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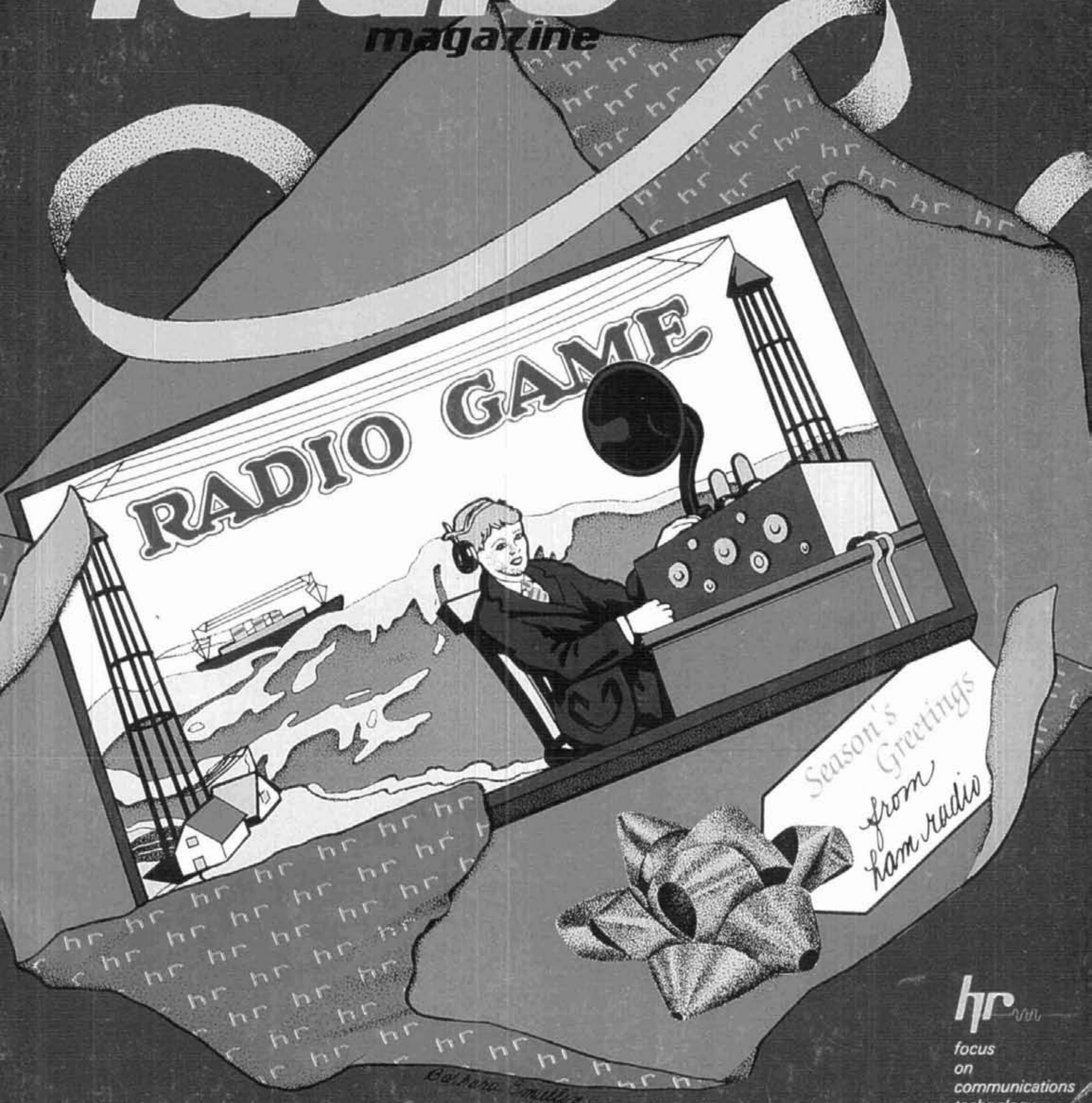
magazine



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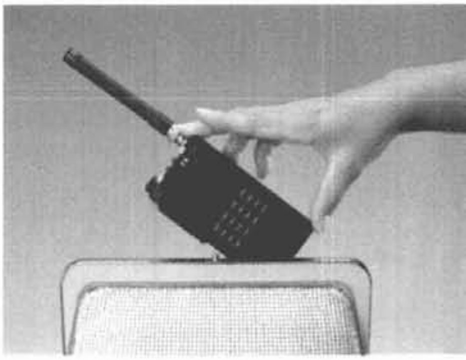

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contents

REFLECTIONS

13 exciting years: looking back

It's been exactly 13 years since Skip Tenney suggested that Amateurs might welcome a short-lead time "newsletter" to cover current news pertinent to Amateur Radio. Skip, Jim Fisk, and I then set to work, and just over a month later the first issue of "HR Report," dated January 2, 1974, was handed out at the SAROC Convention in Las Vegas.

Needless to say, Skip was right. Thirteen years later, *HR Report* is still going strong as *Westlink Report*, under the direction of Bill Pasternak and Burt Hicks. And today, despite a couple of *HR Report's* early would-be competitors having dropped by the wayside, the Amateur fraternity supports two additional broad-coverage newsletters plus a host of others devoted to one special interest or another.

Reviewing the past 13 years through the pages of *HR Report*, *Westlink Report*, and *Presstop* (*ham radio's* newspage, originally distilled from *HR Report but independently written and produced since 1982), one is tempted to say that these have to have indeed been the most exciting 13 years in the history of Amateur Radio. Just consider these Amateur Radio happenings reported in HR Report* during its first two years:

The first thing you'll notice is that while some things change a lot, others change very little or not at all. In the very first *Ham Radio Report*, we reported that CB was threatening 220 MHz and the Emergency Medical Service was after part of 70 cm, FCC license processing was taking 8 to 10 weeks, and a planned SY5MA Mt. Athos operation had been scrubbed. Later that first year *Ham Radio Report* also reported on the initial efforts that led to our getting new bands at the 1979 World Administrative Radio Conference, licensing of the first ATV repeater, FCC elimination of log-keeping requirements, the launch of OSCAR 7 in November, and in December, the FCC's proposed "top-to-bottom" restructuring of the Amateur Service (Docket 20282).

1975 saw Amateur and CB license fees reduced, "environmental impact" and OSHA became Amateur concerns, and the FCC ban on 27-MHz (but not "all-band") linears (and the quick introduction of 4-watt drive all-band "Amateur" linears by various CB suppliers). Dick Baldwin, W1RU, replaced John Huntoon, W1RW, as ARRL General Manager, and the FCC proposed an Automatic Transmitter Identification System for all 25-960 MHz transmitters (except Amateur). The WARC-79/WG/AM (Working Group/Amateur Radio) had its first meeting in May, the FCC reported CB license applications arriving at 15,000 per working day, off-shore navigation systems encroached on 70 cm, the FCC OK'ed special events callsigns, attendance at Dayton exceeded 10,000, *QST* and *ham radio* (and later *73*) announced a change to 8 1/2 x 11-inch formats effective January, 1976, and Texas proposed restricting all rf radiation. John Johnston (then K3BNS, now W3BE) became Chief of the FCC's Amateur and Citizens Division and announced that his would be a "deregulatory" policy (which began by greatly reducing repeater license paperwork), new specific mm-wave Amateur bands through 250 GHz were established, and Amateurs got a nice Christmas present from the FCC when it dropped the minimum operating time and code proficiency requirements for license renewal.

Each succeeding year records an equally diverse list of happenings. Here's just a sampling of some of Amateur Radio's exciting events that occurred during that time:

In space, AMSAT's relatively primitive (but effective) OSCARs 6, 7, and then 8 were joined by the comparable Russian RS birds, and later on, by the very sophisticated OSCAR 10 (whose elliptical orbit finally made worldwide Amateur satellite communication possible) and Japan's "Fuji." Amateurs themselves finally got on the air from space when W5LFL and W0ORE operated from the Space Shuttle.

The U.S. Amateur Service itself grew at a fantastic rate, at least during the CB boom years. At the end of 1974 there were only 253,357 licensed Amateur operators in the United States. Today there are more than 421,000! Much of that growth paralleled the CB boom, which at its peak had users variously estimated at from 15 to 30 million. From 1975 through 1982, an average of over 20,000 new Amateurs were licensed each year, but that died quickly to the present thousand or so a year after CB lost its appeal. The FCC's "restructuring" proposal, which included a no-code "Communicator" class license, also died when the League found strong opposition among its membership.

At Geneva we did get the three new hf bands our volunteer group had worked so hard for, despite the warnings of "gloom-and-doom" advocates who claimed we'd be lucky to come out of WARC '79 with any Amateur bands at all. All the Amateur monthlies increased not only size but price — when HRR began, all had cover prices under a dollar; today, all cost between $2.50 and $3.00 a copy. A court ruled that Amateur and CB license fees were illegal, then made the FCC give back all the fees it had collected. Ever-tightening federal budgets forced the Commission into serious cost-cutting, and one of the more positive results is the very successful Volunteer Examination program that's made access to taking Amateur exams easier than it's ever been before.

The very face of Amateur Radio has changed drastically in the past 13 years. In 1974 vhf/uhf fm, though popular, supported fewer than a thousand FCC-licensed Amateur repeaters; ARRL's latest repeater directory lists well over 10,000! The separate "WR" repeater license, along with secondary station licenses and new club and RACES licenses, all fell victim to FCC "deregulation." Computer technology became an integral part of Amateur Radio and is, indeed, an integral part of many Amateur radios. New computer-based hard copy/data communications modes such as AMTOR and Packet, unheard of just a few years ago, have far eclipsed their predecessor, RTTY, in their number of enthusiastic users.

On the Amateur bands, DXers, vhf/uhf "weak signal" buffs, traffic handlers, and rag chewers alike have enjoyed the benefits and suffered through the depths of a little over one complete sunspot cycle. For hf DXers, there's been the first legitimate activity from BY and YI for many decades, along with a fair number of brand-new "new ones" to keep Honor Roll members and aspirants close to their shacks. We've reported on earthquakes, hurricanes, floods, tornadoes, blizzards, forest fires, and even a volcanic eruption during the past 13 years, and of the contributions of the countless thousands of Amateurs who've responded with skills and equipment to help alleviate the resulting human suffering.

It has indeed been an exciting 13 years for Amateur Radio — though one must wonder if it's really been all that much more so than any similar period of time in the 1920s, 1930s, or post-war years. After all, exciting things have always happened in Amateur Radio, and will, we trust, continue to happen. It's been fun being part of it, as both a participant and a reporter.

Thus it is, with a real feeling of regret, I'm retiring as editor of *Presstop*. After 13 years on the reporter's beat for *ham radio*, a new opportunity outside of Amateur Radio has forced me to relinquish that aspect of my Amateur Radio involvement. That doesn't mean I'm giving up either Ham Radio or *ham radio* — you'll still find me on the air enjoying the former and, when time and my New Hampshire colleagues permit, on the pages of the latter.

73,
Joe Schroeder, W9JUV

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...pacesetter in Amateur radio

3 Choices
70 W/45 W/25 W

Three Choices for 2m!

TM-2570A/2550A/2530A

Feature-packed 2m FM transceivers

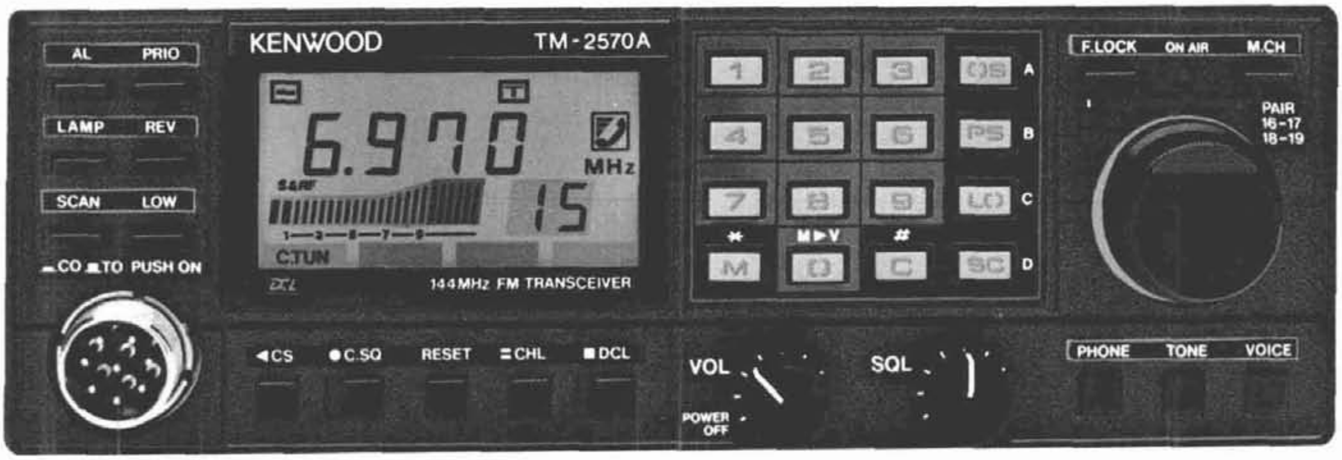
The all-new "25-Series" gives you three RF power choices for 2m FM operation: 70 W, 45 W, and 25 W. Here's what you get:

- Telephone number memory and autodialer (up to 15 seven-digit phone numbers). **A Kenwood exclusive!**
- High performance GaAs FET front end receiver
- 23 channel memory stores offset, frequency, and subtone. Two pairs may be used for odd split operation
- 16-key DTMF pad with audible monitor
- Extended frequency coverage for MARS and CAP (142-149 MHz; 141-151 MHz modifiable)
- Center-stop tuning—**a Kenwood exclusive!**
- New 5-way adjustable mounting system
- Automatic repeater offset selection—**another Kenwood exclusive!**
- Direct keyboard frequency entry
- Front panel programmable 38-tone CTCSS encoder **includes** 97.4 Hz (optional)
- Big multi-color LCD and back-lit controls for excellent visibility
- The TM-3530A is a 25 watt version covering 220-225 MHz. The first full featured 220 MHz rig!

DCL Introducing... Digital Channel Link

Compatible with Kenwood's DCS (Digital Code Squelch), the DCL system enables your rig to **automatically** QSY to an open channel. Now you can automatically switch over to a simplex channel after repeater contact! Here's how it works:

The DCL system searches for an open channel, remembers it, returns to the original frequency and transmits control information to another DCL-equipped station that switches **both** radios to the open channel. Microprocessor control assures fast and reliable operation. The whole process happens in an instant!



Actual size front panel

Optional Accessories

- **TU-7** 38-tone CTCSS encoder
- **MU-1** DCL modem unit
- **VS-1** voice synthesizer
- **PG-2N** extra DC cable
- **PG-3B** DC line noise filter
- **MB-10** extra mobile bracket
- **CD-10** call sign display
- **PS-430** DC power supply for TM-2550A/2530A/3530A
- **PS-50** DC power supply for TM-2570A
- **MC-60A/MC-80/MC-85** desk mics.
- **MC-48B** extra DTMF mic. with UP/DWN switch
- **MC-43S** UP/DWN mic.
- **MC-55** (8-pin) mobile mic. with time-out timer
- **SP-40** compact mobile speaker
- **SP-50B** mobile speaker
- **SW-200A/SW-200B** SWR/power meters
- **SW-100A/SW-100B** compact SWR/power meters
- **SWT-1** 2m antenna tuner

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presstop de W9JUV

CHALLENGING IDEAS FOR AMATEUR RADIO'S FUTURE, particularly with respect to the concept of "personal communications," are contained in the recently released FCC Office of Plans and Policy Working Paper No. 20. With respect to the Amateur Service, author James McNally, WB3APV, notes that Amateur Radio is in a slow growth phase that could continue for many years under present limitations, then suggests such revolutionary ideas as relaxing the limits on "permissible communications," permitting an Amateur's immediate family limited use of his or her station on portions of the VHF/UHF bands, and/or creating a combined Amateur/personal radio service on parts of the 33- or 23-cm bands. Also discussed at length is the GMRS service, which he also urges be greatly expanded and made more flexible.

This Fascinating And Very Thought-Provoking Study should be required reading for anyone who is concerned with the future direction of the Amateur Radio Service.

NOVICE "ENHANCEMENT" PROBABLY WON'T APPEAR IN ANYONE'S XMAS STOCKING this year, despite optimistic predictions from several sources. Though the proposal to give many new privileges to Novices (and Techs) is enjoying broad Amateur support, the usual timetable for seeing a significant proposal through FCC procedures makes such a short turnaround seem unlikely. A more realistic estimate would put Commission action into early 1987.

FCC HAS PROPOSED 40-METER NOVICE BAND EXPANSION TO INCLUDE 7050-7075 kHz in Alaska and U.S. Carribbean and Pacific islands, due to interference in the 7100-7150 kHz Novice band. Comments on the NPRM, PR Docket 86-397, are due December 22; Reply Comments by January 21.

Automatic Control Of VHF/UHF Packet Stations using ARRL AX.25 protocol has been approved by the FCC, effective November 24; automatic HF digital operation wasn't decided.

The Effective Date For VECs To Be Responsible For Maintaining the Amateur examination question pool was still pending at presstime. It should, however, be before year's end.

The Comment Due Date For FCC's Automatic Transmitter Identification System proposal (see October Presstop) has been extended to January 19, 1987; Reply Comments to February 16.

ALLEGATIONS OF FRAUD IN AMATEUR EXAM ADMINISTRATION ARE CASTING A PALL over the VEC program. Serious questions have been raised about certain VE teams in Texas, Puerto Rico, North Carolina, and southern California, and all are believed under FCC investigation. In at least one case there's also reported to be a "repeater war" between some of those involved that may be related to the accusations, but there also appears to be grounds for belief that at least some limited "selling" of Amateur licenses has taken place.

W5YI Reports Two Newly Licensed Amateurs Examined by one of his VE teams were called in for reexamination by a DeVry VE team at FCC request, and that he's removed the accreditation of another of his VEs in California. Fortunately, in terms of the VEC program's size, the improprieties involve only a very small minority of the participants.

THERE'S SOME ENCOURAGEMENT IN THE FCC'S LATEST AMATEUR GROWTH FIGURES, which show another all-time high of 421,082 U.S. Amateurs at September's end, though that's only a 2 percent increase over a year ago. What's more encouraging is the number of new Amateurs licensed during the past 12 months — 20,979, up 20.75 percent over the preceding year. In the same period dropouts decreased by 15.13 percent, to 12,484. By class, Extras are up by 7.38 percent, Advanced 4.73, Tech and Novice 3.6 each, while the only decrease was for General, down 0.5 percent. 22,228 Amateurs upgraded during the year, a 10 per cent increase.

"ARCHIE'S HAM RADIO ADVENTURE," THE INDUSTRY-GROUP-INSPIRED comic book designed to pique youngsters' curiosity about Amateur Radio, is now available in quantity. The story line in this very well done 36-page booklet manages to include HF and VHF fm, DX, OSCAR, autopatch and even packet radio while maintaining an entertaining and coherent story line. Educators and others in a position to place copies in the hands of youngsters in the targeted 10-14 year old age group should contact Viki Armentano at the ARRL.

WESTLINK REPORT'S FIRST "YOUNG HAM OF THE YEAR" IS SHAWN WAKEFIELD, WK5P, a 16-year old Eagle Scout from Bartlesville, Oklahoma. Not satisfied with getting five of his fellow Scouts into Amateur Radio, Shawn led efforts to set up Radio Explorer Post 103 and also organized a radio club in his high school, where he's an honor student. Active in RACES, he also set up and runs a 7274-kHz railroad buffs' net on alternate Tuesdays at 0000z.

Shawn Was The Judges' Unanimous Choice, despite strong competition from several other nominees. He was to receive the award, which includes a complete Yaesu station, at the Ham/West Convention banquet in Las Vegas November 8.

PRESSTOP EDITOR JOE SCHROEDER, W9JUV, IS RETIRING as of this issue, and ham radio's editors have decided not to continue the monthly Amateur Radio news column without him. Joe's just purchased a small gun collecting book publishing firm, and expects his new responsibilities there to keep him fully occupied. He will, however, remain on the ham radio masthead to contribute editorials and an occasional feature article.

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TS-440S Compact high performance HF transceiver with general coverage receiver

Kenwood's advanced digital know-how brings Amateurs world-wide "big-rig" performance in a compact package. We call it "Digital DX-citement"—that special feeling you get every time you turn the power on!

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  General coverage receiver tunes from 100 kHz—30 MHz. Easily modified for HF MARS operation.
- **Direct keyboard entry of frequency**
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  USB, LSB, CW, AM, FM, and AFSK. Mode selection is verified in Morse Code.
- **Built-in automatic antenna tuner (optional)**
  Covers 80-10 meters.
- **VS-1 voice synthesizer (optional)**
- **Superior receiver dynamic range**
  Kenwood DynaMix™ high sensitivity direct mixing system ensures true 102 dB receiver dynamic range. (500 Hz bandwidth on 20 m)
- **100% duty cycle transmitter**
  Super efficient cooling permits continuous key-down for periods exceeding one hour. RF input power is rated at 200 W PEP on SSB, 200 W DC on CW, AFSK, FM, and 110 W DC AM. (The PS-50 power supply is needed for continuous duty.)
- **Adjustable dial torque**
- **100 memory channels**
  Frequency and mode may be stored in 10 groups of 10 channels each. Split frequencies may be stored in 10 channels for repeater operation.
- **TU-8 CTCSS unit (optional)**
  Subtone is memorized when TU-8 is installed.
- **Superb interference reduction**
  IF shift, tuneable notch filter, noise blanker, all-mode squelch, RF attenuator, RIT/XIT, and optional filters fight QRM.
- **MC-43S UP/DOWN mic. included**
- **Computer interface port**

- **5 IF filter functions**
- **Dual SSB IF filtering**
  A built-in SSB filter is standard. When an optional SSB filter (YK-88S or YK-88SN) is installed, **dual** filtering is provided.
- **VOX, full or semi break-in CW**
- **AMTOR compatible**

Optional accessories:
• AT-440 internal auto. antenna tuner (80 m—10 m) • AT-250 external auto. tuner (160 m—10 m) • AT-130 compact mobile antenna tuner (160 m—10 m) • IF-232C/IC-10 level translator and modem IC kit • PS-50 heavy duty power supply • PS-430/PS-30 DC power supply • SP-430 external speaker • MB-430 mobile mounting bracket • YK-88C/88CN 500 Hz/270 Hz CW filters • YK-88S/88SN 2.4 kHz/1.8 kHz SSB filters • MC-60A/80/85 desk microphones • MC-55 (8P) mobile microphone • HS-5/6/7 headphones • SP-40/50B mobile speakers • MA-5/VP-1 HF 5 band mobile helical antenna and bumper mount • TL-922A 2 kw PEP linear amplifier • SM-220 station monitor • VS-1 voice synthesizer • SW-100A/200A/2000 SWR/power meters • TU-8 CTCSS tone unit • PG-2S extra DC cable

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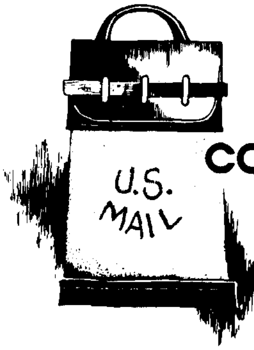

comments

buying topo maps

Dear HR:

Here's some updated information regarding the purchase of topographic maps from the United States Geological Survey.

First, the headquarters of the United States Geological Survey has been moved to Reston, Virginia 22092. All mail orders, however, should be addressed to the Distribution Branch, United States Geological Survey, Box 25286, Federal Center Building 41, Denver, Colorado 80225.

For a copy of the USGS index to topographic maps, call 703 648-5830. Request the index for a specific geographic region — for example, Maryland, Delaware and the District of Columbia, which are grouped together. Each regional index lists local retailers who carry USGS maps as well as a variety of special maps, including state maps, satellite image maps, and maps showing national parks, rainfall, population distribution, and similar information.

I hope this information will be useful to those seeking that ideal site on which to place their "Giant Killer Contest Stations."

Dan Szymanski, K3SKE
Frederick, Maryland 21701

cheers from down under

Dear HR:

Received July's *ham radio* yesterday and was fascinated by K2RR's "Reflections" ("The Phone Call," page 4).

The problems discussed have also been part of an investigation by the Redcliffe Radio Club. . . . We also discussed the problem a few weeks ago and came to a very interesting conclusion, which is probably worth following up in the USA as well.

Attracting youngsters to Amateur Radio is pretty difficult, what with all those distractions — including computers. It's easier, especially if one has access to a modem, to use the 600-ohm twisted pair. Then too, Australian school kids are generally not interested in studying extra-curricular subjects because they don't count as academic credits. Why work hard for something that doesn't count?

A far greater source of new Amateurs would appear to be those approaching retirement age, who are trying to find something to do besides fishing, hunting, or annoying the "missus." This last suggestion has been based on past experience within the Club. We found that most of the adult students persevered and finally passed the Novice exam and within a year upgraded to either Limited License (your Technician License) or General License, while out of ten young students (under 20 years) only three or four made the grade; all the rest all dropped out.

Due to the nature of the Amateur organization in Australia — where, because of the cost, most work is done by volunteers, and not much can be done by either the Federal Council of the WIA or the State Councils — much depends on the Clubs. And of those, only a handful are trying their hardest to recruit more Hams.

There is one danger [in recruiting new hams], however. A club specializing in classes for newcomers may tend to forget those who passed the examinations simply because all the volunteers are involved in training or other work to keep the Club afloat.

I would like to hear of US Clubs who have been able to keep licensed Amateurs interested enough to remain active in the Club.

Thanks for a magnificent magazine — and 73 from Down Under.

John Aarsse, VK4QA
Nambour, Australia

short circuits

Digi-Key address

In the October, 1986 article, "Get on SSTV—with the C-64," the address of Digi-Key, Inc., was stated incorrectly (**fig. 1**, page 45). The correct address is Digi-Key, Inc., P.O. Box 677, Thief River Falls, Minnesota 56701-9988.

low-noise UHF/VCO

In part 1 of my article, "Low-Noise Phase-Locked UHF VCO" (July, 1986, page 33) the noise floor in fig. 3 was shown as −142 dBc/Hz for N = 1. To label the curve shown with N = 1, however, is ambiguous, since the phase detector compares 1152 MHz with the 32nd harmonic of the reference crystal oscillator.

Reference oscillator noise increases by 20 log N where N in this case is 32. Therefore, the noise floor of the 1152 MHz VCO should be moved to about −130 dBc/Hz, if the effect of reference multiplication and noise in the loop is taken into consideration. This puts the noise floor corner at about 20 kHz, with noise rising at 20 dB per decade to around −100 dBc/Hz at 200 Hz. These numbers compare favorably with those of commercial synthesizers currently available.

The UHF VCO PLL discussed in the article is a "direct" type, meaning that the phase detector corrects VCO phase at 1152 MHz, not some submultiple of 1152. It is difficult to achieve better phase noise performance by any other means. — WA9HUV

vhf/uhf world

The schematic shown in **fig. 3** of W1JR's November, 1986 column, "VHF/UHF World: Broadband Amplifiers in Receiver Design" (page 91), should be positioned in **fig. 4**. Likewise, the schematic shown in **fig. 4** should be positioned in **fig. 3**. Only the art should be switched; captions are correctly placed.

communicating on 474,083 GHz

Explore a new frontier with your own lightwave station

Although we might wish for bigger slices of the HF or VHF spectrum, Amateur Radio's frequency allocations extend over 23,600 MHz.

In assigning frequencies, the FCC didn't terminate our allocations at some obscure, arbitrarily chosen microwave band. Instead, they specifically gave us everything above 300 GHz. And although Amateur communication above the 24-GHz band isn't yet very practical, there is a narrow segment where it's really quite easy to work: that is, of course, *light*.

background

I made some of the first Amateur two-way laser contacts during ARRL VHF contests. At that time (June, 1979) the ARRL didn't recognize contacts above the normal microwave bands, even though the FCC regulations did. These contacts, however, were rejected.

I figured that the League would be more ready to accept lightwave contacts if specific guidelines for such contacts were available. With the encouragement of Louis Ancioux, WB6NMT, I began drafting recommendations. In mid-1980, I sent the ARRL Contest Advisory Committee several suggestions for rules.

This is what was ultimately adopted:
Above 300 GHz, contacts are permitted for contest credit only between licensed Amateurs of Technician class or higher, using coherent radiation on transmission (e.g., lasers) and employing at least one stage of electronic detection on receive. . .

The rule also state that while no minimum distance is specified for contacts, equipment should be capable of real communications (i.e., able to communicate over at least a mile). This was no problem at light frequencies; my first laser contacts were over a 15-mile path!

It should go without saying that all equipment used for contest points or records should be Amateur-owned, if not also Amateur-built. After all, there would be no technical challenge or achievement in borrowing a NASA dish to make a 432-MHz moonbounce contact.

what is light?

Light is a part of the electromagnetic spectrum. Visible light starts at around 400 Terahertz; 1 THz = 10^6 MHz. The low-frequency, long-wavelength end of the visible spectrum appears to us as the color red. The high-frequency, short-wavelength end is violet. Green, in the center of the visible spectrum, is the wavelength to which our eyes are most sensitive.

Like "regular" radio waves, light has a wave nature with an electric field and magnetic field component. It also has an associated frequency (which is only rarely referred to) and wavelength (the more customary measurement).

A variety of length measurement units are used to describe light wavelength. Green light, for example, corresponds to approximately 5500 Å (Angstrom Units where $1Å = 1 \times 10^{-10}$ meters), 550 nanometers, 0.55 microns, or a frequency of 545 THz. But even though it follows many of the same rules as rf, light isn't just a radio wave of extremely high frequency. What sets light apart from lower frequency emissions is its particulate nature. Light exists in discrete units called photons and can be made to travel in a very narrow beam with very little divergence or spreading. It's wonderful for point-to-point communications.

Frequency multiplication via a non-linear varactor is a phenomenon well known to the UHF enthusiast. 432 MHz is conveniently reached by tripling 144 MHz. What is both amazing and not commonly known, however, is that light frequencies can also be multi-

Steve J. Noll, WA6EJO, TiC Scientific, 1288 Winford Avenue, Ventura, California 93004

plied in a special non-linear crystal! But light can not only be multiplied in frequency; it can be mixed. It's possible to direct two laser beams into a special crystal and produce a third beam of a different frequency as a result of the mix. It should therefore be possible to build some sort of an optical superheterodyne receiver. It's also possible to build a light "amplifier," though the necessary crystals and lasers are very specialized and expensive.
ceiver. It's also possible to build a light "amplifier," though the necessary crystals and lasers are very specialized and expensive.

light transmitters

The laser was conceived in 1958 and built in 1960. "Laser" is an acronym for Light Amplification by Stimulated Emission of Radiation.

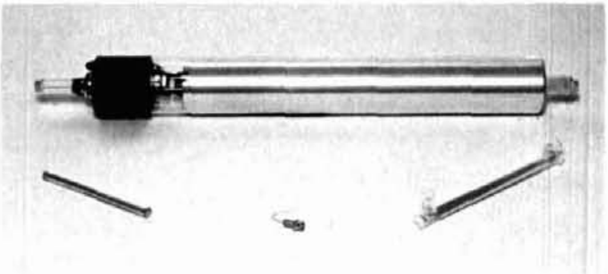

Photo A. Four types of lasers: from top (clockwise), gas laser (helium neon); solid-state laser (ruby rod); semi-conductor laser (infrared pulsed diode type); and dye laser (dye cell filled with organic laser dye Rhodamine B.)

Photo B. This Helium Neon laser uses the power supply circuit shown in fig. 7. Power supply and battery are housed in a tool box.

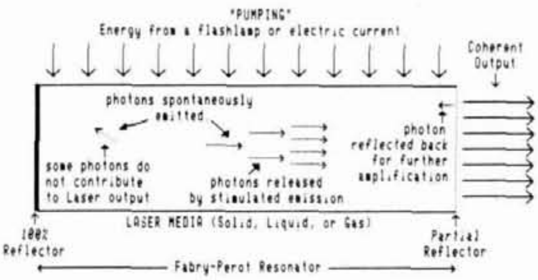

fig. 1. Basic laser operation.

This is how lasers work (**fig. 1**). A gas, solid, or liquid is contained in a cavity. Two mirrors, one at each end of the cavity, are positioned to face each other. Energy is transferred to the atoms inside the cavity that do the actual "lasing"; depending on the kind of laser, the energy can come from a flashlamp, an electric current, a chemical reaction, other energized atoms or molecules, or another laser.

The goal is to raise a lot of the electrons of the lasing atoms to a certain higher energy level. At this level, the atoms are unstable and won't stay there long. When the electrons "fall down" to a lower energy level, they give up this excess energy, which is released in the form of photons. This release of photons — random in time and direction — is called *spontaneous emission*.

If one of these photons strikes an atom that hasn't yet generated its photon, the impinging photon stimulates the atom to produce another photon identical to the first. The result is two photons of the exact same frequency and phase, traveling in the same direction. If everything is just right, this process continues through the lasing medium.

Some of the photons bounce between the mirrors, traveling through the medium, stimulating more coherent photons to be generated. These, then, also bounce between the mirrors, continuing the process. One mirror is partially transparent to let some of the energy escape. Thus is born the laser "beam."

Although most people have heard of the ruby laser and the Helium Neon (HeNe) laser that's commonly used in supermarket scanners, a great number of other materials have been used to make lasers. Most can be categorized as *gas, solid-state, liquid,* or *semiconductor* (**Photo A**).

gas lasers

Output wavelengths range from infrared to ultraviolet. Some are tunable. Power outputs vary from extremely weak to strong enough to burn through steel plate. Outputs vary from a few short pulses per second to a continuous wave. Sizes vary from as small

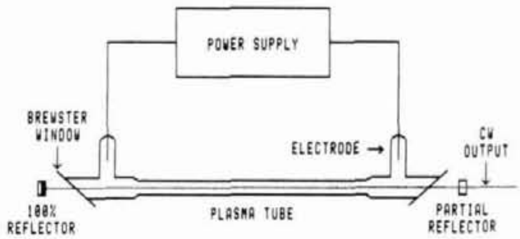

fig. 2. Basic gas laser.

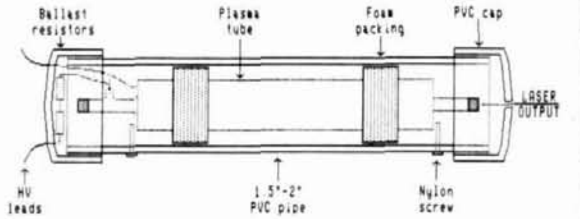

fig. 3. HeNe laser plasma tube packaged in PVC pipe.

as a pencil tip to room-size. And cost ranges from a few dollars (for surplus semiconductor lasers) to hundreds of thousands of dollars.

Known for its high-power infrared output, the carbon dioxide laser is capable of burning through metal. The Argon laser can generate several watts of green and blue light. The Nitrogen laser has an ultraviolet output and so much gain that cavity mirrors are not needed.

Most gas lasers (**fig. 2**) are electrically excited by applying high voltage to electrodes at the ends of the cavity, also known as the "plasma tube" (**fig. 3**). Sometimes windows seal the ends of the tube to let the light through to strike external cavity mirrors. Often there are no windows, and the mirrors are attached directly to the ends of the plasma tube. Gas lasers usually have lifetimes expressed as a few thousand hours, after which time some kinds may be cleaned and refilled with a fresh charge of gas.

solid-state lasers

In this application, "solid-state" doesn't refer to semiconductors, but instead to lasers made of crystal or glass. One of the better known of these is the ruby laser, which consists of an Aluminum oxide "host" with a tiny bit of Chromium mixed in. The laser may take the appearance of a pink ruby rod measuring 1/4-inch diameter and a few inches long, positioned close to a long flashlamp tube. Mirrors may be external or deposited directly on the rod's ends. The ruby laser puts out short, high-power pulses of red light.

The ruby laser may be the most well-known solid-state laser, but the Neodymium YAG laser finds the most use. Capable of continuous output in the 100-watt range, its output is invisible infrared. As with the ruby, the Nd/YAG laser is optically pumped with flashlamps or continuous arc lamps. It is used for cutting and drilling, trimming resistors, and surgery.

liquid lasers

Liquid lasers are often called "dye lasers" because the active material is usually an organic dye dissolved in a liquid solvent. The liquid laser's claim to fame is that it is tunable over a wide frequency range.

In the simplest form of dye laser, the dye is held in a length of glass tubing, its ends sealed with windows. The external mirrors form the lasing cavity and a flashlamp serves as the pump source. CW-output dye lasers are available. Power levels are generally under 5 watts.

semiconductor lasers

Electro-optically similar to Light Emitting Diodes, semiconductor lasers are often called *diode lasers* or *injection lasers*. Output is typically in the infrared,

Photo C. This helium Neon laser is housed in a 2½-inch diameter PVC pipe, which also contains a commercial 12-volt inverter power supply.

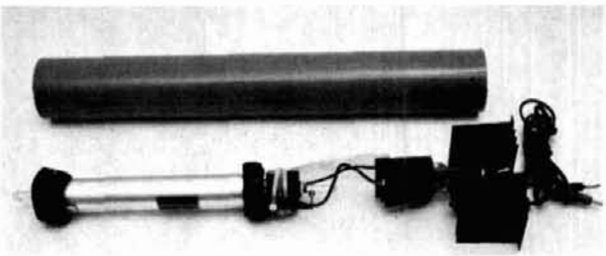

Photo D. Components of a portable HeNe laser.

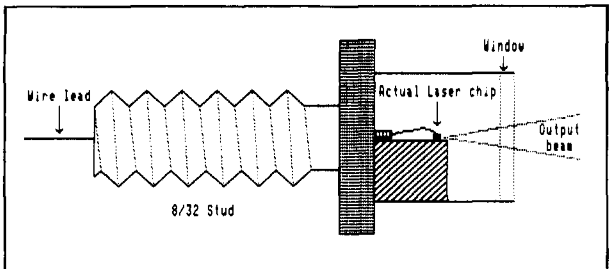

fig. 4. Diode laser in a typical stud package.

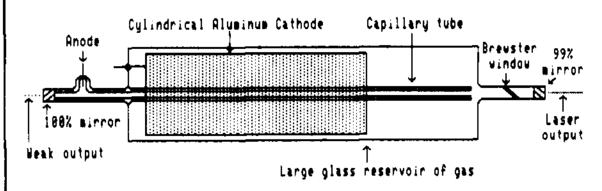

fig. 5. Modern HeNe laser tube.

measuring a few milliwatts CW or several watts pulsed.

