SEPTEMBER 1983 / $2.50

NBC's Roy Neal, K6DUE: Working W5LFL from Space

ham radio magazine

- rf synthesizers
- fail-safe power
- locating orbiting satellites
- effective ground techniques
- local weather radar

focus on communications technology

LINEAR TRANSLATORS

NEW!

ICOM IC-745

A New Transceiver Worth Celebrating!

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What's the celebration about? The IC-745 . . . a new all ham band HF transceiver with SSB, AM, CW, RTTY and an FM option . . plus, a 100KHz — 30MHz general coverage receiver.

And . . . the IC-745 has a combination of features found on no other transceiver at such an incredibly low price.

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- 16 Memories
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- Continuously Adjustable AGC with an OFF position
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- 100% Transmit Duty Cycle

Other Standard Features:

- 100 Watt Output Transmitter with exceptionally low IMD
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- Speech Compressor
- Tunable Notch Filter
- RIT and XIT
- All Mode Squelch
- Scanning
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- IC-PS740 Internal Power Supply for the ultimate in Portability
- IC-2KL Linear Amplifier
- IC-SP3 External Speaker
- IC-MB12 Mobile Mounting Bracket
- IC-AT100 Antenna Tuner (100W)
- IC-AT500 Antenna Tuner (500W)
- IC-BC10 Memory Backup
- IC-EX241 Marker Module
- IC-EX242 FM Module
- IC-EX243 Electronic Keyer
- IC-FL52A 500Hz 455KHz CW Filter
- IC-FL45 500Hz 9MHz CW Filter
- IC-FL54 270Hz 9MHz CW Filter
- IC-FL53A 250Hz 455MHz CW Filter
- IC-FL44A 2.1KHz 455KHz SSB Filter
- IC-SM6 Desk Mic
- IC-HM12 Hand Mic

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ICOM

✓ 151

ICOM America, Inc., 2112-116th Ave NE, Bellevue, WA 98004 **(206)454-8155** / 3331 Towerwood Drive, Suite 307, Dallas, TX 75234 **(214)620-278**

All stated specifications are approximate and subject to change without notice or obligation. All ICOM radios significantly exceed FCC regulations limiting spurious emission

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Superior dynamic range, auto. antenna tuner, QSK, dual NB, 2 VFO's, general coverage receiver.

TS-930S

The TS-930S is a superlative, high performance, all-solid state, HF transceiver keyed to the exacting requirements of the DX and contest operator. It covers all Amateur bands from 160 through 10 meters, and incorporates a 150 kHz to 30 MHz general coverage receiver having an excellent dynamic range.
Among its other important features are, SSB slope tuning, CW VBT, IF notch filter, CW pitch control, dual digital VFO's, CW full break-in, automatic antenna tuner, and a higher voltage operated solid state final amplifier. It is available with or without the AT-930 automatic antenna tuner built-in.

TS-930S FEATURES:

- **160-10 Meters, with 150 kHz-30 MHz general coverage receiver.** Covers all Amateur frequencies from 160-10 meters, including new WARC bands, on SSB, CW, FSK, and AM. Features 150 kHz-30 MHz general coverage receiver. Separate Amateur band access keys allow speedy band selection. UP/DOWN bandswitch in 1-MHz steps. A new, innovative, quadruple "UP" conversion, digital PLL synthesized circuit provides superior frequency accuracy and stability, plus greatly enhanced selectivity.
- **Excellent receiver dynamic range.** Receiver two-tone dynamic range, 100 dB typical (20 meters, 50-kHz spacing, 500 Hz CW bandwidth, at sensitivity of 0.25 μv, S/N 10 dB), provides the ultimate in rejection of IM distortion.
- **All solid state, 28 volt operated final amplifier.** The final amplifier operates on 28 VDC for lowest IM distortion. Power input rated at 250 W on SSB, CW, and FSK, and at 80 W on AM. Final amplifier protection circuits with cooling fan, SWR/Power meter built-in.
- **CW full break-in.** CW full break-in circuit uses CMOS logic IC plus reed relay for smooth, quiet operation. Switchable to semi-break-in.
- **Automatic antenna tuner, built-in.** Covers Amateur bands 80-10 meters, including the new WARC bands. Tuning range automatically pre-selected with band selection to minimize tuning time. "AUTO-THRU" switch on front panel.
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- **Dual mode noise blanker ("pulse" or "woodpecker").** NB-1, with threshold control, for pulse-type noise. NB-2 for longer duration "woodpecker" type noise.
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- **Audio filter built-in.** Tuneable, peak-type audio filter for CW.
- **AC power supply built-in.** 120, 220, or 240 VAC, switch selected (operates on AC only).
- **Fluorescent tube digital display.** Six digit readout to 100 Hz (10 Hz modifiable), plus digitalized sub-scale with 20-kHz steps. Separate two digit indication of RIT frequency shift. In CW mode, display indicates the actual carrier frequency of received as well as transmitted signals.
- **RF speech processor.** RF clipper type processor provides higher average "talk-power," improved intelligibility.
- **One year limited warranty on parts and labor.**

Other features:

- SSB monitor circuit, 3 step RF attenuator, VOX, and 100-kHz marker.

Optional accessories:

- AT-930 automatic antenna tuner.
- SP-930 external speaker with selectable audio filters.
- YG-455C-1 (500 Hz) or YG-455CN-1 (250 Hz) plug-in CW filters for 455-kHz IF.
- YK-88C-1 (500 Hz) CW plug-in filter for 8.83-MHz IF.
- YK-88A-1 (6 kHz) AM plug-in filter for 8.83-MHz IF.
- SO-1 commercial stability TCXO (temperature compensated crystal oscillator). Requires modifications.
- MC-60A deluxe desk microphone with UP/DOWN switch, pre-amplifier, 8-pin plug.
- TL-922A linear amplifier (not for CW QSK).
- SM-220 station monitor (not for pan-adapter
- HS-6, HS-5, HS-4, headphones.

More information on the TS-930S is available from all authorized dealers of Trio-Kenwood Communications, 1111 West Walnut Street, Compton, California 90220.

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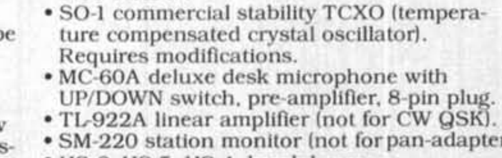

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contents

When two recent American Everest expeditions mounted the Larsen® Kūlduckie® antenna on their radios, it wasn't just because it was there. It was because they knew Larsen performance and reliability would be there when needed the most—even at the top of the world.

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REFLECTIONS

a personal phone call

If I could pick up the phone and call you right now, I'd ask each one of you personally how *you* feel about *ham radio magazine*.

Something akin to this actually happened at Dayton this year, when more than 400 readers took the time to express their views, needs, and concerns to me at our booth. But this number — impressive as it is — represents less than one percent of our subscribers . . . and we need to hear from the other ninety-nine percent.

Since I can't call each one of you personally, I'm doing the next best thing: asking you to take advantage of the survey form printed on this page and the next, and let us know, very clearly, how you feel about *ham radio*.

I see this magazine (and all magazines, for that matter) as a conduit of thoughts — a communications channel. Editors are in a privileged situation. Information arrives from all directions, and can be directed, stopped or modified. Add to that an editor's own personal interests and inclinations and one can see that the different directions a magazine can take are many. But my desire is to provide material that *you* want to read and use.

Because Radio Amateurs are such a diverse group, I fully expect to hear completely opposing viewpoints expressed with fervent conviction. The majority will rule, of course. But the minority will be heard. And we'll do what we can to try to meet their needs, too, without compromising our primary mission, which is to provide the Amateur community with the most useful and informative technical material in the Amateur Radio publishing field.

We all have vested interests in this wonderful hobby; each and every one of us, at one time or another, has expressed our views privately or in the presence of large groups. All I'm asking is for you to do the same now in responding to the questions that follow.

Many of the questions, you'll notice, have been asked before in other surveys. We have to ask them again because an accurate, up-to-date reader profile helps us make the short and long-term decisions that result in a magazine that suits your interests as closely as possible. Some questions ask you to rate the magazine by itself and in comparison to others in the field. (Besides being curious, we at *ham radio* prefer to work with fact rather than fiction.) Other questions attempt to determine, very specifically, your present and future needs. We're only human. Maybe we've left out an area or two you would like to see discussed. Write it down!

What is at stake are your needs. Correspondence and communications — dozens of letters and phone calls each day — coupled with our best intentions and understanding indicate that *ham radio* should continue to provide a technically sophisticated subject menu. With your help we'll be able to vary your diet, make it fuller and more satisfying. Don't stop now — take pen in hand and as neatly as possible (please think of our poor compilers) respond to the survey questions. *All* of your opinions are wanted and needed. Thank you.

Rich Rosen, K2RR
Editor-in-Chief

1983 reader survey

Please reply to the questions below and return this page (or a photocopy) to READER SURVEY, Ham Radio Magazine, Greenville, New Hampshire 03048 by November 1, 1983.

ABOUT YOUR AMATEUR INTERESTS

a. Class of license held__________

Check here if no license held__________

b. Number of years licensed__________

c. In which modes do you operate? (Check all that apply)

	Exclusively	More than 50%	Less than 50%	Never
CW				
SSB/AM				
A5				
RTTY				
FM				
Packet				
Other				

d. What frequency ranges do you work? (Check all that apply.)

	Exclusively	More than 50%	Less than 50%	Never
l-f (1750 meters)				
m-f (160 meters)				
h-f				
vhf				
uhf				
microwave				

e. How much of your equipment do you build?

100%____ 75%____ 50%____ 25%____

Less than 25%____ None____

f. When you build equipment, do you prefer to build:
from a kit____ from "scratch"____

g. What was the most complex piece of equipment you've built in the last 5 years? ____________________

h. How many hours a week do you spend on Amateur Radio operation and activities? ____________________

i. About how much do you spend each year on Amateur equipment?

$100-$500____ $500-$1000____ $1000-$2000____
$2000-$4000____ $4000 + ____

j. From what source do you obtain your books about Amateur Radio?

dealer____ Ham Radio's Bookstore____
other mail order____ at shows____

k. Do you own a personal computer?

Yes____ No____

If "yes," what kind?____________________

If "no" do you:

Plan to purchase within one year ____________
Do not plan to purchase ____________________

ABOUT HAM RADIO MAGAZINE

a. From the following list, please choose the five areas of interest you would most like to see addressed in *ham radio* magazine on a regular basis. Enter your choices, in order of preference (favorite first) in the spaces below:

antennas
awards
book reviews
computers and Amateur Radio
construction (simple)
construction (intermediate)
construction (advanced)
contests
DX
FCC news
future technology
interviews
international Amateur Radio journals
license upgrading

new product announcements
News in Amateur Radio and current events
opinion
operating events
product reviews
Questions and Answers
radio history
receivers
satellites
social events
speech synthesis
surplus (conversions)

test equipment (to build)
test equipment (to buy)
test equipment (to use)
theory (simple)
theory (intermediate)
theory (advanced)
other (please specify)

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________

b. To which Amateur Radio publications do you subscribe?

*ham radio*__________ QST__________ CQ__________ 73__________ Other____________________

c. Of the publications listed above, which one suits your needs best?____________________

d. In general, how do you feel about *ham radio* magazine?

best in the field__________ better than most__________ satisfactory__________ unsatisfactory__________

e. In regard to technical content only, do you feel *ham radio* magazine is:

about right__________ too technical__________ not technical enough__________

f. In regard to clarity and readability, do you find *ham radio* magazine:

well-designed and edited, easy to read__________ satisfactory__________ needlessly complex__________

g. In general, do you feel that the articles in *ham radio* are:

about right__________ too long__________ too short__________

h. Have you ever purchased Amateur equipment as a result of reading about it in *ham radio* advertising?

Yes__________ No__________

i. Have you ever purchased Amateur equipment as a result of reading about it in *ham radio* editorial content?

Yes__________ No__________

j. Have you ever purchased *commercial or industrial* equipment as a result of reading about it in *ham radio* advertising?

Yes__________ No__________

k. Would you be interested in reading about current developments in *commercial or industrial* radio equipment in the pages of *ham radio*? Yes__________ No__________

l. Looking back over the past three months (June, July, August) what one article or feature in *ham radio* did you *most* enjoy? ____________________

Which article or feature did you *least* enjoy? ____________________

m. If you could tell the editors of *ham radio* how the magazine could be improved, what would you say?

____

ABOUT YOU

a. Your age:__________

b. Occupation:__________

c. Income Range (check one): Below $7500______ $7500-$12,999______ $13,000-$19,999______
$20,000-$29,999______ $30,000-$49,999______ $50,000 + ______

Thank you for taking the time to complete this survey.

presstop de W9JUV

1500 WATTS PEAK OUTPUT WILL BE THE NEW LEGAL LIMIT for U.S. Amateurs effective August 29. Acting on PR Docket 82-624, the Commissioners agreed on the new output limits for both SSB and CW July 18. 200 watts out will be the new limit for Novice bands, but 30 meters is still 250 watts input. In addition, AM users will be "grandfathered" use of 1000 watts DC carrier input until June, 1990, as the new limit represents a power decrease for them. At the same time, the FCC deleted the requirement for each Amateur to have instrumentation to assure compliance with the rules on power limits—but individual operators better be sure they're operating within the limits should the FCC decide to inspect their stations!

Next Major New Issue Likely To Appear On The Commission's Agenda is "broadcasting," specifically the endless feuding that occurs between participants in some Amateur nets and individual operators. Expect the subject to surface as a Notice of Inquiry this fall.

OSCAR 10'S NOT-QUITE-AS-PLANNED INITIAL ORBIT apparently resulted from an after-separation collision with the launch vehicle's third stage. Supporting indications include telemetry data from vibration sensors and an apparent change in the radiation pattern of OSCAR 10's 2-meter antenna, a change that could have resulted from collision damage.

The Important Damage Was To The Kick Motor, Which Fired OK for the first burn but did not respond to final burn commands July 25. Though this leaves the orbit significantly off nominal, its final 3951 by 35505 km elliptical path will still provide long openings for users throughout the world. The fact that OSCAR 10 is up and fully operational reflects tremendous credit on its designers, builders and controllers. Just getting a satellite as sophisticated as OSCAR 10 up and operating is a challenge to the most experienced professionals, and for a group of "Amateurs" to accomplish the feat despite a potentially catastrophic accident is almost beyond belief! Congratulations to AMSAT's "Amateurs!"

OSCAR 10's Transponders Should Be Turned On for users by sometime in mid August.

SUPPORT FOR CONTINUING CW LICENSE REQUIREMENTS HAS COME from an unexpected source, the U.S. Air Force, which has advised the FCC it's reinstating Morse proficiency for its radio operator training course. This probably means that a no-code Amateur licensee would not be eligible for Air Force MARS without demonstrating CW ability.

Senator Barry Goldwater Has Strongly Restated His Opposition to "No-Code" in a "Dear Mark" letter to FCC Chairman Mark Fowler. In it he says "I completely support (the ARRL's) Comments" against no-code, and says he believes it would be "a grave mistake to remove the code as a license requirement...." The QCWA also filed strong comments against no-code.

A Decision On No-Code Appears Likely By Year's End, but at this time no one seems to want to make odds as to which way it will go.

"AMATEUR RADIO'S NEWEST FRONTIER," THE NEW AMATEUR RADIO VIDEOTAPE production, is well on its way to release. NBC's Roy Neal, K6DUE, and Westlink's WA6ITF did the taping in mid-July at the ARRL, FCC, AMSAT's Goddard facilities, and with NASA in both Huntsville and Houston. Editing and dubbing were completed July 24, and the new 16-minute Amateur Radio promotional piece should be available about September 1 on VHS and 3/4-inch tape.

THE FCC'S NEW "NO-MAILBACK" NOVICE EXAMS MUST CONSIST of one, two, or three questions from each of 20 FCC-provided groups of 10 questions each. The answers are not included, perhaps because the examiner, as a higher class licensee, should already know what the correct answer--or sometimes answers--is. In addition, it might also give a better opportunity for the examiner to determine if the applicant really knows what he should or is simply parroting back answers from a "study guide."

A Copy Of The FCC's List Of 200 Questions and details on how to administer the new Novice exam are available from ham radio for a business size (#10) SASE.

W5LFL's OPERATION FROM THE SPACE SHUTTLE IS STILL ON SCHEDULE for the end of September. The ARRL is still trying to arrange for a "900" information line to be operational about a week before launch. Information on that line is to be updated frequently, particularly if it pertains to W5LFL's on-the-air activities.

145.55 MHz Should Be W5LFL's Prime Transmit Frequency, with several alternates to be announced shortly before launch along with about 20 receive channels.

"SUPER STRICT" INTERPRETATIONS OF THE FCC'S "BUSINESS COMMUNICATIONS" action that was announced in last month's Presstop were not what the Commission intended. The FCC's action actually changed little in the rules, but was simply meant to be a reorganization and clarification of business communications-related items already there.

Public Service Type Operations Such As Parade or walkathon coordination and the Eye Bank Net are still permitted. Amateur-related operations such as Hamfest "Talk-Ins" and even on-the-air swap nets are also still legitimate. In its release, the FCC stated: "The Order was not intended to impose any new restrictions or to cut back on what Amateurs have legitimately been doing all along. What was intended was to alert the Amateur community to the fact that the Amateur Radio Service should not be used in lieu of other radio services for the transmission of business messages."

Catalysts For The FCC's Action Were Two Recent West Coast Episodes, one in which a "citizens' posse" began using a local repeater as an auxiliary police communications channel. In the other a government facility wanted its employees with Amateur licenses to patrol its fences and gates while using 2 meters for coordination.

PRIVATE RADIO BUREAU CHIEF JIM McKINNEY HAS RESIGNED to become Chief of the FCC's Mass Media Bureau. Jim, who's long been a knowledgeable supporter of the Amateur Service, is replaced by Private Radio Bureau Deputy Chief Bob Foosaner.

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To order, fill out and mail the coupon below. For cash orders enclose a check or money order for $995. Add $5 for shipping and handling in the U.S. and Canada, plus applicable sales tax for CA, CO, CT, IA, MA, NY, WI. (Export price is $1250 F.O.B. Westborough, MA. Specify 50 or 60 Hz.) To use your MasterCard or Visa by phone, call (617) 366-8851.

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☐ Charge to: ☐ MasterCard ☐ Visa

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IF USING CREDIT CARD ______________________

comments

PEP talk

Dear HR:

The article by VK3AFQ (*ham radio*, June, 1983), demonstrates one of the fallacies of defining the legal power limit in terms of PEP output. The metering device described, like the commercially available in-line "wattmeters," is designed to work with a 50-ohm non-reactive load. Not all Amateur stations are equipped with suitable transmatches to arrive at a perfectly matched line at all frequencies within a band — let alone homebrew rigs designed to work into balanced feedline or oddball impedances.

Nor is the statement by Rich Rosen, Editor-in-Chief, that the FCC proposal would increase our power to 1500 PEP output, strictly true. Under present rules there is no limit to transmitted PEP, but practically, the limit is at least 3000 watts (one killowatt input, plate-modulated a-m phone). The power limit for CW, fm, RTTY, and SSTV would be doubled, while the limit for SSB would remain essentially unchanged.

Actually, PEP is useful as an equipment design parameter, but is quite irrelevant to the purpose behind the legal power limit. It is mean, or average, output power that determines the effective field strength of a signal, not the power developed on occasional voice peaks. I believe that if the FCC goes ahead and replaces the relatively simple input power limit with something as complicated to measure as PEP output, the practical effect will be the elimination of a power limit altogether. Many otherwise law-abiding Amateurs will rationalize illegal power by claiming to lack the facilities to make the necessary measurements to comply voluntarily under the new rules. The FCC simply does not have the facilities to routinely inspect Amateur Radio stations for transmitter power.*

Donald Chester, K4KYV
Woodlawn, Tennessee

*It's now official — see *presstop* for details.

simpler "panadaptor"

Dear HR:

I've been an *hr* subscriber since April, 1972, and I can't remember an issue in which I've found more first class technical articles than your February, 1983, number. Congratulations!

Rick Ferranti's "Design Notes on a Panoramic Adapter/Spectrum Analyzer" was particularly interesting. As someone who has worked with a similar homebrew project, I'd like to offer a couple of additional notes.

If you have a receiver with a narrowband CW filter and you don't mind poking a few holes in the cabinet, it may be possible to simplify the panoramic adaptor and reduce the parts count by using the receiver's internal mixer, i-f amplifier chain, and filter. This technique involves substituting an external swept oscillator for the tunable local oscillator of the receiver and substituting the detector and video amplifier of the spectrum analyzer (Ferranti's **fig. 11**) for the receiver's product detector and audio chain. The swept oscillator is connected to the LO port of the receiver's internal mixer stage in place of the internal tuneable LO; and the i-f output is picked off after, rather than before, the receiver's high selectivity filter.

Before this arrangement, the external circuits which comprise the panoramic adapter consist only of: (1) a sweep oscillator, (2) a new "local oscillator" for the receiver having the same tuning range as the receiver's own LO but which can be swept in frequency by the sawtooth output of the sweep oscillator, (3) the detector/video amplifier, and (4) the oscilloscope used to display the signal. For this circuit to function properly, both the tuneable local oscillator and the AGC bus of the receiver must be disabled. The receiver's mixer and i-f amplifiers should have wide dynamic range for best results. Sweep speeds ranging from 50 to 2000 milliseconds are desirable to avoid ringing effects, and these are practical if a long persistence (P7) CRT is used for the display. Finally, it should be noted that this technique is suitable only for receivers that have the same tuneable LO tuning range on each band; but this is true of most modern receivers that use a crystal-controlled first converter stage.

Ferranti's design has the advantage of making it possible to sweep across a wide band of frequencies, regardless of the i-f and LO frequencies of the receiver with which it is used. Using the scheme I recommend, this performance is harder to obtain.

