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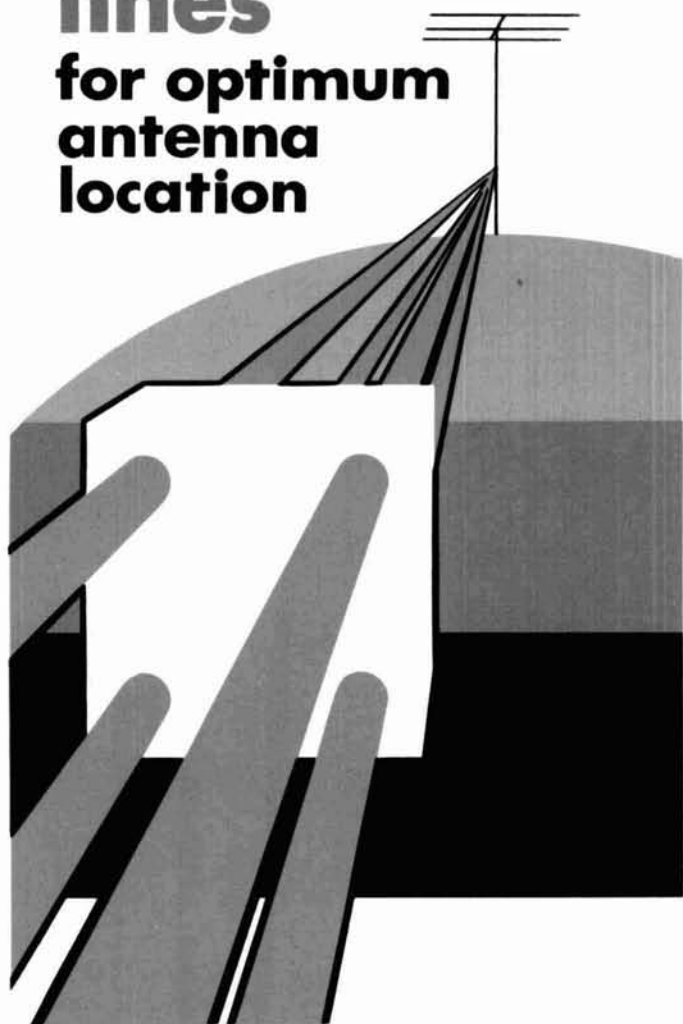
magazine

OCTOBER 1980

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long transmission lines

**for optimum
antenna
location**



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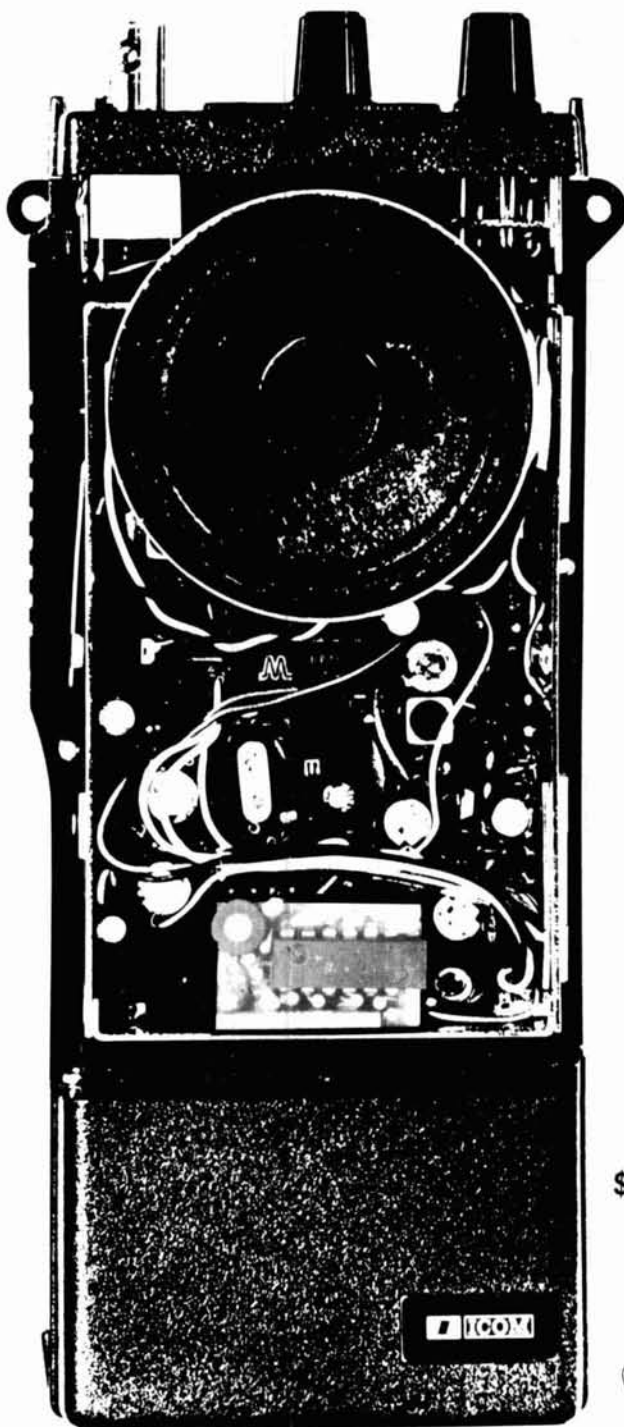
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Compact and sensitive. The 4-band model

measures just 5 1/4" W x 1 1/4" H x 4" D to fit anywhere in your vehicle (the 8-band version is just 1" wider and 1" deeper). Two dual-gate MOSFETS give these converters excellent sensitivity and selectivity when combined with your automotive receiver.

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New model MFJ-723 is similar to the 722 but is for CW only, has a 60 dB notch tunable from 300-1200 Hz, and measures 2x4x6". Other models: MFJ-721, \$59.95, like 722 but less notch; MFJ-720, \$39.95, like 723 but less notch.

Versatile, all models plug into the phone jack, provide 2 watts for speaker or can be used with headphones. All require 9-18 VDC, 300 mA max (or 110 VAC with optional AC adapter at \$7.95 + \$2).

Enjoy pleasant listening and improved readability with one of these new MFJ filters.

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magazine

OCTOBER 1980

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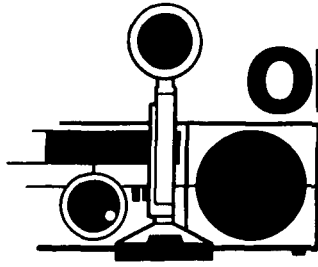
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Observations & Comments

We receive many articles dealing with microprocessors and microcomputers. Only a few of these articles, however, are published in *ham radio*. Here's the explanation.

We are certainly interested in the digital world. Like it or not, digital technology is here to stay. A recent article in *Ham Radio HORIZONS* by Doug Blakeslee, N1RM, pretty well sums it up (*HRH*, October, 1980).

For *ham radio* magazine, our policy is to publish computer articles only if they are Amateur-Radio oriented. We don't publish fun-and-games articles. We're interested in articles that put the computer to work in the *Amateur station*. These are the kinds of things we're interested in:

1. Dedicated or single-purpose microprocessor-based circuits such as keyers, displays, decoders, and data bases, to name a few.
2. Interface of the popular microcomputer systems, such as the TRS-80, APPLE II, or PET with Amateur Radio stations.
3. Use of newer, more sophisticated programmable calculators to solve Amateur Radio problems.

These criteria are not a change in our policy at *ham radio* but rather a clearer statement of our requirements.

Now for the bad news. If your computer or calculator article contains long program or output listings, these listings must be suitable for *direct reproduction*. This means that the printouts must be clean and clear enough so that photographic reproduction can be accomplished directly from your printouts. The task of setting your printouts in type is a formidable one; it is expensive, prone to typesetter errors, and requires extensive proofreading. With a long listing (and we have received quite a few), this problem can be really devastating from a publishing standpoint.

A case in point: suppose your article has a listing or output from a thermal printer. Most of these printouts, especially those from portable calculators, are worse than useless for direct photography. The print paper is fugitive; that is, the copy fades with time and exposure to light. If you must use this kind of printout, immediately get a photocopy before the original fades to oblivion. Send the clean, high-contrast copy with your article. *Do not* send the thermal printout.

A few tips for handling thermal printouts:

1. Do not allow the printout to be exposed to sunlight.
2. Especially avoid exposure to fluorescent lights.
3. Most paper is treated with polyvinyl alcohol. Do not store the tape in or near other vinyl material.
4. Do not mount printouts with *any* adhesive tape. A chemical action causes disastrous results. A recommended adhesive is "Glu Stic"™ from Faber Castell.
5. Try to use printing tape that prints out in black, not blue (publishing cameras have difficulty with blue).

A last tip: *Please* make certain you have copied the final program or output. A "bug" can remain hidden for months and become embarrassing for all. Ask a friend to do your program to see if it is "bomb" proof.

These recommendations were suggested by Dave Buren, N2GE, and associate editor Len Anderson.

Authors who keep these tips in mind will stand a better chance of having their work published in *ham radio*. There are all sorts of fascinating applications. Send 'em in!

Alf Wilson, W6NIF
editor

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Check the specs, and you'll agree, either way you go, ICOM is simply the best.

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Listed below are some of the

IC-551 specifications. IC-251A's specs are identical except where noted (in **bold**).

Frequency Coverage: 50~54MHz
(143.8~148.19MHz)

RF Output Power:

SSB 10W PEP
(1~10W adjustable) (**10W**)
CW 10W
(1~10W adjustable) (**10W**)
AM 4W
(0~4W adjustable) (—)
FM* 10
(1~10W adjustable) (**1~10W**)

Sensitivity: SSB/CW/AM
Less than 0.5 μ V for 10dB S+N/N
FM* More than 30dB
S+N+D/N+D at 1 μ V

Squelch Sensitivity: SSB/CW/AM
1 μ V
FM* 0.4 μ V (**0.4 μ V**)

Selectivity: SSB/CW/AM
More than \pm 1.1KHz at -6dB (**1.2**)
Less than \pm 2.2KHz at -6dB (**2.4**)
(When Pass Band Tuning Unit is installed: less than 1KHz at -6dB)
FM* More than \pm 7.5KHz at -6dB
Less than \pm 15KHz at -60dB

Dimensions: 111mm (H)
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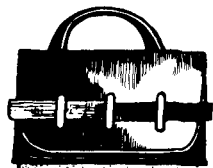
Please send me: IC-551 specifications sheet; IC-251A specifications sheet; List of Authorized ICOM Dealers.

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comments sealing coaxial connectors

amateur band intruders

Dear HR:

I view with great alarm the ever increasing intrusions upon the Amateur 20-meter CW band by Russian and Soviet bloc military CW radio stations, in direct violation of the ITU rules and regulations. I have monitored them on many occasions. These stations use CW with the additional Russian characters, and their traffic is transmitted in 5-character random groups normally associated with cyphering. In addition, the operators use international Q and Z signals reserved for military use.

The transmitters I have monitored exhibit the typical chirp/drift signals usually associated with Russian transmitters. I have found the intruding signals originate on a true bearing between 010 and 030 degrees from my station, signal strength is between S-5 and S-7, and the frequencies are usually between 14,060 and 14,095 kHz.

I hope this letter will make more Radio Amateurs aware of this important problem, and that the FCC and our ITU representatives will be successful in preventing further illegal use of the Amateur bands.

Carl Spikes, W5SAD
Gulfport, Mississippi

Dear HR:

Regarding the short article, "Sealing Coaxial Connectors," on page 64 of the March, 1980, issue of *ham radio*, I agree with Mr. Wheaton that silicone seal doesn't work well, but PVC electrical tape is by no means adequate either.

Here in Oregon, where weather is quite wet during the winter and cold temperatures with snow and ice prevail in the mountains (where I live), better methods must be found. Also, coaxial cable tends to "breathe" from warm to cold weather and draws air into itself, including any moisture in the air.

The best way I have seen of preventing this is to use rubber, self-vulcanizing *Electrical Splicing Tape*. A good seal is provided with one coat of tape; over this, to protect it from sunlight, should be a layer of PVC electrical tape (the rubber tape will decay if exposed to sunlight). Cracking takes one to two years, so allows plenty of time for annual antenna maintenance (which should be done anyway).

Before installing electrical splicing tape, stretch it to 1½ to 2 times its original length. Then wrap the *entire* coaxial fitting, leaving no gaps or open spaces. In winter, cover the wrapped connector with your hand for three to four minutes to warm it and initiate vulcanizing action (not necessary during summer). Then cover the rubber tape with one layer of PVC electrical tape.

Working as a radioman here in Oregon, I have radio base stations in some of the worst places for weather this side of Alaska! At one site in northern California, I have two anten-

nas treated with this tape. Conditions are such in winter that winds as high as 70-80 mph prevail, with ice as much as six inches thick on the tower and coaxial feedlines. Inspection during the summer shows only minor contamination of the coaxial fittings, and this can be quickly cleaned out with *Print Coat Solvent*.

Jim Foster, K7ZFG
Klamath Falls, Oregon

auto-product detection

Dear HR:

I was very interested in K4UD's auto-product detection article (*ham radio*, March 1980). Some six or seven years ago I supervised a student project on DSB at Southall College of Technology. We used an MC1496 as the squarer and regenerated the double frequency carrier with a 567 phase locked loop. We obtained excellent results. One operating hint for anyone who is prepared to transmit DSB is not to suppress the carrier too well. If you only reduce it to about 20-25 dB below peak envelope power it will help keep a PLL receiver in lock during modulation pauses.

DSB certainly simplifies the design of transmitters — both in the areas of frequency stability and complexity — and, I think could have considerable application in VHF/UHF hand portables. (NBFM is wasteful of transmitter battery power as there is a full drain on the battery as soon as the press-to-talk switch is operated.

By the way, it isn't too difficult to modify old-style AM transmitters with parallel output tubes (like the DX100) for DSB and perhaps give them a new lease of life!

Joe Hill, G3JIP
Gerrards Cross SL9 8NS, England

Amateur Radio

Just getting started? This book is ideal for you. It will help you get your first license. Or if you already have your ticket, the book will serve as your handy station manual. Written by Bill Lowry, W1VV, it includes a brief description of major activities, equipment and procedures to help the new ham decide where to begin, what equipment to buy initially, and how to make contacts with other hams after the station is assembled. Most importantly, this book tells the beginner how to study for the test, and presents the facts that must be learned in order to pass the written part of the exam. It includes complete FCC rules and official study guide for all license classes. Also included is a colorful call-area wall map.

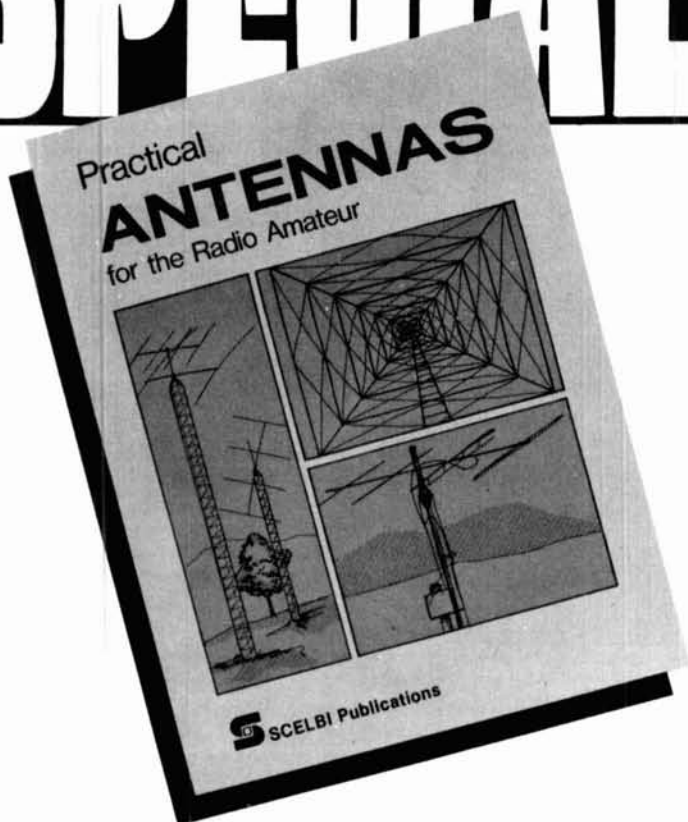
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HAM RADIO MAGAZINE'S NEW EDITOR is Alf Wilson, W6NIF, who had joined the staff earlier this summer as technical editor. Alf, who'd long been one of HAM RADIO's principal assistant editors under former Editor in Chief W1HR, came to New Hampshire to help out during the difficult period following Jim's death in April. Happily for HAM RADIO, he's now decided that he likes both the job and New Hampshire well enough to stay on.

Concurrently, Tom McMullen, W1SL, has been named editor of Ham Radio HORIZONS. Tom was promoted from managing editor in recognition of his fine work in the recent redirection of Ham Radio HORIZONS toward the mainstream of Amateur Radio.

"OPEN CHANNEL" IS THE NAME proposed for the United Kingdom's CB-type service, to be situated just above 900 MHz. Discussions have been going on for some time among Western European nations concerning a UHF CB service, and West Germany proposed assigning 928-930 MHz to such a service in Geneva last year. As NATO frequency coordination also involves the United States and Canada, this British proposal could well indicate the spectrum slot and direction for an internationally recognized UHF CB service.

What This Might Mean to the Amateur service isn't at all clear at this time. In the U.S., an ad hoc committee to prepare a proposal for a 900-MHz Amateur band was discussed and approved by the ARRL Directors at Seattle. The committee is to be made up of Amateurs with experience in UHF spectrum management, to be selected by League President W2HD.

A NEW 10-GHZ DX RECORD, 757 km, was set July 12 when IØSNY/7 worked IW3EHQ/3 and I3SOY/3. Ten milliwatt Gunnplexers and one-meter dishes were used at both ends, from Brindisi on the south end to Col Visentin in the Italian Alps on the north. The former 10-GHz record, 633 km, had also been held by Italians.

A New Meteor Scatter Record is reported to have been established on the night of August 11, when VEIASJ worked England during the Perseid meteor shower.

THREATS AND INDECENT LANGUAGE over the air have cost a Niagara Falls Amateur \$2000 in fines. Conflicts with users of a Buffalo repeater over foul language first escalated into some incidents of window breaking and tire slashing, eventually culminating in over-the-air threats to several repeater operators and their families. At that point the FBI was called in, and on December 5 and 24, 1979, and January 16, 1980, they monitored WB2QHC making such threats over 2 meters. In addition, they heard him using obscene and indecent language on the air on December 19.

After Hearing The FBI's evidence, WB2QHC pleaded guilty on all four counts in Federal District Court. Federal Magistrate Edmund Maxwell then fined him \$500, the maximum penalty, on each count. In its news release on the case the government noted that close cooperation between the Amateur community and the FBI was largely responsible for the successful conclusion.

THE QUESTION OF A PROPOSED NATIONAL RADIO QUIET ZONE, hanging fire for over a year and a half, is now heating up again. Attorneys for the National Radio Astronomy Observatory and the Naval Research Laboratory have just petitioned the FCC to act on its long-stalled NPRM, SS Docket 78-352, originally released in November, 1978 (HRR 130). Both Amateur Radio and Class A CB—principally repeater operations—would be affected to some degree by the proposed quiet area, which encompasses a large part of Virginia and West Virginia near Green Bank and Sugar Grove.

TWO PHONE-BAND EXPANSIONS, and 10 MHz for CW/RTTY only, will be sought from the FCC, ARRL directors voted at their recent Seattle meeting. Planned are petitions to give General, Advanced, and Extra class licensees 10.1-10.15 MHz for CW and RTTY, with a maximum input of 250 watts. They'll also seek 20 meter phone expansion, with Extras to have 14150 up, Advanced 14175 up, and General all above 14225. On 40, a new slot for Extra class phone, 7075-7100, will also be suggested.

RECIPROCAL LICENSING WITH ITALY may become a reality in the very near future. W4YP, recently visiting Italy, discussed the issue with I4CMF, who is reciprocal licensing manager for Associated Radiotechnica Italiano (ARI), and learned that the Italian telecommunications people have been discussing the issue with U.S. embassy officials. As he was departing, W4YP learned that the signing of an agreement would soon be taking place.

PLAIN ENGLISH AMATEUR RULES continue to move along at the FCC, with a draft covering the Amateur satellite Service and RACES as well now circulating within the Commission. If this draft doesn't run into too much trouble, it's possible it could be out for public comment soon. Plain English rules for both the CB and VHF Marine Services are already in effect, and the final version of the Radio Control rules should be out before long.

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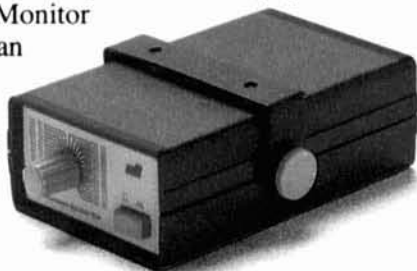
114.8 2000
110.9 841
107.2 853
103.5 1952
100.0 770
97.4 1900
94.8 1840
91.5 1600
88.5 887
85.4 1720
82.5 1700
79.7 1650
77.0 1600
74.4 1500
71.9 1000
67.0 800
DFP

118.8 2100
123.0 2150
127.2 2200
131.8 2250
136.5 2300
141.3 2350
146.2 2400
151.4 2450
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185.8 2750
192.8 2800
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77.0 XB	100.0 1Z	131.8 3B	173.8 6A
79.7 SP	103.5 1A	136.5 4Z	179.9 6B
82.5 YZ	107.2 1B	141.3 4A	186.2 7Z
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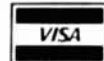
TEST-TONES:	TOUCH-TONES:	BURST TONES:			
600	697 1209	1600	1850	2150	2400
1000	770 1336	1650	1900	2200	2450
1500	852 1477	1700	1950	2250	2500
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long transmission lines for optimum antenna location

This article is for the Amateur who has located the ideal antenna site, but finds that it is too far from the transmitter to be reached in a technically acceptable fashion with coax-cable transmission line. An ideal site, of course, is that part of your property that slopes downward in all directions.

What is "technically acceptable?" Let's assume you have a three-element Yagi with traps that permit operation on 20, 15, and 10 meters. The Yagi has a nominal gain of 8 dB on these bands. As the coaxial transmission line is made longer, the antenna-system gain (antenna plus line) becomes lower. At 30 MHz, RG-8/U line, for example, has a 1-dB loss¹ for every 100 feet (30.5 meters) neglecting losses caused by standing waves (that is, standing-wave ratios greater than 1). If the ideal site is 500 feet (153 meters) from the operating position, a transmission loss of at least 5 dB can be expected. This leaves an antenna-system gain of 3 dB.* A 5-dB loss would be technically unacceptable.

open-wire line

The solution would be either to locate the transmitter at the antenna site or to reduce the transmission line losses substantially by using an open-wire line, which has an attenuation of 0.1 dB per 100 feet (30.5 meters). Thus the antenna could be removed 1000 feet (305 meters) from the transmitter with the same loss as one fed by coax cable located 100 feet (30.5 meters) from the transmitter.

When discussing open-wire lines, one immediately thinks of a two-wire line that can be constructed with 2-inch (51-mm) to 6-inch (152-mm) spreaders using wire sizes of No. 8 to 22.³ With the various combinations permitted, line characteristics of 325-800 ohms can be constructed. However, 325 ohms impedance is higher than desired because, ultimately, the line must match a 50-ohm output impedance from the

transmitter and probably a 50-ohm input impedance to the antenna.

the four-wire line

Although commercial high-frequency communicators have used four-wire transmission lines extensively, little use of them has been made by Amateurs when open wire lines are needed. Their use in transmission-line runs, however, provides considerably lower characteristic impedances. A 200-ohm line using four No. 14 (1.6-mm) wires on a 0.9-inch (23-mm) diameter can be easily made.⁴ This type of balanced feeder has been extensively applied where feeder lengths exceed one-half mile (0.8 km). Its relatively low impedance makes this type less susceptible to the irregularities introduced by insulators and switching arrangements. It has high-power transmission capacity for the amount of copper used, and its attenuation can be less than that of two wire feeders.

Four-wire lines may be either side connected or cross-connected, and such connections are made at both ends of the line. A common arrangement of the four wires provides a square when looking at the cross section of the line (fig. 1). Side-connection is shown in fig. 1A, where the two side wires are connected together vertically at each end of the line. Cross-connection is shown in fig. 1B.

Cross-connected lines have a smaller external field than the equivalent side-connected line and therefore have lower pickup when used for receiving.⁵ This type of line was used extensively at the RCA overseas receiving station, Riverhead, Long Island. In a private communication with Marshall Etter, W2ER, chief engineer of that now inactive installation, I learned that a four-wire line, handled properly, can outperform coaxial lines in terms of reduction of unwanted pickup.

Transmitting loss is not as low in four-wire line as in a two-wire line with large copper conductors, but the loss is probably negligible in relatively short lines, of say 500 feet (153 meters).

*Reference 2 shows that 3 dB doesn't mean very much under actual operating conditions. Editor.

By Henry G. Elwell, Jr., N4UH, Route 2, Box 20G, Cleveland, North Carolina 27013

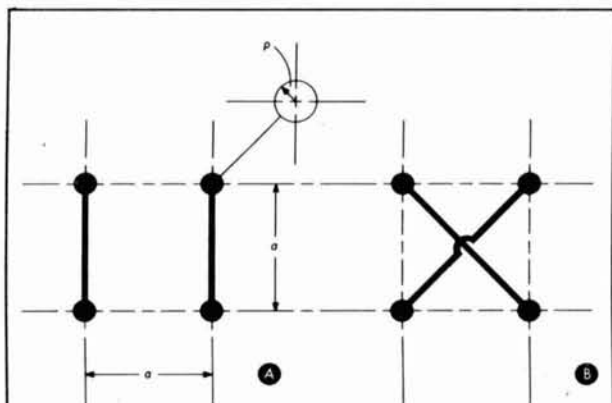


fig. 1. End view of a four-wire transmission line. Side connection is shown in (A) where the two side wires are connected together vertically. Cross connection is shown in (B). The (A) configuration was used in this project for reasons discussed in the text.

The insulation loss in a cross-connected, four-line would be about proportional to the relative characteristic impedances; but since more insulators are required in parallel in its construction than in the side-connected line, overall insulator losses are usually greater. It's therefore not as desirable for transmitting purposes as is the four-wire, side-connected line using the same amount of copper. Its principal use is for receiving, in which its performance is outstanding.

When a square cross section feeder with side-connections is used, the characteristic impedance is equal to that of a pair of two-wire feeders in parallel, each having a spacing equal to the diagonal of the four-wire line. Each diagonal pair is in the neutral plane of the other with no intercoupling. Double power rating is therefore obtained on one set of supports and insulators, and the characteristic impedance is one-half that of one pair.

It's interesting to see the difference in impedance and attenuation between a side-connected and cross-connected line using the same insulators. Consider a four-wire line using the cross section of fig. 1. For the side-connected line, characteristic impedance, Z_0 is calculated from:

$$Z_0 = 138 \log_{10} \left(\frac{a\sqrt{2}}{p} \right) \quad (1)$$

where a is the distance between wires (inches), and p is the radius of the wire (inches).

For the cross-connected line, the characteristic impedance is

$$Z_0 = 138 \log_{10} \left(\frac{a}{p\sqrt{2}} \right) \quad (2)$$

For those wishing to design their own four-wire system, the equation for spacing for cross-connection would be:

$$a = (\sqrt{2}) (p) \left(10 \frac{Z_0}{138} \right) \quad (3)$$

Table 1 shows the characteristic impedances for the two configurations using a spacing, a , of 1.28 inches (32.5 mm) and No. 14 (1.6-mm) bare copper wire, with a radius, p , of 0.032 inch (0.8 mm). These were the constants used in the construction of the four-wire line for this article.

table 1. Comparison of side and cross-connected four-wire transmission line.

configuration	input impedance (ohms)	attenuation:	
		dB/1000 feet (305 meters) copper only	total
side connected	242	1.48	2.04
cross connected	200	1.79	2.48

The losses in a feeder are the sum of copper loss, earth return loss, insulation loss, and loss caused by direct radiation. Radiation loss from a matched feeder is usually so small as to be negligible for carefully designed systems; the loss is always very small with respect to all other losses for almost any type of feeder. Insulation loss in a well-designed system is also a minor quantity, except in long feeders in the high-frequency range. Measurements made on two- and four-wire balanced lines⁵ show that, for a 550-ohm, two-wire line, insulation and other losses are about 70 per cent of the copper loss; for a 320-ohm, four-wire line, that number is about 22 per cent at 20 MHz.

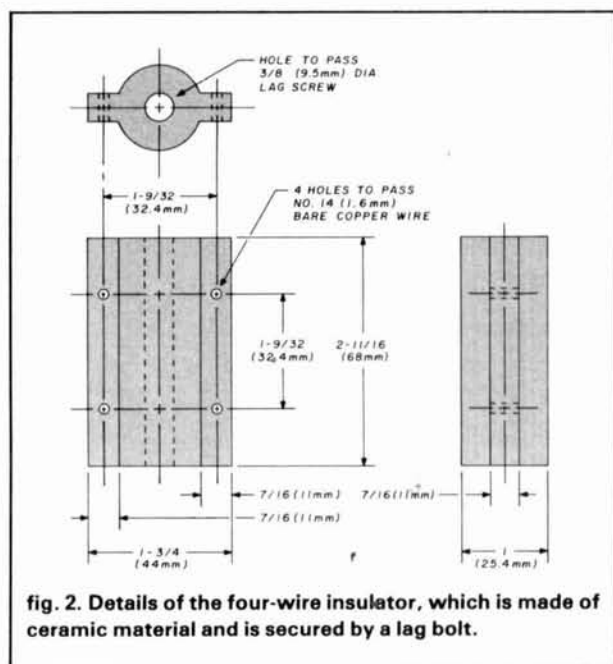


fig. 2. Details of the four-wire insulator, which is made of ceramic material and is secured by a lag bolt.

The attenuation of a four-wire balanced line is:

$$(copper\ loss)\ att = \frac{2.17(\sqrt{f\ in\ MHz})}{p\ in\ inches\ (Z_0)} \quad (4)$$

and the approximate total attenuation for typical construction is:

$$(total\ loss)\ att \cong \frac{3(\sqrt{f\ in\ MHz})}{p\ in\ inches\ (Z_0)} \quad (5)$$

If p dimensions are in millimeters instead of inches, the constants preceding the radical signs in the numerators of eqs. 4 and 5 should be replaced by 53.9 and 74.9 respectively. The attenuation for the two constructions is also shown in table 1 for 28 MHz.

The side-connected, four-wire transmission line was used in this project because I thought the transmitting characteristics were of greater importance than the receiving ones.

The dimensions of the four-wire insulator used in the project are shown in fig. 2.* It's made of a ceramic material called Isolantite and is secured by a galvanized lag bolt. The insulator could also be made from Micarta or Lucite.

selecting the optimum site

In some cases, an Amateur can look at his property and say, "The beam goes on top of the hill." In most cases, the subtlety of the terrain requires that a survey be made of property elevations. By a survey, I mean studying the maps of your area available from the United States Department of the Interior Geological Survey.

using USGA charts

The Geological Survey has a series of standard topographic maps that cover the United States, Puerto Rico, Guam, American Samoa, and the Virgin Islands. Under the plan adopted, the unit of survey is a quadrangle bounded by parallels of latitude and meridians of longitude. Quadrangles covering $7\frac{1}{2}$ minutes of latitude and longitude are published at the scale of 1:24,000. Quadrangles covering 15 minutes of latitude and longitude are published at the scale of 1:62,500.

Each quadrangle is designated by the name of a city, town, or prominent natural feature within it. On the margins of the map are the names of adjoining published quadrangle maps. The maps are printed in three colors. Features such as roads, railroads, cities, and towns (as well as all lettering) are in black ink; water features are in blue, and features of relief, such as hills, mountains, and valleys, are shown by brown contour lines.

The contour interval varies with the scale of the map and the characteristics of the country. On maps

that contain supplemental information, additional colors are used, such as green for woodland areas and red for highway classification, urban areas, and U.S. land lines. A booklet describing topographic maps and symbols is available free upon request.

The extent of coverage of each map is shown on the index map. All quadrangles for which published maps are available have a quadrangle name, publishing agency (if other than the Geological Survey), and the date or dates of survey, also printed in black. Further information concerning maps may be obtained from the Map Information Office, Geological Survey, Washington, D.C. 20244.

An inquiry to the above address might request an "Index to Topographic Maps of (name your state)." You'll receive a folder which contains a chart of your state overprinted with all the available quadrangles, identified by name. The folder will also contain a description of other special charts you can purchase. Order the quadrangle featuring your property and perhaps those charts adjoining.

On the Cool Springs, North Carolina, quadrangle that I used, terrain elevations every 10 feet are shown.† All roads and buildings, including individual homes are shown, making it simple to identify the desired property and its boundaries; the scale is 1 inch = 1,000 feet. Fig. 3 shows a portion of the Cool Springs, North Carolina, quadrangle in the vicinity of my property.

It's desirable to enlarge the area of interest as much as possible. By making successive enlargements of the chart, I obtained a copy in which 1 inch represented 500 feet (fig. 4). A commercial reproduction office should be able to supply the same service.

My property boundaries, including the transmitter location, are placed on the topographical map and the best location for the antenna is then determined. It would appear that the best location for my tower would be directly to the northwest at the 800-foot (244-meter) level. Unfortunately a 2,200-volt line on 30-foot (9-meter)-high poles follows the course of the farm road, shown dotted, all the way to the house. I decided to place two towers to the rear of the house on or near the 790-foot (241-meter) elevation. This provided my optimum location so far as terrain as well as distance between antenna and power lines was concerned.

transmission line poles

With the location of the towers established on the topographical map, a property survey drawing on a 1-inch = 200-foot (1 cm = 61 meters) scale was

*Marshall Etter, W2ER, 16 Fairline Drive, East Quogue, New York 11942, has a limited number of insulators available at \$1.00 each plus postage.

†USGS hasn't yet provided charts with metric equivalents. But that will probably change. Editor.

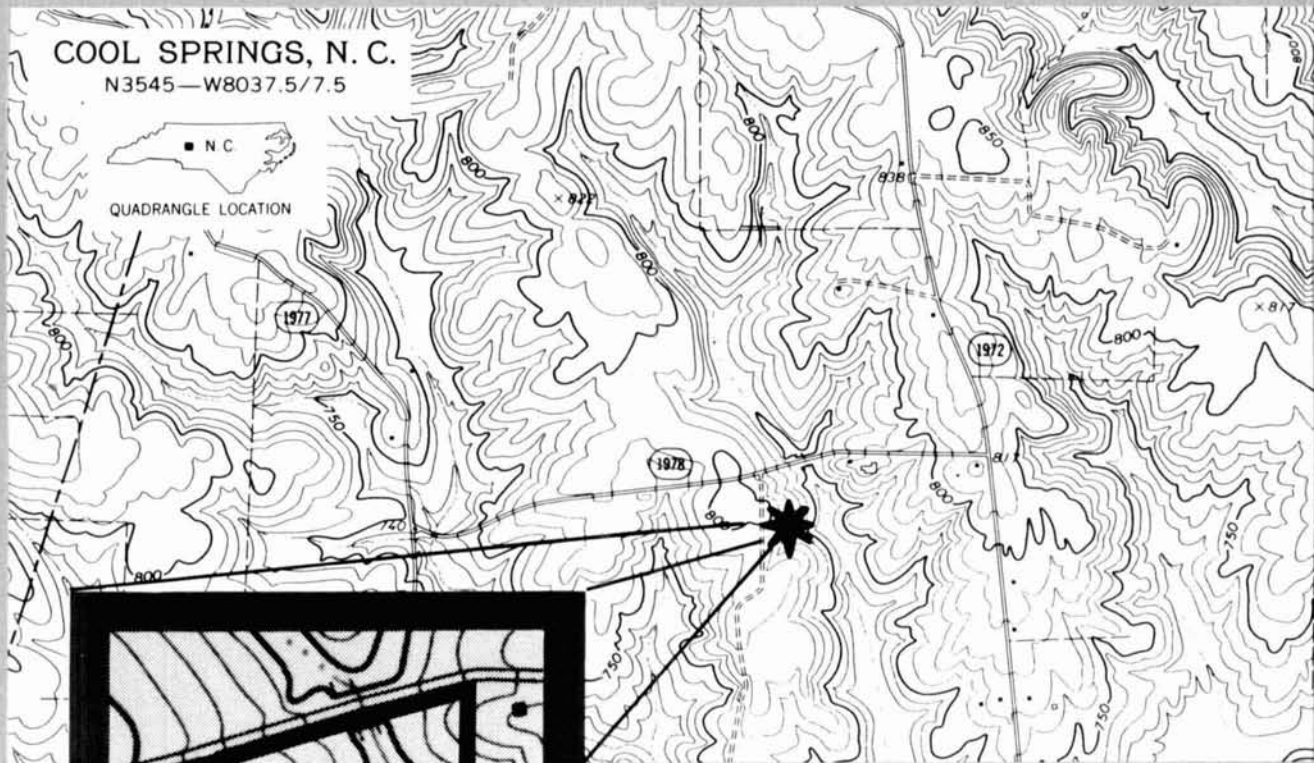


fig. 3 (above). Topographical chart of the author's location (shown by an asterisk). Such charts are available from the U.S. Department of the Interior Geological Survey at nominal cost.