A common package is a stud-type with a window on top to let the radiation out (**fig. 4**). Lasing action is achieved by running current through the tiny diode "chip." Mirrors are formed directly on the chip by cleaving opposing ends of the chip square.

This kind of laser doesn't produce a beam as narrow as most other lasers. Pulsed infrared diode lasers are presently on the surplus market — often for less than $25.00. We expect to see many surplus units in the future because of the growing fiber optic communication and compact audio disk markets.

making the choice

It's not difficult to narrow down the wide choice of lasers to a few suitable for our use. Many lasers are quite expensive, costing several thousand dollars or more. Some are quite bulky because of large power supplies or cooling apparatus. Some produce short bursts of light only at a very low pulse rate. A few are downright dangerous, emanating invisible beams capable of burning through almost any known material.

For communications use we need a laser with the following properties:

- It must be inexpensive, or at least so once it reaches the surplus market.
- It must offer reasonable lifetime — at least a thousand hours between refurbishment or replacement — consistent with its cost.
- It should be small, portable, and not consume a lot of power.
- It must be reasonably safe to operate and work with.
- Although an infrared output that matches readily available infrared detectors would be usable, a visible beam is preferred.
- A continuous wave output is most desirable. A pulsed output with a very high repetition rate could be used.
- There should be a way to modulate the output and then electronically detect the result.

Solid-state lasers are generally quite expensive, infrared, pulsed, and not often available on the surplus market. The liquid lasers are also rather expensive and not available as surplus. They usually have a visible beam, but tend to be bulky.

Semiconductor lasers present some possibilities. The smallest of all lasers, they're inexpensive, readily available, and offer long life. They can be battery-powered. Power output is generally low enough to be considered safe.

Their biggest disadvantage is that the affordable diode lasers put out only infrared radiation; visible light is much easier to work with. Luckily, infrared detectors are plentiful.

The beam from a diode laser is broader than most others and requires shaping by additional lenses or mirrors to make it travel a long distance without too much divergence. The surplus units are usually pulsed only, but the repetition rate is high enough to be useful.

There are many choices of gas lasers, but only a few meet our criteria. The CO_2, Argon, Krypton, and metal vapor units are typically expensive, not available as surplus, large, short-lived, energy-hungry, and dangerously powerful.

One candidate looks especially good, however: the HeNe laser, known as the "light bulb" of the laser industry (**fig. 5, Photo B**). Luckily, the laser that's one of the most suitable for Amateur use is also one of the most common on the surplus market.

Actually, what one usually finds is the plasma tubes, not complete lasers. The choice of a power supply and packaging are left up to the buyer.

The HeNe laser is fairly affordable — under $300 for a small, brand-new, complete unit. Surplus plasma tubes, with integral mirrors but without a power supply, often sell for under $100, and sometimes as little as $30. The HeNe's lifetime is many thousands of hours, i.e. a few years. Its size is reasonable, and power consumption is under 30 watts for the smaller units. The plasma tube itself generally requires up to 2000 volts dc and up to 10 mA. A starting voltage of 10 kV may be required. The high voltage requirement of the plasma tube is perhaps the greatest hazard associated with the HeNe laser.

The common off-the-shelf HeNe lasers have power outputs rated from 0.5 mW to 5 mW. The beam power of the under 1-mW models is high enough to cause blindness. The higher power units will definite-

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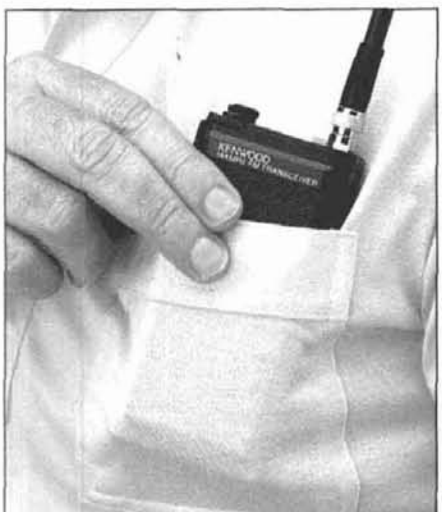

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- **BC-6** 2-pack quick charger
- **DC-21** DC-DC converter for mobile use
- **BT-2** manganese/alkaline battery case
- **EB-2** external C manganese/alkaline battery case
- **SC-8/8T** soft cases with belt hook
- **BH-3** belt hook
- **AJ-3** thread-loc to BNC female adapter
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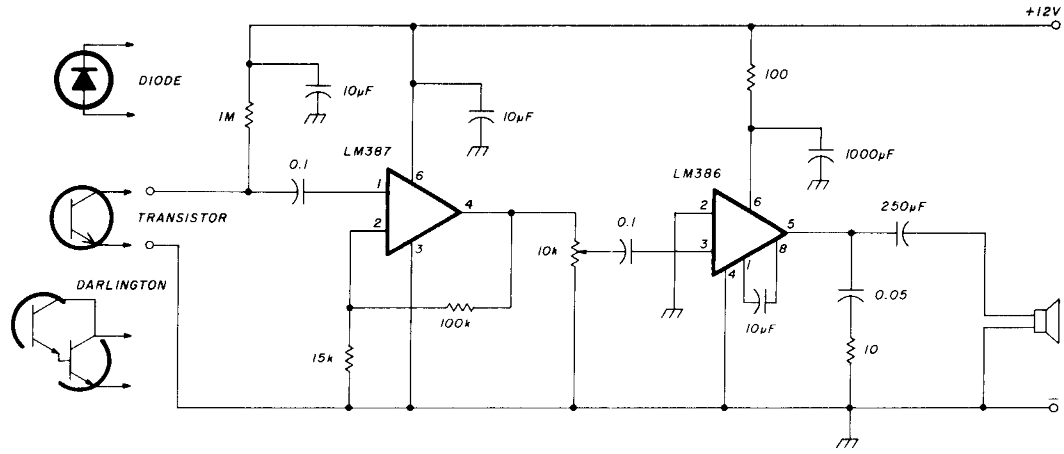

fig. 6. Schematic, electro-optic receiver.

ly require reasonable care in handling, but they're still not capable of burning through things.

The HeNe's beam is bright red, continuous, and very narrow — perfect for Amateur uses. (It's the one I've chosen to work with.) Beam diameters are typically 0.5 to 1 mm and divergence is typically 1 to 2 milliradians, which is extremely tight. Plasma tube sizes are usually 6 to 15 inches long and 1 to 1-1/2 inches in diameter. *Don't buy from anyone who won't guarantee that the laser works. If the plasma tube is dead, there's nothing you can do to fix it.*

The only other major item necessary is a power supply, which, of course, can be homebrewed. There are some nice commercial modules that run from 12 volts dc and supply the starting voltage as well as the high voltage running current.

If you're starting with a plasma tube, a good way to package it is inside a length of PVC pipe. An excellent insulator, PVC pipe is easy to work with and inexpensive. A diameter of 1-1/2 or 2 inches is about the right size (see **Photos C, D**).

HeNe lasers require a ballast resistor which can be mounted in the non-output end of the pipe, inside of an end cap. You might be able to fit the whole power supply in one end of the pipe.

modulating lasers

There are two ways to impress information on a laser beam. One is to modulate the laser itself — that is, to make it generate light in varying amounts. The second way is to insert something the path of the unmodulated beam.

An obvious way to modulate the generation of laser light would be to modulate the power source. In the case of the HeNe laser, this would mean modulating the nominal 2-kV dc power supply.

Unfortunately, this approach doesn't work as well as we'd like. The HeNe laser — sort of a glorified Neon sign — is built around an electrical gas discharge. Perhaps you're familiar with the operation of the common Neon pilot light. The NE51, for example, has a threshold beneath which it will not light. If much more than the rated voltage is applied, however, the lamp will be ruined. It doesn't like its power supply voltage or current to vary very much at all.

Modulation can be achieved via the power supply, but the percentage of modulation will not be high. Even some commercial modulated HeNe lasers, which are specifically made to be modulated, offer only 15 percent modulation.

Power supply modulation does offer some advantages. It won't, for example, distort the laser beam shape. This is very important for long distance atmospheric communications where an extremely narrow collimated beam is necessary.

One form of power supply modulation is to place a modulation transformer in series with one of the high-voltage lines leading to the laser plasma tube. I've tried this using a Collins modulation transformer. A loud signal was picked up by the 931 photomultiplier receiver, although the modulation level was less than 1 percent. Attempts to increase the modulation level simply extinguished the plasma; apparently the modulation causes the high voltage to drop below the plasma threshold. A complete receiver is shown in **fig. 6**; a laser power supply schematic is shown in **fig. 7**.

Modulation in the beam path avoids the previously-mentioned power supply problems. 100 percent modulation *is* achievable. There are a variety of objects that can be used as modulators.

A "chopper" usually takes the form of a disk with notches or holes cut into it (**Photo E**). Powered by a small electric motor, the spinning disk cuts the beam of light. While this may seem like a crude approach, such devices are serious laser tools and can often be seen advertised in the laser-related trade magazines.

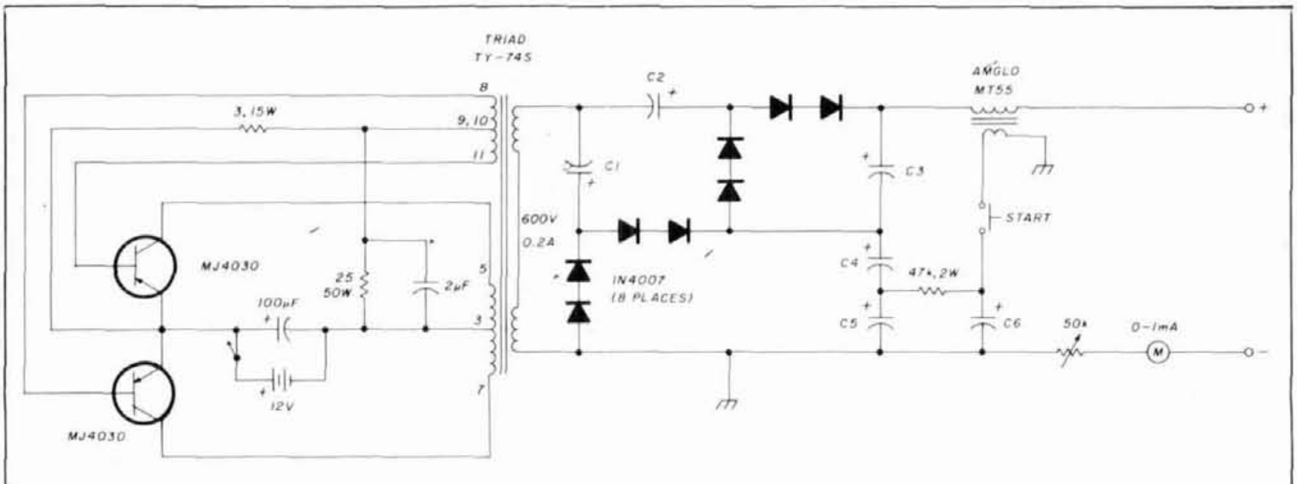

fig. 7. 12-volt dc inverter HeNe laser power supply.

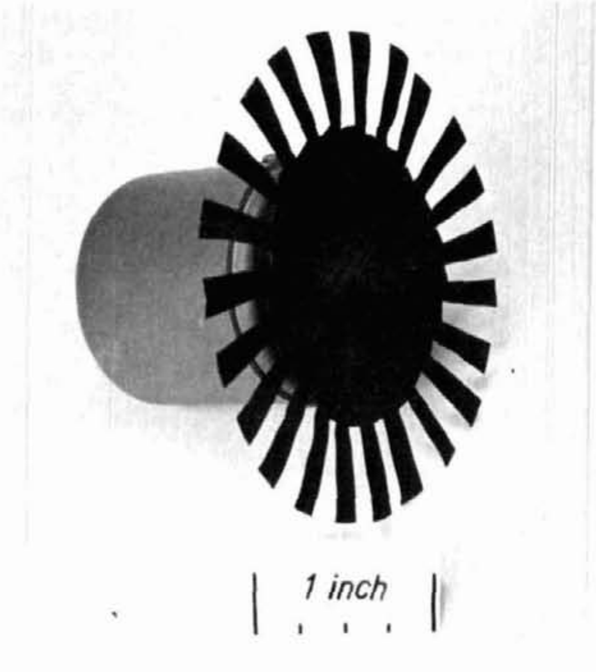

Photo E. Optical chopper made from a small dc motor and tin can lid.

A chopper certainly provides 100 percent modulation. The beam is either on or off, and is not distorted or deflected. With a reasonable motor speed and enough holes or slots in the disk, the beam will be interrupted at an audio rate. The audio-modulated beam then can be interrupted to produce type A2 modulation, modulated CW. The Morse code interruption of the beam can be done with a solenoid activated by a telegraph key or simply by hand.

I used this simple chopper method of modulation for my first contacts. The chopper disk was made from a 3-inch diameter tin can lid. I cut two dozen slots in the perimeter with tin snips, then soldered the center of the lid to a toy electric motor shaft. I clamped the assembly to the side of the laser housing and powered it with a 9-volt transistor radio battery. The resulting audio tone-modulated beam was interrupted by hand to achieve the final Morse code modulation. This crude scheme worked quite well and resulted in a very loud signal over a 15-mile path!

Several kinds of electro-optical modulators use special glasses, crystals, or liquid cells. When high voltage, rf, or a magnetic field are applied, the polarization of light passing through the modulator is rotated. Unfortunately, prices for these devices run from several hundred to tens of thousands of dollars.

Liquid crystal displays are light modulators that have become part of our everyday life. Wrist watches, portable computers, and electronic gear of all kinds use LCDs as light valves to display information. It's possible to modulate light by beaming it through a transmissive type LCD or a reflective LCD with the reflector removed (**Photo F**). The main drawback is speed; the spec sheet for one common display lists the turn-on time as 100 milliseconds and the turn-off time as 200 milliseconds — rather slow for audio frequency modulation. Faster LCDs may become available in the future as the need for rapid graphics displays grows.

the receiver

Unlike trying to modulate light, receiving modulated light presents no serious problems.

Like a simple radio receiver, a light receiver has an antenna for gathering energy, a "front end" filter for selecting the wavelength of interest, a detector for converting the photon energy to electrical energy, and miscellaneous electronics for amplification of the final signal (**fig. 8**).

the "antenna"

As with radio receivers, the antenna of a light com-

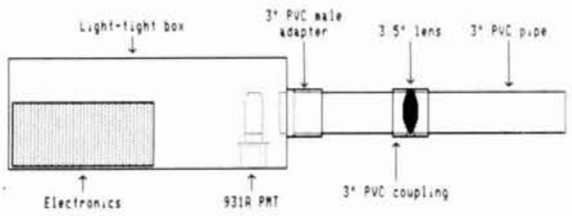

fig. 8. 3.5-inch lens light receiver.

munications receiver presents the best opportunities for system improvements. ("The bigger the better" applies here also.) The purpose of the light antenna is to gather as much light from the desired source as possible, concentrate this light onto the detector, and reject light coming from unwanted sources — i.e., the sun, moon, street lights, and other sources of ambient light. Lenses or curved mirrors mounted in an appropriate tube or holder make a complete antenna system. Obviously, what we need is something like a telescope, though we needn't bother trying to obtain an actual detailed image of the light source. We need merely to gather as much light from the source as possible.

Large-diameter lenses make good antennas. Because of weight and cost, 3 to 4 inches in diameter is about the largest size in which glass lenses are commonly found. The diameter of surplus lenses under $20 usually doesn't exceed 3 inches. (Mirrors take over from there.) One source of large-diameter lenses is stationery or office supply stores that sell magnifying lenses for reading small print. These lenses may be made of plastic instead of glass and will require a little more care in handling to prevent scratches. Also, watch flea markets and other sources of used equipment for Luxo-type magnifying work lights.

Fresnel lenses are flat lenses, often plastic and less than 1/8 inch thick. One side is smooth while concentric ridges are molded onto the other side. Fresnel lenses won't form much of an image, but they will gather a very large amount of light for their cost and weight. I use a 10-inch diameter Fresnel lens mounted in a metal duct pipe to serve as an antenna for one of my portable photomultiplier receivers.

Parabolic and spherical curved mirrors make excellent light antennas, as witnessed by their heavy use in optical astronomy. Swap meets and garage sales may be good sources for old reflector telescopes built around such mirrors. A small telescope with a photosensor mounted in place of the eyepiece would make a great light communications receiver, but a large Fresnel lens would probably gather much more light. Curved sheet-glass mirrors and spun aluminum parabolic reflectors measuring 1 to 2 feet in diameter may work well in spite of their inaccuracies at optical wavelengths.

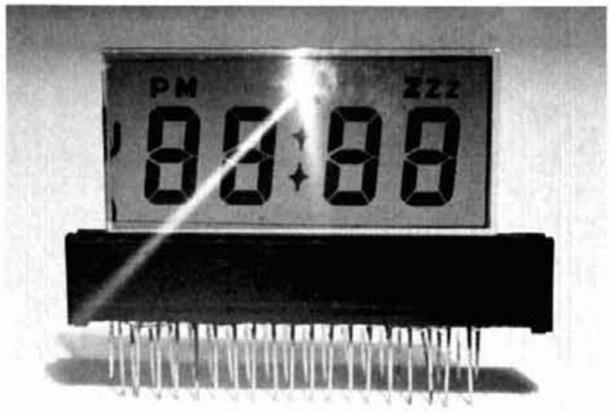

Photo F. A common LCD is used as a laser light modulator. Laser beam is seen entering at bottom left.

Photo G. Portable laser communications receiver uses a 10-inch diameter Fresnel lens for the "antenna" and 931A photomultiplier tube as the detector.

If only nighttime communication is anticipated, optical bandpass filtering can be dispensed with. But daylight communications is a different story; sunlight can swamp the photodetector, limiting your communications range. A very narrow bandpass filter is required. Luckily, dielectric filters, sometimes called interference filters, fit the bill. These filters are made by depositing multiple thin layers of chemicals on a glass substrate. (Edmund Scientific[1] sells these filters for about $20 each.) The specifications for their HeNe laser filter state a half-power bandwidth of only 1.7 percent! The drawback is that the filter insertion loss is 55 percent, which isn't too bad considering the bandwidth.

detectors

As it is with lasers, there are a large number of different photo detectors available. There are photodiodes,

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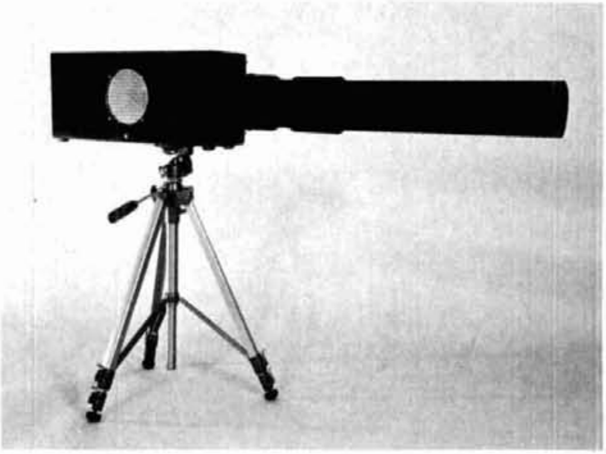

Photo H. Photomultiplier tube communications receiver. A 3-inch diameter lens is housed in the long PVC pipe.

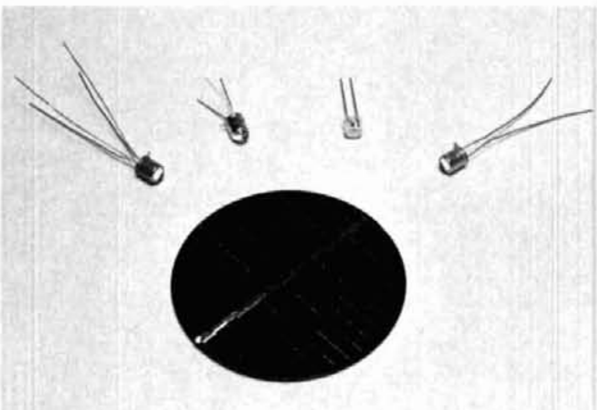

Photo I. Solid-state photodetectors. Left to right: photo FET, bipolar photo transistor, photo Darlington transistor, photo diode. Bottom: photovoltaic (solar) cell.

phototubes, photomultiplier tubes, phototransistors, photoFETs, photovoltaic cells (solar cells), photoresistive cells, avalanche photodiodes, PIN photodiodes, photo Darlington transistors, and even photo traveling wave tubes!

Next to cost, there are three other important areas of concern. The first is *spectral response*. Does the device function well at the wavelength of light we are dealing with? Presumably we will be mainly concerned with the red output of a HeNe laser. Many kinds of detectors do not perform well at this wavelength. The second is *sensitivity*; the light sensitivities of the different kinds of sensors vary by at least a factor of 1000. *Speed*, the third, is mainly a concern with short pulse width applications such as receiving light generated by a diode laser. It is not a concern with audio or mcw continuous output lasers (HeNe).

Solar cells are not considered to be especially good for light communications. Although they are inexpensive and fast enough for audio detection and their "capture area" is very large, this is not an advantage in situations where lenses or mirrors are used to gather light. They are also easily overloaded by sunlight.

Photoresistors are inexpensive and have good sensitivity at red light, but are too slow for detecting modulation.

There are several kinds of photodiodes. PIN photodiodes and Avalanche photodiodes are the best kinds for communications. The Avalanche photodiode is the most sensitive and the fastest. Unfortunately, it is also the most expensive and is generally not found on the surplus market.

The PIN photodiode is an excellent choice. It has a response time on the order of one nanosecond and its sensitivity at red light is good. The Motorola MRD500 and MRD510 diodes sell for about $3.50. The Motorola Optoelectronics data book describes these two diodes specifically as being suitable for laser detection and light demodulation.

In the category of phototransistors, there are bipolar phototransistors, photo Darlington transistors, and

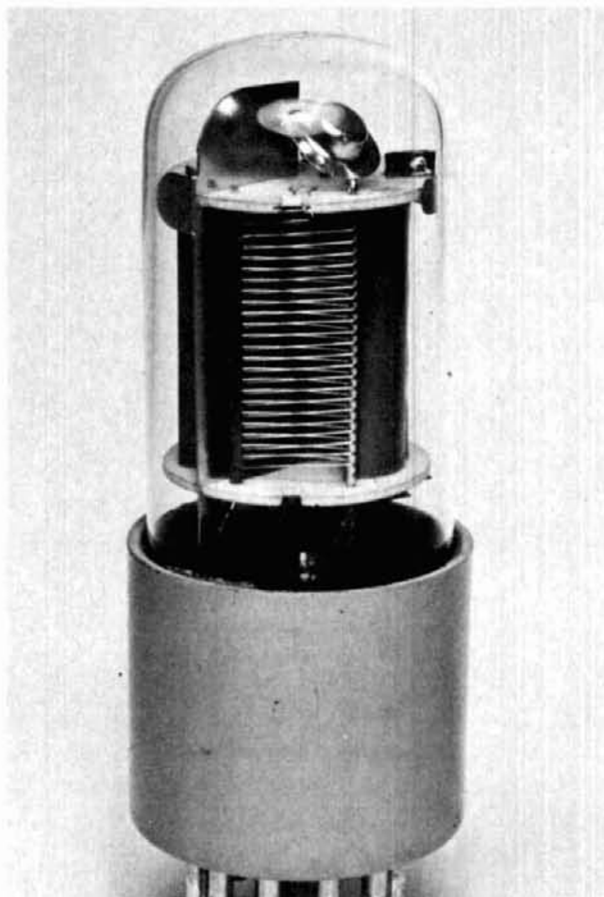

Photo J. 931A photomultiplier tube.

photoFET (**Photo I**). Phototransistors are more sensitive than photodiodes since they have gain. This gain is achieved at the price of speed, although they are still fast enough for audio detection.

Bipolar phototransistors are cheap and commonly available. A search of electronic parts catalogs yielded no fewer than 15 different devices available with prices ranging from 30 cents to less than $3. The response time is around 2 to 20 microseconds and sensitivity to red light is good. They can be saturated by too much light and care should be taken to prevent this by optical shielding and filtering.

The photo Darlington transistor contains a light-sensitive transistor as in the bipolar phototransistor and an additional transistor that amplifies the output of the first one. These devices are very light-sensitive. Speed is correspondingly slower, in the 10 to 100 microsecond range. The Motorola MRD360 photo Darlington is one of the best units and sells for under $5.

Photomultiplier tubes are bulky and fragile, require high-voltage power supplies, cost more than most of the common solid-state devices, and can be hard to find. Their spectral response is usually not the best at red. So why use them? Gain. Lots of gain. Gain into the *millions*. The gain is developed inside the tube and without excessive noise. Rise times of 3 nanoseconds are typical. Photomultiplier tubes can detect extremely low levels of light and are linear over wide ranges of light intensity. The popular 931A (**Photo J**) is linear within 3 percent over a change in light intensity of 10,000,000.

The Avalanche photodiode is the closest solid-state equivalent, but it is even more expensive, extremely temperature-sensitive, and requires a highly regulated high-voltage power supply. If Avalanche photodiodes were ever to become low-priced surplus items, they might then offer some advantage over the photomultiplier. But for now, the "hottest" optical front end is the photomultiplier tube.

The common photomultiplier tubes look similar to a glass envelope octal base radio tube. They typically have eleven or more base pins, depending on the number of stages. There is no filament. The 931A and 7117 are two of the more common tubes. The peak sensitivity is at 4000 Å (violet) and is unfortunately less than 10 percent at red wavelengths. With a 1000-volt supply, the current amplification for the 931A is 800,000.

These tubes were once used in automatic headlamp dimmers, so one source of them would be auto wrecking yards. The Allied Electronics[2] catalog lists the 931A at $34 (new) and Fair Radio[3] sells used units for under $10.

propagation

Obviously propagation is limited to line-of-sight. The range depends on laser power, wavelength, and divergence. The wavelengths we're dealing with travel very well through the atmosphere. The beam divergence is typically one milliradian, which means for every 1000 feet the beam travels, it spreads out by 1 foot. A mile away, the beam is 5 feet in diameter. The range also depends on receive antenna size and detector sensitivity — and, of course, upon the clarity of the atmosphere. I figured that the theoretical range of a 1-milliwatt, 1-milliradian laser and a photomultiplier receiver with a 3-inch lens would be 624 miles. In real life, atmospheric turbulence would limit this. Nevertheless, it's fair to say that if you use a decent receiver, the range is quite far.

Aiming a laser on a target several miles away is no small problem. Turning a 1-milliradian divergent laser by only 1 degree will move the 5-foot diameter beam almost 100 feet at a receiving site 1 mile away.

The laser must be mounted on a very stable tripod. I fashioned a micrometer-type mount to provide fine aiming adjustments. A rifle scope mounted on the laser will also help.

I made several contacts with the K6MEP contesters when I was with the Los Padres Microwave group. I was usually on Mt. Pinos, while MEP was on Reyes Peak, about 15 miles away. I used a 4-mW homebrew laser and K6MEP used a Spectra Physics laser owned by W6OAL. Both my unit and the MEP device used chopper modulation. I built both receivers around 931A photomultipliers. One used a 10-inch Fresnel lens (**Photo G**) and the other a 3-inch glass lens (**Photo H**). We made contact by slowly sweeping the lasers back and forth across what we believed to be the receiving site (the target was too far away to recognize by eye). The receiving site gave a yell on 2 meters when they saw the beam flash by. (The beam at that distance at night appears very bright; it is even visible in daylight.) Then the fine tuning began.

a word of caution

Do be very careful when using lasers. They can cause blindness. Don't ever point one at aircraft; it's not only dangerous, but illegal. Several people have been arrested for doing just that.

Special glasses and goggles that block the passage of the red output of Helium Neon lasers area available and are strongly recommended for anyone who experiments or works with lasers.

Compared to the other Ham bands, the usefulness of the world above 300 GHz certainly has its limits. But the purpose of Amateur radio is not to find the most efficient band, the most practical mode, and the most expedient QSO form. We are here to explore, to experiment, and to investigate.

As it is with the 432-MHz and higher bands, most lightwave communications activity will probably center on ARRL VHF/UHF and microwave QSO parties and contests. But undoubtedly some practical uses will be found. One might be for links between split-site repeaters, for example.

The age of the inexpensive laser is here now. Receivers are simple to build. Effective and affordable modulation methods are all that remains to be developed. Perhaps one of the readers of this text will discover a viable technique.

1. **Edmund Scientific**, 101 East Gloucester Pike, Barrington, NJ 08007.
2. **Allied Electronics**, 401 East 8th Street, Forth Worth, TX 76102.
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6 Frequency Bands

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AIR		108 136 MHz	25 kHz
FM		76 108 MHz	50 kHz
AM	SW	1601 2194 kHz (1603 2194 kHz)	1 kHz
	MW	530 1600 kHz (531 1602 kHz)	10 kHz (9 kHz)
	LW	150 529 kHz (150 530 kHz)	1 kHz

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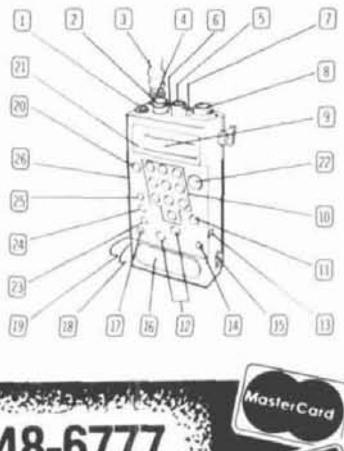

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advanced CW processor

Enhance reception with limiter/filter building blocks

The proper sequence and configuration of voltage amplitude limiters, bandpass filters, and catalytic carriers can enhance CW reception. **Figure 1** shows a series of blocks I have cascaded that work well together. At first glance this sequence may seem strange, but let me explain. To understand the reasons that these blocks help each other, it's best to start from the output end and work toward the input — excluding the power amplifier, which is conventional.

carrier-activated limiter

A technique referred to in part of **fig. 1** as CAL, for Carrier Activated Limiter, was completely described in a previous article.[1] The heart of this device is a wideband limiter that's constantly switched into upper and lower saturation by a high-frequency square wave carrier. Output from the limiter is then fed to a filter that passes a desired signal frequency and removes the square wave carrier. The carrier serves only as a catalyst to create a system that provides an S-shaped nonlinear gain characteristic with a well-defined output amplitude level. **Figure 2** shows the basic performance curve.

With this system, signal and/or noise voltage amplitudes only a few dB below the nominal 0.5-volt p-p designed signal level requirement will begin to be suppressed. If signal and/or noise voltages are 10 dB or more below the 0.5-volt level, they will be suppressed a nominal 14 dB below what they would otherwise be. In a similar manner, the ringing residues caused by the 100-Hz filter, when confronted by the typical rise time of a keyed CW signal, will also be suppressed from a normal 15 to 20 dB below the "dit—dah" level to around 30 or 35 dB below. Because of this feature, it is actually possible to reduce the preCAL filter bandwidth to as little as 20 or 30 Hz without losing the ability to copy relatively high speed CW: you get the essential capability of synchronous detection without its complexity.

The referenced article also carefully explains why the narrow filter in front of CAL is necessary to reduce the problem encountered when more than one signal enters any amplitude limiter function. But also consider what happens when the 100-Hz bandwidth filter is struck by a noise pulse.

pulsed 100-Hz bandwidth filter

This filter is included in the CAL article. **Figure 3** shows the output that results when it receives a noise pulse from the 500-Hz bandwidth filter. You'll note that the peak ringing amplitude from the 100-Hz bandwidth filter is about 1/6th that of the short pulse that caused it. This phenomenon is present for impulse types of noise any time you have a narrow filter following a significantly wider bandwidth system. What basically happens is that a tall, short-duration burst of energy is transformed by the narrower filter to become a low-amplitude, long-duration burst of energy that rings mostly as a sinusoid at the narrow filter's natural geometric center frequency. However, because of our logarithmic hearing characteristic, we cannot detect much difference between the two — perhaps, in part, because the total energy content difference between the input and resulting output pulses isn't nearly as great as the difference in voltage amplitudes.

But the CAL system doesn't care about energy content. It cares only about instantaneous voltage amplitude; so, for example, if a 0.5-volt p-p pulse arrives at the narrow filter's input, its resulting output of less than 0.1-volt p-p is low enough to be reduced by more than 30 dB by the CAL system. This illustrates why the present system already does quite well in controlling noise pulses that are no more than one or two times a properly adjusted signal amplitude. However, when confronted with noise pulses whose amplitudes are above three or four times the 0.5-volt p-p level, little suppression results. The stretched noise pulse is held to the maximum output level of the CAL design,

By Don E. Hildreth, W6NRW, 936 Azalea Drive, Sunnyvale, California 94086

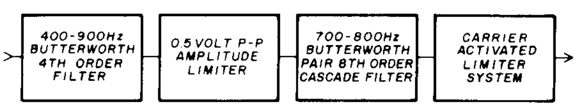

fig. 1. Synergistic sequence.

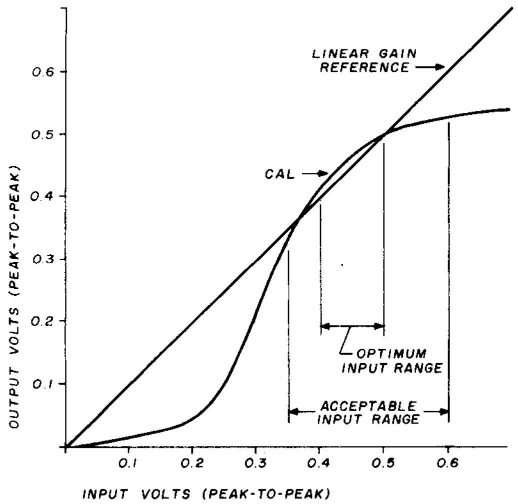

fig. 2. CAL gain curve.

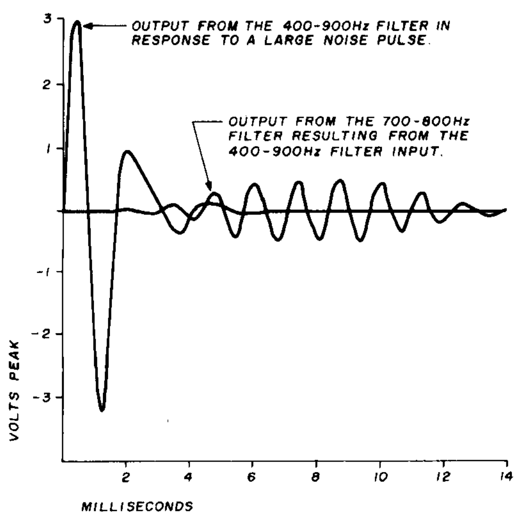

fig. 3. Pulse reactions.

but it can still be heard. Now, suppose a voltage amplitude limiter set at a limit level of 0.5 volts p-p is placed in front of the 100-Hz filter.

limiter addition

The CAL article carefully documents what happens if more than one signal enters a limiter. But how about those times when QRM isn't too heavy? During these opportune times, a front limiter can force noise pulses of very large amplitudes to be held to a value that can be acted on by the CAL's suppression factor. At the same time, a desired signal at 0.5 volts p-p slides right under the "limiter, filter, CAL" system unscathed. However, if a full 3 kHz to 5 kHz or so of audio bandwidth from your receiver is connected to this first limiter, then the number of opportunities for using the limiter may not be too favorable. Now we get to the 500-Hz bandwidth filter.

adding an offset first filter

Now this may seem a bit strange. A 400- to 900-Hz filter will pass a signal to the 750-Hz, 100-Hz bandwidth filter because it embraces that band, but its center frequency is 600 Hz, the geometric center of the band edges. Its residual ringing will be at around 600 Hz, which is outside of the 700- to 800-Hz passband of the 100-Hz bandwidth filter. The combined effect of the wider bandwidth and the offset center frequency enables a filter — restricted to only a 500-Hz bandwidth — to provide the 1/6th impulse-to-ringing signal amplitude ratio out of the 100-Hz bandwidth filter, as is shown in **fig. 3**.

An empirical equation used to design this system is:

$$BW1 = 4(1 + n/8)\ (BW2) \qquad \textbf{(1)}$$

Where BW1 is the 3-dB bandwidth of the first filter and BW2 is the 3-dB bandwidth of the second filter (narrow 8th-order filter).

This calculated minimum usable bandwidth for the first filter is used simply to increase the potential percentage of time when the first limiter can be used. The first limiter can be used with good results directly between your receiver and the 100-Hz bandwidth filter for impulse noise control, but when signal density is high it will often have to be switched out, especially if you are listening to a weak signal that requires high gain from your receiver. The filter shown here provides what I believe to be the best available compromise between potential use time and the degree of impulse noise suppression when the CAL is included. In addition to the use factor, another trade-off must be considered because of the more likely noise sources.

noise types

The efficacy of a noise limiter is strongly influenced by the preceding filter's bandwidth because of the length of time by which a filter stretches impulse noise. An empirical approximation of this for the main energy burst coming from a filter following an exciting pulse is given by the equation:

$$\text{Output pulse duration, } t_p = \frac{(1 + 0.5n/8)}{BW} \text{ seconds}$$

(For flat top filters with six, eight, or more poles, the undulation ringing can greatly exceed t_p given by this equation; see reference **2**).

This filter behavior tends to place a limit on how close together in time noise pulses can be before the system starts to become ineffective. If, for example, a train of pulses that are too close together to allow the filter response to decay between pulses comes along, then a continuous output will build up at the filter's center frequency (this implies another benefit brought about by offsetting the first filter's center frequency). In this design, the first filter's t_p is just slightly longer than 2 milliseconds, so it cannot easily be undone by two of our most ubiquitous noise sources: the woodpecker and those offensive light dimmer controls. The repetition rate of the woodpecker is fairly slow and, although its pulse duration is longer than most noise forms called "impulse," it is still short enough to be suppressed by this system. Dimmer control pulses are very short when they output from a typical receiver, but they come twice per cycle at the 60-Hz power line rate, or every 8.3 milliseconds. To avoid this prevalent noise type, the first filter should have a bandwidth preferably three or four times 120 Hz and should avoid a center frequency at or close to three times 120Hz in particular. Calculations indicate that the system is effective against most automobile ignition noise up to 2000 or 3000 RPM for most modern autos. If you're in an area with heavy, multiple-auto ignition noise, it may be advisable to increase the bandwidth of the first filter in this system.

Noise from those devices that pass current through brushes to an armature, such as some motors and generators, probably can't be helped because the arcing often produces very high repetition rate random impulse-like electrical noise.