If the highest LO frequency is less than 3 or 4 MHz (this would be true of most "Collins type" receivers using 455 or 500 kHz mechanical filters), there is a simple solution, using the Exar XR-205 "Monolithic Waveform Generator" chip as a swept LO. This chip has a guaranteed sine wave output of at least 2 MHz, and individual chips will run as high as 4 MHz. The frequency can be swept over a wide range, and the sweep is extremely linear with applied voltage.

Where the operating frequency of the LO is higher but still too low to permit the oscillator to be swept by a voltage-variable capacitor of reasonable size, some form of heterodyne scheme is a must. Ferranti's 32.82 MHz VCO (**fig. 5**) can be used, mixed with the output of a fixed crystal oscillator. After passing the difference frequency through a lowpass filter, the resultant would be injected at the LO port of the receiver's mixer stage. Even with this added complication, the recommended circuit will have a far lower parts count than Ferranti's double conversion technique, and there should be fewer critical adjustments.

Miles B. Anderson, K2CBY
Sag Harbor, New York

more 10-meter beacons

Dear HR:

A 10-meter beacon, using callsign KA1YE/B, transmits from Connecticut on 28.284 MHz. It sends a 30-second carrier followed by "KA1YE/B SE CT" and operates continuously at a 4 watt output level to a vertical antenna.

The May, 1983, issue of *Practical Wireless* lists 19 worldwide beacons. A list of active beacons is maintained by Willi, HB9AVE. He would appreciate information from any groups or individuals either operating or planning to operate a 10-meter beacon. There is a limited amount of space allocated for beacon operation on 10 meters here in the States, so some prior listening and coordination is highly recommended before activating a beacon.

I am willing to act as a clearinghouse for U.S. beacon information and activities. If anyone is planning to put a 10-meter beacon on the air, or knows about any other beacons active or planned for the U.S., I would appreciate hearing about it.

W. Keith Hibbert, KA1YE
25 Hillcrest Road
Niantic, Connecticut 06357

linear translators

Narrowband technology and linear systems show advantages over conventional fm designs

Narrowband techniques on VHF, namely SSB and CW, have attracted increasing interest among Amateurs over the past few years. While fm and repeaters provide excellent service to thousands of hams, it is apparent in heavily-populated areas that we cannot go on forever with modes requiring 30 to 40 kHz per QSO (the spectrum needed for a repeater input and output). Several solutions to this problem have been proposed, including single-sideband fm, spread-spectrum techniques, and, more recently, ACSB.[1] With a 3:1 to 4:1 advantage of SSB over fm a 3 MHz repeater pair could support as many as 300 repeater channels using SSB-based techniques. Use of these narrower modes places a new requirement on the "repeatering" techniques which are nicely met by LTs or linear translators.

what is a linear translator?

A linear translator (LT) is a multi-mode repeater — with several important differences from fm repeaters.[a] The basic difference between a translator and a repeater is in detection (**fig. 1**). A repeater detects an incoming signal and then uses the resulting audio (or video) to remodulate a transmitter. A translator merely converts the signal to a convenient i-f frequency, amplifies it, and re-converts it to the desired output frequency without ever detecting the signal; that is, the entire system operates at rf frequencies rather than remodulating a transmitter with detected audio or video. All rf stages in a *linear* translator must operate in their linear region. No limiting or logarithmic processing can be applied. In this way it differs from the fm broadcasting translators used in fringe areas to improve weak signal reception.

A repeater can receive only one frequency and one mode at a time, and retransmit what it hears via only one mode. A translator does basically the same thing but it does it at rf, so that if its i-fs are linear, any mode or signal inserted at the input is reproduced at the output. Even multiple signals at the input will be reproduced at the output.

By James Eagleson, WB6JNN, 280 Manfre Road, Watsonville, California 95076

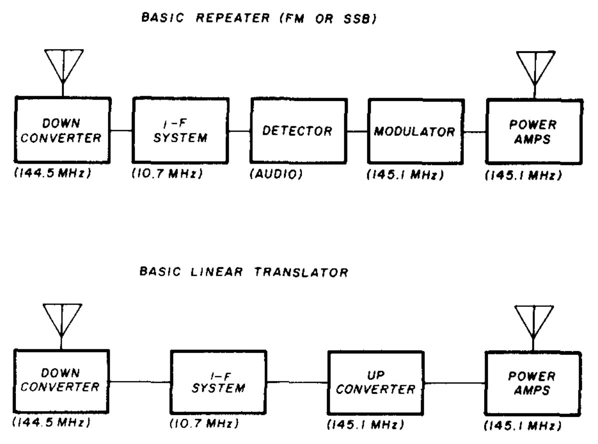

fig. 1. Block diagrams of a repeater and a linear translator.

history of LTs

In early 1980, two linear translators were placed into operation in the San Francisco Bay area.

One machine, built by Narrow Band Communicators, Inc. (NBC, Inc.),[b] is an in-band translator using a standard 600 kHz split. It incorporates two independently AGC'd 10-kHz-wide i-fs and can support as many as four SSB QSOs with minimal interference or two, low-deviation fm QSOs.

The other LT, built by Project OSCAR in cooperation with the Bay Area Two Twenty Group (BATTG),[c] uses an input of 1296.3 MHz and an output of 1269.3 MHz. Its i-f bandwidth is 30 kHz. Its proposed uses as an SDLT (Satellite Development Linear Translator) are:

... to act as a regional "repeater."
... to provide net and bulletin services.
... to provide a source of 1269 MHz signal for OSCAR, Phase III, mode L (24 cm/436 MHz) operation.
... to provide multiple-channel capability for SSTV, Packet Radio and RTTY users.
... to provide experimental data needed to build satellite interties, i.e. interlink translators between satellites.
... to provide an economical means of accessing the proposed commercial geosynchronous satellite with an amateur channel add-on.
... to provide intra/interstate network interties via unused LT channels.

comparing linear translators and fm repeaters

A linear translator provides all the same functions normally provided by an fm repeater. These include extending the coverage of mobile transceivers; extending the coverage of stations with low power, poor locations, or limited antennas; providing a fixed monitoring frequency; and making available a known frequency, power level, and location useful for station evaluation. Additionally, a translator can provide multi-mode operation; multi-station operation; CW (A1); and telemetry, remote sensing, and codestore (mailbox or bulletin) capabilities, all independent of main channel use. With narrowband techniques, both voice and data channels can use an LT simultaneously with only moderate interference.

Although the basic difference between repeaters and LTs is in detection, some operational differences also exist. First, a linear translator does not produce a squelch tail. Also any frequency variations by the incoming signals will also appear at the output — with the same variation. While the noise output of a linear translator is 10-20 dB less than that of an unsquelched fm repeater, its noise floor may be detected by stations close in unless some form of squelch or COR system is used. Another difference is that fringe-area stations may not be able to hear other fringe-area stations, even though all stations local to the LT will easily hear and be able to work both (**fig. 2**).

LT design approaches

SSB translator. Sensitivity: 6-9 dB improvement

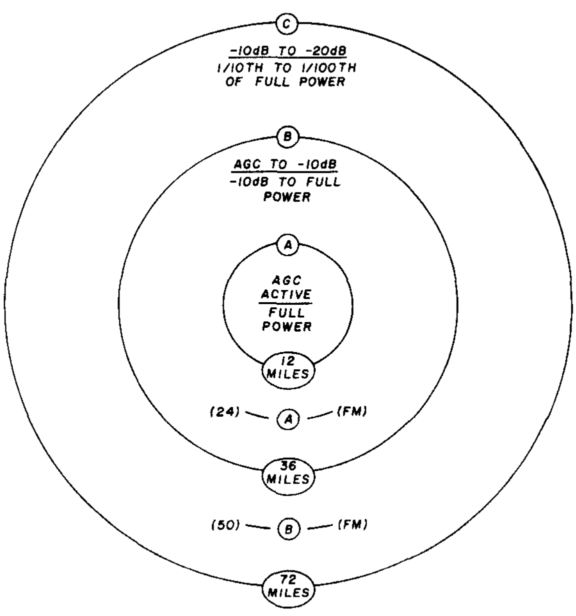

fig. 2. Linear translator coverage diagram. All stations in Region A can hear and work all stations using the LT; stations in Region B can work and hear all but Region C stations; stations in Region C can only work and be heard by Region A stations.

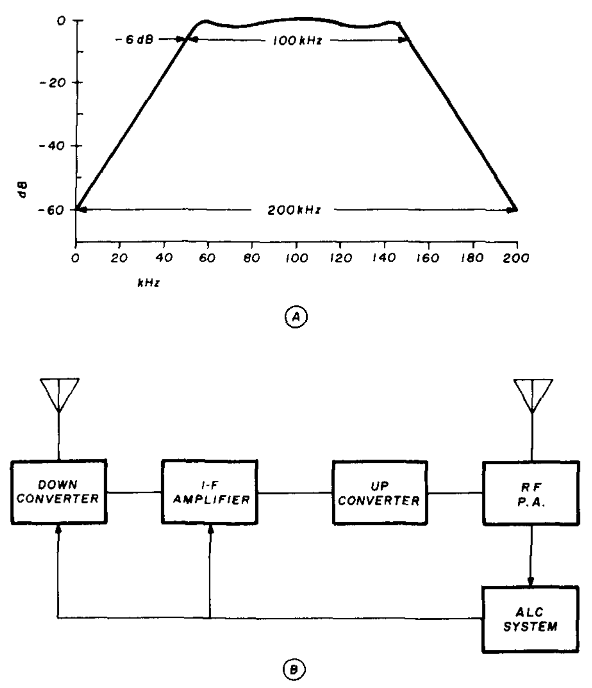

fig. 3. Shared channel block diagram and spectrum requirements.

over an fm repeater;(d) Power output: 200 watts PEP at altitudes limited to 100-watt carrier power on fm; Range: advantage is 1.4:1 over equivalent fm repeater. Using signal-to-noise-ratio enhancement techniques such as ACSB can make this as much as 2:1.(e)

Shared-channel translator. In this system, all stations share one "channel" and derived ALC or AGC is a function of the output of the entire passband (see **fig. 3**). While this technique has the advantage of simplicity and works reasonably well for satellite translators, in which there are only small relative power or range differences between stations, the system is not well suited for land-based use. Several problems exist when using the shared-channel translator with terrestrial LTs that do not occur with multi-i-f LTs.

Selectivity is one of the problems. A 20-kHz i-f filter with a 2:1 shape factor is 40 kHz wide at its −60-dB points. On the other hand, two side-by-side 10-kHz filters are 30 kHz wide at the −60 dB points, since each filter is narrower to start with (**fig. 4**).

Strong signals can desensitize the gain stages in this system and a form of squelch or COR (carrier-operated relay) is needed to reduce or eliminate the LT's noise output when it is not in use. With the single 20-kHz-passband kind of system, the sensitivity of this COR is 3 dB worse than that of a system using two 10 kHz i-fs.(f)

The ARTOB LT. A third method, suggested by Italian ARTOB experimenters,[2] uses multiple i-fs for independent AGC control of smaller portions of a satellite's total passband. This prevents any one station from creating interference on other segments of the passband. The Italian system uses three 30-kHz i-fs yielding a total passband width of 90 kHz. The in-band, 2-meter NBC translator uses a slightly different approach, with two 10-kHz i-fs plus one 3-kHz "single channel" i-f. AMSAT Canada, in their SYNCART proposal,(g) suggests using one 100-kHz general-purpose i-f flanked by two 10-kHz, special-service i-fs (one for data and one for bulletin, net, and special uses). All of these systems were developed about the same time to meet specific requirements.

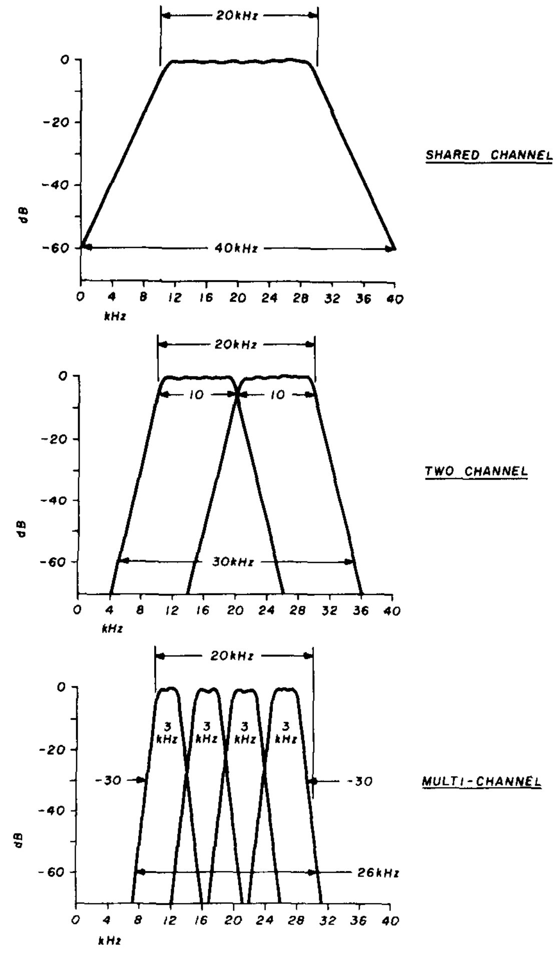

fig. 4. Spectrum allocations for a shared channel, two channel and multi-channel system.

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advantages of multiple i-fs

With the use of multiple i-fs, any i-f can be turned on or off at any time to help control interference, reduce noise from unused channels, or to allow re-use of the edge of one LT by the edge channel of an adjacent one. Out-of-channel noise and i-f-caused distortion products can be more closely controlled by the use of multiple, narrow i-fs. A 20-kHz-wide LT using five 3-kHz-wide i-fs has a −60 dB bandwidth of 24 kHz; by contrast, a single i-f system has a −60 dB width of 40 kHz.

Under low-use conditions, when the number of stations is fewer than ten (the normal situation on a 20-kHz-wide LT), better control of AGC pumping by strong stations can be maintained. With a multiple 3 kHz channelized LT all stations can provide full output regardless of the ratio of the strongest to weakest station. Intermodulation-related interference between the various channels can still occur, but even this is improved by the multiple i-f technique.

A multiple i-f channel system can dedicate specific channels for special uses. SYNCART has a hard-limiting fm-AFSK (ASCII) 15 kHz channel for data transmission, a general-purpose, 100 kHz-wide channel for operation similar to present OSCAR satellites, a special 100-kHz i-f for RTTY, SSTV, and ASCII narrowband techniques, and a reserved 15-kHz i-f for educational, bulletin, net, and emergency uses (**fig. 5**). Terrestrial LTs could have 1-kHz i-fs for CW/FSK, 3-kHz i-fs for SSB, 10-kHz i-fs for fm or shared SSB, or some combination providing multiple uses.

system design

Design considerations for a linear translator are somewhat different from those for an fm repeater.[h] For one thing, many integrated circuits, such as the CA 3089 or MC 1357, are not available for linear receivers.

The general scarcity of knowledge about LTs is reflected in the lack of surplus or commercial linear translators, the unavailability of step-by-step LT repeater handbooks, and the absence of experienced commercial LT users. Even AMSAT, probably the most experienced developer of LTs for the OSCAR satellites, has not published much on their design and construction.

building a linear translator

The power amplifier. Multi-station LT operation requires better than average linearity in the PA stages, with greater than 40 dB third-order IM distortion the goal. A maximum output of 100 watts from the amplifier, using two 80-watt stages, should produce an amplifier capable of meeting the design goal. The addition of a 3 dB or higher gain antenna brings the ERP level up to 200 watts.

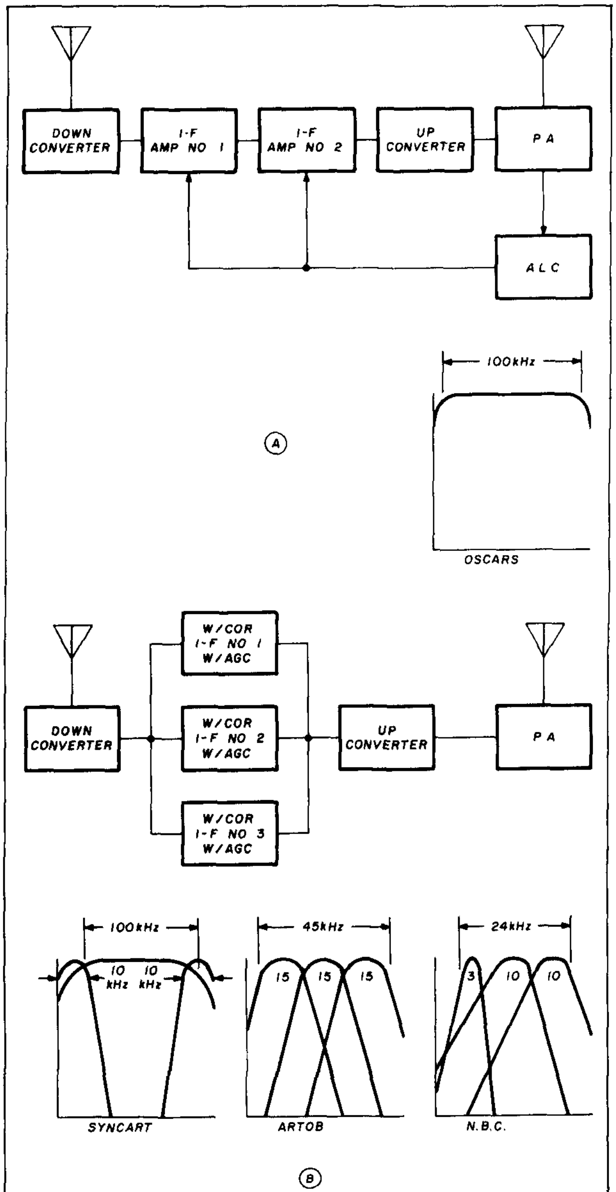


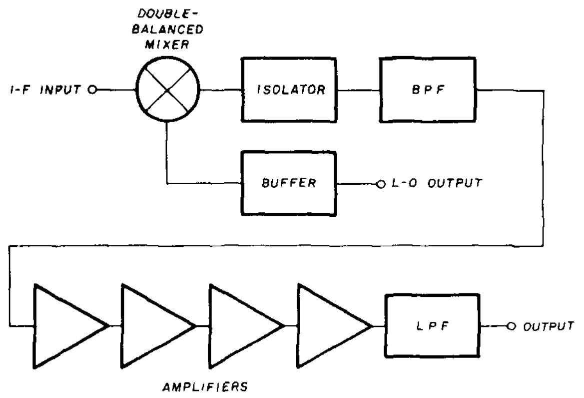
fig. 5. OSCAR transponder and ARTOB, SYNCART, and NBC linear translator block diagrams indicating i-f channel spectrum allocations.

Transmit chain. An output power level of 100 watts helps define the gain required between the transmit up converter and the output port (**fig. 6**). Using a high-level, double-balanced, diode-ring mixer — such as the Mini-Circuits SRA-1H, the Cimmaron CM-1H, or equivalent — IM_3 products should be 40 dB below each output tone at an input signal level of 0 dBm PEP. This translates to an output level of

approximately −7 dBm PEP from the mixer (normal losses) with another 1 dB lost in the image bandpass filter. The resultant input to our transmit PA amplifiers is −8 dBm PEP. An output level of +50 dBm requires +50 − (−8) or 58 dB gain for achieving our goal. **Fig. 7** can be used to work with different power levels.

I do not recommend using lower cost double balanced mixers for the upconverter. A 10 to 25 watt system might be able to make use of them, but the spurious-free output of the high-level mixers is easier to filter than that of the "standard level" units. The addition of a local oscillator buffer helps drive the high-level mixer LO ports to +17 dBm. If standard level mixers are used, all ports must be terminated in 50 ohms at all rf, i-f, LO, harmonic, and image frequencies. Not doing so can affect linearity and spurious content significantly.

The front end. Next in importance to the transmit chain is the front end of the LT. Too much gain can produce intermodulation products, desensitization, crossmodulation products, and other related problems. Too little gain reduces sensitivity for weak-signal reception (poor noise figure) and makes the choice of i-f gain more critical. The best choice for a mixer for the receive converter (down converter) is the double-balanced, diode-ring mixer. Although its inherent loss worsens the front end gain, other kinds of mixers (especially the bipolar) provide gain at the expense of poorer noise figure performance (10 dB typical versus 6.5 dB for a double balanced mixer), poorer IM, desense, or crossmod, or poorer port-to-port isolation.[3] The best compromise seems to be a good low-noise preamp followed by a good double balanced mixer feeding an i-f amplifier with a 2-4 dB noise figure.



recommended active devices

power level	device
100 mW	2N4427, 2N5109
1 W	2N5590, 2N6080
10 W	2N6081, MRF 239, MRF 240
25 W	MRF 240, B-40-12
50 W	MRF 240, B-40-12
100 W	4X 250 (tube)

fig. 6. Block diagram of a linear translator transmit chain. Recommended active devices are listed for each power level.

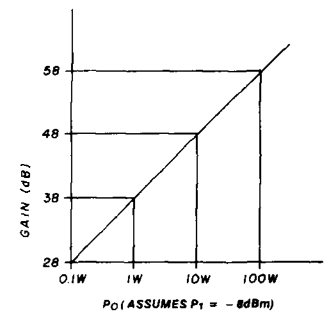


fig. 7. Chart detailing PA gain requirements versus desired output power levels.

The preamp's gain should not exceed 25-30 dB, and it should have a noise figure of less than 2.5 dB. This is easily obtained with single-stage GaAs FETs with noise figures under 1.0 dB. The J-310 and U-310 JFETs can also be used in two-stage preamps yielding a 1.8-2.2 dB noise figure with 25 dB gain. Another good choice is the CP-640 or 643. These units can give reasonable noise figure and excellent high-level performance at higher voltages. The older FETs (such as the MPF-102 and 40673) should be avoided because they do not provide the IMD, crossmod, and desense performance required for LT service.