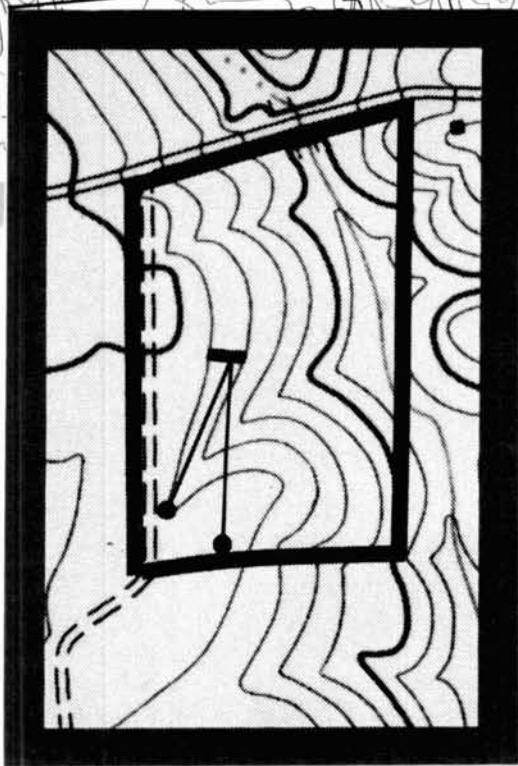
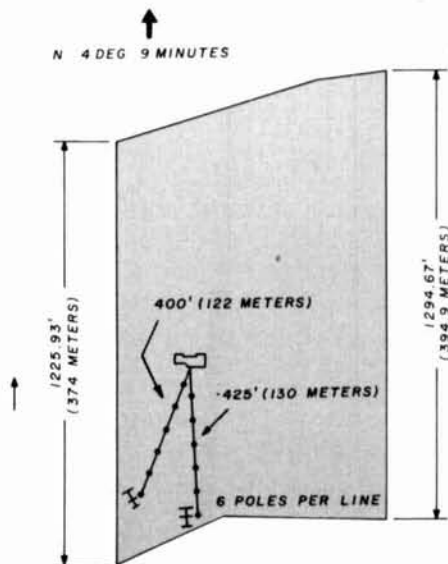


fig. 4 (left). Enlargement of fig. 3 showing author's property boundaries, house location, and tower location. This enlargement helped to determine the best antenna location with respect to local geological factors.

fig. 5 (right). Property survey of author's location showing the relationship between house, transmission line runs, and antenna tower locations. The USGS topographical charts (fig. 3) also include elevation contour lines, which are helpful in determining best location for the antenna towers.



made to obtain distances from house to towers (fig. 5). Then the number and spacing of transmission line supporting poles were determined. I found that the four-wire transmission lines would have to be 425 feet (130 meters) to one tower and 400 feet (122 meters) to the other tower.

W2ER states that, in early lines, poles were all about 25 feet (7.6 meters) apart, but in later years a staggered spacing from 20-30 feet (6-9 meters) was used to prevent recurring discontinuity at poles from resonating at some certain discrete frequency. To minimize the discontinuities, a copper shield, shown in fig. 6, was placed to cover three sides of the line at each insulator. (These shields were not used in this project.)

Pole spacing. I decided on 70-foot (21-meter) pole spacing for economy. While not a mistake it required greater wire tension than originally used to prevent twisting under high wind conditions. The additional tension requirement was noted after I traced an antenna system malfunction to a tangle on the four-wire transmission line after a wind storm. The wider separation also produced a fluctuation of SWR readings with heavy wind. From an operational standpoint I've had no noticeable additional problem.

Height. Insulator height above ground was selected

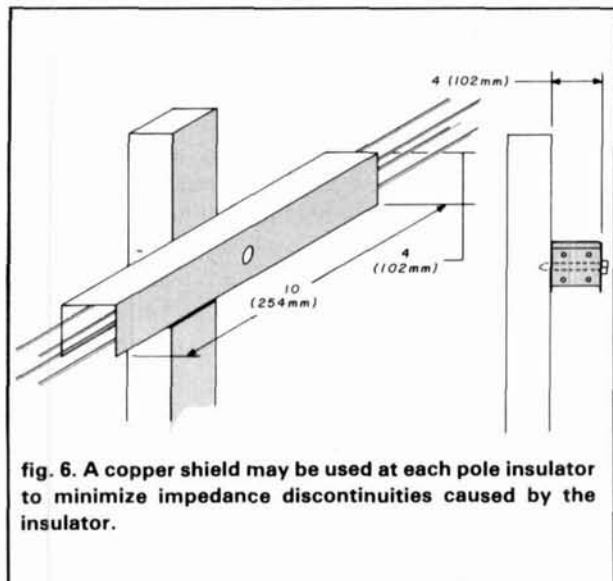


fig. 6. A copper shield may be used at each pole insulator to minimize impedance discontinuities caused by the insulator.

to be 12 feet (3.7 meters) to permit farm equipment to pass underneath. Twelve-foot-high (3.7 meters) treated poles were used (fig. 7).

Stress. Although there are no stresses on the intermediate poles, other than from wind, there are high stresses on the end pole. This pole should be a single

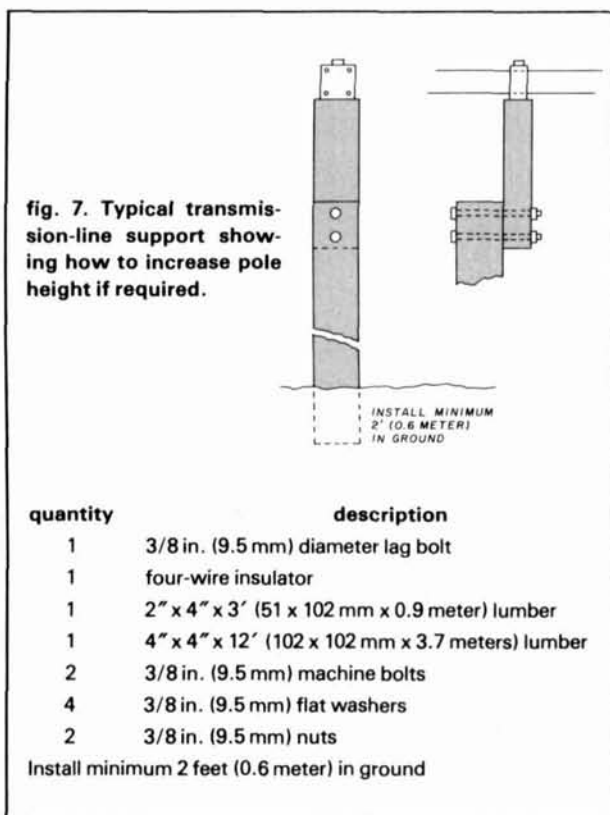


fig. 7. Typical transmission-line support showing how to increase pole height if required.

quantity	description
1	3/8 in. (9.5 mm) diameter lag bolt
1	four-wire insulator
1	2" x 4" x 3' (51 x 102 mm x 0.9 meter) lumber
1	4" x 4" x 12' (102 x 102 mm x 3.7 meters) lumber
2	3/8 in. (9.5 mm) machine bolts
4	3/8 in. (9.5 mm) flat washers
2	3/8 in. (9.5 mm) nuts
Install minimum 2 feet (0.6 meter) in ground	

piece if possible. To maintain the 12-foot (3.7-meter) height, it was necessary to use a 3-foot (0.9-meter) length of lumber cut as shown in fig. 8. The end pole must be guyed as shown and from the level at which the transmission line terminates. The objective is to minimize stresses on the pole and have the guy counteract the pull of the transmission line.

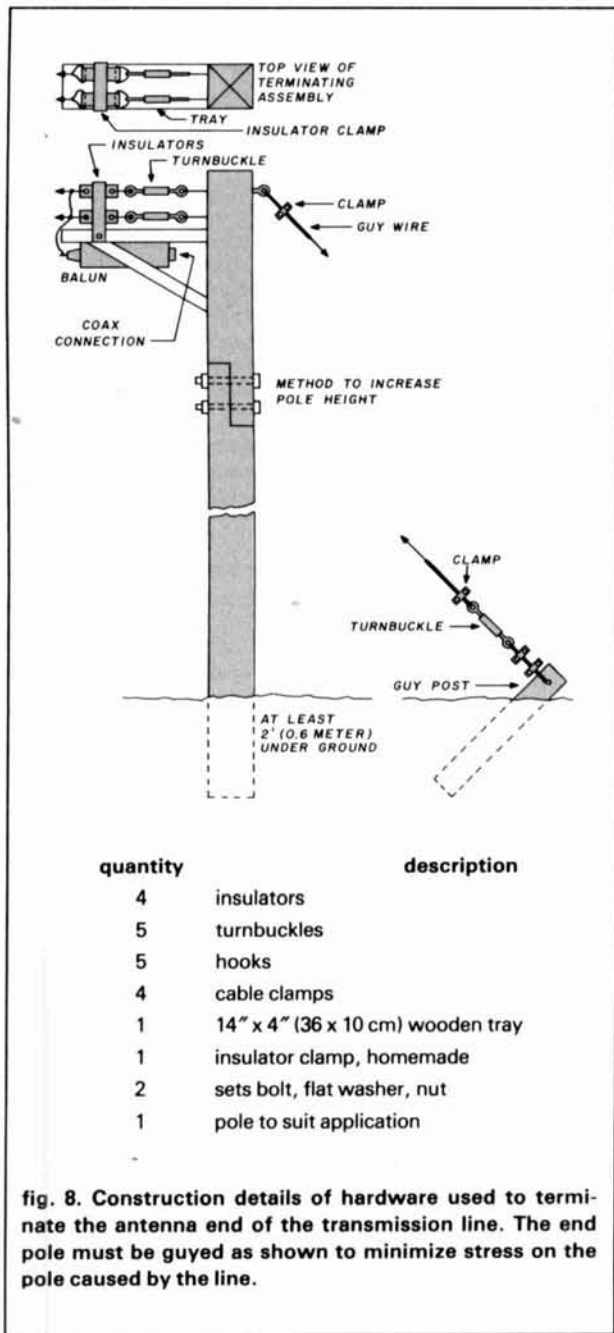
far-end physical termination

Physical termination of the transmission lines is by individual turnbuckles for each wire. Fig. 8 shows the details. Each wire actually terminates on an insulator attached to the turnbuckle by wire. The turnbuckle is connected to a hook on the pole.

The four lines are connected to eye bolts at the transmitter end and threaded through the many four-wire insulators to the terminating post. With the turnbuckle at maximum length, each transmission line is threaded through its end insulator and pulled as tightly as possible by hand. When all wires are installed, the turnbuckles are tightened for uniform tension on all wires.

house termination

A 1/2-inch (12.5-mm) lucite panel was used to tie the transmitting end of the line (fig. 9). Eye bolts were used to terminate the wires. The panel was secured to the house structure by lag bolts. It's very



important to use *flat* washers on the panel bolts to distribute the load and to be sure the house structure selected is a primary member; the pulling force at this point is very high.

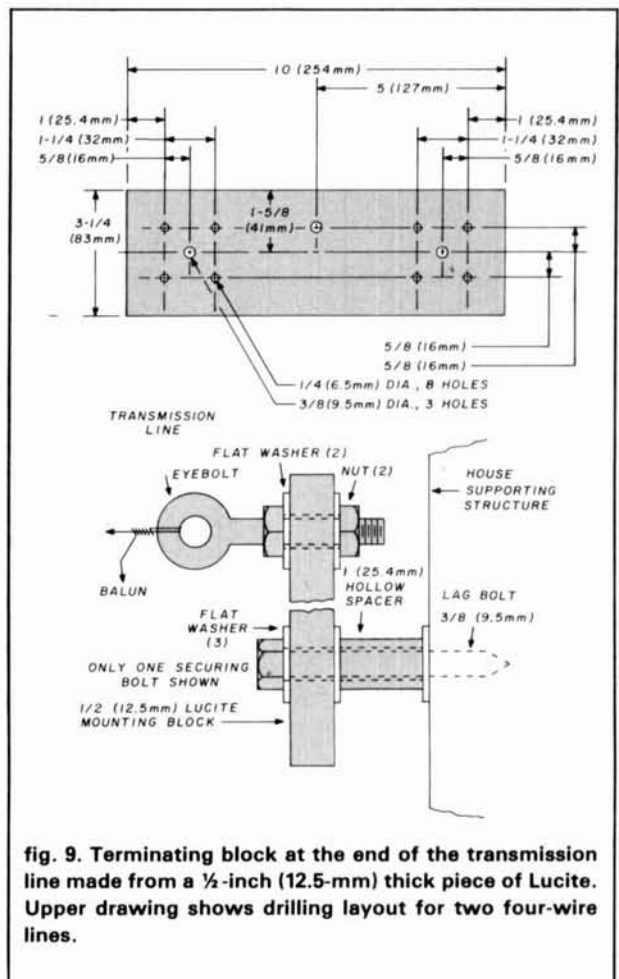
To maintain proper spacing it's desirable for the wires to leave the termination at 90° to the panel; this is also the easiest way. If the wires must leave at a smaller angle because of the location of the house and antenna site, some trigonometry must be employed.

Tie-post displacement. Look at **fig. 10A**, which

shows a transmission line leaving at 90° and 45° . It can be seen that if the wires are connected against the house, distance **A** becomes less as the angle approaches 0° ; that is, at 0° the wires are touching. It's necessary to move the left support out with respect to the right support to maintain the proper spacing. How do you determine how much to move the one support?

Moving the support "out" can mean in either of two directions. The left wire shown in **fig. 10B** will maintain the 1-inch (25.4-mm) spacing at 45° if the support point is placed at point **A** or point **B**. However, if point **A** is used, the left side of the transmission line will be slightly longer than the right wire. Since it's just as easy to use point **B**, this is the one to be pursued. It's necessary to solve the equation $y = mx + b$, where y is the vertical distance from 0 , m is the slope of the wire, x is the distance along the horizontal from 0 , and b is the point on the y axis where the left wire crosses it; that is, point **B**.

To simplify the calculation, find x where $y = 0$. Dimension m is known from trig tables since m is the tangent of the angle between the wire and the sup-



port structure. For the left wire, x is the distance OA . We know the distance OC , which is the desired spacing, and we find CA by solving a right triangle CDA :

$$\sin \angle A = \frac{DC}{AC}$$

Thus $AC = \frac{DC}{\sin \angle A}$, and $x = OC - AC$

Therefore we can say that

$$\left(x = OC - \frac{DC}{\sin \angle A} \right)$$

Going back to $y = mx + b$ and substituting m and x at $y = 0$,

$$0 = \tan \angle A \left(OC - \frac{DC}{\sin \angle A} \right) + b, \text{ or}$$

$$\text{finally: } b = B = -\tan \angle A \left(OC - \frac{DC}{\sin \angle A} \right)$$

Example. Let's say the angle to the antenna from the house is 70° , and a spacing of 1.25 inches (31.8 mm) is required,

$$B = -\tan 70^\circ \left(1.25 - \frac{1.25}{\sin 70^\circ} \right) \\ = 0.22 \text{ inch (5.6 mm)}$$

To calculate dimension B directly in millimeters, merely substitute the metric equivalent of 1.25 inches, or 31.8 mm, into the above equation. Therefore the eyebolts for the left pair of wires must be displaced 0.22 inch (5.6 mm) farther from the terminating panel than the right pair of wires to maintain proper wire spacing.

To complete the construction of the four-wire transmission line, solder each vertical pair of wires together at both ends to produce the arrangement shown in **fig. 1A**. If the design is for a cross-connected line, diagonal wires would be connected. I used the side-connected arrangement even though the transmission line impedance is 242 ohms for the reason mentioned earlier. Some day I'll revert to the cross-connected arrangement to provide the proper match but am accepting the 1.2:1 mismatch at this time.

impedance transformer — receiving and sending ends

It's safe to say that all popular modern transceivers and linear amplifiers have an output impedance of 50 ohms. Thus a 50-ohm-unbalanced-to-200-ohm balanced balun transformer is necessary: a 4:1 ratio.

These are exciting times for those wanting to make their own baluns. After I constructed the system shown here, Joe Reisert, W1JR,⁶ and George Badger, W6TC,⁷ described highly efficient baluns in great detail that would be applicable for the design described in this article.

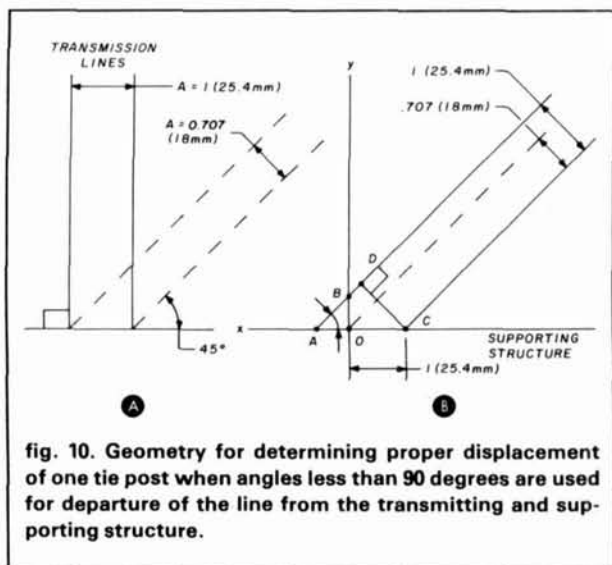


fig. 10. Geometry for determining proper displacement of one tie post when angles less than 90 degrees are used for departure of the line from the transmitting and supporting structure.

Depending on your degree of purism in such matters, you may settle for a commercial balun; references 6 and 7 spell out the consequences. Their work post dates my effort; I'd already gone commercial, with modifications.

I purchased two kW 4:1 baluns from Caddell Coil Corporation, Putney, Vermont. Each balun coil is wound on two stacked toroids with a total dimension of 2 inches (51 mm) diameter, and 2¼ inches (57 mm) in length. The two windings of the coil have fifteen turns of No. 12 (2.1 mm) wire.

This was my first application of 4:1 baluns, and their characteristics were unknown to me. A test setup as in **fig. 11** was used to measure some of the characteristics of the baluns.

Balun measurements. The station transceiver, a Kenwood TS520, was used for the signal generator, and an Allied Radio model A2516 all-band receiver was used as the null detector. The bridge was a

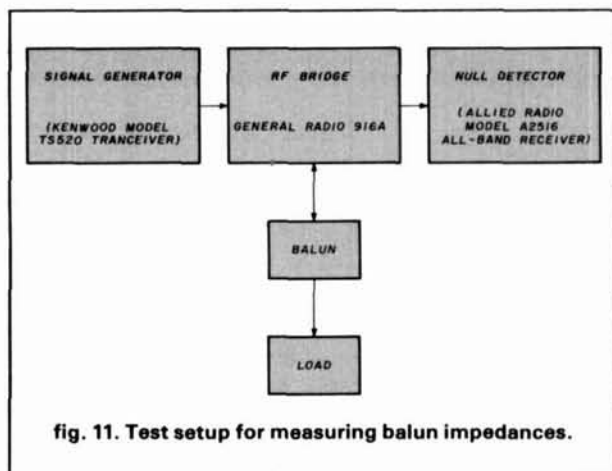


fig. 11. Test setup for measuring balun impedances.

General Radio Model 916A rf bridge. A carbon composition resistor, measured on the bridge at 28.2 MHz, was $250 + j2.8$ ohms. This was used as the load.

Impedance measurements were made on five frequencies, from 3.8-28.2 MHz on two of these baluns. Table 2 shows measurement results.

table 2. Balun characteristic versus frequency.

frequency (MHz)	balun 1	balun 2	Hygain balun	Antennabal balun
3.8	56 /20°	59.1 /18.6°	54.2 /21.1°	55.4 /23°
7.2	55.8 /15°	57 /10.8°	60 /22.4°	60.6 /18.6°
14.2	50.8 /18°	55 /15°	69.8 /17.6°	68 /14°
21.2	42.8 /39.7°	43.9 /38°	79.9 /15.6°	74 /16°
28.2	55 /73°	64 /57°	88.3 /9.7°	80 /16°

Based on the 4:1 ratio and a 250-ohm load resistor, the reflected impedance should be 62 ohms.

Having no real feel for the merit of the above readings, I measured a Hy-Gain 1:1 balun with a 50-ohm load, as well as a 1:1 Antennabal device that was on hand. These measurements are also shown in table 2.

The phase angle, indicative of balun reactance, seemed high, even in the commercial units, but far less than the 4:1 baluns to be used. I wasn't interested in the 80- and 40-meter bands for the transmission line, so I removed turns from the existing baluns. A final value of ten turns produced the optimum impedance for the 20-, 15-, and 10-meter bands (table 3).

table 3. Final balun characteristics.

frequency (MHz)	balun 1	balun 2	baluns back-to-back	complete line transmitter to antenna
3.8	60.2 /38.7°	56 /44.4°	62.6 /65°	-----
7.2	69.3 /23.6°	69.5 /28.6°	61.6 /46.6°	-----
14.2	70.2 /14.5°	73.5 /17.8°	89.7 /28.3°	83.4 /20.8°
21.2	63.9 /17.2°	68 /19.8°	88.4 /10.2°	39.8 /12.7°
28.2	60.4 /26.6°	63.7 /26.5°	46 /0°	94.3 /47°

As expected, removing additional turns beyond five improved the 28-MHz readings but caused deterioration of the 14-MHz impedance.

The next step was to connect the two baluns back-to-back and use a 50-ohm resistor for a load. Measurements on the input of the two baluns produced the readings shown in table 3.

I connected a 50-foot (15-meter) length of RG-8/U coax between the transmitter location and the first balun. Then I connected a 100-foot (30.5-meter) piece of RG-8/U coax between the end balun and antenna. Using a 50-ohm resistor in place of the antenna produced readings as shown in table 3. Therefore, the complete 600-foot (183-meter) trans-

mission line provided standing-wave ratios varying between 1.25 and 1.9.

Attenuation characteristics. More important was the attenuation that such a line would produce. Attenuation equations were used⁸ based on coaxial cable characteristics. These equations were used, although a hybrid transmission line was being measured. My rationale was that the rf bridge was measuring the short-circuited and open-circuited resistances and reactances of what may be considered a "black box," and didn't care what is in the box. The attenuation of the total line, from transmitter to antenna, is as shown in table 4.

table 4. Transmission-line attenuation.

frequency (MHz)	total line attenuation (dB)	attenuation using four-wire line plus two baluns (dB)
14.2	2.39	1.73
21.2	2.74	1.91
28.2	3.95	2.48

The difference in attenuation between the total line and the four-wire line plus balun is caused by the 150 feet (46 meters) of RG-8/U. W2ER had estimated a 1-dB loss per balun without knowledge of the actual loss, and his estimate is good. The baluns most likely account for the loss in the four-wire line. Use of baluns suggested by references 6 and 7 would undoubtedly minimize this loss.

Minimum line loss. Minimum loss would be realized if a tuned line were used and eliminating the baluns altogether. This would require an antenna tuner and would lose the advantage of being able to change bands with minimum tuning. The open-wire could end up in a two-wire polyethylene 200-ohm line for the loop to the rotary antenna.

Another suggestion by W2ER would be to run the four-wire line to the base of the tower, with an exponential line running up the tower, either a two- or four-wire line. The output impedance could be 50 ohms, balanced, and would directly connect to an antenna such as the balanced-input TH6DXX type. With a tower height greater than 30 feet (9 meters) the exponential line would be the minimum permitted length of a half wave on 14 MHz, and of course greater on the 21- and 28-MHz bands; see reference 5.

The use of four-wire lines for the reduction of line losses is wide open for experimenting in the Amateur bands, and the subject is especially pertinent to vhf, where the cost of super coax cable is getting out of hand.

A second tower and transmission line were constructed, as discussed for the first arrangement. Results were almost identical.

results of transmission-line use

The antenna on each tower is a Hy-Gain TH6DXX. The antennas were adjusted using the rf bridge with the affects of the total transmission line subtracted from the measurements of the total system. The final SWR readings, as measured at the transmitter end, are acceptable for the three bands: less than 2:1.

In review, two towers separated by 150 feet (46 meters) were located approximately 425 feet (129.6 meters) from the transmitter. The location was selected to provide an antenna site from which elevations in all 360° compass directions decreased and no other structures were close by. I used a four-wire transmission to minimize line loss with 4:1 baluns at each end to accept 50-ohm input and output matching. The two towers are 60 and 50 feet (18 and 15 meters) high.

Results exceeded all my expectations, with no dead spots in any directions. Perhaps a review of my contest activities since erecting the systems is indicative of its success:

1978 ARRL sweepstakes	first place in North Carolina
1978 ARRL ten-meter tests	first place in North Carolina
1979 ARRL DX contest	winner, Roanoke Division, high band
1979 ARRL Radiosport championship	highest score, North Carolina, phone only

The ARRL DXCC country total has changed from 285 to 320 confirmed during the period from October 1978 to June 1980.

final comments

The expenditure of time and money has been well worth the effort to get the antenna out where it can do the most good for my signal. It's time more Amateurs with ideal antenna sites not currently in use take advantage of them with a low loss four-wire transmission line.

references

1. *The ARRL Antenna Book*, Table 3-1, *Commonly Used Transmission Lines*, and Table 3-II, *Standard Coaxial Cables*, American Radio Relay League, Newington, Connecticut, 1964 edition, pages 84 and 85.
2. A. Wilson, W6NIF, "Trap Yagi Antennas," *Ham Radio Horizons*, June, 1980, page 13.
3. *The ARRL Antenna Book*, Fig. 3-25, *Characteristic Impedance vs. Conductor Size and Spacing for Parallel-Conductor Line*, American Radio Relay League, Newington, Connecticut, 1964 edition, page 81.
4. *op cit*, Fig. 3-26, page 82.
5. Edmund A. Laport, *Radio Antenna Engineering*, Chapter 4, *Radio-Frequency Transmission Lines*.
6. Joe Reisert, W1JR, "Simple and Efficient Broadband Balun," *ham radio*, September, 1978.
7. George Badger, W6TC, "New Class of Coaxial Line Transformers," *ham radio*, February and March, 1980.
8. Leonard H. Anderson, "Antenna Bridge Calculations," *ham radio*, May, 1978.

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versatile CW identifier

Whether you like CW or not, it's still a useful mode for identifying a station, be it a repeater, RTTY, slow-scan TV, or as an anti-theft device. However, most devices that send preprogrammed CW messages are either bulky, complex, or expensive. I've designed a small, simple, and inexpensive CW identifier that will find many uses in your station.

programming logic

In designing the identifier, I used the standard ratios for sending international Morse code: one bit represents a dot, three bits a dash, one bit an element space, three bits a letter space, and seven bits a word space. As an example, the message "CQ DX" would be represented, in a binary format, as: 1110101110100011101110101110000000111010100011101010111. My scheme was to program this sequence (or any message) into a PROM by sequentially programming the "ones" at the appropriate addresses. I chose an 82S126 PROM, which is a 1K device arranged in four sections of 256 bits. Hence, eight bits are required to address each of the four sections of memory. With 256 bits, an average message will last about 15 seconds at 10 words per minute. Fig. 1 shows the circuit.

how it works

The identifier plays back the message stored in the PROM by addressing it with eight address lines from a 4020 binary counter driven by an astable oscillator formed from one-half of a 4011. A particular 256-bit section is selected by S2, which serves as a message selector. This output is NEEDED with the clock signal, giving an output available at R10 consisting of bursts of tone whenever a "one" is encountered in the PROM memory. Tone level is controlled by R9, so that signal deviation may be adjusted in an fm transmitter. The PROM output also is applied to a keying

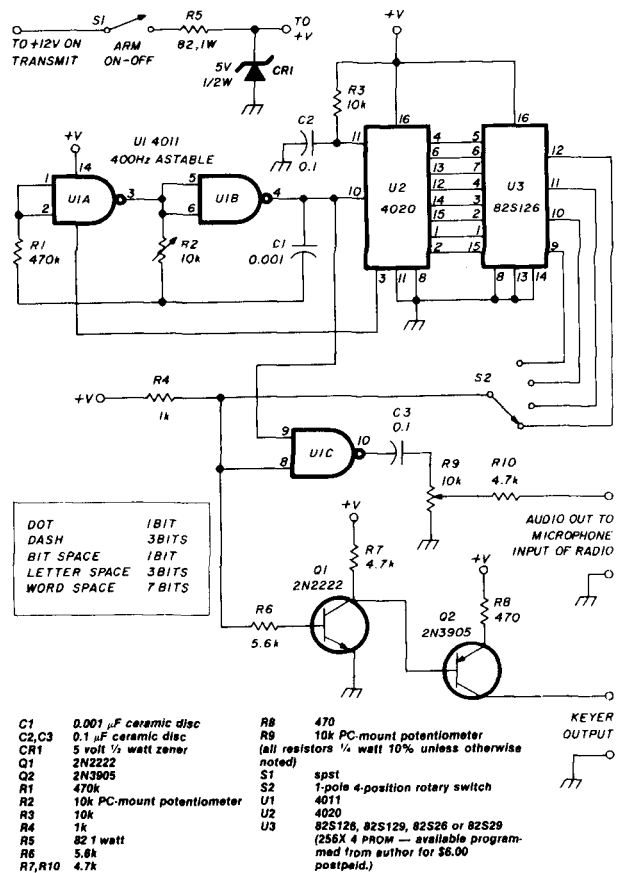


fig. 1. Schematic diagram of the CW identifier. With 256 bits of preprogrammed memory, an average CW message lasts about 15 seconds at a CW speed of ten words per minute.

By Michael J. Di Julio, WB2BWJ, 97 Woodside Road, Maplewood, New Jersey 07040

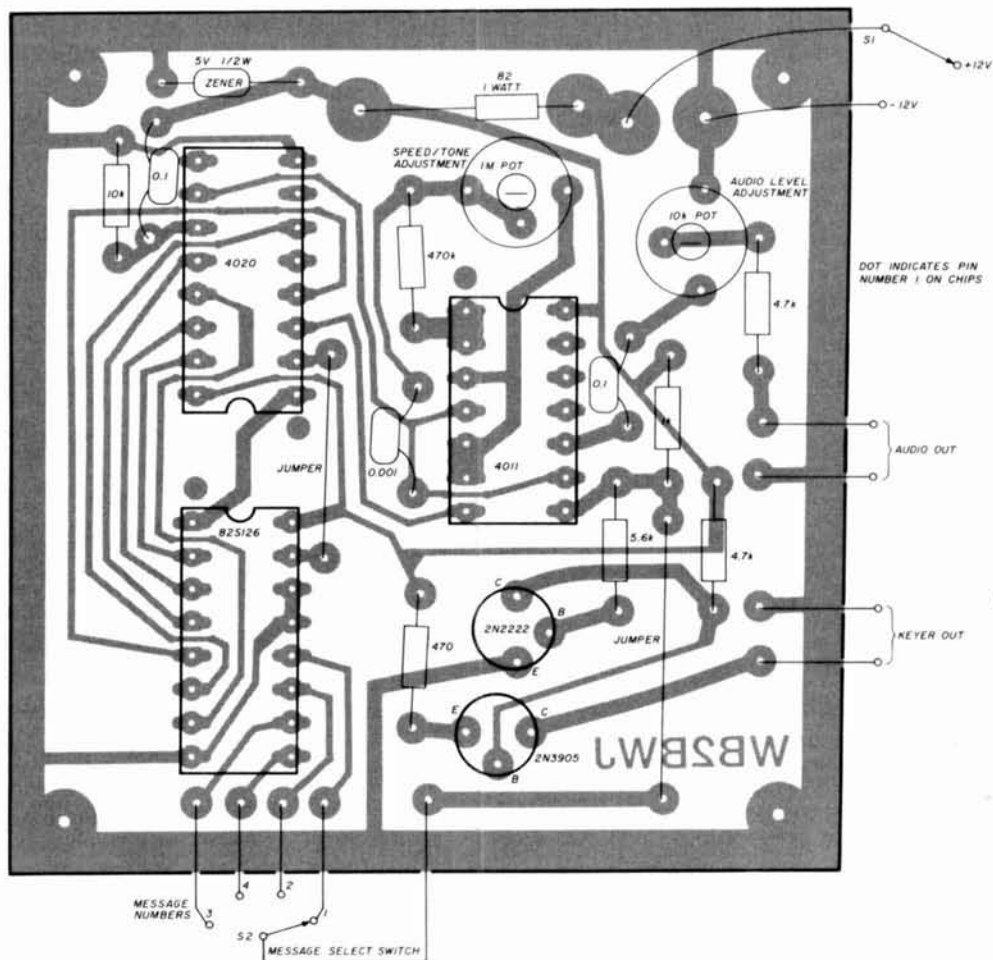
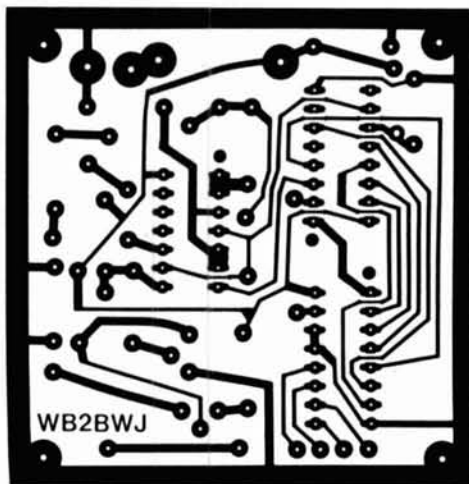


fig. 2. PC board layout and parts placement of the CW identifier. Kits are available (see text).

network composed of Q1, Q2, R6, R7 and R8, which provides an output compatible with the grid-block keying used in most hf transmitters.

Resistor R2 controls the clock rate, which not only determines CW speed but also changes output-frequency tone, since the oscillator does double duty as

a clock and a tone generator. The identifier sends the message only once for each S1 closure because the clock is disabled after a count of 256 is reached by the 4020 IC. The 4020 is reset each time power is applied through the differentiator formed by C2 and R3.