Figure 4 is a detailed schematic of the complete sequence.

operating strategies

I have always tried to limit the number of controls in any add-on device as much as possible. But if the number of controls must grow, at least most of them should be functions that require infrequent attention. In the CAL system, marketed as Model 10, there is just a *Mode* control and an output power level control, which are rarely adjusted. The system shown here adds only a toggle switch. For me, it has resulted in a significant improvement: I can now have ear protection in any position of the mode switch. If I'm listening to a strong signal that isn't being battered about by QRM, I use the wide band position, include the first limiter, and adjust the input level from my receiver to place the signal just at the edge of limiting. If QRM appears, I switch to the 100-Hz bandwidth position, then if — and only if — my desired signal is being "dimpled" by the interference, I toggle out the front limiter. I bring in the CAL only if a signal is quite weak, or if the keying is fast and I want to reduce ringing.

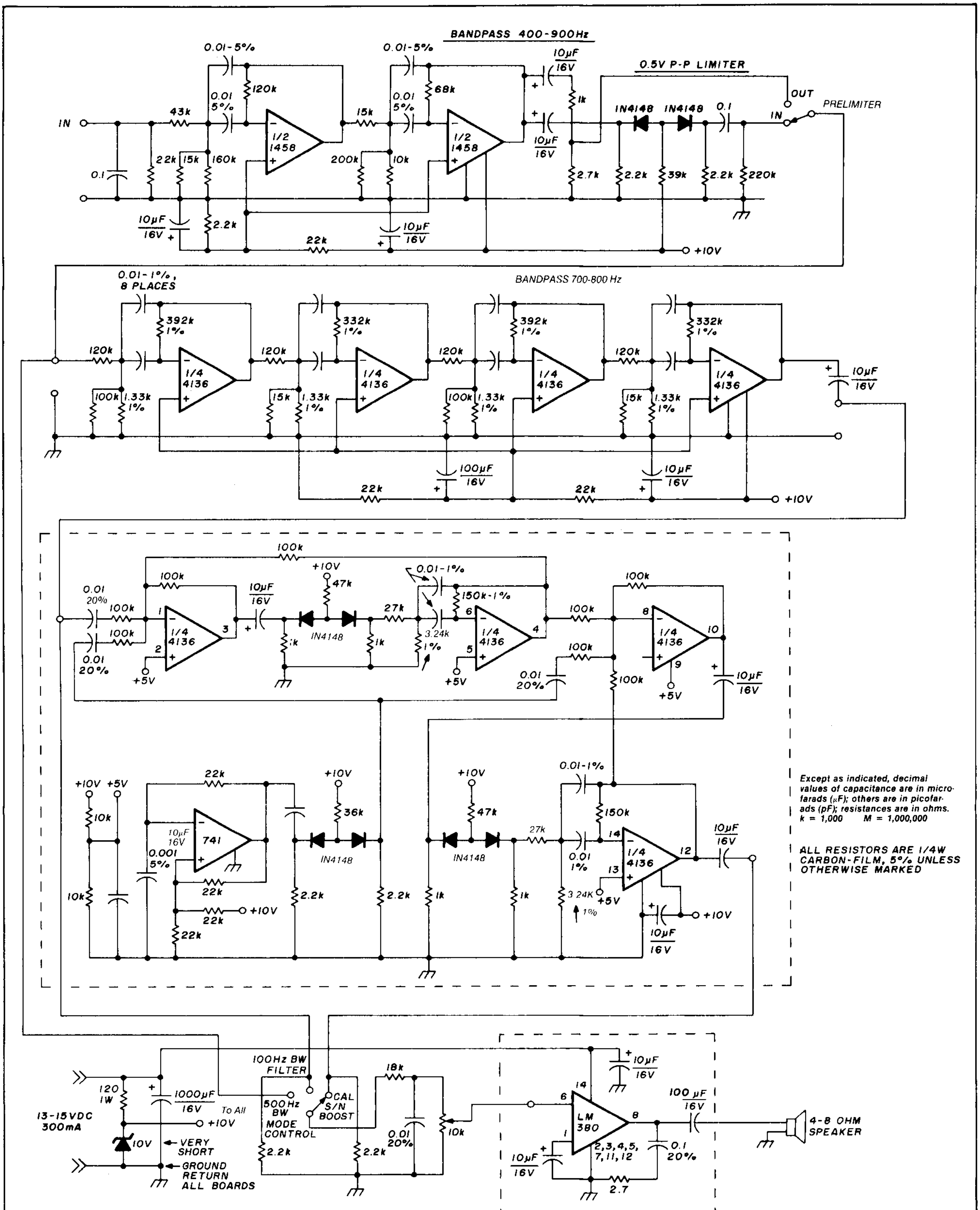

fig. 4. CW processor schematic.

Receiver AGC is off and/or defeated by a moderate-to-low rf/i-f gain setting.

As you can imagine, using the CAL for a weak signal with QSB can be quite a chore — and sometimes impossible (**see fig. 2**). If not too much QRM is present in the 500-Hz bandwidth filter, the first limiter can iron out this QSB very nicely by advancing the signal level from your receiver to absorb the variations. By this action, the signal level fed to the CAL is forced to remain in the optimum region. Using these techniques, I've been able to copy some DX signals that I couldn't read any other way.

final comments

So what about the bad news? Certainly there always has to be some bad news. Well, this is it: because the CAL system suppresses signals on the skirts of the 100-Hz bandwidth filter, the system starts to tune more like 70 or 80 Hz with extremely steep skirts. This can make tuning difficult unless you have plenty of bandspread, very little backlash, and a frequency-stable receiver. Using a Kenwood TS-820S, whose tuning rate is around 20 kHz per 360 degrees of knob rotation, care is required — but it's not difficult with a 100-Hz bandwidth filter. I found that the approximate limit for operation with this tuning rate was a 40-Hz bandwidth Gaussian filter in place of the 100-Hz Butterworth cascade unit. . . and knob control is very demanding with that!

Based upon my observations, the limit on how narrow our useful bandwidth can be for copying most CW signals is determined by the prevalent mechanical/electrical tuning (bandspread), frequency stability, and inherent bandwidth requirements based upon transmitted information rates. Limitations for most equipment are in the order given, with the mechanical problem about ten times worse than the stability factor and the stability limit about ten times worse than the information bandwidth limit. To test this, a special multi-pole 10-Hz bandwidth filter was prepared. Copy was nearly impossible with the straight filter, but quite good when using CAL. Tuning was next to impossible, but once a signal was tuned, it usually remained in the window for the duration of a typical QSO.

Now that frequency synthesizers have found their way into our gear, the 10-Hz bandwidth will become more and more practical. To make these narrow filters easier to work with, and for more other subtle reasons, visual aids to aural-only detection should be applied.[3] One thing I can tell you for sure: the bands seldom seem crowded when you're using these very narrow bandwidths!

references

1. Don Hildreth, W6NRW, "Carrier-Activated CW Reception Limiter," *ham radio*, September, 1985, page 113.
2. Don Hildreth, W6NRW, "Graphic Filter Design," *ham radio*, April, 1984, page 37.
3. Unpublished manuscript; please send SASE for copy.

Note: Write to Hildreth Engineering Corp., 936 Azalea Drive, Sunnyvale, California 94086 for product availability.

ham radio

the ZX-81/TS-1000 controller:

new use for old computers

Four ICs
in interface circuit
link computer
to outside world

If you've been to a hamfest lately, or read the back pages of any ham magazine, you've probably seen used Sinclair ZX-81 or Timex/Sinclair 1000 computers selling for less than $20*. During their heyday several years ago, these computers — which originally sold for $150 — led the way for the personal computer revolution. Although the Sinclair was somewhat of a marvel at the time, many users soon became disenchanted with it, either because of the small membrane keyboard or the difficulty of interfacing it with peripherals.

Perhaps you've stashed a Sinclair away in your junkbox in hope of someday finding something to do with it. Or perhaps you've toyed with the idea of picking one up at a hamfest but decided otherwise. Never mind. *Get one.*

This small, cheap-looking computer has computing power comparable to much more expensive computer systems. The key to harnessing this power is simply finding an application that takes advantage of its strengths. For while it's admittedly disappointing for some applications — such as word processing — it's ideally suited for control functions and can be easily programmed for a host of controller applications.

*TS-1000 computers ($19.95), manuals ($2.95), and accessories are available from Hal-Tronix, Inc., Dep't HR, P.O. Box 1101, Southgate, Michigan 48195 (313-285-1782).

In this article, a simple circuit using only four ICs will be presented, along with a detailed example of how to program your ZX-81 or TS-1000 computer for I/O applications.

With this simple interface circuit attached to the *memory port* of either the ZX-81 or TS-1000, you instantly gain the ability to communicate with the outside world. All sorts of applications — including satellite rotor controls, digital voltmeters, morse code sending and receiving, educational demonstrations, and many others — easily follow once you have an I/O interface. I developed this circuit as part of a school project a few years ago when I used the TS-1000 computer to send and receive RTTY. Since then, I've been selling the information contained herein at cost to Sinclair computer enthusiasts at local hamfests and by mail. If you've been wondering how to make your ZX-81 or TS-1000 perform some useful tasks and are interested in a neat one-evening construction project, then read on.

what is a controller?

While many computers are used for computation, word processing, or data management, many "small" computers, composed of just a microprocessor and a handful of special-purpose chips are built strictly for *controller* applications. For example, microprocessor circuitry is now being installed in automobiles. A microprocessor is programmed with a simple looping program which does nothing more than continuously monitor various data lines and then branch to a par-

By Ted S. Rappaport, N9NB, Box 283, Electrical Engineering, Purdue University, West Lafayette, Indiana 47907

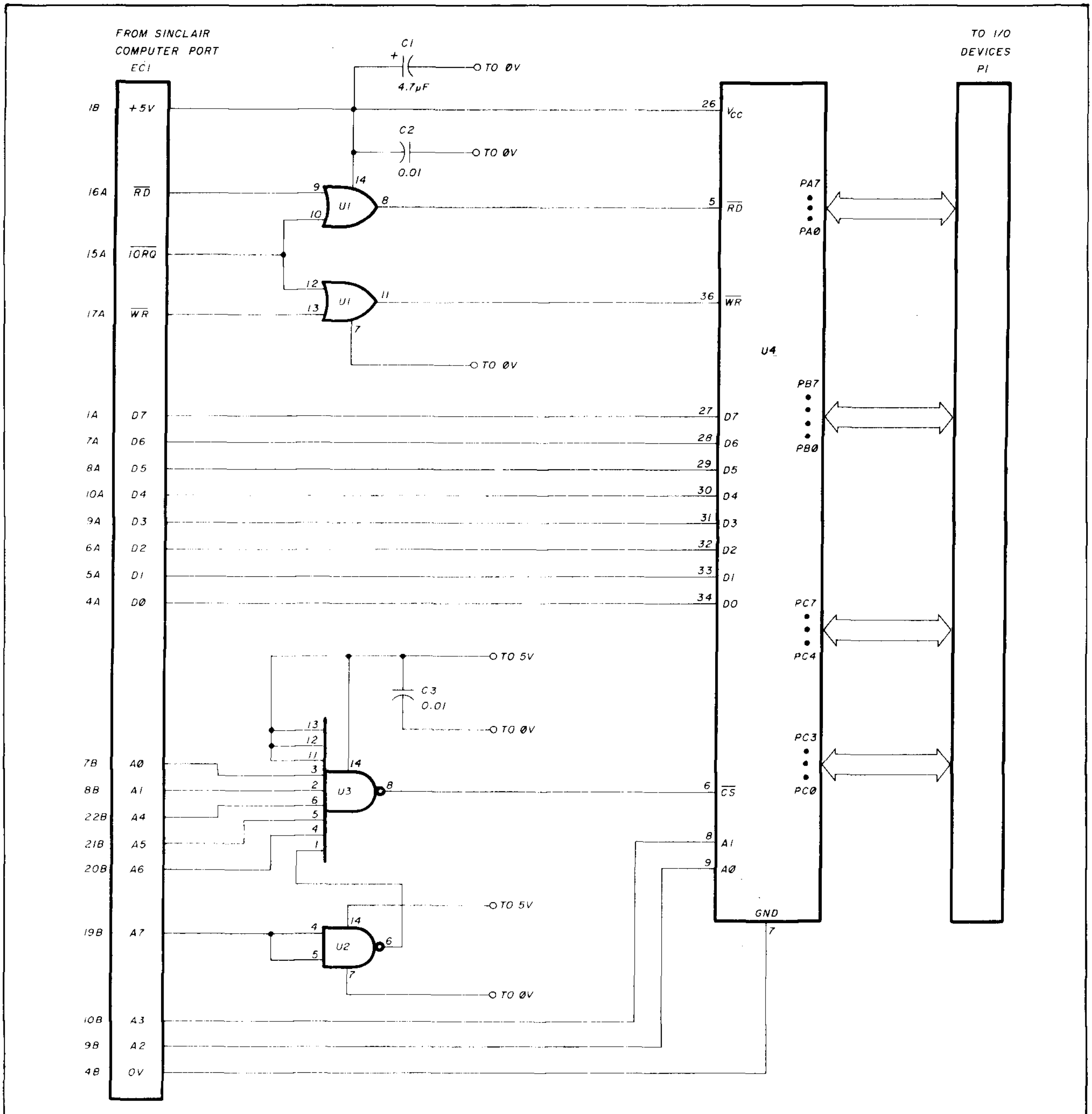

fig. 1. Schematic diagram for interface circuit.

ticular part of the program when specific lines change state. These input/output (I/O) lines are connected to hardware such as the fuel level sensor, the climate control console, and thermal sensors under the hood and inside the passenger compartment. When the driver wants to raise the car's interior temperature to 75 degrees, he or she simply presses a button, entering the desired temperature. The program in the microprocessor is continuously looping, searching for any changes on the input data lines. Finding that the driver has activated the climate control console line, the program then branches to the subroutine designed to effect the desired climate change. In this case, the information (75 degrees) is read into the microprocessor as digital data and a control signal is then sent out to the appropriate hardware (in this case, the heater on/off switch). While this is an overly simplified version of what is actually done in today's automobiles, it illustrates one typical application of a controller.

Of key importance is the fact that in such applications, the computer is programmed to handle a variety of input signals from external hardware and issue

Table 1. Parts list for Interface Circuit (fig. 1).

Schematic Designator	Description
C1	4.7 μF electrolytic capacitor
C2	0.01 μF capacitor
C3	0.01 μF capacitor
EC1	2 row x 23-pin edge connector; 0.1-inch spacing, pin length at least 0.75-inch.
P1	DB-25 D-connector
U1	74LS32 Quad two-input OR chip
U2	74LS00 Quad two-input NAND chip
U3	74LS30 Eight-input NAND chip
U4	8255 Programmable Interface Chip

Miscellaneous:
Single-sided circuit board
Jumper wires (at least 10)
Project box (UNIBOX UB270-130)

Table 2. Operation of 8255 PPI chip (U4).

I/O Instruction	I/O Address	Operation
IN	115	Read from Port A
IN	119	Read from Port B
IN	123	Read from Port C
OUT	115	Write to Port A
OUT	119	Write to Port B
OUT	123	Write to Port C
OUT	127	Write to Control Register

control signals to external hardware. Because the controller's program is simple and repetitive, it doesn't require much memory. The 2K of memory in the ZX-81 and TS-1000 is more than enough to program even a very complex controller. We can also take advantage of the computer's high-level (BASIC) capability to simplify programming the computer for controller applications. An understanding of machine language is important, though, since the I/O interface must allow exchange of data on a level lower than BASIC; this is done through the *PEEK* and *POKE* commands.

description of interface circuit

With the interface circuit connected to the port of the ZX-81 or TS-1000, very fast data signals which appear on the data bus of the computer can be latched by the interface circuit and sent as control signals to external hardware (I/O devices). Similarly, in conjunction with the interface circuit, the computer can read in very fast asynchronous signals from external hardware and use the received signals to make decisions in software.

Figure 1 is the schematic diagram of the I/O interface. A complete parts list appears in **table 1**. Note that no power supply is needed for the interface; all four ICs are conveniently powered by the computer's internal 5-volt supply (the voltage is made available at the computer port).

The heart of the interface circuit is U4, the 8255 programmable peripheral interface (PPI) chip. U1, U2, and U3 serve to decode the address signals generated by the computer. After much trial and error, I found that it's possible to access four I/O address locations not used by any of the internal computer circuitry. These address locations — 115, 119, 123, and 127 (decimal) — may be used to activate any external device connected to the computer port. For my interface circuit, these four address locations are used to access U4, which in turn directs the flow of data between any external I/O device and the computer. In **table 2**, I've shown the addresses used to control the various registers of U4. While some of the basics on how to use U4 will be spelled out later, more details can be found in any Intel databook or in Goldsbrough's *Microcomputer Interfacing with the 8255 PPI Chip.*[2]

When laying out a circuit board, I decided that it would be nice to have the ability to add components or connectors in the future. (I call the upper portion of the board, where there are several inches of 0.1-inch spaced holes, the "playground" area.) By adding components and appropriate jumper wires, it's possible to expand the interface circuit. The single-sided board negative I used, shown in **fig. 2**, requires ten insulated jumper wires, which should be installed on the foil (non-component) side of the circuit board after all of the components are mounted (see **table 3**). Pads are available on the circuit board to permit easy soldering of each jumper. I used 16 additional jumpers to route all eight of the port A pins, four of the port B pins, and four of the port C pins from U4 to molex pins attached on the top of the "playground" area. These molex pins mate with headers that allow for easy detachment of the data lines from I/O hardware or from a case-mounted connector. You may wish to use just one pin or all 24 pins available on U4 for I/O data exchange. Use as many data lines as you need.

The component layout for the circuit board (**fig. 2**) is shown in **fig. 3**. When mounting the ICs, be sure to use a low-wattage soldering iron since the pads are delicate. I strongly recommend the use of sockets for each of the four ICs.

All of the components are easy to acquire at hamfests or electronic shops, except, perhaps, for the 46-pin connector used to attach the interface board to the computer memory port. The connector type is the same as that used on ZX-81 and TS-1000 peripherals such as the 16K RAM-pack, and is a 46-pin, double-sided edge connector with 0.1-inch spacing between contacts. I found that you have to buy a sturdy con-

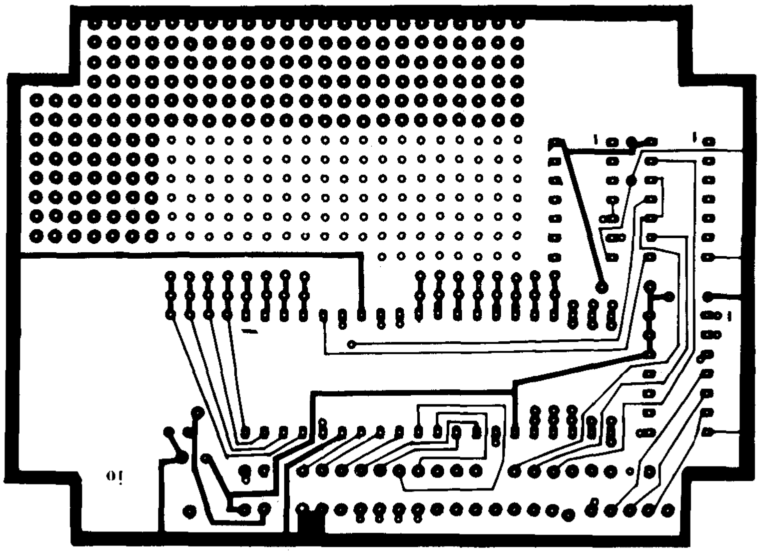

fig. 2. Single-sided circuit board artwork for I/O interface circuit.

Table 3. Jumper wires needed for single-sided circuit board. These connections should be made after all other components are soldered in place.

Jumper between: U1, pin 11 and U4, pin 36
Jumper between: U2, pin 5 and EC1, pin 19B
Jumper between: U2, pin 6 and U3, pin 1
Jumper between: U3, pin 2 and EC1, pin 7B
Jumper between: U3, pin 3 and EC1, pin 8B
Jumper between: U3, pin 8 and U4, pin 6
Jumper between: U3, pin 16 and U1, pin 16
Jumper between: U4, pin 8 and EC1, pin 10B
Jumper between: U4, pin 9 and EC1, pin 9B
Jumper between: U4, pin 27 and EC1, pin 1A

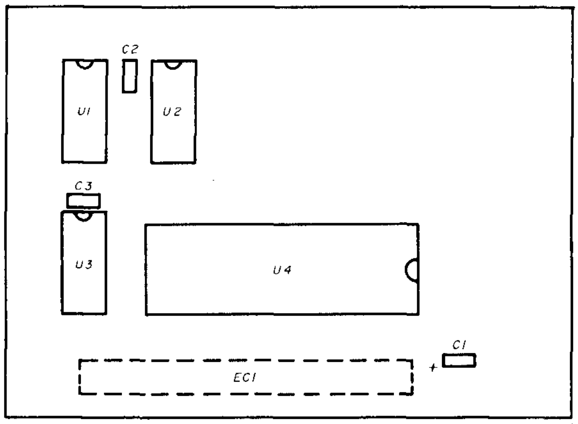

fig. 3. Component layout for interface circuit — view from component side (EC1 mounted on FOIL SIDE).

nector and be prepared to use a Dremel tool or a small saw to cut a larger connector down to correct size. But be careful: I bought a 60-pin, double-sided connector for less than $1.00 from a military surplus dealer at a hamfest. Eagerly, I took the new connector home, cut it to length, and soldered it onto the board. After a couple of trial fits on the memory port of the computer, the connector crumbled into tiny bits! It was a real pain to have to chop off the faulty connector and resolder a new one onto the board! You may notice from the accompanying photographs that the connector must be soldered on the foil side of the board, and protrudes from that side of the board as well.

The entire cost of components is well under $20. The construction time is fast — one evening should be sufficient.

I was able to find attractive plastic boxes made by UNIBOX[3] at a local Radio Shack for less than $4.00 each. The circuit board fits neatly inside, and only two rectangular holes have to be cut into the box: a 0.5 x 2.5-inch hole to allow the 46-pin edge connector to protrude from the circuit board, and a 0.5 x 1.0-inch hole on the other side of the box to allow I/O wires to be fed to a D-connector mounted on the exterior (see **fig. 4**).

interface software

You can add all the hardware in the world to a computer, but it won't serve any useful purpose unless you know how to program the computer effectively. In this section a programming example for an application of the interface circuit is given, and a review of how to

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use the ZX-81 and TS-1000 *PEEK* and *POKE* commands is presented.

In order to perform data exchanges between I/O devices and the computer, it's first necessary to set up the I/O format on U4. U4 has 24 pins which are usable for data exchange. These pins are partitioned into three groups of eight pins. Each group of eight pins is called a *port.*

Any program written for I/O control should begin with an initialization stage. This initialization sets the data flow of the ports on U4. For example, you may want to program the eight data lines of port A for output (data sent to the I/O device from the computer) and have the eight data lines of port B programmed for input (data sent from the I/O device to the computer). While ports A and B require that all eight pins be either input or output, Port C allows for four pins to be input and four to be output. Of course, Port C may also be programmed for all eight pins to be either input or output.

While it's beyond the scope of this article to teach assembly language and machine code programming, let me assure you that mastering them is not difficult. If you find the example in this article insufficient, you may wish to read Chapters 1, 2, and 5 in Hordeski's easy-to-read *Microprocessor Cookbook.*[5]

The following example details the simplicity of controller software. Consider an alarm system that monitors the status of eight windows around the house. Three wires (ground, +5 volts, and data status line) could be routed to each of eight windows. A small switch could be mounted by each window so that if

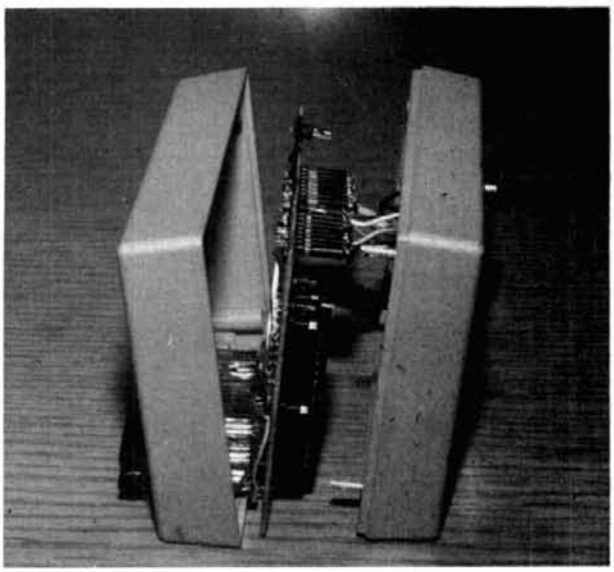


fig. 4. The circuit board fits into the project box. Be sure to use an edge connector with at least ¾" of pin length to allow clearance when the circuit is plugged into the computer port. It is convenient to have a connector on the back of the box for easy access to the I/O lines.

the window is shut, a low-logic level (0 volts) exists on the status line. If any of the windows are open, we want the computer to recognize this and sound a bell. For this case, we may use all eight pins of Port A for input (to read the status of each of the eight windows), and may use Port B for output (although we need to use only one of the eight pins to output a control signal for the alarm). Since we're not using Port C, we don't care what it's programmed for! By connecting the status line of each window to individual pins of Port A, we can read the status of each window into the computer. If we use a simple transistor switch to activate the bell, one of the pins from Port B can be connected to the gate of the transistor switch. When a window is discovered to be open, the computer then sends out a high-logic level (5 volts) to the alarm pin (as well as the unused pins) on Port B, thus sounding the bell.

The programming steps for the window alarm example would be as follows:

1. Initialize data flow on Ports A, B, and C.
2. Look at input data from windows.
3. If any of the input data bits is "1," sound alarm.
4. If the input data is all "0," then go to step 2.

Notice that once the data flow is initialized on U4, no further action is required unless the power is unplugged or U4 is reprogrammed. The assembly language program for this example follows (comments are included in parenthesis):

(Initialization):

LD A, 144 (144 = 10010000. This programs Port A for input, Ports B, C for output. We load 144 into accumulator.)

OUT 127,A (Send contents of accumulator 144 to the U4 control register, which is located at ADDR 127.)

(Monitor window data):

loop IN A, 115. (Read in the eight-bit data at ADDR 115 — Port A — and place data in the accumulator.)

JRZ, *loop* (Compare the eight bits of data in accumulator to the all-zeros data word 00000000; if all eight bits of data are zeros, then jump back to *loop* and continue to monitor.)

(If program gets to this point, then sound the alarm!):

LD A, 255 (Load accumulator with all-ones word, 11111111)

OUT 119, A (Send the accumulator contents out to Port B; this sounds the alarm).

The preceding assembly language program, when written in machine code, requires only 13 bytes of memory! It's entered into the computer via the *POKE* command. The conversion from assembly language mnemonics to machine opcodes is given in the ZX-81 and TS-1000 user's manual appendix. For the previous program, the machine code that would be POKEd is given in **table 4**.

Although not illustrated in this example, it's simple to monitor your I/O activity by going back and forth between BASIC and machine code. In this case, it would have been easy to see on the computer monitor which particular window (or windows) were opened by simply passing the Port A data to the b-c register pair in the machine code program, and then by returning to BASIC by way of the USR command and printing the value of the USR function on the screen.

machine code within BASIC programs

To store a machine code program in the computer, you must first set aside some memory by using a REM statement (usually the first line in your BASIC program). The REM statement sets aside successive memory locations which are never written over, thereby allowing you to store machine code programs safely. Machine code programming may be saved on tape by using the *SAVE* command.

A machine code program is run in sequence by using the USR command, where the argument of the USR command is the address location of the first machine language opcode. The computer returns to the BASIC program once the return opcode (201) is encountered, and assigns the decimal value of the b-c register contents to the variable name to which the USR function is equated. In this manner, it's possible to pass data from machine code programs (and consequently data from external I/O devices) to BASIC. Or you may use the *PEEK* command in a BASIC program to retrieve data from dedicated memory locations in your machine code storage area (REM statement). Either way, it's a simple chore to transfer data from "real world" devices to your computer. By using the *POKE* command in a BASIC program, you may place data from BASIC into data locations of machine code programs. Note that this allows you to make keyboard entries and have these entries correspond to control signals for I/O devices.

When you're ready to enter a machine code program into the computer, clear the computer's memory and begin as if you were writing a new BASIC program. Enter **line 1** as a REM statement, filling in as many letters in the REM statement as the number of bytes required in your machine program. It doesn't matter what you put in your REM statement, because after you *POKE* in your machine code, the REM statement appears as gibberish on the screen. For the TS-1000 computer, the first usable memory slot once a REM statement is entered is 16514. Use the *POKE* command to place the machine code in sequential memory locations starting with 16514. Upon completing the entry of your machine code, place the opcode 201 in the very next memory location following your last program opcode. At this point it's a good idea to save your program on tape (even though it's only a single REM statement). That way if anything happens — for example, if junior unplugs your computer — you don't have to re-*POKE* your entire program! For the machine code in **table 4**, the following would be entered into the computer:

Table 4. Machine code for programming example.

Assembly language instruction	Machine code
LD A, 144	62
	144
OUT 127, A	211
	127
IN A, 115	219
	115
JRZ, -4	40
	252
LD A, 255	62
	255
OUT 119, A	211
	119
RETURN TO BASIC	201

```
POKE 16514,62 (press enter)
POKE 16515,144 (press enter)
POKE 16516,211 (press enter)
. . . .
. . . .
. . . .
POKE 16524,211 (press enter)
POKE 16525,119 (press enter)
POKE 16526,201 (press enter)
```

To verify that the opcodes are in memory, you may use the *PEEK* command to see what the computer has stored.

In order to execute your machine code, you must have a BASIC statement that contains the USR function. For the window alarm program, your next program line (following the REM statement) could be:
2 LET WINDALARM = USR (16514)
By running this simple two-line BASIC program, your Sinclair computer executes the machine code and is able to communicate with external devices through the use of the interface circuit! If the machine code was written so that the Port A data was placed in the b-c register pair, then the value of the variable WINDALARM, which can be viewed on the monitor with a simple print statement such as

3 PRINT WINDALARM,

could be displayed to indicate (in decimal) the window status.

When using the Sinclair computer as a controller, more than one machine language program can be used. It's often convenient to write several *subroutines* in machine code, and store them all in succession in the first REM statement. (Remember they're separate to the computer when they end in the opcode 201). In this manner, your BASIC program can consist of various calls to the subroutines by using USR functions with the appropriate memory addresses in the REM storage.

conclusion

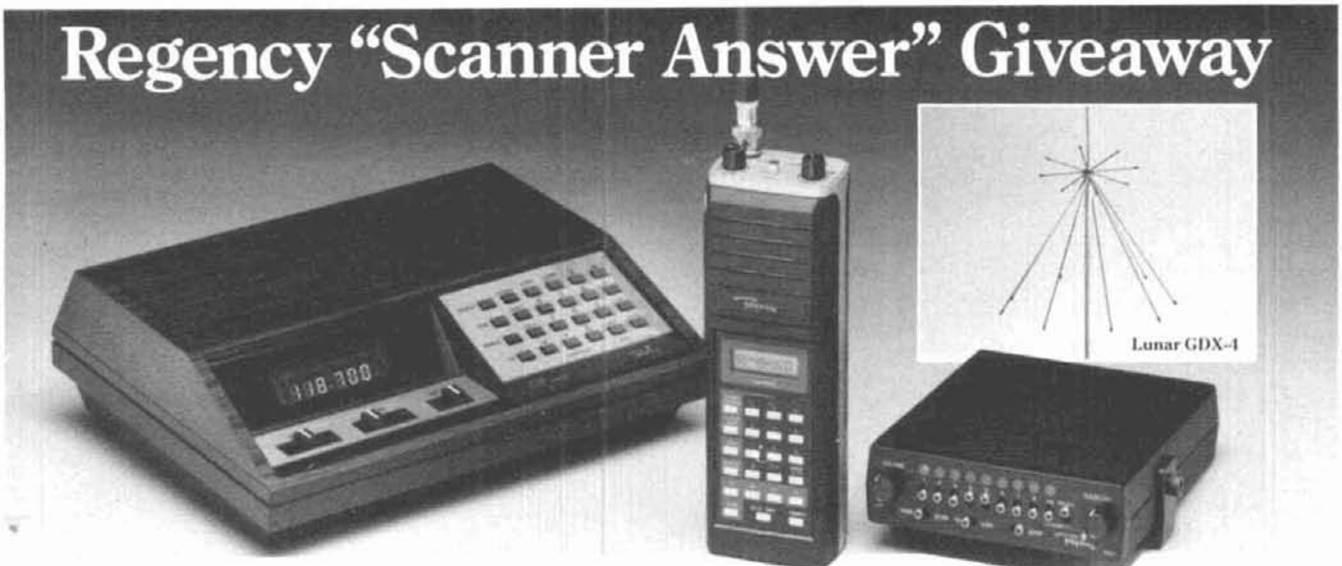
In this article I've discussed the hardware and software needed to provide a communication path between your Sinclair ZX-81 or Timex/Sinclair 1000 computer and any I/O device you might wish to control or monitor. With the price of these computers so low, even those with the tightest budgets can afford to experiment with computer control! By now, you may already have an idea for a controller application in your shack. If you take an evening out to build this circuit and spend a few hours reviewing machine language programming, you'll be amazed at what your small but mighty computer can do!

references

1. *Intel* is a trademark of Intel Corporation. Information on Intel products may be obtained from Literature Department, Intel Corporation, 3065 Bowers Avenue, Santa Clara, California 95051.
2. P.F. Goldsbrough, *Microcomputer Interfacing with The 8255 PPI Chip*, Howard W. Sams, Publisher, 1979.
3. UNIBOX, Amerex Corporation, Riverside, California 92502.
4. Michael Hordeski, *Microprocessor Cookbook*, Tab Books, 1979.

ham radio

Regency "Scanner Answer" Giveaway



Here's your chance to win a complete monitoring package from Regency Electronics and Lunar Antennas. 18 scanners in all will be awarded, including a grand prize of the set-up you see above: the Regency HX1500 handheld, the Z60 base station scanner, the R806 mobile unit, and a Lunar GDX-4 Broadband monitoring/ reference antenna.

55 Channels to go!

When you're on the go, and you need to stay tuned into the action, take along the Regency HX1500. It's got 55 channels, 4 independent scan banks, a top mounted auxilliary scan control, liquid crystal display, rugged die-cast aluminum chassis, covers ten public service bands including aircraft, and, it's keyboard programmable.

Compact Mobile

With today's smaller cars and limited installation space in mind, Regency has developed a new compact mobile scanner, the R806. It's the world's first microprocessor controlled crystal scanner. In addition, the R806 features 8 channels, programmable priority, dual scan speed, and bright LED channel indicators.

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Besides covering all the standard public service bands, the Regency Z60 scanner receives FM broadcast, aircraft transmissions, and has a built-in digital quartz clock with an alarm. Other Z60 features include 60 channels, keyboard programming, priority control, digital display and permanent memory.

Send in a photo (like this one of Mike Nikolich and his Regency monitoring station) and receive a free gift from Regency. Be sure to include your name, address and phone number.

Lunar Antenna

Also included in the grand prize is a broadband monitoring/reference antenna from Lunar Electronics. The GDX-4 covers 25 to 1300 MHz, and includes a 6 foot tower.

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7707 Records Street
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Grand Prize (1 awarded)
1—Regency Z60 Base station scanner
1—Regency HX1500 Handheld scanner
1—Regency R806 Mobile scanner
1—Lunar GDX-4 Antenna

First Prize (5 awarded)
1—Regency Z60 Base station scanner
1—Regency R806 Mobile scanner

Second Prize (5 awarded)
1—Regency HX1500 scanner

Contest rules: Just answer the questions on the coupon, (all answers are in the ad copy) fill in your name and address and send the coupon to Regency Electronics, Inc., 7707 Records Street, Indianapolis, IN 46226. Winners will be selected from all correct entries. One entry per person. No purchase necessary. Void where prohibited by law. Contest ends June 30, 1987.

1. The Regency Z60 is
   ☐ a digital alarm clock ☐ an FM radio
   ☐ a scanner ☐ all of the above
2. The Regency R806 is the world's first ________ controlled crystal scanner.
3. The Regency HX1500 features
   ☐ 55 channels ☐ Bank scanning
   ☐ Liquid crystal display ☐ all of the above
4. The Lunar GDX-4 antenna covers ____ to ____ MHz.

Name: ________

Address: ________

City: ________ State: ________ Zipcode: ________

I currently own ________ scanners.

Brands owned: ________

✓ 201

amateur FSK: a spectral analysis

Experimenting with spread spectrum? Try this technique to assess interference levels and determine channel separation

The increasing use of digital communications techniques in Amateur Radio, be it in RTTY, packet radio, AMTOR, or spread spectrum, makes it increasingly important for the Amateur to understand the characteristics of digital transmissions. This article discusses frequency-shift-keyed (FSK) waveforms, the simple technique of associating one frequency with one level of a digital code and another frequency with the other level. In essence, the binary code switches a carrier between two frequencies, a method well-known in the 1920's, when radio teleprinting first became popular.

This article investigates the spectral characteristics of FSK signals — that is, the way an FSK signal occupies a segment of the radio frequency spectrum. Spectral analysis is invaluable for assessing interference levels, deciding on adjacent channel spacings, and more recently for spread spectrum experimentation. Although two computer-simulated and experimental studies of some FSK signals have appeared in the Amateur press, neither study was based on mathematical analyses of the waveforms, and consequently encouraged little further investigation among the Amateur community.[1,2] Here, the mathematical results will be provided, thus encouraging readers to experiment with FSK waveforms on their personal computers.

generating an FSK signal

There are two basic ways to generate an FSK signal. Referring to **fig. 1**, we see two oscillators running at frequencies f_1 and f_2, with a switch to choose one or the other as an output. The switch is controlled by the ones and zeros of a digital bit stream: f_1 is sent for a zero, f_2 for a one. The resultant frequency-shift-keying waveform has discontinuous phase at the transition times, meaning that when a bit changes from one to zero or zero to one, the phase of the f_1 oscillator is completely *unrelated* to the f_2 oscillator phase. Some Amateur modems generate FSK this way, usually from two separate switched audio oscillators fed into the microphone input of an SSB transmitter.

