopted by the FCC.

Linear Amplifiers: The Commissioners have proposed the outright banning of the commercial manufacture and sale of linear amplifiers capable of operating in the 24-36 MHz range. Individual Amateurs would still be permitted to build their own 10-meter linears, however, and existing used linears with 10-meter coverage could still be bought and sold.

Type Acceptance: The Commission has also proposed that type acceptance be required for all commercially manufactured Amateur Radio equipment. The Commissioners appear to feel that type acceptance would benefit the Amateur Service since it would establish technical standards for Amateur equipment (the Amateur Service is the only FCC-administered service which does not have such a requirement) as well as permit the Commission to set requirements that would make Amateur equipment more difficult to adopt to non-Amateur use. As with the linear ban, individual Amateurs would still be permitted to build their own equipment; type acceptances would apply only to commercially manufactured gear, with provisions for type accepting kit-built equipment.

FCC CONTINUES TO CRACK DOWN on the HFers, and is in the process of lifting the CB licenses of 21 members of HF International for operating on frequencies not assigned to the CB service. All were also cited for participating "in an organized scheme to operate radio transmitting apparatus illegally and avoid detection by identifying with 'HF' numbers in lieu of their assigned call signs."

AMSAT'S AO-D SATELLITE (the future OSCAR 8) is scheduled for launch on November 15th. It'll carry 144- to 29-MHz and 144- to 435-MHz transponders, and with a 500-mile high orbit will be even easier to access — though for shorter periods — than the present Amateur satellites.

Professional Quality Machine Shop, mechanical and drafting work is badly needed to keep the AO-D (OSCAR 8) project on its late 1977 launch schedule. W3GEY brought word from the January 18th, Phase 3 meeting in France that the European Space Agency needs some data on the planned Amateur satellite immediately, putting a very heavy burden on AMSAT's limited manpower — volunteers should contact Perry Klein at AMSAT.

WARC ADVISORY COMMITTEE FOR AMATEUR RADIO meeting was spent on new and strengthened supporting arguments for new Amateur HF bands at 10, 18, and 24 MHz. Even though the FCC's Notice of Inquiry had not included those previously requested bands, the group felt they were important enough — both for improved communications capability and to take care of the predicted Amateur Radio growth through this century's end — that another strong plea was called for.

ARRL GENERAL COUNSEL Bob Booth has added another Amateur to his Washington office, Demetrios (Demy) Pulas, WB2QKT/WB4BTF.

Bob's W3PS Call is well known to Amateurs, of course, but according to one of the trade magazines he also sports the handle "Wet Noodle" on 11 meters!

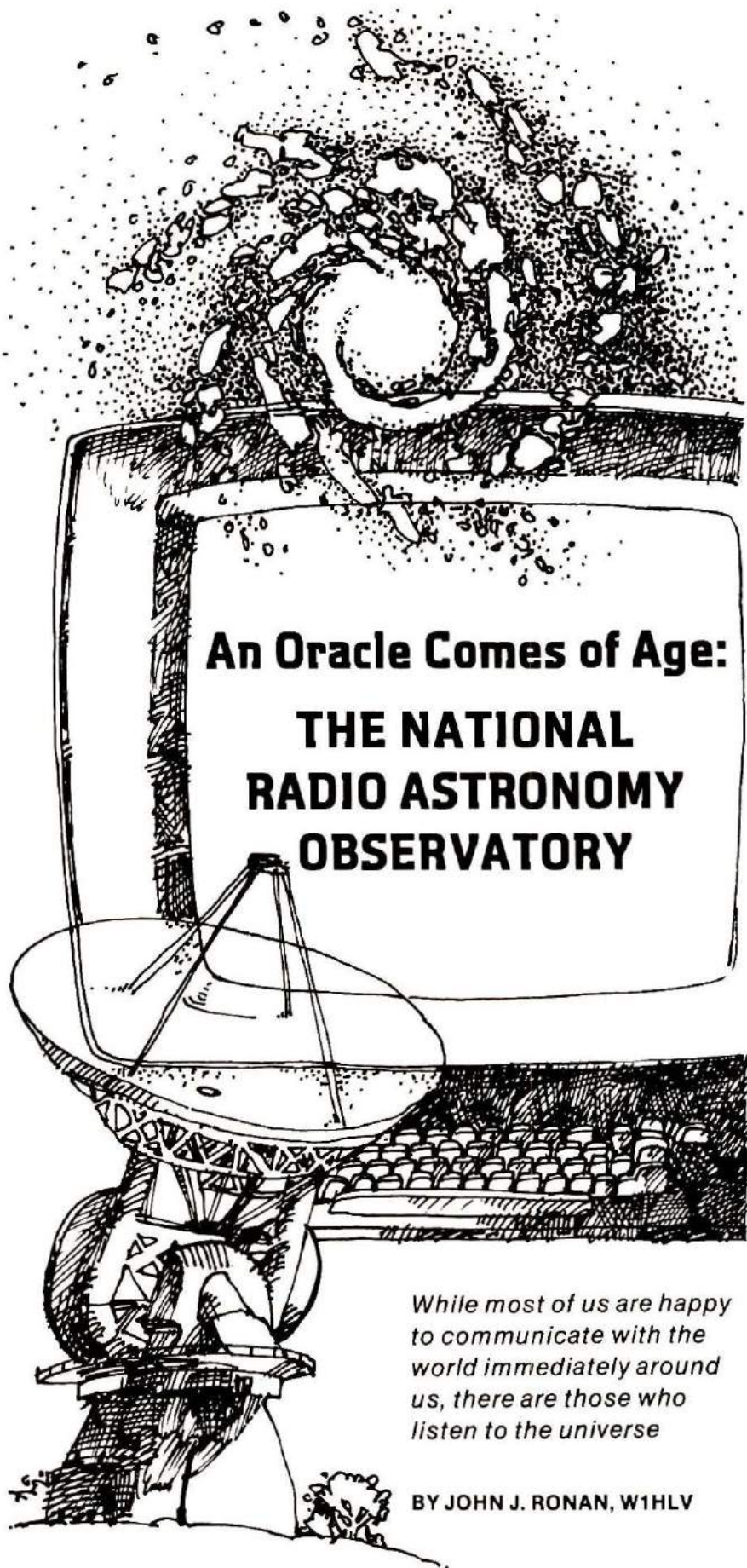
"MOVIN' ON 1977" will be a giant (200,000 expected) CB fair Memorial Day weekend at the Pennsylvania Pocono International Raceway. Camping facilities are available, and the event will provide an outstanding opportunity for some nearby radio club to present Amateur Radio to a tremendous number of prospects while enjoying a group family holiday outing. Contact Ann R. Strawn, Pocono Productions, 842 Hamilton Mall, Allentown, Pennsylvania 18101; toll free (800) 523-9470 for details.

"THE CLUB PAPER," an excellent manual for editors and publishers of radio club periodicals, is available to members of the Amateur Radio News Service. Copies are also available to new members of ARNS — send \$4 (annual dues alone are \$3) to ARNS Secretary WA3HEN to join and receive a copy.

AMECO'S FIRST NEW AMATEUR ACCESSORY in some time is their solid-state Model PT-2 preamp/station control. The updated version of Ameco's popular Model PT uses a field-effect transistor.

BELATED CONGRATULATIONS to W7LHI/WA7KZT, recently elected to Arizona's State House of Representatives.

"AMATEUR RADIO...IN THE PUBLIC INTEREST" is a very attractive report on Amateur Radio in 1976 published by the ARRL for use in presenting the Amateur Service to public officials and the media. Copies for PR use are now available on request, but do specify with your request how and where they'll be used.



**An Oracle Comes of Age:
THE NATIONAL
RADIO ASTRONOMY
OBSERVATORY**

While most of us are happy to communicate with the world immediately around us, there are those who listen to the universe

BY JOHN J. RONAN, W1HLV

Skyline Drive — one of the most scenic roads in the eastern part of the country. A pathway to numerous camping sites, hiking trails, picnic areas — an escape-to-tranquillity for many of the inhabitants of the busy seaboard areas of North Carolina, Virginia, and the District of Columbia. The Drive is an aptly-named part of the Blue Ridge Parkway which follows the ridges and turns of the mountain range that is encompassed by the Shenandoah National Park. From a scenic overlook near the southern end of the Drive you can look east toward Charlottesville on the busy highway from Richmond, Newport News, Washington, and Colonial Williamsburg.

The view to the west is inspiring; mountain ranges pile up one behind the other, with always a distant blue tip hinting of more to be found beyond the last range in sight. Somewhere to the southwest, near the second and third ranges to be seen, is another town that is the western terminus of a trek by many a scientist, engineer, and technician. Green Bank, West Virginia — the name is suggestive of pastoral calm and is not inappropriate. From the quiet, self-confident bustle of Charlottesville to the peace of Green Bank there is little to denote that they are both vital parts of an effort to listen to a universe that man has never heard. The discipline that ties the two together is Radio Astronomy; a field that requires both the serenity of an area isolated from the electronic hubbub of the business world and an administrative center with access to that same world with its computers and technology.

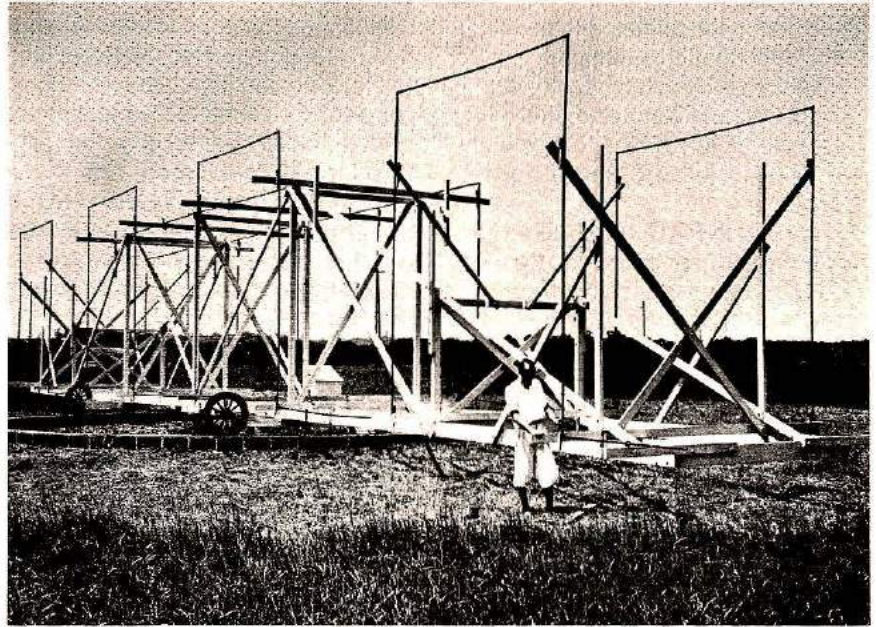
The science of radio astronomy is less than 100 years old. Yet, there are over eighty major installations in the world today, their dishes dotting each of the continents like miniature lunar craters.

Some of the sites — Jodrell Bank in England, Arecibo in Puerto Rico, Vermillion River in Illinois, Hat Creek in California — are well known and beginning to acquire the romance always associated with stars and distant galaxies.

But the vortex of radio research is in Charlottesville, Virginia, hard by the Blue Ridge Mountains, at the National Radio Astronomy Observatory (NRAO). Now 23 years old, the observatory was born in 1954 out of talks between Carnegie Institute, Cal Tech, and the National Science Foundation (NSF). Like its sister institution, Brookhaven National Laboratory, NRAO is operated by the Associated Universities, Incorporated (AUI), a non-profit organization made up of Columbia, Cornell, Harvard, Johns Hopkins, Massachusetts Institute of Technology, Pennsylvania, Princeton, Rochester, and Yale.

Created in 1946, AUI's mission was to run large-scale research facilities which are beyond the economic clout of any single school. NRAO, one of the largest radio-astronomy complexes in the world, with an annual budget nearing \$20,000,000, certainly fits that description.

AUI, whose president is Gerald Tape, is steered by a Board of Trustees. Both of the



One of the pioneers in Radio Astronomy, Karl Jansky, used this antenna array at the Bell Telephone Laboratories to discover radiation from the Milky Way. His work in 1930-32 was intended to study the interference that bothered transatlantic radio telephone circuits. A replica of this antenna stands at Green Bank, West Virginia (Bell Laboratories photograph courtesy of NRAO).

facilities under AUI's guidance get most of their financial support from the federal government: Brookhaven from the Atomic Energy Commission, and NRAO from the National Science Foundation, which are both major sources in this country of "clean," or non-defense, money; a fact that both Brookhaven and NRAO scientists are proud to point out.

NRAO itself is run by a

director, now David Heesch, who manages the budget and over 200 NRAO employees. The elite core of that staff, averaging only 30 members, is made up of the astronomers themselves — the scientific research staff.

The secret behind that small number is another facet of NRAO's existence: It is primarily a visitor institution. Though its staff generates a good deal of the experiments, half of the observatory's purpose is simply to provide access to its equipment for anyone with an approved program, whether American or foreign. And it does serve that purpose: Over 60 per cent of the time on the telescopes is spent by non-NRAO personnel.

Programs run through NRAO have accounted for some spectacular discoveries, such as the first detection of a pulsar* by American astronomers, and later the

*Pulsar: A rapidly rotating star approximately of the mass of the sun, but of much higher density. They emit regular pulses of radio radiation, once or twice per rotation. The Crab Nebula pulsar has also been observed optically and in x-rays.

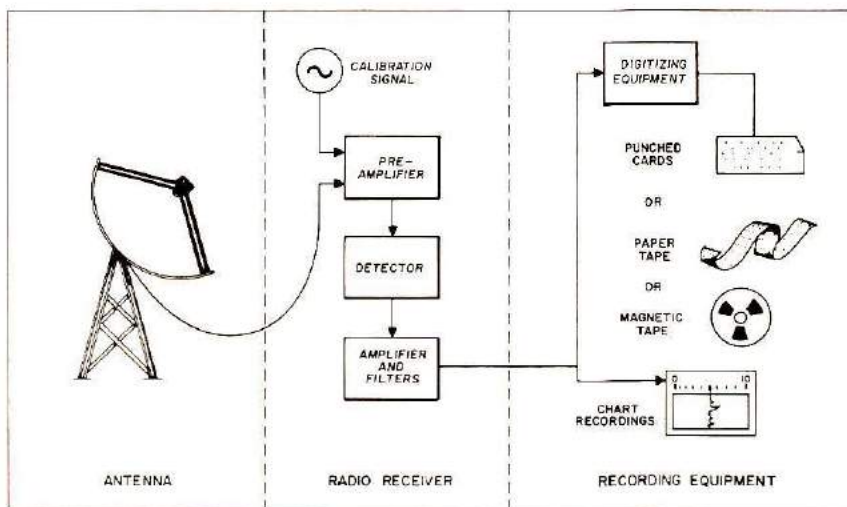


Fig. 1. Here is a simplified block diagram of the sophisticated technique that turns the static-like noise from a distant star or galaxy into something that astronomers can interpret.

detection of a pulsar in the Crab Nebula. This second discovery, in November, 1968, was important because the Crab pulsar is one of the few that is both a radio and a light source.

It was at NRAO that the first measurement of a magnetic field in hydrogen clouds was made, and it is at NRAO that the continuing study of the structure of the galaxies goes on. On a "local" level, the NRAO staff has examined the radio emissions of the planets, especially Venus and Mars. The information, on both atmosphere and ground characteristics, has been used by NASA to help solve practical engineering problems.

Shopping for time

Exactly who gets time for what experiments is determined by an elaborate screening process. It begins when NRAO or visiting astronomers submit a proposal,

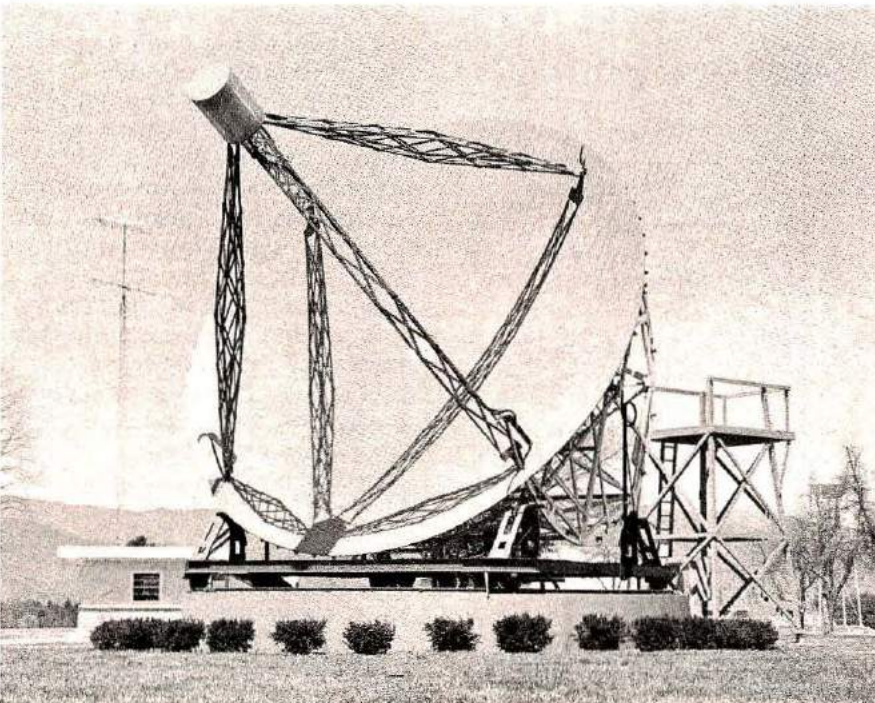
usually months in advance, that not only states the purpose of the experiment but also requests a certain telescope and receiver. Generally, larger telescopes (antennas) are efficient at longer wavelengths, but the precise wavelength used is determined by the receiver, just as in household radios.

Though the actual process is far more complex, the telescopes and receivers are interchangeable in somewhat the way tuners and speakers are in large stereo shops.

The astronomer — or shopper — can request any combination, depending on the "sounds" he is after. The astronomer goes further; he specifies the exact location in the sky as well as the duration of tracking time. Then, he waits.

The NRAO administration hands the proposal over to three independent, anonymous, referees who judge the

Another early explorer of the radio universe was Grote Reber. He built his antenna in 1937, using 26-gauge galvanized iron sheet for the surface. It cost approximately \$4000 at that time, and weighed approximately two tons exclusive of the turntable. Grote explored the 160- and 480-MHz area from his backyard in Wheaton, Illinois. While not exactly a mobile piece of equipment, nevertheless it was moved from Wheaton to Sterling, Virginia, then to Boulder, Colorado, and finally to NRAO at Green Bank. It was restored under Reber's supervision in 1959-60, and stands at the entrance to the West Virginia site of NRAO (*photo courtesy NRAO*).



A closer look at one of the 85-foot antennas. This is the Howard E. Tatel telescope, one of the oldest at the observatory. It is the fixed part of the interferometer array; the other two are movable along a track in order to obtain a variable baseline (*photo courtesy NRAO*).

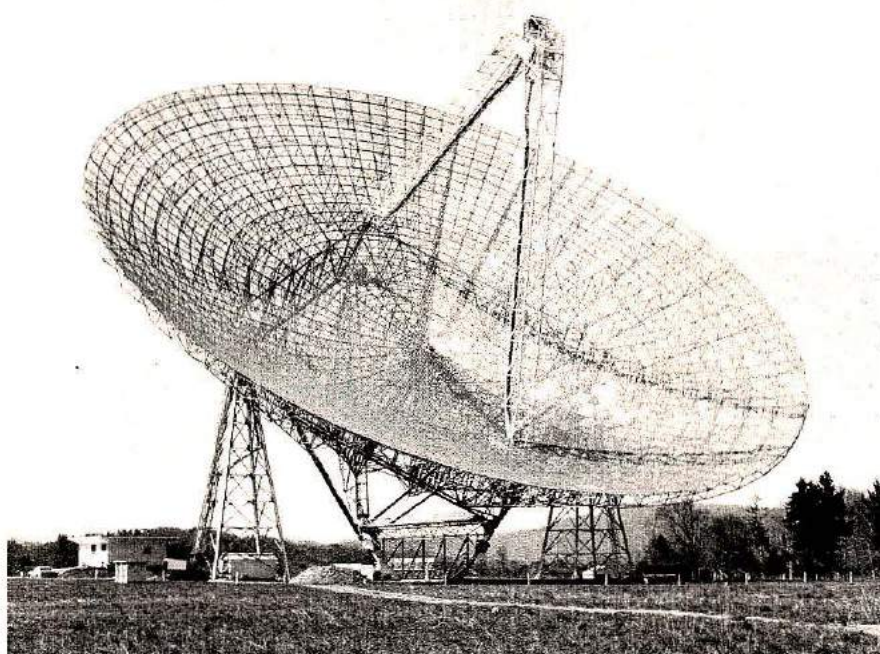
individual proposals solely on merit. Since NRAO is a visitor institution, its staff is in direct competition with radio astronomers from other observatories. They bid against one another for the telescope's time. The decision of the judges, as in other contests, is final.

If a proposal is approved, it is given to the Chief Telescope Operator who in turn gives it to the Duty Operator assigned to the appropriate instrument. The astronomers are never actually allowed to operate the telescopes.

Finally, the experiment is run while its sponsor, somewhat of a tourist for the time being, waits. Once the data is recorded and analyzed, boxes of read-out sheets are at last offered up, like the riddled responses of the ancient oracles, to the man who asked the questions.

Research facility

The purity of scientific research in Charlottesville is complemented by the



A diameter of 300 feet (91 meters) makes this radio telescope at Green Bank an awe-inspiring sight. The first American to discover a Pulsar used this dish to do so in 1968. Some idea of the size can be gotten by comparison to a football field or by considering that many houses in urban areas are on land areas less than one-quarter of the antenna size (photo courtesy NRAO).

atmosphere. The single, three-story brick building that is NRAO headquarters sits quietly at the base of one of the Blue Ridge's foothills, near Thomas Jefferson's University of Virginia. In fact, the structure is leased from the university and the legal tie, along with the physical proximity, gives NRAO much of the colonial calm that Jefferson designed into the University of Virginia.

Visitors come to the glassed-door entrance by way of a circular drive that loops around a large bed of ivy and through the invisible scent of dogwood. Once inside, the mood and pace seem almost monastic. The full-time members of the scientific staff, which has been all male for most of NRAO's history, work in cell-like offices, poring over data that has been disgorged by the IBM 360/65 which is housed in the basement.

Occasionally, a hand flutters over a desk calculator or someone pads down a long, Holiday-Inn-like corridor to

consult with a colleague. Such conversations, heard from a distance, are a garble of syllables marked only by the general lilt and dip of the language; the topic could be baseball. But when the words come clear they are not likely to be about home runs:

"... so it looked like the galaxy dropped by a hundred in flux on the same scan ... no indication of change in the spectral index ...

$10^3 D_p^2 \text{ cm}^2 \dots$ Whatever, it is not baseball.

Reflecting NRAO's university origins, the research staff retains the academic ranking system that includes, at the top, tenure. Moving from the most temporary to the tenured, the ranks are Research Associate, Assistant Scientist, Associate Scientist, and Scientist. The academic penchant for word play, where years of work and study mean the moving of "Associate" from the right to the left, is obvious.

But through the word-murk,

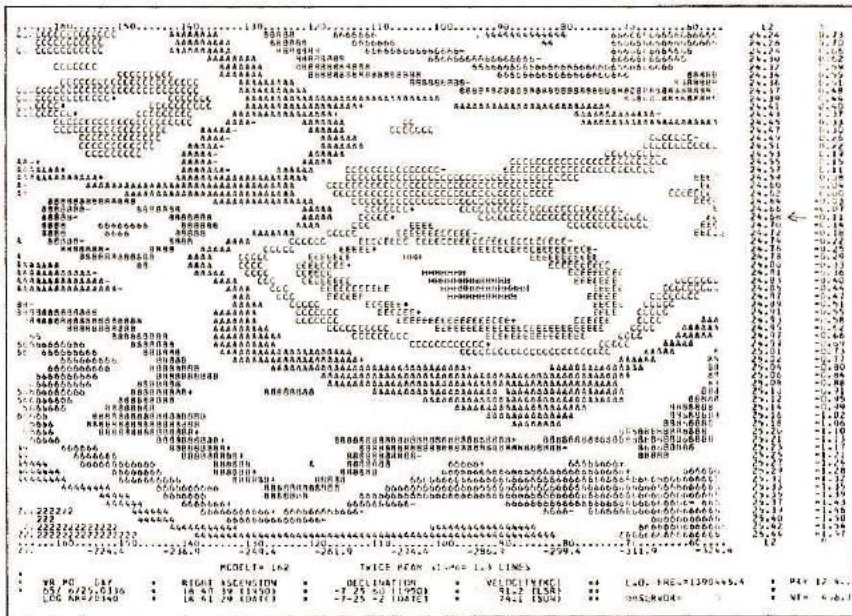
the ladder is clear. Most of the Scientists are tenured and those below are on short-term appointments, ranging from one to three years. The largest single group of staff members, the Research Associates, are on one- to two-year appointments. Unfortunately, this points to one of NRAO's few flaws — insistence that the rapidly changing staff produce quick, visible results, a parallel to the old academic "publish or perish" demon.

Still, the observatory thrives. One of the most striking projects at NRAO is the search for organic matter in interstellar and inter-galactic space. The existence of organic molecules outside of a life environment was once thought impossible but, now, almost thirty different molecules are known to exist in free space. About two-thirds of them were discovered through NRAO.

It is amazing that this research has shown the existence of such complex structures as acetaldehyde (CH_3CHO), used on earth in the manufacture of perfume, methyl alcohol (CH_3OH), commonly known as wood alcohol, and formic acid (CHOOH), the substance which makes a bee sting painful.

The computer used in data reduction is an IBM 360/65. Here Sharon Spooner at the Charlottesville center puts the machine through its paces cranking out the numbers (photo courtesy NRAO).





Computers are used to reduce the received signals to a contour map that is more readily interpreted. This is the intensity chart of the 21-cm hydrogen line as taken through the constellation of Scutum (NRAO photo).

Further, it gives new, positive, clues to the problem-of-problems in all space research — the quest for life.

These are staggering feats for a science just 87 years young. It was only in 1890 that Thomas Edison, pausing between phonograph and vitascope, proposed construction of a radio telescope near Sussex, New Jersey. Edison wanted to encircle a field with telephone wire and "listen" to the sun. The experiment even got so far as the delivery of the poles, but they were never erected. More interested in profitable patents than in radio astronomy, Edison let the experiment languish.

No matter; the instrument would have been too insensitive to work. By contrast, NRAO's telescopes are able to detect signals many light-years distant. It has been estimated that the radio energy that they, and all other radio telescopes, have collected over the past twenty years, is equivalent to the energy expended by the fall of a single snowflake!

To get a look at these delicate beasts a visitor must

leave Charlottesville. NRAO's dishes are located 120 miles west, in Green Bank, West Virginia, nestled between the Allegheny and Back Allegheny ranges of the Appalachians.

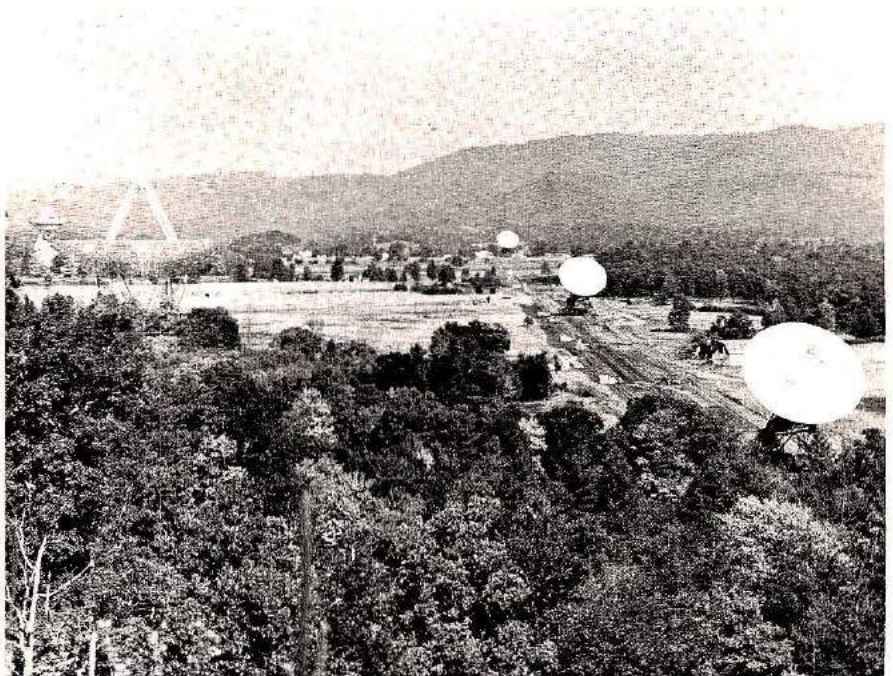
The trip from Charlottesville,

except for the destination, is a trip into the past. It takes three hours on State Highway 250 as the two-lane road twists and toils its way over range after range of mountains, beginning with the Blue Ridge. Beyond West Augusta, in extreme western Virginia, 250 cuts through the George Washington National Forest and seems, at times, to pass by permission of the trees alone.

Past Headwaters, 250 enters some of the remotest country east of the Mississippi. The villages here — McDowell, Monterey, Hightown, through which 250 inevitably becomes the Main Street — are the type where four-bladed ceiling fans survive and turn so slowly in summer, that flies ride them to cool off. They are the last bastions of the eight-ounce Coke. They are America forty years ago.