The identifier is designed to operate on 12 volts, as

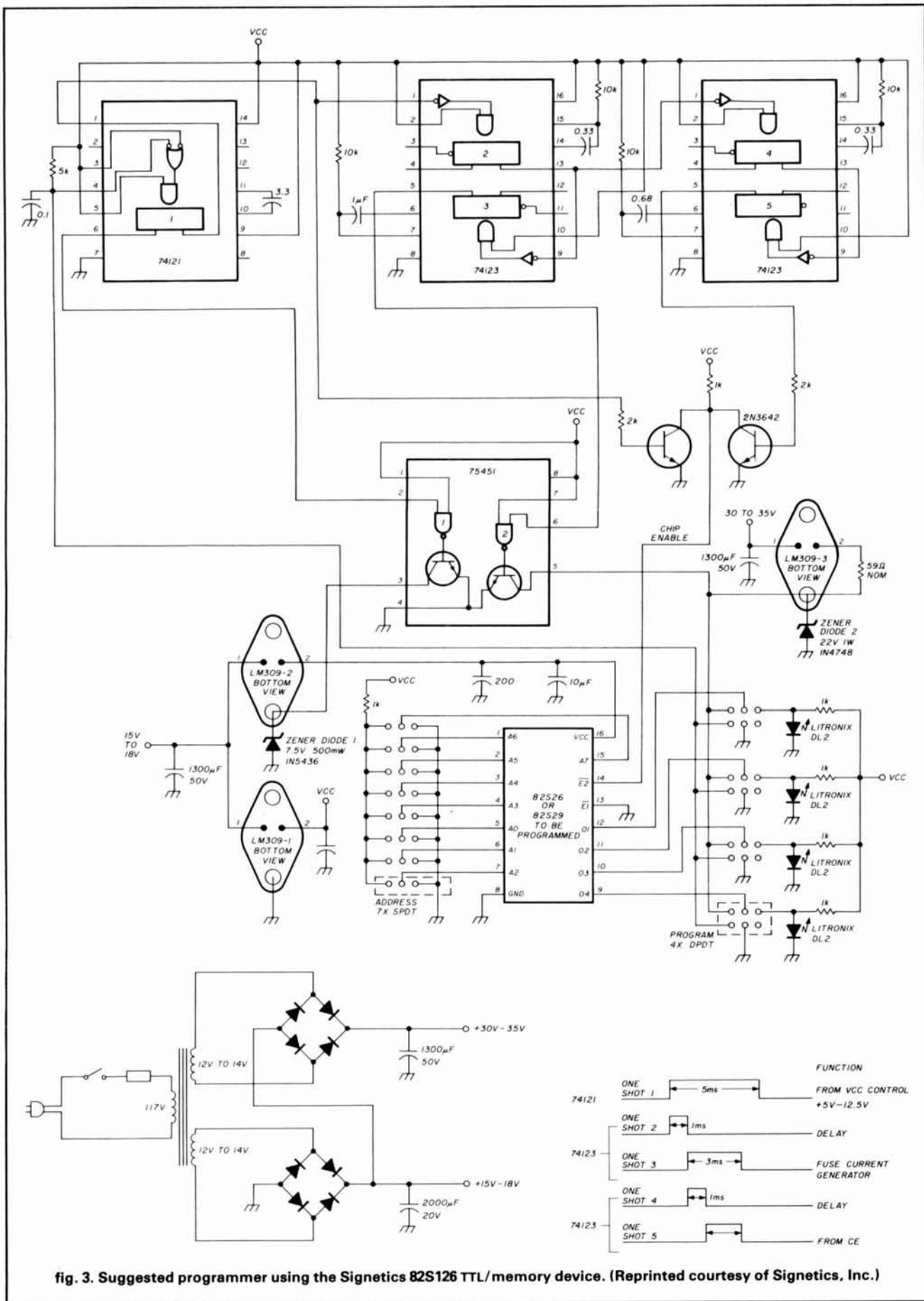


fig. 3. Suggested programmer using the Signetics 82S126 TTL/memory device. (Reprinted courtesy of Signetics, Inc.)

its primary use will be with mobile type equipment. That's why CR1 and R5 are needed to reduce the supply to 5 volts so that the ICs will function properly. If 5 volts are available you can eliminate the regulator network. Fig. 2 shows the PC-board layout and parts placement.*

Fig. 3 is a schematic diagram of a suggested programmer for the 82S126. (The schematic is reprinted from the Signetics *Integrated Circuits Manual*.) After the messages have been decided upon, a table of the binary sequence that must be programmed in the PROM should be made. For each "one" in the table, address its location using the eight address switches, then depress the appropriate program switch depending on whether you're programming message 1, 2, 3, or 4.

suggested uses and installation

As mentioned, the identifier can be used for repeaters, slow-scan TV, or RTTY identification. Other uses are as a contest keyer, a beacon ID, or an anti-theft device. To use it as an anti-theft device, one of the messages that could be programmed into the identifier to protect your rig, is "STOLEN DE (your call letters)."

Install the unit in your mobile rig, replacing S1 with a magnetic reed switch. Install the switch as closely as possible to the cover of the radio. Connect the + 12-volt line to a point of the switched 12 volts within the radio that is available only when in the transmit mode. (This voltage can usually be found on the transmitter strip.) As an alternative, isolate the identifier from ground and connect the ground wire from the identifier to the microphone PTT switch. In this case, connect the + 12 volt line to a constant source of 12 volts in the radio. Now, every time the reed switch is closed and you're transmitting, the message will be sent with your voice. The reed switch will close only when a magnet is held close to it. Hence, when you're using the rig, don't put a magnet near the reed switch!

When the radio is unattended leave a magnet on the cover, about where the reed switch is located, and the identifier will activate when the radio transmits, telling all your friends on the repeater that your radio has been stolen (unknown to the felon operating it).

Many of these identifiers are in operation and are performing reliably. The design is simple and effective.

ham radio

*As an alternative to building the programmer, I'm offering the benefits of a sophisticated, automated programmer that I've constructed. I'll program any PROM that a reader sends me for \$1.00 to cover postage and handling. Please be sure that the total number of bits, that is, "ones" and "zeros," in your message doesn't exceed 256. See also my note in fig. 2 regarding PC boards and kits.

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At N8ET I've done quite a lot of serious contest operating. As a result the antenna system became quite extensive — five elements on 10 meters, four on 15, five on 20, dipoles on 40 and 80, and my 70-foot (21-meter) tower was gamma matched for 80 meters with 2000 feet (610 meters) of radials. Forty meters was the weak link as results in the contests verified. To improve my signal on 40, I began to look for better antennas with low-angle radiation. A bobtail was the first antenna to be tried. It took as much space as an 80-meter dipole and was only 33 feet (10 meters) high. Results were encouraging. I almost missed two KL7s because they were so strong that I thought they were locals. The problem was that I still needed something for the European and ZL/VK paths.

the switchable quad

While going through old *QST* articles I came across one about a 40-meter switchable two-element quad.¹ It looked easy enough to erect, and quads are supposed to have excellent low-angle radiation, even when close to the ground. The spacing used in the *QST* article was 22 feet (6.7 meters), with the feedline switched between elements. Since I just happened to have a 40-foot (12-meter) boom, I decided to go with three elements spaced at 20 feet (6

meters) and to switch the parasitic elements only (fig. 1). The results were far better than expected.

As in the *QST* article, I found that the parasitic elements could be tuned by a reactance some distance from the element by using the correct length of feedline between the element and the reactance. The reactance at the end of the feedline is transformed to the proper reactance at the element to tune the element either as a director or a reflector. By using a dpdt relay, I could switch reactances and change from reflector to director and *vice versa*.

construction

All three elements were cut to the same length using the formula for a quad driven element:

$$l = \frac{1005}{f} \quad (1)$$

where l is element length (feet)

f is frequency (MHz)

In metric terms, eq. 1 is

$$l = \frac{306.6}{f}$$

where l is element length (meters)

f is frequency (MHz)

Using a Smith chart, I determined the correct reactance at the end of a 450-ohm open-wire feedline to make a reflector and a director (about ± 150 ohms of reactance is needed at the element). A variable capacitor with a maximum value of 150 pF easily provides the reactance at the end of a 16-foot (4.9-meter) section of the open-wire line. The line can be any multiple of $\frac{1}{2}$ wavelength long plus 16 feet (4.9 meters). This allows the reactances to be placed at the operating position for optimum adjustment of any signal.

adjustment

I erected the quad at a height of about 60 feet (18

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meters). Each element was in the form of a triangle with the peak at the top. The driven element was fed at the bottom center using a 1:1 balun and 52-ohm coax. This element could have been fed directly, or through a wire gamma match, or even with open wire and a tuner. Don't make the same mistake I did by erecting and tuning the driven element and then erecting the parasitic elements! As the books say, they *do* interact, and I had to resolder all the wire I'd just cut out of the driven element to get a good match. Put up all three elements then adjust the driven-element length for the best match.

Next, adjust the antenna by bringing the receiver out to the antenna base, where you can see the S-meter. A distant station in the appropriate direction can be used as a signal source to adjust the parasitic elements. If a nearby station is used, be sure he's using horizontal polarization. (During my initial check with station AD8P, I had the most gain off the back of the quad until AD8P switched from his vertical to his dipole. Then we obtained the expected results.)

Adjust the capacitors for best front-to-back ratio. This is a fairly critical adjustment (fig. 1) and corresponds very closely to the point of maximum forward gain. The forward-gain adjustment is quite broad, so it's *much better* to adjust for maximum front-to-back ratio and accept the very small loss in forward gain.

The ratio I finally obtained was about 25-30 dB. I was able to get about 50 dB front-to-back ratio using a nearby oscillator as a signal source. This obviously was not right, so be very careful about using signal sources close to the antenna for adjustments. Forward gain over a dipole was not measured, but with the quad I've heard and worked stations I'd never

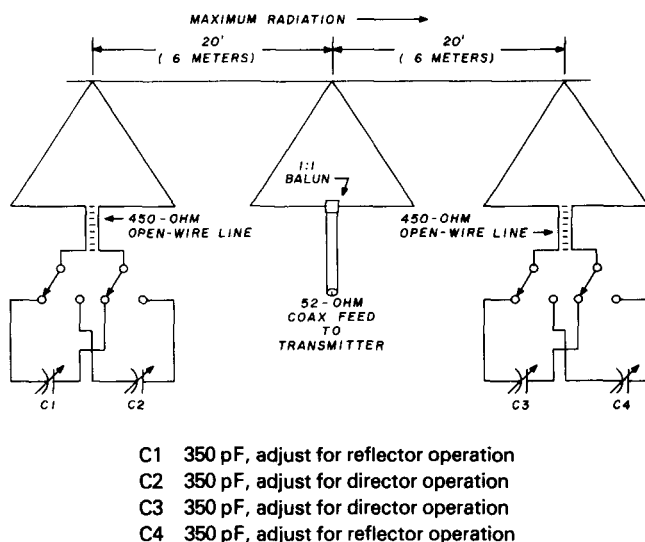
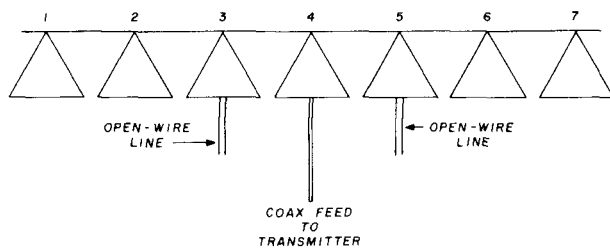


fig. 1. Three-element quad adapted from data in reference 1. The parasitic elements can be switched from director to reflector or vice versa.



Directors:	elements 1,2,6,7
Driven Element:	4
Switchable director/reflector:	3,5

fig. 2. Proposed switchable quad using seven elements. Mechanical construction would pose a problem for a 40-meter array. Perhaps the antenna could be strung between several high trees. See reference 2 for ideas in erecting long antennas.

heard on 40 meters before with my dipole, which is up 60 feet (18 meters).

alternative supports

For those who don't have a 70-foot (21-meter) high tower and a 40-foot (12-meter) boom, there are other ways to get the quad in the air. All you need are two supports at least 40 feet (12 meters) high, spaced at least 40 feet (12 meters) apart in the right direction. The supports could probably even be less than 40 feet (12 meters) high. The triangular loops can be flattened to accommodate the lack of height. The loops don't have to be a perfect triangle. Of course, the higher the antenna, the better it will perform. Instead of a 40-foot (12-meter) boom, a piece of line between supports can be used to hold up the elements.

future work

I hope to try another configuration, which will give more forward gain, by using more than three elements, feeding the center element, switching only the two closest parasitic elements, and making all the remaining parasitic elements as directors, fig. 2. The reflector should isolate the appropriate directors so they have a minimum effect on antenna performance.

I would be interested in hearing from anyone who tries this configuration since I am now living in a house with a very small lot and won't be able to try this idea for some time. Perhaps all the elements will have to be switched.

references

1. John E. Kaufmann, WA1CQW and Gary E. Kopec, WA8WNU, "A Convenient Stub-Tuning System for Quad Antennas," *QST*, May, 1975, pages 18-21.
2. G. E. Smith, W4AEO, and Paul A. Scholz, W6PYK, "Log-Periodic Fixed-Wire Beams for 40 Meters," *ham radio*, April, 1980, pages 26-30.

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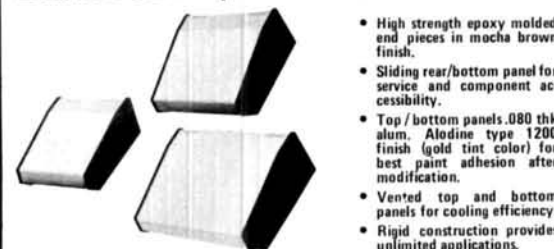
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Yagi antenna design: ground or earth effects

A discussion of ground effects and performance of real Yagi antennas above real ground

To this point, the antennas I've discussed were considered in free-space conditions. In the real world, however, the performance of an antenna is profoundly affected by the proximity of the ground or earth. The ground can be beneficial in some circumstances and detrimental in others; it is important to understand ground effects and how to use the presence of ground advantageously.

Unfortunately, the ground or earth near an antenna is not easily characterized; ordinarily, it is complex in shape with highly variable radio-frequency properties. The ideal "ground" will consist of a flat plane of material with high electrical conductivity, usually approximated quite well by the surface of the ocean. Actual ground, however, has a much lower conductivity and lower dielectric constant than salt water and is ordinarily far from flat. Values of electrical conductivity, σ , range from about 4 mhos/meter for salt water to as low as 10^{-3} mhos/meter for typical residential areas; corresponding values of dielectric constant, ϵ , range from about 80 for water to 5 for typical residential areas.

The presence of ground alters antenna performance in two ways. First, it changes the normal free-space pattern (in the illuminated half sphere) by adding (vectorially) a *reflected* pattern. The combination of direct and reflected radiation fields produces regions of enhanced gain, but at the expense of reduced gain in other regions. Second, it alters the antenna itself; currents that flow in the ground surface couple back into the antenna and change all element currents. In other words, an antenna becomes

a somewhat different antenna when placed near the ground.

reflections from a plane ground

Let us first consider the reflection from a plane ground surface: the reflected wave can be characterized by a reflected amplitude, K , and a reflected phase, ϕ . For horizontally polarized radiation, K_H remains close to unity and ϕ_H is close to π or 180° for all incoming (and therefore reflected) angles with respect to the surface, β . The phase change is due to the fact that if the conductivity of the surface is high, Maxwell's equations require the tangential E-field at the surface to vanish; this can only occur if K_H is nearly unity and ϕ is nearly π . The limiting values only occur if the conductivity of the plane surface is infinite; however, for all practical values of ground conductivity, K_H and ϕ_H remain reasonably close to the limiting values.

By contrast, the reflection of vertically polarized radiation is much more complicated. In this case, the limiting value of K_V (for infinite conductivity where the electric field normal to the surface must be continuous) is also unity and that of ϕ_V is zero. However, these values change drastically where ground has a finite conductivity and dielectric constant. Values of K_V and ϕ_V vary radically with the elevation angle relative to the surface, β . As the surface, β , is changed from zero to $\pi/2$ or 90 degrees, K_V from unity down through a minimum at an angle called Brewster's angle and slowly back up to a value usually significantly less than unity. At the same time, ϕ_V varies from π or 180 degrees monotonically down to zero. Brewster's angle, β_B , is a function of the dielectric constant of the surface, $\beta_B = \cot^{-1} \sqrt{\epsilon}$. Note that for water $\beta_B = 6$ degrees (already quite a low angle) and if $\epsilon = 5$ (poor ground), β_B rises to only 24 degrees. Thus, it is easy to see that if one models flat real ground as an infinitely conducting plane, the result should be generally trusted for horizontal polarization, but not for vertical polarization. It is significant that far-field radiation for vertical polarization over real

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Schenectady, New York 12309

(finite conductivity) ground vanishes at grazing angles. Only when conductivity is truly infinite does grazing angle reflection add to direct antenna radiation.

Let me return briefly to the observation that the ground surface near an antenna is rarely flat. Even if this real ground surface were perfectly reflecting (infinite conductivity), the pattern of reflected radiation would be exceedingly complicated. It is useful to imagine a small optical model of the ground surface terrain made with a good shiny reflecting surface and illuminated by a light source (replacing the antenna). From this it is easy to understand that the reflected pattern will show bright spots or glints where converging rays are focused from "dished" concave surfaces; in fact, the brightness from such dished areas is potentially much higher than the direct light from the light source itself. If the dished surface is ideal, one can realize enormous brightness gains; the ideal surface is, of course, a parabolic reflector at the right distance from the source.

Excellent optical searchlights are made with such reflectors. A modern radiofrequency example is the large Arecibo dish, which started with a natural, roughly parabolic ground surface and was subsequently improved by high-conductivity, accurately figured reflecting surfaces. To get effective cohesive radiation from the entire surface required the surface to maintain an accuracy of a fraction of a wavelength.

The shiny optical model produces a reflected pattern somewhat but not exactly, like the real ground. The principal difference is due to the very short wavelength of light compared with the size of the surface features of the model. The brightness gain of any well-configured dished area is theoretically proportional to the reflecting (concave) area, but inversely proportional to λ^2 . Thus, the optical glints will tend to be small, bright spots, whereas the real radio glints, occurring at the same angles, will be fuzzy, larger, and less bright. Note, however, that the broader radio glint will approximate the average value of the optical glint over the radio glint angle.

Thus, we see that ground around an antenna can not only reflect, but it can focus (and defocus) radiation as well. To get much of a focusing effect, the concave surface must not only be large (compared with a wavelength) and of the correct focal length, but it must also have a surface accuracy of a fraction of a wavelength. This type of surface is not likely to occur naturally at wavelengths in the 10-to-100 meter range, especially if the antenna is situated in a region where the reflecting surface is quite complicated. Nevertheless, for those users fortunate enough to be able to locate their antennas on a relatively smooth,

concave slope of the right curvature, some significant focusing should take place.

ground model

I shall model the ground surface in the conventional way; that is, as an equivalent to a perfectly conducting flat plane. This model should be valid for horizontally polarized radiation at antenna sites in which the actual ground is reasonably flat out to distances where specular reflection occurs at the lowest elevation angles of interest. For high angles, the reflection takes place nearly under the antenna, and the ground must be flat in that area to a fraction of a wavelength for the model to apply; this is usually the case.

As the elevation angle is reduced, the reflection point recedes from the antenna location until, at very low angles, it is many wavelengths distant. Under this condition the real ground does not have to be very flat to reflect energy with amplitude and phase coherence; it can in fact be quite rough, with variations in height of several wavelengths. This situation is analogous to the well-known optical reflection observed from surfaces that are rough in comparison with a wavelength; one can observe at grazing angles nearly specular reflection. A sheet of paper has roughness variations so large compared with the wavelength of light that, at normal incidence, no reflected images can be seen; nevertheless, at grazing angles, one can easily observe specular reflection effects — and even fair images. For these reasons, the model can be expected to be fairly valid for most horizontally polarized antenna systems.

One more point should be mentioned. Because of the finite conductivity of the real ground, the currents which flow are not strictly at the physical surface of the ground but are distributed throughout the top "skin depth" of the ground. This skin depth is usually quite small; as an example, at a radio frequency of 14 MHz, where the free-space wavelength is 21 meters, this skin depth in salt water is less than 0.1 meter, and even for poor ground, where the conductivity is 10^{-3} mhos/meter, the skin depth increases to a value of less than one meter. Therefore, the infinite conductivity plane model of the ground should give quite acceptable results.

Besides adding a reflected wave to the space pattern of an antenna, the presence of the highly conducting ground plane changes the properties of the antenna itself. Excitation of the antenna produces a current distribution in the nearby ground plane surface, which in turn couples mutual voltages back into all antenna elements; these mutual voltages will obviously affect antenna currents in all of its elements.

To model this interaction, it is useful to replace the ground plane conducting surface by an antenna im-

age. This image is located just as far below the original ground plane as the real antenna is located above. For a horizontally polarized antenna, the image is excited equally with, but exactly out of phase with, the real antenna. Because of the geometrical symmetry of the antenna and its image around the original ground plane surface and the opposite excitation, it is easy to see that, at all points on the original ground plane surface, the tangential electric fields vanish (image field cancels the antenna field).

Thus, by means of the image model, we produce exactly the same tangential field at the ground plane coordinates as would be produced by currents flowing in the real conducting ground plane because of antenna excitation alone. The antenna itself cannot distinguish whether a real ground plane conductor or its oppositely excited image exists. Therefore, the ground interaction with the antenna is identical to the image interaction. One can therefore model all antenna properties over the real ground plane by using the antenna and its oppositely excited image in free space.

Note, however, that there is one significant difference between the image model in free space and the real ground plane. In the real ground plane case only a hemisphere is actually irradiated, while in the image model a full sphere is irradiated. Although all fields in the (common) half space will be exactly the same, it is obvious that the total radiated power of the image model will be just twice that of the real ground plane. Therefore, even though antenna element impedances are the same for both situations, gain calculations for the image model must be multiplied by two to get gain for the real antenna over earth.

antenna over earth.

Before I evaluate detailed antenna properties over earth, I would like to briefly discuss the elevation angles that should be of paramount interest. It is well known that long-distance radio communications take place primarily by ionospheric F_2 layer reflection (or, more properly, refraction). While the F_2 layer can vary in (virtual) altitude over the earth (250 to 400 km), it is instructive to make a very simple model of this layer as a reflecting shell at an altitude or height, H , of 300 km. A radiated wave at an elevation angle, β , will bounce from this shell and return to earth at the same elevation angle, β , but at great circle range, R . The relationship of R to β depends only on simple geometry. For a single hop the maximum range on the earth is limited; thus, communications at very long distances will involve several hops.

Fig. 1 shows a plot of β versus R for different numbers of hops (up to 6), n . This diagram shows clearly that a given range can be reached with different dis-

crete elevation angles, or that a given elevation angle arrives back at the earth at discrete ranges. To cover all values of range requires a continuous spread in elevation angle β , but the limits of this spread in β can be narrowed somewhat by taking advantage of different numbers of hops. As an example, all ranges beyond $R = 1600$ km can be accommodated by the heavy line in fig. 1; that is, β varying over a range of only 3 to 17 degrees.

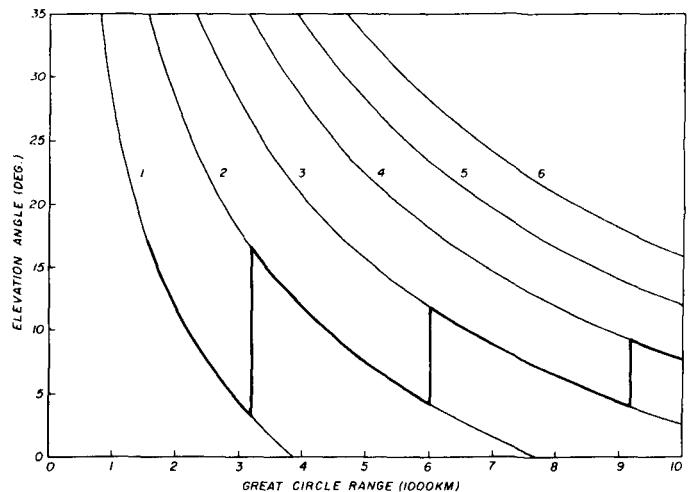


fig. 1. Diagram of the elevation angle required for propagation over various great circle distances and number of hops.

It is generally desirable at the higher frequencies to use low angles to minimize attenuation resulting from multiple hops and reflection losses and to ensure ionospheric refraction at the highest frequency. For such frequencies (say 14 to 28 MHz) the range of elevation angles shown in fig. 1 seems quite appropriate. At lower frequencies, (≤ 7 MHz), however, if the propagation path at either end is in daylight (where absorption is high), a higher range of angles (using a greater number of hops) may give a lower overall absorption. The reasoning derived from this oversimplified model gives expected results not inconsistent with observations reported in the ARRL *Antenna Book*¹ on page 18. However, real propagation is clearly more complicated than is shown in fig. 1.

Kift² has shown in an elegant way that long distance propagation involves many propagation modes. He has shown, in measurements made between Ascension Island and Slough, England, that measured arrival angles, when complete path ionospheric soundings are known, correlate well with ray-tracing expectations. (Ray tracing can identify actual propagation modes.) His results indicate that eleva-

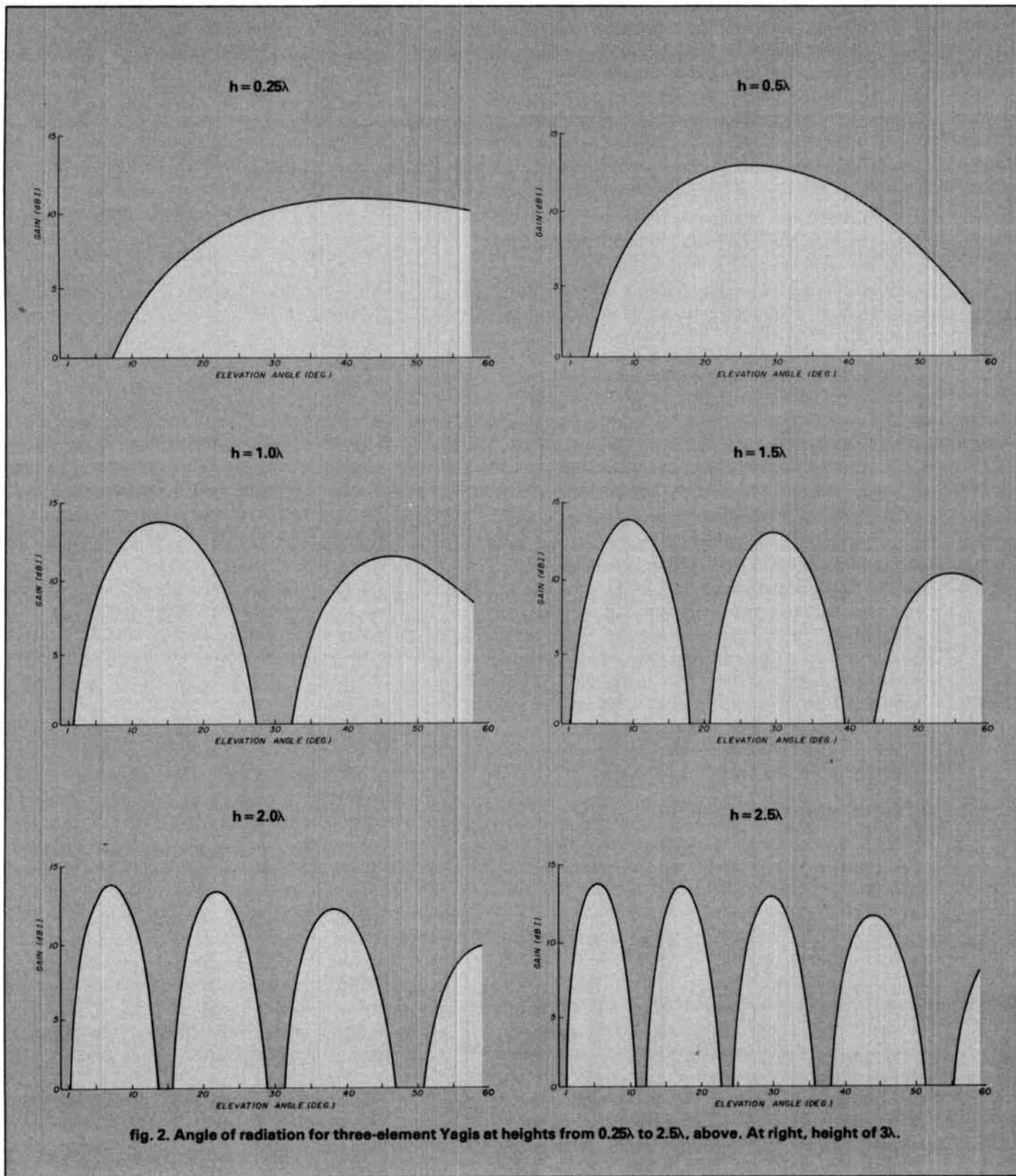


fig. 2. Angle of radiation for three-element Yagis at heights from 0.25λ to 2.5λ , above. At right, height of 3λ .

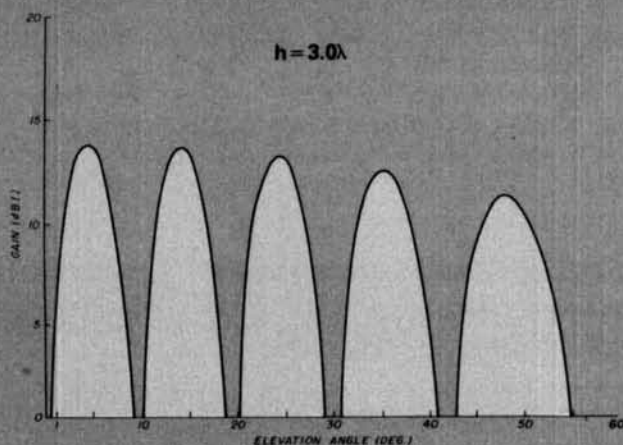


table 1. Representative Yagi beams. All elements are cylindrical with radius $\rho = 0.0005260 (\lambda)$.

element	three-element boom length $1/4 \lambda$		six-element boom length $3/4 \lambda$	
	length (λ)	boom position (λ)	length (λ)	boom position (λ)
reflector	0.49801	0.000	0.49528	0.000
driven	0.48963	0.150	0.48028	0.150
D1	0.46900	0.300	0.44811	0.300
D2			0.44811	0.450
D3			0.44811	0.600
D4			0.44811	0.750

table 2. Three element beam (from table 1) over ground.

height over ground (λ)	gain (dBi)	F/B (dB)	angle (deg.)	driver impedance (ohms)	
				R	X
0.1	9.63	4.90	59	43.05	13.23
0.25	10.88	13.39	42	14.21	-4.25
0.5	12.96	42.94	27	14.76	1.49
0.75	13.46	17.13	19	16.18	-1.25
1.0	13.68	29.42	14	15.15	0.70
1.25	13.69	19.40	11	16.07	-0.66
1.5	13.78	27.22	10	15.32	0.45
1.75	13.77	20.52	8	15.98	-0.45
2.0	13.85	26.24	7	15.42	0.33
2.5	13.84	25.70	6	15.47	0.26
3.0	13.85	25.34	5	15.51	0.22
Free space	7.86	23.60	0	15.70	0.00

tion angles from 3 to 20 degrees are indeed quite important. He also shows focusing effects of a given mode and the great variety of results which can occur in practice. Thus, in evaluating an antenna system over ground, it is most important to ensure good gain over *all* lower angles (say 3 to 17 degrees) and for the lower frequencies (≤ 7 MHz) over even higher angles (up to say 30 degrees). I shall therefore show, in all cases to be presented, a plot of H-plane gain as a function of elevation angle, β .

antenna performance over ground

To illustrate typical Yagi antenna performances over ideal ground, I shall use as representative Yagi beams a three-element Yagi on a 0.25λ boom and a six-element Yagi on a 0.75λ boom; the basic characteristics are given in Table 1. I have made calculations for each beam at a number of different elevations over ground. The results for the three-element beam are shown in Table 2 and those for the six-element beam in Table 3. As a reference, the free-space performance for each beam is also listed in these tables. Figs. 2 and 3 show the H-plane, or vertical, pattern of each of these cases at certain chosen elevations. It is apparent from these H-plane patterns that maximum gain in the forward direction occurs at an elevation angle which is an inverse function of the antenna height; this relationship is tabulated quantitatively in Tables 2 and 3.

These figures also show that the antenna gain has a number of lobes, the biggest lobe is the first one (lowest elevation angle). For each succeeding lobe, the peak gain is somewhat lower. This reduction in gain is caused by the natural free-space directivity of the antenna. The overall pattern is a series of lobes (produced by interference of the direct and reflected waves) essentially modulated by the inherent free-space pattern of the antenna. Note that the relative gain reduction at high angles is greater for the (more directive) six-element beam than for the three-element beam. Moreover, a careful analysis of the lobes shows that the maximum point on each lobe is slightly altered by the natural beam directivity. This is shown in Tables 2 and 3 by the slightly lower elevation angles of the main lobe for the six- versus the three-element beam at a given height above ground.

Thus, we see that the main lobe of an antenna occurs at an angle *primarily* determined by its height over ground, but *secondarily* by the natural antenna directivity. This latter effect is most pronounced at low antenna heights, and it is also responsible for the relatively poorer gain at these heights. One would ordinarily expect the ground reflection to double the radiated field (or to add 6.01 dB to gain), but if it occurs

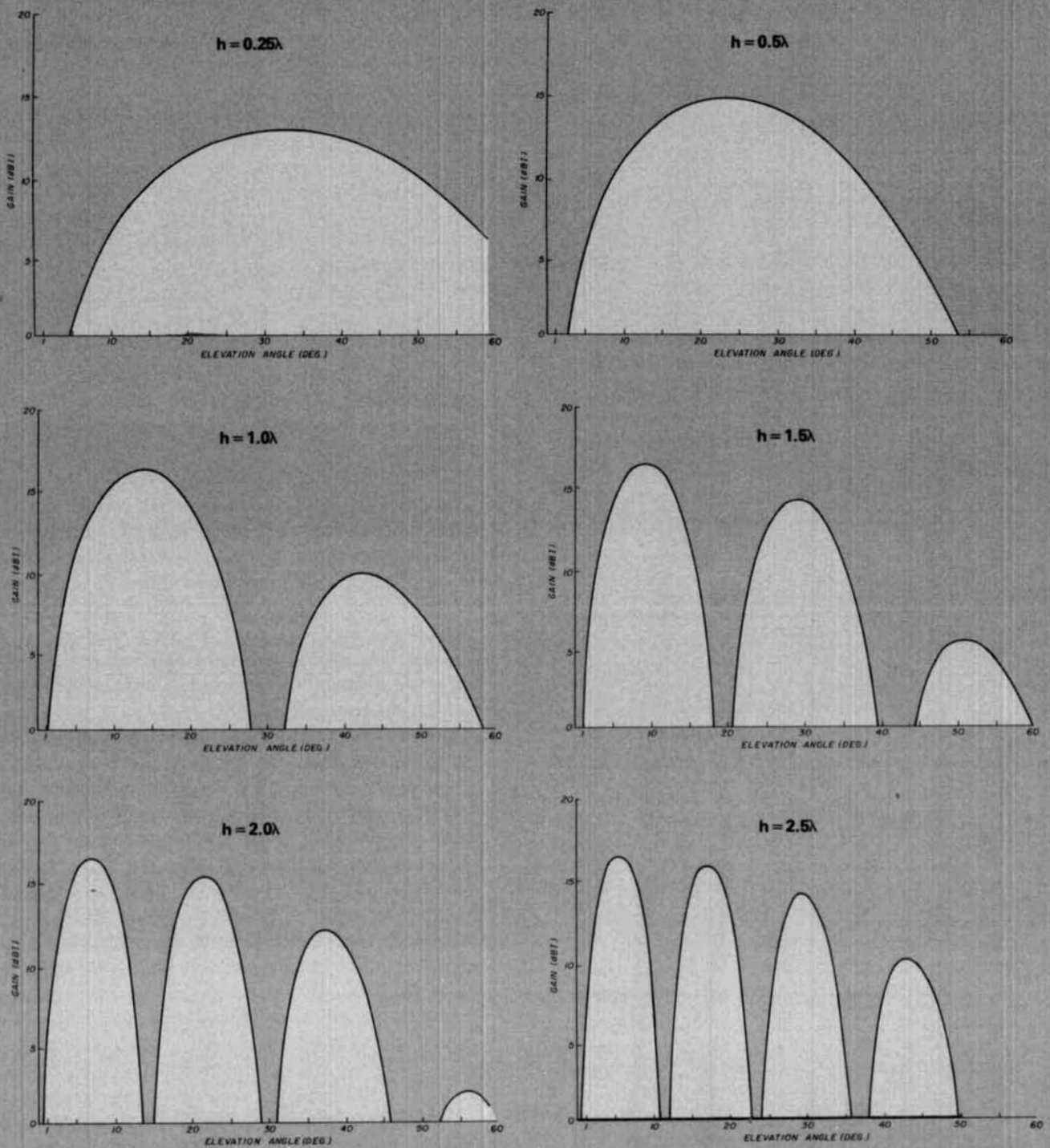


fig. 3. Angle of radiation for six-element Yagis at heights from 0.25λ to 2.5λ , above. At right, height of 3λ .