In **fig. 1B**, the FSK waveform is generated by feeding the digital bit stream to a *single* voltage-controlled oscillator. The oscillator is instantly pulled from f_1 to f_2 and back again, but because there's only one oscillator the phase is continuous at the bit transitions. The old trick of FSKing the VFO of a transmitter by tying an element of the oscillator tube to the keyboard also yields continuous-phase FSK (CPFSK). Modern radio modems generating audio FSK using an integrated circuit like the XR2206 can also generate CPFSK. The difference between discontinuous phase FSK (DPFSK) and CPFSK is illustrated in **fig. 2**, where the bit stream and the two frequencies it controls are plotted. Note the sharp-edged transitions in DPFSK when the carrier switches between f_1 and f_2; these are not present in the smoother CPFSK waveform. As shown later, the spectral responses of these two kinds of FSK are quite different.

overview of spectral analysis

An easy-to-understand time-domain representation of FSK signals, that is, how they would look on an oscilloscope, is shown in **fig. 2**. However, it's much more interesting to consider what these signals look like in the frequency domain. Questions such as how much bandwidth they occupy, why some seem to splatter more than others, and what kind is better for radioteleprinting than for spread-spectrum communications are answered. It's important to realize that we have a couple of parameters to play with here — the

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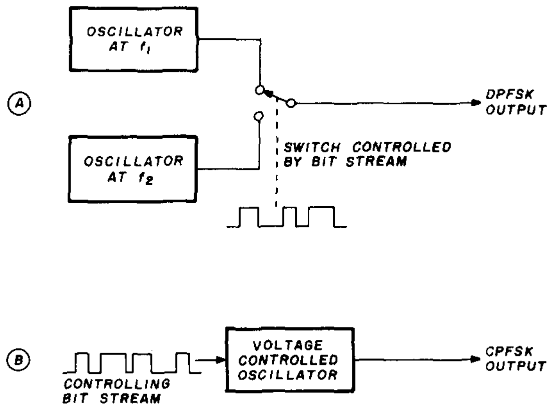

fig. 1. Two methods of generating frequency-shift-keyed signals.

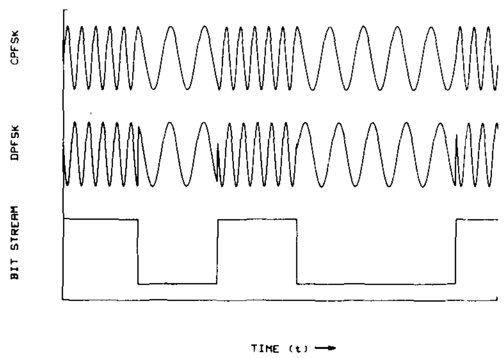

fig. 2. Continuous and discontinuous phase FSK as viewed on an oscilloscope.

```
5 REM **** PROGRAM FRAGMENT FOR
  CALCULATING SPECTRAL DENSITIES ****
10 DIM X(200),Y(200)
20 PI=3.14159265:T=0.022:SHIFT=170:W1=90
83.3*2*PI:W2=(9083.3+SHIFT)*2*PI:WS=(908
3.3+SHIFT/2-1000)*2*PI
30 AL=(W2+W1)/2:BE=(W2-W1)/2
40 FOR Z=1 TO 200
50 REM **** DISCONTINUOUS PHASE CASE
  --- USE LINES 60 TO 120 ****
60 A=WS+Z*20*PI-W1:B=WS+Z*20*PI+W1:C=WS+
Z*20*PI-W2:D=WS+Z*20*PI+W2
70 A1=(SIN(A*T/2))*(SIN(A*T/2))
80 B1=(SIN(B*T/2))*(SIN(B*T/2))
90 C1=(SIN(C*T/2))*(SIN(C*T/2))
100 D1=(SIN(D*T/2))*(SIN(D*T/2))
110 E=A1/(A*A)+B1/(B*B)+C1/(C*C)+D1/(D*D
)
120 Y(Z)=10*CLOG(E):X(Z)=(Z-100)*10
130 REM **** CONTINUOUS PHASE CASE
 ---- USE LINES 140 TO 280 ****
140 W=(2*PI*Z*10)+WS
150 A=W-W1
160 B=W-W2
170 C=W+W1
180 D=W+W2
190 E=W-AL
200 F=W+AL
210 G=2*SIN(A*T/2)*SIN(A*T/2)*SIN(B*T/2)
*SIN(B*T/2)
220 H=2*SIN(C*T/2)*SIN(C*T/2)*SIN(D*T/2)
*SIN(D*T/2)
230 I=(1/A-1/B)*(1/A-1/B)
240 J=(1/C-1/D)*(1/C-1/D)
250 K=T*(1-2*COS(E*T)*COS(BE*T)+COS(BE*T
)*COS(BE*T))
260 L=T*(1-2*COS(F*T)*COS(BE*T)+COS(BE*T
)*COS(BE*T))
270 M=G*I/K+H*J/L
280 Y(Z)=10*CLOG(M):X(Z)=(Z-100)*10
290 NEXT Z
```

fig. 3. Atari BASIC listing for calculating the spectral density of FSK signals. The trig functions evaluate their arguments in radians (not degrees).

words per minute or baud rate, and the frequency shift (from $f1$ to $f2$ in Hertz).* For instance, an 850-Hz shift, 60 wpm Baudot FSK signal has a different spectrum than the same signal shifted by only 170 Hz. By exploring different shifts and data rates, it's possible to optimize FSK for one's particular needs.

The time-domain representation of an FSK waveform is converted to a frequency spectrum by a mathematical operation known as a *Fourier transform*. However, the Fourier transform of one sequence of characters differs from the transform of other sequences of characters. What we really want is a special average (called an *ensemble average*) that smooths the results of all the possible Fourier transformed bit streams that you could send. In a sense, this kind of ensemble averaged Fourier transform (now called a power spectral density or simply a spectrum) best represents the FSK spectrum of *any* message, because it's the average of the spectra of all possible messages. This spectrum, then, tells you how much power exists in a given bandwidth anywhere near the center frequency of the FSK signal.

There are at least three ways to evaluate the ensemble-averaged Fourier transform of an FSK signal. The first, a mathematical approach, uses a description of FSK (either with discontinuous or with continuous phase at the bit transitions), to calculate

*Strictly speaking, there's really only one parameter in FSK, i.e. the phase change per bit, but Amateurs usually speak of frequency shift and wpm or baud rates. With respect to the center radian frequency $(\omega_1 + \omega_2)/2$, the phase change per bit ψ is expressed in radians as $\psi = T \times$ shift $\times \pi$ where T is the data bit length in seconds, and the shift is in Hertz.

Table 1. Equation for power spectral density of discontinuous-phase - frequency-shift-keying.

$$DPFSK(\omega) = \frac{\sin^2\left[\frac{(\omega-\omega_1)T}{2}\right]}{(\omega-\omega_1)^2} + \frac{\sin^2\left[\frac{(\omega+\omega_1)T}{2}\right]}{(\omega+\omega_1)^2} + \frac{\sin^2\left[\frac{(\omega-\omega_2)T}{2}\right]}{(\omega-\omega_2)^2} + \frac{\sin^2\left[\frac{(\omega+\omega_2)T}{2}\right]}{(\omega+\omega_2)^2}$$

where:

ω = radian frequency

$\omega 1 = 2\pi f_1$

$\omega 2 = 2\pi f_2$

T = the data bit time or the reciprocal of the baud rate

Table 2. Equation for continuous phase - frequency-shift-keying.

$$CPFSK(\omega) = \frac{2\sin^2\left[\left(\frac{\omega-\omega_1}{2}\right)T\right]\sin^2\left[\left(\frac{\omega-\omega_2}{2}\right)T\right]}{T[1-2\cos[(\omega-\alpha)T]\cos\beta T+\cos^2\beta T]}\cdot\left[\frac{1}{\omega-\omega_1}-\frac{1}{\omega-\omega_2}\right]^2$$
$$+\frac{2\sin^2\left[\left(\frac{\omega+\omega_1}{2}\right)T\right]\sin^2\left[\left(\frac{\omega+\omega_2}{2}\right)T\right]}{T[1-2\cos[(\omega+\alpha)T]\cos\beta T+\cos^2\beta T]}\cdot\left[\frac{1}{\omega+\omega_1}-\frac{1}{\omega+\omega_2}\right]^2$$

where $\omega 1$, $\omega 2$, and T are as in the DPFSK case, and $\alpha = \frac{\omega_2+\omega_1}{2}$ $\beta = \frac{\omega_2-\omega_1}{2}$

the spectral density equation.[3] The techniques are powerful and the equations are easily plotted and evaluated.

The second method for evaluating the spectra of FSK signals is to simulate a time-domain FSK signal on a computer, take its Fourier transform using a well-known algorithm, and repeat the process several times using different bit streams. The results are ensemble-averaged so that a spectral density begins to emerge from all the individual Fourier transforms. This method requires considerable computer memory and must be repeated every time you want to try a new bit rate or shift.

The third method for obtaining FSK spectral densities is to use an FSK modulator and spectrum analyzer. However, once you use the equations and come up with a shift and baud rate that you like, you can borrow a spectrum analyzer and see how well your theory meets with practice. (See the two examples at the end of the article).

mathematical analysis

The spectral densities of DPFSK and CPFSK have been calculated by an exact mathematical analysis. These results are then easily plotted on a home computer, in fact, we'll give some BASIC listings to help you along. The equation for the power spectral density of discontinuous-phase frequency-shift-keying is shown in **table 1**. The equation for continuous-phase FSK is shown in **table 2**.

Frequency shift is simply $f_2 - f_1$ *(Hz)*, or $\omega 2 - \omega 1$ in radians per second. Note that if your frequency shift is in a whole number of Hertz, then $\omega 2 - \omega 1$ is never *an integer*.

T, the data bit length, can be found for Baudot or ASCII data rates and speeds in any recent edition of the *ARRL Handbook*. For the ASCII case, the data pulses and stop pulses are the same length ($T = 3.333$ mS) for the data and stop bit lengths with 300 baud ASCII, so the spectral density results are exact. However with Baudot, the stop pulse is often 50 percent longer then the data pulses. Since there are five data pulses for each stop bit, and the longer stop pulse would only result in a narrower spectrum than the faster data pulses, I use the data pulse time for the following plots. For example, 60 wpm Baudot (baud rate is 45.45) had $T = 22$ mS. This should be sufficiently accurate for any practical purpose.

An Atari BASIC program listing for both these equations is provided in **fig. 3**. The program calculates either the DPFSK spectrum (use **lines 60** to **120** and delete **130-280**) or the CPFSK spectrum (use **lines 130-280** and delete **lines 60 to 120**). The result is placed in array *Y* (in dB), with the frequency (in Hz) in the *X* array. The shift and bit times can be changed in **line 20**; they are shown for 170 Hz shift, 60 wpm Baudot. If you link this program fragment with your machine-specific plotting package, you can generate plots like the ones that follow. Atari BASIC is sufficiently generic so that the listing should run on nearly any personal computer with few changes.

spectral plots

The spectral density plots, **figs. 4** through **13**,, are for two cases: the FSK signal with discontinuous phase, and the same signal with continuous phase at the bit transitions. The magnitudes are relative and are intended for comparison purposes only — for instance, to show how sidelobe levels compare from one spectrum to another. It may be puzzling to some that there are no lines in these plots, no periodic signals or carriers, particularly at f_1 and f_2. Recall, though, that this is a frequency-modulated waveform with a random bit stream as its input, and in general this kind of modulation result is in a purely broad spectrum with no carriers. The only exceptions occur when special relationships between f_1, f_2, and *T* exist, e.g. $\omega 2 - \omega 1$, $\omega 2 \div \omega 1$ are integers or $2\alpha T$ or $2\beta T$ are odd multiples of $\pi/2$. For these so-called degenerative cases, the reader is referred to the original Bell Labs paper.[3]

Note particularly how, in each case, the continuous-phase FSK spectrum rolls off much faster than its discontinuous phase counterpart; in fact, this is a characteristic of all continuous-phase signals. This means

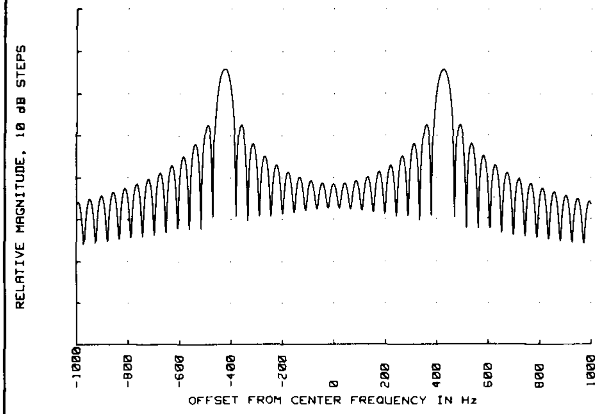

fig. 4. FSK spectrum, discontinuous phase 850 Hz shift for 60 WPM Baudot RTTY.

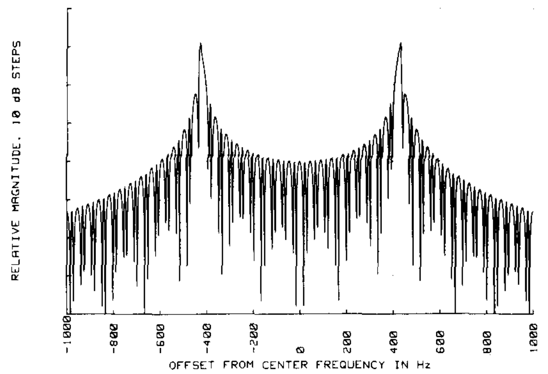

fig. 5. FSK spectrum, continuous phase 805 Hz shift for 60 WPM Baudot RTTY.

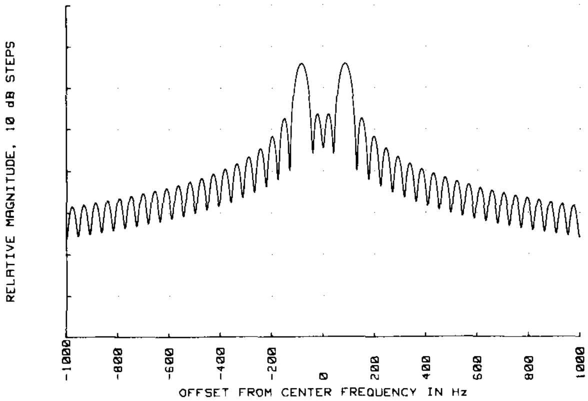

fig. 6. FSK spectrum, discontinuous phase 170 Hz shift for 60WPM Baudot RTTY.

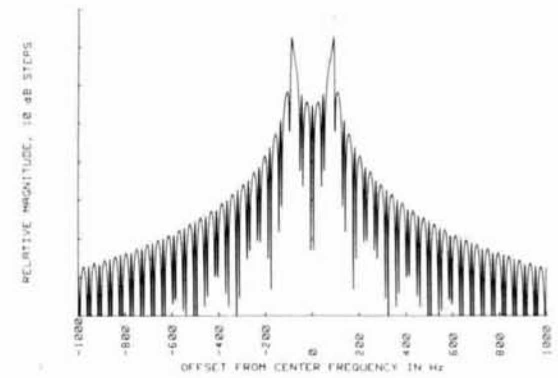

fig. 7. FSK spectrum, continuous phase 170 Hz shift for 60 WPM Baudot RTTY.

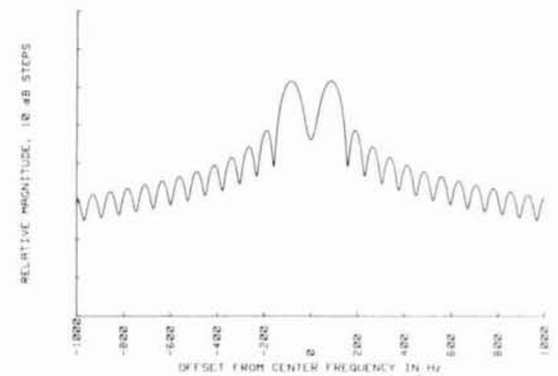

fig. 8. FSK spectrum, discontinuous phase 170 Hz shift for 100 WPM Baudot RTTY.

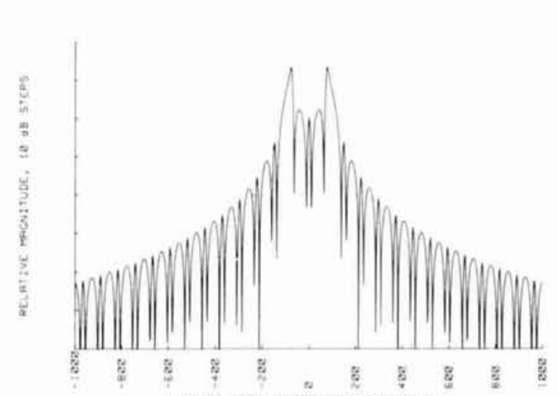

fig. 9. FSK spectrum, continuous phase 170 Hz shift for 100 WPM Baudot RTTY.

that more energy is concentrated near the center frequency of a CPFSK signal, with less energy further from the center frequency that might cause interference with another band user. In short, CPFSK signals are generally more spectrally efficient than DPFSK ones, though spectral efficiency is subject to many definitions. This CPFSK advantage is very evident in the 300 baud, 170 Hz shift ASCII case, where the DPFSK signal is splattered all over the band, and the CPFSK spectrum begins to look like an ideal flat-topped bandpass filter! We'll return to this case shortly.

cumulative power

One advantage of having the mathematical expression for the spectral density is that operations such as integration or differentiation can be performed that would be less accurate and more time-consuming using any other method. Using the expressions given above, the cumulative power in any FSK spectral density can be calculated. By "cumulative power," we mean the following: imagine a frequency window, located at the center frequency of the spectrum, and ever-widening. Each time you widen the window a little, you stop and ask how much of the total power in the spectrum is outside your window's frequency limits. For example, when the window is very narrow, nearly all the spectrum's power is outside. As you widen it, less power is outside the window and your answer gets smaller and smaller. This is then an excellent measure of how well your spectrum concentrates its power in a given bandwidth. It can, for example, be used to estimate the interference levels a given number of Hertz from your signal, or even to design an optimum receiver filter that will capture as much signal power as possible without sacrificing adjacent channel interference rejection.

The cumulative power is obtained by integrating the power spectral densities obtained above. This was not done mathematically, but instead numerically on a computer using the short Atari BASIC listing given in **fig. 14**. The idea is to evaluate the spectral density at ever-widening frequency points, each time adding up the result and scaling by the frequency increment. Numerical integration can be a subtle and tricky business, especially in computer-aided circuit analysis, but these spectra are nicely behaved and the algorithm shown works fine. Note that you use either **lines 110** and **120** (DPFSK) or **lines 140** and **150** (CPFSK); the shift and bit times are given in **line 60** (here 170 Hz shift, 60 wpm Baudot). The results (in dB) are placed in the Y array, and the window width in Hertz is in the X array, ready to pass to your plotting routine. Finally, notice how simple the formulas for the spectral densities become when compared to those in **fig. 3**; this is the result of some clever substitutions made

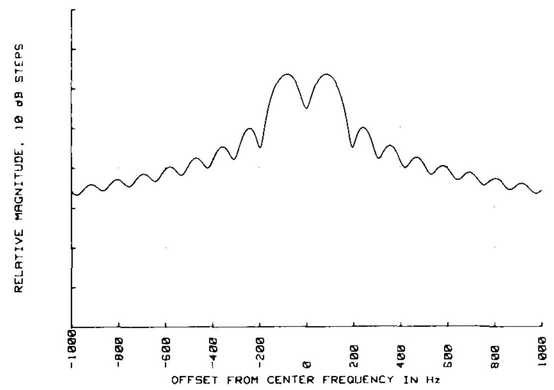

fig. 10. FSK spectrum, discontinuous phase 170 Hz shift for 110 Baud ASCII RTTY.

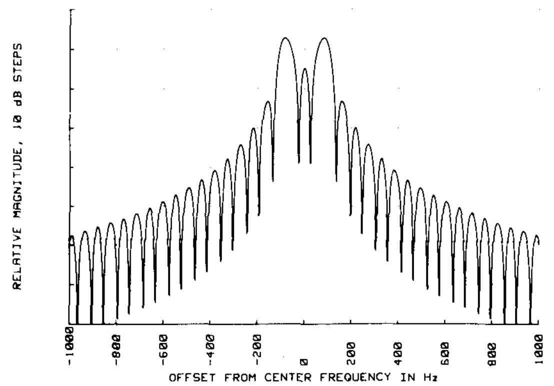

fig. 11. FSK spectrum, continuous phase 170 Hz shift for 110 Baud ASCII RTTY.

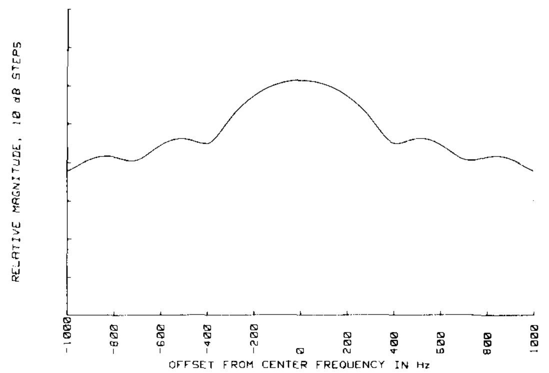

fig. 12. FSK spectrum, discontinuous phase 170 Hz shift for 300 Baud ASCII RTTY.

by sliding the spectra down to a center frequency of 0 Hertz (DC).[4]

The plots given in **figs 15** and **16** compare the DPFSK and CPFSK cases of cumulative power for a Baudot and ASCII waveform. As one would expect from the previous plots, the curves with the faster roll-off are for CPFSK spectra. Note how just a few hundred Hertz away from the center frequency, the CPFSK signal has over 20 dB less power in it than the DPFSK one, an important consideration for evaluating adjacent channel inteference. Other shifts and speeds can be explored using the listing in **fig. 14**.

applications

There are many additional issues one could raise concerning Amateur FSK transmission. One example is the receiver/demodulator design. It was suggested that the receiver filter could be optimized for minimum signal power loss and maximum adjacent channel interference rejection by using the cumulative power plots for a particular FSK waveform. However, the demodulator also has filters in it; the classical Amateur design uses two narrow bandwidth filters centered on *f1* and *f2*, respectively. This type of demodulator filtering makes good sense when receiving FSK transmissions of the kind illustrated in **figs 4-11**, because the filters match the power peaks in the signals, also centered on *f1* and *f2*. However, the 170 Hz shift 300 baud ASCII FSK in **figs. 12 and 13** are another story; here the signal energy is very broad and peaked at the center frequency of the signal, not at *f1* and *f2*. Hence, as illustrated in **fig. 17**, the conventional Amateur FSK demodulator filters waste signal power; their sharply peaked *f1* and *f2* responses no longer match the spectral density. That many Amateurs shy away from 300 baud ASCII on the air begins to make sense . . . their non-optimal modems ignore so much signal energy that they experience high error rates under the usual noisy band conditions. Solutions could involve anything from a radically different 300 baud demodulator design (using a signal correlator, perhaps) to the simple expedient of changing the frequency shift to a new value large enough so that *f1* and *f2* peaks reappear in the spectrum. Of course this will take up more bandwidth, and the former filters will have to be retuned for the new shift, but a definite improvement would be noted over present 300 baud ASCII error rates.

Another issue raised in our spectral analysis of Amateur FSK is its application to spread spectrum communications. The "direct spreading" approach disperses the signal energy so broadly that it lies below the noise level; the signal hides in the mush and goes undetected by conventional narrowband receivers. The spread spectrum receiver is constructed so as to reconstitute the signal from all those bits of energy strewn here and there over the band. The question is, which waveform spreads the energy best? If you look at **fig. 13**, the 170 Hz shift, 300 baud ASCII

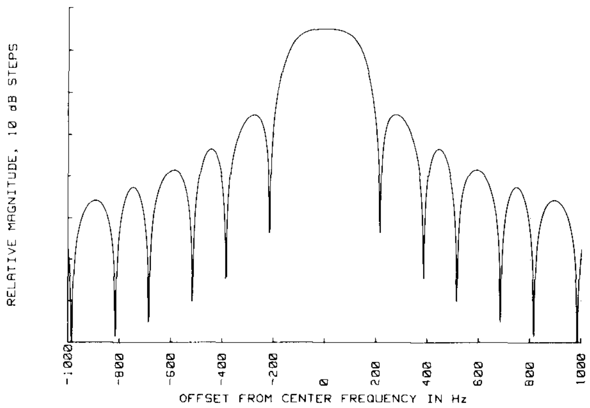

fig. 13. FSK spectrum, continuous phase 170 Hz shift for 300 Baud ASCII RTTY.

```
5 REM *** PROGRAM FRAGMENT FOR
 CALCULATING CUMULATIVE SPECTRA ***
10 DIM X(160),Y(160)
20 PI=3.14159265
30 INC=PI/60
40 NJ=480
50 SUM=0:PT=0:NZ=3:Z=0
60 SHIFT=170:T=0.022
70 A=PI*SHIFT*T
80 FOR J=1 TO NJ
90 B=(J-0.5)*INC
100 REM **** DISCONTINUOUS PHASE CASE
--- USE LINES 110 AND 120 ****
110 YF=2*SIN((B+A)/2)*SIN((B+A)/2)/((B+A
)*(B+A))
120 YF=YF+2*SIN((B-A)/2)*SIN((B-A)/2)/((
B-A)*(B-A))
130 REM **** CONTINUOUS PHASE CASE
--- USE LINES 140 AND 150 ****
140 YF=2*A*(COS(A)-COS(B))/(A*A-B*B)
150 YF=YF*YF/(1+COS(A)*(COS(A)-2*COS(B))
)
160 SUM=SUM+YF*INC/PI
170 Z=Z+1
180 IF Z=NZ THEN YF=1-SUM:PT=PT+1:Y(PT)=
10*CLOG(YF):Z=0
190 NEXT J
200 FOR L=1 TO NJ/3
210 X(L)=L*NZ*INC/(PI*T)
220 NEXT L
```

fig. 14. Atari BASIC listing for calculating the cumulative spectra of FSK signals. The trig functions evaluate their arguments in radians (not degrees).

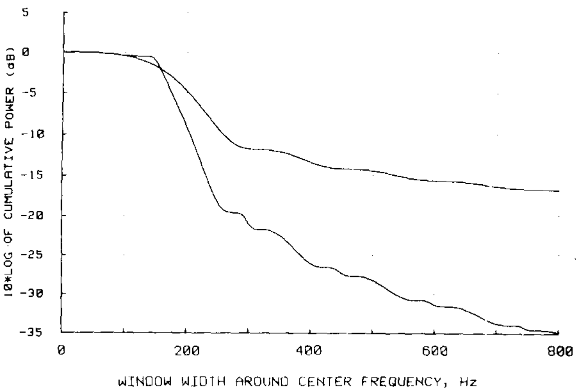

fig. 15. Cumulative spectra of discontinuous and continuous phase FSK for 100 WPM Baudot RTTY, 170 Hz shift.

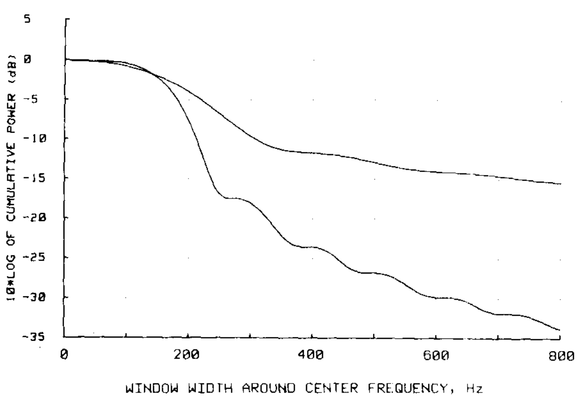

fig. 16. Cumulative spectra of discontinuous and continuous phase FSK for 110 Baud ASCII RTTY, 170 Hz shift.

CPFSK spectrum, you'll begin to get a hint. It can be shown that if you want to fill a given channel or bandwidth with signal energy, the most efficient way to do it is with a rectangular spectral density, because every chunk of available spectrum space will be filled with an equal amount of signal power. Coincidentally, a flat rectangular spectrum also looks most noiselike over the given channel (the spectrum of noise is flat). Now turn to **fig. 18.** It's still 300 baud CPFSK ASCII, but we've changed the shift to 190 Hz. Most striking is the nearly rectangular main lobe, which ideally meets the requirements outlined above. Of course, if you really want to spread your signal energy around and hide the communications under the noise, you can scale everything up by any number you choose; although a 190-Hz shift, 300 baud signal has the same spectral shape as a 19-MHz shift, 30 Megabaud CPFSK signal, it's 100,000 times wider. You could, with this CPFSK waveform and the proper hardware, carry on communication over the entire 420-450 MHz Amateur band and no one except your intended receiver would know you were there!

To demonstrate that these spectral density ideas really work, I generated that rectangular main lobe CPFSK signal and used a sophisticated spectrum analyzer to both ensemble- average and record the resulting spectral density. Shown in **fig. 19**, it nicely confirms the theory of **fig. 18.** The slight raggedness on the spectrum comes from my not averaging every possible bit pattern, which would have taken an infinite amount of time! But this CPFSK spectrum, and all the ones shown here or that you may choose to investigate on your own, can indeed be generated in the laboratory — even the one with that remarkable flat top.

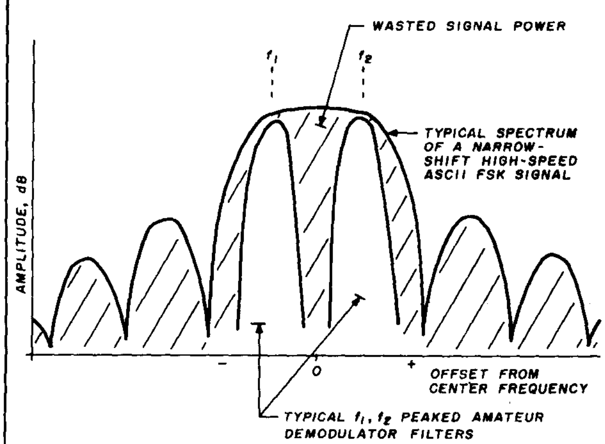

fig. 17. A typical narrow-shift high-speed ASCII FSK spectrum showing how the usual peaked Amateur modem filters ignore a significant fraction of the signal energy.

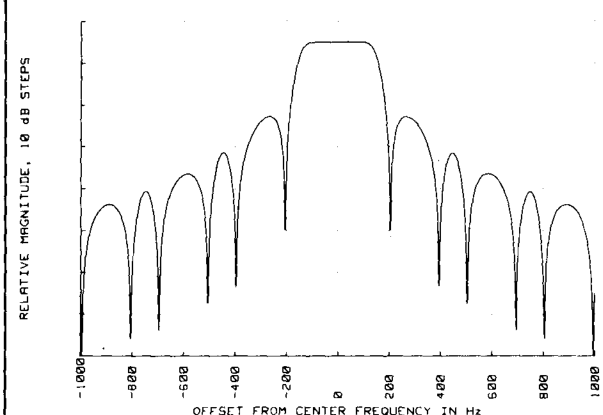

fig. 18. FSK spectrum, continuous phase 190 Hz shift for 300 Baud ASCII RTTY.

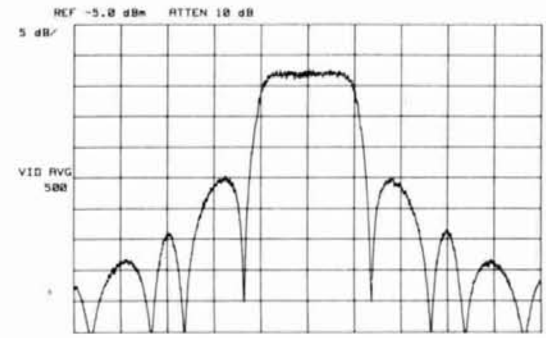

fig. 19. Continuous phase FSK, 190 Hz shift 300 Baud ASCII equivalent.

suggestions for FSK systems

We can summarize this investigation of Amateur FSK spectra with a few suggestions and an invitation. One suggestion is that all Amateurs use continuous-phase FSK in their transmitter modulators. As amply demonstrated above, CPFSK causes much less interference and occupies much less bandwidth than the discontinuous-phase waveform. Fortunately, many modern audio-shift modems already provide phase-continuous signals. Another suggestion is that Amateurs work on FSK demodulator designs which better match the spectral properties of the signal they're trying to receive. This will become increasingly important as bit rates continue to rise, whether in ASCII or in packet communications. Any spectral mismatch in demodulator filtering simply wastes the available (and precious) signal power.

A final suggestion is that Amateurs interested in spread spectrum communications look closely at the family of FSK signals as good candidates for a direct spreading waveform. System performance could significantly improve once the waveform's spectrum is matched to the spreading requirements.

Much more could be said about Amateur FSK — in receiver and transmitter design, in error rate performance, and in application to new types of communications systems. This simple binary keyed waveform carries with it several elegant and easily explored spectral properties, characteristics outlined in this article. I invite the Amateur community to investigate further and make their own fascinating discoveries and conclusions.

acknowledgements

Thanks to Dr. E.J.Kelly, L.A. Bessette, and R.F. Giovannucci for their original contributions to the thesis upon which this article was based.

WA6P operated this solar powered packet station during 1986 Field Day as part of the McDonnell Douglas Amateur Radio Club and Southern California Amateur Club entry. The photographer was WA6AUF.

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2. J.T. Dijak, "Data Bandwidths Compared," *ham radio*, December, 1982. (See also letter from R. Simpson in June, 1983, *ham radio*, concerning Dijak's article.)
3. W.R. Bennett and S.O. Rice, "Spectral Density and Autocorrelation Functions Associated with Binary Frequency-Shift Keying," *The Bell System Technical Journal*, September, 1963.
4. *These formulas and this routine were suggested by* Dr.E.J. Kelly *and used* by the author in "KFSK: A High Performance Waveform for Spread Spectrum and Communications Applications," M.S.E.E. Thesis, MIT, 1984.

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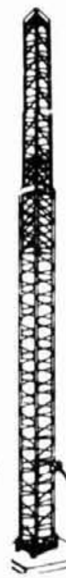

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MacGyver of the '30s— how Amateur ingenuity saved the day

In many man-made and natural emergencies Amateur Radio has proven itself again and again. Here's the story of how Henry Jenkins, W7DIZ, responded when one of the heaviest storms of the 1930s hit the Oregon coast and blinded the Tillamook Rock lighthouse.

The lighthouse, which protected coastal shipping from the dangerous shoals, was under the control of the Department of Commerce. The light atop its tower was perched 85 feet above the ocean. Power for the light, the radio, and the small dwelling of the lighthouse keeper was derived from a gas generator in the basement.

The year is 1934; the month, October. . . .

About 10 p.m., October 20, a fresh southeast wind was blowing with light rain. During the night, the wind increased to gale force and changed to the southwest. About 3 a.m. the seas ran extremely high, swells hitting the base of the rock from the southwest with the spray coming over the rock.

At 9:30 a.m. I was awakened with a sudden jar, completely covered with water. All my clothes and bedding were soaked. The seas at this time were washing over the entire tower, pounding against the window shutters of my room. The window catch let go and the entire room was flooded. At this time the wind was blowing at an estimated 100 miles per hour, seas covering the lighthouse, carrying with it large rocks, debris, and fish which were smashed through the lantern plate glass — 85 feet above sea level — breaking 16 panes and flooding all quarters. In endeavoring to replace glass panes with emergency wooden panels, the Keeper's right hand was deeply cut. While assisting dressing his wound, I read the barometer, which was 28.92 inches, and dropping. Each time the tons of water would cover the building, coming down with terrific impact on the roof, the barometer would drop immediately to 28.72 inches, returning as soon as the impact was over.

The impact from the water and rocks would occur about every three seconds. About 10:15 a.m. a terrific impact occurred and the tower and building were enveloped with giant seas. The large 80-foot derrick and telephone cable to the mainland had been swept away.

A 6-foot section of the west end of the rock was broken off and carried away, hurling rocks weighing as much as 50 pounds through the tower and to the roof, smashing shutters made of half-inch planking. All floors were flooded, breaking the piping and heating system, thereby cutting off the heat, which was badly needed. We were soaked, sloshing in salt water, and extremely tired. The lantern and fog signal were inoperative. Both of these were greatly needed by mariners, and now we had no means of warning them of the rocks and shoals around the light. Finally, we were able to erect a crude, white light, which we hoped somebody could see. But what was needed was a means of informing the Superintendent on land of the damage and the fact that the light was useless.

What was needed was a radio to communicate to land. Since the power was out (and the government radio equipment had not yet been delivered and installed), it was up to me to do the job. A radio had to be built. All that was at hand was a collection of parts from an old Atwater-Kent broadcast set, a few dry batteries and scraps of tinfoil, copper, and brass.

When the storm abated a bit, W7DIZ went to work: *I got two pieces of relatively dry wood. Not having any tube sockets, I drilled holes in each board to take a tube and with the aid of a gas torch, soldered leads on the tube prongs.*

On the transmitter board I placed a coil which I wound from wire taken from an audio transformer. The coil was wound on the cardboard case taken from a No. 6 dry cell. I used 14 turns. The tuning capacitor was salvaged from the old broadcast receiver. Capacitors were made of tinfoil and wax paper taken from a loaf of bread. Since no resistors were at hand, none were used. An rf choke was made from a broadcast coil by removing 100 turns. This junk, when finally assembled, completed a TNT (tuned-not-tuned) oscillator, but had no grid condenser or grid resistor. The batteries to power the transmitter were taken from the defunct telephone system. Eighty volts was available. For a key, I simply broke the battery connection with my hand. Later, I found a piece of spring brass and made a hand key. The antenna consisted of 40 feet of salvaged wire from a broadcast coil.

The receiver was next. For a coil, an old telephone receiver was used as the form and 45 turns of wire stolen from one of the broadcast coils was wound on the form. This made the grid coil. Twenty turns were added at one end for the plate coil. There was no condenser available to control oscillation,

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Photo A. **After the terrible storm, W7DIZ rebuilt his "junk box" radio station. At left is the one-tube transmitter, with the copper tubing tank coil. In the center, in front of the tool box, is the one-tube receiver. A heavy brass hand key is positioned on the table near the transmitter. With this simple, home-made equipment, W7DIZ maintained schedules and kept the Tillamook light on the air, in the ham bands.**

so enough turns were put on the plate coil to keep the circuit oscillating at all times. For the antenna series condenser, two feet of insulated wire were twisted together. A tinfoil condenser was used for the grid condenser, but there was no resistor for the grid leak.

The tuning condenser was made from two brass plates removed from the door knob. One plate was screwed to the wood board and the other placed atop it, separated by a piece of waxed wrapping paper. Tuning was accomplished by shoving one plate over the other with a pencil.