A word of caution concerning GaAs FETs. Though they provide excellent performance with less than 0.5 dB noise figure and better than 100 milliwatts 1 dB compression point performance on 2 meters, they can be destroyed by improper handling. Oscillations resulting from improper terminations, insertion into systems not having adequate TX/RX isolation in the duplexer system, and static discharges (even when the device is not turned on) can all cause failure. Careful handling is necessary.[4]

Noise floor output. The noise floor is the amplified output of the noise generated in the front end and i-f amplifier stages. In an fm repeater this noise is equal to the output of any station received by the system but it is squelched off when no signal is present and masked by signals when they are there. In an LT, the noise output depends on the gain of the system, overall noise figure, and the amount of external noise amplified by the system. Since it's not desirable for a repeater to transmit constant noise, some control is needed.

For high-altitude, balloon-borne LTs like the ARTOB experiments, or for orbiting LTs such as the OSCARs and RS, no COR or squelch is required.

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Everyone is far enough from the LTs so that by setting the noise output at about 30 dB below the maximum LT output level no one complains about the passband noise — even though it is transmitted continuously.

The terrestrial situation is different. Stations may be within one or one hundred miles of an LT, and a 40-dB stronger signal is received at the closer location. At this close station, the noise output of the LT will be heard quite clearly. The answer, of course, is squelch or COR. For the NBC machine we chose to operate the PA systems using COR. Single-channel or multiple-channel systems could use squelch on each channel.

Noise floor versus full output level. A 30-dB full-output to noise-output ratio has been adopted by the ARTOB and OSCAR LTs. Will that suffice for a terrestrial LT? There are several arguments for and against it.

The argument for it is that, almost universally, the typical ham operator begins to feel that a signal is strong when it approaches a 30 dB signal-to-noise ratio (SNR). While we rarely obtain 30 dB SNR on the hf bands (at least signal-to-*interference* levels are more typically in the 5-15 dB range), if there is only noise behind the signal, 25-30 dB SNR is where most of us would start calling it S-8 or S-9.

On the other hand, weaker stations using a system set with the AGC 30 dB above the noise floor are clearly at a disadvantage. A signal arriving at 10-15 dB above the noise floor, for example, would have an output 15-20 dB below the typical strong signal. This means that fringe area stations could access the LT and work stations local to the machine, but would not be heard by another station in their own area or in some other fringe area of the LT.

It is my opinion that an LT using COR or squelch or both can provide more gain so that weaker signals will be more intelligible. The additional noise will be squelched off when the LT is not in use and stronger stations will reduce the gain through AGC action thus reducing the background noise, with a subsequent improvement in SNR. This can be especially helpful in single- or multi-channel systems where AGC pumping of one signal by another signal is less of a factor.

Recommendations. *SSB repeater:* AGC at 12-15 dB above noise floor; *Multi i-f LT:* AGC at 18-25 dB above noise floor. Certain i-fs, especially narrower, single-station ones, can have a 1-3 dB higher AGC setting. *Shared channel:* AGC at 25-30 dB above noise floor.

Measurements are made using 2.4-kHz instrumentation or receiver bandwidth. Noise output is directly related to the noise bandwidth by this formula: $dB\ change = 10 \log B_1/B_2$. Consequently, if a wideband output meter is placed on an LT with a 30 dB SNR in a 2.4-kHz bandwidth, the meter would see only a 20 dB SNR (if the LT's entire passband is 24 kHz wide).

i-f amplifier gain. The i-f amplifier must provide enough gain to bring the equivalent noise input of the preamp/converter up to a level that is 30 dB below the desired maximum output level (AGC maximum level). This assumes, of course, that our design goal is 30 dB AGC to noise output ratio. We've previously shown that the front-end gain consists of 25-30 dB preamp gain with a mixing loss of about 7 dB, leaving a front-end (down converter) gain of about 18-23 dB. For our purposes, we will assume 20 dB.

An additional factor must be considered. All preamps internally generate their own noise. Noise figure is the ratio of a preamp's actual noise output relative to what its output should be if it did not add any noise of its own to the system. In other words, while a perfect 10-dB gain preamp would give $-140\ dBm + 10\ dB$ or $-130\ dBm$ *noise output*, a typical low noise figure preamp would actually give about 2 dB more noise output, that is, −128 dBm. Consequently, a signal arriving only 10 dB above Johnson-Kelvin noise yields a 10 dB SNR with our perfect preamp, but only 8 dB SNR in our practical preamp.

The formula for determining the Equivalent Noise Input (N_{equiv}) of any receiver is:

$$N_{equiv} = -174\ dBm + 10 \log B_{Hz} + NF_{dB}$$

For our LT system, assuming a system noise figure of 3 dB and a bandwidth of 2400 Hz, N_{equiv} is:

$$N_{equiv} = -174 + 34 + 3 = -137\ dBm$$

For a noise output 30 dB below full output, our output noise level is:

$$N_{out} = P_{out_{max}} - SNR_{Desired}$$

Since we've settled on 30 dB for this case, and we've determined that 0 dBm is our $P_{out_{max}}$ i-f noise output is:

$$N_{out} = 0\ dBm - 30\ dB = -30\ dBm$$

The required i-f gain to achieve this noise output is:

$$G_{i\text{-}f} = N_{out} - (N_{equiv} + G_{DnCv})$$

For our example:

$$G_{i\text{-}f} = -30\ dBm - (-137\ dBm + 20\ dB)$$
$$= -30\ dBm + 117\ dBm$$
$$= 87\ dB$$

too much gain

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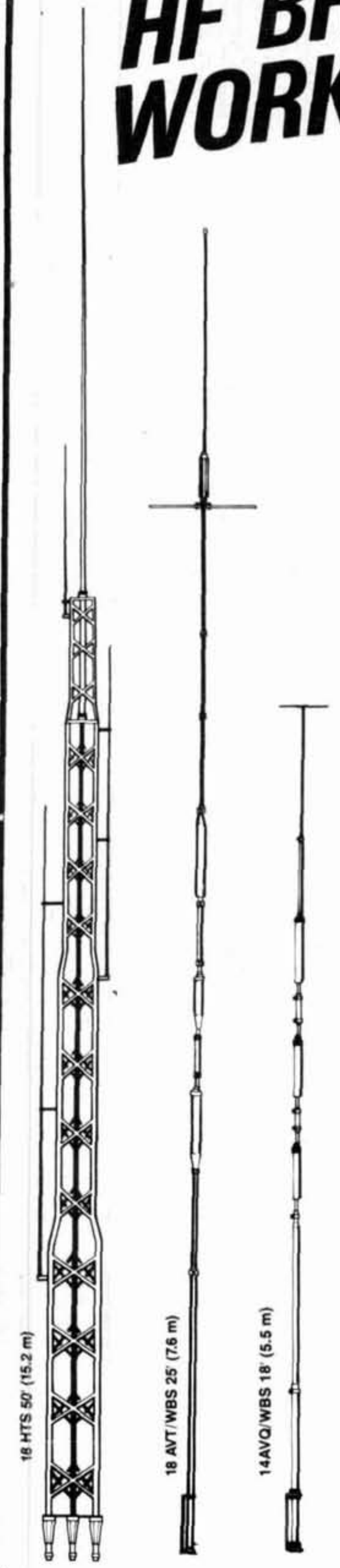

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14AVQ/WBS (40-10 meters) Offers very similar construction and the same excellent broadband performance as 18AVT over the entire 40, 20, 15 and 10 meter bands; automatic band switching with mechanically superior large-coil Hy-Q traps and very low angle radiation pattern. The smaller, low visibility size also makes the 14AVQ very suitable for roof mounting. The optional 14RMQ roof mounting kit includes base plate, mast and radial/guy wires. All antenna hardware is stainless steel.

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Other Hy-Gain vertical multiband antennas are available though not shown here. The 12AVQS (20, 15, 10 meter) is similar to 18AVT above but with VSWR of 1.5:1 or less on all bands. The 18VS (80-10 meter) comes with a base loading coil and may be installed on a short mast driven into the ground. All include stainless steel hardware.

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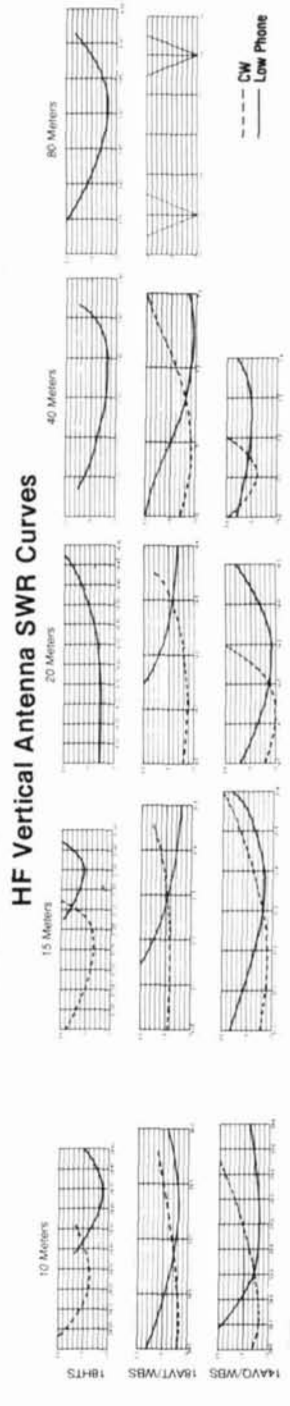

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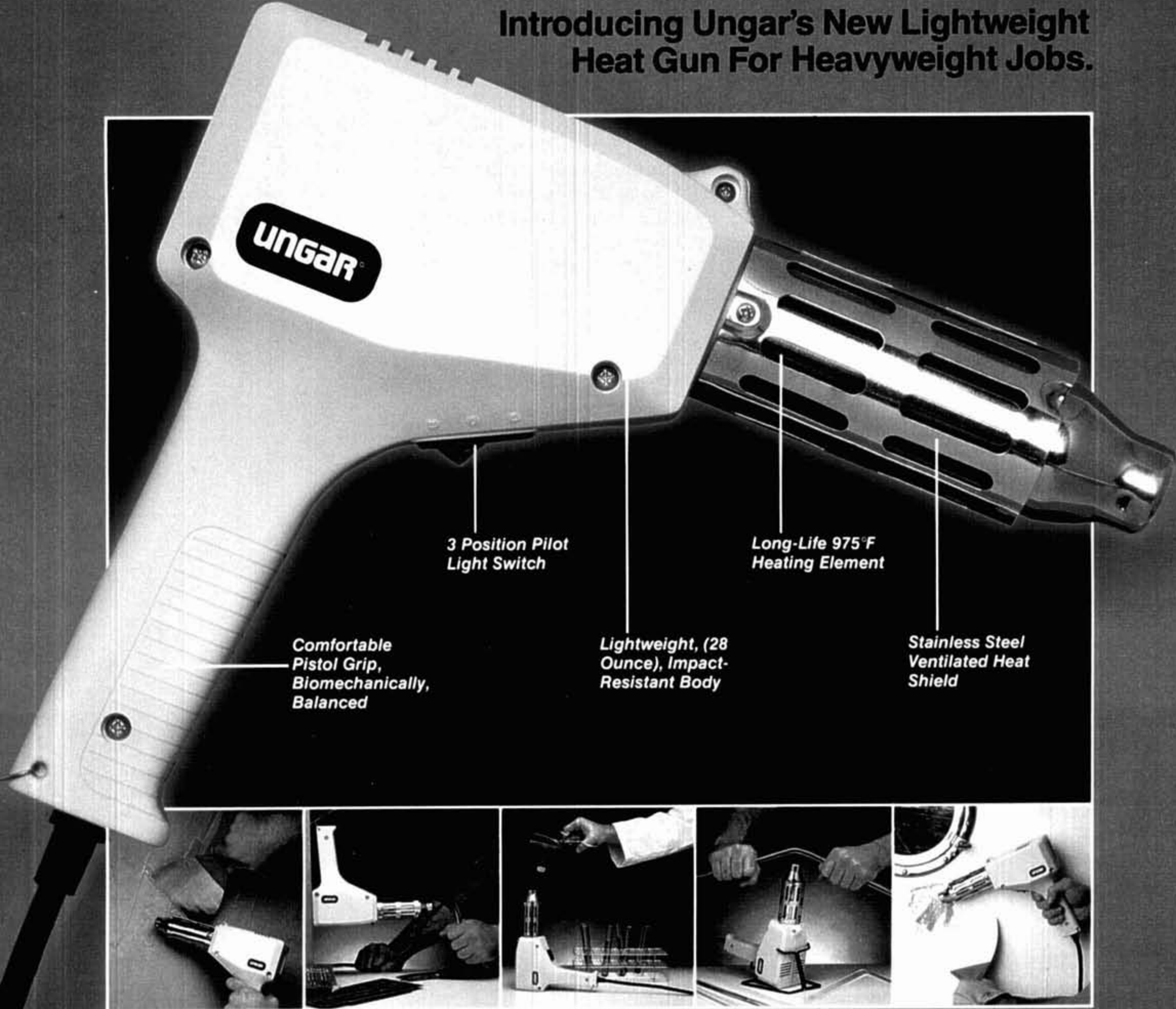

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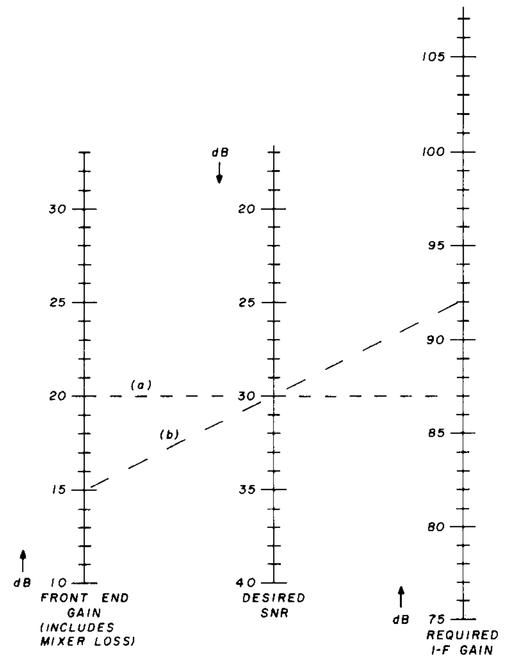

fig. 8. Nomograph illustrating the relationships between front-end, i-f gain requirements and desired signal to noise ratio.

control, gain exceeding 75-85 dB also begins to get unmanageable at most i-fs. This is why most fm radios use two i-fs, 10.7 MHz and 455 kHz, before detection. The amount of gain required to provide good fm limiting (about 90 - 100 dB at i-fs), exceeds the gain practical on any one given frequency. The same technique is applied to the LT design, that of splitting up the gain-producing stages at two different frequencies.

With a practical limit of 85 dB on any given frequency, a translator that uses a single i-f can set the noise floor no higher than about −30 dBm, or about 30 dB below full output. This gain is reasonable for multi-i-f or broadband single-i-f systems (assuming care is taken in shielding and layout), but cannot be pushed further for a repeater-type system (**fig. 8**).

a different approach

An approach I've wanted to try but have not yet had the opportunity to get to is the use of two lower gain i-fs on frequencies separated by the TX/RX offset split. The signal would be converted to 10.7 MHz, amplified by a factor of 50 dB, converted to 11.3 MHz (600 kHz up), amplified another 50 dB, and then converted to the output frequency.

This has two advantages. The same local oscillator can be used for both receive and transmit conversion, since the transmit i-f is already 600 kHz above the receive i-f. Also, improved frequency stability can be achieved using a subharmonic output from a stable oscillator. This means that any receiver LO drift is tracked precisely by the transmit LO (which is the same in this case), and drift of the i-f to i-f converter oscillator is divided by the same ratio used to obtain the 600-kHz injection signal. Example:

$$144.510\,MHz - 133.810\,MHz = 10.700\,MHz$$
$$10.700\,MHz + 0.600\,MHz = 11.300\,MHz$$
$$11.300\,MHz + 133.810\,MHz = 145.110\,MHz$$

The 600 kHz can be derived from a 4.8-MHz crystal (divide by 8). Its drift at 4.8 MHz will likely be less than 100 Hz over moderate temperature excursions, thus the 600 kHz will drift only 100/8 Hz, or 12.5 Hz.

clamping the offset to 600 kHz

For in-band translators or SSB repeaters using normal offsets (600 kHz on 2 meters, 1.6 MHz on 220, and so forth), the one-frequency i-f scheme presents a slight problem in another area. If the offset i-fs are not used, the drift between the upconverter and downconverter LOs can be as high as 200-400 Hz. This is unacceptable on SSB.

NBC's solution was simple. The receiver's LO was made into a VCO (voltage-controlled oscillator) and slaved to the transmit LO after both were divided down to 600 kHz. Using this phase-locked loop (PLL) provides for nearly perfect 600-kHz offset with an error only as large as the drift of the 600-kHz reference oscillator divided by whatever divide ratio one is using. In fact, the NBC system uses a standard 10.240-MHz reference oscillator (as used in many CB sets and ham rigs), dividing everything down to a standard 10-kHz reference frequency using standard, well-proven CB-type PLL circuitry and parts. Thus our TX/RX offset accuracy is 10.240/0.600 MHz, or seventeen times better than that of the 10.240 MHz oscillator. Since this may drift less than 100 Hz under normal temperature conditions, our offset drift will typically run less than 100/17, or about 6 Hz (**fig. 9A,B**).

other problems

LTs have a new set of problems not generally seen on fm repeaters. The first problem is impulse noise. While an fm repeater in the presence of noise squelches more tightly, an LT will break squelch and retransmit that noise with the degree of fidelity its i-f selectivity allows. There are two methods of preventing this: 1. use a more sophisticated squelch system than the usual level detector, or 2. prevent noise from getting to the detector by using an effective form of noise blanking.

Single-channel systems (SSB repeaters, multiple-single channel systems) could use the ratio squelch systems developed by Kahn some years ago (**fig.**

10A and **B**). This device is sensitive to voice characteristics and triggers a squelch detector driven from an audio (or i-f) ratio detector or discriminator.

Single-channel systems can also use sub-audible carriers for COR (**fig. 10C**) or squelch triggering. If each station transmits a carrier, say, within ± 100 Hz of the frequency where the COR or squelch is tuned (whether an audio detector or narrowband 300-Hz i-f filter is used really doesn't matter), only signals at that frequency trigger the system. Noise, being broadband, needs to be much stronger to trigger the system.

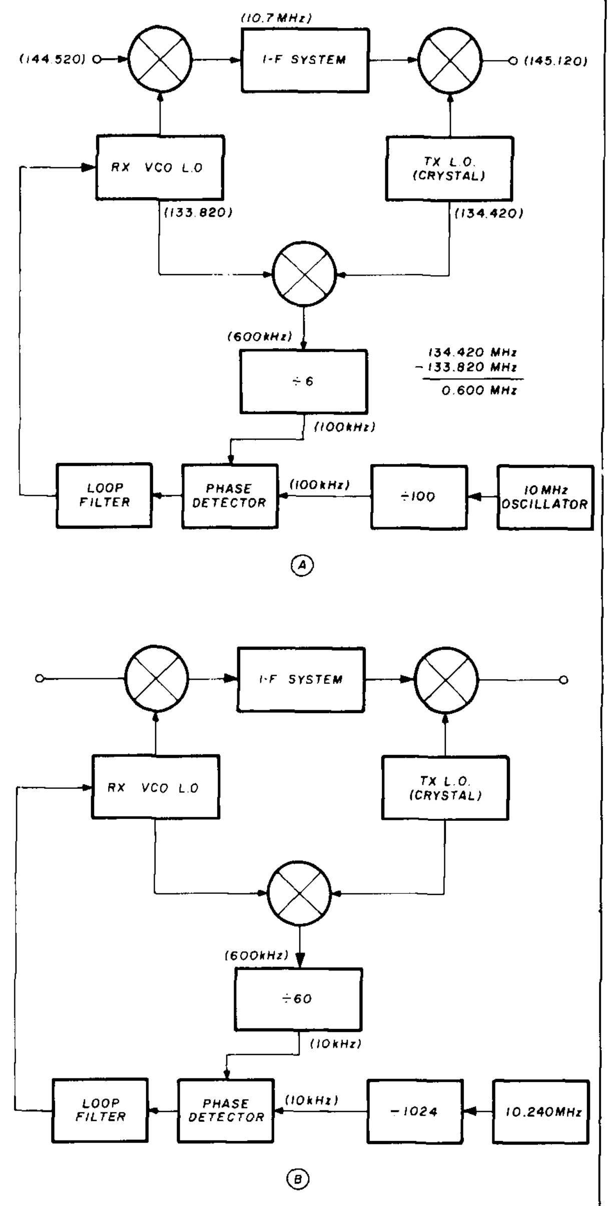

fig. 9. (A) NBC linear translator's solution to the drift problem uses the receiver's LO, a VCO slaved to the transmit LO through a phase-locked-loop. (B) NBC linear translator using an alternate PLL system with a 10.240 MHz reference oscillator.

If the entire passband of the LT is converted to audio frequencies, a series of af filters driving individual detectors can be used to cover the entire passband in 1-kHz steps (**fig. 10D**). If any one detector is triggered by audio in its frequency range, it will turn on the LT. The 1-kHz selectivity still provides some discrimination against triggering on noise by reducing it by 4 dB. Additionally, this provides greater sensitivity to weaker desired signals in the smaller bandwidths.

Another system uses two detectors with a comparator so that one averages noise, pulses, or signals present and the other sees the peak value (**fig. 10E**). CW, SSB, or fm have a fairly low peak to average ratio, so that if the comparator's gate signals were set to trigger only on signals whose peak to average value was less than 4:1, most pulse-type noise would not trigger it, since its peak to average is typically much higher than 4:1.

None of the above systems have been tried on the NBC LT. Reports on your experiments would be appreciated. We have chosen merely to monitor the system and reduce i-f gain when noise becomes a problem. This isn't elegant, but it works!

Noise blankers present a particular problem in LT service. While it is not difficult to produce a noise gate and the associated detector scheme, it is difficult to operate any NB system in a full-duplex system. The transmitter signal is usually strong enough, even after a duplexer, to cross-modulate the noise blanker.