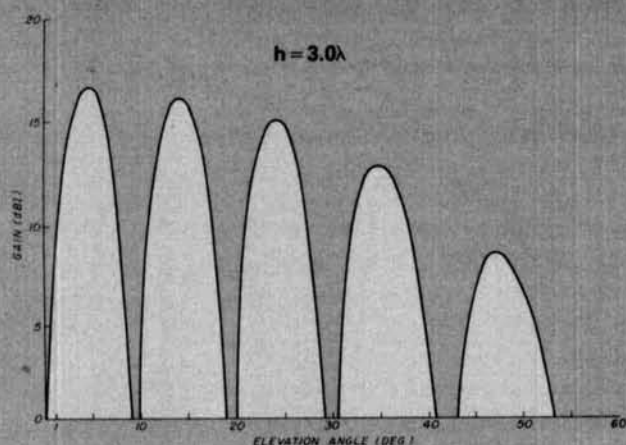


table 3. Six-element beam (from table 1) over ground.

height over ground (λ)	gain (dBi)	F/B (dB)	angle (deg.)	driver impedance (ohms)	
				R	X
0.1	11.89	8.67	46	14.68	8.58
0.25	13.01	13.14	33	23.90	-7.98
0.5	14.86	34.31	24	21.62	-1.73
0.75	15.59	21.52	18	21.24	-0.34
1.00	16.36	35.77	14	22.38	-1.51
1.25	16.23	29.69	11	20.96	-0.95
1.50	16.58	38.61	9	22.23	-1.29
1.75	16.44	35.04	8	21.07	-1.17
2.00	16.67	40.94	7	22.10	-1.23
2.50	16.67	42.86	6	22.01	-1.21
3.00	16.69	44.76	5	21.94	-1.21
Free space	10.70	57.21	0	21.62	-1.28

table 4. Specifications for six-element beam optimized by slight shifts in boom positions for D1 and D3. All element radii are 0.0005260(λ).

element	optimized for free space		optimized for 1.5λ over ground	
	length (λ)	boom position (λ)	length (λ)	boom position (λ)
reflector	0.49528	0.000	0.49528	0.000
driven	0.48071	0.150	0.48028	0.150
D1	0.44811	0.2991650	0.44811	0.3039068
D2	0.44811	0.450	0.44811	0.450
D3	0.44811	0.5999658	0.44811	0.5958952
D4	0.44811	0.750	0.44811	0.750

at a high elevation angle (low antenna heights) the original antenna gain (free space) is significantly lowered (at the same high angle).

The front-to-back ratio is also shown in Tables 2 and 3. Recall that the definition I use for F/B is the ratio of forward energy flux density at the best elevation angle to the reverse energy flux density at the same reverse elevation angle. Tables 2 and 3 show this quantity to fluctuate rather widely with antenna height; the cause of these fluctuations is the altered antenna element complex currents that result from the mutual coupling of antenna and its image. These mutual effects are large when the antenna is low and relatively small when the antenna is high. Note, however, that even when the antenna is three full wavelengths above ground, enough interaction occurs to noticeably alter the free-space value.

Similarly, the antenna driving-point impedance fluctuates with antenna height. When the antenna is very low, for example, at a height of 0.1λ , driving-point resistance and reactance are far from their free-space values. This shows dramatically that if one adjusts an antenna near the ground (say at 0.1λ) for best performance, it certainly will not be the best adjustment at final operating height.

These ground mutual effects, which alter the antenna element currents, are present to some degree at all antenna heights likely to be used in practice. This is tantamount to saying that the antenna over ground is not the same as the antenna in free space. An antenna optimized for free space will therefore not generally be quite optimum over ground. Obviously, one should really optimize the antenna over ground at the desired height.

What is the best antenna height? Recall from fig. 1 that one should strive for a large gain over a range of angles, for example, 3 to 17 degrees. An inspection of figs. 2 and 3 shows that this occurs when the antenna height over ground is about 1.5λ . For 14-MHz radiation, this height would be about 30 meters, or 100 feet. Practical operating experience does verify that such an antenna height gives excellent results. Note also that at a height of 3λ a deep lobe null occurs at an elevation angle of 10 degrees; this angle is sometimes important, such as for a range of 4500 km using two F-layer hops. Such a high antenna, even though excellent as a band opener at very low angles, would not be expected to be a good overall performer. I have tried a large 14-MHz antenna at a height of 2.6λ ; from my location in New York State, the average European signals were found to be substantially inferior to those received from an antenna at a height of 1.5λ .

It is fortunate that an antenna at a height of 1.5λ over ground is not seriously degraded from its free-

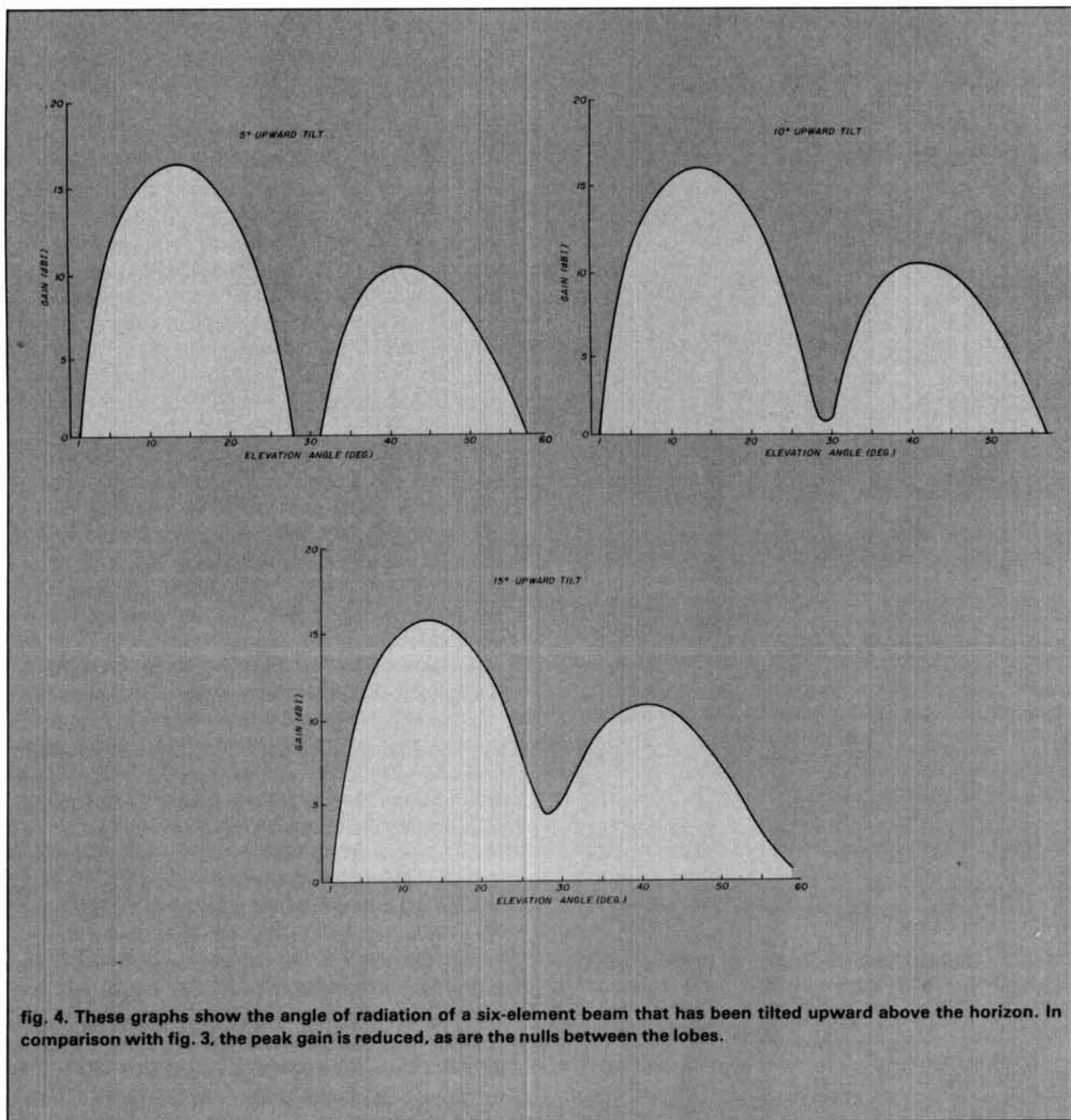


fig. 4. These graphs show the angle of radiation of a six-element beam that has been tilted upward above the horizon. In comparison with fig. 3, the peak gain is reduced, as are the nulls between the lobes.

table 5. Performance of free-space optimized six-element Yagi (specification in table 4).

frequency	gain (dBi)	F/B (dB)	angle (deg.)	driver impedance (ohms)	
				R	X
0.996	10.59	26.59	0	22.42	-6.53
0.998	10.65	32.64	0	22.10	-3.50
1.000	10.70	120.18	0	21.80	-0.42
1.002	10.75	32.69	0	21.51	2.72
1.004	10.79	26.68	0	21.25	5.93

table 6. Six-element optimized Yagi at 1.5λ over ground (specification in table 4).

frequency	gain (dBi)	F/B (dB)	angle (deg.)	driver impedance (ohms)	
				R	X
0.996	16.50	26.45	9	22.40	-6.12
0.998	16.56	32.52	9	22.17	-3.09
1.000	16.61	123.18	9	21.95	-0.00
1.002	16.65	32.59	9	21.75	3.14
1.004	16.69	26.60	9	21.57	6.33

space performance. **Table 3** shows that the F/B ratio (at central design frequency) for the six-element beam is a superb 57 dB in free space and degrades only to a still superb value of 38 dB when the beam is mounted at 1.5λ over ground. In both cases, optimization procedures described in a previous article³ can tune up the F/B ratio with only minor effects on other performance features.

I have carried out such an optimization by varying the boom positions of $D1$ and $D3$ slightly; final beam specifications are shown in **Table 4**, and the performance around the frequency of best F/B is shown in **Tables 5** and **6**. Note that optimization requires very delicate boom position adjustments. These boom positions have been adjusted sufficiently well to give a F/B well over 100 dB at the central design frequency. It is interesting to note that *different* boom positions are needed for the free-space Yagi and for the Yagi to be mounted over ground. This is because they are really slightly different antennas because of ground interaction.

Let me stress, as I did in the previous article on optimization, that although the Yagis are mathematically optimized to give a very high (but narrowband) F/B ratio, the basic model cannot really be trusted to this level of accuracy. It should be quite possible in principle to carry out this type of optimization experimentally on a real Yagi; the basic behavior should be similar, but the final boom positions might be slightly different.

Note that when a Yagi is mounted over ground the lowest lobe of radiation has a maximum at an elevation angle usually sufficiently high that the direct wave from the antenna is somewhat reduced from its peak free-space value. It is interesting to see if any improvement could be made by purposely tipping the antenna boom upwards to increase the direct wave.

Unfortunately, tipping the antenna upward automatically tips the image *downward* by the same angle; the net result is that, while the direct wave is increased, the reflected wave is decreased, and unfortunately by a greater amount. As an example, consider the six-element Yagi mounted 1.0λ over ground. The maximum gain of 16.36 dBi occurs at an angle of 14 degrees as shown in **Table 3**. **Table 7** and **fig. 4** show the result if the antenna is tipped up-

table 7. Six-element Yagi at 1.0λ over ground. Performance vs upward tipping angle.

tipping angle (deg.)	gain (dBi)	F/B (dB)	angle (deg.)	impedance (ohms)	
				R	X
0	16.36	35.77	14	22.38	-1.51
5	16.31	32.85	14	22.51	-1.65
10	16.12	29.58	14	22.47	-1.84
15	15.77	26.60	14	22.27	-1.99

ward at angles of 5, 10, and 15 degrees. It is easy to see that maximum overall gain is actually best when the antenna is parallel to the ground plane; as one tips the antenna the peak lobe gain is reduced slightly and the deep nulls between lobes tend to become shallower. This is precisely the behavior expected from a consideration of the vectorial addition of direct and reflected waves.

summary

1. Although ground is difficult to characterize, there is reason to believe that for horizontal polarization a good model is an ideal, infinitely conducting plane.
2. The H-plane (vertical) pattern consists of a number of lobes caused by the interference of direct and ground-reflected waves. The first (lowest) lobe is the strongest; succeeding lobes are reduced somewhat in gain by the natural free-space directivity of the antenna.
3. Mutual effects between the antenna and ground cause antenna element currents to change; these changes cause significant alterations to the antenna properties. The most noticeable variations occur in F/B ratio, but there are also significant variations in gain and driving-point complex impedance.
4. Best overall antenna performance appears to occur if the antenna height is about 1.5λ . This is not a critical figure, but it is believed that 3λ is probably too high.
5. Tuning or adjusting an antenna near the ground for best performance guarantees that the antenna will *not* be optimum at operating height.
6. Because of the significant mutual effects with the ground, the antenna should be optimized at its final operational height. Generally, this optimization will not be quite the same as the optimized free-space antenna.
7. Large antennas are more handicapped at low heights than small antennas; this is due to their higher natural free-space directivity.
8. For best gain the boom of the antenna should in principle be parallel to the effective ground plane surface; however, the degree of parallelism required is not critical. Tipping the antenna upward to improve gain will, in actual fact, decrease maximum gain.

references

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2. F. Kift, "The Propagation of High-Frequency Radio Waves to Long Distances," *Proc. IEE*, 107 Part B, March 1960, page 127.
3. J.L. Lawson, "Yagi Antenna Design," *ham radio*, July, 1980, page 18.

ham radio

how to determine true north for antenna orientation

Simple procedure
for establishing
a reference baseline
to set up
your beam antenna

Whenever a rotary beam antenna is installed a question arises. Which way is north? This article describes a simple, accurate, and little-known method of laying out a true north-south baseline using the sun for orienting a new installation or for checking the accuracy of an existing rotator direction indicator. The only equipment required is an accurate source of time.

description

The procedure is based on the principle that, at local noon, under certain conditions, the sun bears true south, so the shadow of your tower or other structure may be marked to create a permanent reference baseline. Under most conditions, the time when the sun bears true south occurs at times other than noon. However, the exact time may be easily computed with the data included in this article.

Computing the time. The time correction has two parts: the first remains constant and depends on your location (longitude, actually); the second is variable and depends on the day of the year the observation is made. Once the correction has been calculated it's simply added or subtracted, as the case may be, from local noontime to determine the exact time of the observation.

Although the computation takes less time to perform than to explain, an understanding of the factors composing the total correction is helpful in applying the correction.

Celestial dynamics. As is well known, the earth revolves once every 24 hours. However, for ease of understanding, let's assume that the sun rotates around the earth's equator, from east to west, once every 24 hours. The earth's equator, a circle, is divided into 360 degrees with 0 degrees arbitrarily set at a point at the intersection of the equatorial circle and a line drawn due south from the Royal Navy Observatory in Greenwich, England. Thus, the sun moves in an angular arc of 15 degrees in one hour. It is also equivalent to a movement of 1 degree of arc every four minutes of time or an arc of 1 minute (a degree being subdivided into 60 minutes of arc) every four seconds of time.

The location of a point on the earth may be defined in terms of latitude (degrees of arc north or south of the equator) and longitude (degrees of arc east or west of the line through Greenwich). Longitude in North America is typically stated in degrees and minutes of arc west of Greenwich. For example: Philadelphia is 75 degrees, 0 minutes west; San Francisco is 122 degrees, 27 minutes west longitude. The longitude of your location may be taken from a map or obtained from local civil authorities (U.S. Coast and Geodetic Survey).

Time zones. The earth has been divided into 24 standard time zones based on standard meridians spaced every 15 degrees. Eastern Standard Time is based on the 75th meridian, CST on the 90th, MST on the 105th, PST on the meridian at 120 degrees west, and so on. Each zone is designated by a letter of the alphabet. The Greenwich meridian, for example, is

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designated Z (Zulu). Unless you're fortunate enough to live on one of the standard meridians, the sun will not be on the local meridian passing through your location at noon standard time. However, since we now know the sun's rate of rotation in terms of angular displacement vs time elapsed, it's easy to compute the time of local meridian passage.

examples

The following example illustrates an arc-to-time conversion. My location is Greensboro, North Carolina — longitude 79 degrees, 53.43 minutes west. The local time zone is EST (75th meridian time). The lateral offset in longitude is 4 degrees, 53 minutes, derived from subtracting 75 degrees from 79, degrees, 53 minutes (rounded from 79 degrees, 53.43 minutes). As each degree equals four minutes of time and each minute of arc is four seconds of time, the total offset is 16 minutes and 212 seconds or, ex-

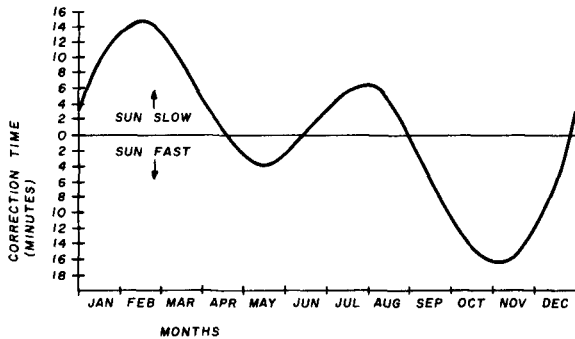


fig. 1. Plot of equation of time (EOT) taken from the *Nautical Almanac*, used to correct bearings for antenna orientation. The phenomenon is caused by the eccentricity of the earth's orbit with respect to the sun. The graph illustrates the difference between solar and local clock time.

pressed more conventionally, 19 minutes and 32 seconds. As the location is west of the standard meridian, the sun will be late and won't arrive on the local meridian (i.e., bear true south) until 12:19:32 clock time, neglecting other factors for the moment.

Another example: Greenville, New Hampshire, longitude 71 degrees, 51 minutes west, zone time, EST. In this case, the offset from the standard time meridian is 3 degrees, 9 minutes. Converting this arc to time gives 12 minutes and 36 seconds. In this case, the location is east of the standard-time meridian, so the sun will arrive early at 11:47:24 AM, neglecting other factors.

the equation of time

The other correction factor, which was neglected in the foregoing calculation, arises from the fact that the sun is like a poorly regulated clock: it runs fast

during some periods of the year and slow during others. This is because the earth's orbit is an ellipse rather than a circle. Fortunately, this eccentric motion is highly predictable and forms a pattern that repeats year after year. The difference between solar time and clock time is called the *Equation of Time* (EOT) by astronomers and navigators. Rather than resetting clocks every day to agree with solar time, civil time uses an average, or mean, of the overall yearly variation; e.g., Greenwich Mean Time or Universal Coordinated Time (UTC).

For any location, the correction for EOT may be taken directly from fig. 1, a plot of data taken from the *Nautical Almanac*, a U.S. Government publication. For Amateur antenna alignment purposes, the data is valid through the year 2100.

correction for daylight savings time

Although perhaps obvious it should be mentioned that, when local time is based upon daylight savings time, clocks are arbitrarily advanced one hour, thus making indicated time one hour ahead of "actual" time. Therefore, an additional correction of plus one hour should be added when applicable. The following example illustrates a complete calculation:

Find: Local time when the sun bears true south
 Given: Location, Greenville, New Hampshire, longitude 71 degrees, 51 minutes west
 Zone time, EDST, 75th meridian
 Day, August 1, EOT, 6 1/3 minutes or 00:06:20

longitude correction	0:12:36 (-)
EOT correction	0:06:20 (+)
combined correction	6:16 (-)

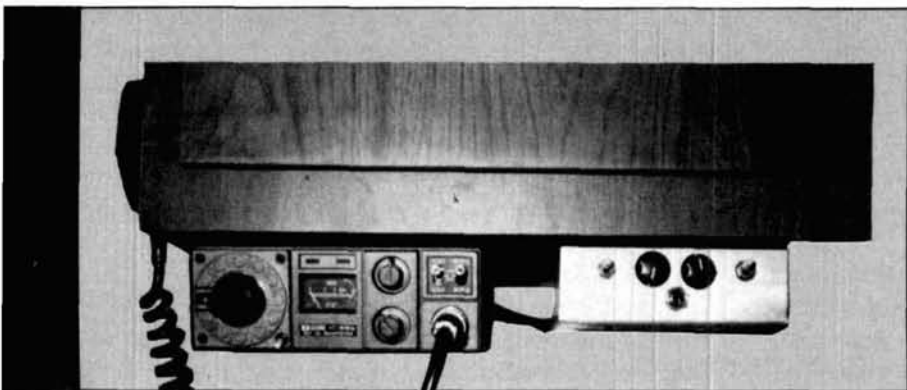
Subtracting from 12:00:00 noon EST (stated as 11:59:60) gives:

11:59:60 EST
06:16 (-)
11:53:44 EST

However, since EDST is in effect, one hour must be added to the calculated time to agree with indicated time: 11:53:44 + 01:00:00 = 12:53:44 EDST. Therefore, the sun will bear true south (and the shadow of your tower or other structure will point true north) at 44 seconds after 12:53 PM clock time.

Once the shadow has been marked you can, at your leisure, sight along the baseline from tower to mark to identify a more distant terrain feature. Then it's simply a matter of aligning the antenna boom along this line (with the rotator control set at north) to ensure an accurately calibrated direction indicator.

ham radio



a phone patch using junk-box parts

Old transformers
used in tube-type radios
are put to use
in this easy-to-build
phone-patch circuit

Often I get the urge to upgrade my station with one accessory or another. In these days of inflation, however, running out and buying accessories usually results in a severe wallet-ache. This article describes how you can raid your junk box rather than rob a bank to build a reliable phone patch. The best part is that the patch takes only a couple of hours to put together.

theory

The main problems to overcome in constructing the phone patch are impedance matching and converting the balanced condition of the telephone line to the unbalanced audio condition of the Amateur transmitter and receiver. A transformer with proper impedance specifications offers the easiest solution.

Not long ago, before transistors or integrated circuits were available, everyone used "field-effect transistors with heaters in them" — more commonly called tubes. Since the age of the inexpensive transistor has arrived, more and more tube-circuit power

transformers have been retired to the junk box. Here's an interesting application of these components.

Examination of the specifications of one of these transformers shows that it may be quite suitable for use in a phone patch. First, since power transformers are designed to operate at 60 Hz, there's little worry of audio distortion because of insufficient core material. Second, a review of the winding information shows good compatibility between an Amateur rig and the telephone line.

Eq. (1) shows the relationship of winding voltages to the winding turns ratio.

$$\frac{V_1}{V_2} = \frac{1}{a} \quad (1)$$

where V_1 = voltage across winding 1 (primary)

V_2 = voltage across winding 2 (secondary)

a = ratio of the number of turns of winding 2 with reference to winding 1

checking out the transformer

After blowing the dust off the old transformer, carefully determine which pair of wires constitutes the primary leads (usually the black pair). By measuring the voltages of the *open* windings while the primary is connected across the 120-volt house current, enough information may be obtained to calculate the turns ratio of the windings. (If your nerve is hardened to the idea of plugging a transformer into 120 Vac house current, a step-down transformer may be used to drive the winding.) I had a transformer with two windings in addition to the primary. The voltages

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measured on the open windings and the turns ratio calculated from eq. (1) are listed in table 1.

After the turns ratio has been determined, another equation may be used to determine the degree of impedance matching possible with the transformer. Eq. (2) relates the impedance that will be observed between the windings of a transformer if the transformer is "ideal." Although no transformer is ideal, most are very good, and the equation will closely predict the impedance relationships.

$$\frac{Z_1}{Z_2} = \frac{1}{a^2} \quad (2)$$

where Z_1 = impedance across winding 1 (primary)

Z_2 = impedance across winding 2 (secondary)

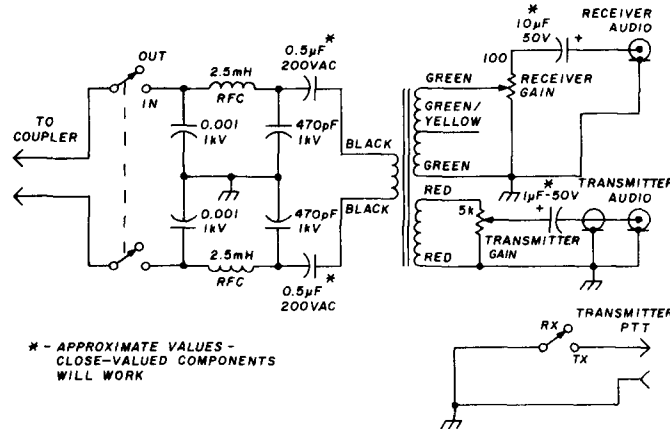
a = ratio of the number of turns of winding 2 with reference to winding 1

The telephone-line impedance is approximately 600 ohms. By using eq. (2), I calculated the impedances that would be present across the secondary windings if the primary were connected across the phone line. The results appear in table 2.

As may be observed from table 2, if the primary (black-black) is connected across the 600-ohm phone line, the 12-volt filament winding (green-green) will present a reasonable load to an 8-ohm speaker output from an Amateur receiver. Likewise, the high-voltage winding (red-red) presents a reasonable microphone input match to either high- or low-impedance Amateur transmitters.

construction

I constructed the phone patch in a minibox chassis. Fig. 1 illustrates the final circuit. Transmitter audio leads should be shielded cable.



* - APPROXIMATE VALUES - CLOSE-VALUED COMPONENTS WILL WORK

fig. 1. The K7NM phone patch made from junk-box parts. The transformer was salvaged from a tube-circuit radio. The text explains how to check out such transformers for compatibility with the telephone line.

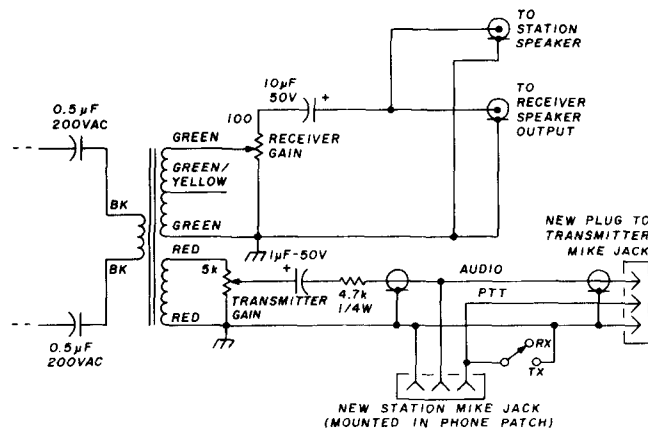


fig. 2. Alternative connection of transmit and receive audio to the transmitter.

table 1. Measured voltages from the power-transformer windings.

winding colors	voltage (Vac)	turns ratio (a)
black-black	120.0	1.000
green-green	12.6	0.105
green-green/yellow (center-tap)	6.3	0.052
red-red	240.0	2.000

table 2. Impedances across windings.

winding colors	turns ratio (a)	impedance (ohms)
black-black	1.000	600
green-green	0.105	6.62
green-green/yellow (center-tap)	0.052	1.62
red-red	2.000	2400

An rf filter was placed in the phone line to prevent rf from entering the transmitter audio through the patch from the phone line. This filter is only necessary if high power levels are used.

The coupling capacitors on the primary winding must be nonpolarized and have at least 200-Vac ratings. These capacitors prevent the primary transformer winding from shorting any telephone-line dc voltages that may be present.

The phone patch is connected to the station telephone through an acoustic coupler (to be installed by the phone company). It provides a 1/4 inch (6.4 mm) phone jack for the phone-patch connection. On most desk telephones, a button on the receiver hook must be lifted to activate the coupler. Wall phones will probably have some method of activating the coupler also. I've used only desk phones in the phone patches installed to date.

The receiver audio is connected in parallel with the station receiver speaker, reducing the receiver speaker load to about 4 ohms.

The transmitter input is connected to the phone-patch input jack on the rig. If no such input is provided, **fig. 2** illustrates an alternative method of connection to the transmitter. The phone patch is connected permanently to the transmitter through the microphone input jack. A new jack is mounted in the phone patch chassis for connection to the station microphone. The transmitter patch audio is coupled through a 4.7-k resistor into the audio line.

operation

When operating the phone patch, simply throw the switch located in the transformer primary to the IN position. The telephone must remain off the hook,

with the coupler button activated, to maintain the phone connection to the phone patch. I've found it convenient to use the telephone exclusively for modulation and monitoring during a phone-patch contact. The transmit switch is placed in the TX mode during transmit and returned to RX during receive periods, facilitating standard push-to-talk operation. When the patch is completed, the primary switch is returned to the OUT position.

Dual level adjustments exist for both receiver and transmitter levels to and from the phone patch. The receiver audio gains on both receiver and patch will affect the line level to the telephone. Also, both the transmitter level adjustment and the gain control in the phone patch will affect transmitter modulation level. To set levels, I set the receiver audio gain to a comfortable speaker volume and the transmitter level for proper modulation from the station microphone. Next, the patch was switched IN and the telephone removed from the hook with the coupler button activated. A single digit (other than 1) was dialed to remove the dial tone. The receiver patch gain was adjusted for a comfortable audio level in the telephone. Similarly, the patch transmitter level was adjusted for proper modulation of the transmitter while I counted into the telephone. If your city has a time number, this service could be used as a reliable source for the transmitter level adjustment. Once the patch levels are set, there should be no need for additional adjustments.

conclusion

Since the first phone patch, several others have been built and work very well. Even though **tables 1** and **2** show that a 6.3-volt filament winding has a very low impedance (about 2 ohms), I've successfully used transformers with this winding as a speaker winding.

Some tube-type transformers have dual 6.3-volt windings, while others may have both a 6.3-volt winding and a 5-volt winding. These transformer windings may be wired in series to improve speaker impedance matching.

Although this phone patch was not designed for VOX operation, some reports have been received that VOX has been used successfully. I've used this phone patch design on both the hf and vhf bands with excellent reports of audio quality. Often Amateurs inquire what kind of patch it is. It's simply a junk box special.

acknowledgement

I would like to thank Rob Yaw (WA7IAL) for his assistance during the testing of these phone patches.

ham radio

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Hustler's 5-BTV™ five band vertical antenna.

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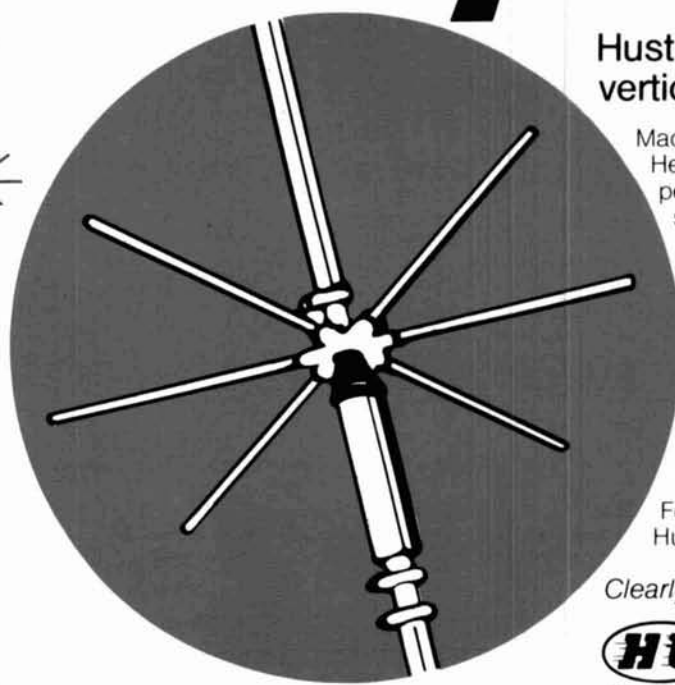
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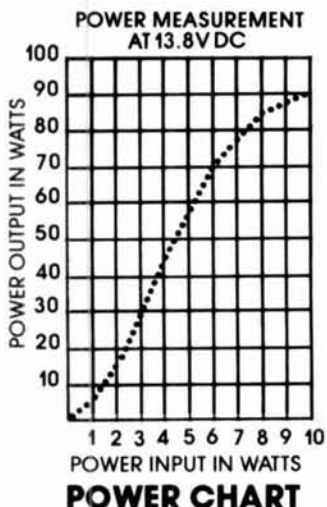
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a folded end-fire radiator

Introducing the "W8" —
an antenna
with modest gain
and interesting possibilities
for the experimenter

This antenna fits into an area approximately $1/10$ by $1/6$ wavelength and provides a compact, effective radiator for the lower-frequency bands. A slight reshaping converts it into a horizontally polarized, omnidirectional radiator for vhf. The antenna can be considered as a folded, series-connected, two-element, end-fire beam.

evolution

Start with a two-element, bidirectional, end-fire beam. If the feed is omitted, the essential elements are two half waves, closely spaced and excited equally but 180 degrees out of phase (fig. 1A). The arrows in fig. 1 indicate current flow, with the large arrows at current maxima. Spacing is usually $1/20$ - $1/5$ wavelength. Gain can approach 4 dB over that of a halfwave antenna.¹ Radiation is maximum

to left and right in the plane of the figure. For illustration, take spacing to be $1/10$ wavelength.

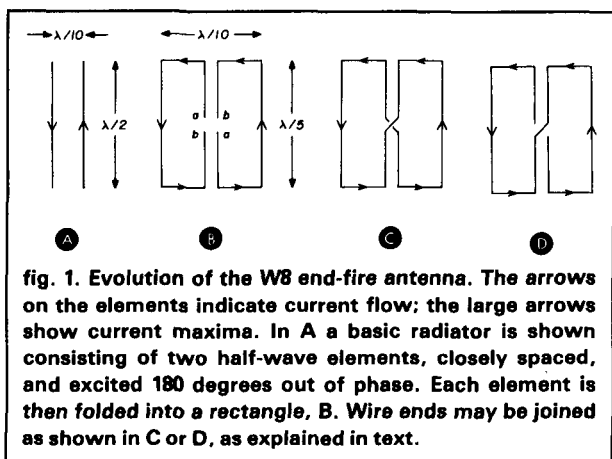
Now fold each element into a rectangle $1/10$ by $1/5$ wavelength, as shown in fig. 1B. Note that the wire ends labelled **a** are at the same rf potential; similarly, the ends labelled **b** are also at the same potential, opposite to that at **a**. These respective pairs of ends may therefore be joined without disturbing the current distribution as shown in fig. 1C. Note that the array now consists of one wavelength of wire folded into a sort of figure eight, accounting for its name, abbreviated "W8." At the center crossover point are two current nodes (voltage maxima). Fig. 1D is another possible arrangement with only one center crossover connected, about which more later.

There is nothing sacred about the $1/10$ by $1/5$ wavelength rectangle. For a low-frequency, vertically polarized array on a single pole the configuration of fig. 2 is appealing. The W8 can be squeezed or stretched, with directivity declining as the shape spreads horizontally (fig. 1).

feed methods and impedance

Of the various possible feeds, I've tried only one, balanced current feed, achieved by opening the W8 at a current maximum and attaching parallel-wire feeders, as in fig. 2. In December 1973 I measured a 6-meter model built to the $1/10$ by $1/5$ wavelength pattern and obtained a driving-point impedance between 400-500 ohms. Measurements were made

By Worthie Doyle, N7WD, 1120 Bethel Avenue, Port Orchard, Washington 98366



with a crude resistance bridge driven by a grid-dip meter. I hope someone who can make more reliable measurements will look into this. For this feed method 450 ohm TV ladder line should do well.

The W8 could be voltage fed at the center crossover point, using either tuned feeders or an open-wire matching transformer as in fig. 3. This might be convenient for the vertically polarized, one-pole configuration of fig. 2, particularly if you wish to run a line along the ground for some distance.

Finally, if the W8 is not broken at a current maximum you should be able to drive it by any of the methods used for plumbers' delights, in particular the gamma match applied at a current maximum. This might be a convenient choice for the omnidirectional W8 mentioned later.

performance and application

A reasonable guess at gain can be made by comparing fig. 1C and the basic, two-element endfire, fig. 1A. The center section, consisting of the folded ends of the original elements, is just a short section of open-wire line and can be expected to have negligible loss and radiation. Thus the only real waste represented by the configuration of fig. 1C is that which results from radiation from the horizontal portions. However, these useless portions are only half the length of the useful radiating sections and, in addition, contain portions of the current distribution farthest from the two current maxima. This argument suggests that gain should still be perhaps 2 dB over a similarly placed halfwave. The 40-meter vertically polarized version was used for a couple of years, but I have no way to make comparisons and can only hope this discussion will arouse some of the more ambitious experimenters.