By cut-and-try, I finally heard signals in the 80-meter band. The first station heard was W7RT in Seattle. [Since most stations in those days were crystal-controlled and remained at one spot in the band, W7DIZ immediately knew where he was. — W6SAI]

I next heard W7CKX, a station relatively close to the light. I left the receiver tuned to that spot and tuned the makeshift transmitter to the same spot by listening to CKX with the transmitter running. Finally, about 6:30 p.m. I called W7CXK. No response. But the station CXK was working — W7WR— told CXK that somebody was calling him! And the contact was made. I sent a message to the Superintendent of Lighthouses, advising him that the light was out of service, and that all shipping should be warned. W7CXK immediately sent the message via Western Union to the Superintendent in Seattle and within minutes the powerful Department of Commerce radio stations up and down the Pacific Coast flashed the news that the Tillamook light was inoperative.

And that's how Henry Jenkins, W7DIZ, succeeded in building an entire radio station from salvaged pieces of junk, put the rig into operation, and effected communication with other Amateur stations in an emergency of great import to the shipping lines along the western coast of the United States.

Within the next few months the light was repaired and the Lighthouse Service, seeing the need for radio communications at the Tillamook light, provided a new, more powerful generator and radiotelephone equipment. A lighted buoy was placed near the light. Jenkins rebuilt his ham gear (see **Photo A**), still using only a single tube in the transmitter and receiver.

At one time, W7DIZ took a telephone microphone, connected it to the transmitter tank coil via a loop and made the little rig into a phone transmitter! W7CXK said the audio quality was excellent, provided Henry didn't move around very much!

While the new radio equipment was being installed, W7WR and W7CXK were hired by the Lighthouse Service (at 50 cents an hour) to provide communication with the light, using the special calls KCBC-2 and KCBC-3. This lasted about four months, running three schedules a day. Many private messages to the families of the men on the isolated lighthouse were handled and, as W7CXK says, "Many hours were spent trying to keep the men from going stir-crazy on the rock. It is unbelievable what a few months of isolation out there could do to a person's mind."

Eventually, the lighthouse came under the supervision of the Coast Guard. In the mid 1960s, the light was no longer required, so it was sold. But as recently as 1971, the buyers of the light had done nothing to it, and it looked much the same as ever.

MacGyvers of the 80s? — a "make-do" hamfest event

Does the "Make-do" spirit still exist in Amateur Radio? I like to think that it does. In this regard, I want to propose a "Make-do Event" at your next local hamfest or convention. Volunteer hams split up into three or four teams, three hams to a team. At hand is a large junk box full of old parts, perhaps a defunct TV set, and one or two old radios. Each team has a small number of appropiate tools — a screwdriver, wirecutters, and pliers — as well as a small collection of nuts, bolts, and woodscrews.

Now the contest begins. It runs for a given period, say, three hours. The goal is to build, literally from junk, radio transmitters and receivers and to effect communication between two groups. The groups that get on the air and establish communication first are, of course, the winners.

Details have to be worked out. Is it permissible to scavenge for wood or other chassis material? I vote *yes*. Can a soldering iron be used? I vote *no*. I also vote that the transmitter be crystal-controlled, to keep all activity in the ham bands. Alternatively, a low-power "standard frequency" signal could be emitted by the managers of the contest so that contestants can "find the band."

With a little thought, a viable and exciting contest can be created. I hope such a contest will prove that the spirit of "Make-do" still exists in Amateur Radio today.

The original story of Henry Jenkins, W7DIZ, was told in the January, 1935 issue of "Radio" magazine. Additional details of the incident were given to me in private correspondence from Henry Goetze, W7CXK, who was a witness and participant in the incident at Tillamook Rock.

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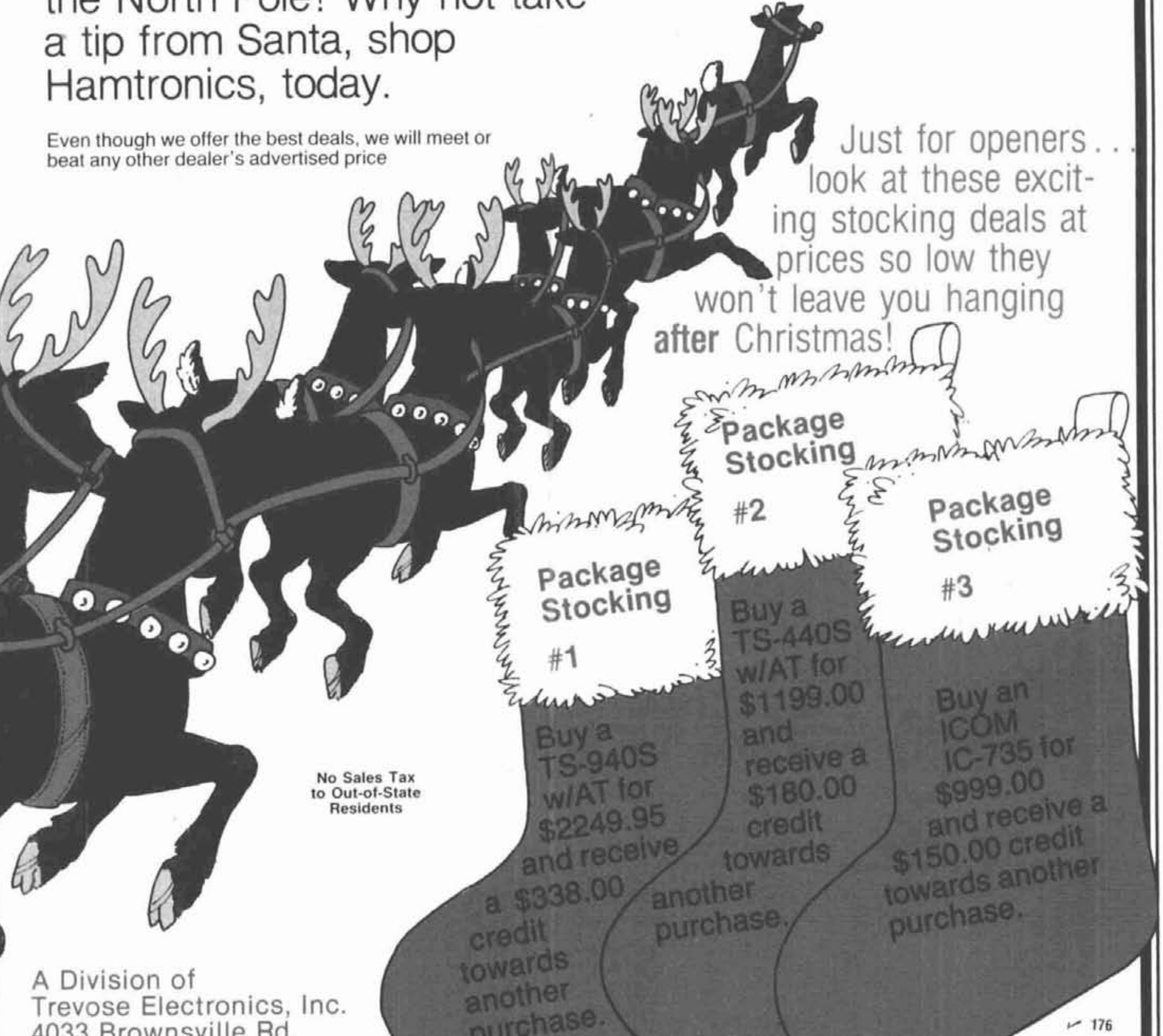

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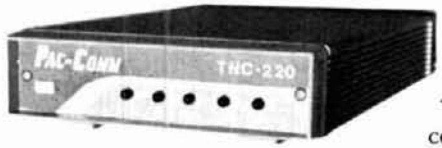

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"function generator" circuits from your signal generator: part 1

Many readers own sine wave or square wave generators, or can make them using simple circuits. In this article, I'll show how to make a function generator out of simple audio signal generators. First, we'll look at making square waves out of sine waves, and then follow up with generating triangle and sawtooth waveforms.

keeping the circuits stable

In preparing this article I had to breadboard several circuits (integrators) to check out the principles presented. Ordinarily, common 741 operational amplifiers are used for my casual projects because those devices are both low-cost and well-behaved. Unfortunately, their "well-behaved" quality is due to their unconditional stability; in other words, the frequency response is rolled off so much that there's little chance of oscillation. That fact makes it easy for the builder to become slack in such matters as power supply bypassing. The 741 will usually operate normally with the power supply leads unbypassed, but op-amps with higher frequency responses (such as the CA-3140 BiMOS device, with its 8-MHz gain-bandwidth product) will become unstable and oscillate if the power supply is unbypassed.

Figure 1 shows the first circuit that I connected. Because the integrator circuits being checked are based on the inverting follower, I first connected an inverting follower with a gain of 1 (R1 = R2 = 470 k) to test the op-amp from my junk box and the breadboard connections. The idea was to then replace the appropriate resistors with the correct integrator components. When a 400-Hz sine wave signal was applied to the input, the oscilloscope showed the waveform in **fig. 2**. Note the thickening of the trace; the fuzziness indicates oscillation at high frequency. Expanding the trace demonstrated that the oscillation was at a frequency somewhat higher than 20 kHz. (**fig. 3**).

The CA-3140 operational amplifier has a higher gain-bandwidth product than the older 741, and requires the bypass capacitors shown in **fig. 4**. When I connected those capacitors into the circuit, the oscilloscope showed the trace in **fig. 5**, which is the correct trace. Beware! Always follow good shop, lab, and design practices.

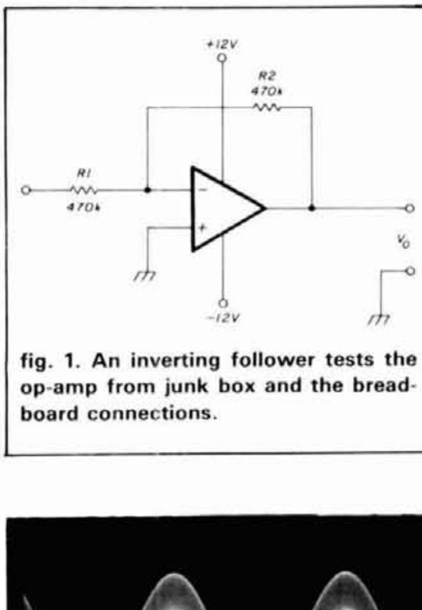

fig. 1. An inverting follower tests the op-amp from junk box and the breadboard connections.

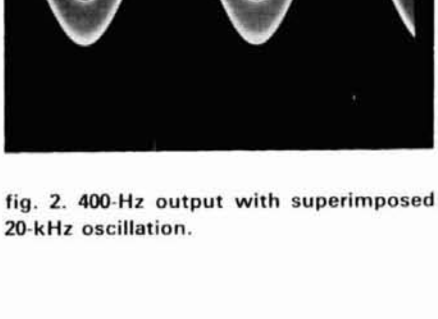

fig. 2. 400-Hz output with superimposed 20-kHz oscillation.

square waves from sine waves

Figure 6 illustrates a method of converting sine waves into square waves. The circuit is an operational amplifier connected as a comparator. Because the op-amp has no negative feedback path, the gain is very high; with typical op-amps gains of from 20,000 to 2,000,000. Thus, a voltage difference across the input terminals of only a few millivolts will saturate the outputs. From this behavior, we can understand the operation of the circuit and the waveform in **fig. 6**.

The input waveform is a sine wave. Because the noninverting input is grounded, the output of the op-amp is zero only when the input signal voltage is also zero. When the sine wave is positive, the output signal will be at −Vo; when the sine wave is negative, the output signal will be at +Vo. The output signal will be a square wave at the sine wave frequency, with a peak-to-peak amplitude of 2Vo. An output level control, variable gain post-amplifier stage or an attenuator network can be used to reduce the signal to a usable level.

Before we turn our attention to circuits for generating other waveforms, let's investigate the topic of operational amplifier integrators.

integrators

Electronic integrators must find the time average of the input waveform. The simplest form of integrator is the resistor capacitor (RC) network shown

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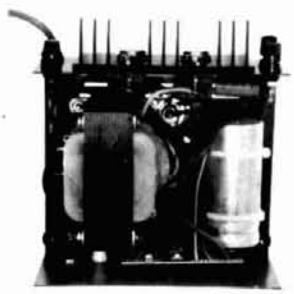

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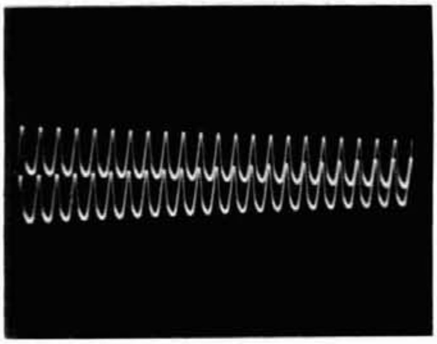

fig. 3. Expanded trace shows oscillation signal.

in **fig. 7**. In this circuit, the output voltage change is related to the capacitor's rate of charge. The rate of increase in Vo depends upon the input voltage and the values of R and C. If you recognize the circuit as a low-pass filter, you are correct. The integrator also functions as an LPF with a roll-off of −6 dB/octave above the −3 dB knee frequency (1/6.28 RC).

An active integrator is shown in **fig. 8**. The active element is an operational amplifier, and it has a capacitor in the feedback network. This circuit is basically the inverting follower with the feedback resistor (R2) replaced by a capacitor. The transfer equation of this circuit is given by the expression shown in **fig. 8.** In this expression, the resistance is in ohms, and the capacitance is in farads. The term "a" is a constant that represents the initial charge on the capacitor, which could be zero. The constant factor −1 indicates that the circuit is inverting, so a positive-going input voltage produces a negative-going output voltage, and vice versa.

The gain of this circuit is −1/RC. Keep in mind that with small values of R and C, this gain can be very, very high, with resulting problems for the designer. Consider this example: what is the gain of an inverting integrator in which R = 10 k and C = 100 pF?

$$GAIN = -1/RC$$

$$GAIN = -1/((10{,}000 \text{ ohms}) \times (100 \times 10^{-12} \text{ farads}))$$

$$GAIN = -1/0.000001$$

$$GAIN = -1{,}000{,}000$$

At a gain of 1,000,000 we find that with a small error or dc offset in the input signal, the output will be tremendous. For example, suppose we have a 1-volt peak-to-peak sine wave that has a 10-mV dc offset (not very much). This dc offset will be integrated with a gain of 1,000,000 so that 10 mV becomes (10mV) x (1,000,000) = 10,000 volts. Of course, the output of the op-amp is limited to about 10 or 12 volts, so the output will saturate quickly. The normal offset of a 741 will saturate the output of such an integrator so fast you'll think it's shorted! In general, the rule of thumb is to make the time constant of the RC network long (i.e., 5X) relative to the period of the input signal.

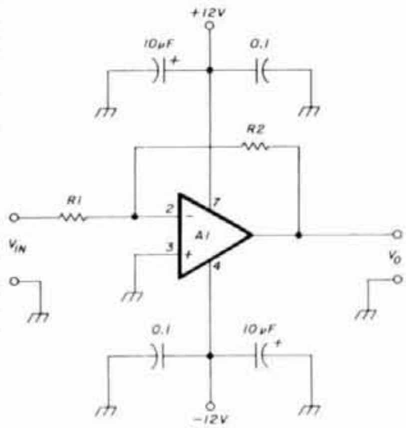

fig. 4. CA-3140 op-amp requires bypass capacitors, as shown.

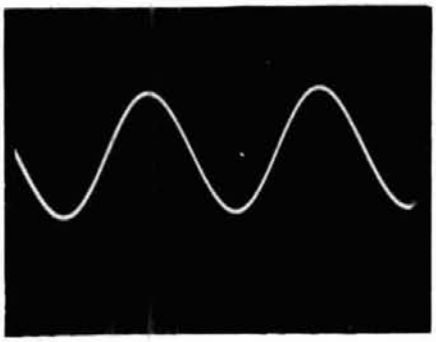

fig. 5. "Cleaned up" waveform from corrected circuit.

Figure 9 shows some common electronic signals at the input and output of an electronic integrator. In each case, the upper trace is the input and the lower trace is the output. For the case of the sine wave shown in **fig. 9**, the output is phase-shifted 90 degrees to become a cosine wave. Thus, the output is in quadrature with respect to the input signal. Although only a few Amateur uses for quadrature signals exist, there are some, so an example is included.

The integrator action on square waves is shown in **fig. 10**. Because the amplitude of a square wave is constant, the integrator output will rise at a constant rate until the square wave drops low again. At that time, the slope of the output waveform changes and starts decreasing. Thus, the integrator makes a triangle waveform out of a square wave. Incidentally, this technique is used in commercial function generators to form triangle waveforms.

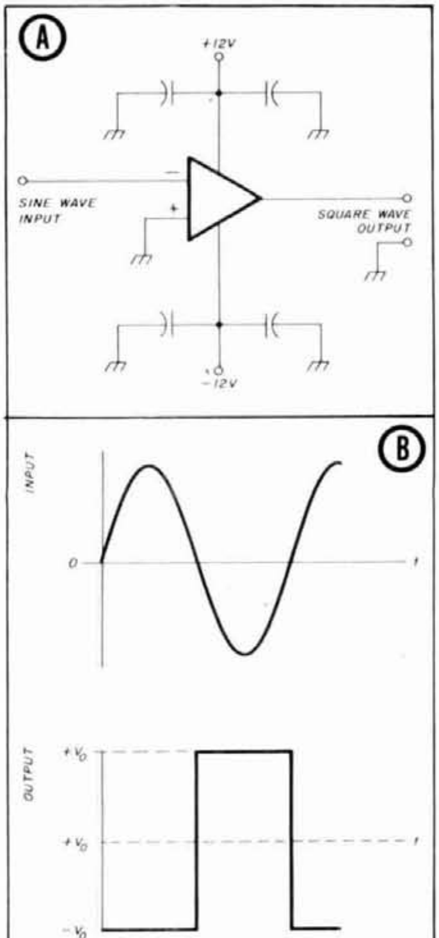

fig. 6. Method of converting sine waves into square waves: (A) circuit, (B) wave forms generated.

next month

In part 2 we'll examine a practical integrator circuit and some practical sawtooth generator circuits.

more on flood damage

After my column on flood damage appeared in *ham radio* (October, 1985, page 95), I used some of the same material, presented differently, in a radio/TV repair trade magazine. One reader, a former Naval officer who had supervised electronics technicians on shipboard, endorsed my advice and added some of his own.

He described an unusual manner of repairing salt water-soaked equipment. A sailor would take the damaged equipment into the shower and slosh it down thoroughly with warm water (distilled or softened water is preferred, though not always available). He'd then take the desalinated equipment to the galley and dry it out in the ovens with low heat and good air circulation.

The retired officer also suggested cleaning equipment covered with oily dirt with a mixture of 8 to 10 ounces of household ammonia, 4 to 6 ounces of a cleaner such as Mr. Clean™ or Lysol,™* 4 to 6 ounces of acetone (the ingredient in some fingernail polish removers), and enough distilled (or softened) water to make one gallon of solution. Dunk the equipment into this mess. (For larger equipment, proportionally larger amounts can be used.) He also recommended using an old Water Pik™ tooth-cleaning device to hose off equipment too large to dunk; the equipment is then dried in an oven set to 140 to 150 degrees F (note: some plastics used in Amateur equipment will melt at temperatures over 130 degrees, so beware) for 4 to 5 hours. All lubricants in switches, potentiometers, and air-variable capacitors must be replaced after this treatment.

The black asphalt-like goop that oozes out of overheated transformers can be easily removed from chassis by using either freeze spray or a blast from a CO_2 fire extinguisher. (Use one that needs refilling; don't waste your fire protection on cleaning jobs.) The brittle, frozen goop can be flaked off using a dental tool or soldering tool.

ham radio

*Mixing ammonia with any cleaning product (such as chlorine bleach) that contains sodium hypochlorite produces chlorine gas. Always check the label of any household cleaner before combining with ammonia, and be sure ventilation is adequate.

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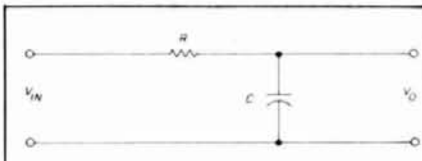

fig. 7. Simplest form of integrator uses two components — a capacitor and a resistor.

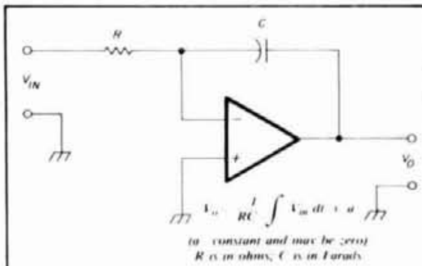

fig. 8. An active integrator uses gain stage plus capacitor and resistor.

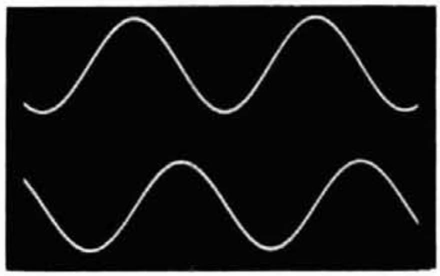

fig. 9. Common input/output signals integrated—sine wave becomes cosine wave (90-degree phase shift).

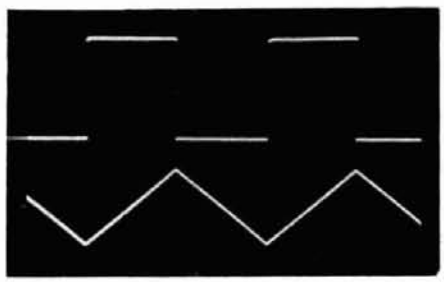

fig. 10. Square waves become triangular waves.

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VHF/UHF WORLD

Joe Reisert W1JR

a high-gain 70-cm Yagi

The Yagi is surely the king of antennas below 450 MHz. There have been tremendous strides in Yagi design in the past decade; they include, but are not limited to, increased gain per unit of boom length, very long boomlength designs (5 to 20 wavelengths), improved side-lobe patterns, wide bandwidth, and improved front-to-back ratios.

Last May's VHF/UHF World summarized many of the facts and fallacies about Yagi design. It also described some of the history associated with Yagi design and presented data on approximate gain and boom correction factors. That column[1] should be reviewed before reading this month's.

That column also mentioned using computers to optimize Yagi designs. Understandably, many Amateurs have neither the specific expertise nor the computer capabilities needed to design their own Yagis. These Amateurs prefer either to purchase commercial antennas or build a tried and proven design. The latter is the subject of this month's column.

metamorphosis of a 70-cm long Yagi

In the mid-1970s I became interested in designing a long Yagi to replace my extended expanded collinear.[2] The NBS 4.2-wavelength Yagi was used on tropo and EME, but more gain per antenna was still desired.[3] Proven designs with high gain were lacking and I didn't have the time to "roll my own" design.

In 1977, Günter Hoch, DL6WU, published an article on long boom Yagis, but I didn't give it much thought at the time.[4] However, in 1981, determined to beat the NBS designs, I decided to see if Hoch's claims were valid. The day before leaving for Sioux Falls, South Dakota, to attend the Central States VHF Conference, I built and partially tested a hurriedly-designed 28-element, 21-foot boom, 432-MHz model.

The reaction of other participants in the antenna measuring contest was as expected: "What's W1JR trying to prove now?" "Will it work?" "What a monster!" But it pinned the test meter in the antenna measuring contest. Tension mounted as this design beat all other entrants by almost 2 dB! The topic of conversation quickly changed from "Will it work?" to "How can I get a copy of the dimensions?"

In this particular design, documented in reference 5, elements were placed through the boom using ohmic contact with NBS boom corrections.[3] The boom was made from a 21-foot length of 3/4-inch square aluminum left over from a previous project. Several Amateurs quickly duplicated the design with great success. Other Amateurs used four of these Yagis successfully on 70-cm EME. Performance seemed to equal that of eight of the then-popular shorter boom-length designs, but with far less feed system loss and complexity.

When DL6WU updated his design,[6] I decided to use the new information to build an improved model, particularly in terms of improving the mechanical design. I wanted insulated through-the-boom elements because they're easier to work with and don't require set screws to get good ohmic contact to the boom.

With the help of the new electrical design information, I built a 21- and a 24-foot boom model using a 1-inch square boom. The boom corrections for insulated through-the-boom mountings had been determined earlier on a similar antenna design. The larger boom was much stronger than the previous design and easier to build because it didn't require all the drilling and tapping.[7]

These new designs had higher gain and an even cleaner pattern than the previous models. Closer observation showed that in addition to slightly higher gain on the 24-foot model (which was as expected), this model also had a better front-to-back ratio. Had the sought-after long Yagi antenna design at last been found?

further development

Just about this time computer-aided Yagi design programs became available.[9] Stan Jaffin, WB3BGU, and Steve Powlishen, K1FO, wasted no time in trying to see if this Yagi had all the gain seen on the antenna ranges. It did, but they noticed that the sidelobes, while as good as other moderate-to-long Yagi designs, weren't as good as required for EME. The antenna also appeared to be tuned higher in frequency than desired. Additional range testing seemed to show that the sidelobes, while not down as far as desired (16 to 18 dB below the main beam), were also not as poor as the antenna program indicated.

Then the MININEC program was obtained and tried by several antenna designers. Voilà! Using this program and modeling with eight segments for each element, the computer generated patterns that were amazingly close to those measured in actual tests.

The pattern of the original 24-foot

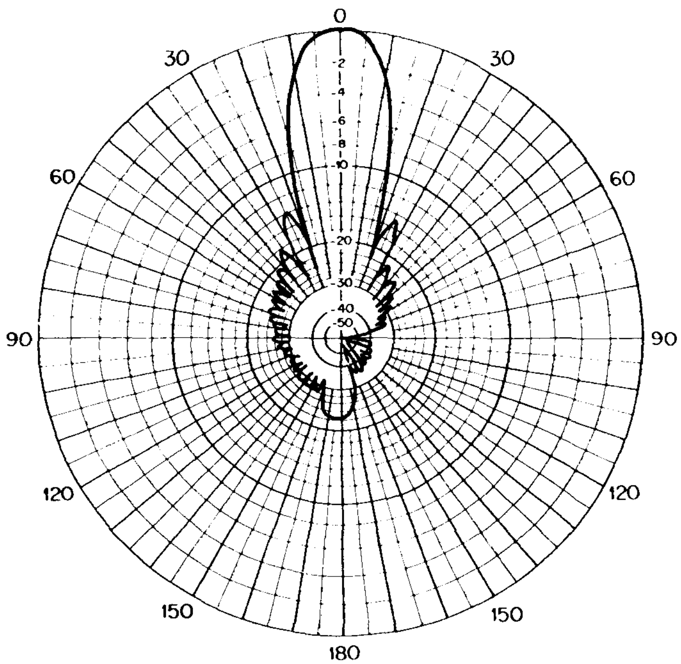

fig. 1. The computed radiation pattern of the original 24-foot boom, 432-MHz Yagi. Note that the E (horizontal) plane is on the right-hand side of the plot and that its first sidelobe is approximately 15 dB below the main beam. The H (vertical) plane is on the left-hand side of the plot and its first sidelobe is approximately 14 dB below the main beam. Gain is approximately 19.15 dBi.

Yagi shown in **fig. 1**, using data from MININEC, seems to very accurately predict the pattern and gain measured on an antenna range. Gain was calculated to be approximately 19.15 dBi with the first sidelobes at 15 and 14 dB in the E and H planes, respectively. Gain on the test range was just above 19 dBi or very close to the predicted value.

Although I still wasn't happy with the pattern, I didn't have a suitable program or computer with which I could try to improve the performance. Because he was designing a new EME array for NC1I,[10] Steve Powlishen, K1FO, was quite interested in the problem. He tried one of his automatic optimization routines on my 31-element design, and after many hours of computer time, found that the first and the last few directors were too short. When these directors were lengthened slightly, the gain increased about 0.25 dB, but the pattern improved considerably with the sidelobes in the E and H plane at approximately 18 and 17 dB, respectively.

Just prior to the 12th annual Eastern VHF/UHF Conference in May 1986, I built the new model. At the antenna measuring party at this conference, the gain was indeed near the predicted value, 19.4 dBi. However, what was even more comforting was that the first sidelobes in the E plane were nearly 18 dB down, right where the computer had predicted they would be. At last, the "almost perfect" long Yagi was working near the theoretically highest possible gain.[1]

I obtained my own version of MININEC and now have it running on a large computer. The plots computed for the optimized 24-foot boom Yagi seem to match the measured pattern closely. Because I can't measure H-plane radiation patterns conveniently, it's quite valuable to have the computer do the pattern work for me. **Figure 2** shows the computer-predicted patterns for the optimized Yagi.

other considerations

Recent tests by many Yagi builders have debunked the theory that long Yagi antenna designs are very critical.[1] In fact, if there is a sufficient number of directors and the original design is duplicated correctly, the opposite may be true. The 1-dB bandwidth may be very large, exceeding 1.5 to 2 percent.

Furthermore, weather conditions such as rain, ice, and snow tend to detune the frequency downwards because the elements become larger in diameter. During extreme icing conditions in past years, I've actually seen the gain of some of the popular Yagi antennas drop almost to zero dB while the antenna actually had more gain off the rear than off the front!

Therefore, it's best to design a Yagi to a slightly higher frequency than the desired operating frequency; 0.7 to 1 percent (3 to 4 MHz at 432 MHz) seems to be a good compromise. Also remember that most Yagi antennas show a gain characteristic similar to that of a lowpass filter. That is, they tend to roll off more slowly in gain as frequency decreases but roll off very rapidly above the design frequency. If the elements are a little shorter than optimum, the gain will be decreased by only a few tenths of a dB at most and the pattern may actually improve at the operating frequency.

high-gain Yagi construction

Figure 3 shows the mechanical details of my latest high-gain 432 MHz Yagi described above. It was originally patterned after the DL6WU model using his recommended element spacings.[6] However, the element lengths shown have been computer-optimized by K1FO. The computer pattern is as shown in **fig. 2.** Four of these Yagis will do very well on EME and eight will be approximately equivalent to 16 of the typical 12- to 15-foot models presently in use.

The boom uses 1-inch square stock with 0.062-inch wall thickness since this is easier to drill and has the equivalent strength of much larger diameter round tubing. Round tubing 1 inch in diameter can be substituted if necessary, but it will be more difficult to drill properly in a home workshop and its

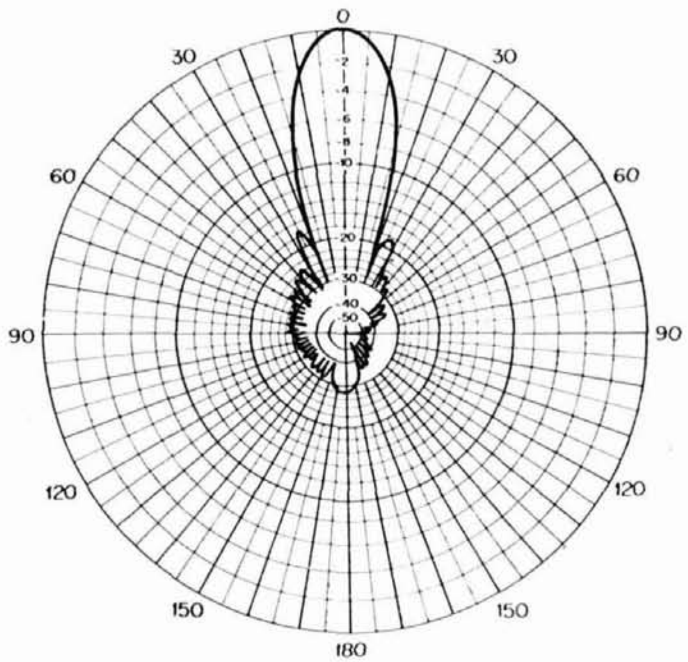

fig. 2. The radiation pattern of the computer-enhanced 24-foot boom, 432-MHz Yagi. Note that the E plane is on the right-hand side of the plot and that its first sidelobe is approximately 18 dB below the main beam. The H plane is on the left-hand side of the plot and its first sidelobe is approximately 17 dB below the main beam. Also note that the magnitude of the sidelobes on both the E and H planes are 3 dB lower than those of the original Yagi shown in *fig. 1.* Gain is slightly higher at approximately 19.4 dBi.

strength will be less than that of a square boom of comparable diameter.

The boom was chosen to be 24 feet long (10.5 wavelengths) because at this length the DL6WU Yagis have good gain and a naturally high front-to-back ratio, as discussed in reference 1. Also, 24 feet is a standard length of square tubing in the United States and Canada. (21 feet, 1 inch is also a standard length in the United States and can be used by joining with an additional 3-foot section if desired.)

The elements are all made from 3/16-inch diameter aluminum rod and are insulated from the boom as discussed earlier. Elements should have about a 0.032-inch bevel (easily accomplished with a file) at the end of the elements instead of a straight cut. Also, all elements should be held in place with "keepers." If the electrical performance is to be retained, it's important to use this mounting method because this design has a built-in boom correction factor unique to this particular model. Some Amateurs have used teflon inserts that don't require the keepers.[11] Although these are satisfactory, they may require a different boom correction factor that I haven't yet determined.

K9KFR and K3IPW* can each supply the proper insulators and galvanized keepers. Galvanized keepers are adequate, but tend to rust out after extended exposure to moisture. Despite the increased cost, I prefer stainless steel keepers for long-term performance. The model 6100-18 retaining ring from Industrial Retaining Ring Company is the type I use, but other suppliers may have suitable equivalents.**

The feed system uses a "T" match because it's well balanced, easy to adjust, and very efficient. A 4:1 balun using semi-rigid 0.141-type coax,[12] patterned after one of my previous

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*Bob Johnson, K9KFR, RR4, Road 600N, Columbia City, Indiana 46725; Tom Rutland, K3IPW, 1703 Warren Street, New Cumberland, Pennsylvania 17070.
**Industrial Retaining Ring Company, 57 Cordier Street, Irvington, New Jersey 07111.

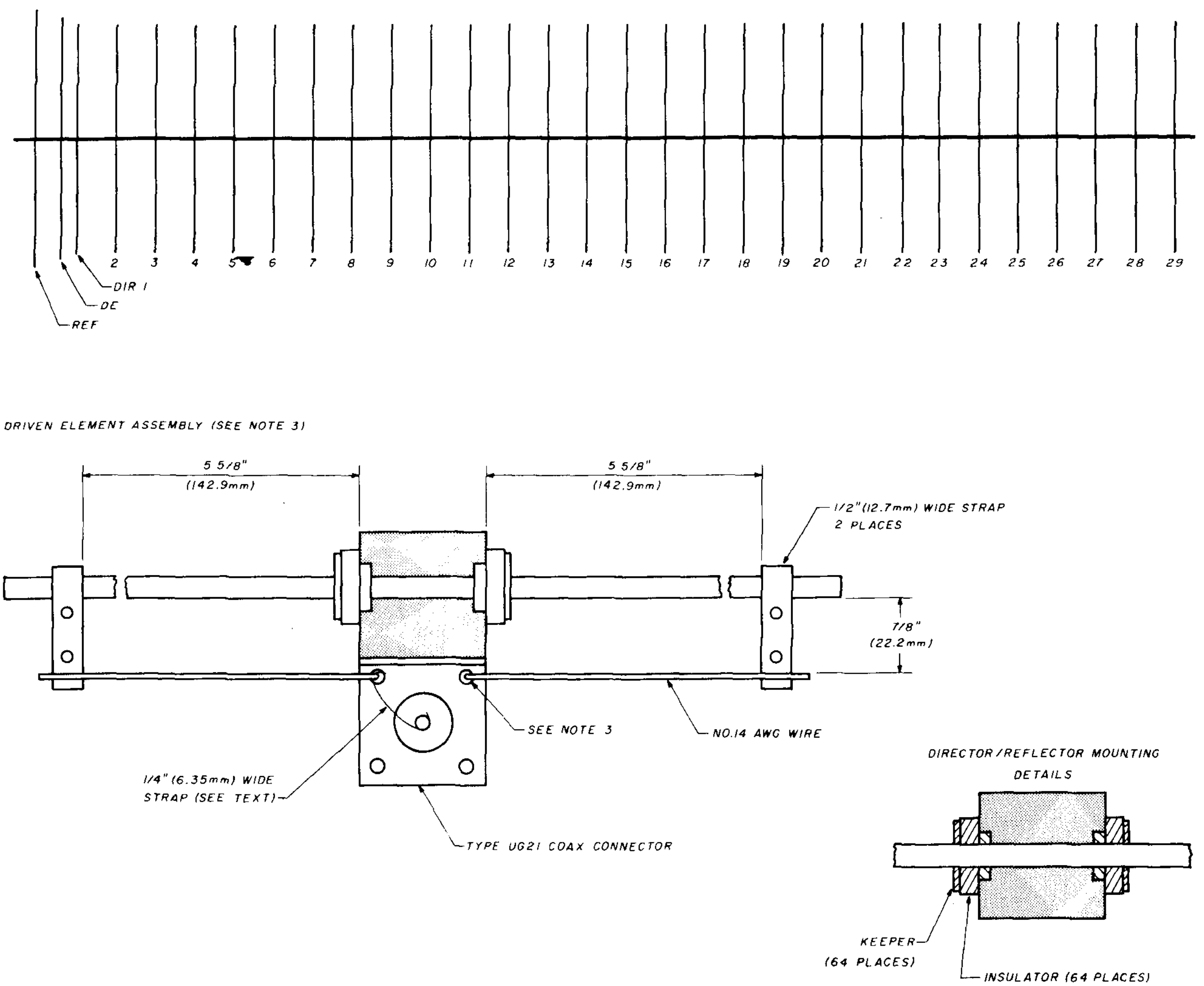

fig. 3. The construction of the high-performance, 31-element, 432-MHz, 24-foot boom long Yagi described in the text and plotted in *fig. 2.* Any deviations from the construction details, dimensions, or the materials specified may decrease performance unless proper compensations are made.

designs, is also used. It's *very* important that a wide (0.25-inch) strap be placed between the center pin on the coax connector and the one side of the balun if the balance of the feed system is to be retained.

All dimensions shown in **fig. 3** *should be copied as closely as possible if performance is to be duplicated. Changing the boom diameter, mounting methods, or element diameter will require the entire design to be modified accordingly and performance can no longer be guaranteed.*

This long Yagi will have about 3 inches of sag if constructed from the materials shown. While lack of boom support will only slightly decrease gain, the mechanical strength will suffer with wind or ice loading. Therefore, I recommend that you support the boom by using either Phyllistran™ or equivalent cable or truss the boom with two pieces of aluminum tubing at least 6 to 8 feet long.

stacking recommendations

This particular design should stack very well. Beamwidth is approximately 20 to 22 degrees in both the E and H planes. The sidelobes are low (17 to 18 dB below the main beam). Therefore the maximum stacking distance (as calculated per reference 13) should be approximately 2.7 wavelengths (74 inches) in the E plane and 2.6 wavelengths (71 inches) in the H plane, but isn't that critical.