Then, turning south onto West Virginia Highway 28 to enter Deer Creek Valley, the driver nears Green Bank, elevation 2700 feet, with 1300 additional feet of green

Not the valley of the dolls, but the valley of the dishes. The row of 85-foot radio telescopes at the right are in an interferometer array that is 5000 feet (1.52km) long. The 300-foot antenna, left, and the 140-foot equatorially-mounted unit, far left, are both in their "stow" positions for maximum safety in windy weather (photo courtesy NRAO).



mountain protecting it to the east and west. Here, in the "Wilderness State," three miles north of town, there suddenly appears, like the first view of the invading machines in *War of the Worlds*,* a field of telescopes. They are gawky, awkward things, each topped by a huge metal dish. Like lunar landers, satellites, and other apparatus built for work in space, they are without even the pretense of a single streamlined line. They obviously have to do with worlds far removed from West Virginia.

Spread over a 2700 acre tract, there are eight telescopes. Wally Oref, the Public Information Officer for NRAO, runs an extensive tour and information service during the summer, and visitors are also free to walk the grounds by themselves. But only walk: sparking automobiles wreak havoc with the receivers.

A stroll around all the telescopes is long, about three miles, and over largely untouched terrain, since the Green Bank operation is as ecologically "clean" as the money that built it. Deer Creek is unpolluted and cattle are allowed to graze up to the very shadows of the telescopes. In fact, it's not unusual to be gaping at a mammoth dish, perhaps tuned to the other end of the universe, and discover that you have put your foot in a more earthly texture, courtesy of the cows.

Among the telescopes at Green Bank are three 85-foot instruments that, together, form an interferometer. One of the elements is fixed and two moveable so that, working together, they are able to simulate a telescope equal in diameter to the separation of

* *War of The Worlds*, a book by H.G. Wells, was used as an early Science-Fiction radio broadcast by Orson Welles. It portrayed an attempted invasion of this planet by creatures from Mars. Because the fictional landing site for the alien ships was in New Jersey, the 1939 broadcast caused wide-spread panic among residents in that part of the country.

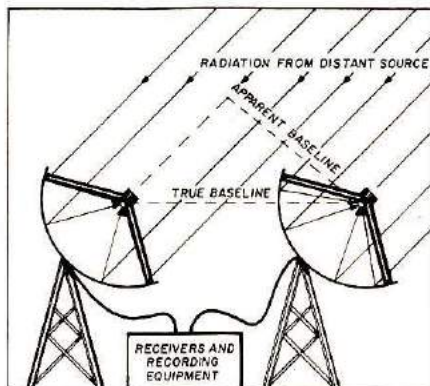


Fig. 2. An interferometer is an instrument that can map the position and characteristics of distant signal sources by making use of the pattern peculiarities of two or more antennas linked together electronically. Because of phase differences in the wave arriving at separate locations, one part of the pattern will be reinforced, another part will be cancelled. A computer can use this information to determine relative size and somewhat precise location of the source.

the two moveable elements: about 5000 feet (1500 meters). Though less sensitive than a real telescope of that size, the addition of longer hours of observation for higher resolution makes it well worthwhile.

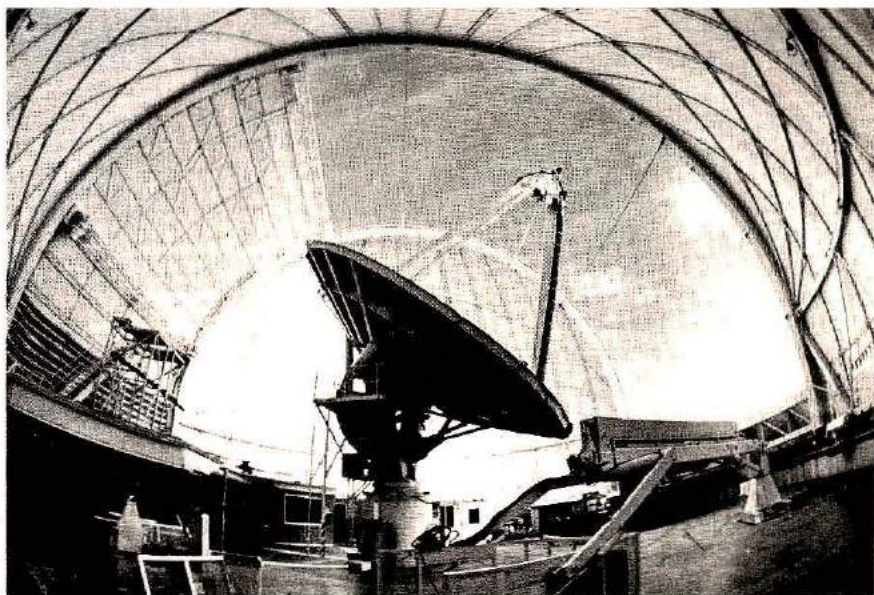
The most imposing instrument is the 140-foot (43

meter) scope, completed in May, 1965, at a cost of almost \$14,000,000. It was this telescope that was used to discover formaldehyde, the first organic molecule found in space.

The largest of NRAO's telescopes, and the one used to find the Crab Nebula pulsar, is a 300-foot (92 meter) dish with a surface area of 1.8 acres (7300 square meters). After its completion in 1962, for almost a decade it was the largest moveable radio telescope in the world.

One telescope not located in West Virginia is a special, high-frequency dish at Kitt Peak National Observatory (KPNO), near Tucson, Arizona. KPNO is the optical counterpart to NRAO and was chosen as a site for a radio telescope for the same reasons that the visual astronomers first claimed the peak: clarity of atmosphere at high altitude, an important consideration for super-high-frequency work. Hence, the choice of a single 36 foot (11 meter), millimeter wavelength telescope for Kitt Peak, the heart of "enemy" territory. (At one time there was a small, 6-inch [15cm], optical

When the wavelengths get so short that they are in what is termed the millimeter-wave band, the surface of the dish must be very accurate to be efficient. This mm-wave telescope is housed in a radome at Kitt Peak, near Tucson, Arizona. The 36-foot (11m) instrument is operated by NRAO in a study of the cold gas in the Milky Way (photo courtesy NRAO).



telescope at Green Bank, but, hinting of a radio vs visual rivalry that still survives in astronomy, it is referred to as a "toy" and never used.)

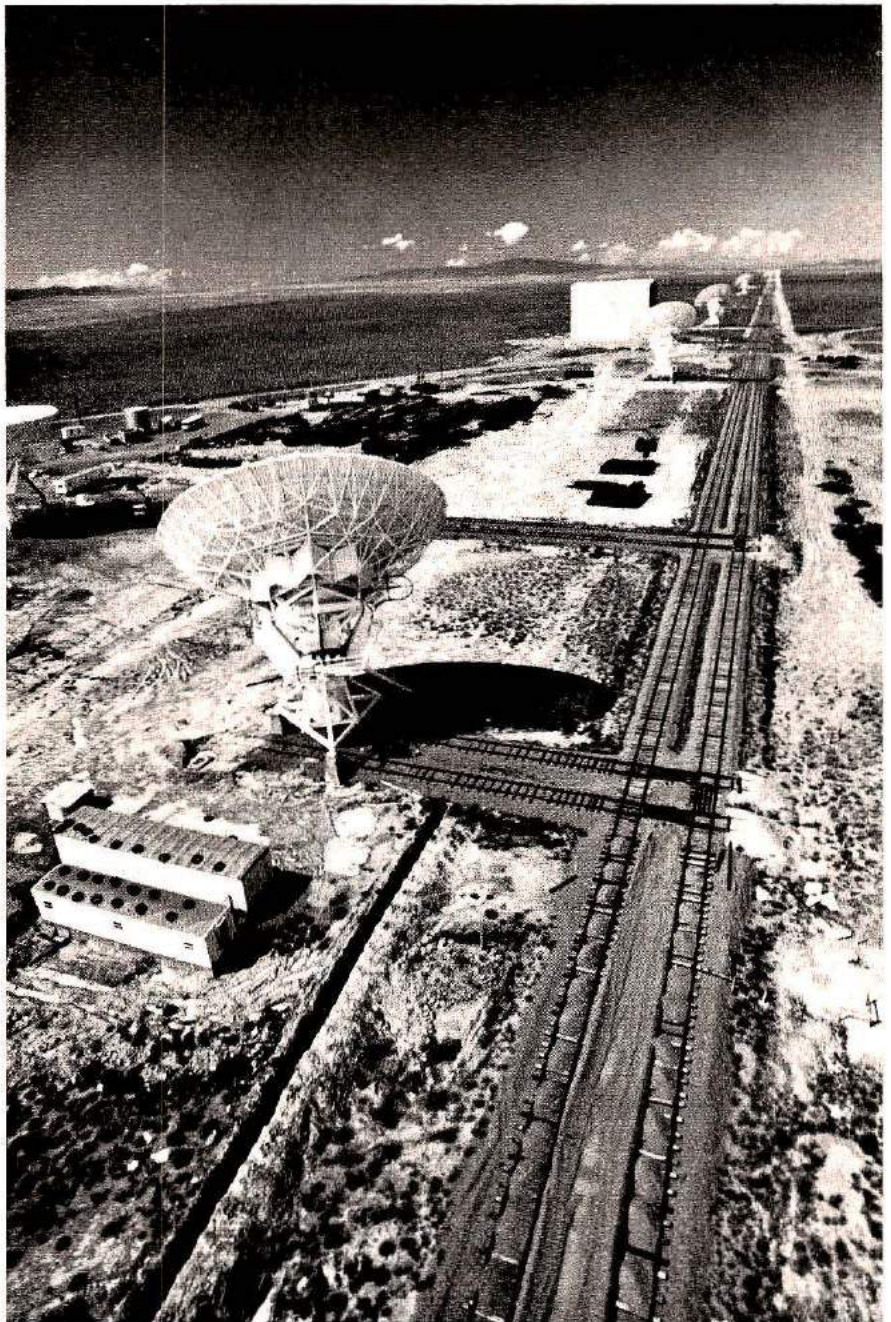
Green Bank, however, remains an ideal site for reception at lower frequencies. To the residents' chagrin, it is virtually impossible for them or the telescopes to pick up commercial radio and television. And, since a state zoning law forbids flying over the NRAO sites, the equipment is safe from aeronautical interference.

Also, the mountains soften the elements. There is little snowfall and the humidity is relatively low year round. Though the telescopes are operational in winds up to forty miles per hour, velocities seldom approach gale force. If they do, the dishes are swung to a "stow," or vertical position, in which the sloped underside of the bowl acts as an airfoil and actually forces the wind to help support it.

Despite their ruggedness, each of the telescopes require eight hours of shut-down time, every week, for maintenance. Only the personal intervention of the director himself can override this procedure.

Larger projects and equipment

That kind of care will be even more necessary in the future. The reason is that 1973 witnessed the first NSF (National Science Foundation) money — \$3,000,000 — toward a project referred to in Charlottesville as the VLA, or Very Large Array. The name is accurate. When completed in 1981, the VLA will be a complex of 27 telescopes, each 25 meters across, spread over a circular area many miles in diameter. Working together, the telescopes will form a giant interferometer, with nine dishes on each of three tracks splaying out from a central hub like the spokes of a peace symbol. The VLA will easily recapture the title of "world's largest" for NRAO. At a total

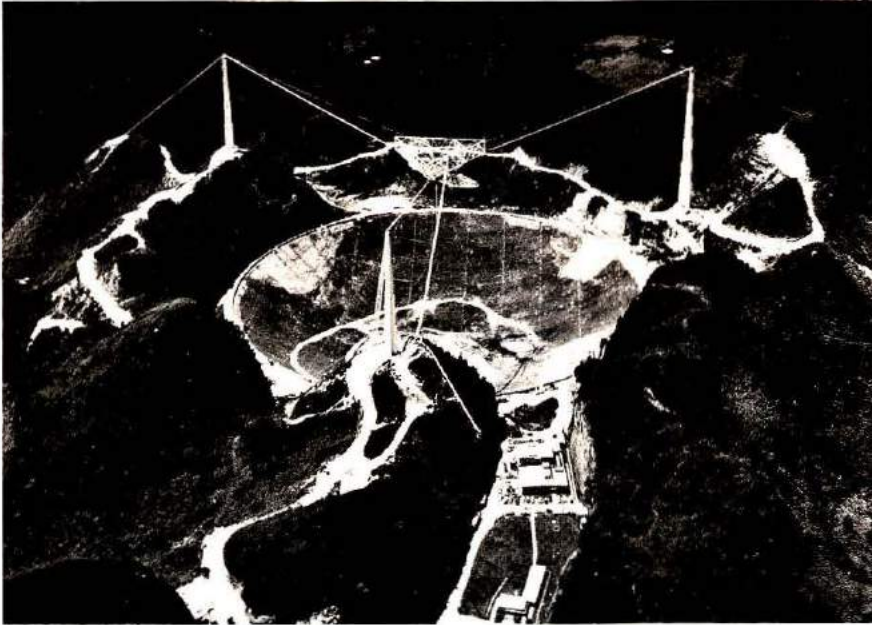


At the Very Large Array site in New Mexico, one leg of the system stretches to the northeast horizon. A unique set of bogey wheels on the transporter allows the dishes to be brought to the main track from the spur, then moved at right angles, to another position. The large building between the second and third antennas is an assembly and repair facility. It is large enough that a complete 82-foot (25m) antenna can be worked on inside. The facility is built in a Y configuration, with two arms 13 miles (21km) in length, and another that is 11.8 miles (19km) long. When it is finished, the 27-dish installation will have the resolving power of a single dish approximately 26 miles (42km) in diameter (photo courtesy NRAO).

price of \$80,000,000, it will also be the "most expensive."

The VLA, however, is not being constructed at Green Bank. The new site is over 1500 (2400 km) miles west and may cause some rather non-

scientific administrative problems. The new location, on the Plains of St. Augustin, in the Magdalena Mountains, outside of Socorro, New Mexico, will eventually employ over 60 people. Because of its

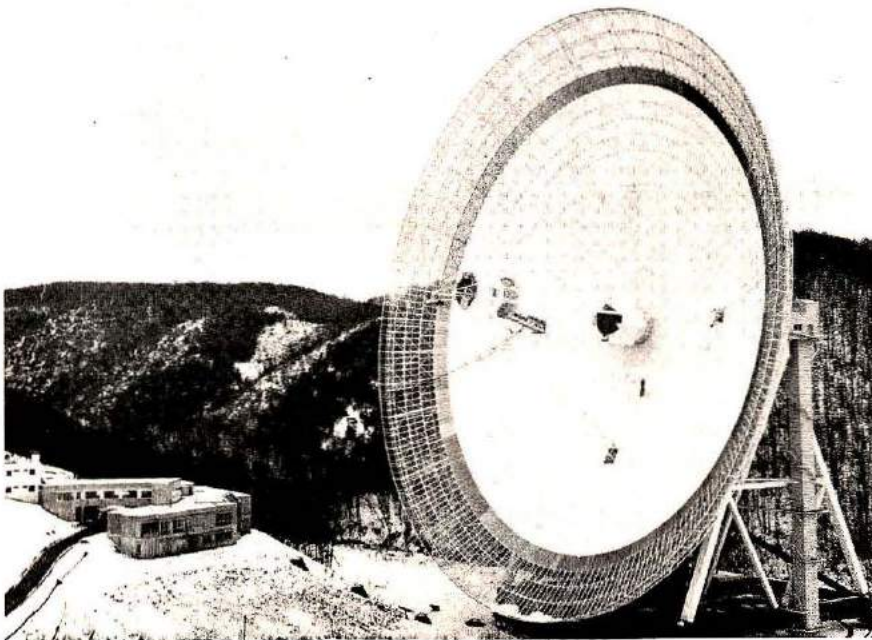


For truly awesome contemplation there is the 1000-foot (305m) installation at Arecibo, Puerto Rico. A depression in the terrain was expanded and shaped, then lined with cables and surfacing panels. Since this photograph was taken the surface has been fitted with panels of greater accuracy to extend the upper frequency range of the dish. It has seen such diverse uses as radar sources, and for Amateur Radio communication by bouncing signals off the moon.

size and the personnel involved, the Socorro site will not be as easily run by remote administrative controls as is the much smaller Kitt Peak operation.

Both the Green Bank and Charlottesville locations will remain in full operation; the seat of power, at any rate, will remain in Virginia. But, since some of the scientific

Other parts of the world are into the Radio Astronomy studies too. The Max Planck Institute for Radio Astronomy in Germany has this 330-foot (100m) dish that is steerable in both azimuth and elevation. In addition to looking for emissions from 50-billion light years away, it will be used to receive signals from a Helios space probe being built jointly by the United States and Germany.



equipment will have to be constructed in New Mexico, there may be a transfer or duplication of some personnel. Beyond that, some non-scientists, in purchasing and accounting, may also be involved in the move.

The important thing to remember about NRAO's administrative pains is that they are the growing kind and not unpleasant. They mean expansion on a grand scale. In the last few years, NRAO's budget has doubled; by 1981, facilities will double. All of which means that radio astronomy will move closer to equality with its older brother, optical astronomy. It will help give the entire science a sort of binocular vision, a way to see the universe in true perspective and depth.

Recommended Reading

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2. *Scientific American*, Vol. 206, No. 2, "The Amateur Scientist," February, 1962, pages 163-174.
3. Dennis M. Downes, "A Simple Radio Telescope," *Sky and Telescope*, Vol. 24, No. 2, August, 1962, pages 75-76.
4. Joseph H. Alexander and Larry W. Brown, "A Radio Telescope For Amateurs," *Sky and Telescope*, April, 1965, Vol. 29, No. 4, pages 212-214.
5. J. Kraus, *Big Ear*, Cygnus-Quasar Books, Powell, Ohio, available from *ham radio's* Communications Bookstore, No. CQB-A, \$3.25.
6. F.S. Harris, "The Parametric Amplifier," *CQ Magazine*, November, 1958, pages 74-75; 159, 164, and 168.
7. Heiserman, *Radio Astronomy for the Amateur*, Tab Books, Blue Ridge Summit, Pennsylvania, available from *ham radio's* Communications Bookstore, No. T-714, \$5.95.
8. J. Shields, *Introduction to Radio Astronomy*, Howard W. Sams, Blue Summit, Pennsylvania, available from *ham radio's* Communications Bookstore, No. 21246, \$4.50.

HRH

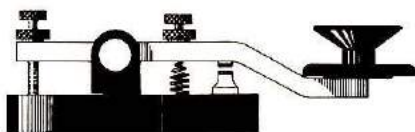
A PLAN FOR MORSE CODE

BY CLAY LASTER, W5ZPV

Why would you want to learn the code? That's a good question! Basically it boils down to whether or not you want to open your own, personal, window on the world. Radio amateurs — hams — have the freedom and the means to communicate with hams in other countries, no matter how small or far away. United States hams are particularly fortunate in the available number of bands and frequencies for their exclusive use; every ham — in a very real sense — becomes a spokesman for himself and his country.

Freedom walks hand-in-hand with responsibility and, in the case of the ham, it is a commitment to himself and to his country that's on the line.

In exchange for your freedom to communicate by ham radio, Uncle Sam asks for something in return: that you send and receive the International Morse Code with a proficiency acceptable to him. Congress has given to the Federal Communications Commission — the FCC — the authority for determining your readiness to be licensed, and it is that body that examines you before granting you your



"ambassadorship of the air."

Beyond that, learning to converse in code is fun; that's right — FUN! The language of the code transcends normal language barriers and enables you to talk to other hams wherever they may be. Radio transmissions using the code are called CW transmissions, and have the unique ability to be heard and understood even when voice transmissions fail miserably due to fading, static, interference, or other problems that plague the airwaves from time to time. In addition to these plus factors, CW transmitters are the simplest of all to build, buy, and operate. Almost any ham anywhere can afford a modest CW transmitter, and in the less affluent countries CW is used by amateurs almost exclusively.

Finally, it is a fact that, watt for watt, radio transmission by code is the most reliable means of communication available, whether on amateur

or commercial circuits, particularly when the going gets rough.

International Morse Code

The International Morse Code is a simple "language" with a fixed set of rules and, unlike formal languages, only two fundamental skills need to be acquired to master conversation in code. The first is to learn the code itself, a set of characters or symbols representing the 26 letters of the alphabet, plus 10 numerals and 8 or 10 of the most commonly used punctuation marks. The second is the ability to send and receive these characters with speed and proficiency enough to pass the Federal Communications Commission test and to facilitate conversation with another radio amateur.

Although it is true that some people adapt to the code more quickly than others, almost anyone can learn to send and receive the code at speeds of 20 or 25 words per minute. The only variable is the amount of time you must spend to develop the required speed and proficiency. Age is no barrier to learning the code, for people from ten to seventy continue

with great regularity to pass the FCC code test after adequate practice and self-study. Sometimes it is easier to learn the code by enrolling in a local class sponsored by an amateur radio club, the YMCA, or a church group.

If you are of average ability, it will only take you about 10 hours to "memorize" the set of International Morse characters. You will need about another 10 to 20 hours to develop the skill required to pass the 5 word-per-minute code speed and proficiency test required by the FCC before they will issue a Novice or Technician Class amateur license. An additional 30 to 60 hours of practice will be needed for you to progress from the 5 word-per-minute level to at least 15 words per minute. (Thirteen words per minute, sending and receiving, are required to pass the FCC tests for either the General or Advanced Class amateur licenses). These are only estimates based on my experience teaching code classes, but your learning rate will probably fall somewhere within these limits.

Fig. 1 is a graph that shows code speed compared with average learning time based on a systematic schedule of study. In most cases the code cannot be learned with a haphazard, occasional study approach, and it is important that you plan a systematic, regular, study schedule, and then make a personal commitment to

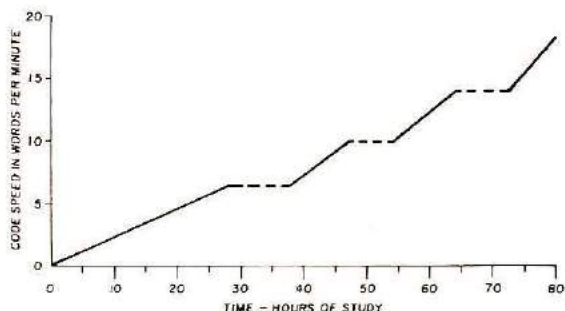


Fig. 1. Code speed compared with learning time for an average person undertaking a systematic course of study.

Letters					
A	dit-dah	J	dit-dah-dah-dah	S	dit-dit-dit
B	dah-dit-dit-dit	K	dah-dit-dah	T	dah
C	dah-dit-dah-dit	L	dit-dah-dit-dit	U	dit-dit-dah
D	dah-dit-dit	M	dah-dah	V	dit-dit-dit-dah
E	dit	N	dah-dit	W	dit-dah-dah
F	dit-dit-dah-dit	O	dah-dah-dah	X	dah-dit-dit-dah
G	dah-dah-dit	P	dit-dah-dah-dit	Y	dah-dit-dah-dah
H	dit-dit-dit-dit	Q	dah-dah-dit-dah	Z	dah-dah-dit-dit
I	dit-dit	R	dit-dah-dit		

Numerals			
1	dit-dah-dah-dah-dah	6	dah-dit-dit-dit-dit
2	dit-dit-dah-dah-dah	7	dah-dah-dit-dit-dit
3	dit-dit-dit-dah-dah	8	dah-dah-dah-dit-dit
4	dit-dit-dit-dit-dah	9	dah-dah-dah-dah-dit
5	dit-dit-dit-dit-dit	0	dah-dah-dah-dah-dah

Punctuation marks and special symbols			
Period (.)	dit-dah-dit-dah-dit-dah	Wait (AS)	dit-dah-dit-dit-dit
Comma	dah-dah-dit-dit-dah-dah	Pause or break (BT)	dah-dit-dit-dit-dah
Question mark (?)	dit-dit-dah-dah-dit-dit	End of message (AR)	dit-dah-dit-dah-dit
Fraction or slant bar (/)	dah-dit-dit-dah-dit	End of work (VA)	dit-dit-dit-dah-dit-dah
Error	dit-dit-dit-dit-dit-dit...	Invitation to transmit (K)	dah-dit-dah

Fig. 2. Recommended set of International Morse Code characters for beginning amateur radio operators. The overscore as used here means that the two letters are run together.

adhere to the plan. Failure to establish such a plan may result in failure to learn the code as quickly as you desire, and perhaps not at all with any degree of proficiency.

You ought to plan on spending between forty-five minutes and one hour of

practice each day of the week. Divide each learning session into practice periods of 15 to 20 minutes, separated by rest periods of 5 to 10 minutes. By resting now and then, you avoid fatigue and increase your learning efficiency. Once in awhile you may have to miss a practice period, but you shouldn't miss more than one period per week or a "slide-back" in proficiency and progress will result.

Fig. 2 is a set of International Morse Code characters recommended for beginners and should be adequate for all FCC code tests. At a later date you may want to learn additional punctuation marks and special symbols not ordinarily used for amateur CW communications.



Tape cassettes offer a convenient way to obtain code practice, either in substantial sessions or in a short lesson of a few minutes duration. They are available for a wide variety of speeds.

During the initial learning period it is highly recommended that you learn the code in groups or blocks of characters and do not try to learn the entire set at one time. You will find that bite-sized groups of letters, numbers, and punctuation make learning the code much easier. You will also discover that there is another advantage to this method: you'll learn the sounds of the dits and dahs rather than visualizing the dots and dashes.

Dits and dahs

One important aspect in initial learning of the code is to always think in terms of dits and dahs instead of dots and dashes. Don't memorize a character as a dot-dash combination. If this is done the mind has to translate a sound (in terms of dits and dahs) to dots and dashes, and finally translate the dots and dashes to the transmitted character. By

learning the characters in terms of their sounds, this two-step process of translation is eliminated.

Many excellent code tapes and records using this approach are readily available in the marketplace, and you will find advertisements for them in most of the amateur radio journals and magazines.* You might also check with local radio club members to see if there are any tapes or records available within the club, or you could also ask your local radio supply store for them. Many radio clubs periodically hold "theory and code" classes for beginners who want to become hams, and often have a set of tapes on file. You will find that a cassette or tape player, a record player, or a code machine will be a valuable aid to your learning process because you will be able to repeat sections of the practice text as you need them, and learn at the rate best for you.

You may already have a receiver for listening to "on-the-air" CW transmissions between licensed amateur radio operators, but unknown

code speeds, poor or noisy signals, and the inability to get a "repeat" when needed are real drawbacks. Major exceptions to such obstacles are the regularly-scheduled code-practice sessions held by W1AW, headquarters station of the American Radio Relay League (ARRL). This station transmits excellent code with automatic keying equipment which provides uniformly-spaced-and-formed code characters. Various code speeds are sent each day, usually in the evening at convenient listening times, and the signal from W1AW is almost always loud and clear. Specific information about the practice sessions is given in *QST*, the monthly publication of the ARRL.

The code character groups recommended for initial learning of the code are given in Fig. 3. This is an arbitrary selection, and variations of characters selected for each group will not affect your learning rate. You should learn each group completely before proceeding to the next one. Practice text, composed of characters in the group being studied — as well as

Group number	character set
1	E, I, S, H
2	T, M, O, R
3	A, W, J, K
4	U, V, F, L
5	N, D, B, G
6	C, Y, Q, X
7	P, Z
8	1, 2, 3, 4, 5
9	6, 7, 8, 9, 0
10	period (.); comma (,); question mark (?); slant bar (/); error
11	wait (AS); pause (BT); end of message (AR); end of work (VA) invitation to transmit (K)

Fig. 3. Recommended character sets for "bite-size" code lessons.

*Cassette tapes from 3½ to 40 wpm are available from *ham radio's* Communications Bookstore, Greenville, New Hampshire 03048.

characters in previous groups — should be available for study sessions.

Regardless of the code transmission rate, each character of the International Morse Code is always transmitted in dits and dahs of uniform lengths, with uniform spaces between them. Spacing between characters and words is also uniform, and **Fig. 4** shows this relationship.

Another suggestion for learning the code is to select a cassette or tape which sends the individual code characters at a speed of approximately 13 words per minute but spaces the characters far enough apart so that the effective overall sending rate is only about 4 or 5 words per minute. In this manner, the sound of the characters is learned at a speed comparable to that required for the FCC code test at 13 words per minute. This means that you don't have to re-learn the sound of each character every time the code speed is increased, and — at the same time — you automatically prepare yourself for the General or Advanced Class code test as well as the Novice and Technician Class code test. The brain has no difficulty recognizing individual characters sent at a faster speed if sufficient time is allowed between the characters. Many companies who supply amateur radio instruction materials employ this technique for their code tapes, cassettes and records.

Getting it down on paper

In order to copy code on paper at a rapid rate, it is recommended that you write the letters and words in longhand rather than print them. This is contrary to what you will hear from many teachers, but at high speeds such as 20 words per minute I have found that the time required to print each character is greater than the allowable

time for copying, with the result that you gradually fall behind. If you plan to progress to the Amateur Extra Class license, you should begin now to write out the letters and words instead of printing them.

A final suggestion that will help you copy code successfully is to ignore missed characters. When your brain refuses to identify a particular character — and this happens occasionally to even the most experienced operator — ignore it and quickly go on to the next character. This ability is not difficult to develop if you start right away, and it will help you avoid the bad habit of stopping to recall the transmitted character and missing the next two or three characters.

One way to help train yourself to develop this valuable technique is to insert a dash in place of the missed character, and continue copying. Later, you can go back and fill in the missing character after completion of the copy. Sol Kupferman, W2GVT, recommends that you learn to insert a random character for a missed character and continue to copy. He reports that in many instances the random character will be the correct one because the subconscious mind had instinctively provided the right response. This method could be a bonus, particularly if you are taking the FCC code test and desperately need that twenty-fifth character to pass the test.