An interesting comparison can be made with the quarter-wave vertical. If the configuration of fig. 2 is used and each radiating section makes a 45-degree

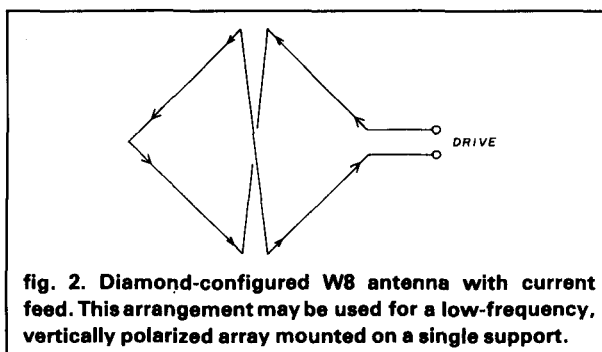
angle with the vertical, then the vertical extent of the array is somewhat less than a quarter wavelength. The mechanical disadvantage of the W8 is that guy cords are needed to position the two side corners of the diamond (I use nylon fish line). On the other hand, the W8 requires no radials or ground plane, and its current maxima are elevated to the array center. This should make it practically simpler to achieve low-angle radiation with a W8.

The small gain of the W8, though interesting, will be swamped by the effects of propagation and interference. Its main advantage is relative simplicity and compactness. A 40-meter horizontal W8, for example, could be supported slightly above your roof in about the same space as a full-sized, two-element 8JK for 20 meters.

dimensions and adjustment

The 6-meter model used 20 feet (6 meters) of wire arranged in a 2 by 4 foot (0.6 by 1.2 meters) rectangle, with the center section of transposed line spaced about 3/4 inch (19 mm). With a small loop soldered across an opening at the center of one side, the grid dipper resonated at about 50 MHz.

When the 40-meter model was put together, 136 feet (41.5 meters) of wire were used at first in the antenna proper, with 68 feet (20.7 meters) of open wire line to the house. When this arrangement was grid-dipped at the sending end, the resonant frequency turned out to be 5.8 MHz. The explanation for this remarkable discrepancy is the capacitive loading effect of the W8 center section. On the 40-meter model, the spacing in wavelengths was closer by a factor of 7 than the spacing on the 6-meter model. As noted in the section describing the evolution of the W8, the center crossover point and most of the center section of line are at high rf potential, so capacitance here is very effective in loading to a lower frequency. The major advantage of the W8 is its compactness, however, and this loading effect makes the antenna even more compact. Incidentally, a small lumped capacitance across the center crossover point is a conveni-



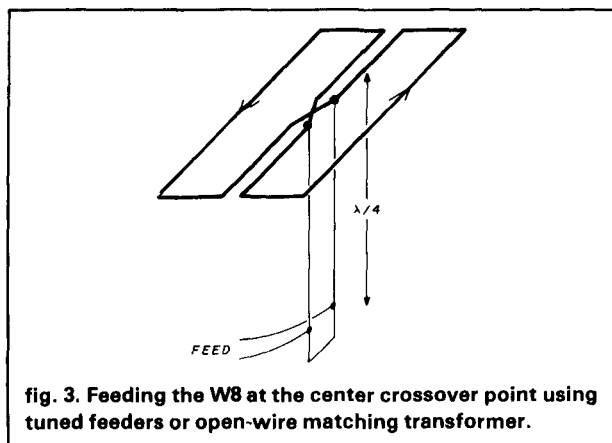


fig. 3. Feeding the W8 at the center crossover point using tuned feeders or open-wire matching transformer.

ent way to tune a vhf W8 to a lower frequency. This was checked in the 6-meter model.

To adjust the 40-meter W8, two steps were taken. The center line section spacing was increased from 3/4 inch (19 mm) to about 3 inches (76 mm) to reduce the loading effect. Then the lengths of the four vertical wires (two radiating portions and the center line section) were gradually reduced from an original 28 feet (8.5 meters) to a final 21 feet (6.4 meters). At this point the antenna, crudely draped horizontally about 4 feet (1 meter) off the ground, grid-dipped at about 7.1 MHz. The full width across the top is 14 feet (4.3 meters). The vertical extend of this W8 is about 1/6 wavelength at the operating frequency.

A few years later the 40-meter W8 was replaced by a 75-meter version following fig. 2. Its slanting sides were 28 feet (8.5 meters) long, forming a square standing on one point, with the center vertical section of line 40 feet (12 meters) long. These dimensions were only a first guess based on experience with the 40-meter model, although the antenna worked about as expected. Although the main radiation was vertically polarized endfire, there was a significant horizontally polarized radiation broadside. Total length of wire in this version was 192 feet (58.7 meters) or about 0.76 wavelength. For the rectangular 40-meter configuration, the total length of wire was 112 feet (34 meters) or about 0.82 wavelength. The diamond configuration produces more center loading, so the shorter length is reasonable, although resonant frequency is unknown for the 75-meter version.

node forcing

An interesting question about the W8 or any other electrical-full-wavelength continuous conductor, such as a quad loop, is, "What determines the location of the current maxima?" Presumably this is fixed by the feedpoint and by the actual loop resonant fre-

quency. If a damped wave train were excited in an unattached loop at a frequency not exactly resonant, you'd expect the current maxima to chase around the loop as the wave train died away rather than remain at fixed locations. However, if the loop were opened at one point, this point is compelled to be a current node.

This brings us to the variation of fig. 1D, where one of the center crossover points is closed while the other remains open, forcing the array to produce a current node at the open ends. I've used the 40-meter W8 with both crossover points connected and with only one connected. As expected, I found no difference.

As an aside, it seems possible that some of the occasional disappointments with quads whose elements are either mistuned or incorrectly coupled might be partly explained by the current distributions on the parasitic elements having "slipped" around the loop, so that the current maxima are not in line with those of the driven element. This may help to explain why quads occasionally "squint." Although I've never heard of anyone doing so, it should be similarly possible to ensure the current distribution on quad loops, particularly the parasitic elements, by opening one of the vertical sides a quarter wavelength from the driven-element feedpoint and at corresponding points for the parasitic elements.

horizontally polarized omnidirectional radiator

When the current maxima are close together, as in fig. 1C, the W8 should have a directivity in its own plane similar to that of the two-element 8JK beam: a figure-eight pattern with the nulls filled in a bit by the radiation from the short ends of the rectangle. As the shape is pulled out, so that the current maxima are farther apart and the center section of line is shorter, more of the current distribution contributes to radiation over the whole of the plane of the array.

It's clear that, if the shape is pulled out to something like that in the sketches of fig. 4, the pattern in the plane of the array will be close to omnidirectional. In three dimensions the pattern should be roughly doughnut shaped. If the array is mounted in a horizontal plane, the result will be omnidirectional horizontal polarization. Because the current maxima pro-

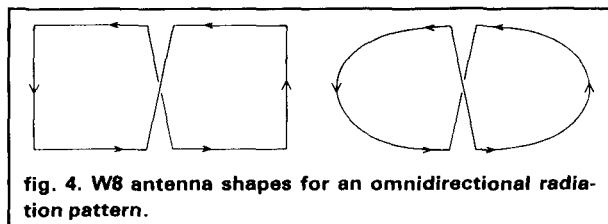


fig. 4. W8 antenna shapes for an omnidirectional radiation pattern.

vide greatest radiation, it's necessary to pull out the shape past the point where it's roughly square or circular. For a start you might try an ellipse with about a 2:1 axial ratio or a rectangle about 1/4 by 1/8 wavelength, as suggested in fig. 4. I hope some vhf experimenter will take a shot at this.

If rod or tubing is used for construction, a quarter-wave transformer can be used for combined support and symmetric center voltage feed, as shown in fig. 3. If you wish to force two current nodes, one of the crossover points can be left open and the corresponding end of the quarter-wave transformer also left free, resulting in a Zepp-fed arrangement.

At vhf, horizontal W8s could also be stacked to produce an omnidirectional array with gain and horizontal polarization. The optimum stacking distance for antennas with some gain of their own is greater than a half wavelength. A convenient choice with the W8 would be one wavelength interconnecting feedlines, bent enough to accommodate the desired spacing.

odds and ends

The W8 is essentially a one-band antenna because the capacitive loading of the center section causes its natural modes not to be harmonically related. However, it can be used at harmonics if one employs tuned, open wire feeders, as I do. Such use should be considered makeshift rather than desirable. I have used the 75-meter version on 40 meters, where the pattern should be roughly omnidirectional with a slight bias toward broadside. On the third harmonic I'd expect a slight endfire directivity.

This may also be the place to point out that the W8 is a narrowband antenna compared to a halfwave antenna. This is a property it shares with the 8JK, although the W8 antenna bandwidth can be expected to be somewhat narrower than that of the 8JK because of its smaller size and center loading. The current maxima are about a quarter wavelength apart, so I'd expect the omnidirectional version of the W8 to have somewhat greater bandwidth than that of the 8JK, however.

A major aim of this article is to interest people with access to facilities in carrying out gain and impedance measurements and in experimenting with the omnidirectional version. I've tried without success to find any hint of this simple but interesting configuration in the commonly available works on antennas.

reference

1. John D. Kraus, *Antennas*, McGraw-Hill, 1950, sections 11-3 and 11-5.

ham radio



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TS-830S FEATURES:

- LSB, USB, and CW on 160-10 meters, including the new 10, 18, and 24-MHz bands. Receives WWV.
- Wide receiver dynamic range. Junction FETs in the balanced mixer, MOSFET RF amplifier at low level, and dual resonator for each band.
- Variable bandwidth tuning (VBT). Varies IF filter pass-band width.

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- IF shift (passband tuning).
- Built-in digital display (six digits, fluorescent tubes), analog subdial, and display hold (DH) switch.
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- 6146B final with RF negative feedback. Runs 220 W PEP (SSB)/180 W DC (CW) input on all bands.
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OPTIONAL ACCESSORIES:

- SP-230 external speaker with selectable audio filters.
- VFO-230 external digital VFO with 20-Hz steps, five memories, digital display.
- AT-230 antenna tuner/SWR and power meter/antenna switch; 160-10 meters, including three new bands.
- YG-455C (500-Hz) and YG-455CN (250-Hz) CW filters for 455-kHz IF.
- YK-88C (500-Hz) and YK-88CN (270-Hz) CW filters for 8.83-MHz IF. (VFOs for TS-830S, TS-130 Series, and TS-120S are compatible with all three series of transceivers.)



SP-230

TS-830S

VFO-230

AT-230

TS-130S/V

"Small wonder"... processor, N/W switch, IF shift, DFC option

The compact, all solid-state HF SSB/CW mobile or fixed station TS-130 Series transceiver covers 3.5 to 29.7 MHz, including the three new bands.

TS-130 SERIES FEATURES:

- 80-10 meters, including the new 10, 18, and 24-MHz bands. Receives WWV.

- TS-130S runs 200 W PEP/160 W DC input on 80-15 meters and 160 W PEP/140 W DC on 12 and 10 meters. TS-130V runs 25 W PEP/20 W DC input on all bands.
- Built-in speech processor.
- Narrow/wide filter selection on both CW (500 Hz or 270 Hz) and SSB (1.8 kHz) with optional filters.

- Automatic selection of side-band mode (LSB on 40 meters and below, and USB on 30 meters and above). SSB REVERSE switch provided.
- Built-in digital display.
- Built-in RF attenuator.
- IF shift (passband tuning).
- Effective noise blanker.

OPTIONAL ACCESSORIES:

- PS-30 base-station power supply.
- YK-88C (500 Hz) and YK-88CN (270 Hz) CW filters.
- YK-88SN (1.8 kHz) narrow SSB filter.
- AT-130 compact antenna tuner (80-10 meters, including three new bands).

- SP-120 external speaker.
- VFO-120 remote VFO.
- MB-100 mobile mounting bracket.
- PS-20 base-station power supply for TS-130V.



Optional DFC-230 Digital Frequency Controller

Frequency control in 20-Hz steps with UP/DOWN microphone (supplied with DFC-230). Four memories and digital display. (Also operates with TS-120 and TS-830S.)



PS-30

SP-120

TS-130S

VFO-120

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easy tuning, digital display

The R-1000 is an amazingly easy-to-operate, high-performance, communications receiver, covering 200 kHz to 30 MHz in 30 bands. This PLL synthesized receiver features a digital frequency display and analog dial, plus a quartz digital clock and timer.

R-1000 FEATURES:

- Covers 200 kHz to 30 MHz continuously.

- 30 bands, each 1 MHz wide.
- Five-digit frequency display with 1-kHz resolution and analog dial with precise gear dial mechanism.
- Built-in 12-hour quartz digital clock with timer to turn on radio for scheduled listening or control a recorder through remote terminal.
- Step attenuator to prevent overload.

- Three IF filters for optimum AM, SSB, CW, 12-kHz and 6-kHz (adaptable to 6-kHz and 2.7-kHz) for AM wide and narrow, and 2.7-kHz filter for high-quality SSB (USB and LSB) and CW reception.
- Effective noise blanker.
- Terminal for external tape recorder.
- Tone control.
- Built-in 4-inch speaker.
- Dimmer switch to control intensity of S-meter and other panel lights and digital display.

- Wire antenna terminals for 200 kHz to 2 MHz and 2 MHz to 30 MHz. Coax terminal for 2 MHz to 30 MHz.
- Voltage selector for 100, 120, 220, and 240 VAC. Also adaptable to operate on 13.8 VDC with optional DCK-1 kit.

OPTIONAL ACCESSORIES:

- SP-100 matching external speaker.
- HS-5 and HS-4 headphones.
- DCK-1 modification kit for 12-VDC operation.



SP-100

R-1000



HS-5



HC-10

Digital world clock with two
24-hour displays, quartz time base

The HC-10 digital world clock with dual 24-hour display shows local time and the time in 10 preprogrammed plus two programmable time zones.

HC-10 FEATURES:

- Two 24-hour displays with quartz time base. Right display shows local (or UTC) hour, minute, second, day. Left display shows month, date, world time in various cities,

- memory time (QSO starting time), and time difference (in hours from UTC).
- Preprogrammed time in 10 cities around the world, plus two programmable time zones.
- "TOMORROW" and "YESTERDAY" indicators.
- Memorization of present time. Can be recalled later, for logging purposes.
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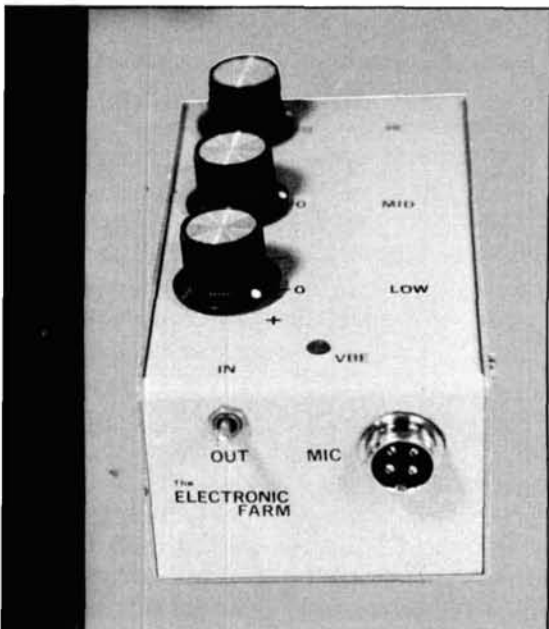
DM-81

Dip meter
performs many RF
measurements

The DM-81 dip meter is highly accurate and features, in addition to the traditional inductive-coupling technique, capacitive coupling for measuring metal-enclosed coils and toroidal coils.

DM-81 FEATURES:

- Measuring range of 700 kHz-250 MHz in seven bands.
- Built-in storage compartment for all seven coils, capacitive probe, earphone, and ground clip lead.
- All solid-state and built-in battery.
- HC-25U and FT-243 sockets for checking crystals and marker-generator function.
- Amplitude modulation.
- FET for good sensitivity.
- Absorption frequency meter function.
- Earphone for monitoring transmitted signals.
- Capacitance probe for measuring resonant frequencies without removing coil shields, and also for measuring resonant frequencies of toroidal coils.



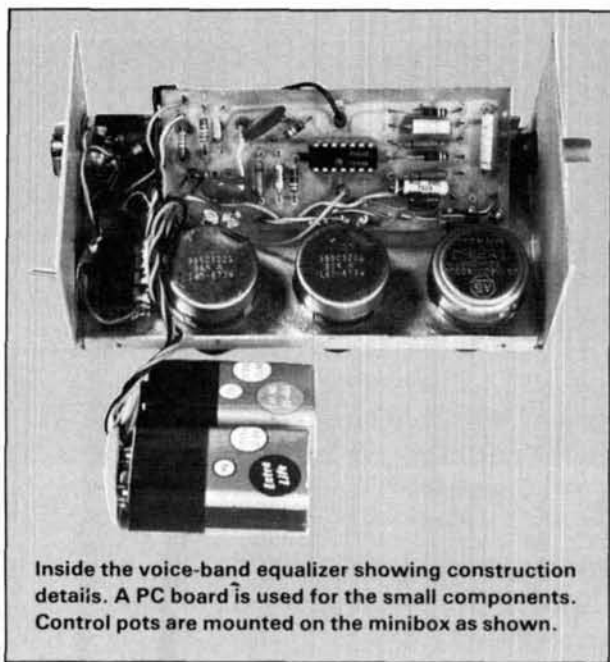
the voice-band equalizer

This addition
to your phone station
uses an LM324 quad op amp

Here is an equalizer for your microphone that plugs into the microphone jack. The voice-band equalizer (VBE) gives you control of your microphone frequency response. Three adjustments allow you to balance the low, mid-range and high frequencies. The VBE uses three bandpass filters designed to work on the most important part of the vocal spectrum. The passband of your transmitter (2.4 kHz nominal) is the section of audio frequencies I call the "voice band." The VBE divides this important voice band into three parts: low, mid-range and high. By adjusting three controls you can change your audio characteristics. You can boost mid-range and high frequencies to add punch — or accentuate low frequencies for more bass — all without changing your microphone. You can easily build the VBE in a few hours.

This article shows how to work with and apply contemporary active circuits to an Amateur Radio design. Well-known passive tuned-circuit theory is reviewed, and newer tuned-circuit theory and design are introduced. The article also gives information on standard construction practices and how these are

applied to build the VBE. Also shown is how to use existing equipment and resources to test the VBE. The voice-band equalizer is a project that will impart a sense of pride and accomplishment to the Amateur who builds one.



Inside the voice-band equalizer showing construction details. A PC board is used for the small components. Control pots are mounted on the minibox as shown.

By R. Bradley, WB2GCR, Box 144, Hannacroix, New York 12087

circuit design

I built the circuit around an LM324 quad op amp. The LM324 consists of four independent operational amplifiers in a 14-pin DIP package. Each amplifier is internally compensated. Three of the amplifiers operate as tuned circuits; one combines the action of the three separate tuned circuits. Each of the three active tuned circuits acts like the passive tuned circuit of **fig. 1**. Using the active rather than passive tuned circuits eliminates the need for bulky and expensive inductors. In **fig. 1** L , C , and R are combined to form a series-resonant circuit. At resonance, the electrical energy presented to LCR is shunted to ground and the inductive reactance, X_L , and capacitive reactance, X_C are equal. Also, at resonance, the impedance of the LC combination is theoretically zero ($X_{LC} = 0$).

The inductive reactance creates a current lag of 90 degrees, while at the same time the capacitive reactance creates a current lead of 90 degrees. Since the two reactances ($X_L + X_C$) are equal and opposite in phase, they cancel. In practice the impedance at resonance is never actually zero. The Q of this series-resonant LC circuit is an expression of the ability of the circuit to reach "zero" impedance with respect to frequency:

$$Q = \frac{F_r}{\Delta F(0.707 F_r)} \quad (1)$$

where Q = quality factor

F_r = resonant frequency

ΔF = excursion of frequency from F_r

Also, $Q = \frac{X}{R}$, where X = reactance (ohms) and R = series resistance (ohms) for passive series-resonant circuits. The resonant frequency of the circuit is:

$$F_r = \frac{1}{2\pi\sqrt{LC}} \quad (2)$$

The passive RLC circuit has low impedance at resonance and high impedance at other frequencies. So energy entering the RLC circuits through the control pots (**fig. 1**) will be shunted to ground at resonant frequencies. As you move the pots toward the noninverting amplifier, input signal is deleted from this input and attenuation occurs within the bandwidth of RLC . Similarly, when the control pot is turned in the opposite direction (toward the inverting input), frequencies are deleted to the IC, causing gain within the bandwidth of RLC . Placing the control pot in the center of rotation causes equal effect on both inverting and noninverting inputs. The amplifier output is then flat.

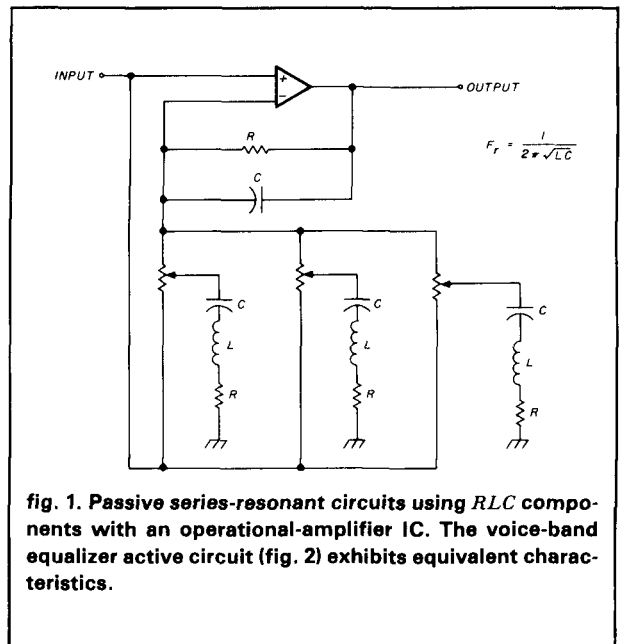


fig. 1. Passive series-resonant circuits using RLC components with an operational-amplifier IC. The voice-band equalizer active circuit (fig. 2**) exhibits equivalent characteristics.**

active circuit

The operation of the active circuit for the VBE, **fig. 2**, is similar to that of the passive design shown in **fig. 1**. Let's look at how the active circuit works. Amplifiers U1B, U1C, and U1D are used in active tuned circuits.² The active design eliminates the need for inductors.

Now, instead of the center (or resonant) frequency being controlled by LC values, C20 and 21 determine the center frequency. R21 and 22 also affect the center frequency. I kept their value constant, since they

table 1. Suggested values for the active tuned circuits. Center (resonant) frequencies have been determined using the equation in **fig. 2.**

filter	resonant frequency (Hz)	capacitor (fig. 2)	value (μF)
low frequencies	335	C21	0.2
	410	C21	0.01
		C20	0.15
	521	C21	0.01
		C20	0.15
	mid-range frequencies	1299	C21
C30			0.05
1412		C31	0.003
		C40	0.047
1959		C31	0.0022
		C40	0.033
high frequencies	2905	C41	0.002
		C40	0.033
	3558	C41	0.001
		C40	0.02
		C41	0.001

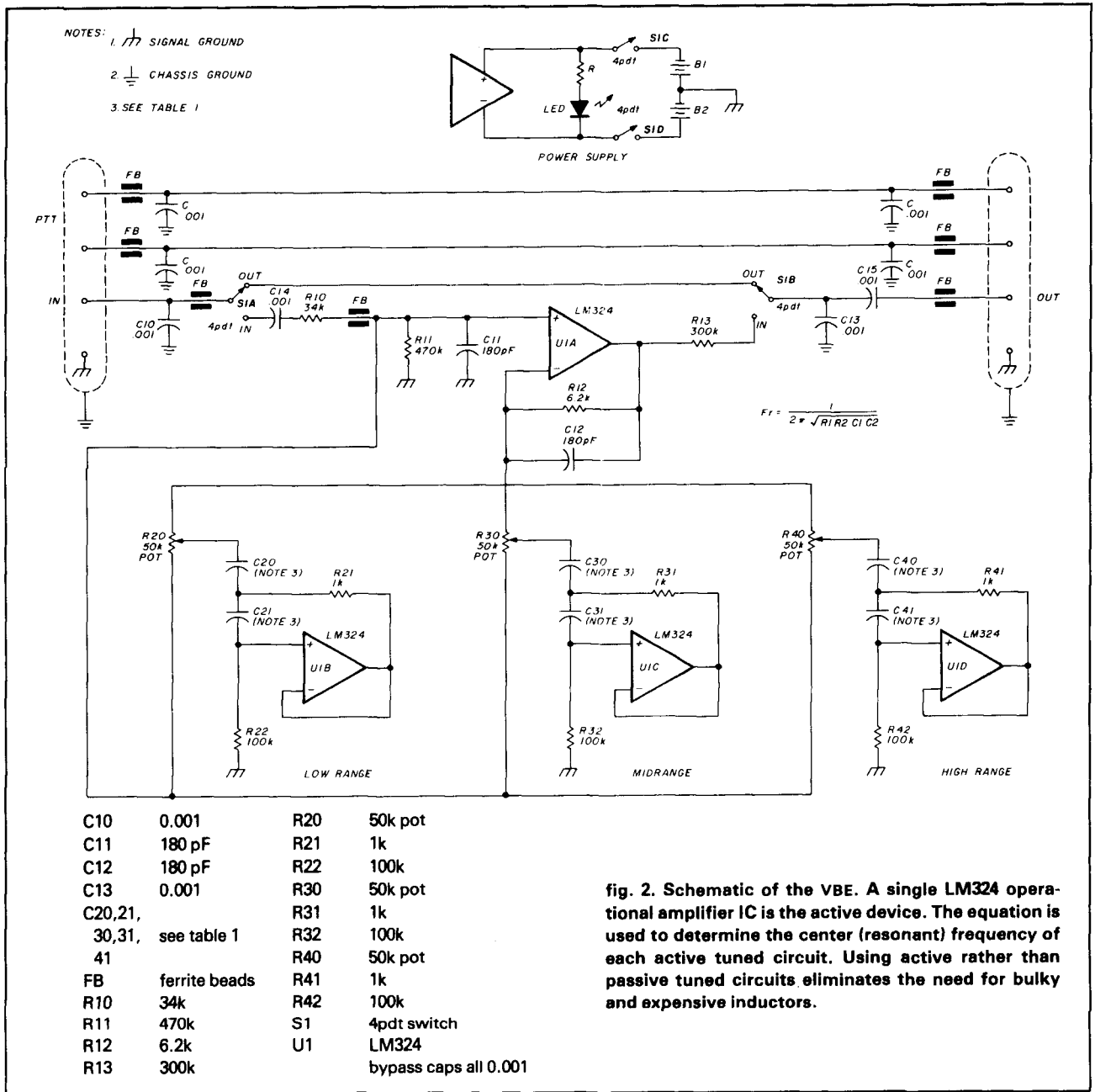


fig. 2. Schematic of the VBE. A single LM324 operational amplifier IC is the active device. The equation is used to determine the center (resonant) frequency of each active tuned circuit. Using active rather than passive tuned circuits eliminates the need for bulky and expensive inductors.

also control the Q . The circuits of U1B, U1C, and U1D are identical except for the center frequencies, which are controlled by the capacitor values. The center (resonant) frequency, can be computed by the equation shown in fig. 2.

In table 1 I've provided some suggested component values and center frequencies for fig. 2. Use 10 per cent or better tolerance values of C to ensure that the center frequencies arrive at computed values.

calculator input

Table 2 is an algorithm for TI30 or similar calcula-

tors. If you decide to experiment with the formula in fig. 2, the calculator algorithm will save time and work. Whether you work longhand or use a calculator, remember that the C values in the equation are in farads; the typical circuit values are in microfarads (μF). Remember also to divide the μF value by 10^6 to convert to farads before substituting into the equation.

bandpass filters

The VBE requires three bandpass filters. The problem is to generate a bandpass characteristic using

only one op amp and a minimum number of related components. At first glance, the circuit of fig. 2 might appear to be a highpass and a lowpass section. A bandpass characteristic can be generated by the circuit of fig. 2 because, at sufficiently high Q , both low and highpass active circuits exhibit bandpass functions.³ The peaks shown in fig. 3 illustrate the similarity to a bandpass function that the lowpass and highpass functions can exhibit. The circuits of U1B, U1C, and U1D (fig. 2) each generate a function similar to those of fig. 3 and fig. 1. To combine the three active circuits, I use each to independently control the response of a master amplifier, U1A. Its output reflects the constant Q peak generated by U1B, U1C, and U1D. The characteristics of the three tuned circuits remain constant. Only the response of U1A is modified by the degree to which U1B, U1C, and U1D are inserted. The VBE circuit gives ± 12 dB of adjustment with minimal interaction between controls.

construction

Construction of the voice-band equalizer is divided between the single PC board and the box that encloses it. Most of the components are mounted on the board. The layout shown in fig. 4 is compact and contributes to easy assembly. Ample space is provided for components of many different sizes. The single quad op amp (LM324) greatly simplifies layout and parts placement. You'll have no difficulty building

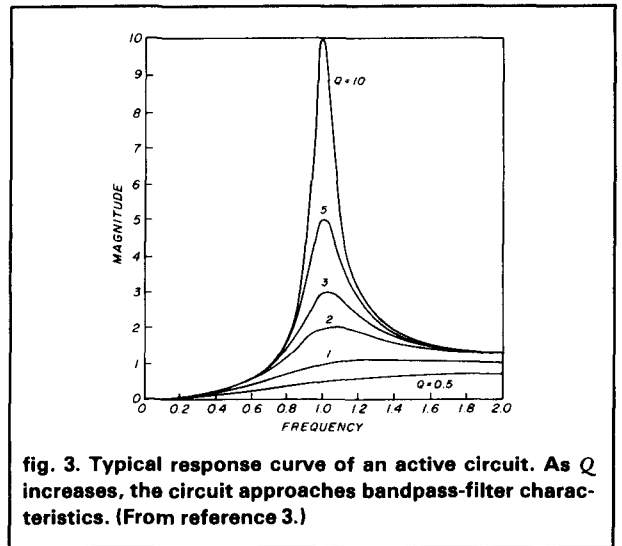


fig. 3. Typical response curve of an active circuit. As Q increases, the circuit approaches bandpass-filter characteristics. (From reference 3.)

the VBE if you follow the suggested layout. If you choose to experiment with single or dual op amp packages, you'll have to duplicate plus and minus power-supply lines as well as the ground connections.

Follow the general layout in either case to simplify construction and ensure predictable results. Be sure to use good electronic and mechanical techniques. Use a low wattage soldering iron, 60/40 solder, and watch for solder bridges, especially near the IC socket.

table 2. Algorithm for determining center (resonant) frequency of each VBE tuned circuit. The algorithm is for a TI30 (or later) calculator.

enter	press	display	notes
R1	x	R1	R in terms of ohms
R2	=	R1R2	the calculator has automatically converted to scientific notation
	STO	R1R2	place R1R2 in memory
	REC	R1R2	check memory
	CL	0	clear
C1	EE	C1	converting to scientific notation
	+ / -		negative exponent
6	x	$C1 \times 10^{-6}$	C in terms of farads. (Don't press = yet.)
C2	EE		converting again
	+ / -		
6	=	$C1 \times C2$	$C1C2$ product in scientific notation
	x		
RCL(R1R2)	RCL		R1R2 from memory
	=	$\frac{R1R2C1C2}{\sqrt{R1R2C1C2}}$	in scientific notation
	$\sqrt{\quad}$		square root
	x		times
2	x		two, times . . .
π	=	$2\pi \times \sqrt{\quad}$	pi
	=	F_0	F_0 (center frequency) in scientific notation
	x		
1	INV		
	EE		convert back to Hz
	=	$F_0 = \text{Hz}$	your answer

fig. 4. VBE circuit board showing foil side.

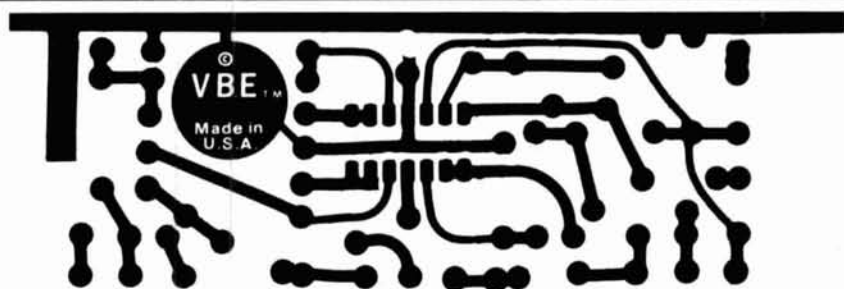
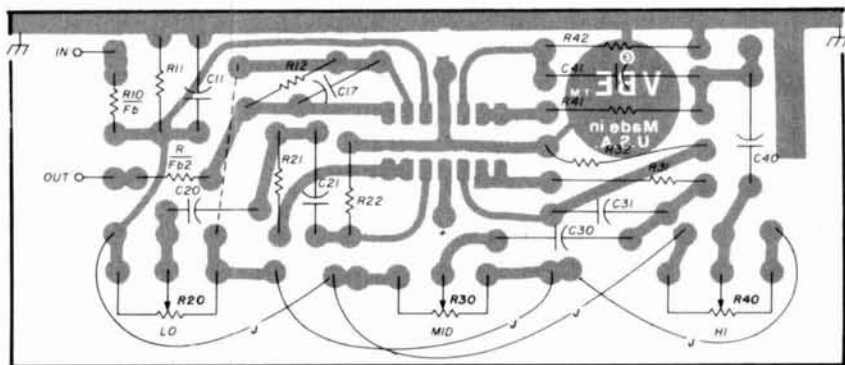


fig. 5. Component placement for the VBE. Control pot jumpers are mounted on the board but are shown off the board for clarity. Switch SW1 mounts onto the chassis as shown.



I started to build the VBE with the printed circuit board.⁴ Etch and drill the PC board. I drilled the nine control-pot connection points to accept small eyelets. I used the three pots to provide a convenient way to mount the board in the box (the copper foil is not strong enough for this). The eyelets provide a strong mechanical connection for the pots. I found this method convenient, but you can use wires for mounting the pots and other means to mount the PC board. I used a good quality 14-pin IC socket for the LM324 op amp. Molex pins or even direct soldering would work too. Next, I mounted the resistors and the jumper according to the parts placement shown in fig. 5. The jumper runs under C20.

Include ferrite beads on the legs of R10 and R13. I installed the capacitors next, and then the jumpers for the control pots. I did not mount the controls until after the holes were drilled into the box. Since I soldered the controls directly to the eyelets on the circuit board, the holes in the box must line up exactly with the controls that have been soldered to the circuit board.

Once the holes have been drilled for the controls, place the pots loosely into the holes, from the outside of the box. Now solder the main board to the controls and they will line up for a good fit. Mount the foil side of the board toward the knob side of the controls so that clockwise rotation results in gain.

The smallest box I could find to fit the VBE was 5 x 3 x 1-3/4 inch (12.7 x 7.6 x 4 cm) minibox. The small box requires good construction techniques and a fair amount of care to make all the parts fit correctly. You can use a larger box for easier construction. A 5-1/4

x 3 x 2-1/8 inch (13 x 7.6 x 5 cm) minibox is a good size. Before drilling the box, I placed all the parts in their relative positions to see how they fit together. Be sure to leave enough space for the batteries, switch, indicator LED and cables or connectors that you choose. Beware of the screws that hold the box together! Drill the required holes and mount the connectors, switch, and LED. This is a good time to attach labels to the box.

S1 controls the power and the input-output switching. When you turn on the VBE, you're also placing it on line. In a pinch you can use two separate switches (dpdt) instead of one 4 pdt; just remember to use them both together! I covered the tail of the switch with some electrical tape to prevent accidental short circuits. Remember that the input and the output are connected to the switch at the front of the box. I forgot this and cut some of the wires too short before realizing it and making corrections. Also don't forget the wires for the PTT circuit. It's a good idea to keep as much rf energy as possible out of the active circuitry. Note the use of ferrite beads and bypass caps. I put some beads inside the connectors to and from the rig and microphone for good measure.

working with the circuit

Two good-quality 9-volt batteries will operate your VBE for many hours. Current consumption is on the order of 30 mA at 15 volts for full rated output. Typical quiescent current is less than 2 mA. The LED indicator can draw as much as several times the current of the circuit, so I chose a low-current LED to increase battery life. I used two batteries to supply

both plus and minus voltages to the LM324 op amp. The bipolar power supply simplifies circuit design and operation; many single-supply designs require additional components to create an artificial ground and to provide a low-impedance dc return for the input circuit. The minibox has enough space to include an ac power supply as an alternative to battery operation.