For optimum stacking results the phasing lines should be made from low-loss coaxial cable[12], be as short as possible, and be cut in odd multiples of quarter wavelength[14]. Recommended feeding configurations are described in reference 14. The estimated gain of four of these Yagis properly stacked is 24 to 24.5 dBi, or approximately equivalent to a 16-foot diameter parabolic dish.

summary

Long boomlength Yagi antennas are now a reality without compromising gain or sidelobe levels. Although bet-

(part of fig. 3)

Element	Length in inches (Note 1)	Spacing in inches (Notes 1 & 2)
Reflector	13.858	0.000
Driven Element	13.500	5.000
Director 1	12.795	6.913
Director 2	12.362	11.830
Director 3	12.126	17.732
Director 4	12.008	24.617
Director 5	11.890	32.294
Director 6	11.654	40.573
Director 7	11.535	49.234
Director 8	11.496	58.277
Director 9	11.378	67.731
Director 10	11.260	77.567
Director 11	11.221	87.812
Director 12	11.221	98.249
Director 13	11.181	108.877
Director 14	11.102	119.697
Director 15	11.063	130.707
Director 16	11.023	141.718
Director 17	11.023	152.729
Director 18	10.984	163.739
Director 19	10.906	174.750
Director 20	10.748	185.761
Director 21	10.630	196.771
Director 22	10.630	207.782
Director 23	10.630	218.793
Director 24	10.551	229.803
Director 25	10.551	240.814
Director 26	10.551	251.825
Director 27	10.472	262.835
Director 28	10.472	273.846
Director 29	10.472	284.857

Note 1: All lengths are given in inches to 0.001 inch. For best performance, tolerances should be kept to ±0.04 inches maximum, with ±0.02 inches preferred.

Note 2: All spacings are referenced from the reflector to prevent tolerance buildup. It is suggested that you first mark off the reflector position about 1.0 inches from the rear of the boom. Then measure all the spacings from this reference point as shown in the table.

ter designs may be forthcoming, they won't significantly increase the gain or decrease the sidelobe levels of this design *if the boomlength is kept the same.*

Properly designed and constructed Yagi antennas offer very high gain without the windload of a parabolic dish offering comparable gain. In fact, backyard 70-cm EME operation with four of these Yagis is now possible without arousing your neighbor's suspicion!

The antenna described in this month's column is a real performer. Easily duplicated by any interested Amateur, its cost is moderate, especially if local Amateurs join together to buy the materials in quantity. Just think of the satisfaction you'll have in building your own high-gain antenna system!

acknowledgments

This particular Yagi design would not perform as well as it does if it weren't for the help and encouragement of Stan Jaffin, WB3BGU, and Steve Powlishen, K1FO. In particular, I want to thank Steve for optimizing the final design and convincing me that he could in fact predict the performance of a given Yagi design using computer modeling techniques.

'60

new records

At the end of last month's column I alluded to a new 23-cm (1296 MHz) DX record. Since then I have been able to verify that a new record was indeed established on August 13, 1986, when WB6NMT, in San Diego, had a two-way SSB QSO with KH6HME, who was operating from the side of Mauna Loa on the island of Hawaii. This extends the 23-cm DX record worldwide to 2528 miles. Congratulations to Louis and Paul.

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Important VHF/UHF Events:

December 2	*EME perigee*
December 13	*Predicted peak of the Geminids meteor shower, 1250 UTC*
December 21 (± 1 month)	*Winter peak of sporadic E propagation*
December 22	*Predicted peak of the Ursids meteor shower, 0400 UTC*
December 30	*EME perigee*
January 3	*Predicted peak of the Quadrantids meteor shower, 1830 UTC*
January 10/12	*ARRL VHF Sweepstakes Contest*
January 28	*EME perigee*

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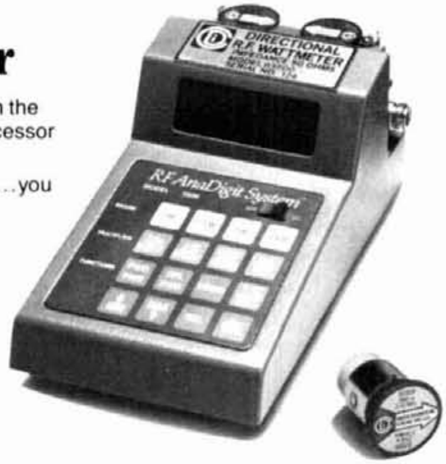

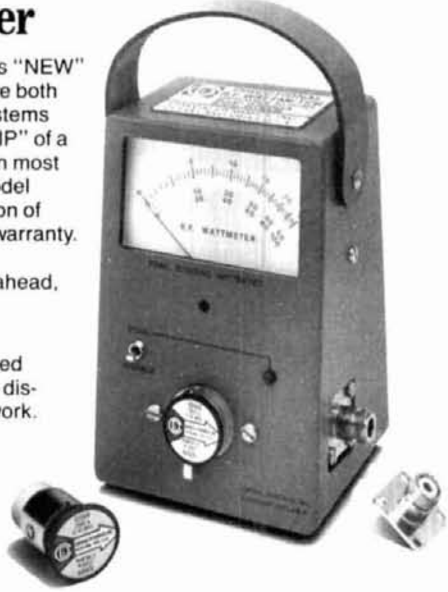

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rewinding transformers with CAD

Let your computer design your next power transformer

Ever have a project that made you feel frustrated, yet pleased? Aggravated, but delighted? Unless you've had plenty of experience, all of these emotions will arise the first time you try to rewind a transformer.

Rewinding a transformer by hand is practical if the transformer's output voltages are below 300 to 400 volts. Winding for voltages below 50 is safe and more suitable than winding for voltages above 500, which creates a series of circumstances not addressed by this article. *High-voltage transformers should be wound only by those with previous experience.*

Although rewinding transformers presents an interesting challenge, books and magazines rarely offer sufficient information on the subject. The computer program included here (**fig. 1**), however, should help.

selecting core material

Before any winding project can begin, core material must be selected. This can be a problem, since new core material is usually not available in quantities of less than 85 pounds.* One pound or less is usually sufficient for most homebrewed transformer projects.

Core material is rated according to type, thickness, tongue width, and the number of flux lines it will support. Soft iron (usually silicon steel) is most commonly used for power transformers because of its lower magnetic retentivity. ("Lower retentivity" means that the material retains very little magnetizing orientation after the magnetizing force — i.e., the primary input power — is removed.)

The number of magnetic flux lines per unit area represents the magnetizing force. Flux ratings are typically given in kilogauss (BM) per square centimeter. (If given in inches, the rating would be in kilolines per square inch.) The flux density of silicon steel typically ranges from 12,000 to 20,000 lines per square centimeter. A flux density rating for a used core from a power transformer could safely be placed at about 15,000 kilogauss for calculations.

Core material should be thin to keep eddy currents to a minimum. Eddy currents are currents induced into the metal core material, causing a residual leakage current to flow in the primary winding. A changing magnetic field around the core material, which is a conductor, will induce a voltage into the core, causing a current to flow if there is a closed circuit path. Making the material thinner and insulating its surface increases the resistance to eddy current flow. The use of E and I cut material takes advantage of the higher resistance path in addition to making it easier to install the laminations into the finished coil. Transformer efficiency is increased by reducing the power lost to eddy-current core heating. Power lost in the core is power drawn from the source but not delivered to the load.

Core material is usually measured along the tongue, or center leg or element of an "E." Tongue widths vary from about 1/8 to 4 inches.

The application and amount of transformer power dictate the core size to use. Data specific to a manufacturer's core material must be obtained from the appropriate data sheet. **Table 1** shows a comparison of typical core data as a function of tongue width. The data listed represents M6 silicon steel lamination 0.014-inch thick in an interleaved square stack. The volt-ampere (VA) rating indicates the amount of power the core can handle in a square stack. (In a square stack, core height is equal to tongue width.) Core area (AC) in the table is the numerical square of the tongue width. The remaining values of core loss (CL), copper regulation (CR), and copper loss (RC) were developed in parallel with the VA and tongue width values to support the computer program calculations.

By **Hugh Wells, W6WTU**, 1411 18th Street, *Manhattan Beach, California 90266*

*Ram Sales, 14823 Aetna, Van Nuys, California 91411, sells 29-M6 silicon steel lamination material in one-pound increments. Tongue widths available: 3/8, 1/2, 5/8, 3/4, 7/8, 1, and 1-3/4 inches. Prices range from $1.50 to $3.60 per pound.

fig. 1. Power transformer design program. (For enlarged copy of program, send SASE to *ham radio*, Greenville, NH 03048.)

```
10 REM POWER TRANSFORMER DESIGN DATA
20 REM DEVELOPED BY HUGH WELLS DEC 1985
30 BM=14.4:REM FLUX DENSITY IN KILOGAUSS
40 REM
50 GOTO 720
60 REM WIRE TABLE
70 IF CM<=8 THEN WS=41:TI=250:SF=0.85:RETURN
80 IF CM<=10 THEN WS=40:TI=239:SF=0.86:RETURN
90 IF CM<=12 THEN WS=39:TI=215:SF=0.86:RETURN
100 IF CM<=16 THEN WS=38:TI=193:SF=0.87:RETURN
110 IF CM<=20 THEN WS=37:TI=170:SF=0.87:RETURN
120 IF CM<=25 THEN WS=36:TI=155:SF=0.87:RETURN
130 IF CM<=31 THEN WS=35:TI=140:SF=0.88:RETURN
140 IF CM<=40 THEN WS=34:TI=124:SF=0.88:RETURN
150 IF CM<=50 THEN WS=33:TI=110:SF=0.88:RETURN
160 IF CM<=64 THEN WS=32:TI=98:SF=0.88:RETURN
170 IF CM<=80 THEN WS=31:TI=88:SF=0.88:RETURN
180 IF CM<=100 THEN WS=30:TI=80:SF=0.89:RETURN
190 IF CM<=128 THEN WS=29:TI=71:SF=0.89:RETURN
200 IF CM<=160 THEN WS=28:TI=64:SF=0.89:RETURN
210 IF CM<=202 THEN WS=27:TI=57:SF=0.89:RETURN
220 IF CM<=253 THEN WS=26:TI=52:SF=0.89:RETURN
230 IF CM<=320 THEN WS=25:TI=47:SF=0.9:RETURN
240 IF CM<=404 THEN WS=24:TI=42:SF=0.9:RETURN
250 IF CM<=511 THEN WS=23:TI=37:SF=0.9:RETURN
260 IF CM<=640 THEN WS=22:TI=33:SF=0.9:RETURN
270 IF CM<=812 THEN WS=21:TI=30:SF=0.9:RETURN
280 IF CM<=1020 THEN WS=20:TI=2[illegible]:SF=0.9:RETURN
290 IF CM<=1290 THEN WS=19:TI=23:SF=0.9:RETURN
300 IF CM<=1620 THEN WS=18:TI=21:SF=0.9:RETURN
310 IF CM<=2050 THEN WS=17:TI=19:SF=0.9:RETURN
320 IF CM<=2580 THEN WS=16:TI=17:SF=0.9:RETURN
330 IF CM<=3260 THEN WS=15:TI=15:SF=0.9:RETURN
340 IF CM<=4110 THEN WS=14:TI=13:SF=0.9:RETURN
350 IF CM<=5178 THEN WS=13:TI=12:SF=0.9:RETURN
360 IF CM<=6530 THEN WS=12:TI=10:SF=0.9:RETURN
370 IF CM<=8234 THEN WS=11:TI=9:SF=0.9:RETURN
380 IF CM<=10380 THEN WS=10:TI=8:SF=0.9:RETURN
390 IF CM<=13100 THEN WS=9:TI=7:SF=0.9:RETURN
400 IF CM>13100 THEN WS=0:RETURN
410 REM CORE RATINGS
420 IF A<=0.02 THEN AC=0.016:VA=0.02:AW=0.03:CL=0.01:CR=98:RC=220:RETURN
430 IF A<=0.04 THEN AC=0.035:VA=0.08:AW=0.05:CL=0.02:CR=97:RC=129:RETURN
440 IF A<=0.07 THEN AC=0.063:VA=0.2:AW=0.12:CL=0.05:CR=96:RC=60:RETURN
450 IF A<=0.15 THEN AC=0.141:VA=0.9:AW=0.17:CL=0.2:CR=95:RC=50:RETURN
460 IF A<=0.27 THEN AC=0.25:VA=3:AW=0.19:CL=0.3:CR=75:RC=44:RETURN
470 IF A<=0.33 THEN AC=0.32:VA=4.5:AW=0.24:CL=0.4:CR=62:RC=39:RETURN
480 IF A<=0.4 THEN AC=0.39:VA=7:AW=0.29:CL=0.6:CR=52:RC=35:RETURN
490 IF A<=0.5 THEN AC=0.47:VA=10:AW=0.35:CL=0.8:CR=44:RC=32:RETURN
500 IF A<=0.6 THEN AC=0.56:VA=14:AW=0.42:CL=1:CR=30:RC=26:RETURN
510 IF A<=0.8 THEN AC=0.77:VA=25:AW=0.57:CL=1.6:CR=20:RC=22:RETURN
520 IF A<=1.1 THEN AC=1:VA=40:AW=0.75:CL=2.3:CR=15:RC=19.8:RETURN
530 IF A<=1.3 THEN AC=1.27:VA=60:AW=0.95:CL=3.4:CR=11.5:RC=15.7:RETURN
540 IF A<=1.6 THEN AC=1.56:VA=100:AW=1.17:CL=4.7:CR=10:RC=14.2:RETURN
550 IF A<=2 THEN AC=1.89:VA=150:AW=1.42:CL=6.8:CR=6.5:RC=11:RETURN
560 IF A<=2.3 THEN AC=2.25:VA=200:AW=1.69:CL=8.1:CR=6:RC=10:RETURN
570 IF A<=3.1 THEN AC=3.06:VA=350:AW=2.3:CL=15.9:CR=5:RC=9.5:RETURN
580 IF A<=4.6 THEN AC=4.5:VA=700:AW=3.87:CL=23.1:CR=3.5:RC=6.4:RETURN
590 IF A<=5.1 THEN AC=5.06:VA=1000:AW=4.4:CL=27.6:CR=3:RC=5.7:RETURN
600 IF A<=6.3 THEN AC=6.25:VA=1500:AW=4.69:CL=37.2:CR=2.6:RC=5.1:RETURN
610 IF A>7 THEN PRINT "CORE IS TOO LARGE FOR THIS PROGRAM":END
620 REM CALCULATE WINDOW/LAYER DATA
630 HA=SQR(AW/3.5):REM CALC WINDOW HEIGHT
640 WB=3.5*HA:REM CALC WINDOW WIDTH
650 HA=INT(HA*1000+0.5)/1000
660 WB=INT(WB*1000+0.5)/1000
670 TL=WB*TI*SF:REM CALC # TURNS PER LAYER
680 TL=INT(TL-0.5)
690 LA=NN/TL:REM CALC # LAYERS
700 LA=INT(LA*10)/10
710 RETURN
720 PRINT CHR$(125):REM CLEAR SCREEN/HOME
730 PRINT :PRINT :PRINT "    POWER TRANSFORMER DESIGN DATA"
740 PRINT :PRINT "ENTER THE VALUES AS REQUESTED---"
750 PRINT :PRINT "CORE TONGUE DIMENSIONS IN INCHES ---"
760 PRINT "   TONGUE WIDTH ";:INPUT W
770 PRINT "            HEIGHT ";:INPUT H
780 PRINT :PRINT "ENTER PRIMARY VOLTAGE ";:INPUT EP
790 PRINT :PRINT "ASSUMING A SINGLE SECONDARY WINDING,"
800 PRINT "ENTER THE DESIRED OUTPUT VOLTAGE";:INPUT ES
805 IF ES>300 THEN PRINT :PRINT "CAUTION: HIGH VOLTAGE IS DANGEROUS":PRINT
"FOR HOME TRANSFORMER WINDING."
810 PRINT :PRINT "ENTER SERVICE RATING # --"
820 PRINT "  1 - INTERMITTANT DUTY (75C RISE)."
830 PRINT "  2 - COMMERCIAL DUTY (50C RISE)."
840 PRINT "  3 - MILITARY DUTY (25C RISE)."
850 PRINT :PRINT "ENTER # ";:INPUT SE
860 IF SE=1 THEN PR=300
870 IF SE=2 THEN PR=500
880 IF SE=3 THEN PR=1000
890 IF SE<1 OR SE>3 THEN 810
900 A=H*W:GOSUB 410
910 REM PERFORM CALCULATIONS
920 NP=(3.49*1000*EP)/(60*AC*0.9*BM):REM CALC PRIMARY TURNS
930 LB=VA/30:LB=INT(LB*100)/100:REM CALCULATES APPROX CORE WEIGHT
940 CP=(4*RC*(NPÅ2)*(IPÅ2)):REM CALCULATES COPPER LOSS
950 EF=(VA*100)/(VA+CL+CP):EF=INT(EF*100)/100:REM CALC EFFICIENCY
960 IP=(VA)/((EF/100)*EP):REM CAL PRIMARY CURRENT
970 CM=PR*IP:GOSUB 60:REM CAL WIRE SIZE
980 NS=NP*(ES/EP)*((CR/100)+1):REM CAL SEC TURNS
990 NP=INT(NP*10)/10:NS=INT(NS*10)/10
1000 IP=INT(IP*1000)/1000
1010 TV=NP/EP:TV=INT(TV*10)/10:REM CAL TURNS PER VOLT
1020 IS=VA/ES:IS=INT(IS*1000)/1000:REM CAL SEC CURRENT
1030 NN=NP
1040 GOSUB 620
1050 PRINT CHR$(125):REM CLEAR SCREEN/HOME
1060 PRINT :PRINT "POWER TRANSFORMER DESIGN DATA"
1070 PRINT :PRINT "RATING IS ";
1080 IF SE=1 THEN PRINT "INTERMITTANT DUTY (75C RISE)"
1090 IF SE=2 THEN PRINT "COMMERCIAL DUTY (50C RISE)"
1100 IF SE=3 THEN PRINT "MILITARY DUTY (25C RISE)"
1110 PRINT :PRINT "PRIMARY VOLTAGE = ";EP;" VOLTS."
1120 PRINT "PRIMARY CURRENT = ";IP;" AMPS."
1130 PRINT "# PRIMARY TURNS = ";NP
1140 PRINT "PRI TURNS PER VOLT= ";TV;" : 1"
1150 PRINT "PRIMARY WIRE SIZE = #";WS
1160 PRINT LA;" LAYERS OF ";TL;" TURNS/LAYER."
1170 PRINT :PH=LA/TI:REM CALCULATES HEIGHT OF PRIMARY
1180 PRINT "SECONDARY VOLTAGE = ";ES;" VOLTS."
1190 PRINT "MAX SEC CURRENT = ";IS;" AMPS."
1200 PRINT "# SECONDARY TURNS = ";NS
1210 NN=NS
1220 CM=PR*(VA/ES):REM CALC SECONDARY WIRE SIZE
1230 GOSUB 60:REM CALC SECONDARY WIRE SIZE
1240 GOSUB 620:REM CALCULATE TURNS/LAYER
1250 PRINT "SECONDARY WIRE SIZE = #";WS
1260 PRINT LA;" LAYERS OF ";TL;" TURNS/LAYER."
1270 SH=LA/TI:REM CALCULATES HEIGHT OF SECONDARY
1280 TH=PH+SH:REM CALCULATES TOTAL HEIGHT OF WINDING
1290 IF TH>=(HA*0.8) THEN PRINT :PRINT "WARNING: WINDOW HEIGHT EXCEEDED--"
1300 REM TH=TOTAL HEIGHT - 20% OF SPACE ALLOWED FOR INSULATION
1310 PRINT :PRINT "ENTER 1 TO CONTINUE RATINGS";:INPUT Z
1320 PRINT CHR$(125):REM CLEAR SCREEN/HOME
1330 PRINT :PRINT "GENERAL TRANSFORMER RATINGS"
1340 PRINT :PRINT "APPROX POWER RATING = ";VA;" VA."
1350 PRINT "EFFICIENCY       = ";EF;"%"
1360 PRINT "COPPER REGULATION = ";CR;"%"
1370 PRINT "APPROX CORE LOSS = ";CL;" WATTS."
1380 PRINT "APPROX CORE WEIGHT = ";LB;" LBS."
1390 PRINT "ASSUMED FLUX DENSITY= ";BM;" KILOGAUSS"
1400 PRINT "SOURCE FREQUENCY = 60 HERTZ."
1410 PRINT "ASSUMED CORE WINDOW RATIO = 3.5:1"
1420 PRINT "WINDOW AREA = ";AW;" SQ INCHES."
1430 PRINT "WINDOW WIDTH = ";WB;" INCHES."
1440 PRINT "WINDOW HEIGHT = ";HA;" INCHES."
1450 PRINT :PRINT "DO ANOTHER? 1=Y 2=N ";:INPUT Z
1460 IF Z<>2 THEN RUN
1470 END
```

The window area (i.e., space allowed for the coil) of a core, another important measurement, usually follows the tongue width in size. Although window width and height may vary from one manufacturer to another, window area appears to remain fairly uniform for a given core size.

The program assumes the typical width-to-height ratio of 3.5:1. For instance, if the winding width is 0.875 inch and the window area is 0.219 square inches, the window height will be 0.25 inch. The number of turns-per-layer and the number of layers is determined from the window width and area. For example, the number of turns-per-layer is found by multiplying window width by the number of turns-per-inch and by the winding space factor. Then the number of layers is found by dividing the total number of turns-per-winding by the number of turns-per-layer. Ultimately, the number of turns of wire that can be wound onto the core will be determined by wasted space, wire bulging, and insulation thickness. This may sound like a lot, but one must keep in mind that only so much window area is available to accommodate the wire.

salvaging a used core

Though it's possible to start from scratch and build your own transformer, it's more fun to tear down an old transformer and rewind the old core. Recovering an old core, however, can be tricky. Perhaps the slowest, most time-consuming chore is cleaning out the old potting compound. Most transformers have been vacuum-impregnated with material that affords protection from moisture and keeps laminations from "singing" by gluing them together. If it's one of the tougher materials such as Hysol or one of the new urethanes, it's not easily removed by anything short of a jackhammer. Such transformers are best set aside — perhaps for use as door stops.

Transformers potted in wax are the easiest to salvage. Wax and some varnishes can be removed by soaking the transformer in paint or varnish remover, and/or a suitable solvent. It's necessary to soften the potting compound sufficiently to allow the laminations to be removed; vacuum impregnation is very efficient and lengthy soaking may be required before the laminations will be ready to slide apart, even with the ad-

Table 1. Core table for silicon steel.

Tongue Width (Inches)	Sq stack Core area (AC)	Volt-ampere Rating (VA)	Sq inch Window area (AW)	Core Loss (CL)	Copper Regulation (CR)	Copper Loss Factor (RC)
0.126	0.016	0.02	0.03	0.01	98	220
0.187	0.035	0.08	0.05	0.02	97	129
0.25	0.063	0.2	0.12	0.05	96	60
0.375	0.141	0.9	0.17	0.2	95	50
0.5	0.25	3.0	0.19	0.3	75	44
0.566	0.32	4.5	0.24	0.4	62	39
0.625	0.39	7.0	0.29	0.6	52	35
0.686	0.47	10.0	0.35	0.8	44	32
0.75	0.56	14.0	0.42	1.0	30	26
0.875	0.77	25.0	0.57	1.6	20	22
1.0	1.0	40.0	0.75	2.3	15	19.8
1.125	1.27	60.0	0.95	3.4	11.5	15.7
1.25	1.56	100.0	1.17	4.7	10	14.2
1.375	1.89	150.0	1.42	6.8	6.5	11
1.5	2.25	200.0	1.69	8.1	6.0	10
1.75	3.06	350.0	2.3	15.9	5.0	9.5
2.125	4.5	700.0	3.87	23.1	3.5	6.4
2.25	5.06	1000.0	4.4	27.6	3.0	5.7
2.5	6.25	1500.0	4.69	37.2	2.6	5.1

ded encouragement of a hammer. Work outdoors — and have patience. It takes time and plenty of elbow grease to remove the debris.

If none of the windings are to be retained, you can partially remove some of the wire by cutting through the coil with a hacksaw before soaking. If you do this, be sure to protect the core from mechanical damage. Be careful, too, with the paper tube or winding bobbin; it will be used again in rewinding the core.

When salvaging the core, it's usually best to remove all of the wire. However, there are circumstances in which you might want to retain one or more of the windings. In these cases, the salvage operation is more difficult because the transformer can't be soaked in paint remover or solvent. If some of the windings are to be saved, the tedious chore of removing the laminations without damaging the wire becomes necessary.

In this procedure, a wood splinter is usually driven between the paper core form and the core to prevent coil vibration. Remove the splinter to free up space to work in, then separate and remove the outer laminations from the others with a thin knife to provide additional room. If the outer laminations are damaged during removal, correct or remove small dents in the metal by tapping lightly with a hammer against a flat surface. (Because silicon steel is almost as soft as most modern automobile fenders, it's sometimes referred to as "fender iron," and the process affectionately titled "body and fender work.") The loss of one or two laminations won't affect the operation of the rewound transformer significantly; any significant loss, however, will reduce the power rating (VA) of the core. You can compensate for this by determining the remaining stack height for entry into the computer's calculation.

The wire sizes used on the old transformer provide an important clue as to the amount of power the original transformer was able to deliver. The power can be estimated by multiplying the secondary winding current by the winding's voltage. For transformers with multiple secondary windings, add up the individual winding power to get the total transformer power. To determine the nominal current value a wire can handle, assume 500 CM per ampere. For example, a No. 23 wire will handle 1 ampere of current. Wire has a resistance value which contributes to heat loss as current flows through it. For a given current value, a larger wire size would dissipate less heat because of its lower resistance.

wire sizes

Table 2 provides comparative data for various wire sizes. Of concern is the amount of current a particular wire will carry and how much space is required when the wire is used for windings on a transformer. Heat rise is affected by wire size and is controlled by the circular mil area (CM) of the wire. For example, a wire of 1000 CM carrying 1 ampere of current will run cool with about a 25-degree C temperature rise

Table 2. Wire table.

Circular mil area (CM)	Wire size (WS)	Turns/inch (TI)	Space factor (SF)
8	41	250	0.85
10	40	239	0.86
12	39	215	0.86
16	38	193	0.87
20	37	170	0.87
25	36	155	0.87
31	35	140	0.88
40	34	124	0.88
50	33	110	0.88
64	32	98	0.88
80	31	88	0.88
100	30	80	0.89
128	29	71	0.89
160	28	64	0.89
202	27	57	0.89
253	26	52	0.89
320	25	47	0.90
404	24	42	0.90
511	23	37	0.90
640	22	33	0.90
812	21	30	0.90
1020	20	26	0.90
1290	19	23	0.90
1620	18	21	0.90
2050	17	19	0.90
2580	16	17	0.90
3260	15	15	0.90
4110	14	13	0.90
5178	13	12	0.90
6530	12	10	0.90
8234	11	9	0.90
10380	10	8	0.90
13100	9	7	0.90

above ambient. At 1 ampere, 500 CM will run warmer with a 50-degree C rise, and 300 CM will run hot at a 75-degree C rise. Enamel insulation (purple to black color) on copper wire must be operated below 50 degrees C rise to keep the insulation from disintegrating. Formvar (orange color) and the newer high-temperature insulation materials are capable of handling the higher temperature rises without failure.

The number of turns-per-inch (TI) and space factor (SF) are provided in **table 2**. The TI number is based upon the diameter of double-coated formvar insulation. Wire coated with enamel will also be of about the same diameter. The SF is a judgment of wasted space at the end of each layer and is dependent upon winding uniformity. Working together, TI and SF values improve the chances of predicting whether or not all of the desired number of turns of the selected wire will fit into the core window. It's better to know the fit up front than after the core has been wound.

core stacking

There are two ways of stacking *E* and *I* material to make up a transformer core. The first way is an interleaved stack, which means that *E* laminations are alternated in direction as they're stacked to create a double closed loop (i.e., with no air gap at the core ends). Individual *I* laminations are pressed into the gaps between the *E's* to fill in the core. The second way is called a butt stack where all of the *E's* are stacked in parallel to maintain the *E* shape. The ends of the *E's* are butted up against a stack of *I* laminations equally as high to form a nearly closed core.

Each stacking method is best suited for a particular application. An interleaved stack is most suitable when the transformer windings support only alternating current power. With only alternating current power applied, a transformer's efficiency is improved with a closed core which keeps the flux lines contained within the core. However, the tendency for core saturation increases with the closed core, particularly with the addition of direct current in one of the windings. When used with a rectifier, the non-uniform waveform of the pulsating dc produced will affect the transformer's performance, but the effect is usually ignored.

If it's necessary to have direct current flowing in one of the windings, a butt stack is preferred over an interleaved stack. Direct currents cause a biasing of the magnetic flux in the core, and if too high, the core could saturate. That means the number of flux lines has been raised to the maximum density the core can handle. (A simple analogy: it's like trying to put more people on a bus than the bus can hold. After the bus is filled, adding another person to the bus causes someone to be squeezed out elsewhere. The bus is "saturated.") When saturated, the core will fail to respond to the AC changes applied to the primary winding. Therefore, the advantage of the butt stack is that a small air gap can be created between the ends of the *E* and *I* stacks to provide a flux leakage path. Flux leakage reduces the tendency for core saturation by allowing some of the flux lines to escape. A thin piece of paper or tape can be used to establish and hold a desired gap dimension.

winding a core

Winding wire onto a core may be accomplished by either hand or machine. Most home experimenters use the hand-winding technique. Whether hand- or machine-wound, the wire insulation must be treated with care to prevent damage; scratches in the insulation can cause the turns of wire to short. Because of potential insulation damage, wire salvaged from used transformers is seldom used for new transformers.

When starting a winding operation, wind the wire on a bobbin or paper tube. The bobbin or paper tube serves as a smooth winding surface for the wire and provides insulation from the core. The form also provides support for the coil before the core laminations

MIRAGE/KLM

SPECIFICATIONS

Electrical

- Band Width .... 1260–1300 MHz
- Gain 18.2
- VSWR .... Better than 1.5 to 1
- Feed Imp...................... 50 Ohms
- Balun .... 4:1 Rigid Coax

Mechanical

- Beam Length .... 12′ 4″
- Element Length .... 4.5″
- Mast........................... 2″ O.D.
- Windload .... 1 sq. ft.

Mirage Communications Equipment, Inc.
P.O. Box 1000
Morgan Hill, CA 95037
(408) 779-7363

✓ 157

```
POWER TRANSFORMER DESIGN DATA

ENTER THE VALUES AS REQUESTED---

CORE TONGUE DIMENSIONS IN INCHES ---
   TONGUE WIDTH
         0.875
          HEIGHT
         0.875

ENTER PRIMARY VOLTAGE
                   120

ASSUMING A SINGLE SECONDARY WINDING,
ENTER THE DESIRED OUTPUT VOLTAGE
                              12
ENTER SERVICE RATING # --
  1 - INTERMITTANT DUTY (75C RISE).
  2 - COMMERCIAL DUTY (50C RISE).
  3 - MILITARY DUTY (25C RISE).

ENTER #
      2

POWER TRANSFORMER DESIGN DATA

RATING IS
COMMERCIAL DUTY (50C RISE)

PRIMARY VOLTAGE = 120 VOLTS.
PRIMARY CURRENT = 0.221 AMPS.
# PRIMARY TURNS = 699.4
PRI TURNS PER VOLT= 5.8 : 1
PRIMARY WIRE SIZE = #29
7.9 LAYERS OF 88 TURNS/LAYER.

SECONDARY VOLTAGE = 12 VOLTS.
MAX SEC CURRENT = 2.083 AMPS.
# SECONDARY TURNS = 83.9
SECONDARY WIRE SIZE = #19
2.9 LAYERS OF 28 TURNS/LAYER.

ENTER 1 TO CONTINUE RATINGS

GENERAL TRANSFORMER RATINGS

APPROX POWER RATING = 25 VA.
EFFICIENCY      = 93.98%
COPPER REGULATION = 20%
APPROX CORE LOSS = 1.6 WATTS.
APPROX CORE WEIGHT = 0.83 LBS.
ASSUMED FLUX DENSITY= 14.4 KILOGAUSS
SOURCE FREQUENCY = 60 HERTZ.
ASSUMED CORE WINDOW RATIO = 3.5:1
WINDOW AREA = 0.57 SQ INCHES.
WINDOW WIDTH = 1.412 INCHES.
WINDOW HEIGHT = 0.404 INCHES.

DO ANOTHER? 1=Y 2=N
```

fig. 3. Sample screen printout of design.

sulation cracking could occur, exposing the copper and increasing the possibility of shorts.

The coil is finished off with a layer of paper or tape to provide a protective cover for the wire. Then the laminations are stacked, using either the interleaved or butt stack method. When using the interleaved method, alternate the direction of the *E's* as they're inserted into the tube or bobbin, then slip the *I's* into the open slots. If using the butt stack, slide all of the *E's* into the form from one side. Stack the *I* laminations to an equal height of the *E's* and hold the *I's* together either with a small amount of wax or varnish. A narrow strip of masking tape may be wrapped around the *I* stack. The tape must be positioned so that it won't interfere with ends of the *E* stack. Tape may be wrapped around the cores edge (not over the coil) to hold the assembly together. Apply power and check out the completed transformer. Unloaded, the output voltage will be slightly higher than the calculated value. It will, however, decrease under load.

the program

The program (**fig. 1**) will calculate the number of turns and wire size for a given core. Both are based upon the maximum power the core can handle (assuming a 90-percent power factor). To keep the winding project simple but usable, and within the grasp of a novice winder, the program was written to accommodate a single secondary winding. For multiple windings, the program is used to find the amount of power (VA) available that must be distributed among all windings. Likewise, the wire size must decrease so that the copper mass will fit within the available core window area.

Formulas used in the program are based on a floating point decimal. Some program adjustment may be required for machines operating with INTEGER BASIC.

The program was written in straightforward BASIC so that it would be transportable to the greatest number of BASIC dialects. All program variables (in **fig. 2**) have been listed to provide a troubleshooting aid in case of a syntax error. Variables have been limited to two characters to maintain program simplicity and to accommodate machines limited to two alpha variables. Should that still be a problem, the second character of each variable may be changed to a number. An abundance of REM statements have been used to aid in following each program step.

Program flow is organized with the GOSUB tables at the beginning of the program. In BASIC, the computer always starts at the top of the program (lowest line number) and searches down for a particular GOSUB line. Execution time is reduced when the GOSUB line is found at the beginning of the search. Upon completion of the GOSUB operation, a stack pointer returns the program to the line number following the GOSUB instruction without having to search further. A sample run is shown in **fig. 3**.

Whether you're an educator or an experimenter, this computer program should become a valuable tool. It will provide comparative winding data for various core sizes and winding voltages. Give it a try!

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ham radio

are inserted. Machine-winding on a plastic bobbin, rather than a paper tube, can allow up to a 30-percent increase in the amount of copper that can fit on the core. Hand-winding onto a bobbin is also desirable. However, in the absence of a bobbin, one must use a paper tube. Tubes made commercially are constructed of pressed paper and impregnated with wax or varnish. The coil form (tube or bobbin) may be reused if salvaged along with the core, but burrs and sharp points should be removed from the form with a smooth file or sharp knife to prevent wire from snagging during the winding operation.

If you didn't salvage the paper tube, you can make one from shoe box cardboard. Tubes for small transformers can be made from a manila folder or post card stock. To shape the tube, it's first necessary to stack the core to form an *E* to the desired height, which is usually square (i.e., height is equal to tongue width). Masking tape wrapped around the outer legs will hold the laminations in place while the tube is being formed. Cut a piece of the cardboard long enough to make one turn around the center leg and as wide as the tongue is long. Care must be taken to prevent creases in the cardboard except at the corners of the core. Creases tend to decrease the strength of the tube, causing it to collapse during the wire winding operation. The seam in the tube may be at one of the corners. Knead the cardboard against the iron core to remove any tendency to bulge; you can use the round shaft of a screwdriver as a kneading tool. After the tube is formed and trimmed to fit tightly around the core leg, lay a single strip of masking tape along the seam to cover the gap. With the tube still on the core, wrap one turn of tape around each end of the tube to increase the end strength slightly and to keep the gap closed. Remove the tube from the core and mark the tube sides that were against the flat sides of the lamination. Because the core stack is not perfectly square, marking of the tube is necessary for core re-stacking orientation. After forming, the tube may be soaked with varnish to improve its mechanical stability and moisture resistance.

During winding, it will be necessary to start and stop wire winding on the flat sides of the lamination. It's usually desirable to place the primary winding (the winding with the smallest wire size) next to the core. Because of the shorter distance around the core, less wire is used. Less wire means lower resistance, lower copper loss, and better regulation. Starting and ending coil ends should be on the same side of the core for convenience. Place the wire near one end of the tube with the wire end extending outward about 6 inches. Use a small tab of masking tape like a flag to hold the starting end in place as close to the tube edge as possible. Wind the wire onto the tube one turn at a time over the flag, positioning the wire tightly against

A	*Core selector*
AC	*Core cross sectional area*
AW	*Window area*
BM	*Flux density*
CL	*Core loss*
CM	*Circular mil area of wire*
CP	*Copper loss*
CR	*Copper regulation*
EF	*Transformer efficiency*
EP	*Primary voltage*
ES	*Secondary voltage*
H	*Stack height*
HA	*Window height*
IP	*Primary current*
IS	*Secondary current*
LA	*Layers of wire*
LB	*Core weight*
NN	*Temporary variable*
NP	*Number of primary turns*
NS	*Number of secondary turns*
PH	*Height of primary winding*
PR	*Temperature rise rating*
RC	*Equiv. series resistance of copper around core*
SE	*Temperature rise selector*
SF	*Layer space factor*
SH	*Height of secondary winding*
TH	*Total winding height*
TI	*Number of turns per inch of wire*
TL	*Number of turns per layer*
TV	*Turns per volt-primary winding*
VA	*Volt-amp rating*
W	*Tongue width (inches)*
WB	*Window width*
WS	*Wire size*
Z	*Temporary variable*

fig. 2. List of program variables.

the adjacent turns of wire. To avoid wasting space, be careful not to overlap one wire over another.

One of the biggest problems with hand-winding is holding the first and last turn of each layer in place on a paper tube; the end turns tend to fall off because of weak end support. A dab of glue from a glue stick, or of paraffin or rubber cement, on the end two or three turns will help hold them in place.