Don't ignore the need to develop a good code sending ability along with a good code receiving ability. One way is to obtain a hand key and code practice oscillator, and practice sending code for 5 or 10 minutes during each training session. Sending practice provides a pleasant and relaxing diversion and also helps you develop greater code receiving proficiency. If a tape recorder is available, record

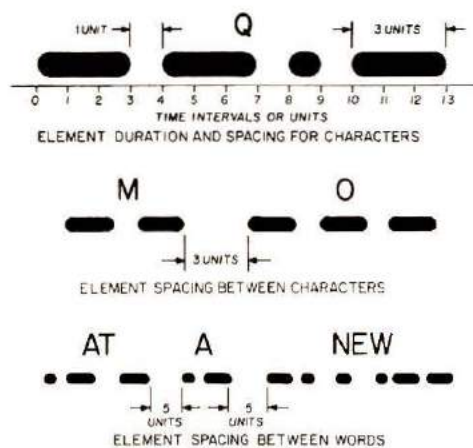


Fig. 4. Time interval spacing for elements of a character, between characters and between words.

your own sending and play it back for analysis. This technique helps you learn to send more perfect code and at the same time augments your receiving ability by the process of repetition.

Finally, if you feel you're "stuck" and not making the progress you think you ought to be making, take heart. Referring again to **Fig. 1**, notice that the learning "curves" are broken by separations or "plateaus." You'll remember that we talked about how long it takes an average beginner to learn the code, based on estimates gathered over a long period of time, and from many code classes. Well, these estimates also allow for the "learning plateaus" experienced by most people.

A plateau is simply a time of little or no apparent progress in sending or receiving speed and is caused by a mental barrier in which the brain simply refuses to adapt to a faster speed for a temporary (and usually short) period. Your plateaus may occur, for example, at 6-7, 10-11, 13-15 words per minute and at higher speeds. The only solution to overcoming these obstacles is practice and more practice. Almost everyone will experience one or more plateaus while learning to

receive code at the higher speeds, so don't be discouraged. Keep at it.

Code practice oscillator

You may want to build a code practice oscillator as a "first" electronics construction project. Kits, such as the Heathkit HD-1416 Code Practice Oscillator (with hand key), can be obtained for this purpose.

An excellent code-practice oscillator may be built from "scratch" using a Signetics NE555 integrated-circuit chip (timer chip) and a handful of small components. The IC and necessary components can be purchased from most electronics parts suppliers or from local Radio Shack or Lafayette Electronics stores. A diagram and parts list for this oscillator is shown in Fig. 5. You can install the oscillator in a small utility box or cabinet for a "professional" appearance, and include a two- or three-inch diameter speaker having an impedance of between three and eight ohms. The oscillator tone is adjustable to suit your ear over

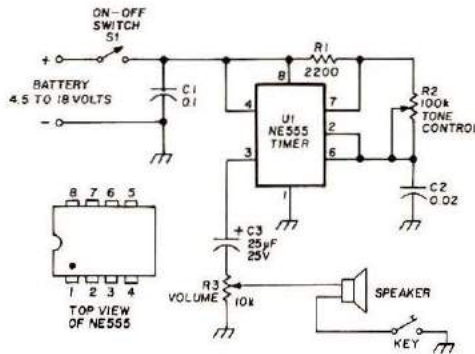


Fig. 5. A simple code practice oscillator can be built around Signetics NE555 and handful of components.

a range of approximately 300 to 1000 Hz by means of a potentiometer, R2. The volume is adjustable to a comfortable listening level with R3. A more complete description of this code-practice oscillator may be found in *The Radio Amateur's Handbook*.

Summary

Seven principles for developing code proficiency are:

1. Practice, practice, and practice some more; this is the primary key to learning the code.

2. Plan a systematic schedule for code practice and stick to the schedule.

3. Ignore missed characters during practice; write in a dash or random substitute character quickly, and concentrate on the next character.

4. When practicing, always copy at a speed that is faster than a "comfortable" speed.

5. Develop the ability to transmit code by devoting a portion of each learning session to code sending practice.

6. Plan for over-qualification when you take the FCC code proficiency test. If you'll be taking a 5 word-per-minute examination, make sure you can copy "solid" at 6 or 7 words per minute; and if you're taking a 13 word-per-minute test, be able to copy 15 words per minute. Everyone experiences some apprehension before and during a test, and the ability to copy "solid" at a slightly higher speed will pay big dividends.

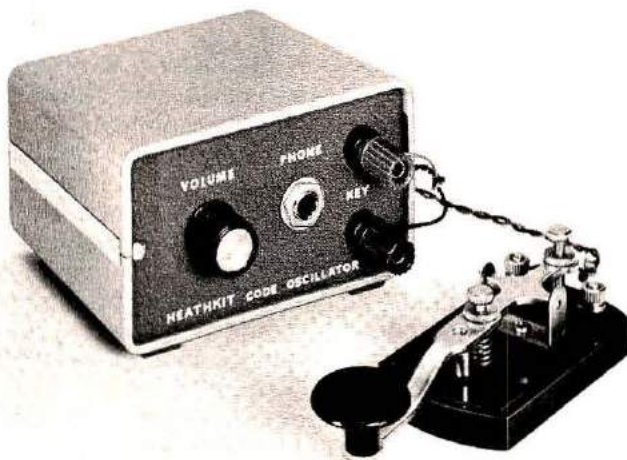
7. Get in touch with some members of your local ham radio club for assistance and possible code and theory classes once a year, or more often, depending upon demand. Working with hams who have passed the FCC tests will provide motivation for you to acquire the necessary skill to carry on conversations in code.

Good luck, pilgrim.

Bibliography

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2. Solomon Kupferman, W2GVT, "Some Ideas on Code Practice," *CQ*, November, 1975, pages 37-38, 79-80.
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HRH



A code-practice oscillator and key are necessary for the beginner to build up his code vocabulary. There are many excellent models available and advertised in the amateur literature.

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*Where it came from,
and what happened to it*

The exploration of the high frequency spectrum in the early 1920s by Marconi in Europe and radio amateurs in the United States led to a revolution in communications that is still producing shock waves today. One of the first parties to grasp the importance of the high frequencies, and to understand the need for improved long distance communication via short waves, was the United States Navy. In spite of the millions of dollars invested in a world-wide, low-frequency network, the Navy moved into the shortwave field with speed and enthusiasm, aided by radio amateurs.

Assisted by the American Radio Relay League, the Naval Research Laboratories observed that frequencies between 2 MHz and 4 MHz carried much further during darkness than during daylight, and that frequencies between 4 MHz and 12 MHz were better for daylight use. A variable-frequency transmitter was used by John Reinartz, W1QP and W1XM, in tests that were monitored in the Laboratory and also in Orlando, Florida. Signal strengths were logged over a period of months. The 1924 tests showed a "zone of silence" which varied with the frequency in use. This was the discovery of *skip distance*, and this phenomenon, which did not fit in with the older wave

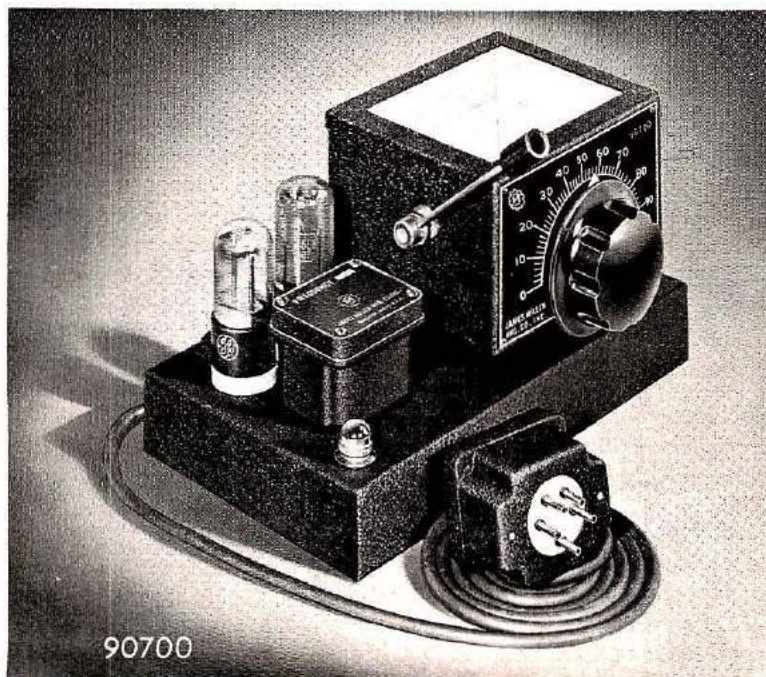
propagation theories, led to vast changes in communications technology and convinced the Navy that the higher frequencies were practical and that a reliable, variable-frequency transmitter design was a prime necessity.

In 1925, an experimental shortwave station, manned by Fred Schnell of the ARRL, was installed on the fleet flagship, the *U.S.S. Seattle*, for long-distance transpacific tests as

BY WILLIAM I. ORR, W6SAI

the fleet moved from San Francisco to Australia. The outstanding results of these transmissions led the Commander-in-Chief to recommend that the Navy be equipped with two-way radio equipment capable of instant operation at frequencies up to 18 MHz. Within a few years the U.S. fleet was provided with far more reliable communications equipment than any fleet in the world.

The James Millen Manufacturing Company of Malden, Massachusetts was among the first of many companies to specialize in equipment for Amateur Radio stations. Quality, price, and performance were their strong points. This Millen 90700 *Variarm* vfo was one of the first vfos available to Amateurs. The main tuning dial was supplemented by a vernier arm connected to a small variable capacitor that allowed the operator to easily shift frequency by 1 kHz or less.



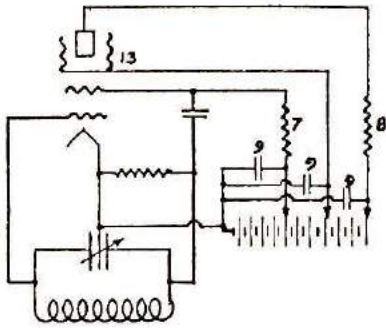


Fig. 1. The Dow "constant frequency oscillator." The screen of the tetrode tube was used for the anode of the oscillator circuit. In this version, the cathode is at ground potential and the screen is at rf potential. A later version shifted the ground point from the cathode to the screen. (Figs. 1-3 from *Proceedings of the IRE*, December, 1931, Volume 19, number 12, "A Recent Development in Vacuum Tube Oscillators" J. B. Dow).

A Congressional appropriation of \$550,000 in 1926 set the stage and the Navy's Bureau of Engineering announced that, "facilities were conducting research based upon the new requirements." It fell to the lot of a radio amateur to solve the complex problem of multifrequency operation and quick frequency change. This is the story of that development and how it affected amateur radio.

The beginning

The February, 1926, issue of *QST* magazine featured a description of amateur station 1BAY, of Cambridge, Massachusetts, owned and operated by a 29-year old Naval Lieutenant, Jennings B. Dow. Dow's transmitter, a 100-watt job, was completely home-built (as were most transmitters of the times) and featured crystal control, a rarity in those days. Dow had ground his own crystal and admitted that his station, "was primarily for experimental purposes and little time was available for operating." Nevertheless, he had received a report from Ireland and had worked the West Coast a number of times.

Radio 1BAY disappeared

from the pages of *QST* after the station description of 1926, but Dow was not unknown to commercial and ham operators; in 1922 he had published the *CW Manual*, a compilation of material concerning the use of *Federal* arc transmitters and it is known that he was a radio officer on the *U.S.S. Utah* during the period 1932-1933. However, it was his work in the Naval Research Laboratory in the late 1920s that is of importance today, as his design of a reliable variable-frequency oscillator took place during that time.

The Navy required a power oscillator for their shore and marine transmitters that was reliable, rugged, and resettable. Dow developed a "constant frequency oscillator" circuit (Fig. 1) which depended for its operation upon the "electron coupling between the oscillation-generating circuit and the load circuit." In the early circuits an 865 or an 860

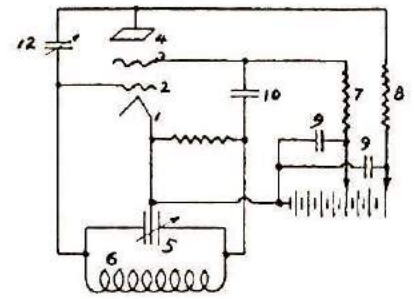


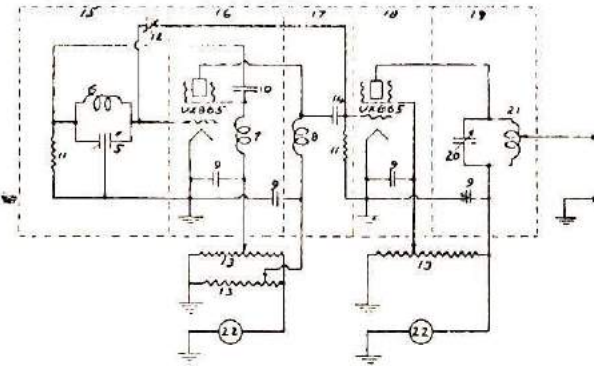
Fig. 2. Electron coupling between oscillator circuit and load circuit minimized frequency variation as load shifted. For maximum isolation, feedback capacitance of tube is neutralized by capacitor 12.

vacuum-tube tetrode was used, at power levels up to 100 watts output. To achieve maximum isolation from load variation, Dow neutralized the feedthrough capacitance of the tube (Fig. 2). His published works included a master-oscillator, power-amplifier arrangement (Fig. 3) which was used as an exciter unit for a 500-watt Navy transmitter

The Millen Model 90711 vfo was a more sophisticated version of the earlier *Variarm*. Note the slide-rule dial, separate bandspread switch, and vernier tuning arm. In those days Amateurs used the 11-meter band, and its inclusion is therefore no surprise. The older vfos were housed in cabinets larger than most modern transmitters. Millen's full line of station accessories supplied the Amateur with everything he needed to put an outstanding signal "on the air."



Fig. 3. Master-oscillator power-amplifier (MOPA) circuit devised by Dow for frequency control unit of 500-watt Navy transmitter. Two UX-865 tetrode tubes are used. Oscillator circuit (5,6) is coupled to screen and grid of first tube. Plate-to-grid capacitance is neutralized by capacitor 12. Second UX-865 acts as an amplifier or as a doubler (18).



capable of operation up to 24 MHz and which provided a "pure dc crystal note."

The radio amateur version

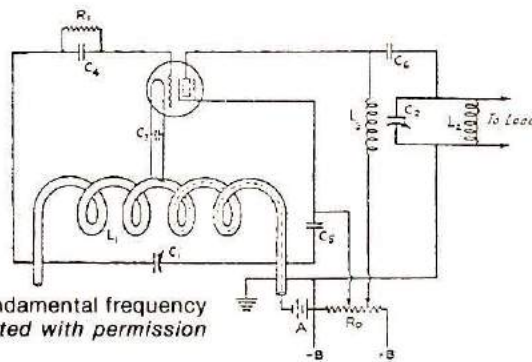
Dow publicized his improved oscillator circuit in *QST* magazine of January, 1932 (Fig. 4). A 100-watt tetrode (type 860) was used, with a frequency-determining circuit consisting of an air-dielectric capacitor and a copper-tubing tank coil (L1-C1). The screen grid of the 860 served as the anode of the triode oscillator circuit. The filament of the tube was above ground potential, as far as the oscillatory circuit went, so a bifilar coil was used, with one filament wire pulled through the copper tubing. In a later version (Fig. 5), published in the March, 1933, issue of *QST*, a special, low-capacitance filament transformer was used so that the bifilar tank coil could be eliminated.

However, amateur interest was minimal in an oscillator that used a 30-dollar tube, and it was not until James Millen, W1HRX, and Jim Lamb, W1AL, the technical editor of *QST*,

revised the circuit for low-power crystal control that the Dow oscillator advanced into ham history (Fig. 6). Lamb analyzed the circuit as a low- μ triode oscillator with its grid directly coupled to a high- μ screen-grid amplifier. He substituted crystal control for Dow's tuned circuit and the so-called *Tri-tet* oscillator was born (Fig. 7).

The plate circuit of the Dow-Lamb oscillator could be tuned to harmonics of the crystal, providing multiband operation. Curiously enough, Lamb's interpretation of the circuit as shown in Fig. 6 was not absolutely correct, as the cathode circuit is not tuned to the crystal frequency for optimum performance. Rather, it is tuned to a frequency approximately 1.5 times higher than the crystal frequency and functions as a feedback control. And finally, by the November, 1933, issue of *QST*, a circuit was developed to provide either crystal control or variable-frequency operation for the amateur (Fig. 8). Capable of providing from 3 to 8 watts

Fig. 4. Improved Dow oscillator circuit was shown in January 1932, issue of *QST*. Oscillator developed 40 watts power output on the second harmonic. "Hot" cathode circuit was fed via secondary winding in copper tubing oscillator coil. Because of the low grid-plate capacitance of the 860 tube, neutralization was unnecessary when the plate circuit was tuned to the fundamental frequency of the oscillator (drawing reprinted with permission of *QST*).



power output on all bands between 160 and 10 meters, this two-tube exciter was a giant step toward all-band operation. Before the efforts of Dow and Lamb, radio amateurs were chained to crystal control on one or two bands, to unstable self-excited oscillator operation on a number of bands, or to separate transmitters for each band in use. Now for a few dollars, a few parts, and a handful of plug-in coils, operation on any

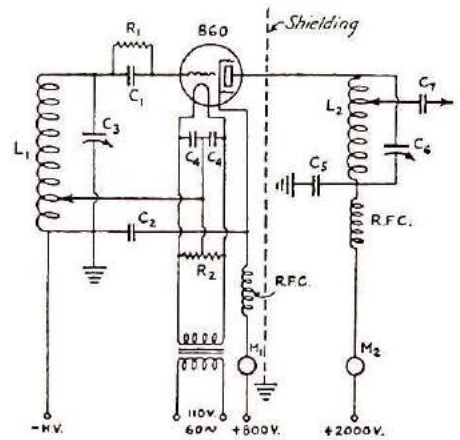


Fig. 5. A practical Dow oscillator for hams. A wire-wound coil was substituted for the copper tubing coil of Fig. 4. A low capacitance filament transformer was used to allow the filament circuit to assume an rf potential. A single 860 oscillator was capable of driving a pair of 860s in parallel for a two-stage kilowatt transmitter. Keying was usually accomplished in the screen circuit (drawing reprinted with permission of *QST*).

high-frequency amateur band was possible.

The Perrine vfo

Crystal control afforded good stability, but variable-frequency high-power oscillator operation, while acceptable for the U.S. Navy, was not stable enough for the narrow amateur bands, and the electron-coupled Dow oscillator gradually got a bad name. By 1936 most amateur stations were crystal controlled, despite the fact that the crystal limited the operator to a single frequency and its harmonics. Changing frequency, therefore, became

an expensive and time-consuming operation. Most hams had one or two crystals, and that was that!

In October, 1938, the cover of *Radio* magazine announced, "W2GOQ, W2UK, and W6CUH work KHBRC around the world!" It was the famous globe-girdling flight of Howard Hughes who circled the globe in three days, nineteen hours, and eight minutes! Amateur radio scored a triumph, too, as contact was maintained with

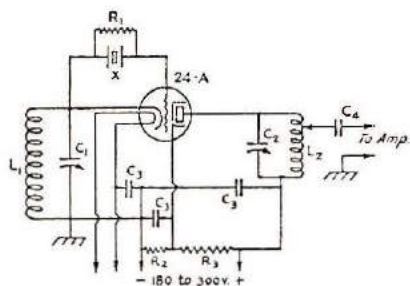
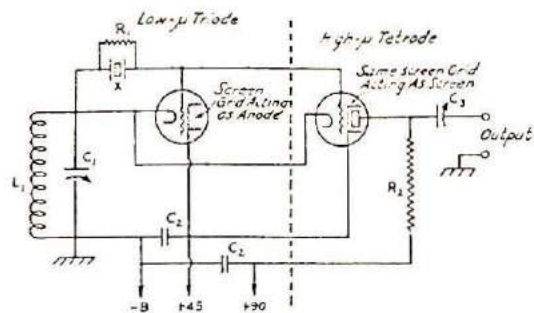


Fig. 7. The Lamb "Tri-tet" oscillator circuit. The name came from the idea of a combination triode oscillator and a tetrode amplifier. The cathode circuit is in the plate to cathode return; rf voltage developed in the plate circuit is imposed on the grid circuit in proper phase and amplitude to sustain oscillation. The main advantage of the Tri-tet was that even a poor crystal could be made to oscillate. Crystal current, however, was very high in this basic design. Later designs incorporated cathode bias for reduced crystal current (*drawing reprinted with permission of QST*).

the Hughes plane by radio amateurs as it sped around the world. Dick Stoddart (call unknown) and Charles Perrine, W6CUH, of Hughes Aircraft Company deserved the credit for the design and development of the ground and air equipment responsible for the radio communication for the record flight.

And it was a few months later at Hughes Aircraft that W6CUH developed the famous "crystal e.c.o.," or XEC exciter. This sophisticated version of the Dow oscillator featured a very high-C tank circuit which helped materially to swamp out the effect of tube and circuit changes on the oscillator

Fig. 6. The Dow oscillator was analyzed by Jim Lamb of QST as a low-mu triode oscillator directly coupled to a high-mu tetrode amplifier. James Millen adapted this circuit to crystal control by placing a crystal in series with the grid of the Dow oscillator. By proper tuning of the tetrode plate circuit power output on the second harmonic of the crystal frequency was achieved. The Lamb circuit (shown here) placed the tuned circuit in the cathode, whereas the Millen circuit tapped the cathode at a point on the grid tuned circuit. Feedback was varied by moving the cathode tap, whereas with the Lamb circuit the impedance of the feedback path was varied by means of a variable capacitor shunted across the feedback coil (*drawing reprinted with permission of QST*).



frequency (**Fig. 9**). It was recognized by Perrine that a high-Q coil, rigidly mounted, contributed to frequency stability. The heater and cathode of the Perrine oscillator tube were held at the same rf potential by the expedient of an interwound coil that carried filament power to the tube. The XEC also incorporated temperature compensation by virtue of the addition of a small capacitor that had a negative temperature coefficient. When used with a regulated plate supply, the oscillator had a drift of less than 1000 Hz at 14 MHz over a temperature variation of 30 degrees fahrenheit. This would be considered mediocre by today's exacting standards, but nevertheless the XEC was head and shoulders above anything else available to the radio amateur, so far as frequency stability was concerned.

The post-war vfo

The lessons learned from the

early oscillators of Dow and Lamb, and from the pre-war XEC exciter of W6CUH, came to fruition after World War II in the improved variable oscillators available in amateur equipment. One of the better oscillator designs was that used in the Collins KWM-2 transceiver (**Fig. 10**). While Dow and Lamb undoubtedly would have recognized the circuit as a version of their original designs, the execution was bold and new. The Collins 70K-2 oscillator used inductive tuning and derived the cathode voltage from a capacitance bridge, instead of from a tap on the oscillator coil. Oscillator readout is linear so the tuning dial could be calibrated in kilohertz, and the vfo could be instantly shifted in frequency by means of a voltage-variable capacitance diode placed across a portion of the oscillator circuit.

And, finally, the vfo concept was converted to solid state. Heat was removed from the vfo by the elimination of vacuum tubes; polystyrene and mylar

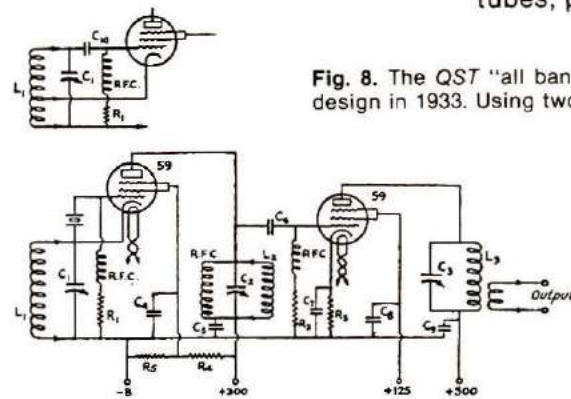


Fig. 8. The QST "all band" exciter unit was the latest design in 1933. Using two 59 pentode tubes, the bread-board exciter provided between 3 and 8 watts on any amateur band between 160 and 10 meters. It was possible to rearrange the grid circuit for self-excited operation, as shown. Most amateurs, however, preferred crystal control (*drawing reprinted with permission of QST*).

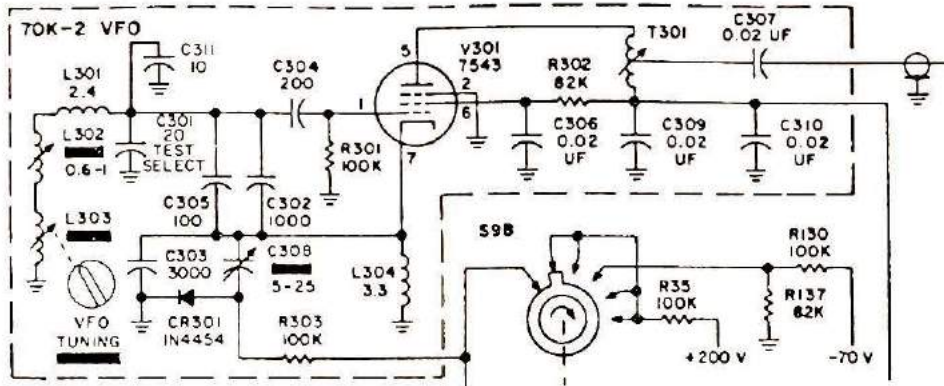


Fig. 10. Ultimate vacuum-tube vfo design is that used by Collins in the KWM-2 transceiver and S-line equipment. Cathode feedback voltage is derived from a voltage divider across the oscillator coil which forms a portion of the tuned circuit. Note that inductive tuning is employed.

capacitors took the place of mica units; oscillation amplitude was diode limited; and frequency control was accomplished with varicap diodes. A modern vfo is

capable of holding frequency within 100 Hz, or better, over an extended period of time. Precision oscillators of this general type, operating in the middle-hf range, can hold

frequency to 10 Hz or less when they are powered by a voltage-controlled supply.

The crystal-controlled Tri-tet oscillator has faded into obscurity as the years have

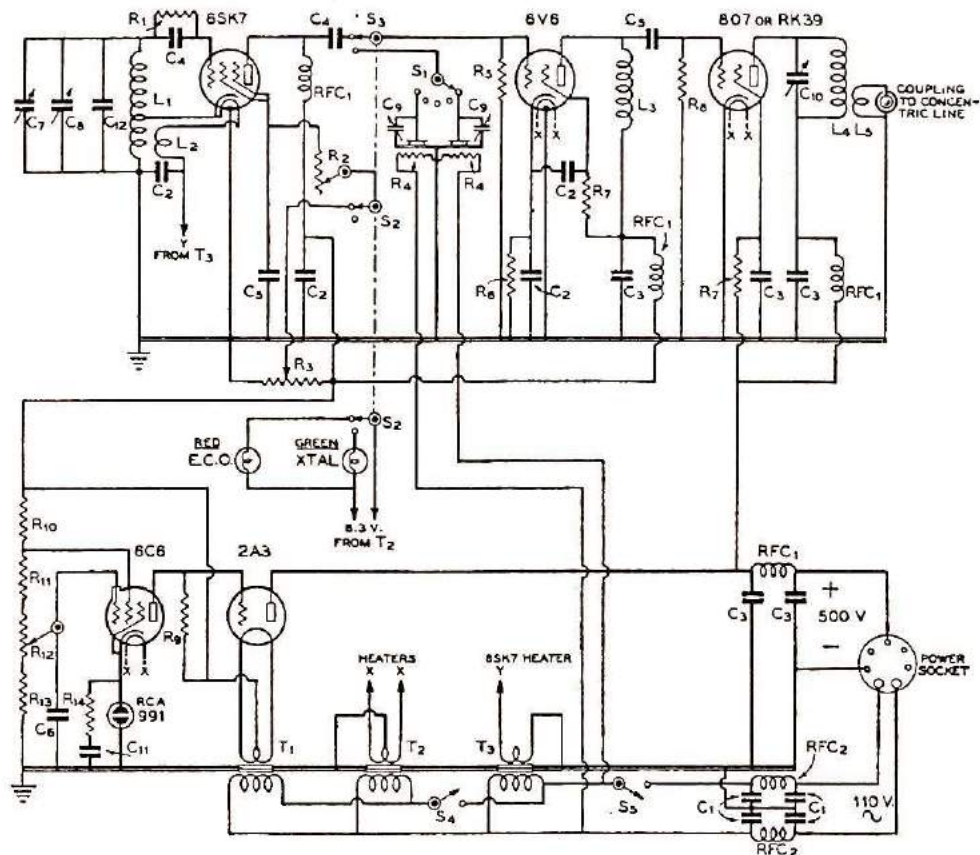


Fig. 9. In December, 1939, the famous W6CUH "XEC" vfo-exciter was shown in *Radio* magazine. This frequency-control unit was voltage and temperature stabilized. The filament of the 6SK7 oscillator was isolated from ground by means of a bifilar winding on the oscillator coil, thus reducing drift caused by varying filament-cathode capacitance within the tube. Optional crystal control, using ovens, was provided. A novel regulated power supply was included in the unit.