Some of the newer solid-state transceivers require that the microphone ground return be separate from the chassis ground. Also, some rigs require a separate ground return for the PTT control lines. Be sure to follow your manufacturer's schematic and instructions explicitly. Misconnecting these critical ground returns can often result in erratic operation or oscillation without apparent cause.

An additional number of filters could be added to the VBE circuit by an enterprising builder. Simply add extra controls and extra active tuned circuits. Adjust their frequency centers by substituting C values according to the equation shown in **fig. 2**.

I used an audio sweep generator and scope to check the VBE. Even if you don't have this equipment available, all you need is a variable-frequency signal source and an output indicator.

If you don't have a signal generator you can use your SSB receiver as the signal source. Place the receiver in the calibrate mode and use the audio output as your signal source. Disconnect the antenna to eliminate background noise and keep the af gain low. An oscilloscope is the best output indicator. You could use an ac VTVM or even a standard VOM in a pinch. The VOM will probably give only a relative indication. The VOM is a linear voltage indicator and it doesn't have flat frequency response. Your tape recorder RECORD meter is a good indicator. It has logarithmic calibration and is reasonably flat for the narrow voice band. Sweep the frequencies and note the output on the indicator you're using. I found it useful to plot the levels onto a graph to get a visual feel for the way the controls work. If you monitor the output you'll hear the VBE operate.

using the VBE

The voice band equalizer low-, mid-, and high-range controls each have a total range of about 24 dB. Each control can boost to 12 dB. The same control can also attenuate as much as 12 dB. A full 12 dB is a considerable amount of gain in a relatively narrow bandwidth. Often the addition of gain will require readjusting the transmitter microphone gain. I watch the ALC indicator on my rig to avoid overdriving.

I often find it more useful to use attenuation to produce the desired response. I try to balance the

boost then attenuate to keep an even average level. For example, I boost the mid and high ranges, but at the same time roll off the lows. Or sometimes I boost the lows but also roll off the highs. Turning up all three controls together offers no real advantage.

I've also found that listening to a tape recording of my station is a good way to hear the VBE work. The next best thing is to let a fellow ham borrow your VBE so you can hear how it sounds on the air. Reports from other hams can be misleading. On SSB the receiver varies the pitch as you tune a signal. This effect makes it difficult for others to describe the sound of the VBE. Keep in mind that the VBE doesn't add any distortion of its own, and most hams have come to expect some distortion from transmitting audio accessories. Using the VBE is most like having several different microphones to choose from. When I heard a tape played of myself, I could hear the sound of the VBE right away. Hearing the VBE myself helped me know when and how to best make adjustments.

speech processors and the VBE

A normal speech pattern consists of highly varied peaks and valleys of rather low average level. Speech processing is a method of creating a more constant pattern with higher average level; this is why a speech processor seems to increase signal strength. Audio limiters, clippers, compressors and rf processors are methods commonly used. Often speech processing will upset your normal tonal balance, imparting exaggerated qualities: too much bass, too many highs, not enough bass. If you already use a processor, the VBE can give you extra control. By using both a processor and the VBE, you can make changes in the sound of the processed audio.

conclusion

The voice-band equalizer offers a new dimension in control and flexibility. Its straightforward design means that the average Amateur can build it successfully. To assist those who may have difficulty finding parts, I can supply many of them at a nominal cost. If you have any questions concerning the VBE or require information or parts, please send me a letter with a self-addressed stamped envelope for a prompt reply. I'll be glad to answer your questions if I can. The basic circuit of the VBE can be used in many applications limited only by your creative ability.

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2. *Linear Applications*, Volume I, National Semiconductor Corporation, Application Note AN 31-14.
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ham radio

installing radials

for vertical antennas

A novel approach
to the problem of
installing radial wires
in a grass lawn

Antennas and propagation are always prime topics for discussion by hams. Each ham develops his favorite type of antenna and will readily champion it to any who are willing to listen. Most antenna discussions are a combination of myth and reality, success and failure. I'd like to share my experience with a vertical antenna.

the vertical antenna

The mention of vertical antennas brings many thoughts to mind. How many have heard these or similar comments from time to time: "A vertical antenna radiates equally poorly in all directions." "You have to copperplate your backyard to make it work at all." "I just nailed it to my fence post and got DXCC in six months."

I'm neither going to make any fantastic claims, nor tell a tale of failure. I will describe a technique of stringing radials that I used as a solution to my vertical antenna installation problems.

The antenna I used was the Hustler 4BTV. This antenna can be used with or without radials when ground mounted. I preferred to use radials, but how many and how long? To answer these questions I researched the literature on vertical antennas. Most of this material indicated that many radials produced the best performance. I was limited by my lot size in the length of radials I could run. Two articles were of particular interest to me because of the problems I was attempting to solve.^{1,2} Using the information in these articles, I decided to use 14 radials each 25 feet (7.6 meters) long. Now I had to decide how to install them.

installation

Installation of radials is another topic that has many "best ways." One method is to bury the radials, while another is to place the radials on top of the earth. Burying the radials defeated my purpose, and placing them on top presented a safety hazard to neighborhood children. I needed something in between.

I derived my method from two completely different bits of information. The first was from an antenna ar-

**By H. Vance Mosser, K3ZAP, 44 Sabino Circle,
Las Vegas, Nevada 89110**

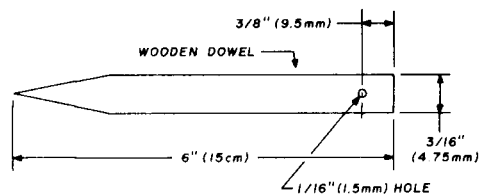


fig. 1. Threading tool made from a piece of wood dowel.

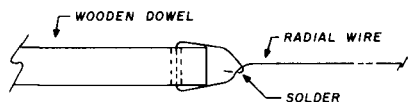


fig. 2. Method for securing radial wire to the wooden threading tool, or "needle."

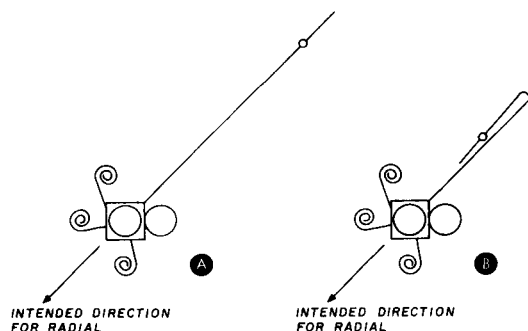


fig. 3. Preparing radials for threading into a grass surface. Each radial is uncoiled and laid on the ground in a direction opposite to that in which it is to be laid along the earth, (A). Sketch (B) shows how the wooden needle is placed underneath the antenna base and pointed in the desired direction. These views are shown looking down on the antenna base.

ticle in which the radials were laid on the ground and grass seed sown over them: when the grass grew, the radials were held under the grass so that you could walk on them, or even mow the lawn, and not disturb the radials. My lawn was in place and I didn't want to strip it out and replant it. However if I could place radial wires along the ground *under* the grass, perhaps the safety advantage was attainable.

The second piece of information was my memory of how I lost many arrows while an archery student many years ago. When I missed the target, the arrows struck the ground at a very shallow angle and traveled along the earth beneath the grass, sometimes becoming completely buried. If I could fashion a tool to penetrate the grass like an arrow perhaps it could pull the radial wires behind it under the grass.

The tool I developed is similar to a large sewing needle. I used pieces of 3/16-inch (4.75 mm) diameter hardwood dowel cut 6 inches (15 cm) long. I sharpened one end of each dowel in a pencil sharpener; then I drilled a 1/16-inch (1.6 mm) diameter

hole through the dowel 3/8 inch (9.5 mm) from the end (fig. 1). I made 14 of these needles — and was then ready to begin laying the radials.

Each radial consisted of a length of No. 22 (0.6 mm) copper wire, wire obtained from a 50-foot (15-meter) spool of twisted antenna wire (Radio Shack catalog no. 278-1329). This twisted wire, which is made of seven strands of No. 22 (0.6-mm) wire, was cut in half, resulting in two 25-foot (7.6-meter) lengths. I soldered one end of each length to a spade lug for attachment to the antenna base. I then untwisted each length into seven individual strands and coiled them to prevent tangles. I threaded the free end of each strand through the hole in the wooden needle, looped it back upon itself to form a bridle, then soldered, (fig. 2).

When all of the needles were attached, I connected the spade lugs to the antenna base mount. I laid seven radials at a time to avoid congestion at the antenna base. This is the point of this article: threading the radials into the lawn.

laying the radials

I began by uncoiling a strand of wire and laying it on the ground in a direction opposite to that in which it is to be sewn, (fig. 3A). Double the strand back on itself so that the wooden needle is under the base of the antenna, (fig. 3B). Now push the needle through the grass and along the earth, making sure it points in the direction the radial is to lay. Work the wooden needle along under the grass with your fingers, and the wire will slowly follow behind it. (A helper is handy during this operation to prevent kinks from being pulled into the wire as it loops back on itself.) When the entire length of the radial is threaded, simply raise the needle up far enough to turn it so that it points downward. Then push it into the earth, thus anchoring the radial.

some useful hints

A little time spent in preparation of the lawn will make the task of threading radials easier. Cut and rake the lawn before working with the radials. This will reduce the mass of grass through which you must work the needle. After installing the radials, rake the surface *in line* with the radials — not across them. My lawn mower is set for a cutting height of 2-1/2 inches (6.4 cm). None of the radials has been disturbed during mowing.

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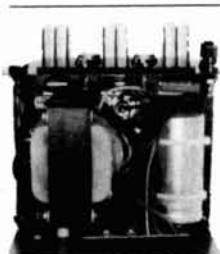


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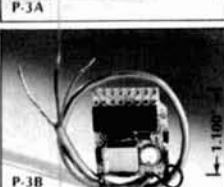
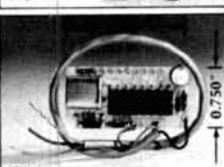
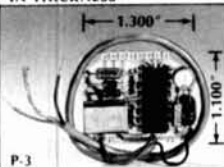
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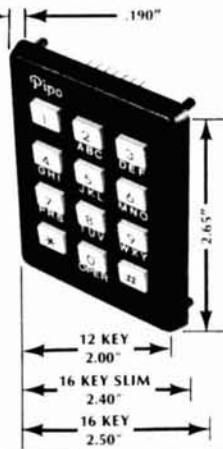
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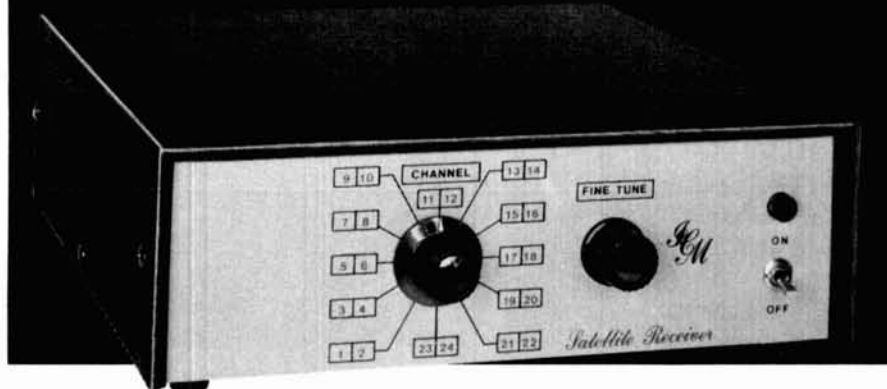
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A CW keyboard using the APPLE II computer

Program listing
and simple interface circuit
for using this popular computer
with your Amateur station

The **APPLE II computer** has numerous possibilities for simplified interfacing to external devices. Four 74LS flip-flop outputs are available that are programmed to set or reset. Three inputs sense whether the data is TTL zero or 1. Four other inputs return a number 0-255, depending upon the series resistance of a 150k pot.

As an example of what can be done, I drive an IDS IP-225 printer at 1200 baud from the GAME I/O socket, although the APPLE serial interface won't operate above 600 baud. The AN0 output provides serial data, while SW0 accepts "handshaking" or CTS signals from the printer. With the four flip-flop outputs fed to a 4-bit decoder, up to 16 circuits can be controlled by the computer.

CW keyboard

Converting the APPLE II to a CW keyboard is quite simple. A program for this follows, with a circuit for interfacing to a relay driver (fig. 1). In the following discussion, \$ denotes hexadecimal numbers, with decimal equivalents in parentheses (see program listing).

Subroutine SBR 5 forms a dash, SBR 6 forms a dot, SBR 7 provides a short space between dots and/or dashes, while SBR 8 inserts a long space after formation of each numeral or letter.

The keyboard is read in line 300 until a key is pressed. The test for numeral 0-9 or letter A-Z is in lines 376-418. Note that there's a relationship between line numbers and the ASCII code read from the keyboard. For example, A = ASCII 193 (with bit 7 set). The test for "Is it an A?" is in line 393. If it is an A, the program jumps to line 193, where the dot, space, dash SBRs are called. The program then returns to line 300 to read the next key. That's all there is to it.

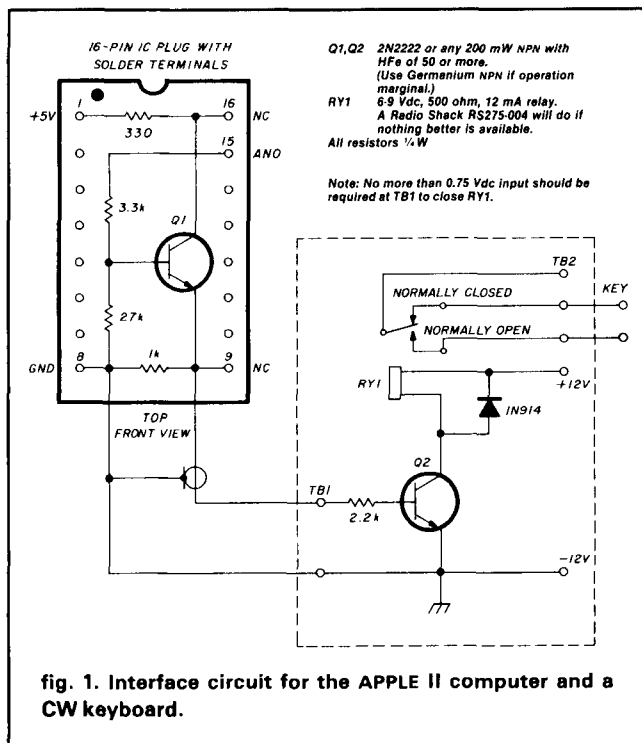
The program sends numerals or letter only. Obviously, punctuation and special characters for AR, SK, etc., could be included. (But see line 420.) String input, then reading ASC for each string character in turn at line 300, would be a simple modification. (See page 89 of the *APPLE Basic Manual* for an equivalent of MID\$.) These refinements are not included in my program because I use a bug for serious CW work. However, if a good keying relay is used, the CW is quite acceptable. (See notes in fig. 1.)

A machine-language listing, resulting from the POKE statements in lines 10-23 follows the basic listing. The number selected for speed is loaded into \$306 (774), although this location is initially loaded with \$FF (255). Note that a simple modification of LDA \$C030, following 0308 D0 FD would provide for sidetone from the APPLE speaker (C030 is the speaker address, of course). Follow this with 88 D0 F5 AD 58 C0 60. Conversion to POKE statements is left as an exercise for the user.

interface/relay driver

The interface comprises an emitter follower, mounted directly on the 16-pin plug that plugs into the GAME I/O socket. Pins 1, 16 are toward the front of the computer, so the two-wire output cable is brought straight back from pins 8, 9 through one of the slots on rear wall.

By **W. S. Skeen, W6WR**, Route 1, Hornbrook Ager Road, Hornbrook, California 96044



The emitter-follower provides 0.8-volt output. The relay driver should be tested to confirm that the relay closes with not more than 0.75 volt. If marginal, the use of a Germanium NPN transistor for Q2 is suggested.

The Radio Shack relay is listed only because of ready availability. If you have a better relay with the same characteristics, by all means use it. The +5 Vdc for the emitter follower is from the APPLE supply (pin 1). The driver uses 12 Vdc. Although this voltage is available at pin 50 of the peripheral sockets — or at the power-supply socket — it's not readily accessible. Inclusion of a small 12-Vdc, 12-mA supply on the relay driver chassis is probably preferable.

For those not familiar with LS chips, *do not* plug anything in with power on. *Do not* reach inside the APPLE cabinet without first grounding yourself by touching the power supply shield.

radio-frequency interference

Judging by what I hear on the ham bands from other computer hobbyists, and by articles in other Amateur publications, there appears to be a real RFI, or "hash" problem with some computers. Fortunately, this is not the case with the APPLE computer. I operate mine within 6 inches (15 cm), or less of the receiver. No hash occurs on 80 or 40 meters except for weak subharmonics of the 14-MHz crystal oscillator. (I also run a color TV set on rabbit ears within 6 feet (2 meters) of the computer. You can't do this with most computers.)

Program listing for the CW keyboard using the APPLE II computer:

```

>LIST
1 GOTO 10
5 POKE 774,SP: CALL 768: RETURN

6 POKE 774,SP/3: CALL 768: RETURN

7 FOR X=1 TO SP/4: NEXT X: RETURN

8 FOR X=1 TO SP/2: NEXT X: RETURN

10 POKE 768,173: POKE 769,89
12 POKE 770,192: POKE 771,160
13 POKE 772,255: POKE 773,162
14 POKE 774,255: POKE 775,202
   REM#(774) = speed selected.
16 POKE 776,208: POKE 777,253
18 POKE 778,136: POKE 779,208
20 POKE 780,248: POKE 781,173
22 POKE 782,88: POKE 783,192
23 POKE 784,96
25 GOTO 500
176 GOSUB 5: GOSUB 7: GOSUB 5: GOSUB
   7: GOSUB 5: GOSUB 7: GOSUB
   5: GOSUB 7: GOSUB 5: GOSUB
   8: GOTO 300
177 GOSUB 6: GOSUB 7: GOSUB 5: GOSUB
   7: GOSUB 5: GOSUB 7: GOSUB
   5: GOSUB 7: GOSUB 5: GOSUB
   8: GOTO 300
178 GOSUB 6: GOSUB 7: GOSUB 6: GOSUB
   7: GOSUB 5: GOSUB 7: GOSUB
   5: GOSUB 7: GOSUB 5: GOSUB
   8: GOTO 300
179 GOSUB 6: GOSUB 7: GOSUB 6: GOSUB
   7: GOSUB 6: GOSUB 7: GOSUB
   5: GOSUB 7: GOSUB 5: GOSUB
   8: GOTO 300
180 GOSUB 6: GOSUB 7: GOSUB 6: GOSUB
   7: GOSUB 6: GOSUB 7: GOSUB
   6: GOSUB 7: GOSUB 5: GOSUB
   8: GOTO 300
181 GOSUB 6: GOSUB 7: GOSUB 6: GOSUB
   7: GOSUB 6: GOSUB 7: GOSUB
   6: GOSUB 7: GOSUB 6: GOSUB
   8: GOTO 300
182 GOSUB 5: GOSUB 7: GOSUB 6: GOSUB
   7: GOSUB 6: GOSUB 7: GOSUB
   6: GOSUB 7: GOSUB 6: GOSUB
   8: GOTO 300
183 GOSUB 5: GOSUB 7: GOSUB 5: GOSUB
   7: GOSUB 6: GOSUB 7: GOSUB
   6: GOSUB 7: GOSUB 6: GOSUB
   8: GOTO 300
184 GOSUB 5: GOSUB 7: GOSUB 5: GOSUB
   7: GOSUB 5: GOSUB 7: GOSUB
   6: GOSUB 7: GOSUB 6: GOSUB
   8: GOTO 300
185 GOSUB 5: GOSUB 7: GOSUB 5: GOSUB
   7: GOSUB 5: GOSUB 7: GOSUB
   5: GOSUB 7: GOSUB 6: GOSUB
   8: GOTO 300: REM 9
190 REM LETTERS FOLLOW
193 GOSUB 6: GOSUB 7: GOSUB 5: GOSUB
   8: GOTO 300 :REM A
194 GOSUB 5: GOSUB 7: GOSUB 6: GOSUB
   7: GOSUB 6: GOSUB 7: GOSUB
   6: GOSUB 8: GOTO 300: REM B
195 GOSUB 5: GOSUB 7: GOSUB 6: GOSUB
   7: GOSUB 5: GOSUB 7: GOSUB
   6: GOSUB 8: GOTO 300: REM C
196 GOSUB 5: GOSUB 7: GOSUB 6: GOSUB
   7: GOSUB 6: GOSUB 8: GOTO 300
   : REM D
197 GOSUB 6: GOSUB 8: GOTO 300
198 GOSUB 6: GOSUB 7: GOSUB 6: GOSUB
   7: GOSUB 5: GOSUB 7: GOSUB
   6: GOSUB 8: GOTO 300: REM F

```

```

199 GOSUB 5: GOSUB 7: GOSUB 5: GOSUB
7: GOSUB 6: GOSUB 8: GOTO 300
200 GOSUB 6: GOSUB 7: GOSUB 6: GOSUB
7: GOSUB 6: GOSUB 7: GOSUB
6: GOSUB 8: GOTO 300: REM H
201 GOSUB 6: GOSUB 7: GOSUB 6: GOSUB
8: GOTO 300
202 GOSUB 6: GOSUB 7: GOSUB 5: GOSUB
7: GOSUB 5: GOSUB 7: GOSUB
5: GOSUB 8: GOTO 300: REM J
203 GOSUB 5: GOSUB 7: GOSUB 6: GOSUB
7: GOSUB 5: GOSUB 8: GOTO 300
: REM K
204 GOSUB 6: GOSUB 7: GOSUB 5: GOSUB
7: GOSUB 6: GOSUB 7: GOSUB
6: GOSUB 8: GOTO 300: REM L
205 GOSUB 5: GOSUB 7: GOSUB 5: GOSUB
8: GOTO 300: REM M
206 GOSUB 5: GOSUB 7: GOSUB 6: GOSUB
8: GOTO 300: REM N
207 GOSUB 5: GOSUB 7: GOSUB 5: GOSUB
7: GOSUB 5: GOSUB 8: GOTO 300
: REM O
208 GOSUB 6: GOSUB 7: GOSUB 5: GOSUB
7: GOSUB 5: GOSUB 7: GOSUB
6: GOSUB 8: GOTO 300: REM P
209 GOSUB 5: GOSUB 7: GOSUB 5: GOSUB
7: GOSUB 6: GOSUB 7: GOSUB
5: GOSUB 8: GOTO 300: REM Q
210 GOSUB 6: GOSUB 7: GOSUB 5: GOSUB
7: GOSUB 6: GOSUB 8: GOTO 300
: REM R
211 GOSUB 6: GOSUB 7: GOSUB 6: GOSUB
7: GOSUB 6: GOSUB 8: GOTO 300
: REM S
212 GOSUB 5: GOSUB 8: GOTO 300:
REM T
213 GOSUB 6: GOSUB 7: GOSUB 6: GOSUB
7: GOSUB 5: GOSUB 8: GOTO 300
: REM U
214 GOSUB 6: GOSUB 7: GOSUB 6: GOSUB
7: GOSUB 6: GOSUB 7: GOSUB
5: GOSUB 8: GOTO 300: REM V
215 GOSUB 6: GOSUB 7: GOSUB 5: GOSUB
7: GOSUB 5: GOSUB 8: GOTO 300
: REM W
216 GOSUB 5: GOSUB 7: GOSUB 6: GOSUB
7: GOSUB 6: GOSUB 7: GOSUB
5: GOSUB 8: GOTO 300: REM X
217 GOSUB 5: GOSUB 7: GOSUB 6: GOSUB
7: GOSUB 5: GOSUB 7: GOSUB
5: GOSUB 8: GOTO 300: REM Y
218 GOSUB 5: GOSUB 7: GOSUB 5: GOSUB
7: GOSUB 6: GOSUB 7: GOSUB
6: GOSUB 8: GOTO 300: REM Z
300 KB= PEEK (-16384)
302 IF KB<128 THEN 300
304 POKE -16368,0
310 REM BY W. S. SKEEN - W6WR FEB 7
9
376 IF KB=176 THEN GOTO 176 :REM 0
377 IF KB=177 THEN GOTO 177
378 IF KB=178 THEN GOTO 178
379 IF KB=179 THEN GOTO 179
380 IF KB=180 THEN GOTO 180
381 IF KB=181 THEN GOTO 181
382 IF KB=182 THEN GOTO 182
383 IF KB=183 THEN GOTO 183
384 IF KB=184 THEN GOTO 184
385 IF KB=185 THEN GOTO 185 :REM 9
393 IF KB=193 THEN GOTO 193: REM A
394 IF KB=194 THEN GOTO 194
395 IF KB=195 THEN GOTO 195
396 IF KB=196 THEN GOTO 196

```

```

397 IF KB=197 THEN GOTO 197
398 IF KB=198 THEN GOTO 198
399 IF KB=199 THEN GOTO 199
400 IF KB=200 THEN GOTO 200: REM H
401 IF KB=201 THEN GOTO 201
402 IF KB=202 THEN GOTO 202
403 IF KB=203 THEN GOTO 203
404 IF KB=204 THEN GOTO 204
405 IF KB=205 THEN GOTO 205
406 IF KB=206 THEN GOTO 206
407 IF KB=207 THEN GOTO 207
408 IF KB=208 THEN GOTO 208
409 IF KB=209 THEN GOTO 209
410 IF KB=210 THEN GOTO 210: REM R
411 IF KB=211 THEN GOTO 211
412 IF KB=212 THEN GOTO 212
413 IF KB=213 THEN GOTO 213
414 IF KB=214 THEN GOTO 214
415 IF KB=215 THEN GOTO 215
416 IF KB=216 THEN GOTO 216
417 IF KB=217 THEN GOTO 217
418 IF KB=218 THEN GOTO 218
420 IF KB<176 OR KB>218 THEN 300
490 END
500 CALL -936
510 PRINT : PRINT " CW KEYBOARD
(RELAY DRIVER)"
520 PRINT : PRINT " BY W6W
R"
530 PRINT : PRINT " SELECT SPEED BY
ENTERING"
540 PRINT : PRINT " A NUMBER 75 TO
255."
550 PRINT : PRINT " 100 = APPROX. 2
0 - 25 WPM"
560 PRINT : PRINT " 255 = VERY SLOW
"
580 PRINT : PRINT " 75 = FAST"
600 PRINT : INPUT " NOW PLEASE SELE
CT SPEED",SP
610 PRINT : PRINT " READY TO SEND"
620 POKE 774,SP
630 GOTO 300

```

>Machine-Language Program.

```

*300L
0300- AD 59 C0 LDA $C059
0303- A0 FF LDY $$FF REM
0305- A2 64 LDX $$64 Set AN0
0307- CA DEX DLY2
0308- D0 FD BNE $0307 DLY/
030A- 88 DEY DLY/
030B- D0 F8 BNE $0305 DLY2
030E- AD 58 C0 LDA $C058 Reset AN0
0310- 60 RTS Return to Basic

```

REMARK: In the example above, \$64 (Speed = 100) has been located in \$306(774), in preparation for a dash.

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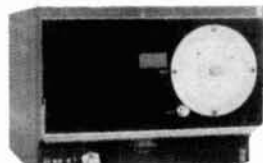
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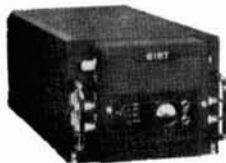
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features

No longer will your headphones be filled with multiple interfering signals, because this device contains useful features. These include:

1. A frequency acquisition adjustment with a range of 400-1800 Hz.
2. A variable release tie between 1-20 seconds for various incoming code characteristics. The circuit will automatically return to normal audio after the conclusion of incoming CW (very useful when my tube-type transceiver was warming up). This feature can be aborted with the front-panel RELEASE control.
3. Adjustments for pitch and gain of the internal tone oscillator. The pitch control has a range of 280-800 Hz. This feature was included as an alternative to monotonous single-tone copying.

physical description

Additional front-panel controls include a) power ON/OFF switch with LED; b) a LED that operates in agreement with incoming CW when the PLL is locked; and c) an OUTPUT impedance selector giving a choice of either 8 ohms or 1 kilohms.

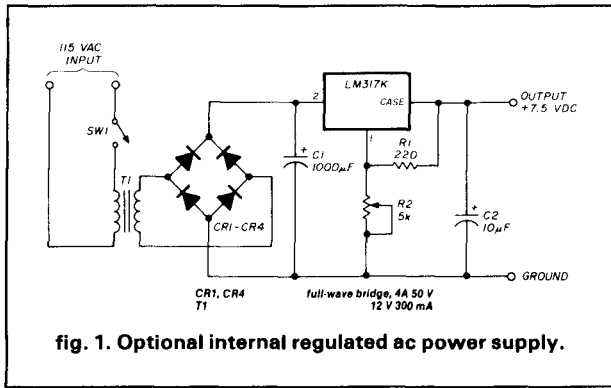
The rear panel supports the audio input jack and the two audio output connections. The power supply connection uses a twisted pair of insulated wires fed through the factory-produced opening in the chassis corner.

The internal layout can be seen in the photo. Ample space is provided for all components by using the low-profile, cut-down chassis design. Obvious in the photo is the absence of an internal power supply. My unit uses an external power source consisting of two batteries: a 6-volt lantern battery in series with a 1 1/2-volt D cell. (The additional D cell was required to pull in relay K1.) An internal ac supply¹ can be included if desired (fig. 1).

operation

Operation of the Golden Articulator begins with receiver audio connected to its input jack (fig. 2). With headphones or a speaker plugged into the output jack, receiver audio can be monitored even if the unit is off. When the power is switched on, C1 feeds audio to the activated LM-567 PLL tone decoder; simultaneously audio is connected to the output device through C2 and K1A. By varying frequency control R2, you can select the particular CW signal you wish to regenerate. When the PLL is locked, the lock LED will operate in agreement with the chosen incoming signal. The resultant digital signal produced on pin 8 of the LM567 is applied to the 555 delay and 7413 in-

By F.T. Marcellino, W3BYM, 13806 Parkland Drive, Rockville, Maryland 20853



verter circuit inputs. The inverter is required because a positive trigger is needed by the 555 tone oscillator, which at this time is activated and output to the open contact of K1A.

auto release

You now have a decision to make. If auto-release switch SW3 is momentarily depressed, relay K1 will energize and K1A contacts will transfer. This action

connects the internal tone oscillator to the output device and voila! — those dream words come true, producing tape-quality interference-free copy. In the auto-release mode, front-panel variable-release control R8 must be adjusted for the incoming CW keying characteristics. This adjustment controls the holding time of K1 and should be set slightly longer than spaces or pauses, whichever is greater. Additionally, at the end of an incoming transmission, the 555 delay will begin its last timing cycle. At its conclusion it will automatically release K1, which returns the circuit to normal receiver audio. This transfer will usually occur during the early seconds of transmission.

incoming-signal drift

The beauty of this feature lies in the fact that, if the receiver is prone to drift, the signal can be first verified as still on frequency, otherwise the headphones may be filled with emptiness. If the signal has drifted off frequency, as indicated by the extinguished lock LED, adjust the main tuning of the receiver — or better yet, slightly vary frequency control R4 while monitoring the lock LED for acquisition. Then depress the

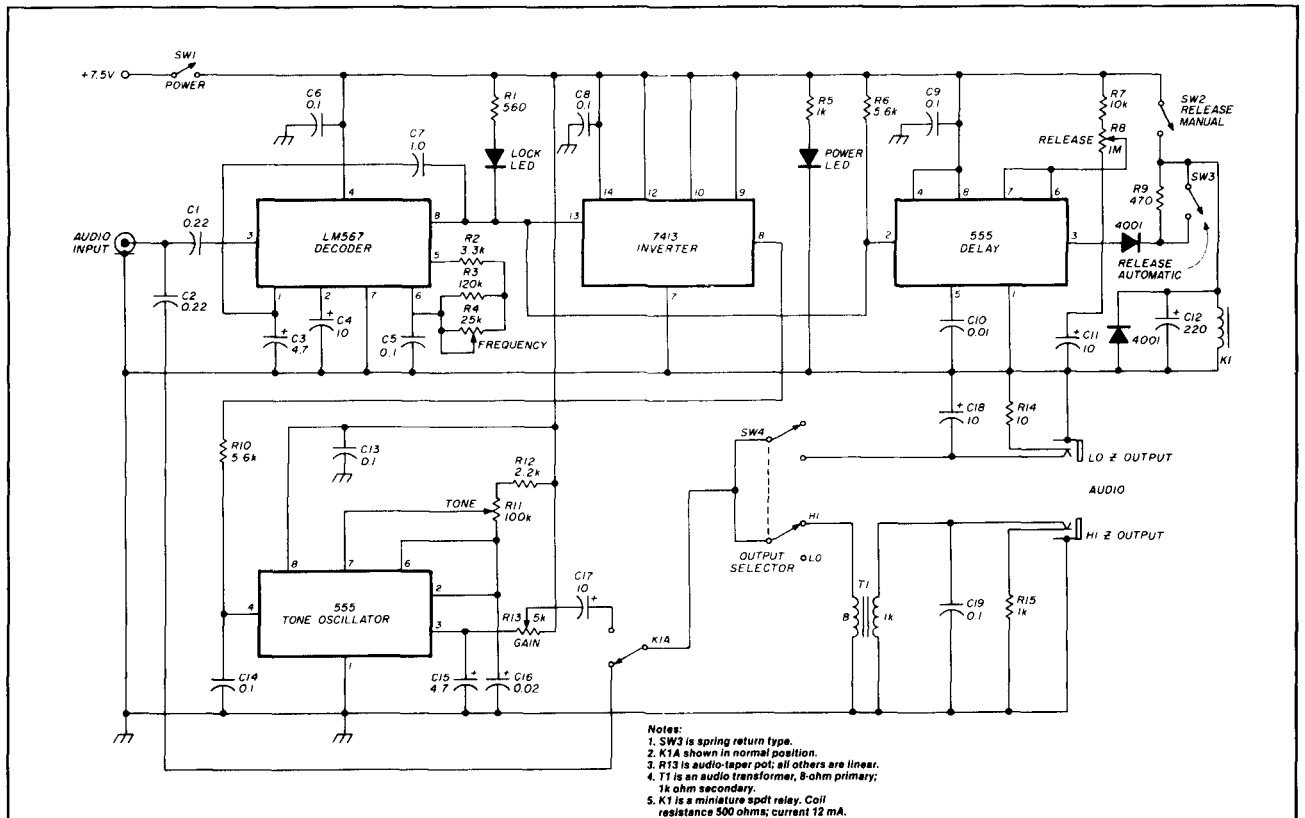
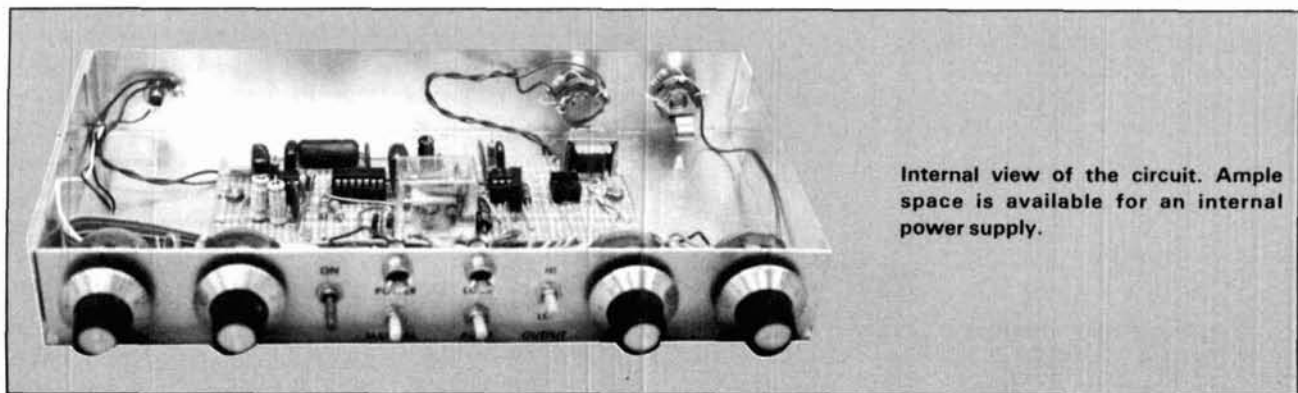


fig. 2. Schematic of the Golden Articulator. Capacitor C7 was chosen to eliminate chatter from the LM567 output at moderate-to-high code speeds. Capacitor C12 across K1 coil eliminates relay dropout during reception of critical information. Caps C15, C18, and C19 tame the 555 oscillator leading-edge spikes to produce a pleasing CW tone.