Each successive layer of wire will tend to fall between the wires of the layer below unless a paper separator between windings is used as a winding surface. Even though it has a slick surface, a strip of wax paper usually works well as a separator. It can be wrapped over the winding layer and tacked in place with a hot soldering iron. Heat from the soldering iron will melt the wax, sticking the paper ends together. The next layer of wire over the separator will hold it permanently in place. Each layer wound onto a paper tube will be progressively shorter (i.e., have fewer turns) than the layer below it, causing the coil to be tapered like the base of a pyramid. Using a bobbin solves the tapering problem.

Keep the wire tight during winding to reduce wasted space and wire bulging. As each turn of wire is added, it's pressed against the form to remove the bulge. In addition, the wire mustn't be stretched because in-

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440	$730	$980

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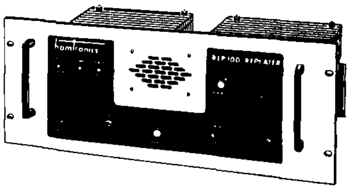

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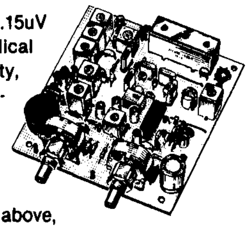
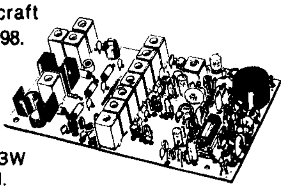


- **R144/R220 FM RCVRS** for 2M or 220 MHz. 0.15uV sens.;8 pole xtal filter & ceramic filter in i-f, helical resonator front end for exceptional selectivity, >100dB at ± 12kHz, best available today. Flutter-proof squelch. AFC tracks drifting xmtrs. Xtal oven avail. Kit only $138.
- **R451 FM RCVR** Same but for uhf. Tuned line front end, 0.3 uV sens. Kit only $138.
- **R76 FM RCVR** for 10M, 6M, 2M, or 220. As above, but w/o AFC or hel. res. Kits only $118. Also avail w/4 pole filter, only $98/kit.
- **R110 VHF AM RECEIVER** kit for VHF aircraft or ham bands or Space Shuttle. Only $98.

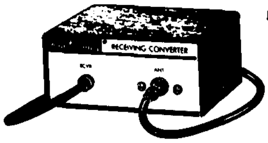


- **TA51 VHF FM EXCITER** for 10M, 6M, 2M, or 220 MHz. 2 Watts continuous, up to 3W intermittent. Kit only $68
- **TA451 UHF FM EXCITER** 2W cont., up to 3W intermittent. Kits only $68. Xtal oven avail.
- **VHF & UHF LINEAR AMPLIFIERS.** For either FM or or SSB. Power levels from 10 to 45 Watts to go with exciters & xmtg converters. Several models. Kits from $ 78.

NOW—FCC TYPE ACCEPTED [illegible] RECEIVERS, AND [illegible] DETAILS.

RECEIVING CONVERTERS

Models to cover every practical rf & if range to listen to SSB, FM, ATV, etc. NF = 2 dB or less.



VHF MODELS

Kit with Case	**$49**
Less Case	**$39**
Wired	**$69**

Antenna Input Range	Receiver Output
28-32	144-148
50-52	28-30
50-54	144-148
144-146	28-30
145-147	28-30
144-144.4	27-27.4
146-148	28-30
220-222	28-30
220-224	144-148
222-226	144-148
220-224	50-54
222-224	28-30

UHF MODELS

Kit with Case	**$59**
Less Case	**$49**
Wired	**$75**

Antenna Input Range	Receiver Output
432-434	28-30
435-437	28-30
432-436	144-148
432-436	50-54
439.25	61.25
902-928	422-448

SCANNER CONVERTERS Copy 806 MHz band on any scanner. Wired/tested ONLY $88.

TRANSMIT CONVERTERS

For SSB, CW, ATV, FM, etc. Why pay big bucks for a multi mode rig for each band? Can be linked with receive converters for transceive. 2 Watts output vhf, 1 Watt uhf.

For VHF, Model XV2
Kit $79
Wired $149
(Specify band)

Exciter Input Range	Antenna Output
28-30	144-146
28-29	145-146
28-30	50-52
27-27.4	144-144.4
28-30	220-222*
50-54	220-224
144-146	50-52
144-146	28-30

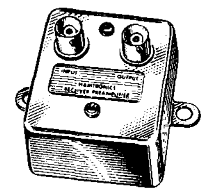
For UHF, Model XV4
Kit $79
Wired $139

Exciter Input Range	Antenna Output
28-30	432-434
28-30	435-437
61.25	439.25
144-148	432-436*

*Add $20 for 2M input

VHF & UHF LINEAR AMPLIFIERS. Use with above. Power levels from 10 to 45 Watts. Several models, kits from $78.

LOW-NOISE PREAMPS



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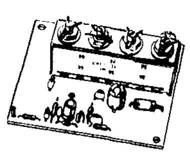
MODEL	TUNES RANGE	PRICE
LNG-28	26-30 MHz	$49
LNG-50	46-56 MHz	$49
LNG-144	137-150 MHz	$49
LNG-160	150-172 MHz	$49
LNG-220	210-230 MHz	$49
LNG-432	400-470 MHz	$49
LNG-800	800-960 MHz	$49

HELICAL RESONATOR PREAMPS

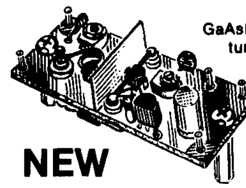
Low-noise preamps with helical resonators reduce intermod and cross-band interference in critical applications. 12 dB gain.



MODEL	TUNING RANGE	PRICE
HRA-144	143-150 MHz	$49
HRA-(*)	150-174 MHz	$49
HRA-220	213-233 MHz	$49
HRA-432	420-450 MHz	$64
HRA-(*)	450-470 MHz	$64

**Specify Center frequency desired*

MINIATURE PREAMPS



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Models available to tune the following bands: 25-35, 35-55, 55-90, 90-120, 120-150, 150-200, 200-270, and 400-500 MHz.

*Specify band

IN-LINE PREAMPS

NEW

GaAsFET Preamp with features like LNG. Automatically switches out of line during transmit. Use with base or mobile transceivers up to 25W. Tower mtg hdwr incl.

MODEL	TUNES RANGE	KIT	WIRED
LNS-144	120-175 MHz	$59	$79
LNS-220	200-240 MHz	$59	$79
LNS-432	400-500 MHz	$59	$79

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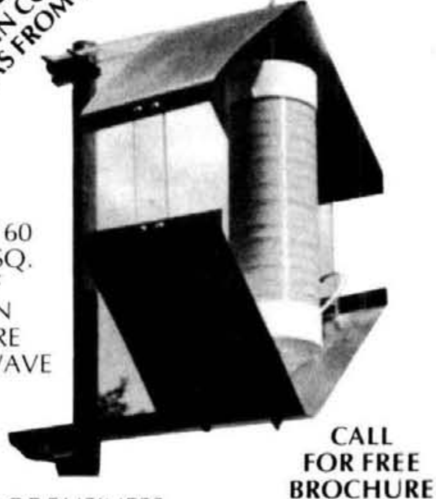

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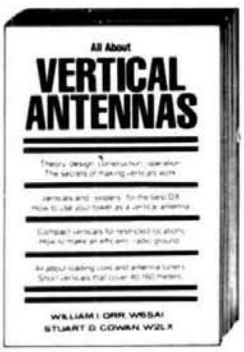

by Bill Orr, W6SAI and Stu Cowan, W2LX

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102	114	126	138	150	162	174	186	198	210	222	234	246	258	270	282	294	306	318	330	342
103	115	127	139	151	163	175	187	199	211	223	235	247	259	271	283	295	307	319	331	343
104	116	128	140	152	164	176	188	200	212	224	236	248	260	272	284	296	308	320	332	344
105	117	129	141	153	165	177	189	201	213	225	237	249	261	273	285	297	309	321	333	345
106	118	130	142	154	166	178	190	202	214	226	238	250	262	274	286	298	310	322	334	346
107	119	131	143	155	167	179	191	203	215	227	239	251	263	275	287	299	311	323	335	347
108	120	132	144	156	168	180	192	204	216	228	240	252	264	276	288	300	312	324	336	348
109	121	133	145	157	169	181	193	205	217	229	241	253	265	277	289	301	313	325	337	349
110	122	134	146	158	170	182	194	206	218	230	242	254	266	278	290	302	314	326	338	350
111	123	135	147	159	171	183	195	207	219	231	243	255	267	279	291	303	315	327	339	
112	124	136	148	160	172	184	196	208	220	232	244	256	268	280	292	304	316	328	340	

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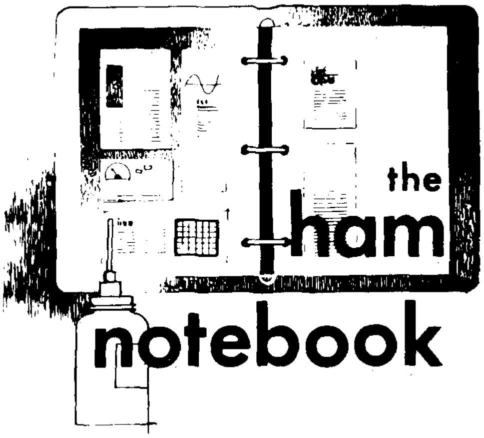


using spreadsheet programs for Amateur Radio projects

Most of us who own home computers have learned to program them in BASIC and found ways to use them in the ham shack. Although BASIC is easy enough to learn and to use, there are alternatives that make some chores much easier. For example, I've been using Lotus 1-2-3™, a highly respected and widely used electronic spreadsheet, for a number of tasks such as keeping and duplicating contest logs, printing QSL cards, and the like. Any of the other popular spreadsheets, such as Multiplan™, would probably work just as well.

Spreadsheet programs are personal productivity tools that allow us to analyze data and create reports. The spreadsheets themselves are large grids of entries that can include text, formulas, and numerics. Since worksheets are able to store formats, formulas, and data, changes can be made to files in order to update or revise data.

I use Lotus 1-2-3 to generate DXCC and WAS records and schedules (**fig. 1**, personalized QSL cards (**fig. 2**), mailing labels, and graphs (**fig. 3**). The QSL application includes a "macro," a list of commands that can be executed as needed in order to make the job of entering information and printing the results largely automatic.

No matter what spreadsheet program you use, you should have no difficulty duplicating the worksheets. The 5BDXCC record (**fig. 1**) is made by entering the names of all countries worked in the first column and placing the various band headings at the top of columns B through F. Using the **@COUNT** function* produces an automatic update of the band totals at the bottom of each column. Subtotals for each country, shown on the right, also use the same **@COUNT** function. As new countries are worked, all that's required is the insertion of new lines where needed to accommodate the new listings. When the **WORKSHEET-INSERT-ROW** command is used, the formulas are revised automatically to count the new totals. The 5BWAS worksheet is basically the same, except that I entered column dividers between each band to improve the appearance of the graph. As with the DXCC record, the program's **@COUNT** or **@SUM** functions have been used to determine the totals.

AD1B

WAS	80	40	20	15	10	TOT
ALABAMA			K4SKX	WA4BTX	W4NCK	3
ALASKA			KL71R			1
ARIZONA			K7RDC	AA7A		2
ARKANSAS			W5QKR	W5ADE	K5NE	3
CALIFORNIA			W6JOH	WD6ERD	WA6QIE	3
COLORADO			WA0MFI	WA0COG	W07V	3
CONNECTICUT	WN1DLG	WA1NEY	W1BGP			3
DELAWARE	WA3PHG	K3DTX		K3RM		3
FLORIDA			K4TFA	WB4LAC	KA4ECQ	3
GEORGIA			K4QVQ		AD4YI	2
HAWAII						0
IDAHO			WA7IRD			1
ILLINOIS		WA9SZN	W9ELG	KB9DO	WD9ADV	4
INDIANA		K9YAK	W9SFR			2
IOWA			WA0LHE	KB0PQ	W0EJ	3
KANSAS			W0HY		AB0X	2
KENTUCKY		K4ZHM		WN4QMQ		2
LOUISIANA		N5II	W5SVP	W5MFR	KA5JEG	4
MAINE	W1RWB	WN1PCT				2
MARYLAND	W3UPY	W3HSD	W3EVJ	WA3EEF		4
MASSACHUSETTS	W1ARH	WA1DUI	W1MQX	WA1FAT	K1HRV	5
MICHIGAN	WB8LZE	W8ERN	W8UM	WBRDX		4
MINNESOTA			WA0YVF	WN0LFL	WA0FPL	3
MISSISSIPPI			K5ADZ			1
MISSOURI			W0GBJ	WN0PRC	WB0MUU	3
MONTANA			AB7U			1
NEBRASKA			W0VSR	K0VVQ	K0OI	3
NEVADA					K7NV	1
NEW HAMPSHIRE	W1ZKA	W1CCM	W1WHP			3
NEW JERSEY	WB2UYB	W2FZV	WB2HGV			3
NEW MEXICO			KB5RK			1
NEW YORK	WB2YBR	K2OPZ	WB2FQJ			3
NORTH CAROLINA	WB4TAA		W4MMR	K4RPH	K4JPE	4
NORTH DAKOTA			W0GH			1
OHIO	WA8UUG	W8OPH	K8OKP	WB8RIB	WB8JUI	5
OKLAHOMA			W5KG	W5TDR	N0IN	3
OREGON			W7YDA	WA7ZVI		2
PENNSYLVANIA	WA3LCO	W3KF	W3VAT			3
RHODE ISLAND	WA1LVU	K1PQM	WA1YDR			3
SOUTH CAROLINA			WA4JJZ		WA4DAL	2
SOUTH DAKOTA			WB0VYU	WB0VYU	WD0DXP	3
TENNESSEE			WB4FFW	WB4VNG		2
TEXAS	W5GG	WD5FYB	K5DKK	WA5DRP	WB5HTT	5
UTAH				N7DF		1
VERMONT	W1TAG	W1GQJ				2
VIRGINIA	W4AKN	W4HV	WB4YPR			3
WASHINGTON			W7JNB	K7ZVB	W7SF	3
WEST VIRGINIA			WBFWF			1
WISCONSIN			K9OBJ		WB9ILG	2
WYOMING					WB7RGN	1
49	16	19	42	26	24	127

AD18

DXCC	80	40	20	15	10	count
ALAND ISLAND					OH2BDA	1
AUSTRIA			OE1HZA	OE4PWW	OE2RDM	3
BELGIUM			ON6DE	ON4DS	ON4AS	3
BERMUDA			VP9IO	VP9JI		2
BRAZIL			PY2FNE			1
BULGARIA			LZ1KSV			1
CANADA	VE1AZZ	VE1DH	VE4US		VE7CXU	4
CUBA				CO2JM		1
CZECHOSLOVAKIA			OK3AS	OK1IM	OK2PAE	3
DENMARK			OZ1CGW			1
E.GERMANY			DM3BF		DM2BYO	2
ENGLAND			G4DUY	G3TXF	G3YBH	3
EUR RUSSIA			UA3QB			1
FINLAND			ON6WY	OH1PS	OH2FS	3
FRANCE			F6BRF	F6FGN		2
FRANZ JOS ISL			UA1ZCW			1
HAITI			HH2PW		4V2B	2
HOLLAND			PA0CJS	PA0XU	PA2IMS	3
HUNGARY			HA5KHF	HA5KHE	HA5KFL	3
IRELAND			EI2CR			1
ITALY		I19KO	I2RRI	I1FLC		3
JAPAN			JA1JOY			1
N.IRELAND			GI5SJ		GI4ELQ	2
NORWAY			LA1BW		LA9FV	2
POLAND			SP1DPA			1
PORTUGAL			CT1OI			1
RUMANIA			YO7BSN	YO6EZ		2
SCOTLAND			GM4HIG			1
SPAIN			EA4MS			1
SWEDEN			SM3DBU	SM4HVK	SM5CMP	3
SWITZERLAND			HB9AUY	HB7RGW	HB9BQB	3
UKRAINE			UY5UV	UY5UV		2
VENEZUELA			YV5DTJ			1
VIRGIN ISLANDS			KV4AA			1
W.GERMANY			DJ1PK	DL7CS	DL3WH	3
WALES			GW2DFD		GW3NNF	2
WHITE RUSSIA				UC2AF		1
YUGOSLAVIA		YU3DDX	YU3TAN	YU3TNH		3
38	1	3	35	18	17	74

fig. 1. Sample worksheet.

QSL card generator

The QSL card generator is a macro-driven file that allows quick, easy preparation of a large or small number of QSLs. **Figure 2** shows a typical card, printed on inexpensive continuous-feed postcards available at most computer supply stores.

The QSL worksheet is designed in columns A through F, using rows 1 through 18. The print range covers rows 1 through 21, which allows the print head to return to the starting point on *the next* QSL card. All entries are made by means of the data-entry and printing macro. When started, the macro moves the cursor around the card as the return key is struck. This feature is a big time-saver, particularly because the macro sends the card to the printer when the *last entry is made*. The line printer must be turned on when the QSL generator is running because the finished card is sent to the printer after the last of the data is entered.

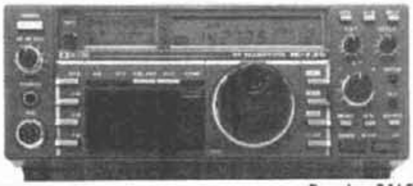
The construction of the QSL template is fairly simple. Starting with a blank default worksheet, save a file under the name "QSL." Referring to **fig. 2**, use rows 1 through 7 to design the call sign. (Although I used numbers and letters to design my card, any character or keyboard symbol may be used.) Next, design the station report in rows 9 through 11. Insert the message, address, or other information in rows 13 through 18.

When the design is complete, use the TAB key to move to a blank cell of the worksheet and enter the macro. The macro listing shows all of the com-

```
    AA          DDDDDD        11   BBBBBBB
   AAAA         DD    D      111   BB     B
  AA  AA        DD     D      11   BB     B
 AAAAAAAA       DD     D      11   BBBBBBB
 AA    AA       DD     D      11   BB     B
 AA    AA       DD    D       11   BB     B
 AA    AA       DDDDDD    111111   BBBBBBB
```

fig. 2. Sample QSL card.

*Commands shown are specific to Lotus 1-2-3. - Ed.



HF Equipment	Regular	SALE
IC-735 HF transceiver/SW rcvr/mic	999.00	849^{95}
PS-55 External power supply	199.00	179^{95}
AT-150 Automatic antenna tuner	445.00	359^{95}
FL-32 500 Hz CW filter	66.50	
EX-243 Electronic keyer unit	56.00	
UT-30 Tone encoder	17.50	

IC-745 9-band xcvr w/.1-30 MHz rcvr	1049.00	899^{95}
PS-35 Internal power supply	199.00	179^{95}
EX-241 Marker unit	22.50	
EX-242 FM unit	44.00	
EX-243 Electronic keyer unit	56.00	
FL-45 500 Hz CW filter (1st IF)	66.50	
FL-54 270 Hz CW filter (1st IF)	53.00	
FL-52A 500 Hz CW filter (2nd IF)	108.00	99^{95}
FL-53A 250 Hz CW filter (2nd IF)	108.00	99^{95}
FL-44A SSB filter (2nd IF)	178.00	159^{95}

IC-751 9-band xcvr/.1-30 MHz rcvr	1399.00	999^{00}
IC-751A 9-band xcvr/.1-30 MHz rcvr	1649.00	1399
PS-35 Internal power supply	199.00	179^{95}
FL-32 500 Hz CW filter (1st IF)	66.50	
FL-63 250 Hz CW filter (1st IF)	54.50	
FL-52A 500 Hz CW filter (2nd IF)	108.00	99^{95}
FL-53A 250 Hz CW filter (2nd IF)	108.00	99^{95}
FL-33 AM filter	35.25	
FL-70 2.8 kHz wide SSB filter	52.00	
RC-10 External frequency controller	39.25	

Other Accessories:	Regular	SALE
IC-2KL 160-15m solid state amp w/ps	1999.00	1699
PS-15 20A external power supply	169.00	154^{95}
PS-30 Systems p/s w/cord, 6-pin plug	299.00	269^{95}
OPC Opt. cord, specify 2, 4 or 6-pin	10.00	
MB Mobile mount, 735/745/751A	24.50	
SP-3 External speaker	61.00	
SP-7 Small external speaker	49.00	
CR-64 High stab. ref. xtal (745/751)	63.00	
PP-1 Speaker/patch	159.25	149^{95}
SM-6 Desk microphone	44.95	
SM-8 Desk mic - two cables, Scan	78.50	
SM-10 Compressor/graph EQ, 8 pin mic	136.25	124^{95}
AT-100 100W 8-band auto. antenna tuner	445.00	389^{95}
AT-500 500W 9-band auto. antenna tuner	559.00	489^{95}
OPC-118 Adapts AT-100/500 to IC-735	16.00	
AH-2 8-band tuner w/mount & whip	625.00	549^{95}
AH-2A Antenna tuner system, only	495.00	429^{95}
OPC-137 Adapts AH-2/2A to IC-751/745	16.00	

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Other Accessories - continued:	Regular	SALE
GC-4 World Clock **(Closeout)**	99.95	59^{95}
GC-5 World clock	91.95	

6-meter VHF Portable	Regular	SALE
IC-505 3/10W 6m SSB/CW portable	549.00	489^{95}
BP-15 AC charger	14.00	
EX-248 FM unit	55.50	
LC-10 Leather case	39.50	

VHF/UHF base multi-modes	Regular	SALE
IC-551D 80W 6-meter SSB/CW	799.00	699^{95}
EX-106 FM option	140.00	126^{95}
BC-10A Memory back-up	9.50	
IC-271A 25W 2m FM/SSB/CW	859.00	759^{95}
AG-20 Internal preamplifier	64.00	
IC-271H 100W 2m FM/SSB/CW	1099.00	969^{95}
AG-25 Mast mounted preamplifier	95.00	
IC-471A 25W 430-450 SSB/CW/FM xcvr	979.00	869^{95}
AG-1 Mast mounted preamplifier	99.50	
IC-471H 75W 430-450 SSB/CW/FM	1399.00	1169
AG-35 Mast mounted preamplifier	95.00	

Accessories common to 271A/H and 471A/H		
PS-25 Internal power supply for (A)	115.00	104^{95}
PS-35 Internal power supply for (H)	199.00	179^{95}
SM-6 Desk microphone	44.95	
EX-310 Voice synthesizer	46.00	
TS-32 CommSpec encode/decoder	59.95	
UT-15 Encoder/decoder interface	14.00	
UT-15S UT-15S w/TS-32 installed	92.00	

VHF/UHF mobile multi-modes	Regular	SALE
IC-290H 25W 2m SSB/FM, TTP mic	639.00	569^{95}
IC-490A 10W 430-440 SSB/FM/CW	699.00	599^{95}

VHF/UHF/1.2 GHz FM	Regular	SALE
IC-27A Compact 25W 2m FM w/TTP mic	429.00	379^{95}
IC-27H Compact 45W 2m FM w/TTP mic	459.00	399^{95}
IC-37A Compact 25W 220 FM, TTP mic	499.00	439^{95}
IC-47A Compact 25W 440 FM, TTP mic	549.00	489^{95}
PS-45 Compact 8A power supply	139.00	129^{95}
UT-16/EX-388 Voice synthesizer	34.99	
SP-10 Slim-line external speaker	35.99	
IC-28A 25W 2m FM, UP/DN mic	429.00	379^{95}
IC-28H 45W 2m FM, UP/DN mic	459.00	399^{95}
IC-38A 25W 220 FM	459.00	399^{95}
IC-48A 25W 440-450 FM	459.00	399^{95}
HM-14 TTP microphone	55.50	
UT-28 Digital code squelch	37.50	
UT-29 Tone squelch decoder	43.00	
HM-16 Speaker/microphone	34.00	
IC-3200A 25W 2m/440 FM w/TTP	599.00	499^{95}
UT-23 Voice synthesizer	34.99	
AH-32 2m/440 Dual Band antenna	37.00	
AHB-32 Trunk-lip mount	34.00	
Larsen PO-K Roof mount	20.00	
Larsen PO-TLM Trunk-lip mount	20.18	
Larsen PO-MM Magnetic mount	19.63	
RP-3010 440 MHz, 10W FM, xtal cont.	1229.00	1099
IC-120 1W 1.2 GHz FM Mobile	579.00	499^{95}
ML-12 1.2 GHz 10W amplifier	379.00	339^{95}
IC-1271A 10W 1.2 GHz SSB/CW Base	1229.00	1079
AG-1200 Mast mounted preamplifier	105.00	
PS-25 Internal power supply	115.00	104^{95}
EX-310 Voice synthesizer	46.00	
TV-1200 ATV interface unit	129.00	119^{95}
UT-15S CTCSS encoder/decoder	92.00	
RP-1210 1.2 GHz, 10W FM, 99 ch. synth	1479.00	1299

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Hand-helds	Regular	SALE
IC-2A 2-meters	279.00	249^{95}
IC-2AT with TTP	299.00	259^{95}
IC-3AT 220 MHz, TTP	339.00	299^{95}
IC-4AT 440 MHz, TTP	339.00	299^{95}
IC-02AT 2-meters	399.00	339^{95}
IC-03AT for 220 MHz	449.00	399^{95}
IC-04AT for 440 MHz	449.00	389^{95}
IC-u2A 2-meters	299.00	269^{95}
IC-u2AT with TTP	329.00	289^{95}
IC-12AT 1W 1.2GHz FM HT/batt/cgr/TTP	459.00	399^{95}
A-2 5W PEP synth. aircraft HT	599.00	499^{95}

Accessories for IC series	Regular
BP-7 425mah/13.2V Nicad Pak - use BC-35	74.25
BP-8 800mah/8.4V Nicad Pak - use BC-35	74.25
BC-35 Drop in desk charger for all batteries	74.95
BC-16U Wall charger for BP7/BP8	20.25
LC-11 Vinyl case for Dlx using BP-3	20.50
LC-14 Vinyl case for Dlx using BP-7/8	20.50
LC-02AT Leather case for Dlx models w/BP-7/8	54.50

Accessories for IC and IC-O series	Regular
BP-2 425mah/7.2V Nicad Pak - use BC35	47.00
BP-3 Extra Std. 250 mah/8.4V Nicad Pak	37.50
BP-4 Alkaline battery case	15.25
BP-5 425mah/10.8V Nicad Pak - use BC35	58.50
CA-5 5/8-wave telescoping 2m antenna	18.00
FA-2 Extra 2m flexible antenna	11.50
CP-1 Cig. lighter plug/cord for BP3 or Dlx	13.00
CP-10 Battery separation cable w/clip	22.50
DC-1 DC operation pak for standard models	23.25
EX-390 Bottom slide cap	5.50
MB-16D Mobile mtg. bkt for all HTs	21.99
LC-2AT Leather case for standard models	54.50
RB-1 Vinyl waterproof radio bag	31.50
HH-SS Handheld shoulder strap	16.95
HM-9 Speaker microphone	47.00
HS-10 Boom microphone/headset	23.25
HS-10SA Vox unit for HS-10 & Deluxe only	23.25
HS-10SB PTT unit for HS-10	23.25
ML-1 2m 2.3w in/10w out amplifier ... **SALE**	99.95
SS-32M Commspec 32-tone encoder	29.95

Receivers	Regular	SALE
R-71A 100 kHz-30 MHz, 117V AC	$949.00	799^{95}
RC-11 Infrared remote controller	67.25	
FL-32 500 Hz CW filter	66.50	
FL-63 250 Hz CW filter (1st IF)	54.50	
FL-44A SSB filter (2nd IF)	178.00	159^{95}
EX-257 FM unit	42.50	
EX-310 Voice synthesizer	46.00	
CR-64 High stability oscillator xtal	63.00	
SP-3 External speaker	61.00	
CK-70 (EX-299) 12V DC option	12.25	
MB-12 Mobile mount	24.50	
R-7000 25 MHz-2 gHz scanning rcvr	1099.00	969^{95}
RC-12 Infrared remote controller	67.25	
EX-310 Voice synthesizer	46.00	
AH-7000 Radiating antenna	89.95	

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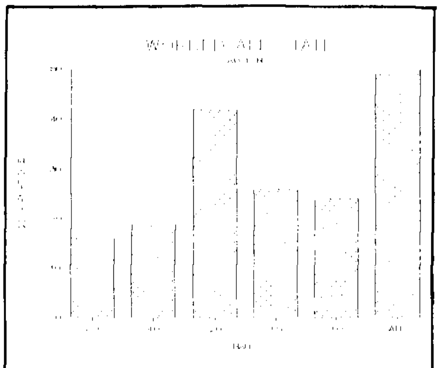


fig. 3. Sample graph.

/
RANGE
NAME
CREATE
"\Z"
"RETURN"
"RETURN"

These commands establish the macro name, allowing us to run the system by typing only two keys, "ALT-Z." Next, enter the macro commands listed in **table 1** and save the completed file. To run a batch of QSL cards, load the QSL file, placing the cursor on the cell where the call sign is to be entered. Start the macro with "ALT-Z" and enter all of the station report data. After each item, hit the "RETURN" key to move to the next. Load the line printer with postcards and turn it on; printing will begin as soon as the last entry is made.

To improve the appearance of the QSLs, I've added a setup string to the macro to emphasize print on the call sign. The two lines that turn the emphasized type on my Epson printer on and off are, respectively, "/027/069" and "/027/070". Other printers will require different instructions; consult your manual.

I've found the QSL generator helpful because it processes data quickly and easily. New designs can be prepared to cover special events, portable operations, and holidays.

label-maker

A simple application, but one that's useful for preparing mailings to club members or the like, is a label-maker. Although routines written in BASIC are often used to generate labels, using Lotus 1-2-3 is simpler, quicker, and more convenient.

I've been using labels consisting of nine rows from top to bottom. This allows plenty of room for even the most complex mailing address. The starting point is the creation of a list of names and addresses in a single column of a worksheet. It's not necessary to set the column width to any particular size because the text will simply run into the next column.

Each new record starts nine rows below the prior starting point. If you select blank mailing labels with only six rows, *be sure to change the spacing accordingly*. Also remember that any time you enter a street address — "1 Main Street," for example — the program requires that an apostrophe precede the entry to tell the program that text, rather than numerals, is being entered. To create a new file, simply type the names and addresses in a column as you want them to appear on the labels.

To prepare the file for printing, type the following commands:

/
PRINT
PRINT
OPTIONS
OTHER
UNFORMATTED
MARGIN
TOP 0
MARGIN
BOTTOM 0
QUIT
RANGE (SET YOUR RANGE)
QUIT

Next, save the label file under some descriptive name. When you're ready to print, load the label file and enter the following commands:

/
PRINT
PRINT
ALIGN
GO [Note: labels will be generated at this point.]
QUIT

No provision has been made to allow alphabetical sorting. New names can be added to the end of the list; names can be deleted with the program's "WORKSHEET-DELETE-ROW" feature. To print a batch of labels, all that's required is the six keystrokes listed above. Hint: starting printing with the print head set two rows down from the

Table 1. QSL card macro. Note: explanations in right-hand column are not necessary for operation.

\Z	{?}~	ENTER THE CALL SIGN
	{RIGHT}{RIGHT}	MOVE TO THE RIGHT
	{RIGHT}	MOVE TO THE RIGHT
	{?}~{DOWN}	ENTER THE DATE AND MOVE DOWN
	{LEFT}{LEFT}	MOVE LEFT
	{LEFT}	MOVE LEFT
	'{?}~	ENTER THE TIME
	{RIGHT}{RIGHT}	MOVE TO THE RIGHT
	{RIGHT}	MOVE TO THE RIGHT
	'{?}~{DOWN}	ENTER THE FREQUENCY AND MOVE DOWN
	{LEFT}{LEFT}	MOVE LEFT
	{LEFT}	MOVE LEFT
	'{?}~	ENTER THE REPORT
	{RIGHT}{RIGHT}	MOVE RIGHT
	{RIGHT}	MOVE RIGHT
	{?}~	ENTER THE MODE
	{LEFT}{LEFT}	MOVE LEFT
	{LEFT}	MOVE LEFT
	/PPCAARA1.G8~	SEND THE QSL TO THE PRINTER
	OOUMTO~MBO~S	USE CONTINUOUS FEED FORMAT
	\027\069~QG	SEND DOUBLE-STRIKE CHARACTER
	CARA9.G21~	PRINT BALANCE OF QSL
	OOUMTO~MBO~S	USE CONTINUOUS FEED FORMAT
	\027\070~QGQ	CANCEL DOUBLE-STRIKE
	{UP}{UP}	MOVE TO START
	/XG\Z~	RESTART THE MACRO

the ham notebook

mands required to run the application. To start, enter the following in the selected cell:
top of the label will help center the text on the label.

graphs

You can use Lotus 1-2-3 to generate line graphs, bar graphs, stacked bar graphs, pie charts, and such. A graph such as shown in **fig. 3**, requires the following data entry:

80	**16**
40	**19**
20	**42**
15	**26**
10	**24**
ALL	**49**

These data are entered in columns A and B, starting in the first row. The following commands are then entered in the worksheet before saving the final product:

/
G
TYPE BAR
X-AXIS A1..A6
A RANGE B1..B6
OPTIONS TITLES
FIRST "WORKED ALL STATES"
TITLES SECOND "AD1B"
TITLES X-AXIS "BAND"
TITLES X-AXIS "CONFIRMATIONS"
QUIT
VIEW [This allows the graph to be seen.]
QUIT

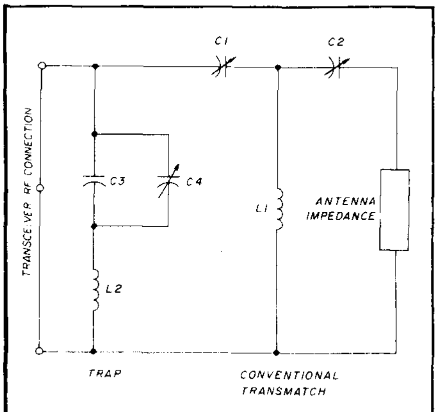
The **VIEW** command allows you to see the graph and print it. You can also save the data while in the GRAPH menu and make a print by using the PRINT GRAPH disk in the Lotus package. **Figure 3** shows the final appearance of the sample graph for my 5BWAS certificate.

Thomas M. Hart, AD1B

suppression of high-level AM broadcast signals

A transmatch and/or receiver input high-pass filter will provide effective attenuation of AM broadcast signals particularly troublesome on the 160-meter band. Transceivers with diode T/R switching, however, are vulnerable to inter-modulation and cross-modulation interference caused by rectification of very high-level signals from close-in, high-power broadcast stations. A transmatch may not provide sufficient attenuation of the offending signal, and filtering in the receiver input after the diodes will not alleviate the problem. A conventional receiver high-pass filter cannot be put ahead of the diode switch because it would be subjected to the 100-watt output of the transceiver.

A method of suppressing a high-level AM broadcast signal is shown in **fig. 1**. C3 and C4 in series with L2 form a series shunt trap tuned exactly to the



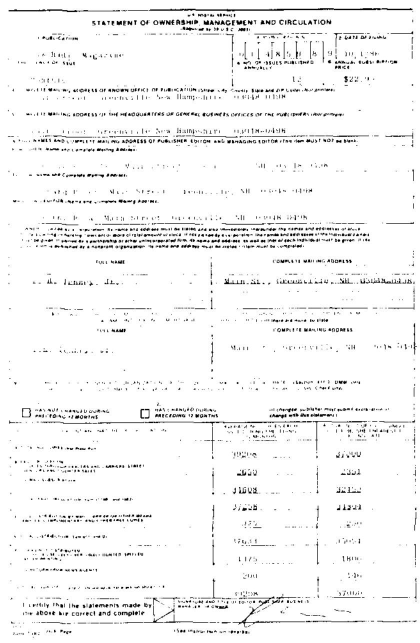
C3 330 pF, 1000-volt mica (add 270 pF for low part of broadcast band)
C4 100 pF mica trimmer
L2 59 turns, No. 24 enameled wire on 0.75-inch acrylic (Plexiglass or Lucite) tube. Winding length 1.25 inches. Approximately 31 μh (increase to 85 turns for low part of broadcast band).

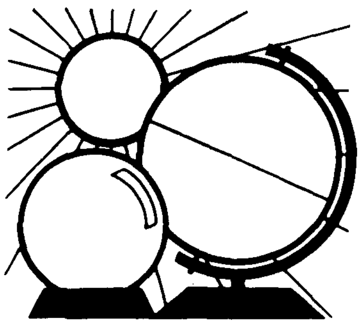
frequency of the broadcast station. L2 is a high-Q coil providing a very low shunt resistance at resonance, thus providing deep attenuation of the broadcast station signal. With the LC trap shown the impedance is high enough above 1.8 MHz so as not to attenuate signals on any of the bands. The high trap impedance also limits the current through L2 on transmit to an insignificant value above 1.8 MHz. In this arrangement the combined trap and transmatch becomes the impedance-matching network. It is necessary only to readjust C1 and C2 for minimum SWR in the normal manner.

In my case there is a 50-kW station about 2/3 of a mile away on 1500 kHz. The trap reduces the 1500-kHz signal from 2.5 to 0.08 volts. It has cleaned up the 160-meter band dramatically and does not affect received signals above 1.8 MHz. Proper impedance match to the transceiver is achieved on *all* bands by tuning for minimum SWR in the normal manner. The trap coil is not even warm to the touch after transmitting 100 watts, key down.

Jack Geist, N3BEK

ham radio


STATEMENT OF OWNERSHIP, MANAGEMENT AND CIRCULATION



DX FORECASTER

Garth Stonehocker, KØRYW

more on winter anomalous absorption

December 1984's DX Forecaster discussed the wintertime increased absorption anomaly that results in periods of weak signals, each lasting a few days. Recent research has produced a *more detailed explanation of its cause* and effects, as well as a method of prediction.

The cause is not simple, but basically involves the arrival of particles into the polar regions during a geomagnetic disturbance. Their arrival triggers a series of events: the particles ionize nitric oxide (NO) and molecular oxygen (O_2) in the auroral zone's (60- to 70-degree latitude) D and E regions, causing auroral absorption there and electron depletion in these regions for about *three days of disturbance.*

About two to four days later, the heat buildup from the process produces stratospheric winds that blow the neutral NO and heat to the west (in the *northern hemisphere*) and to lower latitudes (e.g., 40 degrees). As a result, the NO ionizes in the *D region* signal absorption areas (1000 to 2000 km in diameter) and spreading, affecting mid-latitude east-west DX propagation paths for the following five to six days.