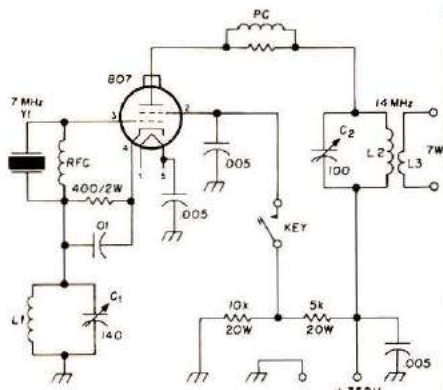


Fig. 11. Modern version of the Tri-tet oscillator. Using an FT-243 style 7-MHz crystal, the 807 oscillator will deliver 7 watts at 14 MHz. The cathode circuit is tuned to about 10 MHz.

passed. Better circuits, providing enhanced harmonic output and a higher order of stability, have come into being. But for the amateur interested in trying out this interesting idea, a modern circuit, using an 807 tube, is shown in Fig. 11. This version makes use of the large FT-243 style crystal because the more compact crystals in the HC-6/U holder won't stand the gaff. With a 7-MHz crystal, appreciable power is available on 14 MHz from the oscillator, with crystal current held to less than 50 mA. The improved circuit features cathode bias which provides protection for the tube in case oscillation ceases; this also tends to reduce crystal current. The circuit will work equally well with a 6L6GC or a 6V6GT at reduced voltage.

Most oscillator circuits are named after their inventor, or the engineer who popularized them: Hartley, Colpitts, Pierce, Seiler, Clapp, and Vackar are a few of the names that come to mind. But Dow never received the recognition due him, as his circuit is generally known as the "electron-coupled oscillator". Lieutenant Dow continued his career in the Navy electronics through World War II, retiring shortly thereafter with the rank of Commander. He died in February, 1970.

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TRANSMISSION

LINES . . .

YOUR PIPELINE

TO THE OUTSIDE WORLD

*How to choose
the right feedline
for your station
and how to get
the most out of it*

BY JIM FISK, W1HR

Receiver, transmitter, transmission line, antenna — each is equally important to the operation (and success) of your amateur station. No matter how good your antenna is, or how powerful your transmitter, if your receiver is insensitive or unable to separate strong, nearby signals, you won't be able to hear all the stations that can hear you. Likewise, if your receiver is super, but your transmitter isn't doing the job it should, you will be able to hear weak, faraway stations that your transmitter just can't reach. So it is with each of the

building blocks in your station — like a chain which is only as strong as its weakest link, you can't neglect one of the links without affecting overall station performance. Your transmission line is one of these links.

After spending a good chunk of your hard-earned money on a transmitter and receiver, and putting up the best antenna you can afford (or your landlord will allow), the transmission line is often an afterthought. Little attention is paid to its selection or installation, and yet, for only a few dollars, its

performance can often be improved a hundredfold! In this article we'll give you some tips on how to select the best transmission line for your station and how to hook it up.

Balanced feedlines

Years ago all amateurs used balanced open-wire feedlines made from no. 12 or 14 (1.5-2.0mm) copper wire, separated every two or three feet (1m) by spacers as shown in Fig. 1A. In the very early days most amateurs made their own feedline spacers by boiling wooden dowels in beeswax; later on, after ceramics were perfected, several firms made low-cost ceramic spacers which were very popular. Following the war, plastics with good rf insulating properties became available and they quickly replaced the more expensive ceramic spacers. Plastic spacers also lended themselves to the manufacture of commercial "ladder line" — whereas wood and ceramic spacers had to be tied in place, plastic spacers had a low melting point so they could be attached by simply heating the wire and pressing it into the plastic.

Twinlead or ribbon line, Fig. 1B, was the next step in the development of balanced feedlines. Originally designed for use with television receivers, it consists of two parallel wires imbedded in a web of polyethylene plastic. Although television twinlead was an inexpensive answer to the feedline problem, the conductors were pretty small for transmitting purposes, and losses increased dramatically whenever it rained. The manufacturers solved the conductor problem by



introducing heavy-duty twinlead with heavier conductors which was marketed specifically for transmitting purposes. The effects of rain were minimized to a certain extent by the use of the tubular construction shown in Fig. 1C which provides a longer path between the two conductors.

There was a time, 45 or 50 years ago, when practically every transmitting station in the world used open-wire feeders — there was simply nothing else available. Although balanced feeders had very low loss, a big plus, they also had their problems: They had to be kept well away from metal objects; they had to be installed high above ground; bends and turns in the line had to be very gradual, and they often twisted in the wind, shorting out the two conductors. Since balanced, two-wire feedlines were used

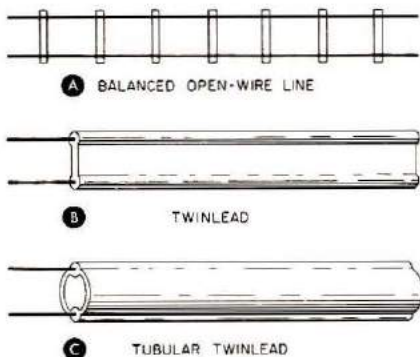


Fig. 1. Three types of balanced feedlines which are sometimes used by radio amateurs. Many years ago the open-wire feeder in A was used by practically every radio station in the world; today it is seldom seen. Twinlead B was originally developed for home television receivers, although heavy-duty versions are available for transmitting use. The tubular twinlead in C has somewhat lower loss than conventional twinlead, but is available only in low power versions.

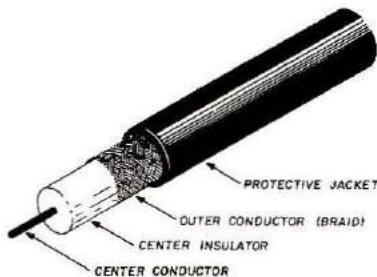


Fig. 2. Construction of modern, flexible coaxial cable. Center insulator may be polyethylene, Teflon, polyfoam, or other low-loss plastic. Some types may have a double braid covering for extra shielding, or silvered conductors for low loss.

by everyone, the transmitters of the time were designed to match them. That isn't true anymore, but some of the popular amateur antenna handbooks still persist in pushing the use of twinlead and open-wire feeders. This is not to say that balanced feedlines are all bad — in some applications they are a very good choice — but modern amateur equipment is designed for use with coaxial cable and is not directly compatible with balanced feedlines. In fact, if you were to make a survey of active amateurs, you'd probably find that 99 out of 100 are using a coaxial transmission line.

Coaxial cable

The coaxial transmission line is inherently unbalanced and consists of a center conductor which is surrounded by a grounded shield or outer conductor as shown in Fig. 2. Since the rf field is contained completely within the shield, this type of transmission line is not sensitive to nearby objects — unlike balanced feeders, it can be run through metal

conduits, taped to tower legs, buried in the ground, or even run underwater. Although balanced feedlines predate coaxial cable so far as amateur use is concerned, the basic coaxial structure received considerable attention from telephone engineers in the late 1800s who were trying to improve telephone transmission, particularly in transatlantic submarine cables.

In the early 1930s Bell Telephone engineers started experimenting with coaxial lines for the transmission of high-frequency radio waves, and found that they worked very well. The rigid, air-spaced, solid copper lines used in these studies weren't practical for amateur stations, but commercial broadcasters quickly adopted them as standard equipment. Most of these early coaxial lines were built with ceramic disks or beads spaced at intervals along the line to support the inner conductor, a technique that is still used today (Fig. 3).

Flexible coaxial cable first appeared on the scene in the late 1930s, but it was

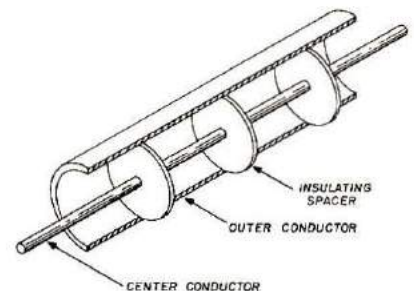


Fig. 3. Construction of coaxial air-insulated line which is used by high-power, commercial stations. This arrangement was first devised more than 40 years ago, and except for the use of modern plastic spacers (usually Teflon), it has changed very little.

expensive, and amateur transmitters of the day were designed for *balanced* feedlines, so few amateurs were interested in giving it a try. Although this cable used woven copper braid for the outer conductor (and a natural rubber weather shield), the resemblance to modern flexible coax stopped there. Polyethylene was discovered in 1937, but wasn't available in commercial quantities until much later, so this first flexible coax used ceramic spacers like its more expensive cousins. Some manufacturers tried using natural rubber as a flexible dielectric, but the losses were far too great for use at radio frequencies.

Most of the military equipment built during the war was designed for use with coaxial transmission lines, and the armed services bought thousands and thousands of feet of flexible coaxial cable which used polyethylene as the center insulator. After the war ended, much of this cable showed up on the surplus market, but many amateurs were still using transmitters from the 1930s and didn't think the conversion from balanced feedlines was worth the

trouble. However, commercial television was on its way, and the impact of television interference quickly put an end to unshielded radio transmitters — and their balanced feedlines. Although balanced feeders don't radiate under ideal conditions, few amateur stations were ideal, with the result that the feedline often radiated unwanted rf into nearby television sets. Coaxial transmission line didn't solve all the TVI problems but it did keep the rf bottled up until it reached the antenna where it belonged.

Feedline characteristics

If you've read the operating manual for your transmitter (or transceiver), you know that the rig likes to "look into" a 50-ohm load, with a standing-wave ratio (swr) not greater than 2:1. You have probably asked yourself, "Why a 50-ohm load? Why not 25, 75, or 100 ohms, or some other value?" This is a good question — with an answer that has an interesting story behind it. But before we get to the story, let's talk a little about one feedline parameter that's always listed in the catalogs: Characteristic impedance.

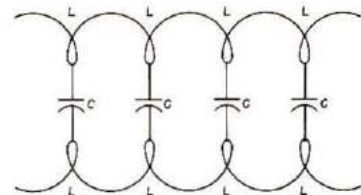
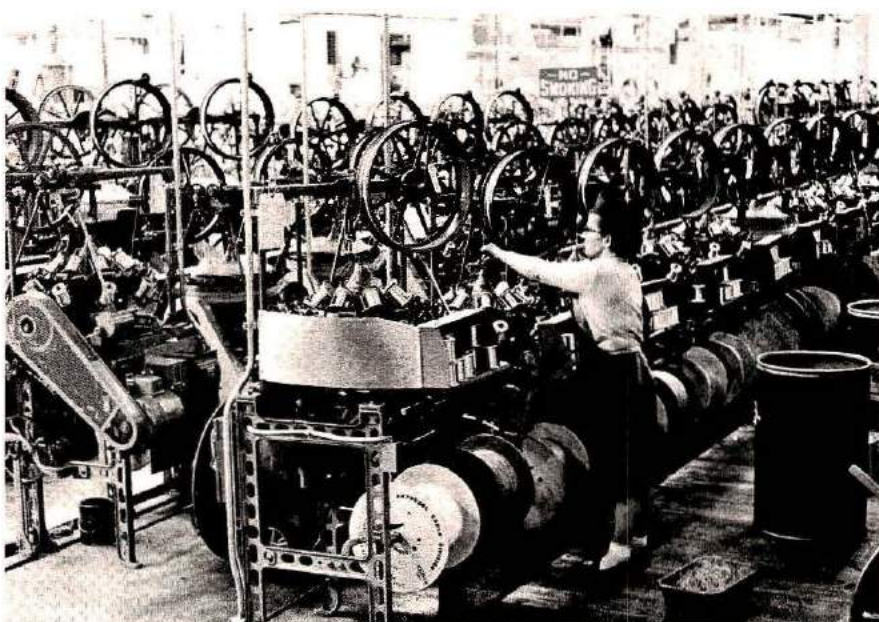


Fig. 4. Every transmission line is made up of distributed capacitance and inductance, as shown here. When rf energy is applied to the line, these components set up a fixed relationship between voltage and current, thereby establishing the characteristic impedance of the line.

Any transmission line, balanced or unbalanced, twinlead or coaxial line, has a certain amount of capacitance and inductance per unit length as shown in **Fig. 4**. These components are distributed equally along the length of the line (called *distributed* components) and don't behave exactly like individual capacitors and inductors (which are called *lumped* components). When rf energy is applied to the transmission line, the distributed components establish a fixed relationship between voltage and current which, from Ohm's law, results in the characteristic impedance of the line.

Since the distributed capacitance and inductance along the line are a direct result of conductor diameter and spacing, and the insulating material used between them, it follows that the characteristic impedance of the line can also be calculated from the same dimensions. For coaxial transmission line the characteristic impedance is determined by the ratio of the size of the outer conductor, D , to that of the inner conductor, d , as shown in **Fig. 5**. Assuming the outer diameter is held constant, say at 1 inch (25mm), the smaller the center conductor, the higher the characteristic impedance.

Unfortunately, there is no one ratio of conductor diameters which is optimum for all important transmission parameters. For example, a



Braider machines in Amphenol's Chicago plant; machines cover thousands of feet of coaxial cable daily with copper braiding (photo courtesy Amphenol).

coaxial line which has minimum loss (called attenuation) is not optimized for maximum power, and a line which is designed for maximum breakdown voltage does not have minimum loss. This is shown graphically in Fig. 6. As can be seen, power handling peaks at a characteristic impedance of 30 ohms, breakdown voltage peaks at 60 ohms, and minimum attenuation occurs at about 77 ohms.

Where, then, did the 50-ohm standard originate? Well, when the U.S. Navy was establishing standards for coaxial cable during the war, an industry committee recommended that 50 ohms be selected as a compromise between the three important transmission parameters and commercially available copper water-tubing sizes. It's interesting to speculate where we would be today if the plumbers hadn't come to the rescue!

Actually, the 50-ohm coaxial transmission line is a pretty good compromise because loss is only about 10 per cent greater than the minimum at 77 ohms, and the power handling capability is only about 14 per cent less than optimum. This is of little consequence on the

high-frequency amateur bands because most of the commonly used 50-ohm coaxial cables can easily handle the maximum amateur power limit of 1000 watts.

The attenuation minimum which occurs at 77 ohms (Fig. 6) explains why the CATV companies use 75-ohm coax in their cable distribution systems — they're looking for minimum signal loss over a cable which may be thousands of feet long. In amateur stations the transmission line is seldom more than 150 or 200 feet (40-60m) long, so the difference in loss between 50- and 75-ohm coaxial lines is so small it can't be measured (assuming, of course, that both lines have the same type of center insulation). If you compare Teflon insulated line (such as that used by the CATV companies) with polyethylene lines, you'll find a measureable difference — Teflon is an easy winner.

Cable loss factors

If a transmission line were perfect it would have absolutely no losses, and no power would be lost as the rf traveled from your transmitter to your antenna. Unfortunately, it's impossible to make a perfect line so all transmission

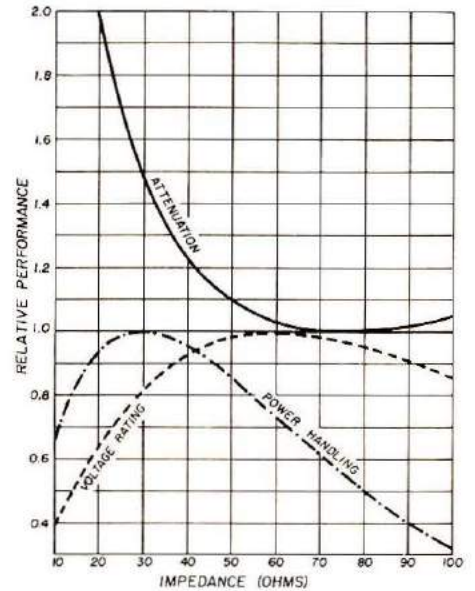


Fig. 6. The important transmission line parameters as a function of the characteristic impedance of a coaxial line. Power handling peaks at 30 ohms, voltage breakdown is highest at 60 ohms, and minimum loss occurs at 77 ohms. The 50-ohm lines often used by amateurs represent a good compromise between these values.

lines have a certain amount of loss. This is usually measured in terms of decibels (abbreviated dB) per hundred feet of line. Decibels are a measure of power input to power output, or power ratio, as shown in Fig. 7, and greatly simplify the mathematics when you have to figure out total loss (or gain). For example, when a transmit/receive relay which has 0.5 dB loss is connected to a lowpass filter which has 0.3 dB loss, which is connected to a transmission line with 3 dB loss, the total loss from the transmitter to antenna is 0.5 + 0.3 + 3.0 or 3.8 dB (see Fig. 8). If these same losses were expressed in simple arithmetic terms, 0.5 dB loss through the relay means that only 89 per cent of the power at the input connector makes it through to the output. Similarly, 0.3 dB loss in the filter corresponds to 93 per cent power transmission, and 3.0 dB cable loss is the same as 50 per cent transmission.

Let's say your transmitter

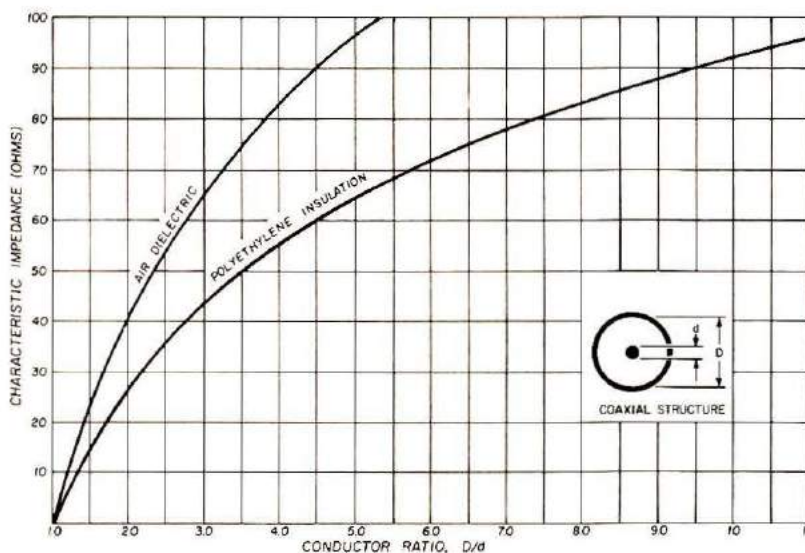


Fig. 5. The characteristic impedance of a coaxial line is determined by the ratio of the conductor sizes, and the material which is used for the center insulator.

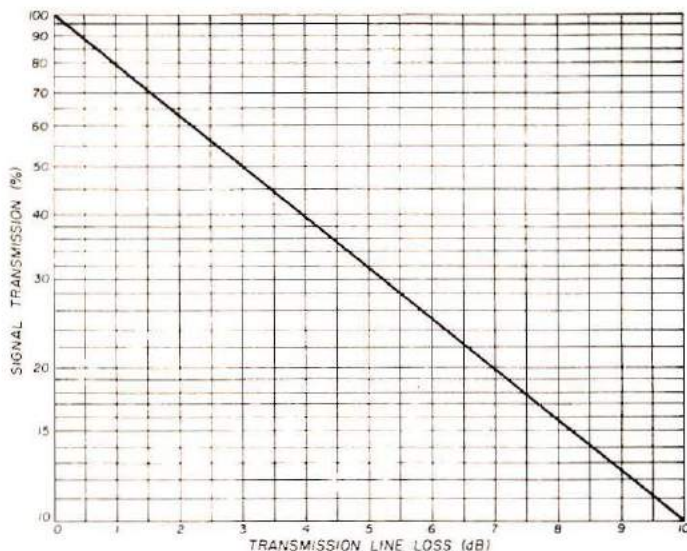


Fig. 7. Decibel or dB values expressed in terms of power ratio. Since cable loss in dB is directly proportional to cable length, the use of dB simplifies loss calculations, as discussed in the text.

has 100 watts output. Because of loss through the relay, only 89 per cent of the power at the input is available at the output, or 89 watts. The loss through the filter reduces this still further, so 93 per cent of 89 watts (about 83 watts) is available at the input connector to the transmission line. Since only 50 per cent of the power makes it through the transmission line, the power into the antenna is about 41.5 watts or 41.5 per cent of the total power delivered by the transmitter. This is exactly the same as 3.8 dB loss, as can be seen from Fig. 7, but the dB values are obviously a lot easier to use because they can be simply added together.

If you're not familiar with using dB, here are some guidelines which may be helpful: First of all, 1 dB is about the minimum change which you can detect with your ear; -3 dB represents 50 per cent loss; -6 dB corresponds to 75 per cent loss; and -10 dB is the same as 90 per cent loss. With these values in mind, it's not too difficult to interpolate for values in between.

Given in Table 1 are the loss figures for coaxial transmission

lines commonly used by amateurs. RG-8/U, for example, has 0.66 dB loss per 100 feet (30m) at 14 MHz. With 100 watts into the transmitter end of the transmission line, this means that 86 watts will make it to the antenna to be radiated. However, this figure assumes that the antenna is matched to the feedline — that the input impedance to the antenna is the same as the characteristic impedance of the coaxial cable. If the line is not matched to the antenna, the loss will be slightly higher, as will be discussed later.

Note from Table 1 that the higher the frequency, the higher the loss per 100 feet. This is a characteristic of all types of feedlines and explains why cable selection at vhf and uhf is even more important than it is for the high-frequency bands. Note also that the smaller diameter cables have much higher losses. RG-58/U, for example, has 3.5 dB loss per 100 feet (30m) at 50 MHz — with 100 watts into the transmission line, only 45 watts get to the antenna — the other 55 watts are used to heat up the cable!

Although dB loss figures are almost always given for 100

feet (30m) of transmission line, it's very easy to translate this figure to the actual length of line which you are using. This is another benefit of using dB values — they are directly proportional to line length. If 100 feet (30m) of cable has 4 dB loss, for example, half that length or 50 (15m) feet will exhibit half the loss or 2 dB; 40 feet (12m) will have 40 per cent of the loss or 1.6 dB; 30 feet (9m) will have 30 per cent of the loss or 1.2 dB, and so on. Conversely, 150 feet (45m) of line will have 1.5 times the loss of 100 feet (30m) or 6 dB, 200 feet (60m) will have twice the loss, etc.

Choosing coaxial cable

Table 1 lists the important operating parameters for the various types of coaxial cable which are commonly used by amateurs. At last count there were something like 300 different types of coaxial cable on the market, but many of these are specialized types which are not designed for use as rf transmission lines; RG-62/U, for example, a 93-ohm line which is used for pulse work, or RG-125/U, a 150-ohm line with extremely low capacitance per unit length. There are coaxial cables with lead sheaths for underwater installations, cables with braided steel armor, and even some with very high attenuation for use in test equipment. However, most of the types used by amateurs are listed in Table 1.

Perhaps the most popular type of coax is RG-8/U, a medium-size cable with a maximum power rating of 2000 watts at 28 MHz, and somewhat more

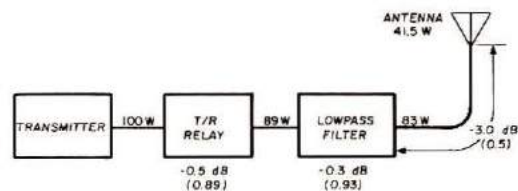


Fig. 8. Example of a loss calculation using dB. The total loss of 3.8 dB corresponds to power transmission of 41.5%.

Table 1. Important operating characteristics of 50- and 75-ohm coaxial cables used by amateurs. Types with non-contaminating jackets (designated NV) should be selected for long life. Power rating is given for 30 MHz and is somewhat higher on the lower frequencies; this is power into the transmission line, *not* transmitter input power.

Cable Type	Jacket*	Z ₀ (Ohms)	Loss in dB/100 Feet (30m)					Power Rating at 30 MHz (watts)
			3.5 MHz	7.0 MHz	14.0 MHz	21 MHz	28 MHz	
RG-8/U	V	52.0	0.29	0.43	0.67	0.81	0.98	1900
RG-8A/U	NV	52.0	0.29	0.43	0.67	0.81	0.98	1900
RG-11/U	V	75.0	0.34	0.55	0.81	1.0	1.2	1375
RG-11A/U	NV	75.0	0.34	0.55	0.81	1.0	1.2	1375
RG-17/U	V	52.0	0.13	0.22	0.35	0.42	0.52	6400
RG-17A/U	NV	52.0	0.13	0.22	0.35	0.42	0.52	6400
RG-58/U	V	53.5	0.54	0.82	1.25	1.6	1.9	575
RG-58A/U	V	52.0	0.69	1.05	1.6	2.1	2.5	500
RG-58B/U	NV	53.5	0.54	0.82	1.25	1.6	1.9	575
RG-58C/U	NV	50.0	0.69	1.05	1.0	2.1	2.5	500
RG-59/U	V	73.0	0.55	0.80	1.15	1.4	1.7	700
RG-59A/U	NV	75.0	0.55	0.80	1.15	1.4	1.7	700
RG-59B/U	NV	75.0	0.55	0.80	1.15	1.4	1.7	700
RG-8 Polyfoam	V	50.0	0.28	0.41	0.60	0.75	0.90	2000
RG-11 Polyfoam	V	75.0	0.32	0.51	0.73	0.93	1.10	1425
RG-58 Polyfoam	V	50.0	0.80	1.18	1.70	2.1	2.5	500
RG-59 Polyfoam	V	75.0	0.40	0.59	0.88	1.1	1.3	750

*V indicates a vinyl jacket; NV indicates a non-contaminating vinyl jacket.

than that on the lower high-frequency bands. Attenuation ranges from about 0.3 dB per 100 feet (30m) on 3.5 MHz, up to nearly 1 dB per 100 feet (30m) on 10 meters. RG-8A/U (also marketed as RG-213/U) has identical electrical characteristics but has a so-called "non-contaminating" outer jacket which means that it has considerably longer life. The black plastic covering on RG-8/U contains chemicals (called plasticizers) which, when exposed to sun and weather, leach into the center insulator and increase cable loss. In practical terms this means that it should be replaced about every five years. The newer RG-8A/U (or RG-213/U), however, doesn't have this problem and has a useful life of 20 years or more. Since the cost difference is only a few cents per foot, RG-8A/U or RG-213/U is a better choice. (or its later "non-contaminating" version, RG-58B/U and RG-58C/U), but note that it has significantly greater

loss and lower power limits than RG-8/U. It also costs less, which may be a consideration, but since the difference is something less than \$10 per 100-foot roll, in the long run I think RG-8/U is well worth the slight extra cost. However, for connections between various equipment in your station where short lengths of cable are used, RG-58/U is an excellent choice.

At the other end of the size spectrum is RG-17/U, a heavy, large diameter cable which has less than half the loss of RG-8/U. It is also much more expensive so it's seldom used by amateurs unless the transmission line is several hundred feet long. "Non-contaminating" versions of RG-17/U are RG-17A/U (also designated as RG-218/U), and RG-17B/U, which has a silver-plated double braid and is designed for uhf use (also designated as RG-177/U).

Although I haven't mentioned the 75-ohm cables listed in **Table 1**, the same sort of arguments apply. RG-59/U is

a small diameter cable recommended for short cable runs between equipment in your station; RG-11/U is medium sized cable recommended for long runs to your antenna. Except for their impedance difference there is little practical difference between RG-8/U and RG-11/U, or between RG-58/U and RG-59/U for that matter.

Standing-wave ratio

As was mentioned earlier, the feedline losses given in **Table 1** assume the input impedance to the antenna is the same as the characteristic impedance of the transmission line. However, if the antenna feedpoint impedance is not the same as that of the line, a mismatch results, and a portion of the rf energy is reflected back down the line toward the transmitter. This is most easily measured in terms of standing-wave ratio or swr. Although the complete story of reflected power and standing-wave ratios is beyond the scope of this article, just let me say that,

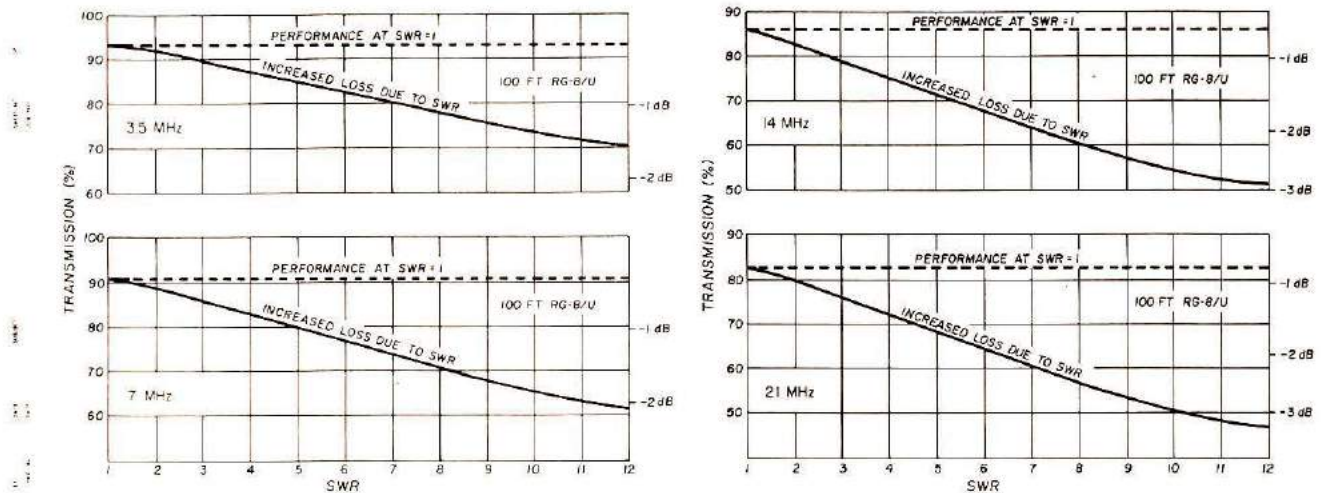


Fig. 9. The effect of swr on transmission line loss. So long as line loss with a matched load is low, as it is on the high-frequency amateur bands, swr has little effect.

contrary to popular belief, reflected power is *not* lost. However, a mismatched load does have the effect of increasing power loss because the portion of the rf power which is reflected makes two complete trips through the cable — once toward the antenna, the other back toward the transmitter. Since the reflected power makes two trips through the line, each with attenuation, it receives twice as much loss as that portion of the power which makes only one trip down the line to the antenna.