Here are a few suggestions for resolving the noise blanker problem. The first is to detect and trigger on out-of-band noise pulses. Collins has used this technique for years and many CB sets have NBs tuned at 24 MHz rather than 27 MHz so that stronger signals aren't detected in the pulse detector circuit, causing crossmodulation products in the system. For 2 meters or other VHF/UHF frequencies one can tune just below or just above the band to find a 100-200 kHz range that is free of strong signals, convert it to an appropriate i-f, then build the pulse detector around that. A notch filter at the output frequency of the LT might also be required to protect the NB downconverter.

A more standard i-f-type noise blanker immediately following the downconverter of the LT could be used if run through a 30-kHz crystal filter to remove the output and strong adjacent signals. This will not be quite as effective due to the narrow bandwidth (pulses will tend to ring and broaden), but is used effectively in many 2-meter SSB rigs. Strong signals on immediately adjacent channels (± 20-30 kHz) may also cause some problems. Use of a 40-60 kHz filter

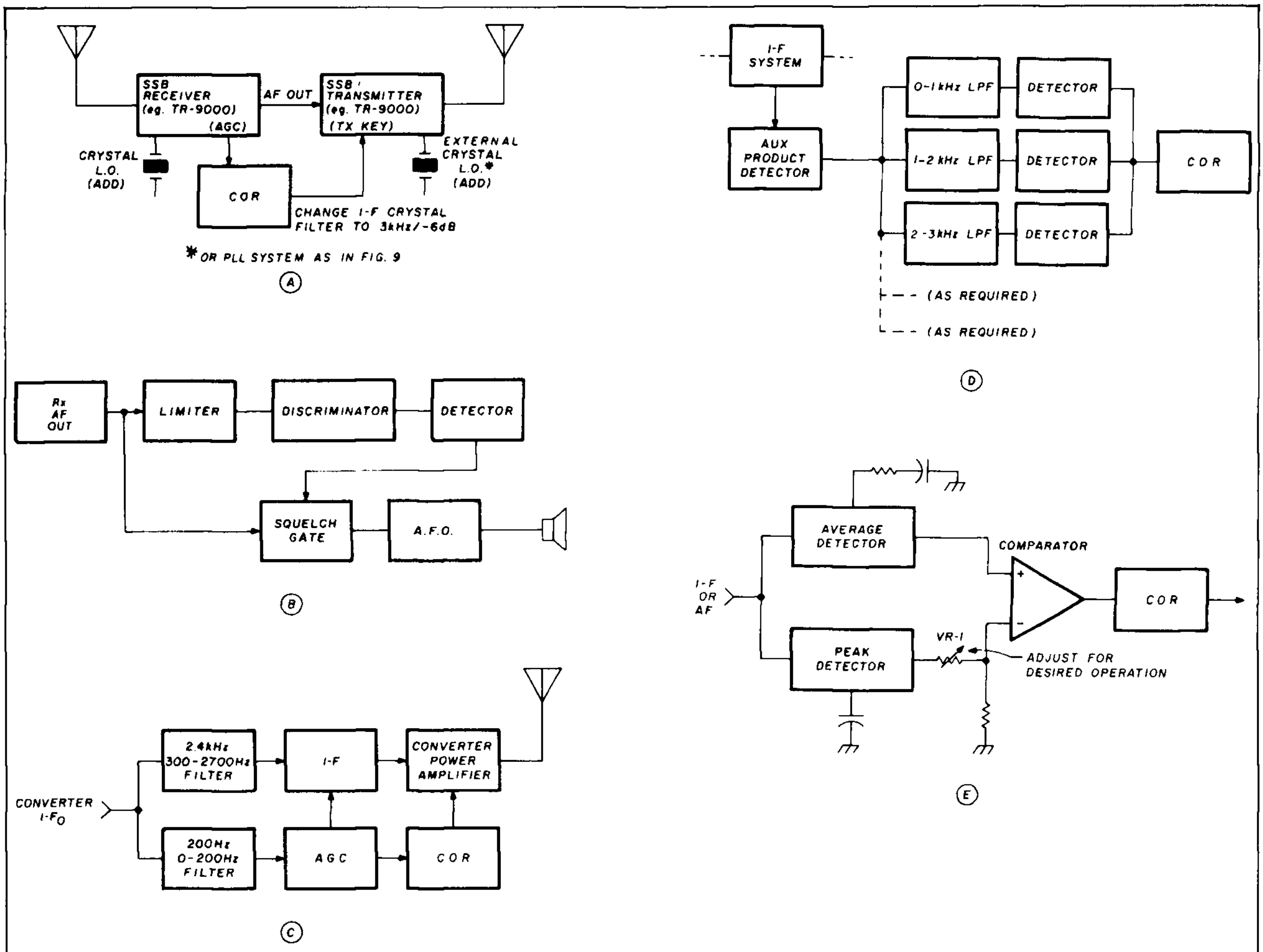

fig. 10. (A) SSB repeater block diagram. Use external TX and RX LO's or PLL system of fig. 9(A) and (B); (B) Ratio squelch design developed by Kahn is useful in both single and multi-channel systems; (C) Single-channel system use of sub-audible carriers for COR or squelch triggering. AF filtering off a detector or appropriate i-f filters can be used; (D) An alternate method of turning on an LT uses a series of 1 kHz bandwidth audio filters that drive individual detectors; and (E) An alternate COR system uses a comparator fed by an average and peak detector circuit. Decision is based on the ratio of average to peak levels received at the comparator.

might improve pulse sensitivity giving better blanking, but would increase the risk of adjacent channel crossmodulation.

With either technique some further crossmodulation protection can be obtained by using an averaging AGC having a slow attack and release characteristic. This will clamp CW, a-m, or fm signals (including SSB) when they start approaching the crossmodulation level, but will not clamp fully on quicker noise pulses. This technique is used quite effectively on many h-f ham rigs, but can be difficult to set up properly (as can be seen by other hf rigs having similar noise blankers that don't work). Fortunately, we are working with a single band and only a few kinds of noise on VHF, so that level setting of the AGC and its attack/release characteristic is not as critical.

I should point out that the reduction of gain which prevents crossmodulation of the noise blanker by signals will also reduce sensitivity to noise pulses so that such signals will at some point, in essence, turn off the blanker.

For the NBC translator we use an attenuator in front of the i-f amplifier to reduce the overall gain (prior to AGC) so that the normal noise floor and external interference are both dropped below COR threshold. This also reduces weaker station levels, but without some kind of noise blanker those stations can't be copied anyway. The argument in favor of the use of a noise blanker in spite of these technical problems is that they extend the weak signal capability of the LT by 6-12 dB in typical environments. Mountain-top locations may be quiet enough, however, to obviate the need for a blanker.

A comment on i-f clean-up filters should be interjected here. Unlike repeaters whose bandwidth is automatically limited by de-emphasis and modulator bandwidth, an LT passes all i-f generated noise to the output frequency. Since the crystal filter is normally placed at the very front of the i-f strip to provide best IMD/selectivity performance, it does not limit the output of noise from any of the following i-f stages. The only selectivity limiting noise output from the i-f stages is provided by the interstage transformers and tuned circuits. At 10.7 MHz we see a noise bandwidth of about 120-250 kHz at the 3 dB points and only about 30 dB down at the 500-1000 kHz points. Needless to say, this is unacceptable at the output of the LT.

Fig. 11 illustrates several ways to improve this situation. The best (and most expensive) is to use an input and output filter on each i-f so that the noise output is essentially limited to the bandwidth of each i-f. A good compromise, though not best in terms of adjacent-channel and front-end and IM considerations, is to use a single filter as wide as all i-fs combined in front of the first couple of i-f stages, then split (or convert) the signal to individual i-f amplifiers each having individual filters. This controls the channel to channel IMD and noise outputs. Only noise from active channels can reach the upconverter and PA stages. Additionally, IMD products created in the first i-f will not spill over into the second i-f, and the output clean-up filter of i-f number 1 will not allow IMD products outside of its passband to be passed to the upconverter.

In areas of high signal congestion, better selectivity at the input may be more desirable. In this case, filters are placed at the input of each i-f with one clean-up filter at the output-combining point of the system. This causes broader i-f noise and IMD output and loses some of the advantages of shutting off unused i-fs to reduce output bandwidth.

Last, unlike fm repeaters, an LT will likely see positive feedback or regeneration when there is insufficient TX/RX isolation because of poor shielding, filtering, or inadequate duplexers. This shows up as what most people would term distortion, though it is really regeneration or noise pumping. Oscillations can also occur. Squelch and COR setting can also be aggravated as can the ratio of AGC to noise floor.

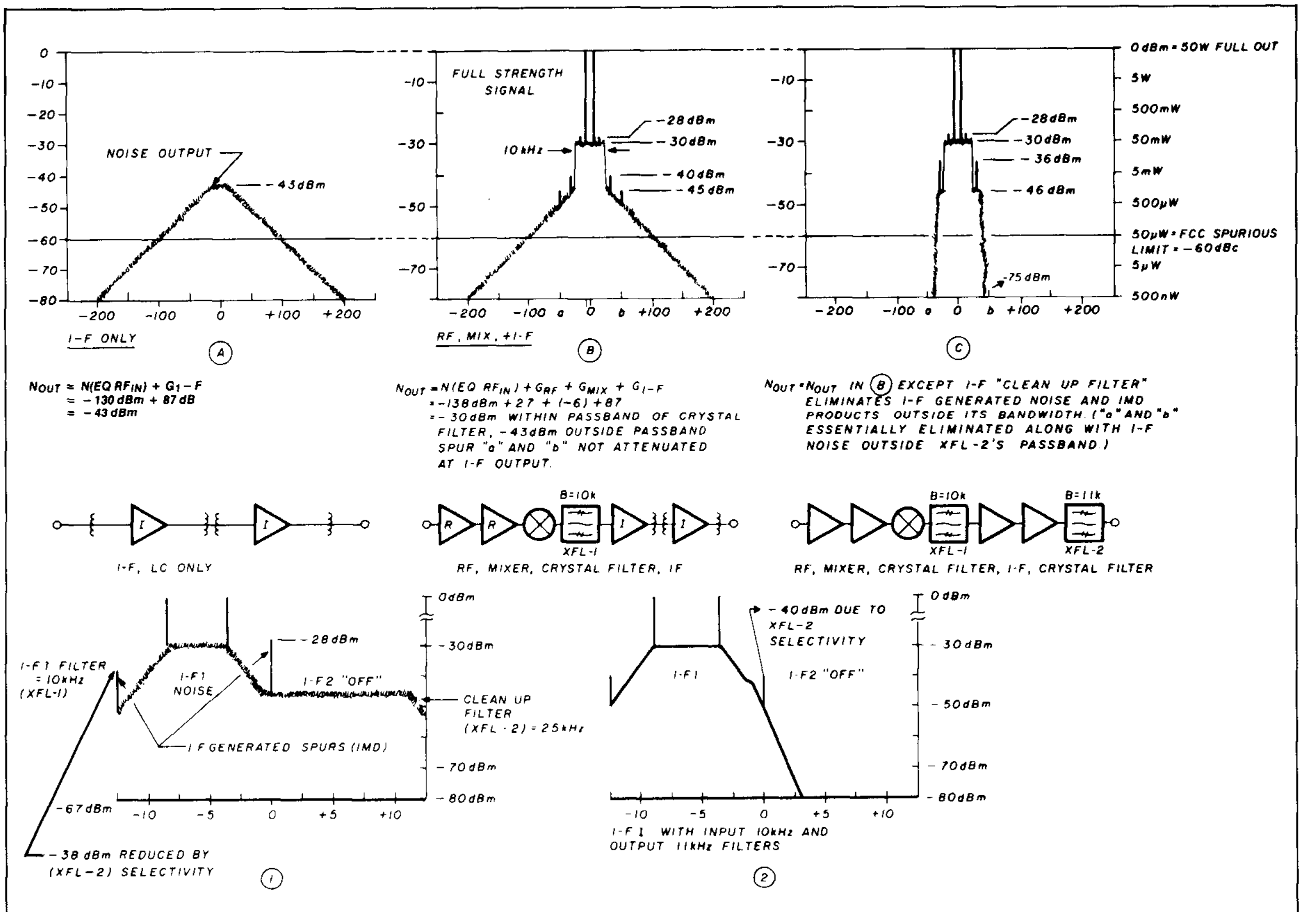

fig. 11. Filter techniques used to reduce the noise output of an LT.

summary

Current exploration of narrowband modes by the FCC, coupled with our understanding of the bandwidth, DX, and multipath advantages of SSB, now make the time right for hams, as the most experienced users of VHF/UHF SSB, to contribute once more to experimentation and expansion of the state-of-the-art. Building an LT is, at least, challenging, and, at most, could help develop a new technology.

I would be happy to assist anyone wishing to build an LT. For a complete set of schematics of the NBC LT, send $1.50 and a large SASE directly to me. I'll also respond to questions; just enclose an SASE with all inquiries.

notes

(a) FCC practice in fm and TV broadcasting is to give the name "translators" to stations that receive signals and change them to another frequency to extend coverage. AMSAT and many satellite agencies tend to use the term "transponder." My feeling is that after many years of such use in aviation, "transponder" has come to mean a device that returns a specifically coded signal when interrogated by a radar pulse; a "translator" merely translates, with no other modification or detection, an incoming signal from one frequency to another.

(b) The two meter, in-band Linear Translator is located in Twaine Harte, California and provides 50 watts ERP at 144.52/145.12 MHz in keeping with suggested ARRL Two Meter Band Planning. Information can be obtained by writing Neil Lewis, WB6VIV, 8119 Phaeton Drive, Oakland, California 94605. For specific technical information, contact the author. (SASE requested in either case.)

(c) This machine was taken off the air in 1981 for modifications and has been overhauled to act as a development LT for Project OSCAR's SYNCART satellite project. It should be back on the air by the time this is published, with input at 1296.3 MHz and 145.7 MHz with output at 435.415 MHz. Inquiries concerning it should be addressed to Project OSCAR, c/o the author at his home address. (SASE required.)

(d) Fm receiver selectivity = 18 kHz, typical SSB receiver selectivity = 2.4 kHz, typical SNR improvement (SSB over fm) = 10 log 18/2.4 = 9 dB.

(e) Note the 9-dB bandwidth advantage (particularly below threshold for fm) coupled with the additional 6 to 18 dB SNR improvement given by use of ACSB. This offsets most, if not all, of fm's noise-limiting capability.

(f) Sensitivity improvement = 10 log 20/10 = 3 dB.

(g) This proposal has been reworked recently by AMSAT Canada and Project OSCAR. The original host launch was cancelled due to delays in the Space Shuttle program. Two possible upcoming launches will not allow time for a SYNCART-style transponder to be developed. Work continues, however, on SYNCART development for possible later launches.

(h) This section, although describing an LT design, can be used to improve fm repeater designs.

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2. Piero Moroni, I5TDJ, "A New Transponder for Amateur Satellites," *AMSAT Newsletter*, June, 1978.
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ham radio

a fail-safe amplifier power supply

An improved method of providing dc voltages to GaAs FET amplifiers

It has long been recognized that certain semiconductor devices require a pair of voltages of opposite polarity for proper operation. Amateurs have begun using one of these devices, the gallium-arsenide field-effect transistor (GaAs FET), in low-noise preamplifiers on the bands above 100 MHz. But the (N-channel) GaAs FET requires that a negative voltage always be present between its gate and source leads whenever a positive voltage is present between the drain and source leads of the same device. Failure to provide the negative gate-source voltage ($-V_{gs}$) before the positive drain voltage ($+V_{ds}$) is provided leads to the destruction of the device.

single dc lead

The problem of providing gate-source bias voltage at a time no later than the drain-source voltage is provided, is rather easily solved if both positive and negative voltages are available for the amplifier. However, because full advantage of the low noise-figure of a GaAs FET preamplifier is obtained only if the amplifier is mounted at the antenna feed, it is often undesirable to provide three dc wires (+ voltage, − voltage, and ground) to the antenna-mounted preamplifier. A preamplifier can be operated with a single positive voltage if some form of self-biasing configuration is used. Typically, self-bias is provided by a resistor from the device source lead to ground; however, a very low-loss bypass capacitor must parallel the source resistor to effectively place the device source lead at rf ground potential. The bypass capacitor is generally of the chip capacitor type, and may often be self-resonant at the Amateur band of interest.[1] However, as the frequency of use is increased to beyond about 3 GHz, even the best available bypass capacitors add undesired reactance; the GaAs FET device is best operated with the source lead connected directly to the circuit ground. When this connection is made, the pair of opposite-polarity voltages are again required, and the problems of power supply sequencing and number of supply wires are again encountered. Because it is very desirable to provide a single voltage, generally of positive polari-

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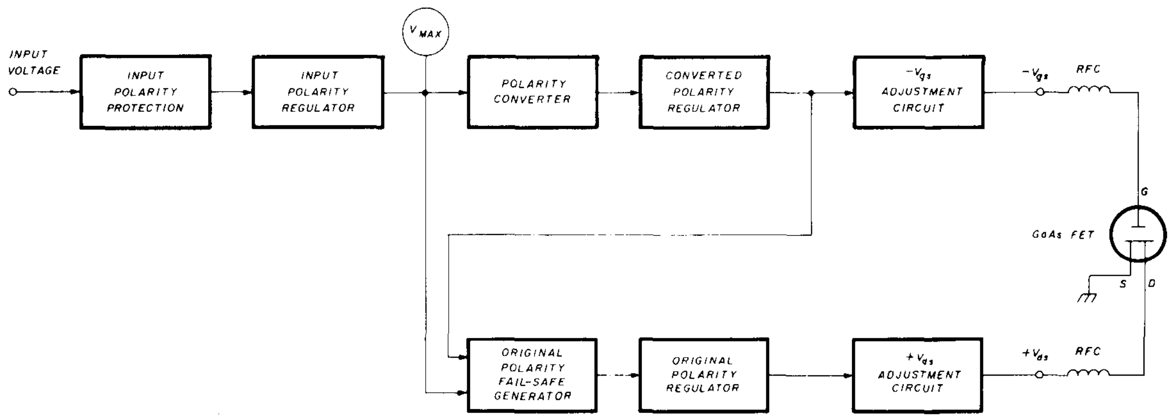


fig. 1. Block diagram of a fail-safe power supply for a GaAs FET low-noise preamplifier.

ty, along the inner conductor of the coaxial cable to the preamplifier output, with the coaxial cable outer shield providing its normal ground connection, some form of power supply at the preamplifier is necessary to provide both polarities of voltage in proper sequence.

My fail-safe power supply (**fig. 1**) was developed to solve this problem (and was subsequently found to be novel enough to be granted a patent in the United States). It is, in some ways, very much similar to the power supply described by Norman Foot, WA9HUV, in an earlier issue of this magazine.[2] My patented circuit has several features worth consideration by anyone planning to power a GaAs FET preamplifier from a single polarity voltage supply.

GaAs requirements

Consider first the voltage and current requirements of a typical (low-noise) GaAs FET device: V_{gs} usually must never exceed -6 volts, at a very small current (generally less than 1 microampere); V_{ds} is generally about $+3$ volts at about 10 milliamperes in operation and must generally never exceed $+6$ volts or a maximum current of 50-100 milliamperes. It is important to reduce the supply voltage to a voltage no greater than the 6-volt maximum voltage, as soon as possible in any proposed power supply. This maximum voltage V_{max} is provided by an input polarity regulator, utilizing a 78L05 integrated circuit. The input polarity regulator is itself protected from receiving an input voltage of improper polarity by the use of a so-called "idiot diode", CR_1. An input capacitor, C_1, is used to prevent input voltage surges when the power supply is in the presence of a larger rf field (as may occur with the power supply at the antenna). The input polarity regulator device U_1 is suitably bypassed and is protected from reverse voltages, during power-down, by diode CR_2. The net result is a positive voltage at test point TP1 which is less than the maximum safe drain voltage, provided at a very early point in the power supply, and protected against both reverse-polarity and overvoltage faults by diodes CR_1 and CR_2.

The positive voltage is converted to a negative voltage in a polarity converter using a relatively new integrated circuit, U_2, the ICL7660 from Intersil, Inc. The ICL7660 requires only two associated components, the pair of 10 μF capacitors C_4 and C_5, in order to generate a negative voltage at test point TP2 of about -4.5 volts. While I have tried the polarity converter circuit using a 555 timer integrated circuit, as suggested by WA9HUV (and the 555 timer circuit does work as intended), the three-component circuit of **fig. 2** is somewhat simpler, more compact, and more reliable. The negative output voltage is of almost the same magnitude as the positive input voltage and requires neither a voltage doubler nor operating voltages greater than the maximum voltage of the GaAs FET, a preferred feature in case of component failure in the polarity converter.