The absorption develops in two areas on opposite sides of the earth. The areas in between experience lower than normal *winter absorption*. This results in the earth's division into four alternating longitudinal bands: one quarter of the earth's longitudes experiences above-average signal strengths; a second quarter, signal strengths below average; the third, above-average signal strengths, and the fourth, signal strengths below average. This pattern moves about 30 degrees — the equivalent of two time zones — per day. This same pattern appears five to six days later in the lower *latitudes (e.g., 40 degrees)*. However, it does not coincide with the previously described trough condition. The amount of absorption is generally 20 dB, but can be as high as 40 dB for several hours during a day.

From the above discussion, a procedure for forecasting becomes apparent. Geophysical scientists call the warm stratosphere accompanying the anomalous absorption "Stratwarm." Station WWV announces the presence (and location) of Stratwarm conditions at 18 minutes after the hour. During December and January, if a high-value A index is announced, listen for the Stratwarm location. The complementary Stratwarm location will be on the other side of the earth, with lower absorbing regions (depleted NO) in between.

The higher signal strengths in the low-absorption regions are a boon to DXers. A globe or polar map is useful in tracking these regions. Remember, these regions move *west* at a rate of 30 degrees (longitudinally) per day.

Anomalous absorption usually occurs in the months of December and January, with the most useful activity occurring after January 15.

last-minute forecast

The higher frequency bands are expected to be best during the third and fourth weeks of the month, when the probability of a solar flux increase is highest. The resulting increase in MUFs may be up to 10 degrees above the mid-latitude mid-day median value of 16 MHz. Look for *transequatorial* openings at that time as well as around December 5 and New Year's Day, when geomagnetic disturbances are expected.

The first, second, and fifth weeks are forecast to have lower solar flux and consequently lower activity. Therefore the lower frequency bands should be excellent then. Disturbances, of *course, can provide DX signals from* some unusual locations from late in the day to early the next morning — i.e., 10 pm to 4 am local time.

The Geminids meteor shower, which will peak on December 13-14, will provide the richest and most reliable display of the year, with rates of 60 to 70 per hour. Because optical observations may be difficult or impossible during periods of poor weather in December, actual numbers must be determined by radio reception. A *smaller version of the shower will be* noted on December 22. Lunar perigee will occur on the 2nd and 30th of December and a full moon on December 24th. Winter solstice occurs on December 22nd at 0402 UT.

band-by-band summary

Ten, twelve, and fifteen meters, the day-only DX bands, will be open from morning to early evening almost every day, and to most areas of the world. The openings on the higher of these *bands will be shorter, occur closer to*

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WESTERN USA

GMT	2300	2200	2100	2000	1900	1800	1700	1600	1500	1400	1300	1200	1100	1000	0900	0800	0700	0600	0500	0400	0300	0200	0100	0000	
PST	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	
ASIA FAR EAST	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	30	30	40	N
EUROPE	40	40	40	40	40	30	30	30	20	30	40	40	40	40	40	40	40	40	40	40	40	40	40	40	NE
S. AFRICA	20	15	12	12	10	10	10	12	12	12	20	30	30	30	30	30	30	30	30	30	30	20	20	20	E
S. AMERICA	10	10	10	10	10	10	10	10	12	12	20	30	30	30	30	30	30	30	30	20	20	20	20	12	SE
ANTARCTICA	12	12	12	12	12	15	15	15	20	30	30	40*	30	30	30	20	20	20	20	20	20	12	12	12	S
NEW ZEALAND	10	10	10	12	12	15	20	20	20	30	30	30	30	30	30	30	30	20	20	20	15	12	10	10	SW
OCEANIA AUSTRALIA	12	12	15	15	20	20	30	20	20	30	30	30	30	30	30	30	30	30*	20	20	15	12	10	10	W
JAPAN	20	20	20	30	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	30	20	20	20	NW

MID USA

MST	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	
ASIA FAR EAST	40	40	40	40	40	40	40	40	40	30	40	40	40	40	40	40	40	40	40	40	40	40	40	30	N
EUROPE	40	40	40	40	40	30	20	20	20	20	30	40	80	80	80	80	80	40	40	40	40	40	40	40	NE
S. AFRICA	20	20	15	12	10	10	10	10	10	12	12	15	20	30	30	30	30	30	30	30	30	30	30	20	E
S. AMERICA	10	10	10	10	10	10	10	10	12	12	15	20	30	30	30	30	30	30	30	20	20	20	20	20	SE
ANTARCTICA	12	12	12	12	12	15	15	15	20	20	30	30	30	30	30	30	30	30	20	20	20	20	20	12	S
NEW ZEALAND	10	10	12	12	15	15	20	20	20	20	30	30	30	30	30	30	30	20	20	20	15	12	12	10	SW
OCEANIA AUSTRALIA	12	12	15	15	20	30	20	20	20	20	30	30	30	30	30	30	30	20	20	20	15	12	12	10	W
JAPAN	20	20	30	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	30	20	20	NW
CST	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	

EASTERN USA

EST	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	
ASIA FAR EAST	40	40	40	40	40	40	40	40	40	40	40	30	40	40	40	40	40	40	40	40	40	40	40	40	N
EUROPE	40	40	40	40	40*	30	20	20	20	20	20	20	30	40	80	80	80	80	80	80	80	80	40	40	NE
S. AFRICA	20	20	15	12	10	10	10	10	10	10	10	12*	12	15	30	30	30	30	30	30	30	30	30	20	E
CARIBBEAN S. AMERICA	20	10	10	10	10	10	10	10	10	12	12	15	20	30	30	30	30	30	30	20	20	20	20	20	SE
ANTARCTICA	12	12	12	12	12	12	12	15	15	20	20	30	30	30	30	30	30	30	30*	20	20	20	20	20	S
NEW ZEALAND	12	12	10	12	12	15	20	20	20	20	20	30	30	30	30	30	30	30	30	30	20	20	20	15	SW
OCEANIA AUSTRALIA	12	12	12	15	20	20	30*	20	20	20	20	30	30	30	30	30	30	30	30	30	30*	20	20	15	W
JAPAN	30	20	30	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	NW

local noon, and provide paths mainly to the southern hemisphere, with a possibility of transequatorial openings.

Twenty, thirty, and forty meters are both day and night bands. Twenty will be the maximum usable band for DX in the northern directions these days during the daytime. Throughout the night, it will team up with 30 meters. Forty meters will become the main over-the-pole DX daytime band, with some hours covered by 30. This path may be affected by anomalous absorption during a few days of the month.

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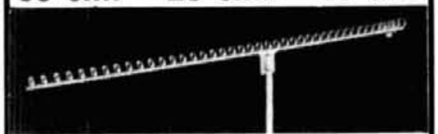

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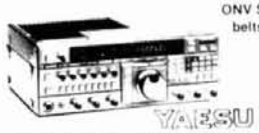

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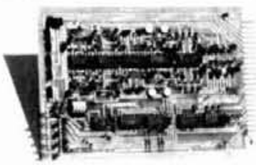

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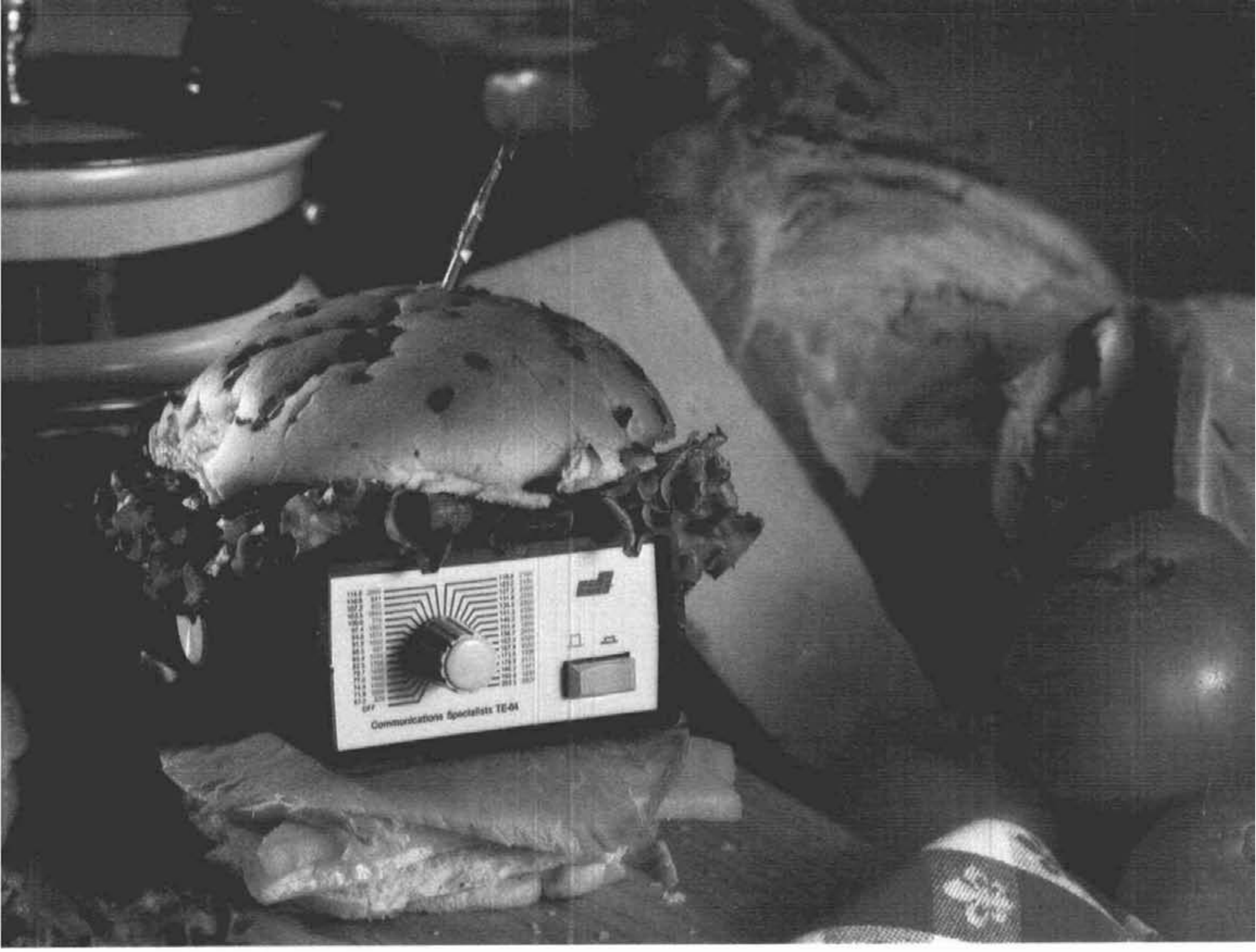

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- Low impedance, low distortion, adjustable sinewave output, 5v peak-to-peak
- Instant start-up.
- Off position for no tone output.
- Reverse polarity protection built-in.

Group A

67.0 XZ	91.5 ZZ	118.8 2B	156.7 5A
71.9 XA	94.8 ZA	123.0 3Z	162.2 5B
74.4 WA	97.4 ZB	127.3 3A	167.9 6Z
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
85.4 YA	110.9 2Z	146.2 4B	192.8 7A
88.5 YB	114.8 2A	151.4 5Z	203.5 M1

- Frequency accuracy, ± .1 Hz maximum - 40°C to + 85°C
- Frequencies to 250 Hz available on special order
- Continuous tone

Group B

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
2175	941	1633	1750	2000	2300	2550
2805			1800	2100	2350	

- Frequency accuracy, ± 1 Hz maximum - 40°C to + 85°C
- Tone length approximately 300 ms. May be lengthened, shortened or eliminated by changing value of resistor

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NEW products

antenna polarity switcher model APS-1

The APS-1 from Mirage is a self-contained control head designed to allow remote polarity switching of circular antennas such as the Mirage/KLM range of crossed Yagis.

The APS-1 may be powered by the power adapter (included) or may alternately be powered from a vehicle or other 13- to 17-volt dc source.

In addition to switchable outputs for two antennas, the APS-1 also contains a 6- to 13-volt regulated dc power supply. This feature is designed for powering items such as preamplifiers and VHF/UHF converters, but may also be used whenever a low-current, stabilized variable voltage source is required.

Total output current is 500 mA with the ac transformer (included), 1 amp with optional high-current transformer or external dc supply.

For information, contact Mirage, P.O. Box 1000, Morgan Hill, California 95037.

Circle #307 on Reader Service Card.

new CTCSS encoder

Kenwood has added a programmable CTCSS encoder to its Smallest HT™. The new BT-Series accessory lets you access more "private line" machines with different PL tones.

The introduction of the new BT-Series doesn't mean that the original Smallest HT™ will be discontinued; users who don't need the CTCSS encoder can choose the TH-216A-Series without the front panel programmable tone encoder.

The new BT-Series retains all the same features and uses the same accessories as the original Smallest HT™ and adds a valued feature in the same "pocket-portable package."

For information, contact Trio-Kenwood Communications, P.O. Box 7065, Compton, California 90224.

new Ku-band satellite tv package

Luxor has announced a new Ku-band package for viewers who want to receive both Ku-band and C-band satellite television programming. The Luxor package consists of a Luxor 9995 C/Ku Block Satellite Receiver, a new 1.2- or 1.8-meter fiberglass antenna, choice of mounts, a 9769 Ku-band Low Noise Block Downconverter (LNB), and dual-mode signal feed. The LNB converts the 11.7-12.5 GHz band to 950-1,750 MHz, the input frequency of Luxor block receivers. Its block signal conversion technology permits independent channel selections on TV sets throughout home, building, or neighborhood while sharing one TV antenna.

The 8003 1.2-meter dish and 8004 1.8-meter dish are available with fixed (azimuth elevation)

mounts for **commerical** use or polar mounts for consumer use.

The Luxor 9769 microwave head consists of the low noise pre-amplifier, mixer, local oscillator, and i-f amplifier, combined in one unit to form the LNB. This LNB (noise factor 2.5 dB maximum), together with the new Luxor 1.2 meter dish, gives an excellent picture on the newer 12 GHz satellites. For reception at footprint edges where signal strength is weak, Luxor recommends its 1.8 meter dish.

For details, contact Luxor North America Corporation, 600 108th Avenue N.E., Suite 539, Bellevue, Washington 98004.

Circle #306 on Reader Service Card.

antenna current probe

Antenna experimenters will find the new MFJ-206 antenna current probe to be a handy addition to their hamshack. Designed to detect magnetic fields around rf conductors such as antennas, transmission lines, and ground leads, it can also be also used to detect electromagnetic radiation from wiring, enclosure shields, and other objects. It can also be used as a field-strength meter with the included telescoping antenna. The MFJ-206 is priced at $79.95.

The relative strength of a magnetic field is determined by the magnitude of the rf currents flowing through a conductor. To detect current distribution, you simply move the slotted end of the probe along the conductor at right angles. As current increases, you'll see a higher reading on the probe's meter.

For further information, contact MFJ Enterprises, Box 494, Mississippi State, Mississippi 39762.

Circle #305 on Reader Service Card.

SSB voice-activated squelch

Naval Electronics announces a new commercial-grade voice-operated squelch (VOS) for upgrading solid-state SSB receivers and transceivers.

Easily installed in most modern receivers and transceivers, the 11-pin module provides commercial communications-grade squelch operation immune to noise, static crashes, heterodynes, and steady tones. The circuit incorporates a syllabic rate detector which provides for superior squelch operation, looks for signal changes similar to changes normally occurring in human speech, and uses the VOS to switch the speaker audio on. (An on/off switch is provided.)

The VOS is most helpful where a single channel must be monitored continuously, reducing operator fatigue.

For further information, contact Naval Electronics Inc., 5417 Jetview Circle, Tampa, Florida 33634.

Circle #310 on Reader Service Card.

digital oscilloscope peripheral for pc's

Rapid Systems has announced the release of the new "4x4," a digital oscilloscope peripheral for IBM PC, XT, and ATs and compatibles. This turn-key, high-performance, 128K data buffer digital scope is the first serious instrument peripheral for PC's to offer simultaneous acquisition of four channels. It also offers the largest number of data buffers per channel in the market. Turn-key digital scope software is provided with unit. No programming is required.

For information contact Rapid Systems, Inc. 755 North Northlake Way, Seattle, Washington 98103.

Circle #304 on Reader Service Card.

free update disks

Free update discs are available to anyone who's bought *RF Notes 1* (through Version 2.4), *RF Notes 2* (through Version 2.4), or *RF Notes 3*, Volume 1 (through Version 1.5).

For a free copy, simply return your original program disk to Etron RF Enterprises, P.O. Box 4042, Diamond Bar, California 91765.

Circle #303 on Reader Service Card.

new DX Edge®

There's a new DX Edge from Xantek — the Super DX Edge®, the successor to the "Computerized DX Edge." Available for the Commodore 64 and Commodore 128 computers and their associated disk drives, the Super DX Edge adds two significant features not found in earlier versions: it calculates Maximum Usable Frequency (MUF) between any two locations and calculates Great Circle Bearings (antenna direction) and distance between any two locations.

The program calculates the MUF between any two points for any sunspot number or solar flux value, and also the great circle bearing between the points. The MUF is the frequency to use for most effective communications between any two points. Results are given for every hour of the day.

The super DX Edge displays and automatically updates the position of the Gray Line to give a continuously accurate picture of the world's daylight and darkness areas. Sunrise and sunset times for any location and any time of year may also be calculated and displayed.

The DX Edge is used by DXers around the world to help determine the optimum times for long-distance contacts. It is particularly helpful in determining the best times and bands for long path and Gray Line contacts. With the addition of the MUF and Great Circle Calculators, the Super DX Edge contains all the propagation aids that DXers need to plan their on-the-air activity.

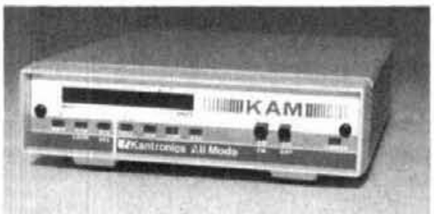
Available from Ham Radio's Bookstore or directly from Xantek, Super DX Edge is priced at $34.95. (Add $3.50 for shipping and handling if ordering from HR's Bookstore.) Owners of the Computerized DX EDGE can trade up to the Super DX EDGE for $24.95 plus their disk.

For information, contact Xantek, Inc., P.O. Box 834, Madison Square Station, New York, New York 10159.

Circle #302 on Reader Service Card.

all-mode communicator

The KAM™ is a true all-mode digital "smart" communicator available from Kantronics. A state-of-the-art radio modem that operates CW, RTTY, ASCII, AMTOR, or PACKET, KAM



features over 100 software commands, bar graph tuning and user-programmable MARK and SPACE tones for RTTY and hf packet, RS-232/TTL terminal interfacing, and limiter/limiterless operation on hf for weak-signal operation. In addition, the CW demodulator is programmable for both center frequency and bandwidth. In effect, you get a flexible, all-mode unit, with any shift — including 170 Hz for RTTY — without compromise.

Like a packet unit, KAM operates with a command mode and operating modes. You can choose RTTY or packet by command. In addition, you can set mark and space tones for RTTY or packet while in command mode for hf operation. Standard packet tones are used in the VHF mode. You'll need a terminal program to access KAM with you computer; any standard communications program will do.

KAM comes with a power adapter, an operator's manual, cables, and connectors; you provide the transceiver mic connectors and your computer's RS-232 connector.

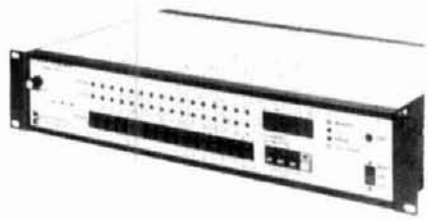
For details, contact Kantronics, 1202 E. 23 Street, Lawrence, Kansas 66046.

Circle #301 on Reader Service Card.

✓ 126

"talking" DTMF remote control

The Model 5001 DTMF Remote Control from Monroe Electronics answers DTMF-coded inquiries and generates alarm reports in English using synthesized speech. The device monitors 16 on-off type logic inputs and controls 16 outputs through built-in Form C relays. Communication with the unit is by means of dual tone multiple-frequency (DTMF) signals from any touch-tone telephone or over any other voiceband link equipped with a touch-tone keypad.



The Model 5001 controls its output relays as instructed, and reports the state of its logic inputs when queried by the user. It will generate an alarm report spontaneously when designated inputs change state, autodialing one of two preprogrammed telephone numbers or transmitting via two- or four-wire audio ports. User-selectable protocols for status reporting include synthesized speech, DTMF tone strings, DTMF tones, and single tone signals.

The 5001 accepts instructions via the public, switched telephone network. It answers after a user-designated number of rings, and hangs up automatically after a selectable period of inactivity. Relays may be programmed for a variety of configurations. Applications include repeater and satellite uplink/downlink control.

For information, contact Monroe Electronics, Inc., 100 Housel Avenue, Dept. 555, Lyndonville, New York 14098.

Circle #308 on Reader Service Card.

prime factor FFT

Alligator Transforms has announced the release of Prime Factor FFT, a Fast Fourier Transform Subroutine Library usable with the IBM PC, XT, AT, and Compatibles equipped with an 8087 math coprocessor. The library includes the forward and inverse FFT for single and double precision floating point complex number sets.

Prime Factor FFT may be called from any high-level language including Turbo Pascal, Fortran, BASIC, C, or Assembly Language. Interface examples are provided in all languages with extensive documentation on how to use Fast Fourier Transforms in your application.

With Prime Factor FFT, the user is not limited to radix two data set sizes. You may perform frequency analysis on data set sizes as small as two data points to as large as 65,520 data points. Choose from over 300 data set sizes.

Prime Factor FFT fully utilizes the 8087 math coprocessor to complete calculations quickly. A 1008-point double precision floating point complex forward FFT will complete in 2.428 seconds. Larger data sets execute quickly as well with a similar 32,760 data point set FFT completion in 133.863 seconds. Priced at $159.00 each, Prime Factor FFT is extremely accurate, with typical error levels as low as 3.3307e-16 in double precision.

For information, contact Alligator Transforms Scientific Software, P.O. Box 11386, Costa Mesa, California 92627

Circle #309 on Reader Service Card.

ICOM IC-μ2AT 2-meter handheld

ICOM has announced the release of its pocket-sized 2-meter handheld, the IC-μ2AT. The "Micro" receives from 139 to 174 MHz and transmits from 140 to 150 MHz, has ten memories which will store offset and tone, an LCD readout on the top panel, scanning, 1-W power output (with 1.5W optional), and 32 built-in subaudible tones. It measures only 2.3 × 5.6 × 1.1 inches and weighs only half a pound.

For details, contact ICOM America Inc., 2380 116th Avenue N.E., Bellevue, Washington 98009-9029.

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BUG COLLECTORS: Original Bunnell Gold Bug, S/N 715. Also have Bunnell-Martin Flash Key, Type No. 5-46. Make offer. Ray Nether, W3KFB, 184 McClure Road, RD 2, Cheswick, PA 15024.

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SPECIAL ANTENNAS by K3IPW featuring the RIW-19 432 MHz beam, 14.9 dBd for $69.95 and the K1FO 22 el. 14 ft. 432 MHz beam, 15.8 dBd for $76.64, SASE for information. Thomas H. Rutland, 1703 Warren St, New Cumberland, PA 17070.

GENERAL RADIO TEST EQUIPMENT 1211B unit oscillator 0.5 to 50 MHz $35. Two 1209B unit oscillators 250 to 920 MHz $30 each. 1201B regulated unit power supply $20. 1203B unit power supply $15. All work. All for $100. Shipping extra. Victor Smith, 147-29 Hoover Avenue, Briarwood, NY 11435.

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R-390A Receiver: $195 checked; $115 reparable. Parts, tubes, sections. Info SASE. CPRC-26 six meter transceiver (see HR, March 1985) $17.50 apiece, $32.50 pair (add $4.50/unit shipping). Baytronics, Box 591, Sandusky, OH 44870. 419-627-0460 *evenings.*

MARCO: Medical Amateur Radio Council, Ltd. operates daily and Sunday nets. Medically oriented Amateurs (physicians, dentists, veterinarians, nurses, physiotherapists, lab technicians, etc.) invited to join. Presently over 550 members. For information write MARCO, Box 73's, Acme, PA 15610.

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WANTED: Heath ET-100. Call 913-898-4695. Mike W0XM.

MORSE CODE Practice program for IBM-PC and Compatibles. Send $19.95 check to SP Microcomputing Co., 1008 Swallow Drive, Cherry Hill, NJ 08003. Developed by KD2SM.

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COMING EVENTS

Activities — "Places to go . . ."

CALIFORNIA:FCC exams, Novice-Extra. Sunnyvale VEC ARC. (408) 255-9000 24 hour. 73, Gordon, W6NLG, VEC

MASSACHUSETTS: The MIT UHF Repeater Association and the MIT Radio Society offer monthly Ham Exams. All classes Novice to Extra. Wednesday, December 17, 7 PM, MIT Room 1-134, 77 Mass Avenue, Cambridge MA. Reservations requested 2 days in advance. Contact Ron Hoffmann (617) 253-0160/646-1641 or Craige Rodgers (617) 494-1986. Exam fee $4.25. Bring copy of current license (if any), two forms of picture ID and completed form 610 available from FCC in Boston (223-6609)

PENNSYLVANIA: Amateur Radio Brunch. The Chaverim of Delaware Valley will hold their 7th annual brunch, Sunday, January 18, Parktowne Place Apartment Complex, 2200 Benjamin Franklin Parkway, Philadelphia at 10 AM. Everyone invited. Contact Bill Soble, W3OXT (215) 676-6769 or write to 9357 Hoff Street, Philadelphia, PA 19115. Reservations are necessary.

WISCONSIN: The 15th annual Midwinter Swapfest, sponsored by the West Allis Radio Amateur Club, Saturday, January 10, Waukesha County Expo Center Forum, 8 AM to 3 PM. Admission $2.00 advance, $3.00 at the door. 4' tables $3.00 advance, $4.00 at the door. Elec. outlet $5.00. Advance deadline January 2, 1987. Dealers welcome. Amateur exams given, write for details. For tickets or information write WARAC Swapfest, PO Box 1072, Milwaukee, WI 53201. Please SASE.

OPERATING EVENTS

"Things to do . . ."

December 6: The University of Idaho ARC, W7UQ, will hold its 2nd annual Alumni Reunion on the Air, 2000Z, December 6 to 0400Z December 7. All Amateurs, especially U of I alumni, are invited to participate. Listen for "CQ Reunion". QSL available by sending SASE via callbook address. For more information contact W7UQ.

December 6-7: 22nd Annual Pioneer Radio QSO Party sponsored by the John D. Burlie Chapter No. 89. For further information Ted Phelps, W8TP.

Feb 1-2: YL-ISSB QSO Parties. CW 0001Z to 2359Z. Phone 0001Z March 21 to 2359Z March 22. Open to all. U.S. General Class portions of bands. Exchange call, report, QTH, name, ISSB number and partner or teammate. Certificates to category, country/state winners. For information: Bill Early, WA9AEA, PO Box 401, McHenry, IL 60050-0401, USA.

SOUTH BEND, INDIANA Hamfest Swap & Shop, January 4, 1987, first Sunday after New Year's Day, Century Center downtown on US 33 Oneway North between St. Joseph Bank Bldg and river. Four lane highways to door from all directions. Tabl;es: $5/5 ft. Round: $10/8x2.5. Rectangular: $2/ft. wall locations. Talk in freq: 52-52, 99-39, 93-33, 69-09, 145.29. K9IXU (219) 233-5307.

December 12-14: Christmas, Florida. The Coronado Wireless Assn. will operate K4HML from 1400Z to 220Z, lower 10 kcs of General bands, phone and CW. Send QSL and No. 10 SASE to K4HML, PO Box 1, Edgewater, FL 32032.

December 20-21: Christmas City Station Members of the Delaware-Lehigh ARC will run this special event station, W3OK. 1600 UTC to 2200 UTC. Contact the station and send QSL and No. 10 SASE to W3OK, Delaware-Lehigh ARC, Greystone Building, Nazareth, PA 18064.

December 13-14: Bethlehem, IN. Clark County ARC will operate W9WWI/9 from 1700Z to 0300Z December 13 and 1300Z to 2000Z December 14. *Certificate for large SASE via CCARC,* Box 532, Jeffersonville, IN 47131.

ADVERTISER'S INDEX AND READER SERVICE NUMBERS

Listed below are the page number and reader service number for each company advertising in this issue. To get more information on their advertised products, use the bind-in card found elsewhere in this issue, select the correct reader service number from either the ad or this listing, check off the numbers, fill in your name and address, affix a postage stamp and return to us. We will promptly forward your request to the advertiser and your requested information should arrive shortly. If the card is missing, send all the pertinent information on a separate sheet of paper to: *ham radio* magazine, Attn: Reader Service, Greenville, NH 03048.

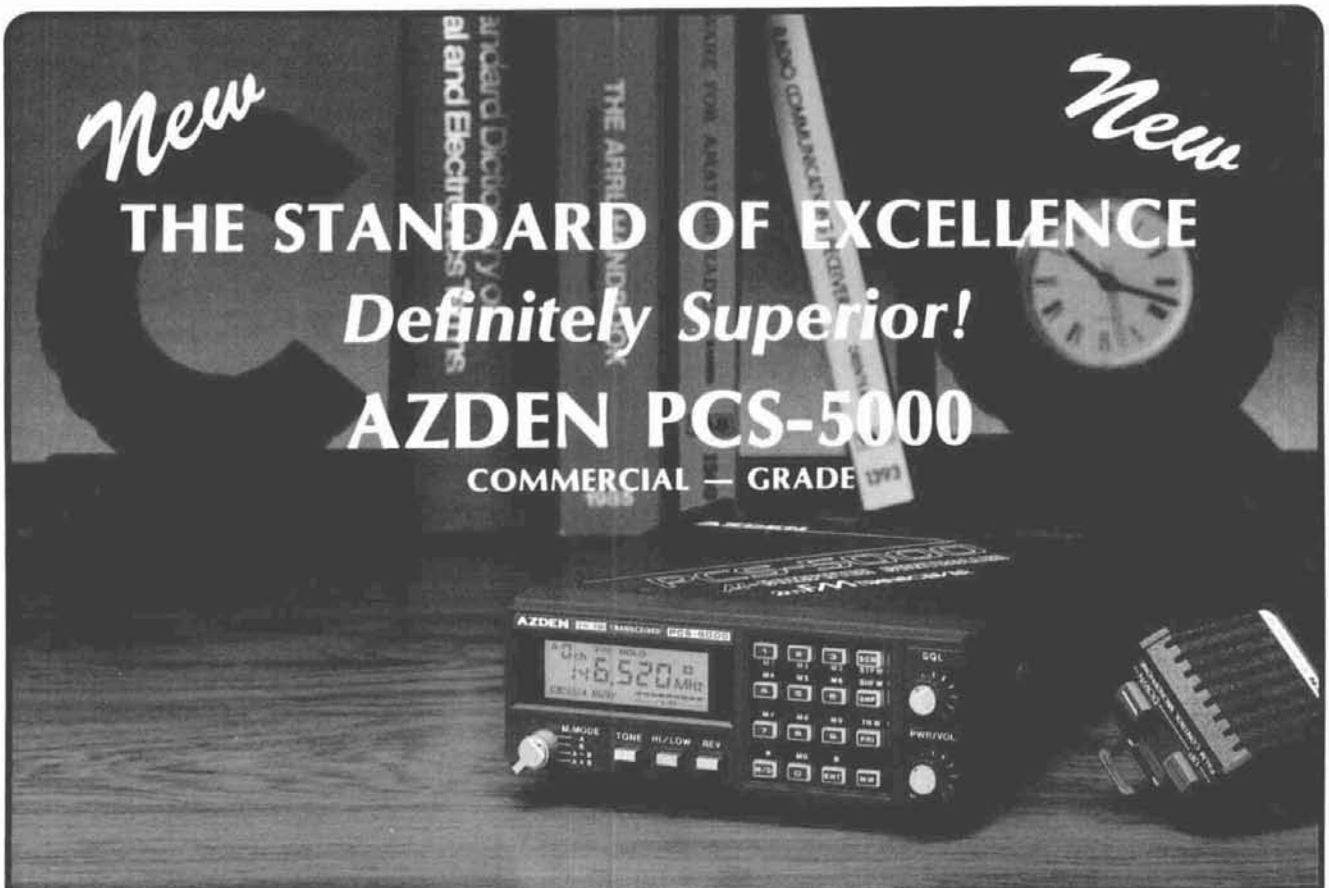
READER SERVICE # — PAGE #

PRODUCT REVIEW/NEW PRODUCTS

*Please contact this advertiser directly.

Limit 15 inquiries per request.

Please use before December 31, 1986.



UNPRECEDENTED WIDE FREQUENCY RANGE: Covers 140.000-153.000 MHz in steps that can be set to ***any*** multiple of 5 kHz up to 50 kHz.

CAP/MARS/NAVY MARS, BUILT IN: The wide frequency range facilitates use of CAP and ALL MARS FREQUENCIES including NAVY MARS. ***COMPARE!***

TINY SIZE: Only 2 inches high, 5½ inches wide and 7¼ inches deep!

MICROCOMPUTER CONTROL: Gives you the most advanced operating features available.

UP TO 11 NONSTANDARD SPLITS: ***COMPARE*** this with other units!

20 CHANNELS OF MEMORY IN TWO SEPARATE BANKS: Retains frequency, offset information, PL tone frequency.

DUAL MEMORY SCAN: Scan memory banks separately or together. ***ALL*** memory channels are tunable independently. ***COMPARE!***

MEMORY SCAN LOCKOUT: Allows you to skip over channels you don't want to scan.

TWO RANGES OF PROGRAMMABLE BAND SCANNING: Limits are quickly reset. Scan ranges separately or together with independently selective steps in each range. ***COMPARE!***

BUSY SCAN AND DELAY SCAN: Busy scan stops on an occupied channel. Delay scan provides automatic auto-resume.

DISCRIMINATOR CENTERING (AZDEN EXCLUSIVE PATENT): Always stops on frequency desired when scanning.

PRIORITY MEMORY AND ALERT: Unit constantly monitors one memory channel for signals, alerting you when channel is occupied.

LITHIUM BATTERY BACKUP: Memory information can be stored for up to 5 years even if power is removed.

FREQUENCY REVERSE: Allows you to listen to repeater input frequency.

ILLUMINATED KEYBOARD WITH ACQUISITION TONE: Keys are easily seen in the dark, and actuation is positively verified audibly.

CRISP, BACKLIGHTED LCD DISPLAY: Easily read no matter what the lighting conditions!

DIGITAL S/RF METER: Shows incoming signal strength and relative transmitter power.

MULTI-FUNCTION INDICATOR: Shows a variety of operating parameters on the display.

FULL 16-KEY TOUCHTONE PAD: Keyboard functions as autopatch when transmitting.

MICROPHONE CONTROLS: Up/down frequency control and priority channel recall.

PL TONE GENERATOR BUILT IN: Instantly program any of the standard PL frequencies into the microcomputer. ***COMPARE!***

TRUE FM, NOT PHASE MODULATION: Unsurpassed intelligibility and audio fidelity. ***COMPARE!***

HIGH/LOW POWER: Select 25 watts or 5 watts output — fully adjustable.

SUPERIOR RECEIVER: Sensitivity is better than 0.15 microvolt for 20-db quieting. Commercial-grade design assures optimum dynamic range and noise suppression. ***COMPARE!***

DIRECT FREQUENCY ENTRY: Streamlines channel selection and programming.

OTHER FEATURES: Rugged dynamic microphone, built-in speaker, mobile mounting bracket, remote speaker jack, and all cords, plugs, fuses and hardware are included.

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EMERALD SPF-2

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Retail $59.95

SAPPHIRE SPF-1

Switched, EMI-RFI Filtered, adapts to duplex outlet; • 3 Outlets, 15 Amps Total 125 Volts, 1875 From Single or All Combined • *Operating Temperature: -40°C to* +85°C • Peak Pulse Power Dissipation @ 25°C, 585,000W for 20 Micro Sec. • Maximum Clamping Voltage @ Test Current 50A (8/20 Micro Sec.) 340V *Clamping Occurs Line to Line (Normal* Mode) and Line to Ground (Common Mode) • Clamping Response Time 1 Nanosecond (1 × 10–9 sec.) • Dielectric Test: 3000 VAC 60 Sec. • Forward Surge Rating @ 25°C, 1440 Amps for 1/120 Sec. • Mode Noise Protection: Normal and Common Mode • Noise Rejection Frequency: 150KHZ–30MHZ • Attenuation: 5DB–58DB, Lifetime Warranty

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Built for the realities of operating. Despite their miniature size, both radios have all the operating capabilities of larger microprocessor-controlled HTs. Yet operating them couldn't be easier. Consider: ■ You get a 10-volt, 2-watt battery pack. (Optionally, a 12-volt, 5-watt pack, or a 10-volt miniature 2-watt pack.) 10 memories that store frequency, offset and PL tone. (7 memories can store odd splits.) Memory scan at 2 frequencies per second. Band scan at 10 frequencies per second. Tx offset storage. Priority channel scan. Tuning via tuning knob, or up/down buttons. PL tone board (optional). PL display. External PL selection. Independent PL memory per channel. PL encode *and* decode. Expanded Rx coverage. LCD power output and "S"-meter display. Battery saver circuit. Push-button squelch override. Eight-key control pad. Keypad lock. High/low power switch (½ watt on low power.) ■ Options available: Dry cell battery case for 6 AAA-size cells. Dry cell battery case for 6 AA-size cells. DC car adapter/charger. Programmable CTCSS (PL tone) encoder/decoder. DTMF keypad encoder. Mobile hanger bracket. External speaker/microphone. And much more. ■ So get the intelligent mini HT that's built for life's realities. Yaesu's 2-meter FT-23R, or 440-MHz FT-73R.

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Kenwood brings you the greatest hand-held transceiver ever! More than just "big rig performance," the new TH-215A packs the most features and the best performance in a handy size. You will want to keep this HT "close at hand" all of the time. And our full line of accessories will let you go from hamshack to portable to mobile with the greatest of ease!

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- CTCSS encoder built-in. TSU-4 CTCSS **decoder** optional.
- 10 memory channels store any offset. Each memory channel can store frequency, frequency step, offset, **reverse switch position,** and CTCSS frequency.
- Nine types of scanning! Including new **"seek scan"**— A Kenwood exclusive!
- Intelligent 2-way battery saver circuit extends battery life. Two battery-saver modes to choose, with power save ratio selection.
- Easy memory recall. Simply press the channel number!
- 12 VDC input terminal for direct mobile or base station supply operation. When 12 volts is applied, RF output is 5 W!
- New Twist-Lok Positive-Connect locking battery case.
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