However, this slight additional loss is not serious on the high-frequency bands where cable attenuation is low, as shown in the four graphs in Fig. 9 for 100 feet (30m) of RG-8/U on 80, 40, 20 and 15 meters. Even at 21 MHz, where cable attenuation is relatively high at 0.81 dB per 100 feet, an swr of 5:1 — high compared to normal standards — increases total line loss by less than 1 dB; the difference would be barely perceptible in terms of received signal strength. On 3.5 MHz the effect of swr is perhaps even more surprising: An swr of 10:1 increases line loss by the same, barely perceptible 1 dB.

If cable attenuation is high, as would be the case at vhf or if you were using long runs of

higher loss cables such as RG-58/U, high swr can drastically increase power loss. This is another good reason to choose lower loss lines such as RG-8/U or RG-11/U. If high swr doesn't cause significant power loss on the high-frequency bands, why, you may ask, do so many operators worry about getting the swr down to 2:1 or less? Because the tank circuits in modern transmitters simply aren't designed to cope with an swr greater than that. They could be, but it would increase their selling price. Also, high swr seriously degrades the power handling ability of the line so if you run high power and have high swr you may find that you are operating above the power limits of the line. If this happens, the line may actually get hot enough to burst.

On the other hand, you're not going to gain much by twiddling with your high-frequency antenna to get a perfect match. So long as the swr is less than 2:1, your transmitter doesn't care, and the station at the other end won't be able to tell the difference.

If the swr on your transmission line is greater than 2:1, you probably won't be able to tune your transmitter to its maximum rated input. Swr

can be reduced only at the load end of the line, so you may be able to get a better match to the line by pruning your antenna — a better match means lower swr. On the other hand, you may be using an antenna with a feedpoint impedance that presents more than 2:1 mismatch to your transmission line — such as a very short vertical, or a dipole that is operated at a frequency well away from resonance. This often happens on 80 meters when you want to use a single antenna to work CW on the low end near 3.5 MHz, and 75-meter sideband near the upper band edge. If you cut the dipole for the center of the band, at 3750 kHz, you'll find that the swr at 3.5 and 4.0 MHz will be close to 5:1. The solution here is to use an antenna tuner or Transmatch between your transmitter and the feedline as shown in Fig. 10. When the Transmatch is tuned properly, it will present a 50-ohm load to your transmitter. So long as the swr on the line is within reasonable limits — say 10:1 with RG-8/U on 80 meters — the stations you are working won't know the difference.

Installing your transmission line

If you're using coaxial cable, it's pretty hard to get into trouble,

but here are some tips that will help get the most out of it.

1. Use coaxial connectors which are designed for the cable you are using, and make sure they are properly installed. Complete assembly directions are usually provided when you buy the connectors, but if they're not, any recent edition of the *ARRL Antenna Handbook* will show you how.

2. If you use a coaxial connector where it's exposed to the weather, weather-proof it with several coverings of plastic electrical tape. If moisture seeps into the cable through an unprotected connector, at the very least it will increase loss — at the very worst it will short-circuit the line.

3. If you suspect that moisture has gotten into the line, you can often tell by removing the connector. The copper braid should be bright and shiny, and the center insulator should look the same as it did when you originally put the connector on. If you're in doubt on this point, compare it with a piece of new cable. If



Some of the many types of coaxial cable which are available on the market. Several of the cables shown here have double braids for additional shielding.

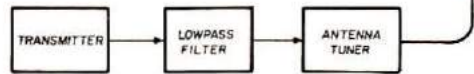


Fig. 10. Using an antenna tuner to provide a good match to your transmitter. Swr on the line between the tuner and the antenna is of little importance if line loss is low. The lowpass filter behaves as it should only when it's terminated in a matched load, so it should be placed between the transmitter and the antenna tuner.

you do find evidence of moisture you probably won't have to replace the entire length of cable — unless it has been exposed to moisture for a fairly long time. If you cut it back a foot (30cm) at a time, you'll probably find that several feet (1-2m) back from the damaged end the line is as good as new.

4. If you have to run your coaxial line under a window to get to your antenna, don't push the sash down so hard it mashes the cable. If the cable is pinched, it changes its characteristic impedance and increases the swr on the line, no matter how well your antenna is matched. If you want to run your cable under a window, make a wood spacer that runs the full width of the window and close the sash on it. Then drill a hole through the spacer slightly larger than the outside diameter of the cable (or large enough to pass the connector if it is already installed).

5. Don't install coaxial cable with tight bends; this changes the conductor spacing which affects the impedance of the line. If you have a very tight bend in the cable, the center conductor may eventually work its way through the insulator until it touches the outer braid, shorting out the line. What do I mean by a tight bend? A bend radius less than about ten times the diameter of the cable — about 4 inches (10cm) for medium-sized cable such as RG-8/U, or 2 inches (5cm) for

small cables like RG-58/U and RG-59/U.

6. Don't install coaxial cables near hot-air ducts, furnace pipes, or steam radiators. The thermoplastics used in cable manufacturing get soft with rising temperatures and may swell out through the braid. The center conductor can also sink, from the force of gravity, through the temperature-softened center insulator and short out the cable. When either of these things happen, the cable is permanently damaged and must be replaced.

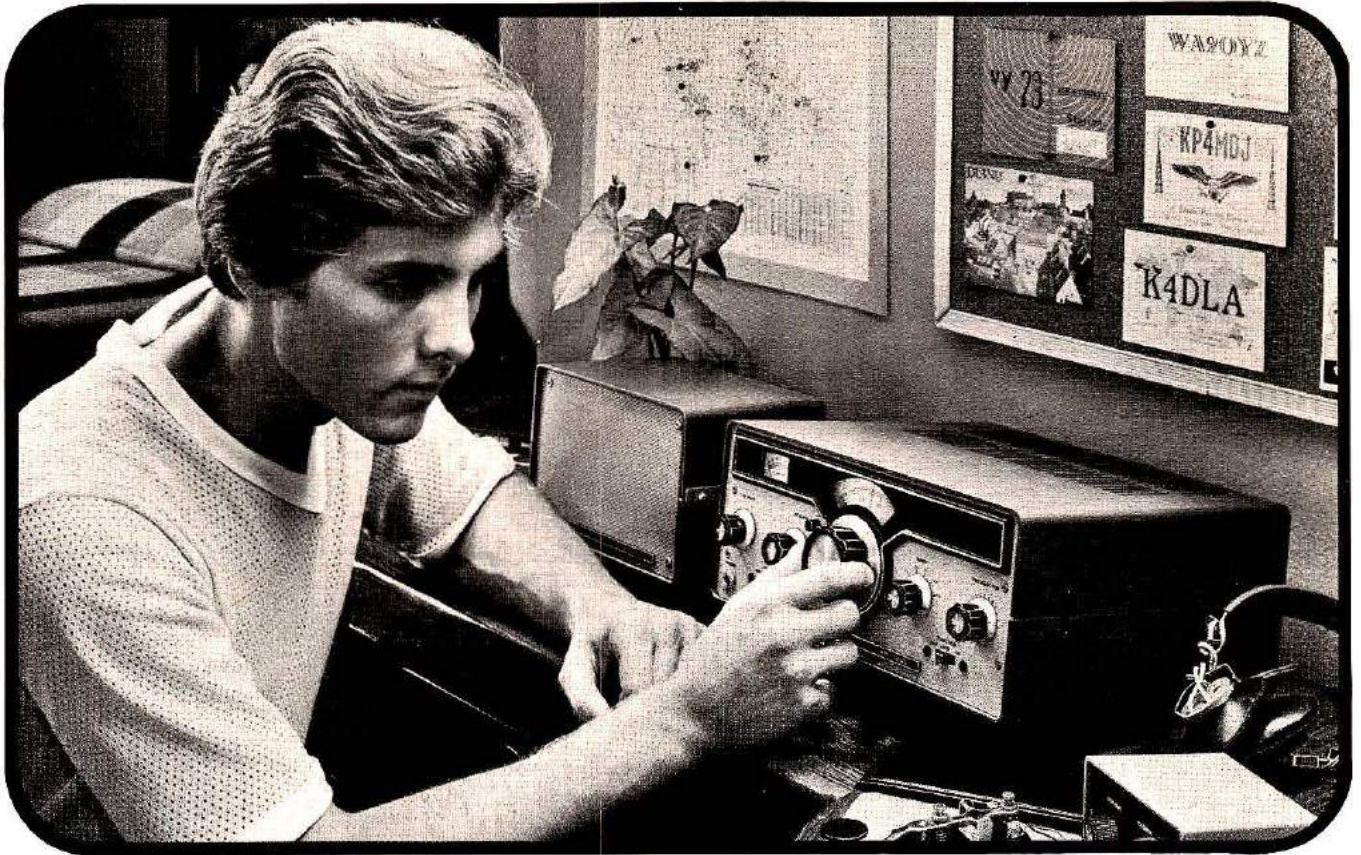
7. Use cable hangers or supports for long cable runs. The "Pop-Top" lids from drink cans fit nicely over RG-8/U and make excellent cable hangers — just drive a small nail through the tab into the nearest support. If you run a coaxial cable to the top of your tower, tape it to one of the tower legs every four or five feet (1-2m).

8. Inspect the cable every six months or so to make sure it hasn't been knicked, cut, or otherwise damaged. If you discover the problem soon enough, you may be able to repair it before moisture destroys the usefulness of the complete cable. If you find a damaged spot in the center of a long run, cut the cable in two, remove the damaged portion, and install connectors on each end. Then buy a straight adapter (such as a PL-258) and connect the two cables together. If the junction is outside, seal it well with plastic electrical tape.

If you carefully choose your feedline, and follow these simple guidelines, your transmission line should last for a good many years. In fact, if you buy coaxial cable with a non-contaminating jacket you may never have to replace it; I know of one length of RG-8A/U in an underground run to a tower that doesn't have any more loss now than it did when it was buried fifteen years ago!

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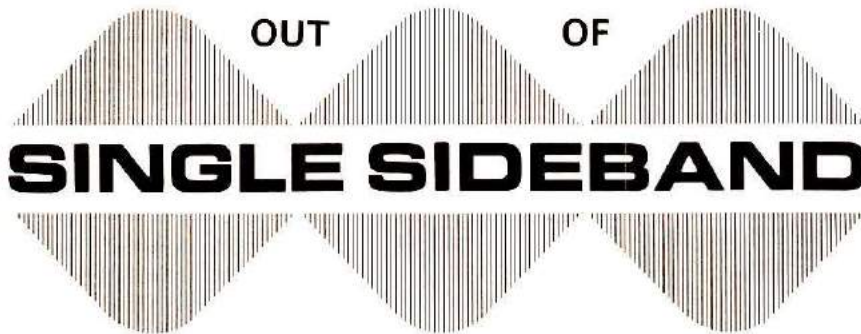
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TAKING THE MYSTERY

OUT OF

SINGLE SIDEBAND



BY THOMAS McMULLEN, W1SL

In the previous two issues of *Ham Radio Horizons* I talked about single-sideband in general, covering the reasons for the improvement in communications ability, and about receiving ssb. Much of the information covered is still applicable to this part of the ssb picture — transmitting. The basic process of generating the sideband signal has been explained, which makes this “transmitting” portion of the discussion a bit easier. All that remains is to delve just a bit more into the generation process, and then apply the principle to developing a useful signal for some of the popular amateur bands.

Audio processing

Throughout most of this discussion I have talked about a single audio tone instead of a “band” of tones or frequencies, just to make the steps a bit easier to follow. Where reference was made to voice frequencies, the example used was limited to frequencies between 100 and 5000 hertz. I am sure that you realize that many voices cover more than that range, depending upon the gender and individual characteristics (Fig. 1). Actually, the range of voice frequencies used in ssb communication is made even more narrow — 300 to 3000

hertz in some instances. This practice did not apply only to the development of ssb, though. As far back as the middle 1930s the more popular ham bands were becoming crowded enough that many authorities recommended that the speech-amplifiers in a-m (amplitude modulated) transmitters be modified to limit the range of frequencies that would be amplified especially the higher tones. Not too many amateurs were enthused about giving up their “wide-range” sound on the air, but there was a small group that did follow the suggestion. Part of the great space-saving ability of ssb is that one sideband and the carrier has been eliminated, as we have seen. Almost as important is the restricted range of frequencies that the audio amplifiers and filters will allow to pass (Fig. 1). Considerable experience was required before a majority of amateurs were convinced that it really was possible to transmit reasonable sounding audio — good enough for communications purposes — by using only part of the voice frequencies. This not only had the benefit of decreasing the spectrum taken up by each signal, but the additional filtering involved in the receivers allowed the amateur

to “hear better” as well. Transmitters could “punch through” when the conditions got rough, and the receivers could “dig down deep” in the layers of signals that sometimes appeared when a rare station made its presence known.

A second type of speech processing is very much talked about today, and it has both good and bad points. This system is one of trying to fill in the valleys between voice peaks, thereby making the transmitter more efficient. The human voice is a very complex thing, and there still is much research being done to analyze the purpose and effects of each part of the spoken sound. In addition to the wide range of tones found in the voice, there are also great variations in the strength, or amplitude, of those tones. An example of this is shown in Fig. 2. The greatest amplitude represented in the drawing is called the “peak.” It is that part of the voice that drives the transmitter to its greatest output, so you can see that if the “peak” voltage is there for only a short period of time, then the transmitter is sending out its maximum power for a correspondingly short time. If there was some way to increase either the length of time of the peak, or to build up the portions that were not as “loud,” it should cause the transmitter to produce its greatest power for a longer time.

The type of speech processing that does this little trick can perform its deed either by limiting the amplitude of the strongest parts, while allowing the weaker ones to go untouched, or it can use a complex circuit that detects how strong the signal is, and by electronically changing the gain of a stage, force the output to stay at or below a desired level. In other words, the stronger you talk, the more

off it turns the amplifier!

Either the limiting or the gain-changing method must be accompanied by numerous other circuits that do such things as keep the voice from becoming badly distorted, keep the amplifiers from creating new frequencies outside the voice range, and other house-keeping duties. There are several ways of getting to the same goal, and, since the confusion factor is high enough with just the basics of ssb, I'll not go into all that in this series.

Some of the benefits of speech processing for ssb are; **a)** you get more overall efficiency from a transmitter because it is kept working hard longer, **b)** it fills the frequency (channel) you are using with more signal, thus making it easier to receive at the other end, and **c)** it can build a weaker voice up to a real "loudmouth" level if needed. Most of the disadvantages tend to show up when a speech processing system is misadjusted or improperly used. If the overall gain is set too high, background noises tend to be almost as loud as you are — believe it or not, most people do not like to hear the dog barking next door, your kids playing upstairs, and the Saturday Night Movie from the

TV set, all while you are trying to say something. Furthermore, if the amount of limiting or compression is set too great (not enough difference between the peaks and valleys) the voice loses its character and people will wonder if you are in great pain. Certainly either condition is not of great value to communication.

Another fault with the use of many processors lies in the mistaken idea that there is no limit to the amount of improvement in output power that can be obtained by simply turning up the gain knob or by talking closer or louder. The limitation comes in the transmitter elements themselves. Many tubes and transistors are working close to their rated values in Amateur equipment, and it does not take much of an increase in input from the speech end of things to make them reach their limit. Beyond that limit, any further "push" from the microphone will simply cause the transmitter to "saturate," which means that it has "had it right up to here," and cannot work any harder. Under these conditions, you are most likely doing more harm than good, because the people who want to carry on a conversation on an adjacent frequency are being "splattered on."

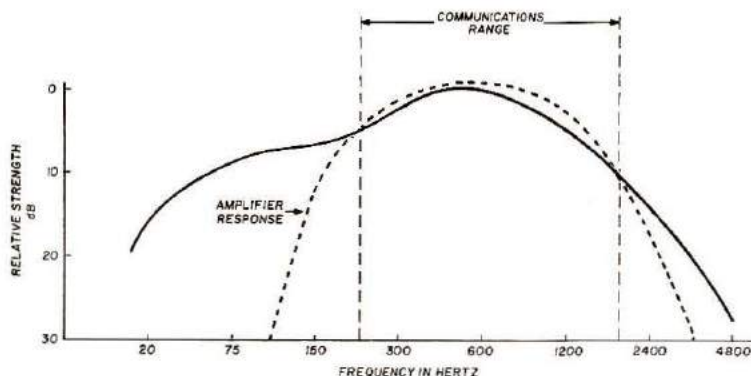


Fig. 1. The power involved in voice frequencies shows a response peak between 400 and 1000 hertz. This plot is for an average male voice when speaking at normal loudness. By selecting the proper portion of the curve, none of the essential tones necessary for communicating are lost. The dotted line shows an idealized response curve for an audio amplifier that would let the important parts of speech through. If the curve were shifted lower, the voice would sound boomy; emphasizing the higher parts would cause the voice to sound tinny and lack "punch."

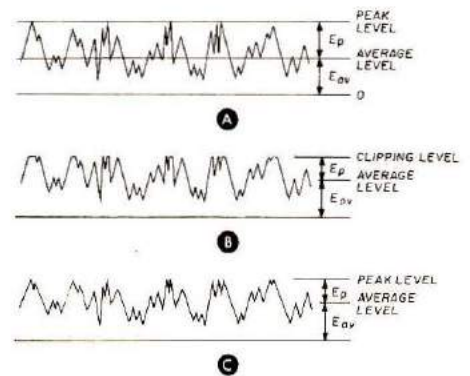


Fig. 2. Speech processors can also be designed to reshape the maximum strength of the modulating tones or voice. The variations in average voice peaks can be seen in **A**. A clipper can be designed into the circuit, and will remove the upper part of the highest peaks, **B**. A volume compressor or gain-reducing circuit will keep the original form of the peaks, but prevent them from rising as high, shown in **C**. The important thing here is that the *average* level is increased, thereby allowing better efficiency in the transmitter and improved signal readability.

Modulator or mixer

In earlier portions of this series, I used the terms "balanced modulator," "balanced mixer," and "mixer," from time to time. In many ways they are alike — practically interchangeable. It's just that if you are using a given circuit as a part of a transmitter that produces a sideband signal from voice, then you call it a modulator. If you happen to use the same one for the purpose of translating a low-frequency to a higher one, or vice-versa, then it is more properly called a mixer. The balanced part stems from the application of the voltages in such a manner that the whole circuit is working, rather than having one part of the circuit working against ground (**Fig. 3**).

In part 1, I explained how a sideband was generated, and in part 2 I showed how it could be translated to a particular Amateur frequency (and then "detranslated" so you could hear it). Now I'll refresh your memory and at the same time use as a practical example some frequencies that might

be found in a piece of modern ssb gear.

In Fig. 4, you can see the familiar balanced modulator that has been talked about before, along with a speech amplifier and a carrier generator. Since this is not a construction article, I have not shown all of the components needed to build a circuit like this. However, there have been many very similar circuits published in Amateur literature, so if you would like to explore further, you can do so. (See References for additional reading suggestions). The carrier used here is 9 MHz, and the carrier-generator oscillator is crystal controlled. Either upper or lower sideband can be obtained by simply switching the crystal that is in use.

Following the balanced modulator you will notice a filter. This is a crystal filter that has the response curve necessary to select the right portion of the sideband and reject the unwanted parts, along with the unwanted sideband. (Refer to Fig. 5 in the March issue). The filter stage is followed by an amplifier, necessary because the filter

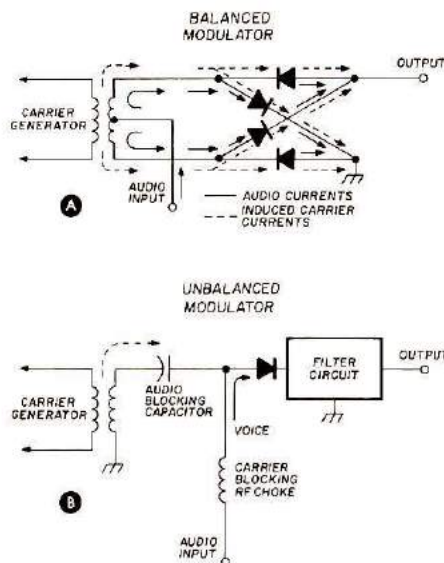


Fig. 3. The balanced modulator A, is used in many ssb-generating circuits because of its greater efficiency and because the carrier more effectively cancels itself after performing the basic function of turning the diodes on and off at a rapid rate. This is in contrast to the unbalanced modulator (or mixer) at B, which requires good filters at the output to remove leftover carrier energy.

has an appreciable loss (you get less out than you put in), which is, in turn, followed by a mixer.

This mixer is a "translating"

stage, or (here *he* comes again!) it *heterodynes* the 9-MHz sideband signal to an Amateur band. Here I have placed more crystals and a vfo in the circuit. Thus you can select an output frequency in the 3.8-, 7-, 14-, 21-, or 28-MHz band. Nothing hard about that — it is nearly the same as I told you about last month in the receiver portion of the series. But, with one of these switch positions I am pulling a sneaky on you. When you switch the vfo to obtain an output on the 3.8-MHz band, the voice comes out upside down! (Remember Fig. 4 in the April issue?) There's an easy cure for that, however — you simply connect this set of crystals and the 9-MHz carrier generator crystals to the same switch, and wire them so that it changes the crystal at the same time you change bands. How about that! Incidentally, the voice starts out upside-down, right from the modulator and filter. It has to because of the frequency translation that takes place in the second mixer for the bands 40 through 10 meters. The mixer stage should be followed by several

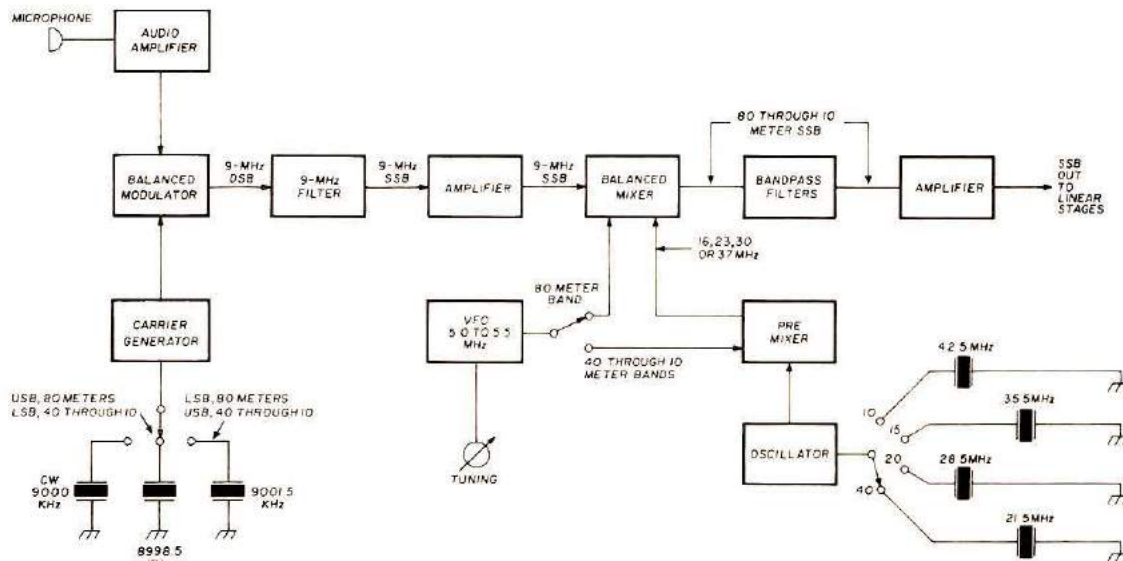
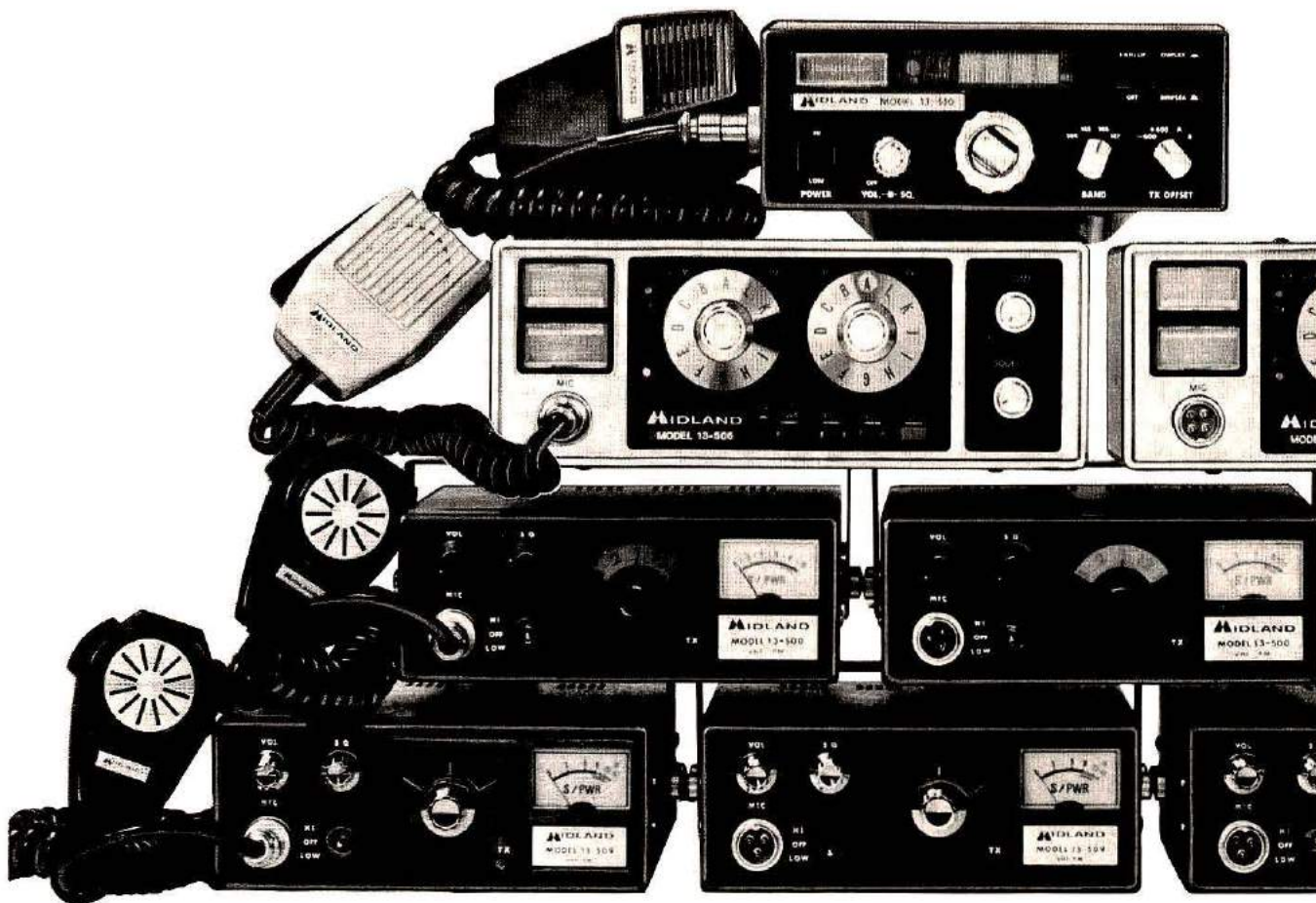


Fig. 4. A simplified block diagram of an ssb transmitter that is typical of many units in use today. The choice of frequencies to use for generating the basic ssb signal is determined somewhat by the availability of good filter components. Fortunately there are several good crystal filters available in the hf range between 3 and 21 MHz. However, great care must be used in selecting all of the frequencies involved because unwanted mixing products are often difficult to eliminate. They could cause trouble by being transmitted along with the correct product, or could block the receiver with a very strong signal.



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amplifiers, of course, because the power level at this point is very low — only a few tenths of a watt. Several stages can be used, one after another, until the power is built up to whatever level is needed — hundreds or thousands of watts.

The "third method"

I have already talked about two common types of ssb generated circuits, the filter type and the phasing type. There is another way of obtaining a sideband signal; one quite popular in Europe and England. Generally, it is referred to as the "third method." It may eventually gain in popularity over a larger part of the world because it makes use of some digital circuitry, which is the "in" thing these days.

A block diagram of a system using the "third method" is shown in Fig. 5. The basic generation can be accomplished in six integrated circuits. Other circuitry, not shown, is required to provide the clock input, and of course there must be an audio amplifier stage and a vfo to complete the picture. In one example of this system, reported in the Radio Society of Great Britain publication *Radio Communication*, October, 1974, the designer (A. de Muijnck of Holland) used 7400 Hz as the clock input and a vfo frequency of 14 MHz, to provide ssb output in the 3.5- to 4-MHz band. (See References for further reading).