Internal view of the circuit. Ample space is available for an internal power supply.

auto release and you're back in business. This process sounds time consuming, but in reality it takes only a few seconds.

manual release

As mentioned earlier, you have a decision to make in the selection of release modes. The second choice is manual operation. By switching manual release SW2, K1 is immediately connected to the power supply. To use this feature the incoming signal must be frequency stable. This capability was additionally useful during checkout of the unit, thereby avoiding the repeated dropout of K1. Incidentally, while on the subject of checkout, I used the calibration signal from my transceiver as a very convenient variable audio source.

measurements

The bandwidth of the tone decoder was measured over its input frequency range of 400-1800 Hz. As shown in **table 1**, the bandwidth varied between 40-120 Hz over the range. The bandwidth can be shifted, if desired, by changing PLL loop filter capacitor C4. A smaller value will widen the bandwidth and vice versa.

Input sensitivity was measured for the same input frequency range. A value of 28 mV rms sine wave input was required for the LM567 to produce a stable lock and transfer its output state high to low.

precautionary notes

The output circuit of the LM567 will develop chatter² when C3 is relatively small. This phenomenon is

a result of the output stage moving through its threshold more than once after lock. At moderate-to-high code speeds this chatter severely disrupted the input triggering for the 555 tone oscillator. To remedy this situation, capacitor C7 was connected between output pin 8 and output-filter pin 1 of the LM567. This eliminated the switching transient, thereby cleaning the trigger pulse to the tone oscillator.

One other critical component is capacitor C12 connected across K1 coil. This capacitor's charge holds the coil energized during periods when pin 1 of the 555 delay is positive *and* the delay has just timed out. Admittedly, this condition doesn't occur very often. But it becomes a nuisance when K1 drops out during reception of critical information. A value of 220 μ F was sufficient to overcome this problem.

The 555 tone oscillator produced a displeasing square wave output, which needed some help to produce a pleasant tone. With the addition of C15, C18, and C19, the annoying leading-edge spikes were removed and sufficient waveform rounding was induced to produce a pleasant tone.

construction

Fabrication of the unit began with the modification of a standard 5 x 10 x 3 inch (12.7 x 25.4 x 7.6 cm) aluminum chassis. The bottom of the chassis was removed, leaving an open box measuring 5 x 15 x 1 1/2 inches (12.7 x 38.1 x 3.8 cm). This low-profile design gives a streamlined appearance to the unit, accompanied by the cover and four graduated knobs. The switches are packaged with several different colored

Rear view showing low- and high-impedance output jacks and audio-input jack. Note twisted-pair power-supply wires in lower right corner.



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table 1. Tone-decoder bandwidth measurements.

F center (Hz)	F low (Hz)	F high (Hz)	BW (Hz)
400	380	420	40
600	580	630	50
800	775	835	60
1000	970	1040	70
1200	1150	1230	80
1400	1370	1460	90
1600	1540	1650	110
1800	1750	1870	120

Notes:

1. Loop filter C4 10.0 μ F.
2. Output filter C3 4.7 μ F.
3. F low data taken when lock LED just energizes with increasing input frequency.
4. F high data taken when lock LED just de-energizes with increasing input frequency.

toggle slip-ons. To aid in switch identification I used one of each color.

Board layout, as seen in the lid-off photo, follows the circuit diagram with parts being ordered left to right. The board is spaced from the chassis bottom with $\frac{1}{4}$ inch (6.4 mm) spacers leaving adequate space above the highest part; that is, K1.

The right side of the board shows an empty socket. The original design used this socket with an audio-amplifier circuit. Experimentation indicated that this circuit was really not required because the 555 tone oscillator could drive either a speaker or headphones with more than enough audio. The only loss was the convenience of gain adjustment for normal receiver audio, but the transceiver gain control served the same purpose.

concluding remarks

Operation has been a pleasant experience in CW copying. With the 7.5-volt battery supply, total current drain is 150 mA. Obviously battery life will depend on use of the equipment, but a conservative estimate would be 3-4 months.

The greatest obstacle I encountered in phasing this unit into my operating habits was the pronounced absence of anything but one signal in my headphones. After all, some of us old timers will find it difficult to accept the fact that there are other ways besides listening to headphones filled with ear-splitting interference and noise.

references

1. *Voltage Regulator Handbook*, National Semiconductor, 1977 edition.
2. Howard M. Berlin, *Design of Phase-Locked Loop Circuits with Experiments*, Howard W. Sams & Co., Inc., Book No. 21545, 1st edition, 1979.

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geometry of Phase III Spacecraft orbits

Despite the failure of AMSAT Phase III on May 23, 1980, AMSAT officials have urged publication of this article. Their thinking is that a vast majority of the Amateur fraternity was, at launch time, "too far down the learning curve" to have been effective users of the new satellite. We must begin now to prepare for the next satellite, scheduled for launch in 1982.

I have just completed a project for AMSAT in which I wrote a BASIC tracking program for the Phase-III Spacecraft elliptical orbits.* While this project is still fresh in mind I'd like to share some facts I've gleaned about the first of these satellites, Phase III-A, which was to be launched in May, 1980. My source for this data is Rich Zwirko, K1HTV, Vice President of Operations, AMSAT. This satellite, after the kick motor is fired, will have the following orbital characteristics:

$a = 25028 \text{ km}$ (length of the semi-major axis)
 $e = 0.6852$ (Eccentricity)
 $i = 57 \text{ degrees}$ (Inclination)
 $P = 655 \text{ minutes}$ (Period)
 $\omega = 210 \text{ degrees}$ (Argument of perigee)

*This program listing is available from *ham radio* on receipt of a self-addressed, stamped, 8x11 envelope. AMSAT volunteers may make available cassette duping for the PET, TRS-80, AIM65, APPLE, and others. Watch the AMSAT newsletter, *Orbit*.

(The *argument of perigee* will increase about 0.08 degree per day.) These are the projected data if everything goes well. Now, for the uninitiated, I'll explain each one individually.

orbit with respect to earth — definitions

The orbit will be an ellipse (fig. 1), which lies in a plane called the *orbital plane*. Once and for all let's agree to view the satellite from "above" from where the satellite appears to move counterclockwise. The Earth will be at one focus of the ellipse. The closest approach to the Earth is called *perigee*; the furthest approach *apogee*. The perigee, the two foci, the geometric center of the ellipse, and the apogee all lie on a line called the *major axis*. Exactly one half the distance from perigee to apogee, that is, the distance from the center of the ellipse to perigee (or apogee), is called the *length of the semi-major axis*, a .

The *eccentricity*, e , is a measure of ellipse elongation. If $e = 0$, the ellipse is a circle. If e were, say, 0.99, the ellipse would be elongated and very flat.

In fig. 1, I've tried carefully to show an accurate drawing of the actual shape of Phase III-A orbit. If c is the distance from the ellipse center to either focus, $e = c/a$; so perigee will occur at a distance of $a - c = a(1 - e)$ and apogee at a distance of $a + c = a(1 + e)$ from Earth center.

By C. R. MacCluer, W8MQW, Post Office Box 1858, East Lansing, Michigan 48823

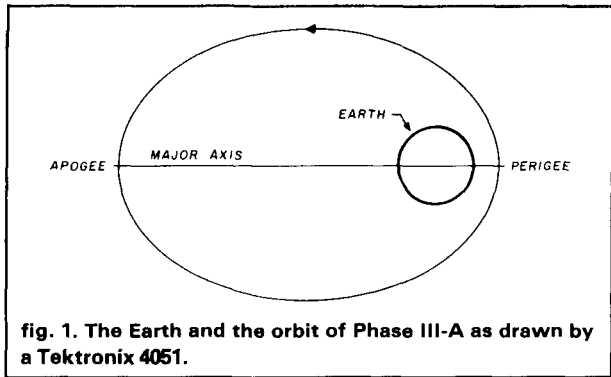


fig. 1. The Earth and the orbit of Phase III-A as drawn by a Tektronix 4051.

The orbital plane is inclined i degrees to the *equatorial plane*, the plane containing the equator of the Earth (fig. 2). The *inclination*, i , is the angle between the two upward-pointing normals: one perpendicular to the orbital plane pointing upward and one perpendicular to the equatorial plane (along the axis of rotation) through the north pole.

The period, P , is the time in minutes needed for the satellite to complete one orbit from perigee to perigee.

The last of the orbital characteristics, the *argument of perigee*, is not encountered in circular orbits. This angle, ω , is measured counterclockwise in the orbital plane and is the angle between the *line of the ascending node* and perigee (see fig. 3). This is only one example of the "Lord Kelvinesque" language that seems to abound in this discipline.

The line of the ascending node is simply the line connecting the Earth's center with the equator crossing, EQX, of the ascending (northward-bound) pass. The northbound EQX is the *ascending node*. For instance, if a satellite had an argument of perigee of 180 degrees, apogee would occur in an EQX of the ascending pass, while perigee would occur at the EQX of the descending pass.

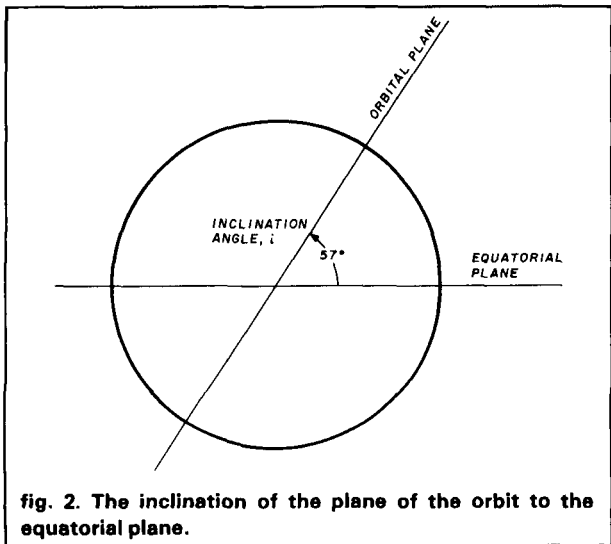


fig. 2. The inclination of the plane of the orbit to the equatorial plane.

argument of perigee — examples

The argument of perigee of Phase III-A satellites will be affected by the oblateness of the Earth. This will cause a *precession* of its orbit; that is, the argument of perigee will increase daily at an estimated 0.07-0.08 degree. Thus the ellipse will slowly rotate counterclockwise in the orbital plane about the center of the Earth. A precession of 0.08 degree per day seems small until compared with Mercury's precession of 574 seconds per century!

After launch, Phase III-A will have apogee only 30 degrees (true anomaly) past EQX, so that a significant portion of some passes will be at low elevation; thus antennas should be able to see to the horizon.

For example, suppose a pass begins with a longitude of perigee of 270 degrees. Then almost 7-3/4 hours of this 9-hour pass will be at elevation angles less than 15 degrees as seen from the Midwest. How-

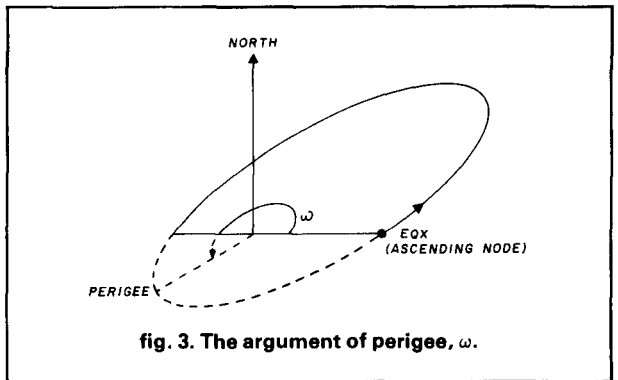


fig. 3. The argument of perigee, ω .

ever, after two years, Phase III-A will have an argument of perigee equal to 270 degrees; thus apogee will occur at the maximum possible latitude of 57 degrees. The satellite will then, for most passes, hang high in the sky and will be accessible by small picnic-table-mounted arrays. At this writing it's estimated that a user will need, at apogee, a transmitting power of 700 watts ERP at 435.1 MHz and, for the average modern 2-meter receiver, an antenna with a gain of 13 dBd at 145.9 MHz with circular polarization. Received signals will, at apogee, be 5-6 dB weaker than those of AMSAT-OSCAR-7B.

In contrast with the past sun-synchronous satellites, there will be no "typical" passes with Phase III. For instance, if the longitude of perigee is 0 degrees, then at no time during such a pass will the satellite be visible from the midwestern U.S.A. On the other hand, if the longitude of perigee is 180 degrees, the satellite can be worked for 9 hours continuously with 6 1/2 hours of elevations exceeding 45 degrees.

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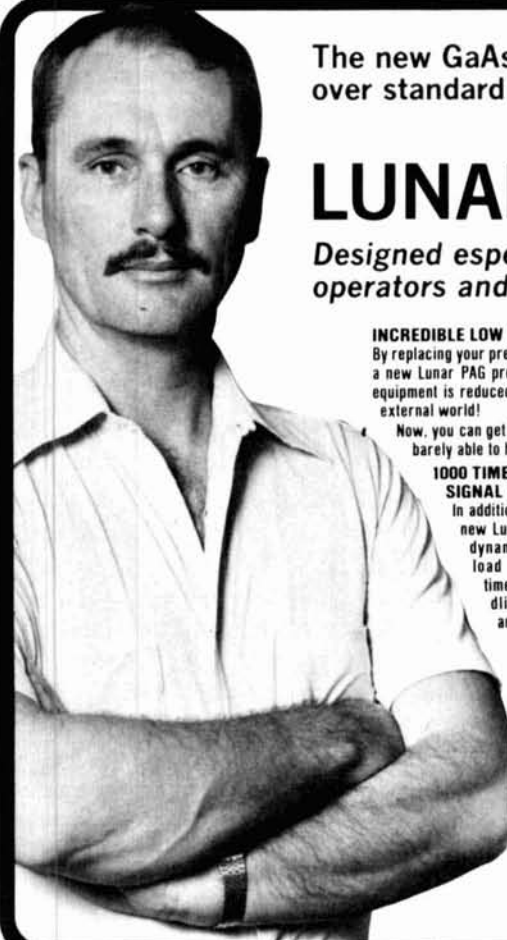
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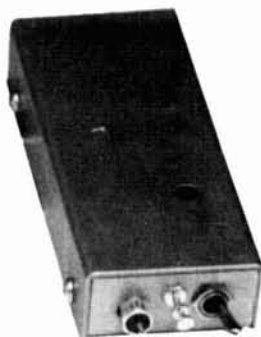
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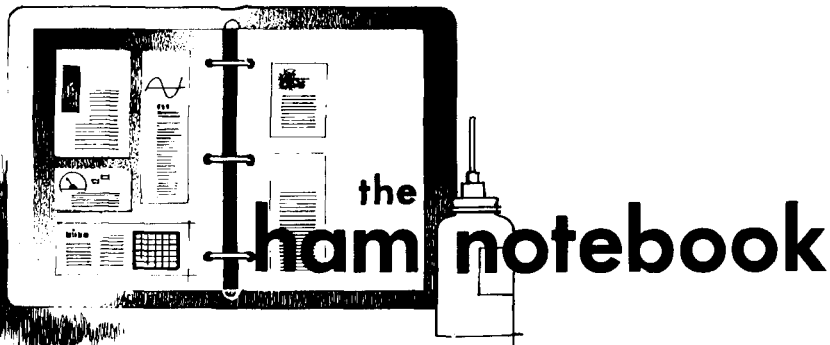
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the ham notebook

using the Radio Shack ASCII keyboard encoder for microprocessor-controlled CW keyboard

I found that the Radio Shack 277-117 ASCII encoder will not interface with the microprocessor-controlled circuit by WB2DFA in *ham radio*, January, 1978, page 80, unless some minor modifications are made.

The problem is that the control key function designed in the Radio Shack encoder is not compatible with the microprocessor circuitry. To overcome this, I've installed an outboard, normally open, single-pole pushbutton switch, which is connected to a 7400 as shown in fig. 1. This circuit places the two most-significant outputs of the keyboard in the LOW state

when the control button, SW2, or switch SW1 is activated.

I prefer to use my old trusty electronic keyer for contest operating; however the memory in the CW keyboard sure is a work saver for calling CQ. That's why I've installed SW1 in parallel with SW2, so that it's only necessary to press the letter T to send the message stored in the memory. The rest of the sending is done with the electronic keyer in such an operation.

Frequently, when typing at higher speeds, letters would be missed. It turned out that the microprocessor chip did not like the strobe waveform produced by the keyboard. To overcome that problem I installed a 74LS13 Schmitt trigger to change the pulse into a nice, clean square wave, which eliminated the problem nicely.

It's been a good project, and I ex-

tend my thanks to Jim, WB2DFA, for his assistance in getting the PROMs programmed and getting on the right track in this project.

Frank Van der Zande, VE7AV

more quad variations

The familiar cubical quad antenna has been twisted into many shapes and variations, to the eminent pleasure of the twisters, and has performed quite well, nevertheless. Here are three more variations, two of which I've tried and found to be worthy of being added to the other modifications.

The first two variations were vertically polarized arrays for two-meter fm operation. First comes the double quad, which consists of two driven elements in the diamond configuration with a common apex (fig. 2). The two loops are operated in parallel, thus reducing the load impedance presented to the transmission line, which might be expected to more closely match the line. Note that the parasitic elements have a slightly different configuration, with a crossover of the wires rather than a junction. The reflector was 5 per cent larger than the driven element and spaced a quarter wavelength from it. The two directors were 5 per cent smaller than the driven element and were spaced 0.15 wavelength from the driven element, and from each other.

This antenna was cut to size and assembled without any effort to maximize tuning or dimensions. The VSWR was below 1.5. The antenna gave very good results until it suf-

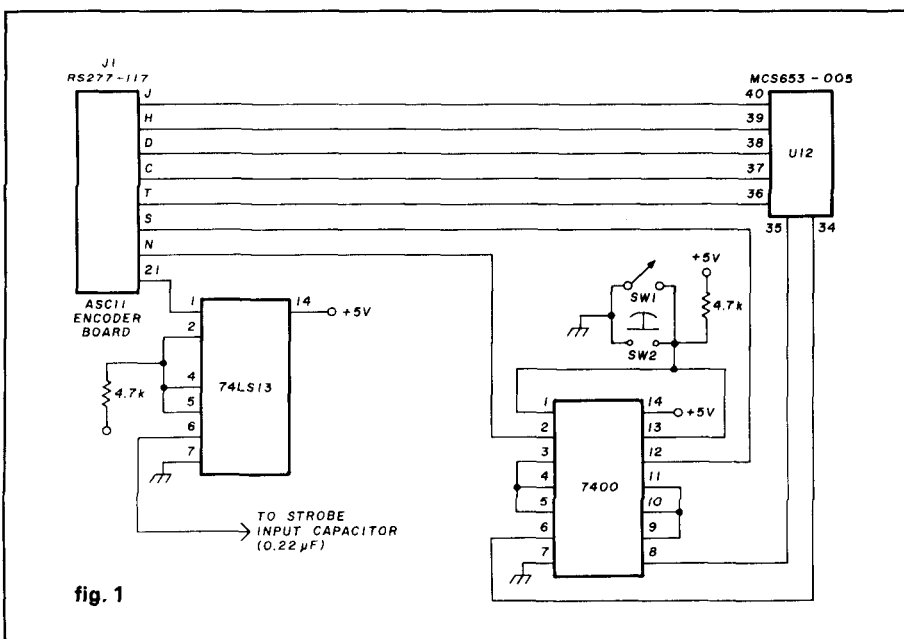


fig. 1

ferred mechanical damage because of violent weather.

This multiple-quad concept can probably be expanded, particularly as a fixed array for use on the lower-frequency bands. The configuration of the driven and parasitic elements would be something like **fig. 3**.

The second variation, which replaced the double quad in an attempt to simplify the construction, was an adaptation of the bi-square beam, where the array measured a half wavelength on a side. Because this array is fed at a voltage point, a tuned stub was needed on the driven element. To bring the feed point nearer to the center of the structure, a half-wavelength open-wire stub was used, with a coaxial balun to obtain a balanced feed. Again, the reflector was 5 per cent larger than the driven element and spaced a quarter wavelength from it.

This was only a two-element beam, so no directors were used, although they should function as well with this configuration as with any other. The dimensions of the final arrangement are shown in **fig. 4**. After a careful adjustment, consisting of trimming the tuning stub and locating the feed points, it was possible to bring the VSWR below 1.05.

This antenna was somewhat smaller and easier to assemble than the other and has given a good account of itself. Not having an antenna testing range, I'm unable to give a measured pattern of it, but the front-to-back ratio appears to be all that can be expected from a two-element affair, and the forward gain is very satisfactory.

The third variation suggests a means of building a balun into the driven element of a monoband quad. I haven't tried this one as yet, but it

looks very interesting. As seen in **fig. 5**, the driven element is composed entirely of coaxial line. The feed line is continuous all the way to the top center of the driven element, at which point the outer conductor ends. The center conductor connects to the other half of the driven element, which, in the interest of symmetry, is made of the outer conductor of the same-size coaxial line.

Back at top center, currents flowing on the outer conductor of the feed line reach the end of that conductor and flow back on the outside of the outer conductor, thus balancing the currents on the other half of the driven element. The result should be a completely balanced feed, with minimum feedline radiation to complicate the problems of TVI and unwanted rf in the shack. Any takers?

Henry S. Keen, W5TRS

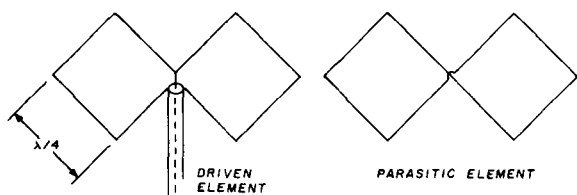
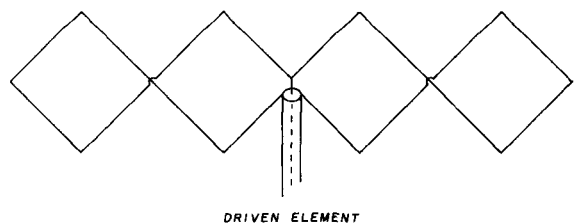
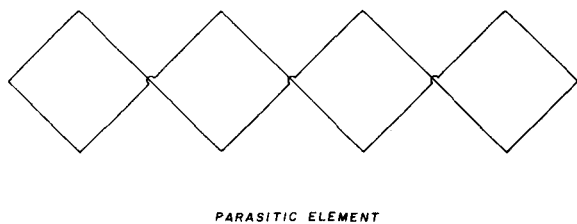


fig. 2



DRIVEN ELEMENT



PARASITIC ELEMENT

fig. 3

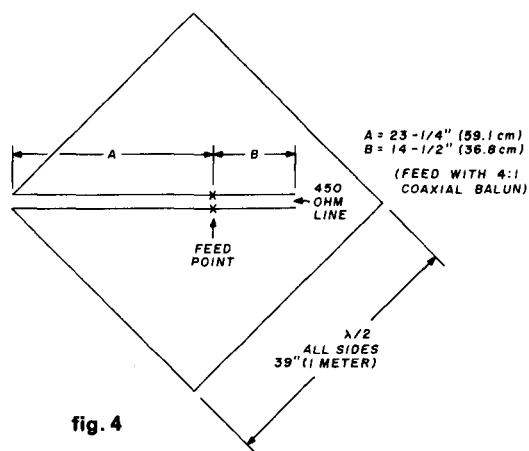


fig. 4

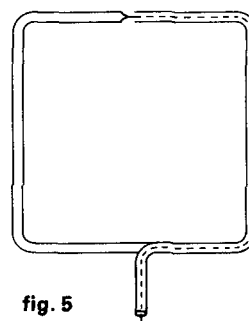


fig. 5

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From the folks at SCSELBI, **PRACTICAL ANTENNAS** is not quite like any of the other ham antenna books. Written by a knowledgeable DX'er, this new book is chock-full of helpful hints and suggestions on the how-to's of putting up a super antenna system. Chapters include information on design and construction of practical Yagis, quads and wire type antennas. Inside you'll also find a complete bibliography of antenna articles from the popular amateur publications. Charts and tables are designed to eliminate all those tricky calculations. And, SCSELBI has included a list of computer generated beam headings from major population centers to all the countries of the world. A new format, large easy-to-read text and durable vinyl cover make **PRACTICAL ANTENNAS** a "must" for every amateur library. ©1979.

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THE ARRL ANTENNA ANTHOLOGY

by the ARRL staff

This brand new book pulls together a wide selection of antenna articles from QST. Written for Amateurs of all levels and interests. Included are phased arrays, verticals, Yagi's . . . even the VHF Quagi! Detailed instructions and full illustrations make this a really useful book for any Amateur. 152 pages. ©1979.

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by Oliver P. Ferrell

Radioteletype to many hams and SWL's is an exotic, complicated form of electronic communication. The author is a well known expert in this interesting field and brings to you a wealth of knowledge and practical experience. First he covers the basics of RTTY identification codes and equipment. Once you've mastered the basics, he gives you a complete rundown on how to receive and understand what you'll be seeing. And — there are over 60 pages of worldwide station listings. For your convenience, listings are made by frequency with station location and service. ©1980. 96 pages.

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FM and REPEATERS for THE RADIO AMATEUR

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This completely new and updated edition gives you the latest in FM technology and design theory. Highlights include microprocessor control circuitry, and a Phase Lock Loop 2 meter transceiver. This mobile operator's favorite now has more to offer. If you're into FM and repeaters or just want to learn more, we have the book you're looking for. 176 pages. ©1978.

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ANTENNA BOOKS by Bill Orr, W6SAI

THE RADIO AMATEUR ANTENNA HANDBOOK

by William I. Orr, W6SAI and Stuart Cowan, W2LX

If you are pondering what new antennas to put up, we recommend you read this very popular book. It contains lots of well illustrated construction projects for vertical, long wire, and HF/VHF beam antennas. But, you'll also get information not usually found in antenna books. There is an honest judgment of antenna gain figures, information on the best and worst antenna locations and heights, a long look at the quad vs. the yagi antenna, information on baluns and how to use them, and some new information on the increasingly popular Sloper and Delta Loop antennas. The text is based on proven data plus practical, on-the-air experience. We don't expect you'll agree with everything Orr and Cowan have to say, but we are convinced that *The Radio Amateur Antenna Handbook* will make a valuable and often consulted addition to any Ham's library. 190 pages. ©1978.

RP-AH **Softbound \$6.95**

ALL ABOUT CUBICAL QUAD ANTENNAS

The cubical quad antenna is considered by many to be the best DX antenna because of its simple, lightweight design and high performance. In Bill Orr's latest edition of this well known book, you'll find quad designs for everything from the single element to the multi-element monster quad, plus a new, higher gain expanded quad (X-Q) design. There's a wealth of supplementary data on construction, feeding, tuning, and mounting quad antennas. It's the most comprehensive single edition on the cubical quad available. 112 pages. ©1977.

RP-CQ **Softbound \$4.75**

SIMPLE LOW-COST WIRE ANTENNAS

Learn how to build simple, economical wire antennas. Even if you don't know a feedline from a feed-through, W6SAI will get you on the air with an effective low-cost wire antenna. And, apartment dwellers take note! Fool your landlord and your neighbors with some of the "invisible" antennas found here. For the old-timer as well as the beginner, it's a clearly written, well diagramed, and even humorous antenna book. 192 pages. ©1972.

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BEAM ANTENNA HANDBOOK

Here's recommended reading for anyone thinking about putting up a yagi beam this year. It answers a lot of commonly asked questions like: What is the best element spacing? Can different yagi antennas be stacked without losing performance? Do monoband beams outperform tribanders? Lots of construction projects, diagrams, and photos make reading a pleasurable and informative experience. 198 pages. ©1977.

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SHORTWAVE PROPAGATION HANDBOOK

Edited by George Jacobs, W3ASK, and Theodore J. Cohen, N4XX

For many hams, both new and old, radio wave propagation is still a mystery. Realizing this, the authors went about the task of preparing a simplified text that could be understood by hams, swl's and engineers alike. Stress has been given to simplified explanations and charts. The authors also detail a simplified method of do-it-yourself propagation forecasting. To assist your forecasting efforts, the book contains a complete listing of the 12 month smoothed sunspot numbers since 1749. Join those who know how to predict when the bands will open to specific areas of the world. ©1979.

CQ-PH **\$7.50**

ARRL Q & A SERIES

Each book is full of sample questions that cover just about every aspect of the FCC Amateur exam series. These handy study guides are a must for the soon-to-be or ready-to-upgrade Amateur. Convenient pocket size lets you take your study guide with you everywhere. Softbound.

AR-QA Novice ©1979 **\$2.00**
 AR-TG Technician, General ©1979 **\$2.50**
 AR-AE Advanced, Extra ©1979 **\$3.00**

RADIO HANDBOOK — 21st Edition

by William I. Orr, W6SAI

This 21st edition includes 1080 easy to read pages on everything from oscillators to antennas. In addition you'll find new and enlarged sections on frequency synthesizers, IC design, HF and VHF linear amplifier construction and NBVM. Radio theory, construction projects, tests and measurements, and reference data — all here, under one cover. W6SAI and more than 20 other notable Amateurs have combined their talents to produce one of the finest and most complete Amateur Radio reference sources in print. 1080 pages. ©1978.

24034 **Hardbound \$21.50**

GENERAL CLASS AMATEUR LICENSE STUDY GUIDE

by Phil Anderson, W0XI

This book was written in simple laymen's language with uncomplicated explanations and examples used to present electronic radio concepts and ideas. Throughout each chapter, questions and answers are used to strengthen your understanding of the terms and concepts presented. This book also covers several methods that can be used to improve code reception skills. The final chapter is a sample FCC exam which the author feels he would ask if he were to give the FCC exam. 160 pages. ©1979.

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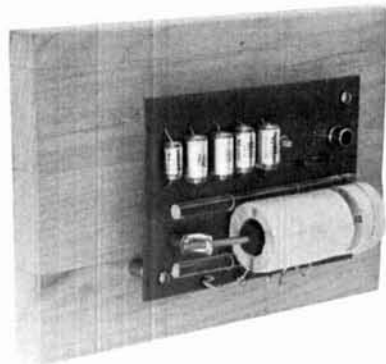
repeater "Tail-Chopper"

Circuit Electronics, Inc., of Salina, Kansas, is introducing a repeater squelch-tail eliminator called "Tail Chopper." Two models are featured: TC-2000 and the TC-2100. Both use temperature-compensated operational amplifiers and digital logic, and have a five-turn control and LED indicator for maximum sensitivity.

TC-2100 is a universal module (as shown) that can be connected to most repeaters to eliminate squelch tails. It has a squelch enable-disable function if needed for tone operation.

TC-2000 is a plug-in module to fit Regency's U10R uhf repeater, with simple, one-wire hookup. Existing squelch can remain functional.

A PC-board with parts and instructions is available for kit builders. For more information, write Circuit Electronics, Inc., 621 Bishop, Salina, Kansas 67401.



1750-meter transmitter

Palomar Engineers has announced a new transmitter kit for the 160-190 kHz experimenter's band. Operation at one watt input power and with a 50-foot maximum antenna length is permitted by the FCC, with no license required.

The transmitter is in two parts: the main transmitter assembly contains the frequency generator, power supply, and the control panel. It is located at the operating position. The antenna-tuning assembly mounts at the base of the antenna.

All the difficult assembly and wiring (including winding the Litz wire coils) is factory completed. Wiring of the kit takes about an hour with simple tools. Complete assembly and operating instructions are supplied.

The transmitter is for CW operation but easily can be a-m modulated if desired. Price is \$145. For more information write Palomar Engineers, Box 455, Escondido, California 92025.

Millen grid-dip oscillator

A tube-type grid-dip meter for testing radio frequency circuits, rf chokes, oscillators, antennas, and similar devices, formerly manufactured by Millen, is now available from Caywood Electronics, Inc., of Malden, Massachusetts.

The Millen model 90651-A Grid Dip Meter is an oscillating frequency meter that determines the resonant frequency of de-energized circuits. Accurate to ± 2 per cent, it covers a range of 1.7 to 300 MHz with 7 plug-in coils, and provides signal power output for use as an antenna bridge source. A semiconductor electronic voltmeter indicates output amplitude.

With seven direct-reading scales and a universal scale, the Millen model 90651-A Grid Dip Meter weighs 3-1/2 pounds and measures 7-1/4 x 3-1/2 x 3-3/16 inches. The rugged, copper-plated unit and coils store in a sturdy carrying case. Additional coils for frequencies to 165 kHz, and a 3-foot extension probe are optional.

The Millen model 90651-A Grid Dip Meter is priced at \$180, complete with seven coils and case; each additional coil is \$17.75. Literature is available on request.

For more information contact Caywood Electronics, Inc., Wade Caywood, 67 Maplewood Street, P.O. Drawer U, Malden, Massachusetts 02148.





ATV downconverter

P.C. Electronics has introduced a new fast-scan ATV downconverter which converts the entire 420-450 MHz band down to TV channel 2 or 3, or to a 45-MHz i-f, with full bandwidth for color and computer video.

The standard model TVC-4 contains a new microstrip converter with a low-noise MRF901 preamp stage, 12 Vdc power supply, BNC antenna input connector, and type F output connector. The low-noise-figure preamp stage enables seeing sync bars down to as low as 0.3 microvolts. An ultra-low-noise NE64535 preamp stage is also available as an option to get sensitivity down to 0.2 microvolt in the TVC-4L.

The TVC-4 downconverter comes in an attractive Ten-Tec JW-5 enclosure, and Ten-Tec has specially coated the Cyclac woodgrain side panels with a conductive coating for excellent shielding.

Pricing for the downconverters is \$85 for the standard low-noise TVC-4, \$115 for the ultra-low-noise TVC-4L. Both prices include shipping in the U.S. For those who wish to build their own cabinet and power supply, the downconverter modules by themselves, wired and tested, are available (TVC-2 and TVC-2L) for \$49.50 and \$79.50 respectively, postage paid. Write for a complete ATV catalog. Send a self-addressed, stamped envelope to P.C. Electronics, 2522 S. Paxson Lane, Arcadia, California 91006.