Because the amplifier noise figure and, to a somewhat lesser extent, the amplifier gain are directly related to the device drain current I_d (set by the gate voltage V_{gs}), the converted-polarity voltage must be highly regulated. The converted polarity regulator uses a series resistor, R_1, and a zener diode, CR_4, to provide this regulated voltage; -3.3 Vdc is provided at test point TP3. The zener diode CR_4 also prevents a positive voltage from ever appearing at the device gate. CR_4 is shunted by filter capacitor C_6 to remove any noise components generated by the zener. The regulated negative voltage appears across potenti-

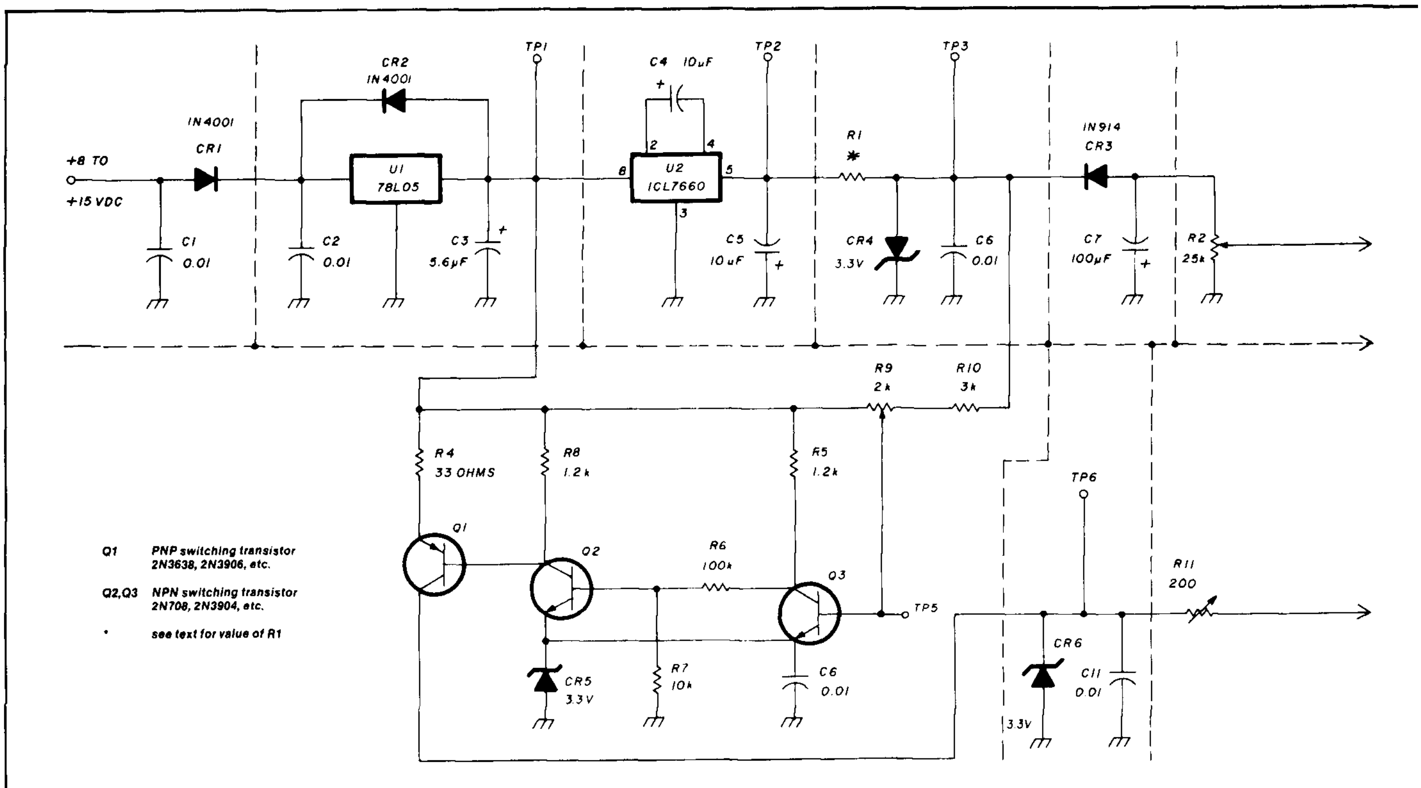


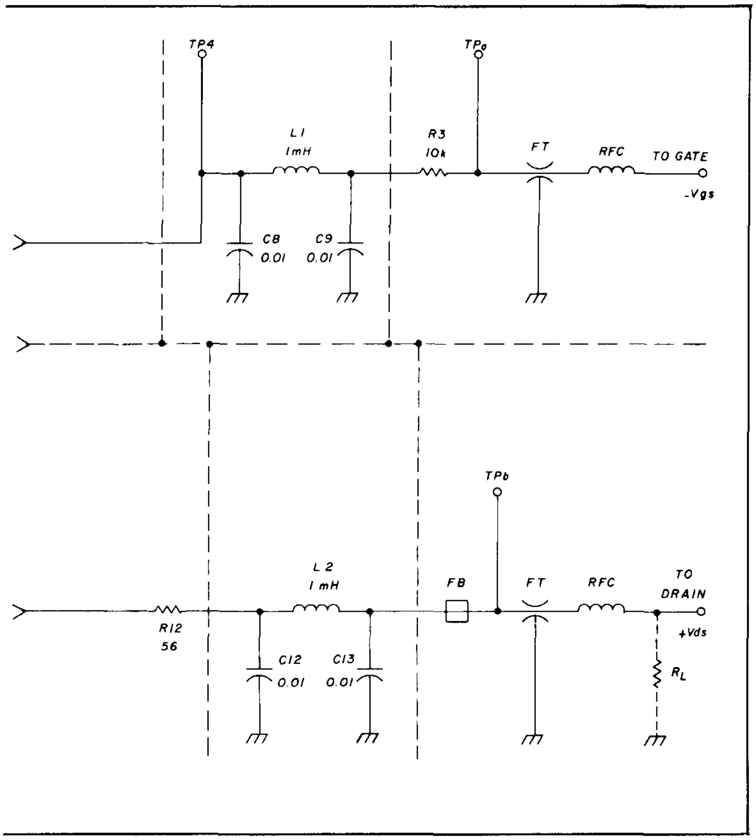
fig. 2. Circuit diagram of a fail-safe power supply for a GaAs FET low-noise preamplifier.

ometer R_2, which is adjusted to set the amplifier device voltage $-V_{gs}$.

failure mode protection

The input-regulated voltage V_{max} and the converted-polarity regulated voltage at test point TP3 are used in an original-polarity fail-safe voltage generator subcircuit to provide a positive voltage for the amplifier device drain circuit *only* if the negative amplifier device gate voltage is present. Reason dictates that a switch, transistor Q_1, is open until the negative voltage at TP3 is present; that is, when the Q_1-Q_3 circuit of **fig. 2** fails in an open condition, with voltage and current not supplied to the subsequent original-polarity regulator subcircuit, which uses zener diode CR_6. Compare this approach to that of the crowbar/regulator U_2 circuit discussed in WA9HUV's article, in which failure of the crowbar circuit no longer reduces positive regulator U_2 input and thereby allows positive drain voltage to continue to be supplied to the amplifier device. My original-polarity fail-safe generator uses a Schmitt-trigger circuit (transistors Q_2 and Q_3, zener diode CR_5 and resistors R_5-R_8). The switching input voltage of the trigger is determined by the setting of potentiometer R_9, and operates as follows: if the proper -3.3 Vdc is present at TP3, then the voltage at trigger input test point TP5 can be adjusted to be sufficiently close to the zener voltage of diode CR_5, so that transistor Q_3 is cut off. The voltage at the base of transistor Q_2 is then greater than the voltage across zener diode CR_5, and transistor Q_2 is saturated, turning on transistor Q_1 and allowing a current, set by resistor R_4, to flow into zener diode CR_6. This provides a regulated $+3.3$ volts at positive regulator test point TP6. If the negative voltage at test point TP3 decreases, for any reason, by an amount determined by the setting of potentiometer R_9, the voltage at test point TP5 increases (becomes more positive) by an amount adjusted to raise the base of transistor Q_3 *above the voltage of zener* diode CR_5. Transistor Q_3 switches into saturation and transistor Q_2 switches into the cut-off condition, cutting off current flow through transistor Q_1 and reducing the voltage at positive regulator test point TP6 toward zero.

Resistor R_1 can be selected, in the 100-500 ohm range, to cause one of two results to occur when the fault condition causing the negative regulator test point TP3 voltage to be less than the design value is cleared. For lower values of resistor R_1, clearing of a fault (such as a short across zener diode CR_4) causes the trigger to reset and the circuit to return to normal



operating condition. For higher values of resistor R_1, clearing of a fault and return of the TP3 voltage to about -3.3 Vdc can cause the positive drain voltage to remain at about 0 volts until the main input power is removed and reapplied. This latter condition, somewhat dependent upon the setting of potentiometer R_9, is observable if the total current into the power supply is monitored. It can be useful in providing an automatic fault alarm, even while the device is being protected by the application of a safe negative V_{gs} *and simultaneous removal of* V_{ds}.

The amplifier device drain voltage V_{ds} is set by potentiometer R_{11} in conjunction with fixed resistor R_{12}. Typically, the drain voltage V_{ds} has an effect upon the amplifier noise figure and gain, although this effect is somewhat less than the effect of varying the device drain current, which is varied by adjustment of the gate voltage $-V_{gs}$ at potentiometer R_2.

One problem which will be encountered, but was not addressed in WA9HUV's article, is the possibility of voltage spikes occurring at the oscillation frequency of the polarity converter subcircuit. These spikes are generated by the squarewave switching inherent in either the 555 timer or ICL7660 converter integrated circuits. The first step necessary to prevent these spikes from showing up at either the amplifier $-V_{gs}$ input at test point TPa, or the drain voltage $+V_{ds}$ input test point TPb, is to build the power supply in a separate shielded box mounted next to the preamplifier shielded box. The negative and positive voltages are then run through short, shielded wires to the preamplifier input feed-through capacitors FT. As a second step, the converter "hash" is suppressed by a π-section lowpass filter (L_1, C_8 and C_9 or L_2, C_{12} and C_{13}) placed after adjustment potentiometers R_2 and R_{11}. Ideally, each of the filters should be in its own little shielded enclosure within the main power supply shield enclosure.

The additional circuit of diode CR_3 and capacitor C_7 *is an added protective measure.* During normal operation the voltage drop across diode CR_3 will provide a maximum gate voltage of slightly less negative magnitude than the zener voltage of diode CR_4. The voltage drop across diode CR_3 is substantially constant and the initial setting adjustment of potentiometer R_2 takes this voltage drop into account. However, during power supply turn-off, under either normal operation or because of a decrease in the voltage at TP3, the previously-charged storage capacitor, C_7, maintains a sufficiently negative voltage at the gate output to prevent destruction of the protected device while the voltage at the drain connection rapidly falls to zero. Typically, drain voltage will fall to zero in under ten milliseconds, while the voltage at gate test point TP4 requires about one second to fall to zero magnitude, providing an additional degree of GaAs FET protection.

circuit test

The circuit test should be carried out before the power supply is connected to the companion preamplifier. A dc load resistor, R_L, is connected to approximate the desired amplifier device drain load. For a typical 3.0 Vdc drain voltage at a typical 10 milliampere drain current. R_L is a 300 ohm, 1/8-watt resistor. Since the amplifier device gate electrode does not draw any appreciable current, the gate end of series-protection resistor R_3 is left open.

Apply a positive voltage in the 8 to 15-volt dc range to the power supply input and check for the following voltages, using a voltmeter with at least 20K ohm resistance (all voltages are ± 10 percent): $+5.0$ Vdc at TP1; about -4.5 Vdc at TP2; and -3.3 Vdc at TP3. The voltages at TP4 and TPa should be variable from zero to about -2.8 Vdc, which is less than the voltage at TP3 because of the drop in diode CR_3.

The positive-polarity portion of the power supply is tested by adjusting potentiometer R_9 until a 3.3-volt dc level appears at TP6. The operation of the fail-safe generator subcircuit is tested by temporarily placing a short circuit from TP3 to ground and noting that the voltage at TP6 falls to zero. Some adjustment of potentiometer R_9, while monitoring the TP5 voltage, may be required to obtain the proper operation of the trigger circuit. Potentiometer R_{11} is then adjusted for the desired target drain voltage at TPb, with the dummy drain resistance, R_L, connected.

As a final check before connecting the power supply to the amplifier, monitor the TPa and TPb voltages with an oscilloscope (preferably starting at one volt per division and working down to the greatest sensitivity possible) and look for spikes in the kHz repetition frequency range. If such spikes should be found, increased values of the lowpass filter components may be necessary.

applications

The fail-safe preamplifier power supply has been used with, among other circuits, a π-network input/output preamplifier for 1296 MHz.[3] A number of different GaAs FET devices were tested; optimum noise performance could be obtained by varying the potentiometers R_2 and R_{11} in a noise-figure measurement test setup. The same devices in the same preamplifiers were also tested with a source-resistance-biasing scheme; a small but discernable increase in noise figure was found above the case where the device source leads were directly grounded and the fail-safe power supply used.

A very-low-noise receiver was built at 3456 MHz, using a simple single-balanced mixer[4] built on G-10 printed circuit board stock and garden-variety mixer diodes (HP2810). While the use of G-10 board is not recommended at this frequency, and resulted in a mixer conversion loss of about 13 dB (and a noise figure estimated at about 15 dB), a two-stage GaAs FET preamplifier with 29 dB of gain completely overcame the mixer noise. The preamplifier is almost identical to a well-known TVRO preamplifier,[5] with the exception of an NE21889 device used in the input stage and improved input matching through the use of a pair of 1/8 inch wide by 1/4 inch long copper foil "flapper" capacitors. The power supply recommended by the manufacturer requires a +15 volt supply and a −15 volt supply, in addition to a pair of 747 dual operational amplifier integrated circuits, a handful of zener diodes, and other components. In my receiver, that power supply was replaced by a pair of power supplies as shown in **fig.2**, allowing not only the independent setting of the drain voltages of each stage (which could not be done with the manufacturer's recommended power supply), but also the independent setting of the drain current of both stages, to provide a preamplifier noise figure of about 1.0 dB at the indicated 29 dB gain figure. Application of the usual series-stage gain and noise figure formulas will show that the overall converter (preamplifier plus mixer) gain is about 16 dB, with a total noise figure of about 1.1 dB. This illustrates that the poor mixer specs are, in fact, overcome by the superior gain of the preamplifier.

conclusion

A power supply circuit requiring only a single polarity of input voltage, yet offering a high degree of fail-safe protection for GaAs FET amplifiers — especially for the microwave Amateur bands — is now available. Any questions addressed to the author accompanied by an SASE will be answered.

license grant

United States patent laws prevent anyone, unless specifically licensed by the patent owner, from "making, using or selling" any circuit covered by the claims of my U.S. patent 4,320,447; this includes the circuit of ***fig. 2*** *as well as the circuit used in reference 2. The patent owner, being the author of this article, therefore expressedly grants a non-assignable license to any licensed Amateur Radio operator in the United States of America, to make and use the fail-safe amplifier power supply covered by the claims of U.S. Letters Patent 4,320,447 for use with amplifiers operating only in the authorized U.S. Amateur Radio bands and only for Amateur Radio activity. This limited license cannot be sub-licensed. Use of the circuit covered by the claims of Patent 4,320,447 with amplifiers operating on non-Amateur bands or for non-Amateur use, or the sale of the circuit for any use, are all expressedly excluded from this license; grants and terms of such licenses can be discussed directly with the patent owner.*

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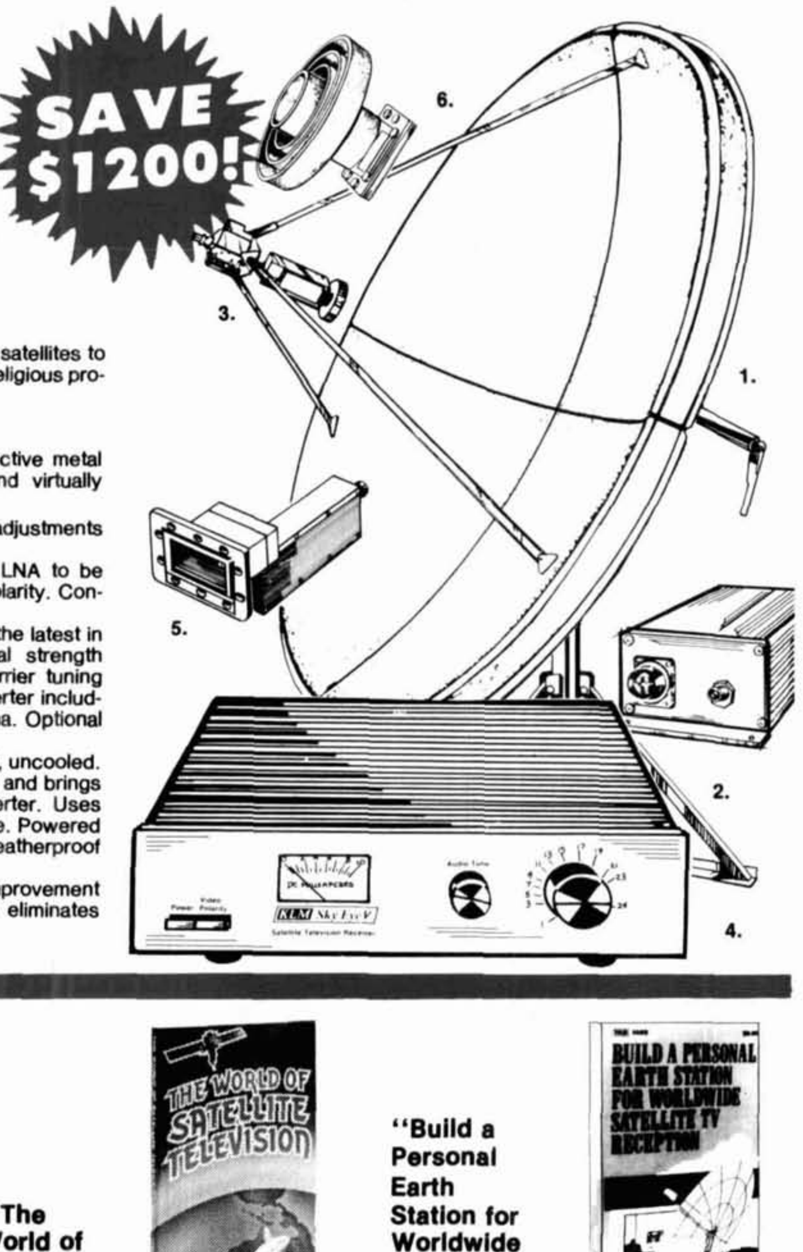

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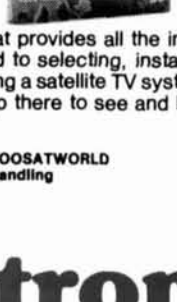

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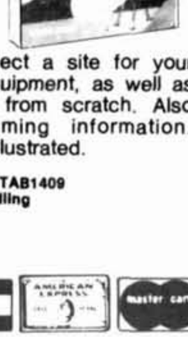

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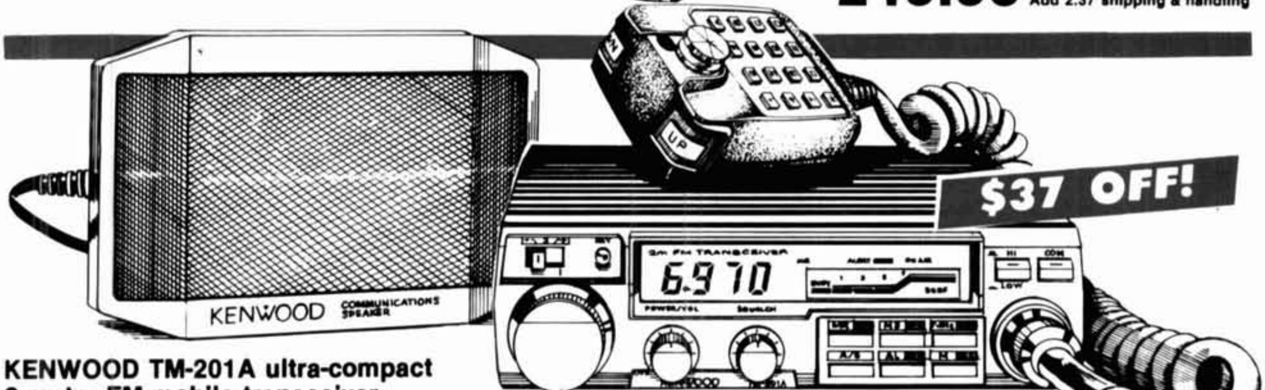

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✓ 161

ham radio TECHNIQUES

Bill Orr W6SAI

Just about the time you are reading this column, the summer static level should be dropping off and the low frequency DX bands should be coming back to life. Low frequency DX conditions should improve during the next few years as the sunspot count continues to drop. This means that the 160 meter band will be a good performer for a number of years. Some Amateurs have stuck to 160 meters, year in and year out, but many of the newer Amateurs are not yet aware of the DX possibilities of this band.

A majority of the new transceivers have incorporated the 160 meter band and the 1983-84 winter season promises to be a good one for this venerable Amateur band, with a high level of activity.

the 1983/84 DX season on 160 meters

The number one DX operator on 160 meters is Stew Perry, W1BB, who has been active in that portion of the spectrum since 1920! (See **figs. 1**

fig. 1. Stew Perry, W1BB, on the alert for 160 meter DX in 1920. Transmitter is a single tube oscillator, modulated for a-m phone. Running 35 watts, Stew quickly discovered the thrill of working DX.

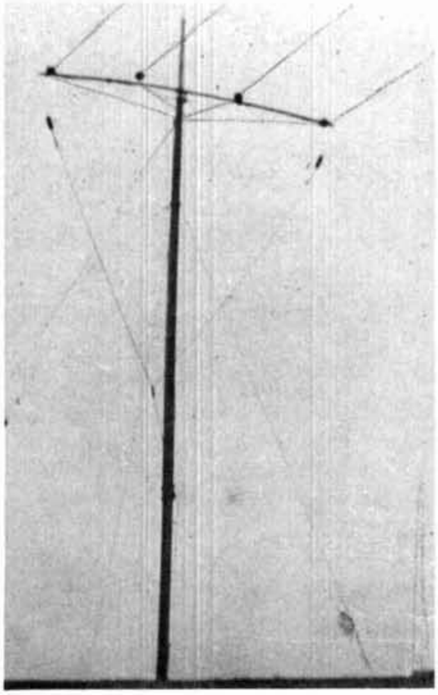

fig. 2. The 160-meter flat-top antenna of W1BB in 1920. This was a Marconi affair, working against a good ground. Even in the 1920's, Steve was an old-timer, since he'd been licensed since 1912. (He's now celebrating his 71st year on the air!)

and **2.**) I asked Stew what he thought about the forthcoming season and this is what he said:

> While I've not been very active recently, I've made a few good contacts this year (4X4NJ-Israel, PY1ARS-Brazil, and others). I think conditions seem quite sound and feel "right" for a good season. In spite of some changes, it still is the "gentleman's band", where folks are friendly and cooperative, without so much push and shove!
>
> By its nature, you're forced to work DX the hard way, at all hours of the day and night for world coverage. Sunset and sunrise (local time) are excellent periods, full of good DX surprises.
>
> As far as antennas for the "top band," the best receiving and transmitting antennas are required for top results, but you will be surprised what can be done with a simple inverted-L Marconi, or a Sloper with a **good** ground system.
>
> Come on down to 160 and meet some fine guys.