It is basically a phasing type of generator, with the phase changes taking place in the frequency-divider ICs. For those of you who are not familiar with the workings of digital circuitry, let me point out that the output of a divider, such as the 7473 used here, consists of a pulse from what is termed the "Q" output, and another from what is called the "not-Q," represented by an overscored Q (\bar{Q}). The \bar{Q} output is off

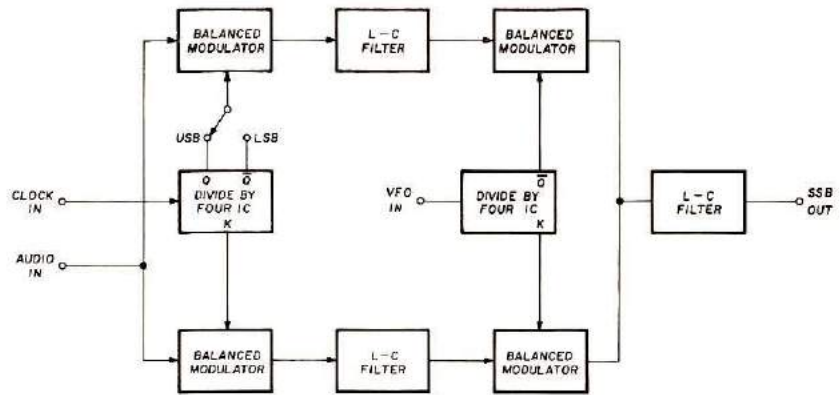


Fig. 5. A block diagram of a "third-method" of developing ssb. Although it is a variation of the phasing system, it makes use of modern components and digital techniques to an extent. Because of the upper frequency limit of most divider ICs, the system works to approximately 8 MHz. Improved integrated circuits could extend this limit. The "clock" mentioned in the text and shown here has nothing to do with timekeeping in the normal sense, but rather designates the function of turning a portion of the circuit on and off at a periodic rate.

whenever the Q is on, and vice versa, thus one IC can give you two outputs, which are 180 degrees out of phase with each other, and an output from the K section that is 90° out of phase with both the Q and the \bar{Q} pulses.

An advantage to this method of ssb generation is that the filters needed are relatively simple and inexpensive, consisting mainly of inductance and capacitance in combination. Another plus is that the system can directly produce a variable-frequency output, without the addition of an external mixer that accepts the ssb and the vfo input. A disadvantage, at the moment, is that the frequency-divider ICs most commonly available will operate only to 30 or 40 MHz. Since the vfo input must be at four times the expected output frequency, this puts a limit on the number of bands that can be covered with present ICs. There are some dividers available that work well into the uhf range, but the expense is prohibitive.

Conclusion

This series of ssb exploration articles has been intended to help the beginner to understand some of what goes on inside the many boxes that send and receive that mode. There are many

variations in the approach to building an ssb transmitter, receiver, or transceiver. However, they must all follow one of the three methods I have talked about, at least until someone finds a "fourth method." A reference section follows, containing some recommended reading for those who would like to delve deeper into the principles, circuitry, and perhaps the ways in which you can build your own.

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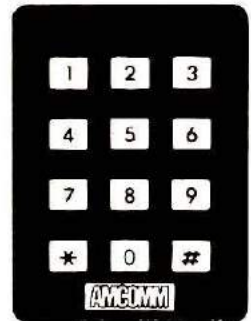
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instant phone patch

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BY ALEX F. BURR, W5QNG



The voice on the two-meter repeater contained a note of urgency: "Does anyone on frequency have a phone patch?" Dead silence followed the squelch tail as seconds dragged into minutes. An autopatch system for the repeater had been under construction for three years, but no recent progress had been made. The only known phone patch owner was away from his rig and the matter at the fire truck accident and fire was too complicated to be handled by the usual formal message procedures. Finally, a radio car from the sheriff's office arrived and the fire marshal was able to complete his emergency call, but an opportunity for amateur radio

to render a public service had been lost.

Why? Because some two-meter repeater users consider a phone patch too expensive, too time-consuming to build, or too complicated to connect between their commercially-constructed rigs and the telephone equipment.

Would you like to have a good phone patch that takes only 30 seconds to put together and requires no modifications to your rig or the telephone set? Yes, it can be done, and costs less than \$16, too!

The key to this "instant" phone patch is a two-way telephone amplifier of the type readily available from radio and electronic supply houses. Radio Shack, for instance, has

one for \$15.95, unless it happens to be on special sale for less.

To operate this particular unit, just place the telephone handset in the cradle on top of the amplifier, turning the amplifier on. The signal from the telephone handset is picked up by an induction coil beneath the cradle, is amplified, and carried into the room by the amplifier speaker. A simple volume control allows you to set the audio at a comfortable listening level for anyone in the room.

To couple the telephone amplifier to your radio, just place the amplifier's acoustic chamber in front of the transceiver speaker and hold the microphone above the speaker of the telephone amplifier. The photograph shows the arrangement I use with my two-meter transceiver.

I found that by holding the microphone about one inch (2.5cm) above the amplifier speaker when it is adjusted for a comfortable listening level, my transceiver provides just the right deviation for the local repeater. For the telephone to pick up audio from my transceiver speaker at a useful level, I found that I had to turn the radio's volume control up until it seemed a bit louder than normal.

Results

My instant phone patch has been quite successful, and I find it particularly useful when some mobile radio operator wants me to make a complicated phone call. Usually he has not thought out the message he wants conveyed and it turns out to involve three contingencies and two choices. Then I just say, "Here, I will dial the number and you can talk." I push the amplifier in front of the rig, dial the number, place the phone on the amplifier cradle, hold the mike over the speaker, and push the mike button at appropriate intervals.

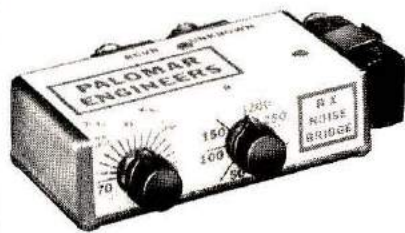
Of course something as simple and inexpensive as this instant phone patch does not have all the refinements of a more complicated system. However, because it has no direct connections to the telephone line, you need only be concerned about two things: Do not put too much audio into the telephone, and make sure that no tones in the region of 2700 Hz are used. I use this arrangement only for two-meter fm work, although in principle it will work on all bands. On two meters the signals from repeaters are almost always clear, strong and noise-free, hence acoustic coupling works well. Most modern transceivers incorporate automatic deviation-limiting circuits so it is hard to overmodulate the transceiver. The audio output from most transceivers is not overwhelming, so there is little danger of overloading the phone lines. Besides audio loud enough to cause overload of the telephone system would drive you out of the room. Furthermore, on fm there is usually no trouble with heterodynes or other tones which would cause trouble for the telephone switching circuits.

HRH

Glossary of Terms

- Phone patch** is a device that connects a radio and a telephone for two-way conversations.
- Repeater** is an automatic radio relay station, remotely controlled, that receives, amplifies and retransmits a low-power signal over considerable distances.
- Deviation** refers to the frequency "swing" imparted to an fm signal by modulation.
- Squelch tail** is the burst of noise heard from a squelched receiver every time a repeater ceases transmitting and awaits the next signal to be repeated.
- Autopatch** is a phone patch at the repeater site that can be dialed remotely from any properly equipped and authorized station.

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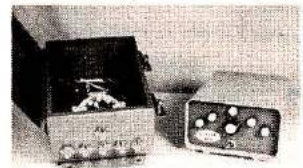
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THE YOUNGEST HAM



BY JAMES GRAY, W2EUQ

Who says you can't learn Morse code? Who finds it difficult to unravel the mystery of electronics theory, and despairs of ever passing that first big hurdle — the Novice Class license exam? Well, even if you feel that way sometimes, don't let Neil Rapp, WN9VPG, ever hear you. Neil, called Rusty by his family and friends, is five years old; that's right — five! He is the youngest radio amateur ever licensed by the FCC and, as far as we know, the youngest radio amateur in the world. Until now, that distinction was held by Gary Lewis, WN7BBG, of Seattle, Washington. Back in 1964 Gary received his Novice license at age 7.

Rusty is the only son of Delbert and Margaret Rapp, Vincennes, Indiana, and is

presently a first-grade student at La Salle Elementary School in Vincennes. Around Christmas time a year ago, Rusty (then in Kindergarten) and his dad became interested in ham radio and joined a Novice license preparation class led by Howard Hazelman, K9SLV, and Bill Sage, K9IHU. The class was sponsored by the recently-reorganized Old Post Amateur Radio Society and met in the Radio and TV building at Vincennes University. Rusty was the youngest member of the class; the oldest member was Arthur Rinehart, 55. Although a half-century separated the two, both found a common interest in amateur radio.

After practicing the code and learning basic theory, the class members took the FCC Novice

Class license examination. Of the 47 prospective Novices who started, 24 passed the code test, and, of these, 19 passed the theory examination. It is a matter of record that Rusty received a better score than his dad, but that doesn't matter. On July 17, 1976, Rusty received his new call, WN9VPG, making him a **Very Proud Guy!**

His very first on-the-air QSO took place the next day with Jim Cobb, K3DIF, in Silver Spring, Maryland. Jim is a member of the staff of the Washington bureau of Associated Press, and promptly sent Rusty his first QSL card commemorating that all-important first contact.

Soon after, Rusty racked up his furthest contact at that time with WN1YNA in New England. Although a "seasoned" ham by



Barry Copeland, left, tells Rusty that the new TS-520 is his to keep. Rusty's expression says it all (photo by Paul Ingram).

now, WN9VPG still enjoys talking to his former classmate Carol Smith, WN9UKC, also of Vincennes. Carol is 10!

Rusty has become a much sought-after personality at hamfests and on the air. He even has a fan letter from "First Mama" Betty Ford who sends from the White House "all good numbers" his way along with her "best wishes for a good day today and a better day tomorrow."

When Barry Copeland, WB6EJV, heard about Rusty's unique accomplishment, he decided to do a bit of private investigating and learned, for example, that radio station WN9VPG — though adequate

— was by no means elaborate. It was modest, like Rusty himself, but older — much older. Barry also discovered that radio operator WN9VPG would be soon celebrating his sixth birthday on September 22nd.

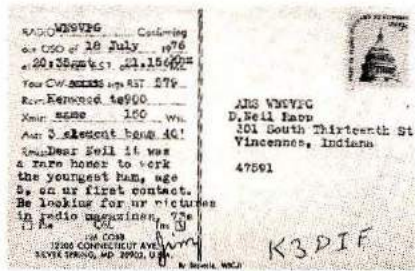
As Sales Coordinator for Trio-Kenwood Communications, Inc., Barry approached his company with the idea that Rusty's birthday celebration would be an appropriate time to reward a remarkable accomplishment and, at the same time, further the cause of amateur radio. Management liked the idea and gave Barry the green light to put it into effect. Unfortunately, Barry

couldn't be in Vincennes on September 22nd, but he did the next best thing. He called Rusty, congratulated him, and told the Rapps that a new Kenwood TS-520 transceiver was on its way with the compliments of the company! Following the telephone call, Rusty asked his mom: "Do you mean I'll get to keep the radio?" Answered in the affirmative, he replied: "Well, I sure hope *he's* paying for it!" (Rusty and his dad had started saving for a new radio, but knew it would be a long time before they could afford it.) When the package arrived, Rusty couldn't believe it, and still wasn't sure he'd be allowed to keep it. It took a while for the significance of it all to sink in, but when it did, Rusty sent an ARRL Radiogram to Barry.

There was more to come, however. A birthday party had been arranged for October 7th, and Barry planned to be at the Rapps home for the celebration and formal presentation of the transceiver. This, too, was a big event for Rusty, as you can see from the photograph. It turned out that not all the surprises

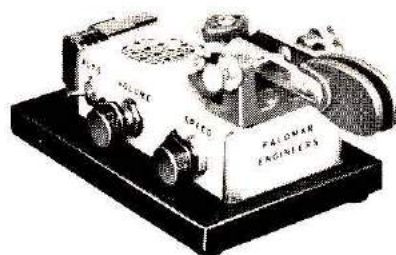


Rusty's first QSO was with Jim Cobb, K3DIF, Silver Spring, Maryland. Jim is with the Washington Bureau of Associated Press. The QSL card shown is a facsimile of the original.



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World's youngest ham, Neil "Rusty" Rapp, WN9VPG, is shown at the operating position of his first station in July, 1976. The Station is jointly operated by Rusty and his dad, who received his Novice license at the same time (photo by Paul Willis, Vincennes Sun — Commercial).

were one-sided, however, for when Barry arrived at the Rapp home, a handmade sign greeted him: "Welcome WB6EJV," and a homemade cake spelled out the words "Thank you Trio-Kenwood" on its icing.

Bill Sage and Howard Hazelman, Rusty's instructors, were there, too. Perhaps Barry best conveyed the feelings of

all with the words, "Stay in ham radio all your life. It's the best hobby in the world." Coincidentally, the final surprise was provided by FCC. Only a few days after the party, Rusty received a letter containing his new license and callsign — WB9VPG — issued under the FCC program which will eliminate distinguishing Novice callsigns.

What does the future hold for Rusty and his family? Well, for one thing, Rusty and his dad will be using the new TS-520 a lot, as you'd expect. Then there's study and practice for the General Class ticket that they hope to get soon. Meanwhile, Rusty has his first-grade activities to keep up with at school.

His parents, Del and Margaret, agree that the family needs a rest and a break from the pressures and tensions that accompanied the events of the last year. That next step to the General Class ticket is expected to be long and drawn out because it's time for Rusty to relax and have some fun. After all, he's only six! **HRH**

Margaret and Del Rapp, Rusty's parents, are understandably proud of their son who seems to be thinking, "Okay if I operate now?" (photo by Paul Ingram).



SIMPLE ELECTRONIC KEYERS

Get your feet wet with integrated circuits — here are two simple electronic keyer circuits which are based on the low-cost 555 timer IC

BY JOE BUSWELL, WA5TRS



Many amateurs, beginners and old timers alike, would like to experiment with some of the new integrated circuits which are available on the market, but are scared away by their apparent complexity. Many of these devices are designed with essentially one electronic task in mind, and since you can't get into the innards of the IC to modify the circuit, you have little choice — you use it for its intended job or select another IC. With thousands of different ICs available, this is no easy task, especially if you don't have any hands-on IC experience — and access to the various manufacturers' data books.

So, the question arises, how do you get started with ICs? Well, there's at least one low-cost device on the market that can be used in any number of amateur applications. This is the versatile 555 timer IC which currently sells for about 45 cents. It can be used to provide variable time delays from hundreds of a second to hours, as an oscillator, as a tone-burst generator, or as a touch control. It has been used by the automotive industry as a seat-belt timer, speed warning device, and auto burglar alarm. If you looked inside your washing machine, you'd probably find one providing the automatic timing cycle.

Although the 555 timer circuit actually uses 24 transistors and 16 resistors, broken down to its essentials it consists of a flip-flop which is controlled by two comparators, as shown in Fig. 1, a simple multivibrator (oscillator) circuit. The flip-flop drives two outputs: one is used to control external circuits; the other is used to control charging and discharging current through the external timing capacitor, C_t .

Operation

Free-running oscillation of the 555 timer IC occurs when pins 2 and 6 are connected together, and the voltage on pin 4 is higher than 0.7 volt. If the voltage across the capacitor is less than one-third the supply voltage, V_{CC} , the comparator connected to the trigger toggles the flip-flop, causing the output, pin 3, to go high, and the discharge, pin 7, to go to a virtually open circuit. The capacitor now charges from V_{CC} through resistors R_a and R_b . When the threshold voltage at pin 6 reaches two-thirds the supply voltage, the second comparator toggles the flip-flop, causing the output to go low, and the discharge to go to ground. The capacitor now discharges through R_b to pin 7 until the voltage at pin 2 drops to one-third the supply voltage. At that time, the flip-flop retoggles and a new cycle begins. By varying the values of the two resistors, R_a and R_b , and the timing capacitor, C_t , you can adjust how long the output is low, and how long it is high. The timing formulas, if you're interested, are provided at the end of the article.

If, in the circuit of Fig. 1, the value of resistor R_a is small compared to the value of R_b , the output will be a square wave with a 50 per cent duty cycle — “high” time equals “low” time. If you were building an electronic keyer, this would be the requirement for generating the dots of the Morse code. Unfortunately, if you keyed this simple circuit, the voltage on pin 6 must rise from nearly zero to two-thirds the supply voltage ($2/3 V_{CC}$) on the first dot, and from $1/3$ to $2/3 V_{CC}$ on the succeeding dots. This means that the first dot would be 40 to 50 per cent longer than its successors.

This problem is solved with the bias arrangement shown in Fig. 2, which holds the voltage on pin 6 slightly higher than $1/3 V_{CC}$ when the circuit is at rest, allowing it to fall below the required threshold during key down — forming an almost perfect first dot.

The control, R2, is used to adjust the resting voltage slightly higher than the internal trigger voltage and allows for the voltage drop of diode CR1. R2 should be approximately equal to the value of R1 to allow sufficient adjustment range. The task of R1 is to limit the current drain on the power supply when the key is closed and R2 is inadvertently adjusted to maximum voltage. Diode CR1 is included so that the bias circuitry won't disturb operation of the timer during the charge-discharge cycle.

Dash-dot ratio

The generation of dashes



Simple electronic keyer has speed range from 4 to 26 words per minute and has a built-in sidetone monitor.

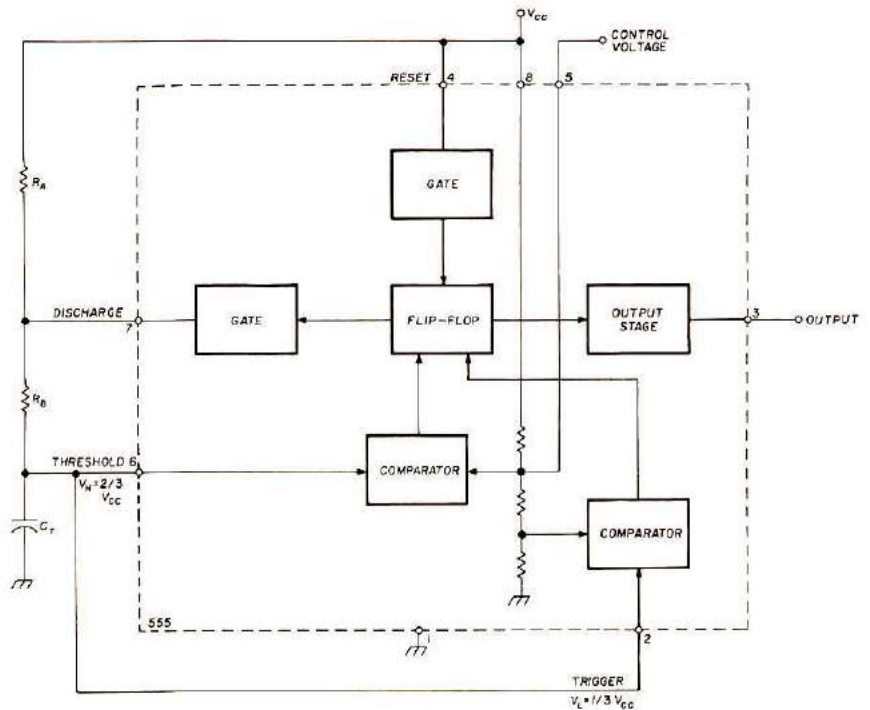


Fig. 1. A stable multivibrator (oscillator) circuit using a 555 timer IC.

can be accomplished by various methods, of which two are described here. The first, which is generally used with digital logic circuits, is to frequency divide the dot pulse train by two and add the results to the dot pulse train as shown in Fig. 3. The length of the dash formed by this technique is always three times the length of one dot, which is the standard dot/dash ratio. The method also provides a dash space equal to one dot-length. The circuit for accomplishing this little feat is shown in Fig. 4. The 7470 J-K flip-flop divides the incoming train of dots by two; this pulse train is added to the dot output by diodes CR2 and CR3.

Closing the dash key grounds the timer control through diode CR4 and initiates a dot. At the same instant the timer is initiated, the J input (pin 5) to the 7470 flip-flop is brought low — this readies the Q output (pin 8) to go high on the next rise of the dot pulse (also called the clock). However, it is important that the J input be low *before* the

dot pulse goes high. This is normally accomplished by the slight time lag caused by the discharge of the timing capacitor, C2, down to the trigger voltage where the 555 output toggles high.

If the bias voltage set by R2 is too close to the trigger voltage, there may be insufficient time between grounding of the J input and the arrival of a dot. The result is a dot followed by a dash. The remedy is to increase the bias voltage by R2 until reliable dash operation is accomplished without excessive delay in initiation of characters after key closure.

After the dash starts, the key can be opened because the Q output, in the low state, will keep the timer running through the second dot initiation by virtue of diode CR5. At the end of the first dot the Q output is left high. The leading edge of the second dot resets Q low but the dash continues for the duration of the dot. The timer cannot start another dot (or dash) until the time lapse of a space has occurred. Also, a dot

cannot be changed into a dash while the incoming dot pulse is high. Therefore, the keyer is self completing.

Keying speed control

The speed range of the keyer with the components shown is four to twenty-five words per minute. You may prefer to use values of 250k and 33k for R3 and R4, respectively (Fig. 2). This will give a speed range of 6 to 50 words per minute. Use a reverse log taper control for R3 if it is available. If not, an audio taper control can be wired backwards (counterclockwise rotation increases speed) to help linearize speed vs shaft rotation.

Variable dot-dash length

A second keyer circuit which was built to explore the use of logic control circuits and exploit the capabilities of the 555 timer is shown in Fig. 5. In this circuit, when no character is being formed, both inputs of gate A are high, forcing the output low (gates are part of a 7400 quad NAND gate IC). Gate B, wired as an inverter, has a high output. R1, acting as a voltage divider, places a bias on pin 6 of the timer IC, designated U2, which prevents the internal flip-flop from toggling, leaving it in its last state which is low on the output, pin 3. The low imposed on one of the inputs of gate C forces it high. This high is placed on one of the inputs of gate D. The other input of gate D is also high so the output is low. This latches gate C output high.

When the dot key is closed,

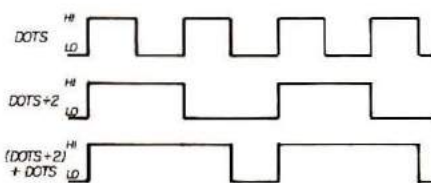


Fig. 3. Timing diagram showing the formation of a dash length that is three times as long as one dot. Circuitry for accomplishing this is shown in Fig. 4.

the output of U2, if it is low, is impressed on one input of gate A, causing its output to go high. Gate B inverts this to a low which allows the bias on pin 2 of U2 to be removed. The charge on C2 is bled through R3 and R4 to pin 7 of U2, which is grounded. When the voltage on pin 2 drops to $1/3 V_{CC}$, the internal flip-flop toggles, opening the ground on pin 7 and presenting a high state to pin 3, the output.

The states of gates A and B reverse, but U2 is not affected by the bias change because C2 is charging above the bias voltage. Since the output of gate C is high, there is very little voltage drop through R2, so pin 7 assumes nearly the supply voltage potential. The rate of charge is thus dependent on the values of R4 and R3. When the voltage on pin 6 reaches $2/3 V_{CC}$, the flip-flop toggles, causing pin 7 to go to ground and pin 3 to go to logic low. The current through R2 is increased because of grounded pin 7. C2 now discharges through R3 and R4.

If the dot key is still closed, gates A and B would have again changed state at the beginning of the space, removing the bias from diode CR3 and allowing pin 2 to go to $1/3 V_{CC}$, which would restart the cycle and initiate another dot. If the dot key is opened after the dot is initiated, the bias from R1 will remain on CR3 preventing pin 2 of U2 from dropping to $1/3 V_{CC}$ and leaving U2 in an off state.

If the output of the timer, U2, is low when the dash key is closed, one of the inputs of gate A is forced low, which causes the outputs of gate A to go high and gate B to go low. U2 triggers and the output goes high. C1 delays the high signal to the dash paddle for a sufficient length of time to allow gate C to switch low latching the combination of gates C and D for the duration of the dash. The output of gate C, which is

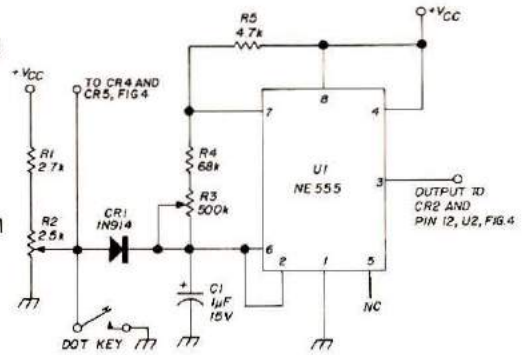


Fig. 2. Dot generator using the 555 timer IC. Potentiometers R2 and R3 should have a linear taper (see text).

low, causes current flow through R2 and CR1 and a resulting low condition on CR2.

This allows capacitor C2 to charge through R3, R4, R5 and R6 until pin 6 of U2 reaches $2/3 V_{CC}$. At that time the flip-flop toggles, ending the dash and beginning the discharge of C2. Capacitor C2 discharges through R3, R4, and pin 7 of U2, resulting in the length of the dash being a function of the values of R3, R4, R5, and R6, and the length of the space being a function of the values of R3 and R4.

If the dash key has been kept closed, another dash will be initiated at the end of the space when the output goes high. It is impressed on one of the inputs of gate C, latching it for the duration of the second

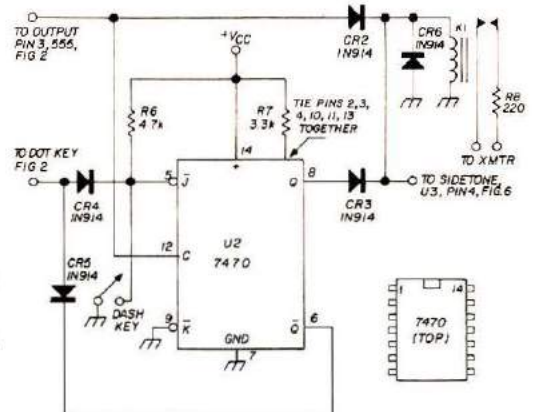


Fig. 4. Dash generator circuit. Reed relay K1 is a 1A5AH, manufactured by the Electronics Application Company, 2213 Edwards Avenue, S. Elmonte, California 91733.

dash. If the dash key is opened after dash initiation, gates C and D will reset when the output of U2 goes low.

Adjustment

The standard duration of a dash is three times the duration of a dot; the length of a space equals that of one dot. Adjustment of the keyer is best accomplished by first setting the dot speed and then the dash length. Close the dot key and count the dots generated in 2½ seconds (or 5 seconds, dividing by 2). This will be close to the keying speed in words per minute. Set R3 to the desired speed. Now, close the dash key and adjust R5 until the number of dashes generated in 5 seconds equals the number of dots generated in 2½ seconds. (One dash plus one space equals 2 dots plus 2 spaces). The keyer is now set correctly. If, at extremely low or high speeds, you want to vary the dot-dash length ratio from the standard to improve readability, controls R3 and R5 can be adjusted to suit your own taste.

Sidetone Generator

On either keyer it is desirable

to include a tone generator to allow tune up without keying the transmitter sidetone, to allow code practice with the keyer, or simply for "show and tell" demonstrations. There is nothing exciting about a tone generator, but the one I used in these keyers is about as simple (and inexpensive) as any you're likely to find.

Fig. 6 shows the tone generator circuit using, you guessed it, another 555 timer. In this circuit, the 555 is wired as an astable multivibrator (which means oscillator) the same as the dot generator used in the keyers. Refer to the operation of the timer in either keyer for a description of why it oscillates. The only difference in hookup is pin 4 of U3. This is a reset pin. Grounding this pin (less than 0.7 volt) forces pins 7 and 3 to logic low, regardless of what else is going on. When the keyer is making a dot or dash, the reset pin is high and the timer is allowed to cycle and generate a tone. Normally, the output of pin 3 would be a square wave, but because of inductive loading by the speaker voice coil, the output looks like a sloppy sawtooth. However, the resulting tone is

satisfactory.

Audio frequency is adjusted by R1. Since the timing calculations are upset by the speaker load, the value of R1 was determined experimentally. R2 is only included to prevent pin 7 from drawing damaging current when it is grounded. Capacitor C2 limits the current which would flow each cycle after the initial voltage rise has thumped the speaker cone and done its job. The value of C2 can be varied to achieve the desired volume level.

On one of the keyers I built I chose prepunched, unclad circuit board with holes on 0.1 (2.5mm) centers. Conductor paths and solder connections were made by combining adhesive-backed copper conductors and insulated hookup wire. The ICs were plugged into Molex connectors.

When using this method of construction, first decide on your layout, then stick on the conductors for the IC and other components. When this is done, install the Molex connectors and solder them in place. Then break off the tie strip between the connectors, install the ICs, and begin wiring.

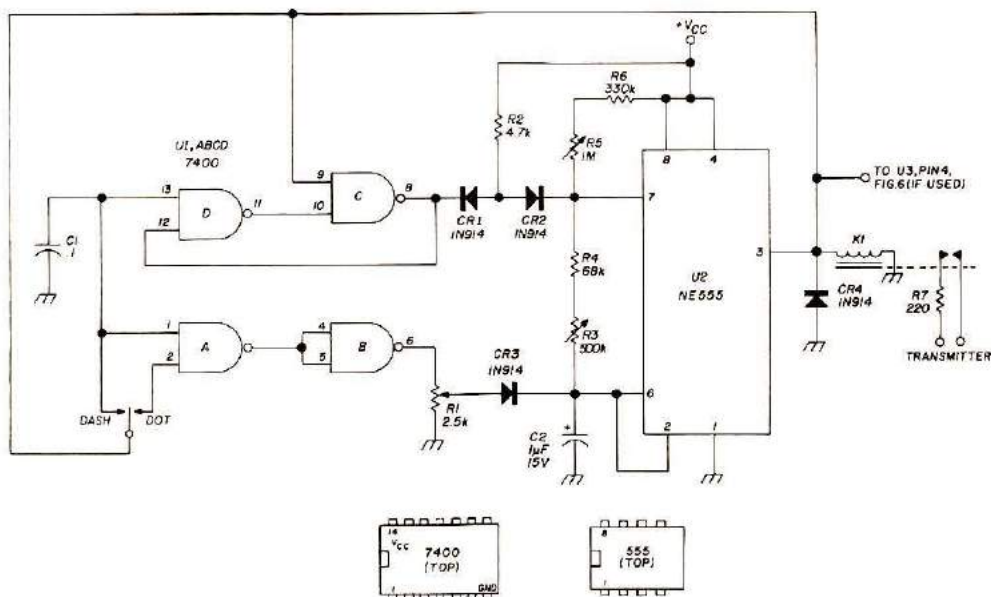


Fig. 5. Variable dash length keyer circuit. Each of the gates are part of a 7400 quad NAND gate IC. Reed relay K1 is a 1A5AH, same as that used in the circuit of Fig. 4.