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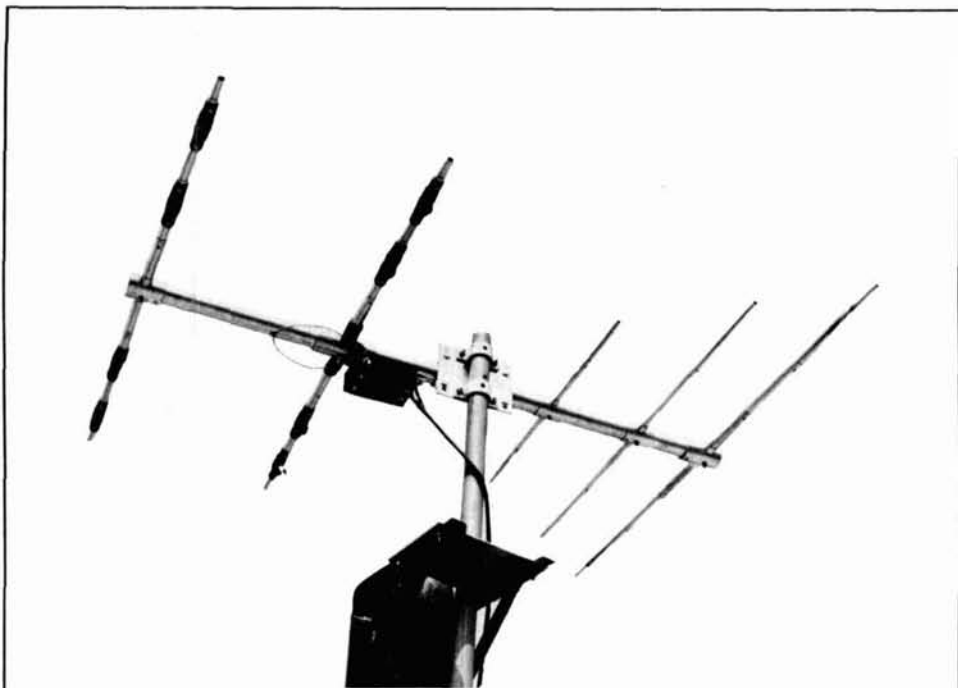
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Telrex introduces the latest in its series of professionally engineered antennas, a five-element, balun-fed 10, 15, and 20-meter tri-band beam, Model TB5ES. The TB5ES provides optimum forward gain, front-to-back ratio, and signal-to-noise ratio, in an antenna which exhibits a clean and precise pattern.

The quality of the TB5ES is also in keeping with its famous Telrex predecessors, the TB5EM and the TB6EM. A precision-machined boom, hermetically sealed, epoxied traps, stainless-steel electrical hardware, preformed gusset mounting straps, reinforced, extremely heavy-walled boom and elements, elements driven through the boom, high-strength, seamless, drawn-dural aluminum tubing, and a non-ferrite, coaxial high-performance Balun (provided with the antenna) are only a few of its many attributes.

Consistent with the workmanship normally associated with Telrex, the TB5ES is a hand-crafted, precision-machined antenna.

The TB5ES has an 18-foot boom, 36-foot longest element, 22-foot turn-

ing radius, 7-square-foot wind surface area, weighs 49 pounds, and is shipped via motor freight in a 13-foot long carton.

The half-power beamwidth is 60°, with 35 dB side nulls and a 1 kW peak power rating.

The price is right at \$315.00 f.o.b. Asbury Park, New Jersey.

For further information write Telrex Labs, P.O. Box 879, Asbury Park, New Jersey 07712, or phone (answer phone available day or night, Saturdays, Sundays, and holidays) 201-775-7252 and leave your mailing address.

short circuit

Yagi antenna design

In W2PV's article, page 39 of the June, 1980, *ham radio*, the highest gain value on the graphs should read 15, not 0.5. The three graphs in the left-hand column should all read Boom = 0.75λ ; the three in the right-hand column should all read Boom = 1.25λ .

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More Details? CHECK—OFF Page 94

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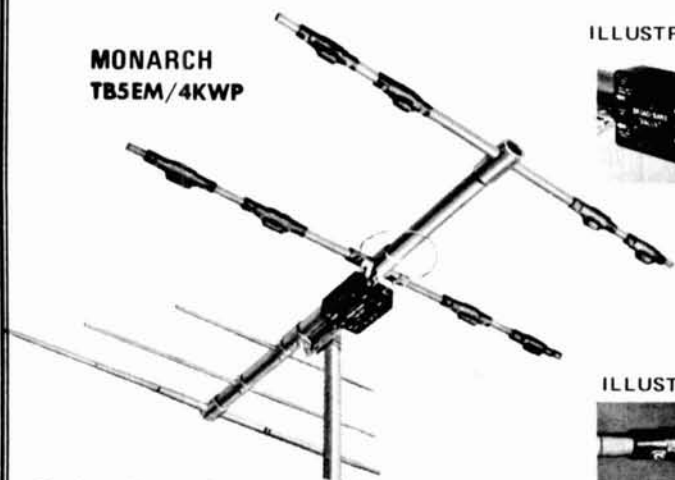


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This circuit provides about 43 dB gain with 50 ohm input and output impedance. It is designed to drive the HOWARD/COLEMAN TVRO Demodulator. The on-board band pass filter can be tuned for bandwidths between 20 and 35 MHz with a passband ripple of less than 1/2 dB. Hybrid ICs are used for the gain stages. Bare boards cost \$25. It is estimated that parts for construction will cost less than \$40.	
.01 pF CHIP CAPACITORS	\$7.00
For use with 70 MHz IF Board. Consists of 7 — .01 pF.	
DEMODULATOR BOARD	40.00
This circuit takes the 70 MHz center frequency satellite TV signals in the 10 to 200 millivolt range, detects them using a phase locked loop, de-emphasizes and filters the result and amplifies the result to produce standard NTSC video. Other outputs include the audio subcarrier, a DC voltage proportional to the strength of the 70 MHz signal, and AFC voltage centered at about 2 volts DC. The bare boards cost \$40 and total parts cost less than \$30.	
SINGLE AUDIO	\$15.00
This circuit recovers the audio signals from the 6.8 MHz frequency. The Miller 9051 coils are tuned to pass the 6.8 MHz subcarrier and the Miller 9052 coil tunes for recovery of the audio.	
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Duplicate of the single audio but also covers the 6.2 range.	
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8691A	1 to 2 Gc Plug In For 8690A Sweeper	800.00
8692A	2 to 4 Gc Plug In For 8690A Sweeper	800.00
8693A	4 to 8 Gc Plug In For 8690A Sweeper	800.00
8742A	Reflection Test Unit 2 to 12.4 Gc	1800.00

Alltech:		
473	225 to 400 mc AM/FM Signal Generator	750.00

Singer:		
MF5/VR-4	Universal Spectrum Analyzer with 1 kHz to 27.5 mc Plug In	1200.00

Keltek:		
XR630-100	TWT Amplifier 8 to 12.4 Gc 100 watts 40 dB gain	9200.00

Polarad:		
2038/2436/1102A	Calibrated Display with an SSB Analysis Module and a 10 to 40 mc Single Tone Synthesizer	1500.00

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Input Voltage 3 to 32 Vdc.

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2N1562	15.00	2N5591	11.85	MM1552	50.00
2N1692	15.00	2N5637	22.15	MM1553	56.50
2N1693	15.00	2N5641	6.00	MM1601	5.50
2N2632	45.00	2N5642	10.05	MM1602/2N5842	7.50
2N2857JAN	2.52	2N5643	15.82	MM1607	8.65
2N2876	12.35	2N5645	12.38	MM1661	15.00
2N2880	25.00	2N5764	27.00	MM1669	17.50
2N2927	7.00	2N5842	8.78	MM1943	3.00
2N2947	18.35	2N5849	21.29	MM2605	3.00
2N2948	15.50	2N5862	51.91	MM2608	5.00
2N2949	3.90	2N5913	3.25	MM8006	2.23
2N2950	5.00	2N5922	10.00	MMCM918	20.00
2N3287	4.30	2N5942	46.00	MMT72	1.17
2N3294	1.15	2N5944	8.92	MMT74	1.17
2N3301	1.04	2N5945	12.38	MMT2857	2.63
2N3302	1.05	2N5946	14.69	MRF304	43.45
2N3304	1.48	2N6080	7.74	MRF420	20.00
2N3307	12.60	2N6081	10.05	MRF450	11.85
2N3309	3.90	2N6082	11.30	MRF450A	11.85
2N3375	9.32	2N6083	13.23	MRF454	21.83
2N3553	1.57	2N6084	14.66	MRF458	20.68
2N3755	7.20	2N6094	7.15	MRF475	5.00
2N3818	6.00	2N6095	11.77	MRF476	5.00
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2N3866JAN	2.80	2N6097	29.54	MRF504	6.95
2N3866JANTX	4.49	2N6136	20.15	MRF509	4.90
2N3924	3.34	2N6166	38.60	MRF511	8.15
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2N3950	26.86	2N6266	100.00	MRF5177	21.62
2N4072	1.80	2N6439	45.77	MRF8004	1.60
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2N4429	7.50	A50-12	25.00	PT4628	5.00
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2N4958	2.92	BLY568CF	25.00	PT9784	24.30
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2.7pf	47pf	300pf	2200pf
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3.9pf	68pf	360pf	3300pf
4.7pf	82pf	390pf	3900pf
5.6pf	100pf	430pf	4700pf
6.8pf	110pf	470pf	5600pf
8.2pf	120pf	510pf	6800pf
10pf	130pf	560pf	8200pf
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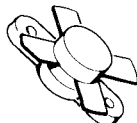
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Efficiency = 50%
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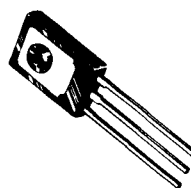
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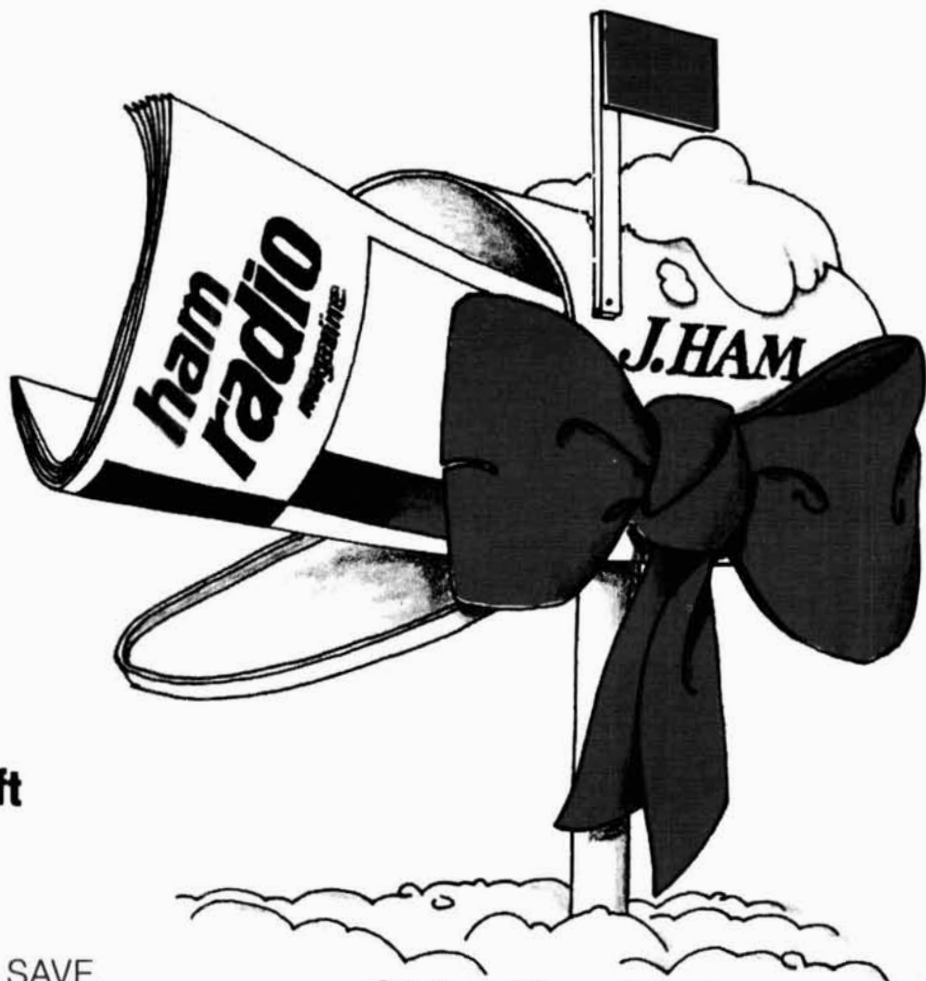
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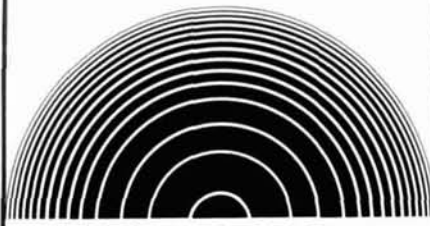
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STOLEN EQUIPMENT: The following was stolen June 22, 1980: SRC 145A 2 Mtr. Walkie-Talkie with Touchtone pad Ser. #504279; SRC 432 450 MHz Walkie-Talkie, Ser. #408052; Midland 13-509 220 MHz Transceiver, Ser. #61001736; Icom IC-320 Transceiver (450 MHz), Ser. #3603560. Since this equipment was all obtained in Japan and not imported through normal distribution channels, it should be easy to identify should anyone request information or order crystals. Any information regarding this equipment, please contact the Houston Police Department (Case #R79164).

Coming Events

OHIO: Heart of Ohio's 5th annual Ham Fiesta on October 29 at the Marion County Fairground's Coliseum in Marion, OH. Flea Market, prizes, XYL drawing. Talk-in on 90/30 and 52. Dealer space available. For more info: Paul Kilzer, W8GAX, 393 Pole Ln. Rd., Marion, OH 43302.

ENGLAND: L.A.R.C. Swap and Shop on Sunday October 26 at Lord Dorchester High School. Free parking, indoor display, food available, forums, hourly prize drawings and much more. Admission: \$2.00. Reservations: Dick Reiber, 417 Regal Drive, London, N5Y 1J8. Talk-in on 52 and 78/18.

MARYLAND: Columbia Amateur Radio Association's fourth annual Hamfest on October 12 at the Howard County Fairgrounds at 8 a.m. Admission: \$3.00, tailgating and tables: \$5.00. Food, prizes, and more. Talk-in on 147.735/135; 52/52; 146. Reservations and info: Dennis Parra, 6955 Spinning Seed, Columbia, MD 21045.



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MASSACHUSETTS: 19-79 Repeater Association of Malden, Massachusetts, first annual flea market on October 19 at the Beachmont VFW Post, 150 Bennington Street, Revere, Massachusetts. Admission: \$1.00. Talk-in on 19-79 at .52. More info: P.O. Box 221, Malden, MA 02148.

INDIANA: Marshall County A.R.C.'s Plymouth, Indiana, Swap and Shop on October 12 at the National Guard Armory in the west part of Plymouth. Tickets: \$2.00 advanced and \$2.50 at door. More info: P.O. Box 151, Plymouth, IN 46563.

PENNSYLVANIA: Foothills A.R.C. of Greensburg. Annual swap and shop on Nov. 8 at the St. Bruno's Church in South Greensburg. 9:00 A.M.-5 P.M. Prizes and much more. Talk-in on 146.07-.67 and .52 simplex. Dealers welcome. Advanced table reservations: Jim Yex, WB3CQA, (412) 256-3531. More info: Chuck Hamman, WB3HZM (412) 837-9194.

TEXAS: El Paso Hamfest on October 11 and 12 at the Missile Inn, 9487 Dyer Street (U.S. 54). Talk-in on 146.28-.88. Seminars, swap tables, door prizes, and more. Write El Paso Hamfest, P.O. Box 4573, El Paso, TX 79914 or call Mary Ann or Roy Gould, (915) 751-7638.

NEW ZEALAND: New Zealand Association of Radio Transmitters Inc. VK/ZL Oceania DX contest 1980 from 1000 GMT Saturday, October 4, to 1000 GMT Sunday, October 5, Phone. 1000 GMT Saturday, October 11, to 1000 GMT Sunday, October 12, CW.

JAMBOREE-ON-THE-AIR: Starts: 0001 UTC October 18. Ends: 2400 UTC October 19. Sponsored by the World Scout Bureau. Not a contest, just an opportunity for all kids to talk about scouting. No logs required. Certificates available from W2GND, H. A. Harchar, 216 Maxwell Avenue, Hightstown, NJ 08520. Freqs. Phone: 3940, 7290, 14.290, 21.360, 28.990, 50.500. CW: 3590, 7030, 14.070, 21.040, 28.190, 50.050. Novice: 3750, 7125, 21.140. All SSVT, RTTY frequencies.

GREATER DELAWARE VALLEY — 80 HAMFEST will be held October 19, 1980, in Pennsauken, New Jersey, at the Nashville East Cotillion Ballroom on Rt. 73 from 8 AM to 5 PM. Over 19,000 square feet of exhibit space (no hallways). Seminars, YL/YL activities, and films. Door prizes hourly until 3:30. Talk-in 146.22/82. Tailgating is \$3.00/10' space, indoor tables are \$5.00. Tickets are \$2.50 at the gate and \$2.00 in advance. For reservations, maps or tickets write GDV-80, 15 East Camden Avenue, Moorestown, New Jersey, 08057 or call 609-234-3926.

NEW YORK: Radio Amateurs of Greater Syracuse Hamfest on October 4 at the Arts and Home Center, New York State Fairgrounds. Exhibits, indoor/outdoor flea market, woman's program, door prizes, food and more. Talk-in on 31/91 and 90/30. Tickets: \$2.00. More info: R.A.G.S., P.O. Box 88, Liverpool, NY 13088.

MASSACHUSETTS: Framingham A.R.A. flea market, Sunday, November 9, 1980, at the Framingham Police Station Drill Shed. Doors open 9 A.M. Admission \$1; Sellers: \$5/table. Talk-in on 147.75/15 and 146.52 simplex. Information — Ron Esalka, K1YHM, F.A.R.A., P.O. Box 3005, Saxonville, MA 01701; tel: (617) 877-4520.

PENNSYLVANIA: Pack Rats fourth annual Mid-Atlantic States VHF Conference on October 4 at the Warrington Motor Lodge, Rte. 611, Warrington, Pennsylvania. Advanced registration: \$3.00, \$4.00 at the door. Includes admission to Hamarama 80 flea market at Bucks County Drive-in, Rt. 611, Warrington. Flea Market alone is \$2.00. Tailgating: \$2.00 per space. Talk-in W3CCX on 52. Info for both events: Ron Whitsel, WA3AXV, P.O. Box 353, Southampton, Pennsylvania 18966. (215) 355-5730.

NEW YORK: ARRL Hudson Division convention on November 7-9 at Pines Resort Hotel in South Fallsburg, New York. Exhibits, door prizes and much more. More info: Randy Gutentag, WA2RMZ, 86 Balch Ave., Piscataway, NJ 08854.

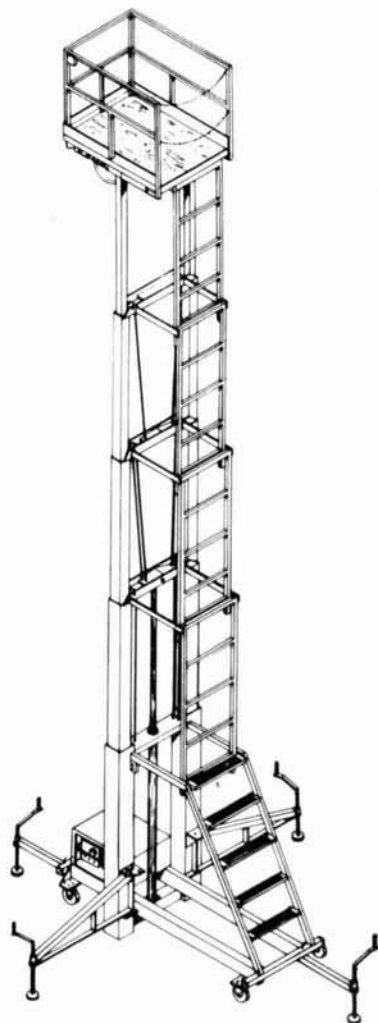
VIRGINIA STATE ARRL CONVENTION: The Fifth Annual Tidewater Hamfest and ARRL Virginia State Convention will be in the great new Virginia Beach, Virginia Arts and Conference Center, October 4 and 5, 1980. ARRL, Traffic, DX Forums, XYL free bingo and lounge. Admission \$3.50. Advance admission ticket drawing for Kenwood FM transceiver. Flea market spaces \$3.00 day. Ticket and information — TRC, P.O. Box 7101, Portsmouth, Virginia 23707 SASE.

MICHIGAN: Oak Park High School Electronic Club's 11th annual Swap-N-Shop on November 30 at the Oak Park High School, Oak Park, Michigan. 8:00 A.M. to 4:00 P.M. Door prizes, refreshments and more. Admission: \$1.50 in advance and \$2.00 at the door. More info or tickets: Herman Gardner, Oak Park High School, 13701 Oak Park Blvd., Oak Park, Michigan 48237 or call Bruce at 313-543-8569.

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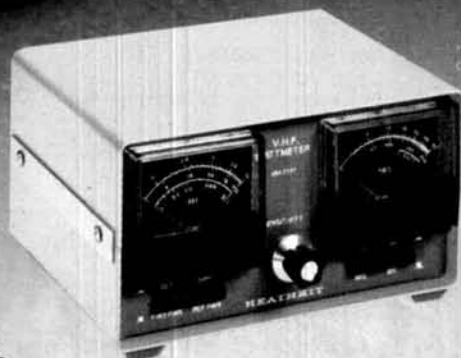
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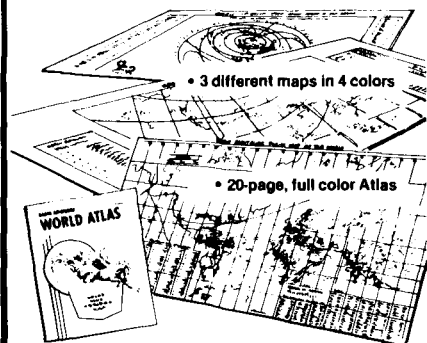
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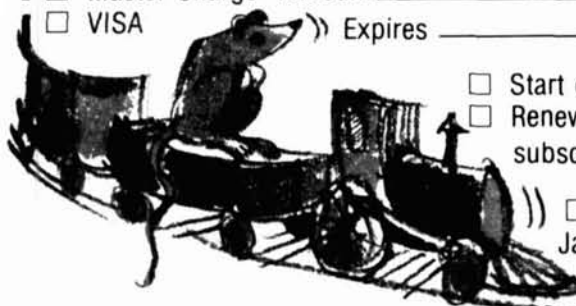
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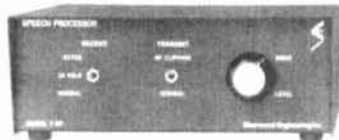


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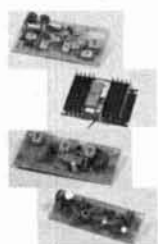
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AS-1

15 minutes to install; scan restarts when carrier drops off; busy switch controls automatic scan on-off; includes module and instructions.

Model AS-1.
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9 DIGITS 600 MHz \$129⁹⁵ WIRED

SPECIFICATIONS:
 Range: 20 Hz to 600 MHz
 Sensitivity: Less than 10 MV to 150 MHz
 Less than 50 MV to 500 MHz
 Resolution: 0.1 Hz (10 MHz range)
 1.0 Hz (60 MHz range)
 10.0 Hz (600 MHz range)
 Display: 9 digits 0.4" LED
 Time base: Standard-10,000 mHz, 1.0 ppm 20-40°C
 Optional Micro-power oven-0.1 ppm 20-40°C
 Power: 8-15 VAC @ 250 ma

PRICES:
 CT-90 wired, 1 year warranty \$129.95
 CT-90 Kit, 90 day parts warranty 109.95
 AC-1 AC adapter 3.95
 BP-1 Nicad pack + AC Adapter/Charger 12.95
 OV-1 Micro-power Oven time base 49.95
 External time base input 14.95

The CT-90 is the most versatile, feature packed counter available for less than \$300.00! Advanced design features include: three selectable gate times, nine digits, gate indicator and a unique display hold function which holds the displayed count after the input signal is removed! Also, a 10mHz TCXO time base is used which enables easy zero beat calibration checks against WWV. Optionally, an internal nicad battery pack, external time base input and Micro-power high stability crystal oven time base are available. The CT-90, performance you can count on!

7 DIGITS 525 MHz \$99⁹⁵ WIRED



SPECIFICATIONS:

Range: 20 Hz to 525 MHz
 Sensitivity: Less than 50 MV to 150 MHz
 Less than 150 MV to 500 MHz
 Resolution: 1.0 Hz (5 MHz range)
 10.0 Hz (50 MHz range)
 100.0 Hz (500 MHz range)
 Display: 7 digits 0.4" LED
 Time base: 1.0 ppm TCXO 20-40°C
 Power: 12 VAC @ 250 ma

The CT-70 breaks the price barrier on lab quality frequency counters. Deluxe features such as: three frequency ranges - each with pre-amplification, dual selectable gate times, and gate activity indication make measurements a snap. The wide frequency range enables you to accurately measure signals from audio thru UHF with 1.0 ppm accuracy - that's .0001%! The CT-70 is the answer to all your measurement needs, in the field, lab or ham shack.

PRICES:
 CT-70 wired, 1 year warranty \$99.95
 CT-70 Kit, 90 day parts warranty 84.95
 AC-1 AC adapter 3.95
 BP-1 Nicad pack + AC adapter/charger 12.95

7 DIGITS 500 MHz \$79⁹⁵ WIRED

PRICES:

MINI-100 wired, 1 year warranty \$79.95
 MINI-100 Kit, 90 day part warranty 59.95
 AC-Z Ac adapter for MINI-100 3.95
 BP-Z Nicad pack and AC adapter/charger 12.95

Here's a handy, general purpose counter that provides most counter functions at an unbelievable price. The MINI-100 doesn't have the full frequency range or input impedance qualities found in higher price units, but for basic RF signal measurements, it can't be beat! Accurate measurements can be made from 1 MHz all the way up to 500 MHz with excellent sensitivity throughout the range, and the two gate times let you select the resolution desired. Add the nicad pack option and the MINI-100 makes an ideal addition to your tool box for "in-the-field" frequency checks and repairs.

SPECIFICATIONS:

Range: 1 MHz to 500 MHz
 Sensitivity: Less than 25 MV
 Resolution: 100 Hz (slow gate)
 1.0 KHz (fast gate)
 Display: 7 digits, 0.4" LED
 Time base: 2.0 ppm 20-40°C
 Power: 5 VDC @ 200 ma

8 DIGITS 600 MHz \$159⁹⁵ WIRED



NEW READ RECEIVER FREQUENCY

SPECIFICATIONS:

Range: 20 Hz to 600 MHz
 Sensitivity: Less than 25 mv to 150 MHz
 Less than 150 mv to 600 MHz
 Resolution: 1.0 Hz (60 MHz range)
 10.0 Hz (600 MHz range)
 Display: 8 digits 0.4" LED
 Time base: 2.0 ppm 20-40°C
 Power: 110 VAC or 12 VDC

The CT-50 is a versatile lab bench counter that will measure up to 600 MHz with 8 digit precision. And, one of its best features is the Receive Frequency Adapter, which turns the CT-50 into a digital readout for any receiver. The adapter is easily programmed for any receiver and a simple connection to the receiver's VFO is all that is required for use. Adding the receiver adapter in no way limits the operation of the CT-50, the adapter can be conveniently switched on or off. The CT-50, a counter that can work double-duty!

PRICES:

CT-50 wired, 1 year warranty \$159.95
 CT-50 Kit, 90 day parts warranty 119.95
 RA-1, receiver adapter kit 14.95
 RA-1 wired and pre-programmed (send copy of receiver schematic) 29.95

DIGITAL MULTIMETER \$99⁹⁵ WIRED



PRICES:

DM-700 wired, 1 year warranty \$99.95
 DM-700 Kit, 90 day parts warranty 79.95
 AC-1, AC adaptor 3.95
 BP-3, Nicad pack + AC adapter/charger 19.95
 MP-1, Probe kit 2.95

The DM-700 offers professional quality performance at a hobbyist price. Features include: 26 different ranges and 5 functions, all arranged in a convenient, easy to use format. Measurements are displayed on a large 3 1/2 digit, 1/2 inch LED readout with automatic decimal placement, automatic polarity, overrange indication and overload protection up to 1250 volts on all ranges, making it virtually goof-proof! The DM-700 looks great, a handsome, jet black, rugged ABS case with convenient retractable tilt bail makes it an ideal addition to any shop.

SPECIFICATIONS:

DC/AC volts: 100uV to 1 KV, 5 ranges
 DC/AC current: 0.1 uA to 2.0 Amps, 5 ranges
 Resistance: 0.1 ohms to 20 Megohms, 6 ranges
 Input impedance: 10 Megohms, DC/AC volts
 Accuracy: 10.1% basic DC volts
 Power: 4°C cells

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- Great for PL tones
- Multiplies by 10 or 100
- 0.01 Hz resolution!

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ACCESSORIES

Telescopic whip antenna - BNC plug \$ 7.95
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For measuring extremely weak signals from 10 to 1,000 MHz. Small size, powered by plug transformer-included.

- Flat 25 db gain
- BNC Connectors
- Great for sniffing RF with pick-up loop

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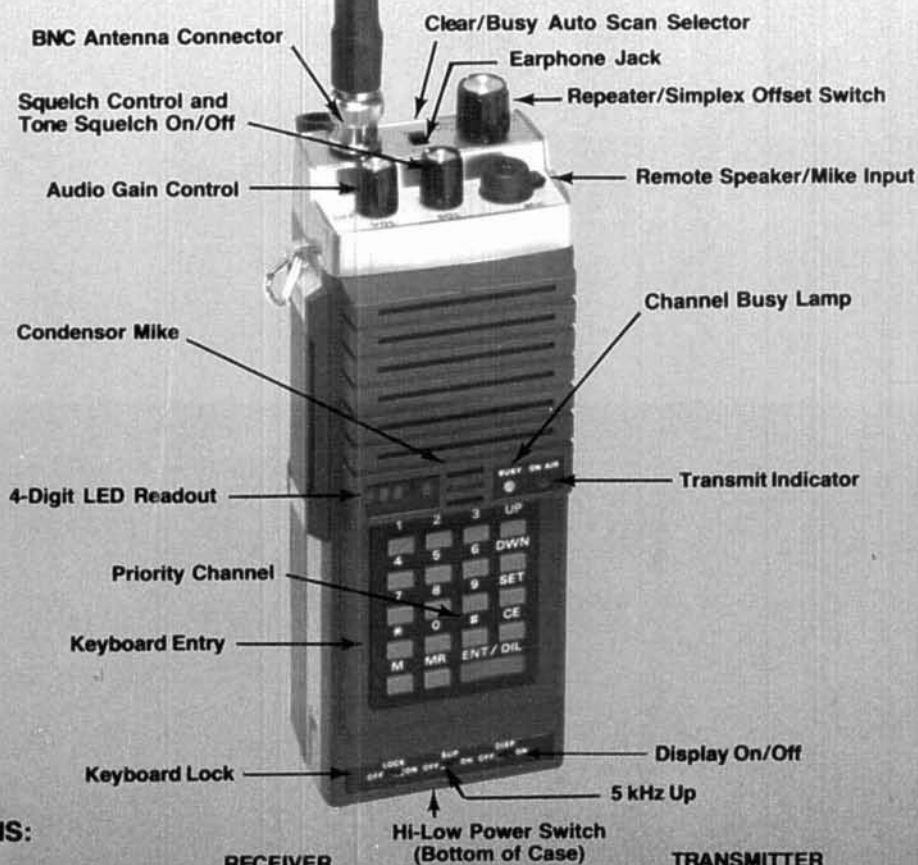
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includes
FT-207R
NBP-9 BATTERY PACK
NC-9B WALL CHARGER
AND MINI EARPHONE



SPECIFICATIONS:

GENERAL

Frequency coverage: 144-148 MHz
Number of channels: 800
Emission type: F3
Batteries: NiCd battery pack
Voltage requirement: 10.8 VDC
± 10%, maximum
Current consumption:
Receive: 35 mA squelched (150 mA unsquelched with maximum audio)
Transmit: 800 mA (full power)
Case dimensions: 68×181×54 mm (HWD)
Weight (with batteries): 680 grams

RECEIVER

Circuit type: Double conversion superheterodyne intermediate frequencies.
1st IF = 10.7 MHz
2nd IF = 455 kHz
Sensitivity: 0.32 μ V for 20 dB quieting
Selectivity: ± 7.5 kHz at 60 dB down
Audio Output: 200 mW at 10% THD

Price And Specifications Subject To Change Without Notice Or Obligation

TRANSMITTER

Power Output: 2.5 watts minimum /200mW
Deviation: ± 5 kHz
Spurious radiation: -60 dB or better
Microphone: Condenser type (2000 ohms)

OPTIONS

LC-C7 Leather Carrying Case
YM-24 Remote Speaker/Microphone
Tone Squelch Unit



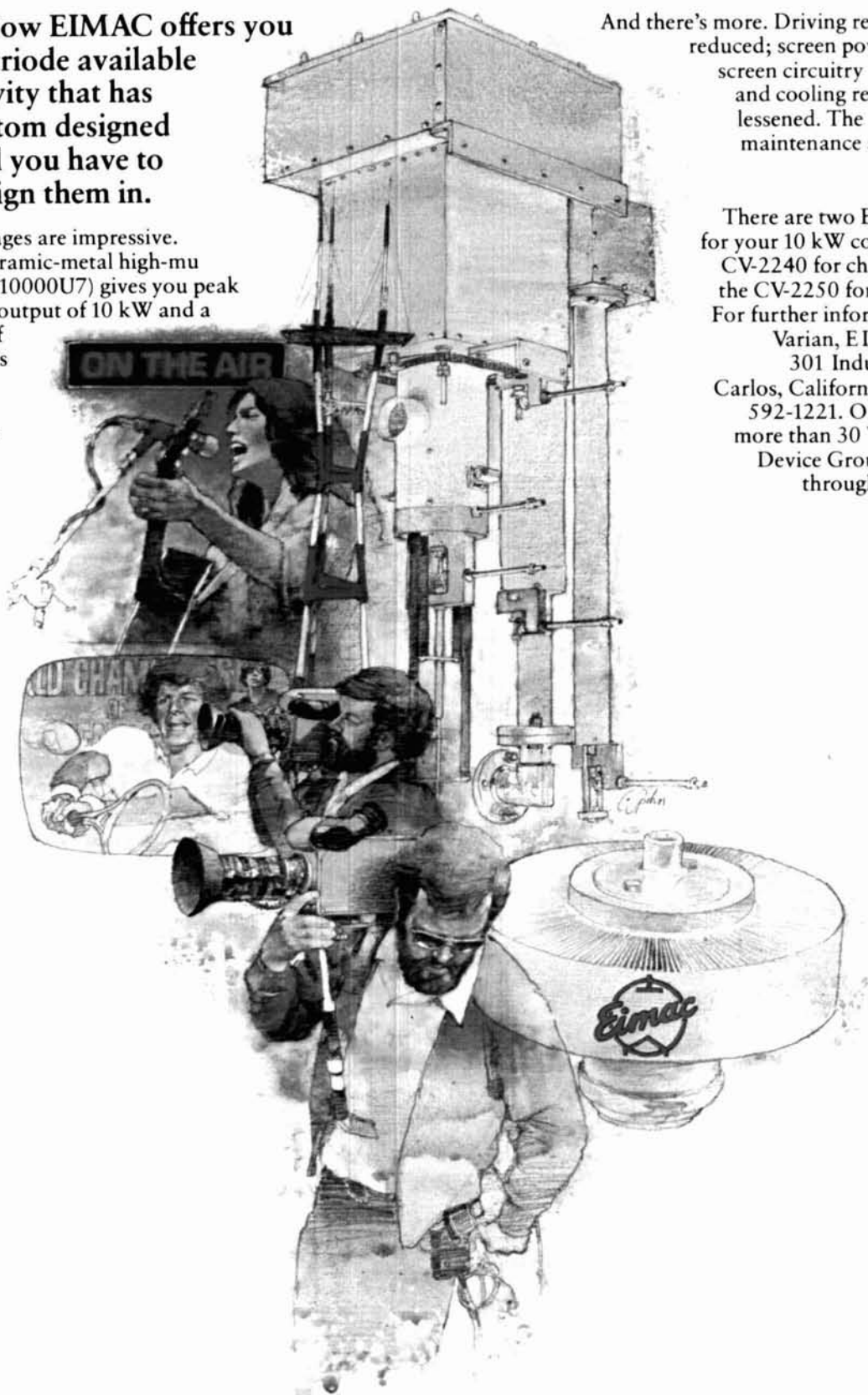
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There are two EIMAC cavities for your 10 kW combination, the CV-2240 for channels 2-6, and the CV-2250 for channels 7-13. For further information contact Varian, EIMAC Division, 301 Industrial Way, San Carlos, California 94070, (415) 592-1221. Or call any of the more than 30 Varian Electron Device Group Sales Offices throughout the world.



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