FCC rules and regulations

A collection of the FCC rules and regulations governing ham radio fills a thick notebook! Is it all worth the effort? Let's return again to the simple regulations of the Federal Radio Commission of 1927 **(fig.3)**. Think of how many problems these simple rules would solve. As a famous philosopher once said, "I have seen the past, and it works!"

horizontal versus vertical antennas

I am still getting mail on my comments concerning horizontal versus vertical polarization for simple high frequency antennas (October, 1982, and April, 1983). A recent letter from my friend Win Wagener, W6VQD, says, in part:

> Too many people discuss the pros and cons of polarization without a good understanding of what is involved. It is not a simple question of which is better, a vertical or a horizontal antenna; but a need to consider the full environment of the antenna system.
>
> Too many articles on the effect of the surface of the earth in the vicinity of an antenna assume a perfectly conducting and flat surface for the

October 28, 1927.

Supervisors of Radio and Others Concerned:

For your information and guidance the Federal Radio Commission has established the following regulations governing the licensing and operation of amateur radio stations:

Amateur radio stations are authorized for communication only with similarly licensed stations and on wavelengths or frequencies within the following bands:

Kilocycles	Meters	Kilocycles	Meters
401,000 to 400,000	0.7477 to 0.7496	8,000 to 7 000	37.5 to 42.8
64,000 to 56,000	4.69 to 5.35	4,000 to 3,500	75.0 to 85.7
16,000 to 14,000	18.7 to 21.4	2,000 to 1,500	150.0 to 200.0

and at all times unless interference is caused with other radio services, in which event a silent period must be observed between the hours of 8:00 p. m. and 10:30 p. m., local time and on Sundays during local church services.

Amateur radio telephone operation will be permitted only in the following bands:

Kilocycles	Meters
64,000 to 56,000	4.69 to 5.35
14,500 to 14,000	20.68 to 21.4
2,000 to 1,580	150 to 190

Spark transmitters will not be authorized for amateur use.

Amateur stations must use circuits loosely coupled to the radiating system or devices that will produce equivalent effects to minimize key impacts, harmonics and plate supply modulations. Conductive coupling, even though loose, will NOT be permitted, but this restriction shall not apply against the employment of transmission line feeder systems to Hertzian antennas.

Amateur stations are not permitted to communicate with commercial or government stations unless authorized by the licensing authority except in an emergency or for testing purposes. This restriction does not apply to communication with small pleasure craft such as yachts and motor boats holding limited commercial station licenses which may have difficulty in establishing communication with commercial or government stations.

Amateur stations are not authorized to broadcast news, music, lectures, sermons or any other form of entertainment.

No person shall operate an amateur station except under and in accordance with an operator's license issued to him by the Secretary of Commerce.

W. D. TERRELL.

rk

Chief, Radio Division.

fig. 3. Early FCC regulations were simple, straightforward.

mathematical calculations. Unless the antenna is located above salt water (bay, tidal land, or ocean), which gives a flat, low-loss surface, the real earth is usually quite different and does not meet this requirement.

Calculations for the radiation intensity at different vertical angles from an antenna are based on combining the direct radiation from the antenna at a particular wave angle with the wave reflected from the ground. Wave reflection takes place at a distance from the antenna which varies with the particular angle of elevation being studied. For a high angle the reflection area is near the antenna, but for low angles the area of reflection is more remote, and for nearzero takeoff, that area is many wavelengths from the antenna.

For vertical polarization at low angles, the absorption of energy by the earth increases with ground loss for some distance from the antenna. There is considerably less ground loss upon reflection when antenna polarization is horizontal.

In addition to the need in real life to consider the effect of ground loss, the surface of the earth is often not flat, but hilly out to a thousand feet or so from an antenna. This must be taken into consideration. If, for instance, the radiation from an antenna system fifty feet above a flat surface is desired at an angle of five degrees elevation, the earth surface involved in the reflection area is five hundred to six hundred feet away from the antenna. If the ground slopes away from the antenna, the reflection area is closer and if the ground rises, the area is further away.

In my case, near the top of a ridge with thin topsoil and shale below, slopers and phased verticals seemed always below the performance of a halfwave horizontal antenna.

Win brings up a good point. Antenna reflection drawings in handbooks and articles are comforting, but they assume a perfectly conducting ground surface. In actuality, the "lay of the land" within five hundred feet, or more, of your antenna determines the actual reflection pattern.

Many Amateurs, surrounded by other people's houses, telephone and utility wires, and television antennas, can only guess at the angle of takeoff of their signal as the reflecting ground surface is obscured. So don't take

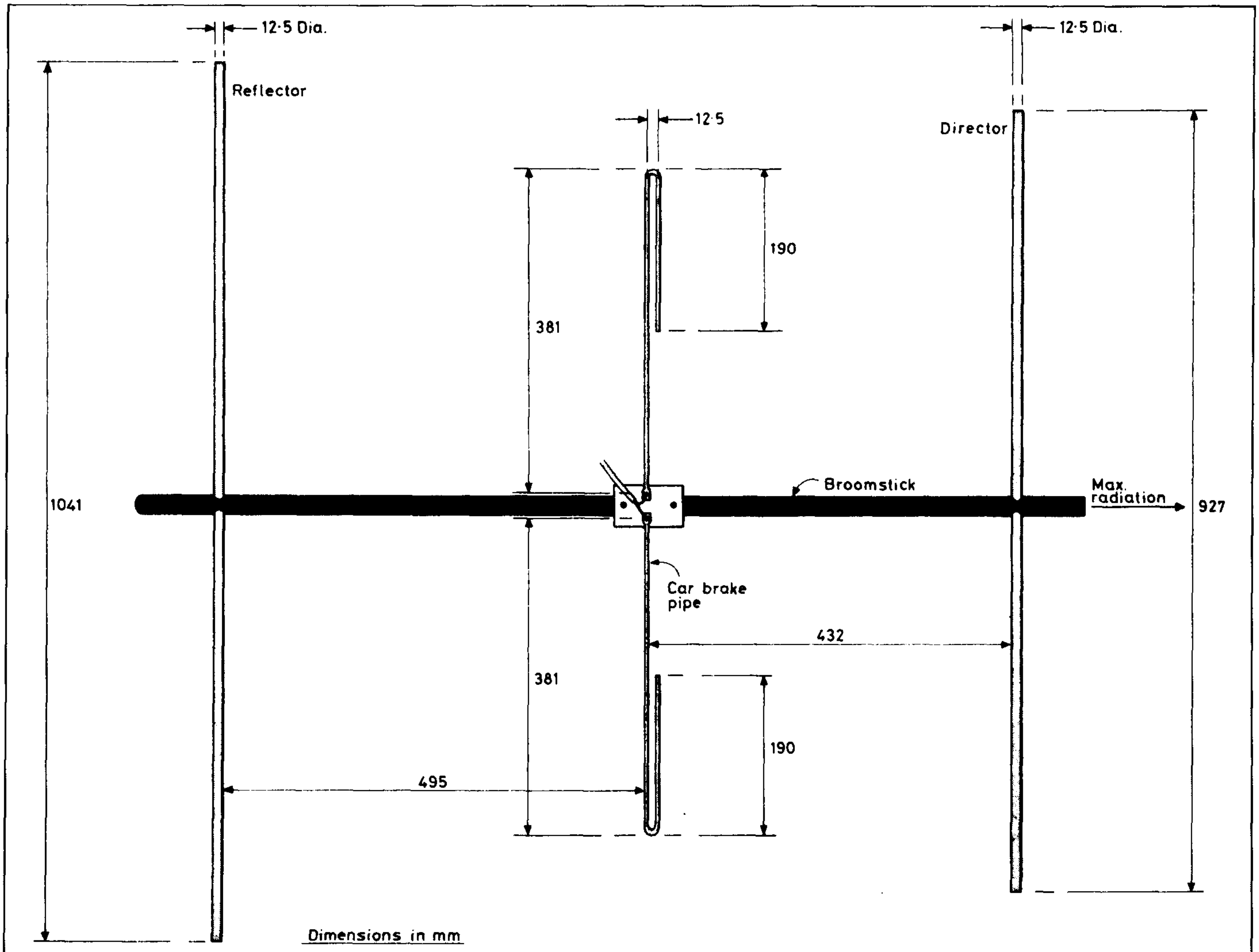

fig. 4. The unusual 2 meter Yagi beam designed by G6AFJ. Note that the driven element is folded back upon itself at the tips. Does this provide a good match for the 50 ohm transmission line? Try it and see! (Dimensions are in millimeters.) Illustration from *Practical Wireless*.

the patterns seriously. In most cases, the higher the antenna, the better the DX results. And that's probably due less to the reflection angle of takeoff than to elevating the antenna above nearby conducting structures!

the G6AFJ beam antenna for 2 meters

Is someone pulling my leg? Or does it really work? (See **fig.4.**) This is reproduced from the February issue of *Practical Wireless,* a well-known British publication. (Antenna dimensions are given in millimeters.) The noteworthy aspect of this three-element Yagi for 144 MHz is the unusual driven element, with its tips folded back upon themselves, presumably to provide a match to the 50-ohm line. G6AFJ says "the antenna can be tuned by altering the position of the bends in the folded elements to vary the gap."

The driven element is made of "car brake pipe," a substance that is unknown to me, but I would assume that it is thin-wall copper tubing. It appears to be about 3/16 of an inch (5 mm) in diameter.

In any event, the antenna is simple to make, and if any readers try out the idea, I'd like to hear about the results.

inexpensive station clock

Would you like a small, accurate station clock that you can set to WWV and buy for less than $15.00? I found one at my local hardware store. (I also found the same item for sale in several drug stores.) I am talking about the Timex model 5204-412 digital clock that sells for $9 to $14. This compact clock has a large red LED display of hours and minutes, plus an indicator of "a.m." and "p.m." It also has an alarm which is handy for keeping to schedules.

The instruction manual tells everything about the clock except how to set it to WWV, so the "minute" LED advances exactly on the proper WWV time-tick. Once you know how to do it (and I found out by experimentation), it is easy to lock the clock within a second of WWV. Here's the trick. Advancement of time as shown on the "minute" LED is performed when the clock is turned *on.* For some obscure reason (don't ask me why) there is a built-in 30 second time-shift in the clock. The trick is to plug the clock into your power receptacle exactly 30 seconds *after* a WWV minute tone. If you do this, then when you set the clock to WWV the LED will advance exactly on the minute tone of WWV. Once you accomplish this simple feat, the little clock runs right along with WWV UCT time.

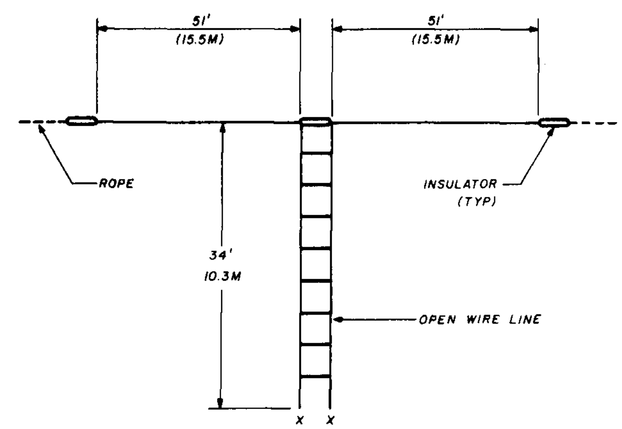

fig. 5. The G5RV multiband antenna. This simple device has been operated on all Amateur bands between 160 and 2 meters! One version of the antenna connects a 50 ohm coaxial line at points X-X and uses an antenna matching unit at the station to reduce the SWR on the line to a low value suitable for the transmitter. Another version extends the open wire line to the transmitter and uses a balanced antenna tuner to match to the transmitters coaxial output.

the G5RV "all band" antenna

Have you ever noticed the antenna description on an overseas QSL card was the "G5RV antenna?" Little-known in W-land, the G5RV is a popular multiband wire antenna used by many overseas operators. Popularized by Louis Varney, G5RV, the basic antenna is shown in **fig. 5**.

A 102 foot long flat-top is used, fed at the center with a length of open wire transmission line. The antenna operates as a shortened dipole on 80 meters, an extended dipole on 40 meters, nearly three 1/2 wavelengths on 20 meters, and as a center-fed long wire on 15 and 10 meters.

There are many methods of feeding the G5RV antenna. The original design uses an open wire stub plus a length of coaxial line. An antenna tuning unit is used in the station, as the SWR on the coaxial line can be quite high at certain frequencies.

A second feed system is to extend the open wire line directly into the station, and use a balanced antenna tuner at this point.

The G5RV feeders can be connected in parallel at the bottom of the stub and the antenna operated against ground as a top-loaded vertical on 160 meters. Some hams have even used it on 6 and 2 meters by using a VHF antenna matching unit at the station!

My preference is to run open wire line from the antenna directly to an antenna tuner in the station. (Saxton makes heavy-duty open wire line, I believe.) For low power (a hundred watts or so), TV-type twin lead may be substituted for the open wire line.

moonbounce revisited

The popular brochure "All You Want to Know About Moonbounce (EME) Transmission" has been reprinted and is once again available. If you wish a copy, send four 20¢ stamps, or four IRCs, to me at the following address: Eimac Division of Varian, 301 Industrial Way, San Carlos, California 94070.

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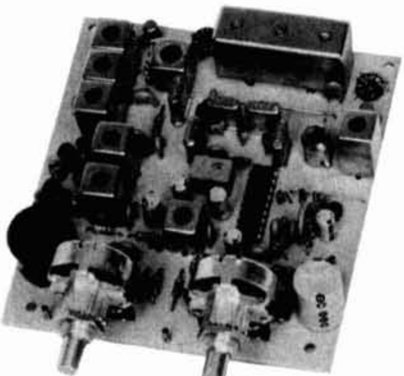

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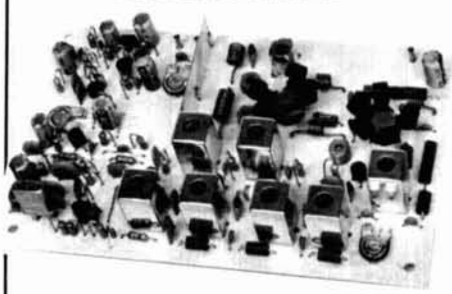

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Part one described the functional blocks of a PLL synthesizer and loop operation and presented a simple approach to PLL synthesizer design. This part details the loop components with an analysis that points out aspects critical to an understanding of the loop. The open loop performance is then examined in terms of its individual sections which leads to a comparison of open and closed loop operation. Finally, phase noise basics are discussed, showing the effects of a PLL on closed loop VCO phase noise.

VCO operation

VCO gain defined by $K_{VCO} = \Delta f_{VCO}/\Delta V_t$, indicates the dependency of VCO frequency on a tune or control voltage. However, a VCO when used in a phase locked loop incorporates a **phase** not a frequency detector. Therefore the effect of ΔV_t on VCO phase, relative to the reference oscillator phase (f_{REF}), is seen as a system integration.

Fig. 1A shows a perfectly stable reference oscillator at a frequency of f_{REF}, and a VCO that has a $K_{VCO} = 1\ MHz/volt$. The phase detector is a perfect phase detector with an input range of zero degrees to infinity and a $K_\phi = \frac{1\ volt}{10\ degrees}$. If f_{REF} and f_{VCO} equal exactly 5 MHz, and are in phase, then the phase detector output will be 0 volts.

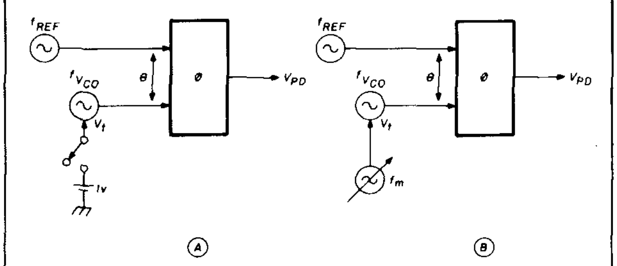

fig. 1. Circuit block arrangement to show combined VCO-phase detector response to a voltage step and swept frequency on V_t.

At $t = 0$ a plus 1 volt applied to the VCO tune line causes an instantaneous 1 MHz jump in VCO frequency. 100 nanoseconds after voltage is applied the phase difference between f_{REF} and f_{VCO} is:

$$\theta = 360° t(\Delta f)$$
$$\theta = 360° (100\ ns)(1\ MHz) = 36°$$

At 1 μs, $\theta = 360°$, at 10 μs it becomes 3600°, or in other words, a linear accumulation in phase difference. The output of the phase detector is a ramp going from zero volts towards infinity, as shown in **fig. 2A**. The VCO can be considered a perfect integrator.

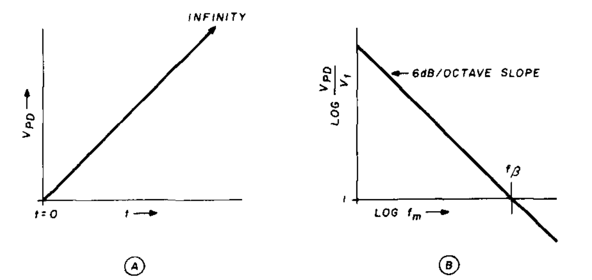

fig. 2. Step and swept frequency response of VCO-phase detector combination.

Since θ, and therefore V_{PD}, are a function of time and V_t, they must also be a function of signal frequency and amplitude at V_t.

Fig. 1B, is similar to **fig. 1A** except that in **fig. 1B**, the tune line is connected to a swept frequency sinewave source with fixed amplitude (in this case 1 volt P-P). Plotting the ratio V_t/V_{PD} versus f_M (**fig. 2B**)

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shows a 6 dB/octave slope and crosses unity *($V_t = V_{PD}$)* at a frequency:

$$f_\beta = \frac{K_{VCO} K_\phi}{2\pi}$$

$$f_\beta = \frac{(1\ MHz/volt) \cdot (5.73v/RAD)}{2\pi}$$

$$= 912\ kHz$$

Besides having a frequency response similar to a perfect integrator, it also has a constant 90 degree phase lag when comparing V_{PD} to V_t. This can be seen by using **fig. 1B** and **fig. 3**. At time A the voltage on V_t is zero volts (f_{VCO} in phase with f_{REF}).

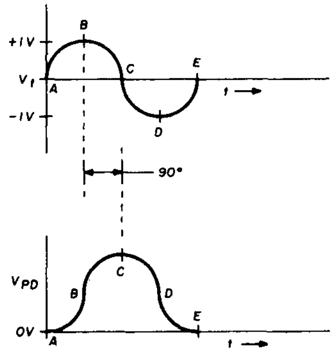

fig. 3. Plot of V_t and V_{PD} showing 90 degree phase lag due to integration of phase difference between f_{VCO} and f_{REF}.

Therefore, $V_{PD} = 0$ *volts*. As voltage V_t approaches +1 volt at time B, f_{VCO} becomes greater than f_{REF} so the phase difference at the phase detector accumulates causing V_{PD} to rise. Between time B and C the voltage on the VCO tune line decreases, but because f_{VCO} is still greater than f_{REF} the accumulated phase difference continues to increase, only at a decreasing rate. A plot of both V_{PD} and V_t over 360 degrees shows that V_{PD} lags V_t by 90 degrees.

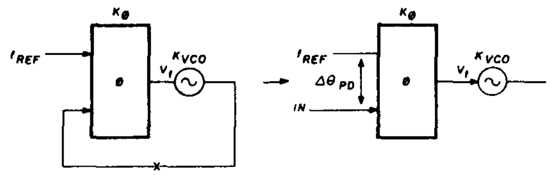

fig. 4. Breaking a simple loop to examine open loop properties.

open loop properties

Gain, frequency, and phase are open loop characteristics as shown in **fig. 4**. The total gain, K_t, is

$$K_t = K_\phi K_{VCO}$$

This means that with a phase difference at the input of the phase detector ($\Delta\theta_{PD}$) there is a frequency change of the VCO frequency (Δf_{VCO}), or:

$$K_t = K_\phi K_{VCO} = \left(\frac{\Delta V_t}{\Delta\theta_{PD}}\right) \cdot \left(\frac{\Delta f_{VCO}}{\Delta V_t}\right)$$

$$= \frac{\Delta f_{VCO}}{\Delta\theta_{PD}}$$

frequency divider

Adding a frequency divider (**fig. 5**) with gain term, K_N, changes the open loop gain equation to:

$$K_t = K_\phi K_{VCO} K_N$$

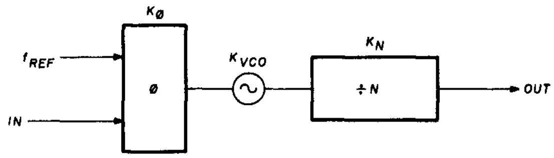

fig. 5. Open loop with divide by N.

Plotting K_t as a function of f_M gives a plot similar to that of **fig. 2B** except unity open loop gain occurs when:

$$f_M = \frac{K_\phi K_{VCO} K_N}{2\pi}$$

loop filter

Because of the more complex gain and phase versus frequency characteristics of the loop filter, K_F, it is examined separately, and then added to the loop.

Use of a simple loop filter (**fig. 6**) provides the gain and phase plots (**fig. 7**). Gain equals unity when:

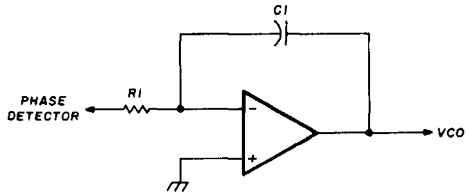

fig. 6. Simple op-amp integrator as a loop filter.

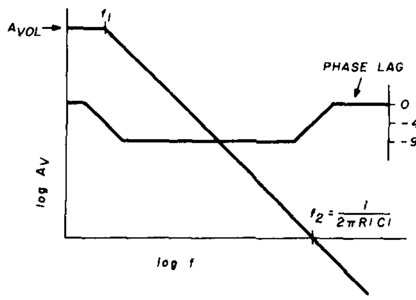

fig. 7. Amplitude and phase plot of simple loop filter in fig. 6.