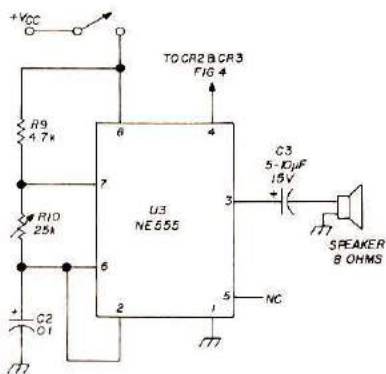
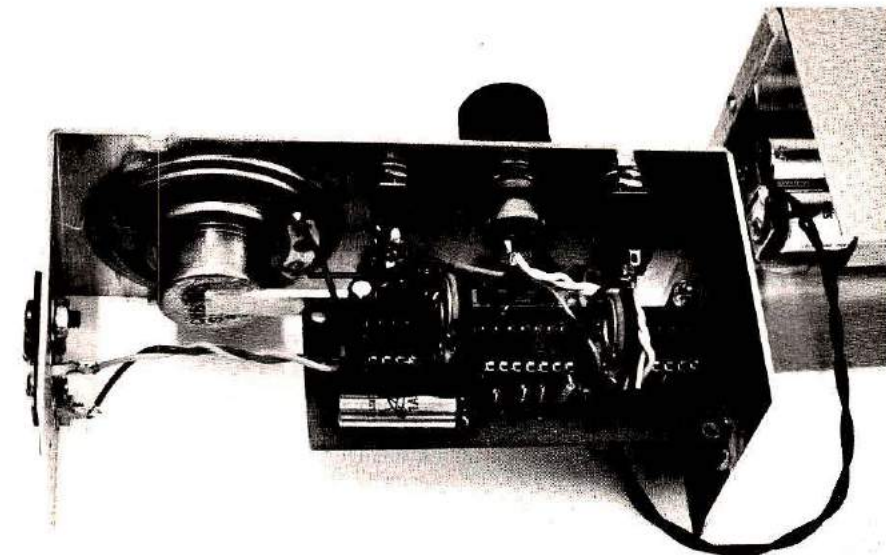


Fig. 6. Sidetone audio generator circuit using the 555 timer IC. Adjust the value of C2 for suitable volume.

The ICs are plugged into the Molex strip before wiring so the connectors don't fall out of the perf board when you're soldering nearby. The tie strip could be left intact until the wiring is completed, but to test for small solder bridges between pins, the tie strip must be removed to check for short circuits with an ohmmeter.

A later version of the keyer was built on a printed-circuit board. The foil side of the board and component layout are shown in **Figs. 7 and 8**. Construction with a printed circuit board is straight forward — with the small number of components which are required, the circuit can be completely built in less than an hour. It will take somewhat



Construction of the simple IC electronic keyer. A reed relay is used to key the transmitter. Printed-circuit component layout is shown in **Fig. 8**.

longer to lay out and drill the small chassis box.

Power supply

I prefer a power supply that doesn't have to be plugged into the wall, doesn't require recharging or battery replacement, and doesn't run down when it's accidentally left on — unfortunately, it hasn't been invented yet. Therefore, I ran one keyer with four penlight batteries and the other with a regulated power supply.

The fixed-ratio keyer was battery powered and ran

satisfactorily between 4.5 and 7 volts, the range to be expected from batteries. The bias voltage on the timer IC was adjusted on the threshold of free running with the speed control set to maximum and supply voltage at the minimum which would operate the relay. This should be around 4.5 to 4.7 volts, depending on the relay and the particular ICs you use (they all vary slightly, even though they have the same part number). The keyer, thus adjusted, has a built-in warning that the battery is getting low.

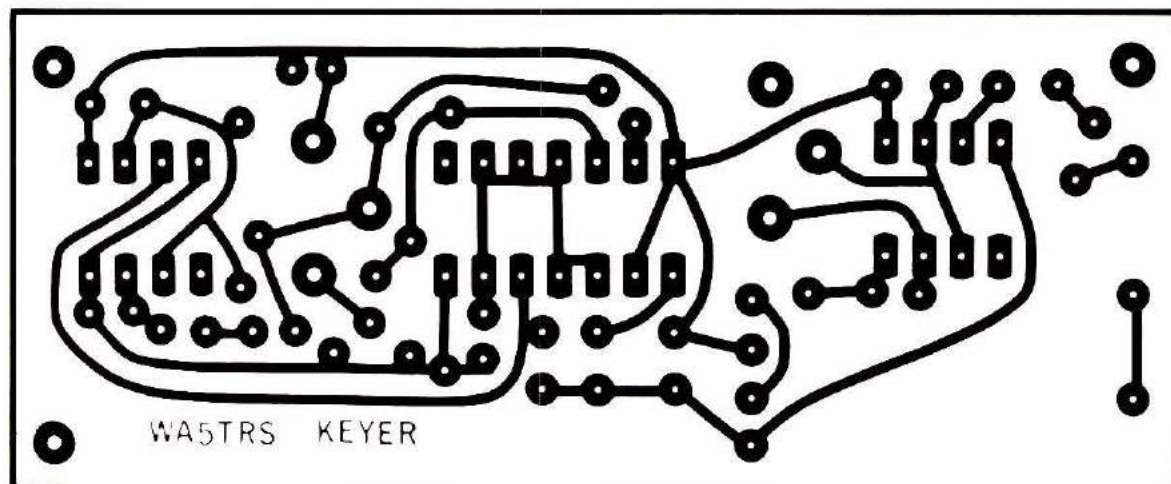


Fig. 7. Full-size printed-circuit board for the simple electronic keyer. Component layout is shown in **Fig. 8**.

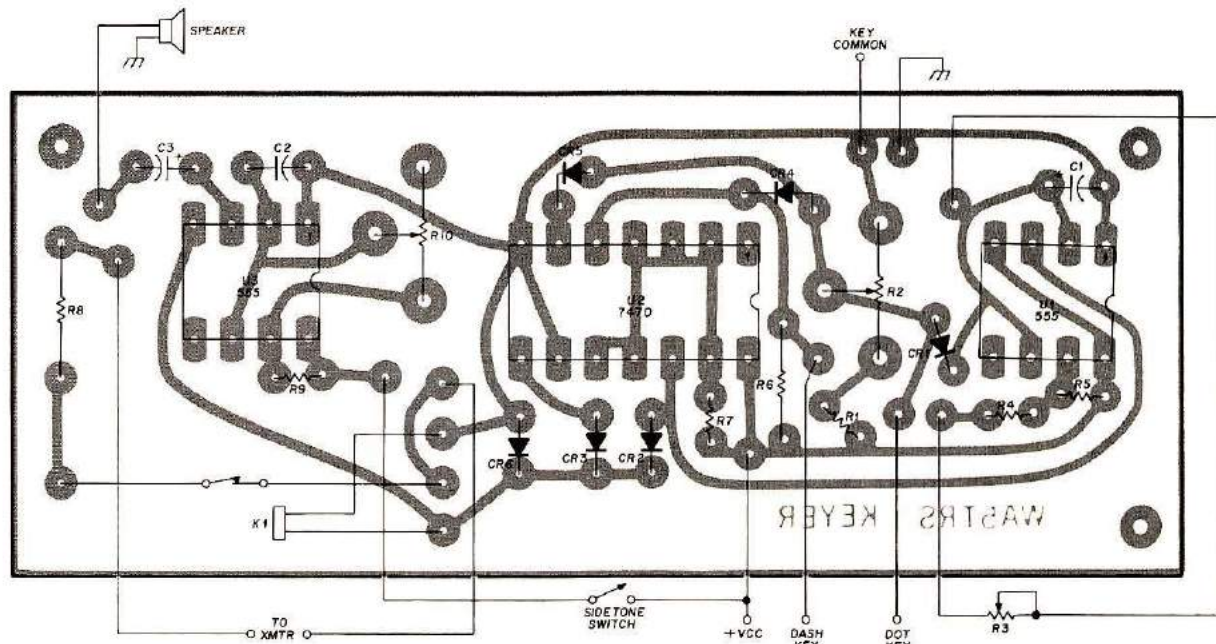


Fig. 8. Component layout for the electronic keyer circuit board. Printed-circuit boards are available from G. R. Whitehouse & Co., 15 Newbury Drive, Amherst, New Hampshire 03031.

While making a character, current drain is 46 mA with sidetone on, 35 mA with it off. Quiescent (resting) current is 27 mA.

I tried a timer circuit which interrupted the power if the keyer was left idle for ten minutes, but it drew valuable battery power and added unnecessary complexity to the keyer.

The simple regulated power supply in Fig. 9 is good for up to 100 mA if the transformer and filter capacitor are stout enough. The voltage-regulator IC, 78L05, provides a 5-volt output with excellent regulation, and includes built-in protection so you can't damage the device, even if you put a short circuit across the output.

Final comments

Within the pages of this magazine are the means to generate the thrill of discovery in anyone with a little curiosity and even less money. The cost of the parts is certainly nominal; the 7400 quad two-input NAND gate cost me 16 cents, the 7470 JK flip-flop, 42 cents, and the 555 timer, 45 cents. At those prices I'm not

afraid of blowing something up. The devices must be pretty sturdy because I make a lot of mistakes and haven't burned up an IC yet. I would recommend, for the sake of spontaneity, the use of a breadboard such as the one manufactured by E & L Instruments, Inc; I have wasted a lot of perf board before I got smart. Now I can wire up any of the circuits described here in less than fifteen minutes (including correcting mistakes).

I was afraid that rf would create some problems without shielding and bypassing these circuits, but there was no problem around my equipment with the transmitter turned on. However, there was a problem with stray, power-line field-

generated voltage, and transients carried by the power line to my home. A large metallic tool held in the hand and touched to the circuitry would trigger the timer. I could not duplicate the condition in the lab where an oscilloscope was to be used to track down the method of spurious triggering. The final solution, on my radio bench at least, is to refrain from touching the live circuitry with large metallic tools!

Timing calculations

Although it's not necessary to make any timing calculations if you build either of the electronic keyers described in this article, you may like to try the 555 timer in

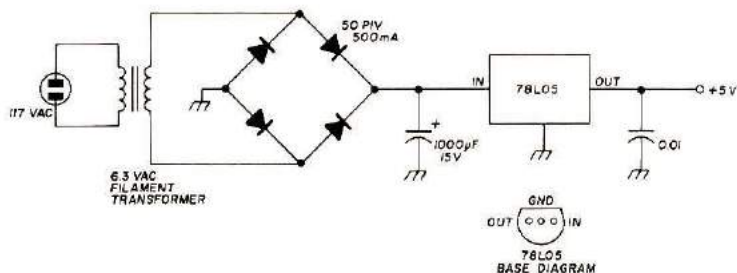
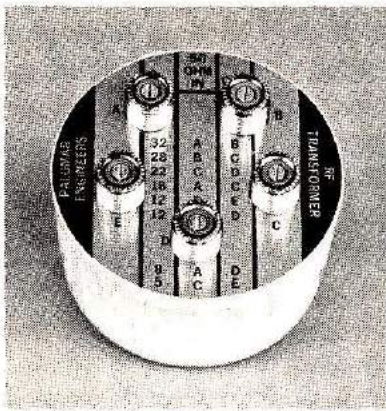


Fig. 9. Regulated 5-volt power supply for the 555 electronic keyers. Diodes are 500 mA, 50 PIV. Maximum available current from the supply is 100 mA.

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another project, such as an audio generator, for example. If that is the case, you'll have to change the values of the timing capacitor, C_t , and the two resistors, R_a and R_b (see Fig. 1). The time the 555 output is high, and low, is given by the following equations:

$$T_{high} = 0.685 (R_a + R_b) C_t \text{ seconds}$$

$$T_{low} = 0.685 (R_b) C_t \text{ seconds}$$

The total time period is

$$T_{high} + T_{low} = 0.685 (R_a + 2R_b) C_t \text{ seconds}$$

where R_a and R_b are in ohms, C_t is in farads, and T is in seconds.

For example, assume you want to build a 1000-Hz audio generator using the 555 timer IC. A 1000-Hz square wave has a period of 1/1000th of a second (1 millisecond). With a 50 per cent duty cycle, this means that T_{high} and T_{low} are each one-half this or 500 microseconds. Choosing a 0.1 μ F timing capacitor,

$$T_{high} = 5 \times 10^{-4} \text{ seconds} = 0.0685 \times 10^{-6} (R_a + R_b) 0.1 \times 10^{-6}$$

$$R_a + R_b = \frac{5 \times 10^{-4}}{0.685(0.1 \times 10^{-6})} = 7300 \text{ ohms}$$

Since the value of R_a should be about 1/5th the value of R_b for a 50 per cent duty cycle,

$$R_a + R_b = 1.2R_b = 7300 \text{ ohms}$$

$$R_b = \frac{7300}{1.2} = 6083 \text{ ohms}$$

$$R_a = 7300 - 6083 = 1217 \text{ ohms}$$

These are not standard values, as is usually the case in circuit design, so you can use the nearest standard components, 5600 ohms for R_b and 1000 ohms for R_a . This yields an output frequency of about 800 Hz. If you use a 10k pot for R_b , the output frequency may be varied from about 700 Hz to well over 5 kHz.

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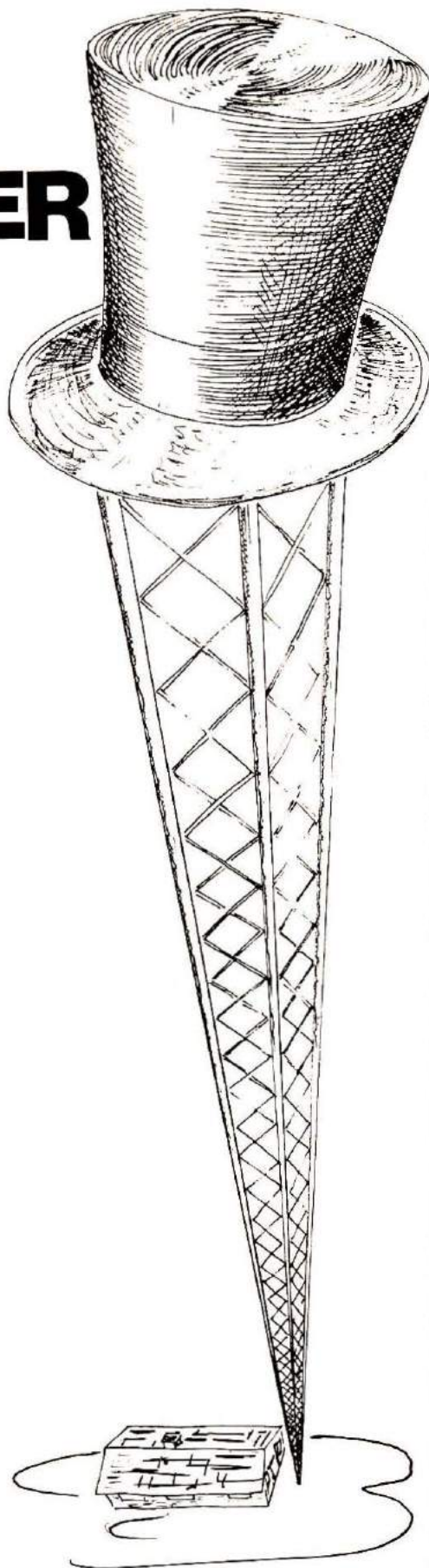
To work DX on 80 meters, you need a lot of real estate for the antenna farm, right? Not necessarily! If you can spare a chunk of yard 50 feet (15m) in diameter, this vertical may be just what you need. It has been used on 80 CW and 75 ssb at W3TQM's station to consistently work Europe, South America, Australia, and New Zealand with only 200 watts input to the final.

Description

Fig. 1 is an isometric sketch of the antenna system. The main pole, 28 feet (8.5m) tall, is mounted on a ground stake with two insulators. The ground stake is a 6-foot (1.8m) galvanized steel pipe driven half-way into the ground.

Four metal guy wires are electrically connected to the top of the main pole. The wires are 39 feet (11.9m) long and terminate at 6-foot (1.8m) vertical poles spaced at 90-degree intervals about the main pole, to form a capacitive "top hat." With this arrangement, the current near the top of the vertical can be much higher than that of a base- or center-loaded whip. In addition, the Q of this antenna is lower than that of a whip of the same height, giving it greater bandwidth.

Sixteen radials, each 25 feet (7.6m) long, are spaced evenly on the ground, and radiate outward from the ground stake at the base of the main pole.



BY STANLEY SMITHSON

They are not buried, but are securely fastened to the turf at one-foot (30cm) intervals with "hairpins" of no. 15 (approximately 1.4 metric gauge) galvanized wire. A year of lawn mowing at our station has not disturbed the ground plane.

Construction

To build this vertical, begin by driving a 6-foot (1.8m) galvanized steel ground stake half-way into the dirt. I used a two-inch (5cm) diameter "line post" of the type sold by Sears Roebuck or Montgomery Ward for chain-link fencing.

Next, assemble the 28-foot (8.5m) main pole. This can be done with telescoping aluminum tubing, as I did, or with other material.* Fig. 2 shows two suggested methods of assembly. My antenna used the system of Fig. 2A, but if telescoping tubing is not available, the "lap joint" method of Fig. 2B can be used. Either aluminum or steel pipe will work. But *beware* — if you use commonly available TV masting, remove the paint or anodized coating to insure good electrical contact between sections.

The four top-hat wires are attached as shown in Fig. 3. They are 39 feet (11.9m) long. I used 15-gauge (approximately

*I obtained the aluminum from a mail-order firm, and you could do the same. Write to Smithe Aluminum, Box 442, Laurel, Maryland 20810.

1.4 metric gauge) aluminum wire in the first model, but found that 17-gauge galvanized electric fence wire works just as well in the second model. Both are available through the Sears Roebuck catalog.

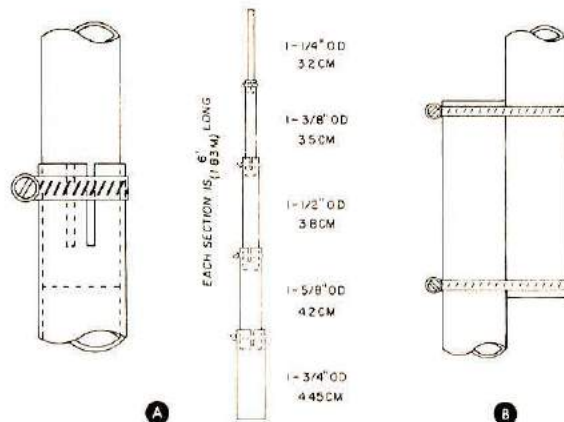
Mount the main pole on the ground stake as shown in Fig. 4. Insulate it with two pieces of 2-inch (5cm) black polyethylene plastic pipe. These are 2 inches (5cm) long and are slit along their length with a hacksaw to form insulators shaped like the letter C. Wrap them around the base of the main pole. Exercise care to overlap the cut ends of the insulator, or to adjust the gap so the hose clamp does not short against the main pole. Allow 2 inches (5cm) of space between ground and the bottom of the main pole.

In my installation, I used two hose clamps to wrap around each insulator. The slotted, stainless-steel band of one was pulled taut by the worm of the other, giving the effect of using one large clamp. If you cannot find large clamps to do the job, you can copy my procedure. I used this trick only because the junk box coughed up a bag of smaller hose clamps.

Clamps of the type needed are available at most hardware and auto parts stores. They are also available in the plumbing department at Sears Roebuck and Montgomery Ward.

While you're perusing Fig. 4, go ahead and install two more

Fig. 2. Aluminum tubing sections are joined to form the center pole. If non-telescoping tubing is all that is available, the sections may be joined as shown in A. Telescoping tubing sections are slotted at ends and joined with hose clamps as shown in B. If necessary, TV mast sections may be used.



hose clamps. Only this time, make sure that one wraps around the base of the main pole and makes good electrical contact. It is used to attach the "hot" end of the feedline to the pole. The other clamp wraps around the ground stake and connects the 16 radials and shield braid of the feedline to the ground stake.

Install four posts to hold the top hat. I used 6-foot (1.8m) steel fence posts of the sort sold for wire fencing. Tie the ends of the top hat wires to nylon rope, using about 3 feet (1m) of rope as an insulator on each wire. Be sure to insulate the ends of these wires, as the rf voltage is high at these points.

Finally, spread the 16 ground-plane radials uniformly around the ground stake. Attach one end of each wire to the ground stake hose clamp. Fasten the radials to the ground with 8-inch (20cm) hairpins of galvanized steel wire, using one hairpin per foot or two (30 to 60cm) of radial length.

Tuning and operation

I worried a bit about feed-point impedance, bandwidth, swr, and matching. But, before measurements were completed, I took the easy way out — the "what, me worry?" approach of Fig. 4. I attached the coax directly to the vertical and radials as if it were a standard quarter-wave antenna. *It worked!* To be sure, the line swr was not 1:1, but I can't be convinced that I should do anything about it! It seems I read a

series of articles by W2DU a few years ago, and have not worried about swr since!

Who can argue with success? While most books prompt you to tune antennas for low SWR, and leave the impression that my vertical couldn't possibly fly with this means of feeding it, I ignored their advice. I was too busy working DX to worry much about the matter. It seems that most signals that could be heard could be worked, and QSOs with Gs, Is, Fs, OKs, VKs, etc. were racked up without trying hard.

If you have trouble with matching, I have since found the simple network of Fig. 5 very useful on the *second* model. It was first suggested to me by ex-W3MTI some quarter-century ago. The LC circuit is resonant on 80 or 75 meters. The coax cable is permanently connected between ground and the midpoint of the coil.

Begin by attaching the vertical to the same coil tap as the coax, and tune the LC circuit for minimum swr. Move the *antenna* tap up or down one turn and re-tune the circuit

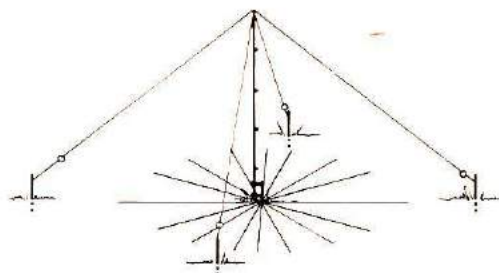


Fig. 1. Is a view of the top-hat vertical antenna for 75 and 80 meters. Center pole is only 28 feet (8.5m) high, radials are 25 feet (7.6m) long, and top-hat wires are 39 feet (11.9m) long. This antenna is very effective for DX operation, and feedline matching does not appear to be a problem. A simple tuning network may be used if desired. See text and Fig. 5 for details.

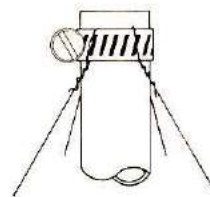


Fig. 3. Method of attaching the top-hat wires to the tip section of the center pole. A single hose clamp secures the four wires which also serve as guy wires for the system.

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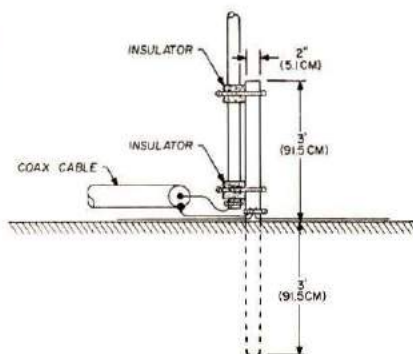


Fig. 4. Method of attaching the base of the center pole to a six-foot ground stake. Insulators are made from slotted pieces of plastic pipe that fit over the base of the pole. Note that shield braid of coaxial cable feedline and ends of radials all connect to the ground stake, and that center conductor of cable attaches to center pole with hose clamp.

for lowest swr. Repeat this procedure to get the lowest swr you are willing to work for.

Weatherproof the LC network with a large plastic container, such as a polyethylene freezer container, or an empty bleach bottle. I generally use a bleach bottle as a "rain hat" with the bottom left open for air circulation.

Closing comments

You will find this antenna rather surprising, particularly if you've been trying to DX with some of the commercial vertical antennas on 80 meters. Use a base tuning network if you must, but I am still going direct — I can't seem to be bothered with weatherproofing coils and variable capacitors.

HRH

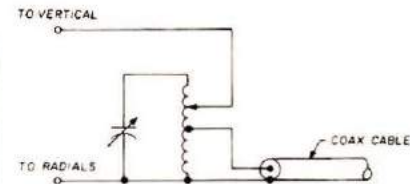


Fig. 5. An optional tuning network for matching the feedline impedance to the impedance at the base of the antenna. The coil and capacitor combination are chosen to resonate on the desired operating frequency. Note that center of coaxial cable is permanently attached to the center tap point on the coil, and that only the antenna connection is moved. Swr can be brought to 1:1 with this arrangement.

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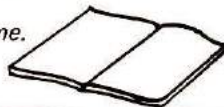
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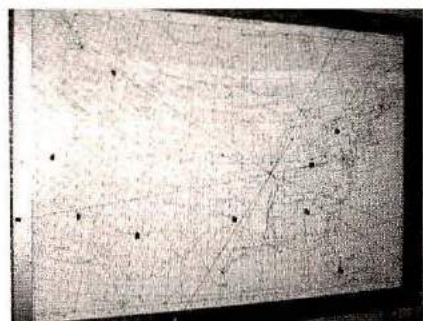
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HRH INTERVIEWS

JOHN JOHNSTON, K3BNS Chief, FCC Amateur and Citizens Division

When we concluded last month's segment we had been talking about the growth of Amateur Radio and the current, more receptive attitude toward prospective Amateurs. We open with another question.

HRH: Do you see the implementation of Novice Licensing on the local level — the resolving of the legal objections that have been raised so clubs or schools can get on with some sort of "certification" for Novice



Direction-finding equipment at several FCC monitoring stations can take bearings on a signal under investigation. The headings are all plotted on a large board to indicate where the transmitter is located — at the intersection of the lines.

applications and thus speed up the licensing process?

John: We've got to find ways to speed up the process, because if we don't, the new hams — the very ones we want to

encourage to get on the air — will be stuck with the long license delays. We hope the experimental program will show us the standards needed for good novice training courses. With well-trained graduates, there might be a number of things that could be

One important area of concern in the present Novice mail-exam system is the dropout rate.

done to get them on the air right away. Otherwise, with the system we have, there's the mailing delays, back and forth. We have to be careful about abuses. We have to check each time, for example, to make sure the volunteer examiners are licensed amateurs. The system we have now is not very satisfactory from the time standpoint. We hope the experimental program will suggest some possible solution to these problems.

HRH: If you could go into this training program — having authorized or certified clubs, schools, and the like certifying Novices — would you do so to the exclusion of the traditional individually administered Novice exam or would that method still be open?

John: We have no intention of terminating the mail exams on

an individual basis. One important concern in the present Novice mail exam system is the dropout rate. Less than half the Novice licensees have been moving up to the higher operator class, which indicates some things are probably wrong with the system as it is. Perhaps the old hit or miss training isn't very good. Maybe the Novice experience doesn't add the knowledge or incentive needed to move up the ladder. Perhaps the training methods for the next step up aren't as good as they could be.

We believe good Novice training courses might solve these problems. If more newcomers understood that a sound grounding at the Novice level can greatly reduce their problems later on, maybe that would help, too.

I've wanted to do some formal surveying along these lines for some time — I worked out a program a while ago, which I couldn't get funding for, to follow a group of new Novice licensees as they progressed or dropped out and find out why. I had questions like:

- How did you find out about Amateur Radio?
- What do you expect from ham radio?
- Where did you get your training?
- Why did you drop out?

and so on. We know that most Novices won't carry through, but what we don't know is why. I understand the League survey asked a group who had already dropped out similar questions. Practically all of them said they really intended to come back into Amateur Radio some day! Whether they will or not, of course, is something else. It's too early to predict the impact on what the deletion of the 1 year wait before re-exam will have. We hope it will be beneficial.

HRH: We're working on an article on that subject already, to be called something like, "Why Didn't Johnny Novice Make It?"

John: We'd sure like to get some statistics on that subject. I've always felt that it isn't just a problem with the training phase, but that the step between Novice and Technician may be too big. That's one of the things Docket 20282 tried to address. Moreover, Tech privileges greatly exceed the Element 3 requirements. But even those requirements may still be too big a step up from Novice.

HRH: Of course, now that Technicians have Novice privileges, the whole structure makes more sense and you can move up in a step-by-step fashion and you no longer give up something at that important Novice-to-Tech upgrade!

John: That change was a key issue in the restructuring matter. It was a very pragmatic decision. As you know, the



The FCC has many monitoring stations; this one is a Grand Island, Nebraska.

restructuring proposal met with a lot of opposition, much of it possibly just resistance to change. I do think that, some day, people are going to say, "You know, that 'dual ladder' (from the restructuring docket) wasn't such a bad idea at that!" There, of course, the idea was to keep the high-frequency bands and privileges pretty much as is, and to make the vhf/uhf bands more available to newcomers to amateur radio. As I see it, the big challenge to amateurs now will be to accommodate their growing ranks in the limited HF bands.

HRH: How about higher class licensing and licensing programs? Hasn't the League been doing something in that area?

John: I understand they've conducted a survey as to why hams have or have not been upgrading, and presumably are

"Do you see a code-free license on the horizon anymore?"

basing their training programs on that. It wasn't until recently that anyone took much interest in why people stay in or drop out of Amateur Radio.