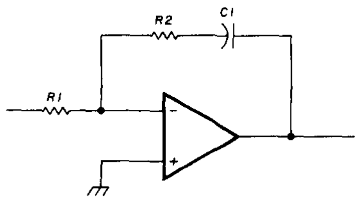

fig. 8. Adding resistor R_2 to integrator for better control of gain and phase.

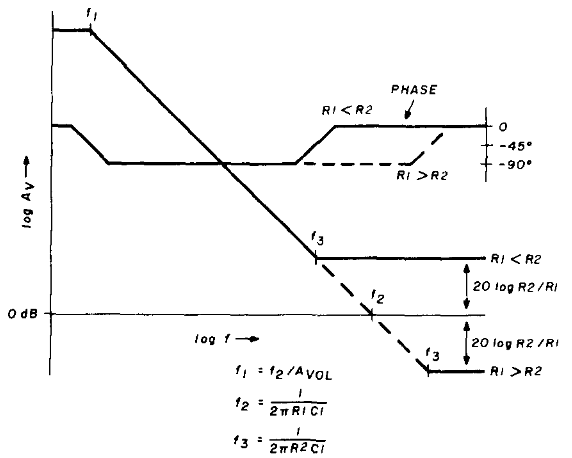

fig. 9. Amplitude and phase plot of loop filter in fig. 8.

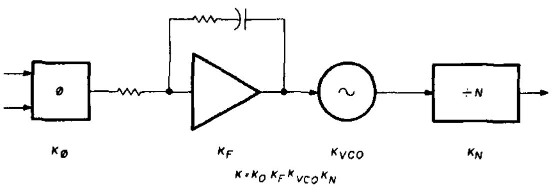

fig. 10. Open loop with loop filter.

$$f = \frac{1}{2\pi R1C1}$$

The phase will lag by 90 degrees from approximately f_1 to f_2.

To have more control over gain and phase, another resistor, R2, is added to the loop filter (**fig. 8**). The effects of R2 are seen in **fig. 9**.

open loop phase

By adding K_F to K_ϕ K_{VCO} K_N, (**fig. 10**) the final open loop characteristics are determined. This is accomplished by plotting K_F and K_ϕ K_{VCO} K_N separately on log-log paper and then adding the gains in dB together (**fig. 11**).

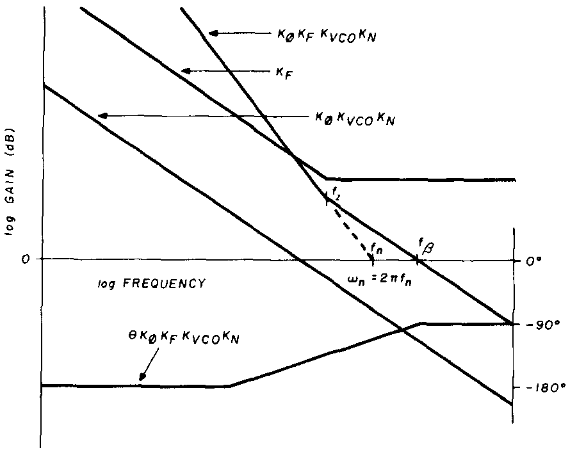

fig. 11. Plotting K_F separately from K_ϕ K_{VCO} K_N and then adding them to show combined frequency and phase characteristics.

The plot of phase shows the additive phase lags of both the loop filter and the VCO. Though the phase lag from the VCO is constant, the loop filter will start to reduce its own phase lag at:

$$f_Z = \frac{1}{2\pi R2C1}$$

About one decade of frequency past f_Z the loop filter phase lag will be close to zero.

closing the loop

Finally, closing the loop gives an essentially flat response from dc to frequency f_β, which is the frequency where the open loop gain equals unity (**fig. 12**). From frequency f_β and higher the closed loop gain follows the open loop gain. f_β is defined as the closed loop 3 dB bandwidth.

Since the PLL uses negative feedback, 180 de-

More Details? CHECK—OFF Page 110

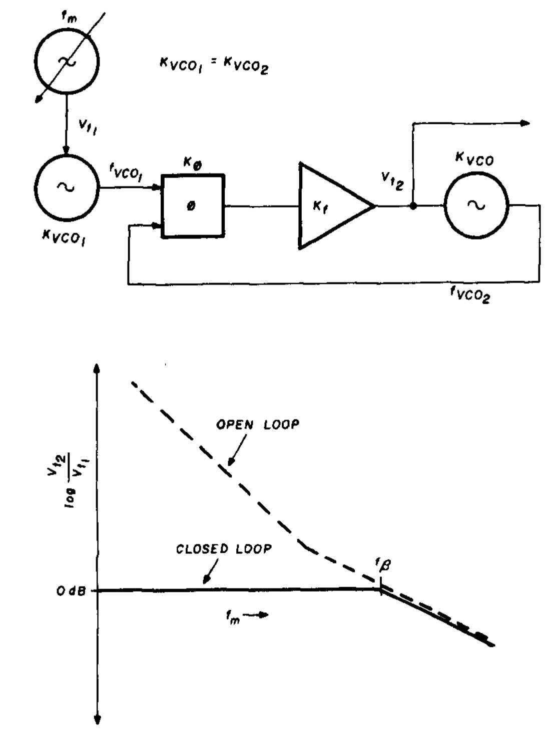

fig. 12. Open and closed loop responses of a simple loop. (Oscillator f_M is the modulating f_{VCO_1}. Both K_{VCO_1} and K_{VCO_2} are equal.)

grees of constant phase shift is required in the loop. This is usually obtained through proper selection of phase detector inputs. However, since both the loop filter and the VCO introduce phase lag, and if the accumulated lag becomes 360 degrees before the frequency where unity (open loop) gain occurs, f_β, the loop will oscillate. Since the phase detector introduces a constant 180 degrees, and the VCO a constant 90 degrees, the loop filter must introduce less than 90 degrees phase shift at f_β. The closer the loop filter comes to 90 degrees the more the loop will be inclined to ring to the point where it finally oscillates.

The distance the total loop phase lag is from 360 degrees at frequency f_β is called *phase margin* with zero being the smallest distance and 90 degrees the maximum. The damping factor, ξ, is related to phase margin by:

$$\textit{phase margin} = 90^\circ - \tan^{-1}\sqrt{\frac{\sqrt{1+\frac{1}{4\xi^4}}-1}{2}}\;*$$

The loop natural frequency, $\omega_n\ (= 2\pi f_n)$, sometimes called the loop resonant frequency, is the frequency the loop would oscillate at if $\xi = 0$ (no damping). While ω_n has limited importance in basic PLL synthesizer design, it is very important in other PLL uses such as PLL demodulators. In this article, however, ω_n is used only as an intermediate answer in calculations.

phase noise

Phase noise is random phase fluctuations of a signal. Typically hard to see on an oscilloscope except in severe cases, phase noise is more often examined on a high-resolution spectrum analyzer as shown in **fig. 13**. Since an identical noise component exists on either side of the carrier, usually only a one-sided spectrum, SSB, is shown on phase noise plots (**fig. 14**). Noise power is usually normalized to a 1 Hz bandwidth.

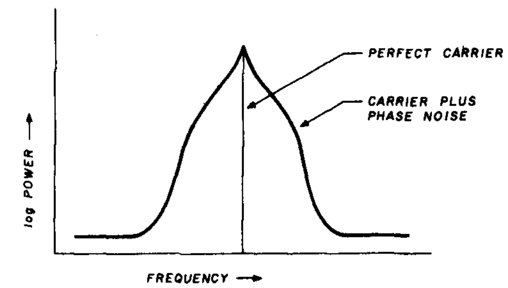

fig. 13. Oscillator phase noise as seen on a spectrum analyzer.

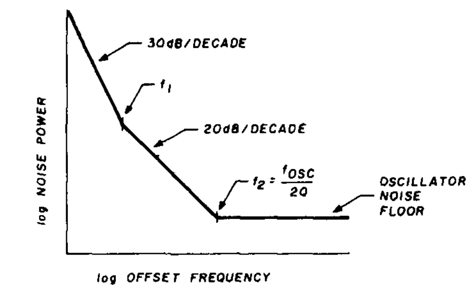

fig. 14. SSB plot of phase noise on a carrier using log-log scales showing effects of resonator Q and l/f noise.

Fig. 14 shows a typical noise spectrum of an oscillator. The phase noise will start to rise from the oscillator noise floor at a 20 dB/decade slope at:

$$f_2 = \frac{f_{OSC}}{2Q}$$

where Q is the loaded resonator Q of the oscillator.

---

*William F. Egan, *Frequency Synthesis by Phase Lock*, John Wiley & Sons, 1980, page 46.

At small frequency offsets from the carrier the noise rises with a 30 dB/decade slope due to additive 1/f noise generated by the oscillator active device.

In high performance receivers not only are synthesizers required to assume crystal-like frequency stability but crystal-like phase noise performances as well. PLL frequency synthesizers have the unique ability to improve oscillator (LC, RC, etc.) phase noise performance approaching that of the reference oscillator (typically crystal).

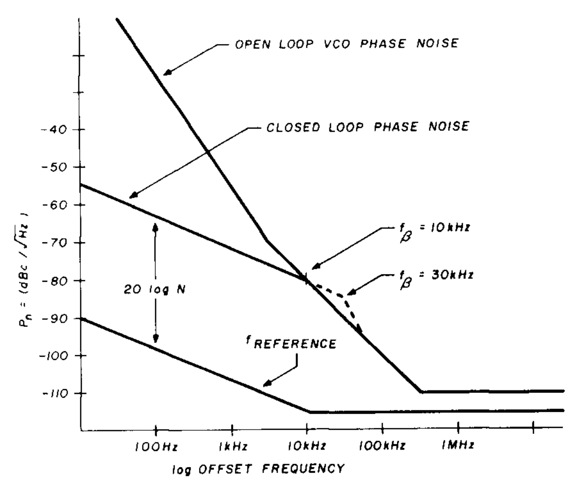

fig. 15. SSB phase noise plot comparing closed and open loop VCO phase noise and the effect of N.

Fig. 15 shows an open loop phase noise plot of a VCO. Also shown is what might be the phase noise of a crystal controlled reference oscillator. When the VCO is incorporated in a PLL and the loop is closed the VCO achieves improved phase noise performance within the bandwidth of the loop, and assumes its normal open loop phase noise response outside the loop bandwidth. However, the phase noise within the loop bandwidth is largely determined by the value of N and the phase noise of f_{REF}. This can be illustrated by a simple loop where the divider equals one, and the reference oscillator suddenly incurs a short term shift in frequency (phase noise). The phase detector senses this and generates a voltage to adjust the VCO frequency to the new reference oscillator frequency.

When the programable divider value, N, is greater than one, then in order for the phase detector to see zero phase difference at its inputs, after the same short term shift in f_{REF}, the VCO must change to a frequency N times the change in f_{REF}. Therefore the effect of N on VCO phase noise, within the loop bandwidth, is to multiply it by N, showing up on phase noise plot as a 20 log N more phase noise than the reference oscillator. This effect of N on phase noise can be a determining factor when selecting the optimum loop bandwidth (see **fig. 15**).

Often in medium performance receivers it is acceptable just to have the local oscillators meet the phase noise performance of the VCO. It happens that this can simplify the synthesizer design, allowing N to be large and f_β small for optimum phase noise performance, instead of using a more complex design in order to keep N small and loop bandwidth wide for improved phase noise performance. Problems encountered in using the simpler loop is an increase in lock time (due to the narrower loop bandwidth) and increasing difficulty in reducing reference feedthrough due to f_β approaching f_{REF}.

For increased synthesizer phase noise performance without too high a lock time and reference feedthrough, a more complex loop structure is required. **Figs. 17-19** show more complex loops, with the simple loop in **fig. 16** as a reference, while **fig. 20** plots their approximate relative phase noise performance.

The loop in **fig. 17** requires closer attention. This loop used in-loop mixing to reduce the required size of N. With N reduced the phase noise within the loop bandwidth decreases and the optimum value of loop bandwidth increases, decreasing lock time. More importantly, the local oscillator used in the in-loop mix-

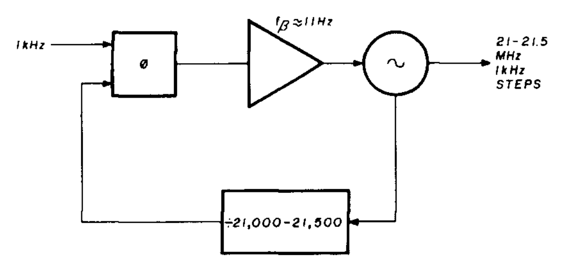

fig. 16. Simple frequency synthesizer to be compared against those in fig. 17-19.

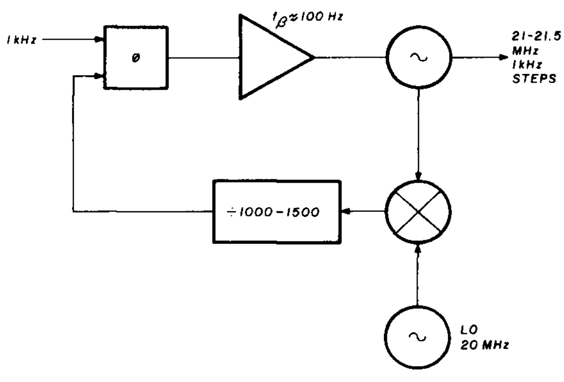

fig. 17. More complex synthesizer to reduce value of N and therefore phase noise within f_β.

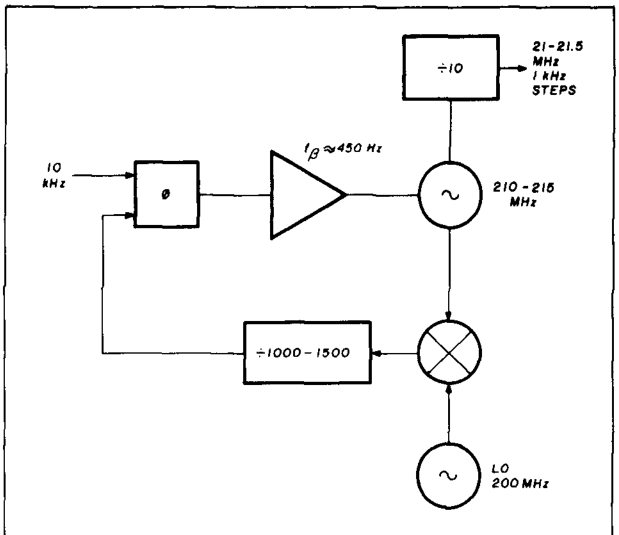

fig. 18. A synthesizer similar to than in fig. 17 only using a ÷ 10 on the VCO output to reduce frequency by 10 and phase noise by 20 log 10.

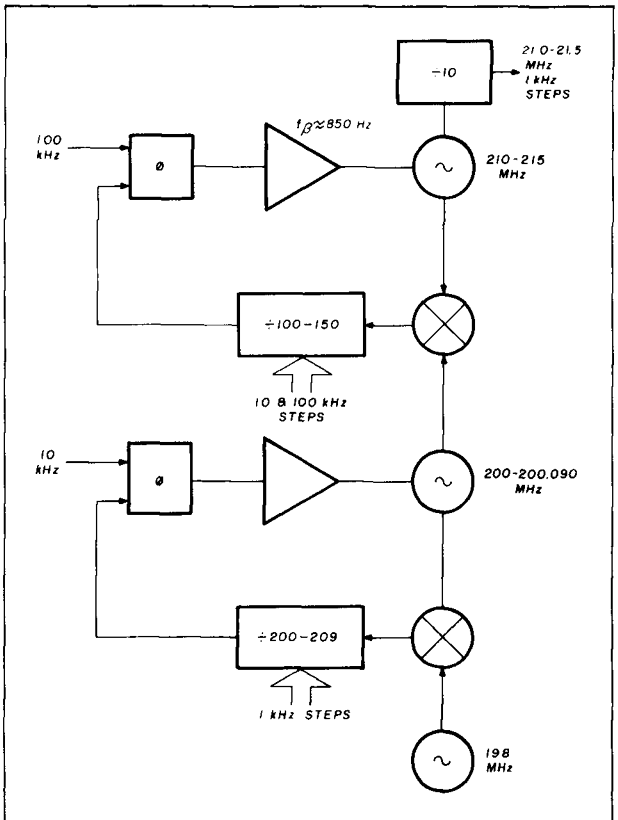

fig. 19. Using another synthesizer for in-loop mixing to help improve phase noise performance. Using various adaptations of this can help keep lock time short and phase noise low.

ing can be a VFO, VCO, VCXO, or even another synthesizer (**fig. 19**) for finer frequency steps. Some Amateur radio transceivers use this technique by letting the synthesizer step in 1 kHz increments by changing N and then step in 100 Hz increments by tuning the VCXO local oscillator using a DAC (Digital to Analog Converter).

VCO phase noise and K_{VCO}

In real synthesizers the phase noise is more than expected due to additive noise generated by both ac-

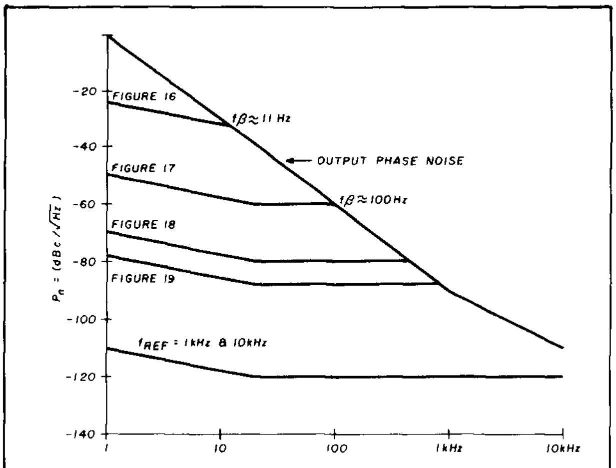

fig. 20. Relative phase noise plot of synthesizer in figs. 16-19.

tive and passive devices modulating the VCO. Therefore, for best performance, choose the components used in the synthesizer wisely, especially those in and around the VCO and loop filter.

The effects of noise and spurious signals on the VCO tune line can be approximated if the modulation index caused by these is known to be small.

$$P_n \approx 20 \log \frac{2\sqrt{2}\, V_t K_{VCO}}{8\pi f_M}$$

where P_n = SSB noise power in a 1 Hz bandwidth, or spur power, in dBc

V_t = RMS noise, or signal voltage on VCO tune line

f_M = frequency of noise or signal on VCO tune line

For example a VCO with a $K_{VCO} = 628.3\,(10^3)$ has 100 μv (RMS) of spurious signal at 1 kHz on its VCO tune line. This spurious signal appears as 1 kHz sidebands with a sideband spur power of:

$$P_n = 20 \log \frac{2\sqrt{2}\,(100\ \mu v)\ 628\,(10^3)}{8\pi\ (1\ kHz)}$$

$$or\ -43\ dBc.$$

frequency division and phase noise

External to the phase locked loop, synthesizer phase noise can be reduced through the use of frequency division by 20 log N if a reduction of frequency by N is acceptable. This is quite common in commercial synthesizers and is shown in **figs. 18** and **19**.

As is always the case, using this technique to reduce phase noise has its limits, in this case the noise floor of the digital divider.

For MOS, TTL, and ECL devices, the noise floors are typically -120 to -140 dBc $\sqrt{Hz}$, MOS devices having poorer noise performance than TTL and ECL.

In the third and final part of this series, two techniques for designing a 5.000-5.500 MHz synthesizer — as well as trade-offs common in PLL design circuits — will be discussed.

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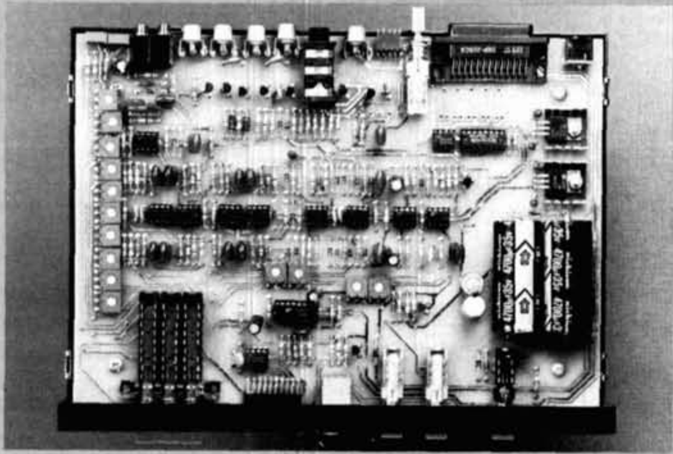

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10-GHz weather radar

A unique application for a Gunnplexer transceiver

Commercial weather radar systems have become quite popular in recent years and have proven their true life-saving ability. And over and above their use during dangerous storms, they have now become almost a part of our daily lives. The only drawbacks to these commercial radar systems are their inability to scan a small area (such as an individual's neighborhood), and the fact that commercial radar scans are generally made available only at fixed times.

To overcome these limitations, I have designed a mini weather radar system which is both inexpensive and easy to build. A short scanning range was my only criterion. Guidelines are provided for those interested in pursuing and refining this unique concept.

This mini weather radar is based on two simple facts: a radio signal travels one mile in 5.4 microseconds; and an electron beam can be timed to travel across a CRT's screen at a predetermined rate. If a radio wave leaves a transmitting antenna at the same time that a horizontal line begins on the left side of a CRT display, that radio wave will travel approximately 12.1 miles in the 63 microseconds it typically takes for one scan of a horizontal line in conventional TV.

operation

The first version of this unit is shown in **fig. 1**. An oscilloscope with horizontal trigger output is used with a 10-GHz Gunnplexer, an NE555 pulse modulating circuit, and a high gain amplifier to produce a distance-and-azimuth Amateur weather radar. The Gunnplexer's mixer uses the unit's constantly transmitted signal for a local oscillator, eliminating the need for a T/R device. A horizontal scan-initiating sync pulse from the oscilloscope's horizontal trigger output is used to key the NE555 oscillator, which becomes the modulating signal for the Gunnplexer's varactor input.