HRH: Do you see a code-free license on the horizon any more?

John: A lot of people, both inside and outside the Commission, want that. One real holdup for us is the lack of resources to process the number of new Amateurs we'd probably get with such a license! This is true for any changes in privileges which would make ham licenses more attractive, or easier to obtain.

HRH: That brings us back to another point we discussed a bit earlier. Eventually something will happen with the experimental training program and could possibly have



Mobile monitoring units can be used for many purposes. This one can be used to compile data on how the radio spectrum is occupied.

Novices being authorized on the local level. Do you see that philosophy moving the administration of higher class Amateur exams out from under direct FCC supervision being extended? As it's presently set up, we're really limited, particularly in rural areas, by the lack of FCC Field Offices and personnel to provide Amateur exams on a frequent schedule.

John: That is a possibility. If the Amateur ranks grow appreciably, the FCC could be forced into such a move.

HRH: Do you think it would be good if you were forced into something like that?

John: Well, first I'm sure that everyone wants a good system. The test program we had for a while with Civil Service administered exams had some advantages, but it cost money. If someone could only come up with something like that that didn't cost money! Field Office Bureau is making adjustments to the exam schedules to reduce the travel problem as much as possible.

HRH: Have you thought about charging a premium for special examination handling? For example, what if a local postmaster would give an

Amateur exam but you'd have to pay a service charge say \$10 for his time. That would be cheaper and more convenient than driving even 50 miles to a big city, and a lot of the population is much farther from an FCC Field Office than 50 miles.

John: The Field Office Bureau is always looking for better ways to do their job. They have already done several things to broaden the individual's examination opportunities. Many of the bigger hamfests now have FCC license examinations as a regular part of the program. One suggestion that sounds interesting is the setting up of an "FCC Auxiliary," something like the Coast Guard Auxiliary, with part time or volunteer people authorized to give exams, answer questions, and the like.

HRH: So far we've barely touched "deregulation," yet it is really one area in which you've done a great deal. Where do we go from here? What's going to happen next on restructuring Docket 20282?

John: We're no longer under the pressure for deregulation that we were last year. Then we were under specific instructions to deregulate the Amateur service because of inputs from various Amateur groups and individuals who'd presented arguments to the effect that "Amateur Radio is in a straitjacket," and "we need only minimal regulations." The Commission was anxious to see us respond to those inputs because, frankly, if deregulation doesn't work for the Amateur service, it probably isn't going to work anywhere! Again, there's that fine reputation that Amateur Radio has for self-regulation.

We got off with a running start early in 1976. Probably more items and more deregulatory actions came out in 1976 than ever before in a similar period of time. Give the credit for all that to Joe

Johnson, W3GGO, and Greg Jones, WB6KAV, in the Rules and Legal Branch. They did much of that work on their own time. We were so busy here during the day that there was simply no time to sit down with the door closed and think things through, so they took a lot of it home with them. For a while we were turning out an item a week, but then we started running into opposition from amateurs.

We first ran into opposition on the portable/mobile identification proposal (deletion of the requirement that an Amateur station indicate his status when operation away from the licensed premises, which finally became effective on November 26, 1976. **Editor**). Initially, we did not anticipate such problems and thought it could be done with a simple order but some negative comments on the idea popped

There's nothing in Part 97 that forbids contest sponsors from making the rules they need for their own purposes.

up. So we had to go through a proposal and comment phase. Then the bandwidth docket — Docket 20777 — got very negative reception and we started hearing some comments to the effect that deregulation was going too far.

In the end, the Commission went ahead and dropped the "portable/mobile" requirement. While we're talking about that rule change, it's a good opportunity to reflect on the whole deregulatory theme and Amateur reaction to it. Many Amateurs filed comments to the effect that a portable identifier was useful for contest work so we asked ourselves, "why should a government regulatory agency have a Rule simply because someone wants it for his contest?" There's nothing in Part 97 that forbids contest

sponsors from making the rules they need for their purposes. Amateurs really should give more thought to what they can do for themselves, rather than depend upon the FCC to do it for them.

Of course, Amateur reaction to the bandwidth docket was a big disappointment to us. That setback, plus many other things, have come along since to take our minds away from Amateur matters, so we've simply put bandwidth on the back burner. Recently CB has been taking a lot of time. For example, we've started a big project rewriting the CB rules to make them more readable. There's simply so much to do in CB right now that I don't see as many actions affecting the Amateur service in 1977 as we accomplished in 1976.

HRH: We touched on CB a bit earlier . . . in the relationship between the two services. Is Amateur Radio benefiting from or being hurt by CB?

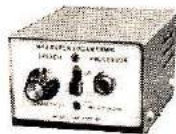
John: I used to see much misunderstanding and lack of cooperation between people who were in only one service or the other but that seems to be correcting itself. At one big hamfest recently I asked the question at the FCC Forum, "How many of you came into ham radio through the CB ranks?" A good number of hands got up, and I'm sure if you made a survey you'd find that many new hams are indeed coming from CB. I did myself. My family is into CB quite heavily. We find it very useful.

As crude a radio service as some amateurs view CB to be, I happen to think it is providing great training and research. Millions of people are finding out how two-way radio can be of real use to them. We're all learning what the needs for personal radio are. I think we will some day credit the amateurs for some of the technology that will be needed to satisfy those needs.

HRH

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DX forecaster

May, 1977

With seasonal progression, Spring DX opportunities slowly give way to the doldrums of the summer solstice. The DX word is *humdrum*. Increasing atmospheric noise from thunderstorms means that the 1.8-MHz (160-meter), 3.5-MHz (80-meter), and 7.0-MHz (40-meter) bands will be generally poor for DX. Although the 21-MHz (15-meter) and 28-MHz (10-meter) bands will be quieter because they are not as subject to "atmospherics," (static, or *QRN*), they will be quieter for another reason — fewer DX signals.

28 MHz will provide occasional openings along a generally north-south path between the United States and Central and South America during afternoon and early evening hours. *Short skip* is a favorite summertime trick of the ionosphere, so if DX to you means 750 to 1500 miles (1200 to 2400 kilometers), keep your receiver tuned to ten meters, especially on those days when WWV tells you that the solar index is above 70 and the geomagnetic index is below 5!

21 MHz will be open to South and Central America frequently during this month, and Caribbean QSOs will be commonplace. The best times to listen will be from noon local time until 8 or 9 PM. Occasionally, when the solar index is up, trans-equatorial paths to Africa and the South Pacific will open and provide surprises for those who don't

give up easily. *Short skip* signals will be present on most days of the month, with good contacts possible between about 600 and 2400 miles (1000 and 4000 kilometers).

14 MHz is the "steady Eddie" of DX bands, and will continue to maintain its reputation in May. Opening shortly after sunrise local time, it will peak about an hour or two later, decline somewhat during midday, and peak again during the late afternoon. In general, the 20-meter band will be open all day and well into the evening for DX to most parts of the world, especially when the solar index is up. DX will blend with *short skip* of 400 to 2400 miles (650 to 4000 kilometers) during the afternoon hours, and it will sometimes be difficult to tell which signals will be stronger in your receiver!

7 MHz can still provide some good DX openings, particularly if you're a "night owl" living in a part of the country where thunderstorm activity is not severe. Start checking just before sundown and scan this band frequently until an hour or so after sunrise.

Short skip conditions are "normal" for forty meters during daylight hours and will bring in stations from distances of 150 to 750 miles (250 to 1250 kilometers). Later in the evening "short" skip will lengthen to about 2000 miles (3500 kilometers) or so. As always, the major problem with forty is the foreign

broadcasting that takes place throughout the band. The S-9 plus signals of these stations often mask the DX. A sharp filter will be a big help to you on the 40-meter band.

3.5 MHz is a bit unpredictable this month, because May is a transition period between Spring and Summer. Although absorption levels play havoc during midday, rendering the band practically useless between about 11 AM and 3 PM, the morning and afternoon hours will keep you happy and busy with signals coming in from all directions between about 50 and 250 miles (85 to 425 kilometers). After dark, "short" skip will provide QSOs out to about 1800 miles (3000 kilometers) or more, particularly if the country around you is free of thunderstorm activity.

1.8 MHz will be dormant until Fall. Nothing will be coming through during the daylight hours, and very little during the evening. Be alert for nice evenings when the noise level is low, and look for occasional stations from as far away as 1000 miles (1600 kilometers), but don't expect the "solid" winter-type signals.

Propagation special

Sometime around the 11th or 12th of May, there is a possibility of some extra-special ionospheric activity, accompanied or shortly followed by unusual atmospheric activity.

Propagation chart

An asterisk (*) indicates that the same path may be open for the next higher band. A hyphen (-) means that the path is not open on any band at that time. Wherever a band is indicated, the path should be open at that time on an average of 50% of the days. Don't forget that *Daylight Savings Time* will come into effect in May; times given are Standard, one hour later than Daylight. **HRH**

WESTERN USA

MID USA

EASTERN USA

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



Dear Horizons:

You are off to a good start. I liked the article by W6SAI as I have one of the Taylor Tubes still in the carton. I am not interested in getting too deep into the new stuff. I am more interested in the person-to-person side.

Hope you will have more articles that new hams will like.

Joseph M. McClain, W9KNY
Kokomo, Indiana

Dear Horizons:

Congratulations on your first issue — may all future issues equal or exceed it. I visualize HRH helping hams to upgrade their license and ease the transition of serious CBers into the wonderful world of ham radio. And ham radio certainly needs a large influx of enthusiastic newcomers to replace the old timers and increase our total numbers. Hungry vultures are eyeing our frequencies and privileges. My subscription is enclosed — of course. Good luck.

Francis E. McAllan W2SPB
Ocean, New Jersey

Dear Horizons:

I just finished reading the March issue of your magazine and I was most interested in "The Not So

Rocky Road From CB to Ham" and "Get on the Air on a Budget."

I am not a Ham but am very interested in becoming one. Before reading your articles I always believed that to become a Ham you had to be an electronics expert and also be very wealthy to afford the equipment. Your articles were very informative and that is why I am writing this letter.

Please send me the information on becoming a Ham; I would appreciate it very much.

W. E. Minnick
Bena, Virginia

Dear Horizons:

Congratulations! I have just received the first issue of *Ham Radio Horizons* and I think it's a wonderful magazine for both beginner and old timer.

Having been licensed since 1934, I think I qualify as an Old Timer and it's great to see a magazine for both categories of users of the Amateur Service. May we be ever mindful that the frequencies allocated to us are loaned and that we police them and use them as they were intended.

I have a couple of interested parties in my town and no doubt they will make excellent amateurs. I have recommended they read *Ham Radio Horizons* and have assured them it will not be necessary to use a slide rule to understand the basic fundamentals of radio.

Geo. W. Warren, Jr., W4EXJ
Whiteville, North Carolina

Dear Horizons:

I am one of your initial subscribers to the new *Ham Radio Horizons* magazine.

I just received and read my "complimentary copy."

Even though I hold the Advanced class license, I must admit this is the *first* Ham magazine that I've read from cover to cover, and actually *understood* what I read.

Thanks for taking care of us "ordinary hams." Keep up the good work. I'll be looking forward to the next issue.

Mike Witenko, WB8UBG
Springfield, Ohio

Dear Horizons:

Just received my March copy of HR *Horizons* after having submitted my charter subscription. I am very much impressed with the publication and especially like the clear bold face type employed. The articles were very interesting and informative.

I've been a General for 18 months and am still learning ham radio, especially the technical angle of it. The manner utilized in HRH for an explanation of propagation was superb. And that is the adjective which describes the magazine . . . Congratulations and good luck.

Gene Molter, WB2BAM
Irondequoit, New York

Dear Horizons:

Just read Tom McMullen's article on ssb. Absolutely beautiful! Written with exceptional clarity and accompanied by illustrations that make a point. Can't remember anything ever written in a ham magazine that communicated so well.

Keep it up! My subscription is in the mail.

Martin Wincoll K2BRY
Harrison, New York

Dear Horizons:

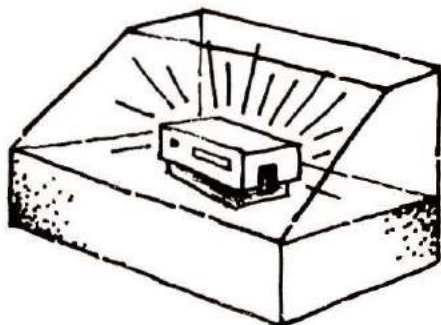
Your new magazine provided just the encouragement I need! I'm taking my Novice written exam tomorrow and the Technician exam for the second time in March. Since I'm not technically oriented it's a struggle but I intend to be the winner.

As an XYL (my husband is W8KEL) and potential Ham I'd like to say thanks for *Horizons*. I have subscribed to it *for myself* but I may let my husband borrow it!

Diana Slabinski
Chagrin Falls, Ohio

The Horizons staff extends a sincere thank you to our many readers who took the time to write, as represented by this small sampling of the mail. We are grateful for your plaudits, comments, and criticism because that is a vital part of keeping in touch with people — and that is what communicating is all about.
Editor

PRODUCT



SHOWCASE

Newest Yaesu HF-Band Transceiver



Yaesu Electronics Corporation has revealed the newest addition to its extensive line of amateur radio equipment, the FT-301D all solid-state digital transceiver.

The FT-301D covers the amateur bands 160 through 10 meters with provisions for WWV/JJY reception for time signals. Frequency readout to six places is accomplished by large, red-colored light emitting diodes. Yaesu states that their new FT-301D is the first completely solid state transceiver available with 200-watt ssb PEP power input, 200 watts CW and 50 watts a-m and fsk.

The fsk feature should please the growing numbers of amateurs interested in teletype communication. Provision is made to accept keyboard contacts with shifts of 170 or 850 Hz, depending upon the operator's desires.

The transmitter audio re-

sponse has been tailored to voice frequencies, 320 Hz to 2700 Hz at -6 dB. Distortion products are less than -31 dB. Frequency stability of the unit during any 30-minute period is less than 100 Hz of drift.

Receiver sensitivity is 0.25 microvolts at S/N 10 dB. Selectivity is variable: 2.4 kHz at -6 dB for ssb; 4.0 kHz at -60 dB for CW and fsk; 0.6 kHz at -6 dB; 1.2 kHz at 60 dB with 6 kHz at -6 dB; and 12 kHz at -60 dB for a-m operation.

Being entirely solid state, the FT-301D may be directly powered by a 13.5-volt dc battery source, negative ground, at 21 amperes in transmit, 0.9 amperes receive. A matching ac supply, Model FP-301D with self-contained speaker is available. A series of transformer taps enables the unit to operate on a range of line voltages from 100/110/117/200/220 or 234 volts ac, at 50/60 Hz. Compact and lightweight, the transceiver measures 11" x 4.9" x 7.7" (280 x 125 x 195mm), and weighs 9 kg. The matching ac supply measures 212x125x195mm and weighs 10kg.

For further information, contact an authorized Yaesu dealer, or write Yaesu Electronics Corporation, 15954 Downey Avenue, P.O. Box 498, Paramount, California 90723, or use *ad check* on page 78.

New Catalog of Hard-To-Find Tools

A new 128-page catalog of unusual and hard-to-find tools is offered *free* by Jensen Tools and Alloys. The catalog describes with photographs, many in full color, over 2800 tools of interest to engineers, electronic technicians and instrument mechanics working on fine assemblies.

Major categories include micro-tools, power tools, test equipment, soldering equipment, engineering supplies, screwdrivers, pliers, wire strippers, tweezers, and a 30-page section featuring famous

Jensen tool kits and tool cases.

Also covered is technical data on tool selection, metric and temperature conversion charts, glossaries of tool terms, equivalency tables, safety tips, and specific information on plastics and the solderability, tensile strength, and melting points of various metals.

To obtain your free copy, write: Jensen Tools and Alloys, 4117 North 44th Street, Phoenix, Arizona 85018; or use *ad check* on page 78.

Long Wire Antenna Tuner From MFJ



Most of us, at one time or another, have longed for the simplicity and performance of an inexpensive long wire antenna, but we just haven't been able to find a single tuner covering the 160-through 10-meter Amateur bands and capable of accepting 200 watts of power, at a price we could afford. Now, at last, there is such a tuner — and it's available from MFJ Enterprises.

The MFJ-16010 Antenna Tuner provides all hf-band coverage with a single random-wire antenna, and allows you to run up to 200 watts of rf *output* power without any problems. Even better, the MFJ-16010 Antenna Tuner is small enough to carry in your hip pocket, measuring only 2-3/16 x 3-1/4 x 4 inches (11.3x8.26x10.2cm)!

Low and high impedances can be matched by merely interchanging input and output connections, and SO-239 connectors are provided for convenient attachment of coaxial cable transmission line. This unique, wide range, high-performance tuner employs a 12-position

tapped inductor and two stacked toroid cores. Price is only \$39.95.

For additional information, write MFJ Enterprises, Box 494, Mississippi State, Mississippi 39762; call (toll-free) 800-647-8660, or use *ad check* on page 78.

Brasspounders Delight



William M. Nye Company knows a good thing when they sell it, and you will too! Their Viking Speed-X telegraph key, model no. 114-310-004 G.P., is made from the finest materials and finished with loving care to last a lifetime.

As a special tribute to the Bicentennial Year, the Speed-X is available with gold-plated hardware, offering a deeply satisfying, rich beauty for the discriminating CW man who has everything. The key lever is mounted in adjustable pivots on a heavy metal base finished in black crackle, and the base is mounted on a black plastic sub-base that provides a solid, non-slip, yet attractive support for the key. The key lever can be set to any desired "feel" from that of an Old Timer to the needs and requirements of the youngest Novice. A separate lever arm can be used to close the key temporarily, leaving your hands free to make transmitter tuning adjustments.

This truly beautiful key with its plated hardware, crackle finish, and "Navy" knob will grace the most elaborate station for only \$50, prepaid, in the United States. A standard, nickel-plated model is also available.

For additional information on

this and other Nye products for the Amateur, write Wm. M. Nye Company, Inc., 1614 - 130th, N.E., Bellevue, Washington 98005; or use *ad check* on page 78.

Fet Volt-Ohmmeter

How many times have you wished for a volt-ohmmeter that you could use to measure resistances or make continuity checks without removing components from their circuits? How about a portable, battery-operated meter that is drop-proof and burnout-proof; or one that doesn't bias or destroy sensitive diodes, ICs, or transistors?

Well, your wishes have been granted by Triplet Corporation with their recently introduced Model 64 fet volt-ohmmeter. This new, solid-state meter is super-safe and features six low-power ohms ranges with an open circuit voltage of only 90 millivolts. The exclusive Triplet micro-power circuitry permits *continuous* meter operation for over one year without changing its batteries!

Developed for use in test laboratories, manufacturing quality control and inspection departments for field servicing, plant maintenance, and vocational or trade schools, the Triplet Model 64 covers 29 ranges clearly indicated in colorful bright green and easily selected by a single range-selector switch. Beyond this, the meter has a specially engineered internal electrical system to prevent explosive arcs in high energy circuits up to the 1-ampere, 1000-volt fuse capacity, and features complete insulation and protective-type test leads.

A single selector switch simplifies access to 29 ranges, including: dc volts 0-0.3-1-3-10-30-100-300-1000; ac volts 0-0.3-1-3-10-30-100-300-1000; ohms (low power: 0-1k-10k-100k-1M-10M-100M; ohms (conventional) 1000M; junction test, forward and reverse conduction.

For further information on the new multirange Model 64 Volt-ohmmeter priced at only \$130.00, and additional optional accessories to extend its use in highly specialized applications, contact the Triplet Corporation, Marketing Department, Bluffton, Ohio 45817, or use *ad check* on page 78.

Filters Reduce TV Interference



You'll be glad to know about these three TV interference filters from Avanti Research & Development.

The problem could be at the transceiver, the TV set or in the ac power line. If the transceiver is radiating harmonics of the same frequency assigned to one or more of the local TV channels, installation of the Avanti Model AV-800 Low Pass Filter on the transceiver should clear up the problem. If the problem is at the TV receiver due to *front end* overloading, installation of Avanti's Model AV-811 Filter on the TV lead-in should solve it. The filter lets the TV signals come through the line unhindered, while choking off the incoming amateur or CB signal. The third type of problem is caused by transmission of the signal through ac power lines. This calls for the Avanti Model AV-820 AC Line Filter which can isolate the signal at the transceiver. When used at the TV set this filter prevents an outside signal from entering the TV through the ac line.

For further information, contact Avanti Research & Development, Inc., 340 Stewart Ave., Addison, Illinois 60101 or use *ad check* on page 78.

All-Band Whip Antenna For Receiver Use

If you are an apartment dweller, or have other restrictions that prevent you from installing that long-wire receiving antenna you've always wanted, your problems are over.

McKay Dymek has just introduced its new DA100, all-wave, omni-directional whip antenna; the first practical replacement for the traditional outside long-wire receiving antenna. The DA100 is a four-foot collapsible whip attached to a small weatherproof box that does away with the necessity of having to string an outside wire, while providing excellent performance.

The DA100 contains a broadband, untuned preamplifier having a 50-ohm output impedance covering the frequency range of 50 kHz to 30 MHz. It includes a standard coaxial connector for attachment to any multi-band communications-type receiver that will accept an external antenna. The whip/amplifier section mounts to a pole or pipe, window frame, ledge or any high place; the higher, the better. The control module, measuring only 9 x 5 x 9 inches (23x13x23cm) operates from standard house current and can be placed at any convenient location indoors. Power consumption at 110 or 220 volts, 50-60 Hz, switch selectable, is 4 watts maximum. Weight: 9 pounds (4 kilograms). Price: \$125.00, available from the factory only.

For additional information, write McKay Dymek Company, Box 2100, 675 North Park Avenue, Pomona, California 91766; nationwide (toll-free) telephone (800) 854-7769; California (toll-free) telephone (800) 472-1783; or use *ad check* on page 78.

Underground Buying Guide



Peninsula Marketing Services has just published a new directory that helps amateurs, CBers, experimenters and computer hobbyists locate equipment, parts, supplies and services.

Over 600 sources of standard and hard-to-find gear are listed in the handy guide. Many of the 600 sources are mail order firms and many allow discounts, too. All are firms that do business with electronic hobbyists.

The first section of the book lists the firms alphabetically, and their complete mailing addresses and phone numbers. Then, a list of the products or services they offer is provided along with key product information, minimum order amounts, shipping charges, etc. You'll find everything from the million-dollar mail order firm that handles hundreds of product lines to the week-end garage operation offering a low-cost accessory for a microprocessor or CB transceiver.

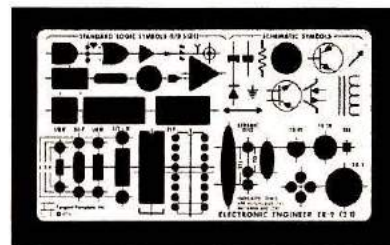
The second section of the book is a breakdown of products and sources in over 200 categories. Under each category is a listing of all firms that sell or manufacture the items cross referenced to the first section.

The last section of the book includes all sources by state so you can buy from the firm nearest you when there are several choices. You'll probably

find some local firms that you didn't know existed.

The Underground Buying Guide is available only by direct mail from Peninsula Marketing Services, 12625 Lido Way, Saratoga, California 95070. The price is \$5.95 plus 55¢ postage and handling. Californians add 39¢ sales tax. Moneyback guarantee within 10 days if you are not completely satisfied. For further information contact Dennis A. King of Peninsula Marketing Services at above address, Phone (408) 996-0471, or use *ad check* on page 78.

Three-Function Template for Circuit Design



Tangent Template has just introduced its new electronics engineer template that incorporates on one template the most commonly used logic, schematic and component layout patterns required for the majority of electronic circuit design applications. Each template includes a complete set of half-size logic symbols and basic schematic symbols for preparing circuit diagrams. Component layout patterns include capacitors, resistors, diodes, transistors, ICs and DIP.

The template is designed expressly for use by electronics engineers, circuit designers, technicians, and draftsmen. The Electronics Engineer template is available with 1:1, 2:1, and 4:1 component patterns, at \$5.00, \$5.50, and \$7.50, respectively.

For further information contact Tangent Template, Inc., P.O. Box 20704, San Diego, California 92120 (714) 282-0494, or use *ad check* on page 78.



RATES Regular classified is available at 50¢ per word. Display classified (1 inch deep x 2 1/4 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.

MULTI-BAND DIPOLE TRAPS. PACE-TRAPS are the key devices required to build the All-Band dipole depicted in the ARRL Hand-Book. Two models available. NG-Series (novice gallon) \$14.95 pr. FG-Series (full-gallon) 16.95 Pace-Sulator (weather-proof no-solder center - insulator) 4.95. Antenna instructions furnished. Shipped post-paid in USA. Check or M.O. To Pace-Traps, Upland Rd., Middlebury, Conn. 06762.

ATTENTION MICHIGAN HAMS! See us for Collins, Drake and Ten-Tec gear. W8RP, W8BUXO, W8VGR. Purchase Radio Supply, 327 E. Hoover Ave., Ann Arbor, MI 48104. Ph. 313-668-8696.

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.

TUNE IN THE WORLD WITH HAM RADIO and other fine ARRL publications are available at:
CB CENTER OF BERGEN COUNTY
 11 Bennet Road
 Englewood, New Jersey 07631
 (201-568-0738)
 We also stock 2 meter crystals, antennas and fine quality transceivers — 73-Mike Cresci WA2GPY.

STOP LOOKING For a good deal on amateur radio equipment — you've found it here — at your amateur radio headquarters in the heart of the Midwest. We are factory-authorized dealers for Kenwood, Drake, Collins, ICOM, Ten-Tec, Atlas, Tempo, Regency, Swan, Midland, Alpha, Standard, Dentron, Hy-Gain, Mosley, Cushcraft, and CDE, plus accessories. For the best deal around on HF or VHF gear, write or call us today for our low quote and become one of the many happy and satisfied customers of HOOSIER ELECTRONICS, P.O. Box 2001, Terre Haute, Indiana 47802. (812)-238-1456.

DESK CONSOLE EQUIPMENT CABINET. Build from design drawings, photographs, \$4.75. Amateur radio monthly publications listing, \$2.95. Bill Morris, WA5RSC, P.O. Box 411, Lubbock, TX 79408.

PARALYZED and legally blind 40 year old man studying for General license now could really use an Amateur transceiver. Please help Richard Jastrow, 10660 Melvin Ave., Northridge, CA 91324. Telephone 213-781-2004.

B&K TEST EQUIPMENT. 15% discount. Free shipping. Free catalog. Spacetron, Box 84, Broadview, IL 60153.

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.

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

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

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.

STAINLESS AND GALVANIZED STEEL ANTENNA GUY WIRE our specialty. Wilcox Electronics, Box 1331, S.L.C., Utah 84110.

WYOMING
 Ranch land. Antelope, deer, elk, wild horses — Your "Antenna Ranch." 10 Acres \$30 down, \$30 month. FREE info — maps — photos. Owner:
Dr. Michael Gauthier, K6ICS
 9550HH Gallatin Rd., Downey CA 90240

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) 376-8887
 SST ELECTRONICS, P.O. BOX 1, LAWDALE, CA. 90260

OVERSEAS HELP — Do you have small parts, basic components for electronic projects, or useful station accessories that would help a beginner? Your help here could increase amateur activity overseas. Contributions should be sent to: Peter Mallalieu, VP2DM, c/o RFD 2, Pulpit Road, Bedford, NH 03102.

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 weekdays at (312) 595-0020.

18TH ANNUAL STARC HAMFEST, May 7th, Binghamton, NY. Flea market, snack bar, tech talks, hourly door prizes. Admission \$2.00, banquet reservation \$6.00. Indoor exhibit reservation \$5.00/table. Contact STARC, P.O. Box 11, Endicott, NY. 13760.

HAMFEST! INDIANA'S FRIENDLIEST and largest hamfest. Wabash County amateur radio clubs 9th annual hamfest will be held Sunday, May 22, 1977, rain or shine, at the Wabash County 4-H fairgrounds in Wabash, Indiana. Large flea market (no table or set-up charge), technical forums, bingo for the xyl, plenty of free parking, lots of good food at reasonable prices. Only one ticket to buy this year. Admission is \$2.00 for advance tickets, \$2.50 at the gate. Children under 12 years old are admitted free. For more information or advanced tickets, write Bob Mitting, 663 Spring Street, Wabash, Indiana, 46992.

NEW YORK CITY. The 4th annual Hall of Science A.R.C. Flea Market and Hamvention. 111th Street and 48th Ave. Corona Queens. Refreshments, Zoo Museum. Dealers booths, test bench. Family fun Sunday, June 12 (rain date June 19) 9 AM-3. Admission \$2.00 door prizes. Talk in .34/.94. Information (212) 699-9400.

BIRMINGHAMFEST AMATEUR RADIO CONVENTION. May 7 and 8, 1977. Alabama State Fairgrounds, Birmingham, and Rodeway Inn — Oxmoor at I-65 and Oxmoor Road. One of the country's largest flea markets, technical and operating forums, huge prize drawings, manufacturers and distributors displays, ladies and children's activities. TALK-IN: 34/94, 3965 kHz. No admission charge. Prize ticket donations - \$1. For booth display space, information, and reservations, write. Birminghamfest, P.O. Box 603, Birmingham, Alabama 35201.

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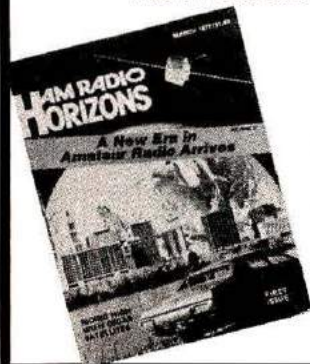
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