The Gunnplexer transmits its signal toward a distant object, such as heavy storm clouds, and its reflection is then received. The return signal heterodynes in the Gunnplexer's mixer, the output of which drives a high-gain amplifier. The amplified echoes are then fed to the oscilloscope's vertical input for display. Since the scan started during the pulse-transmission time, its round-trip delay time is indicated in **fig. 2** as displacement on the screen.

The Gunnplexer's modulating frequency should be between 200 kHz and 1 MHz. This frequency deter-

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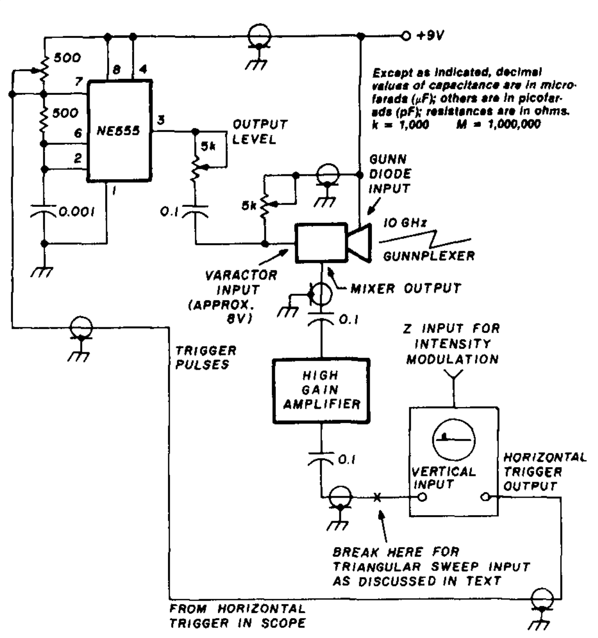

fig. 1. Arrangement of the first-generation Amateur weather radar, using an oscilloscope for generating timing pulses and displaying returned echoes.

mines the exact pulse width. Using the formula $F = 1/T$, a 200-kHz modulating frequency translates into approximately 5 microseconds: approximately one mile on the screen's display. A 1-MHz modulating signal encompasses approximately 1 microsecond (1/5 mile) on the screen. Although the Gunnplexer transmits a carrier continuously, only the brief modulating pulse causes indications on the CRT display. This unit will provide distance indications and information on the density of rain clouds, but it does not provide information on the direction of storm clouds. This shortcoming does not usually pose a problem.

refinements

The second version of this weather radar uses an NE555 triangular wave generator and adds a modified oscillating house fan motor to make possible directional (azimuthal) readings. An outline of this arrangement is shown in **fig. 3**. The fan motor causes side-to-side movement of the remote Gunnplexer, while a microswitch at one end of the sweep provides synchronizing pulses for the NE555. The output from the triangular wave circuit is applied to the oscilloscope's vertical input; the high-gain amplifier's output is applied to the intensity (Z) input of the oscilloscope. The oscilloscope is adjusted for a dark screen until an intensity-modulating echo is received. Range markers can be added to this system with another NE555 circuit, or can simply be drawn on the screen with a washable-ink felt pen. I also suggest that you replace the oscilloscope's P-1 phosphor cathode ray tube with a long-persistence-display P-7 equivalent tube.

During operation, horizontal sweep pulses from the oscilloscope trigger the NE555 modulation circuit, while vertical sweep is provided by the fan-motor-synchronized triangular wave generator. The Gunnplexer transmits a 200-kHz-modulated 10-GHz signal which is reflected according to cloud density and displayed on the screen. Horizontal displacement on the CRT indicates distance, and vertical height (with respect to the base line) indicates direction.

The received echoes are heterodyned with the Gunnplexer's carrier, amplified, and applied to either the oscilloscope's Z modulation port or vertical input (depending on the particular version of weather radar you build). Although a low-power 10-GHz Gunnplexer can transmit and receive over line-of-sight distances

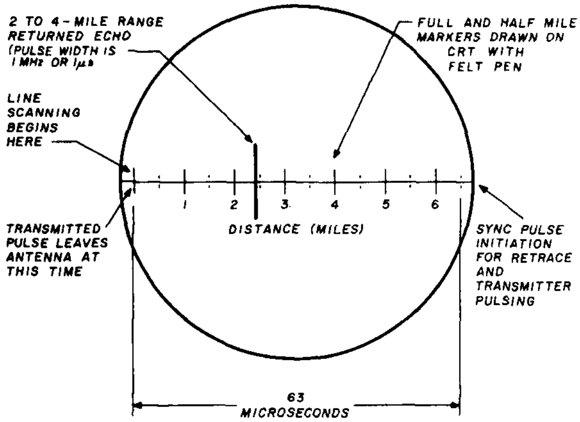

fig. 2. Visual display obtained with first-generation Amateur weather radar. The 10-GHz Gunnplexer transmits a modulation pulse at the same time a scan line begins on screen at left. The time periods shown provide a range of approximately 6 miles.

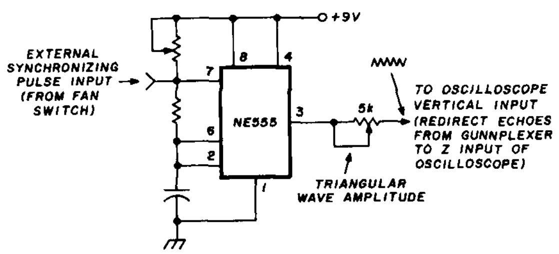

fig. 3. Triangular wave generator for vertical deflection in synchronization with Gunnplexer movement, as described in text. Circuit insertion point is shown in fig. 1.

in excess of 20 miles, I suggest that you limit its range in this application to less than 12 miles (a number chosen because of the oscilloscope's horizontal scan rate and the frequency of the Gunnplexer's modulator). This safety margin ensures reliable operation and permits accurate interpretation of the displayed information.

a third mini radar

A third version of the mini weather radar is being developed now, and its capabilities look promising. This system employs a used black-and-white TV set rather than an oscilloscope, using the TV circuits to generate precisely timed transmitter pulses and to display the reflected signals. Since the set's tuner and i-f stages are bypassed, with the radar information applied directly to the video amplifier section, usable TVs could be picked up inexpensively at TV repair shops.

An outline of the system is illustrated in **fig. 4**. Narrow-width (and highly accurate) horizontal AFC pulses obtained from one of the low-voltage windings on the TV's horizontal output transformer trigger the Gunnplexer's NE555 modulator. This arrangement establishes radar timing while maintaining horizontal line sync in the television. A single-shot multivibrator or Schmitt trigger proves useful for buffering flyback pulses. Alternatively, a dropping resistor may be placed in the keyed AGC line for lowering that voltage to approximately 5 volts. A schematic diagram of the TV is needed for locating the keyed AGC line and determining its voltage level (don't "hunt around" in the horizontal output section: HIGH VOLTAGE!). The desired modulator-keying line is usually found connected to the AFC's discriminator diodes. You will also see a "second line" carrying sync pulses from the sync separator stage in the AFC's discriminator. That guidepost will help you locate the desired AGC keying takeoff point.

Output from the Gunnplexer's modulator is applied to that unit's varactor. The returned echoes are amplified to approximately 4 volts by a wideband amplifier similar to a single video stage in a television set, and applied to the TV's video amplifier section (a suitable injection point for this signal is quite often between the contrast control wiper and ground. If an ac/dc TV is used, be sure this point is not hot). The resultant echoes are displayed as intensity variations on the screen, with distance and timing calibrations provided by techniques similar to those in the second unit, described earlier. The next step in this system's development will include electronically sweeping the 10-GHz radar signal in sync with the TV's 60-Hz vertical scan rate. An illustration of the resultant display is seen in **fig. 5**.

A fourth generation Amateur weather radar is presently on the drawing board, and this version

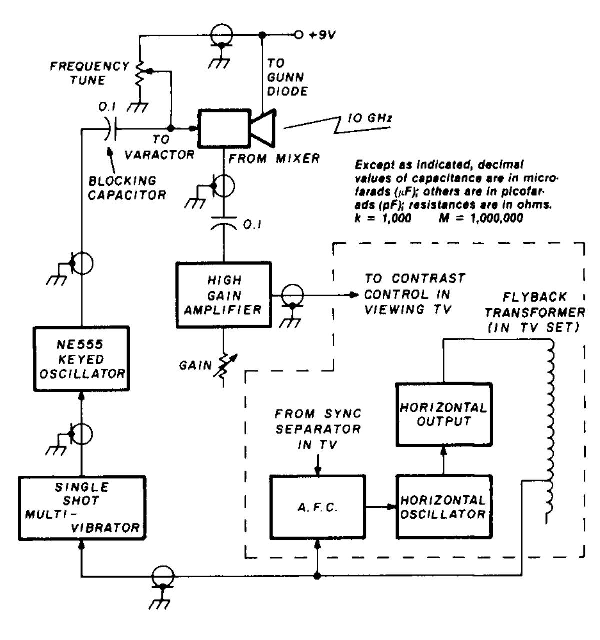

fig. 4. The third-version Amateur weather radar uses a modified television set for timing and display of target information.

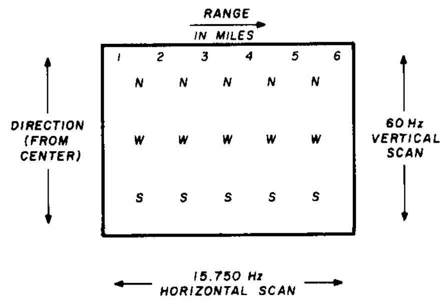

fig. 5. Display of sector scan as accomplished by version-three Amateur weather radar. A modified TV set is employed.

holds some truly exciting possibilities. Basically, this system employs an inexpensive home computer, such as the Apple II or TRS 80C, for generating all the required timing pulses and for creating a color-level display similar to that of commercial units. Since these microcomputers are easily programmed for various timing ranges and color presentations, they are quite useful for Amateur radar work. The integration of A-to-D and D-to-A converters in these units makes computer interfacing relatively simple.

Alden Electronics (Washington Street, Westborough, Massachusetts 01581) manufactures a weather chart recorder (Model 9321), available in assembled or kit form, that displays data generated by NOAA and other sources. — **Editor**

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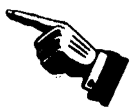

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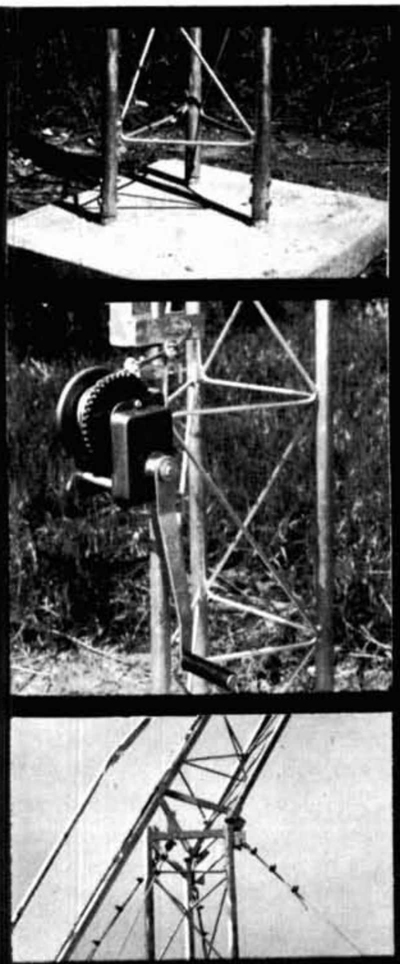

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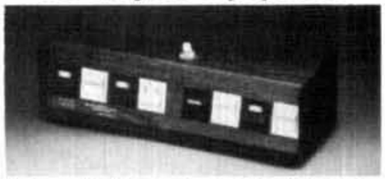

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There are two phases in the establishment of an effective ground system. The first involves properly bonding together all equipment in the shack. The second entails the construction of a low resistance earth ground.

what should be bonded?

All pieces of equipment in the shack should be correctly bonded together. This includes transceivers, transmitters, receivers, power supplies, keyers, antenna tuners, etc. Unlike dc or ac, all current flow is at or near the surface of a conductor at radio frequencies. Thus, the ideal bonding material should have a large surface area to present the least impedance to the flow of rf currents. The best and most expensive conductors are braided copper strap and flashing copper, which both possess large surface areas. No. 6 gauge copper wire, normally used for grounding, has *less* surface area than the shield of RG-58 coaxial cable. In addition to being expensive, large gauge solid copper wire is very stiff, making it difficult to use.

A less expensive substitute for copper flashing or braided copper strap is the shield of RG-8 coaxial cable. It isn't necessary to use new cable. If you replace your coaxial cable every three to five years, as do most hams, the cable you replace will probably be adequate for grounding purposes.

A ground bus using the entire cable is shown in **fig. 1**. It is not necessary to pull the shield off the coaxial (a nearly impossible task). The center conductor is not used in order to avoid making the cable self-resonant. In the installation shown in **fig. 1**, short lengths of RG-58 cable were used to make connections to individual pieces of equipment. Again, only the shield was used. To facilitate connection, the center conductor and insulation were cut to allow 2 inches of free shield at each end. The RG-8 bus was stapled across the back of the desk to place it as close as possible to the equipment.

cold water pipe

Amateurs are often advised to ground their equipment to the nearest cold water pipe. But this is impossible if the pipe is plastic or corroded metal. Even with copper pipe, these makeshift grounds may be difficult or impossible to reach — unless you operate from the kitchen, bathroom, or laundry room. The use of water pipe instead of a good earth ground is justified only if you live above the first floor of an apartment building.

achieving good earth grounds

The construction of a good earth ground, while not difficult, involves more than driving a metal rod into the lawn. The soil into which the ground rod is driven should present minimum resistance to the flow of electric currents. When completely dry, most soils are non-conductors. Pure water is a very poor conductor. The basic electrical conductivity of a soil is the result of electron transfer through electrolytes dissolved in the water present in that soil. However, there are many factors that can affect this basic conductivity.

By Bradley Wells, KR7L, 5053 37th Avenue, S.W., Seattle, Washington 98126

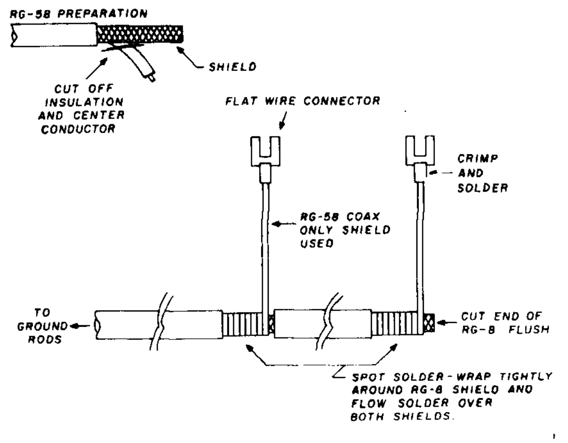

fig. 1. Using RG-8 coaxial cable as a ground bus.

material	conductivity (millimhos/meter)
poor soil	1-5
average soil	10-15
very good soil	100
water	10-15
salt water	5000

fig. 2. Soil conductivity chart.

Soil type has an important effect on local ground resistance as shown in **fig. 2** and **3.** Commercial broadcast stations require excellent ground systems for their vertical antennas. This is why they show a marked preference for low swamps over rocky mountain tops. Soil particle size and density influence conductivity, which explains the differing resistances between clay and sandy gravel. A fact to consider in locating your own earth ground is that soil type can change over very short distances, both vertically and horizontally. The flowerbed may look like a good place for a ground rod, but it won't be if the topsoil is resting on gravel or rock.

The moisture content and concentration of dissolved salts markedly affect soil resistance (see **figs. 4** and **5**). There is a direct correlation between increased soil moisture and lowered resistance. The same effect is noted with respect to dissolved salts in the soil. Little information is available on the changes of soil conductivity with respect to different types of salts. The importance of soil moisture and salt concentration cannot be overemphasized. Salts disassociate into the ions involved in electron current flow; water provides the medium to facilitate easy flow of these ions through the soil.

Two other interrelated factors affect soil conductivity. As shown in **figs. 6** and **7,** soil resistance rises quickly as the temperature drops. Soil conductivity is lowest during the winter months and highest in summer. However, these temperature and climatic effects become less noticeable with increasing depth in the soil. Those of you living in cold climates will notice the large jump in soil resistance as the soil freezes. This is due to ions being trapped in the crystalline structure of the ice. Maintaining a low ground resistance during winter months means driving your ground rods well below the frost line.

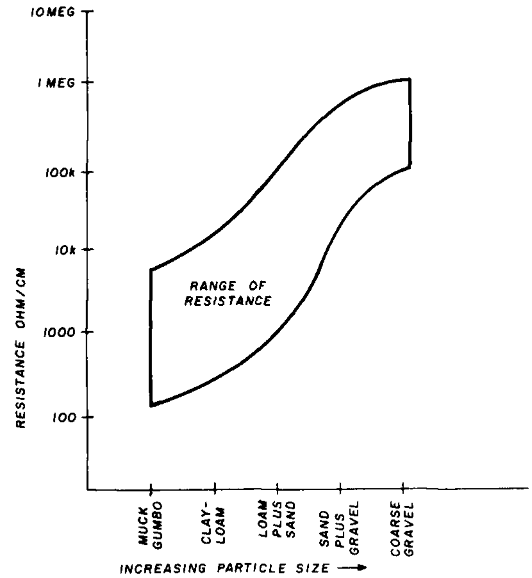

fig. 3. Resistance values of various soils.

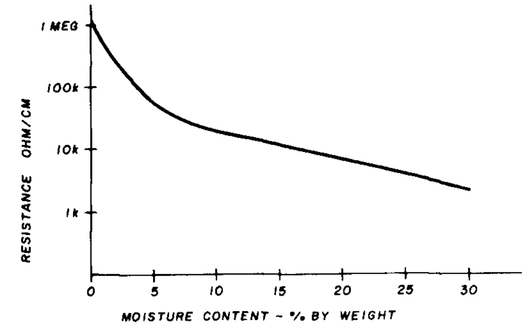

fig. 4. Effects of moisture in sandy loam soil.

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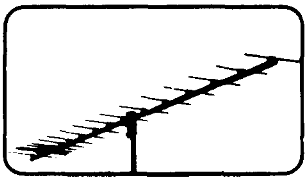

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Front / Back	20 dB	25 dB			
Front / Side	>40 dB				
SWR	<1.5 / 1				
Aperture Angle E	2 x 29°	2 x 18°	2 x 18°	2 x 15°	2 x 15°
Aperture Angle H	2 x 46°	2 x 24°	2 x 24°	2 x 16°	2 x 16°
Impedance	50 ohm				
Mast Diameter	50 mm				
Boom Lenght	1.1 m	4.5 m	4.55 m	6.45 m	6.5 m
Surface Area	0.03 m2	0.12 m2	0.16 m2	0.18 m2	0.23 m2
Weight	1 Kg	3 Kg	3.4 Kg	5 Kg	5.5 Kg
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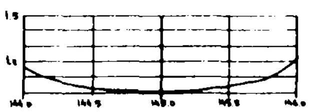

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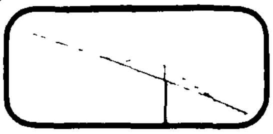

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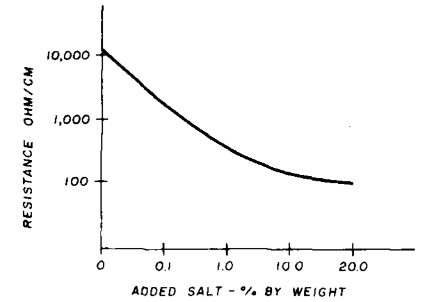

fig. 5. Effects of dissolved salts in sandy loam soil.

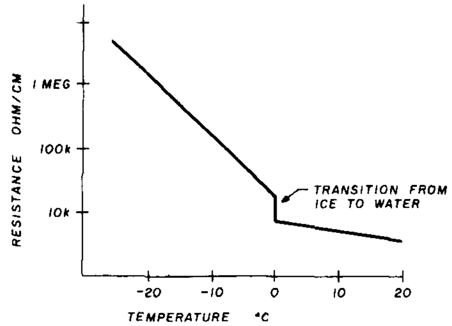

fig. 6. Temperature effects on sandy loam.

chemical treatment

Chemical treatment of the soil around a ground rod will increase the effectiveness of your ground system.* Rock salt, copper sulphate or magnesium sulphate (commonly known as Epsom salt) will inject large quantities of ions into the soil increasing its conductivity while reducing seasonal variation. However, these salts will gradually be washed away by rain and groundwater. They should be replaced every one to three years depending on climate and soil type. Rock salt is the most readily available and least expensive. Magnesium sulphate (Epsom salt) is available at any drugstore. Copper sulphate is the most effective but the most expensive.

ground rods

Copper pipe makes the best ground rod, but unfortunately, it's expensive and too soft to be driven into the ground. The best practical rods are made of steel plated with copper to decrease resistance. These are available through most Amateur Radio outlets. Remember that the length of a ground rod is more important than its diameter. Doubling its length will cut resistance by 40 percent, while doubling the diameter will result in only a 10 percent reduction.

Spaced rods provide large reductions in the resistance of your earth ground system as shown in **fig. 8.** Ground rods should be separated from each other by a distance equal to their length. This reduction of resistance is not proportional to the number of rods in the system. Three rods spaced 15 to 25 feet apart will provide an optimal ground for all Amateur stations.

A typical ground rod set-up is shown in **fig. 9.** This is most effective since the chemical salts are distributed through a large volume of soil. Unfortunately, these salts are toxic to vegetation and can leave a ring of bare soil around each rod.

An alternate installation method for ground rods is shown in **fig. 10.** This was used for my station since I have a small city lot and all the good locations for driving ground rods seemed to be covered with petunias. All excavation was done with a post-hole digger to minimize damage to the flower beds. While not quite as effective as the method in **fig. 9**, it allows much greater latitude in the placement of your ground rods.

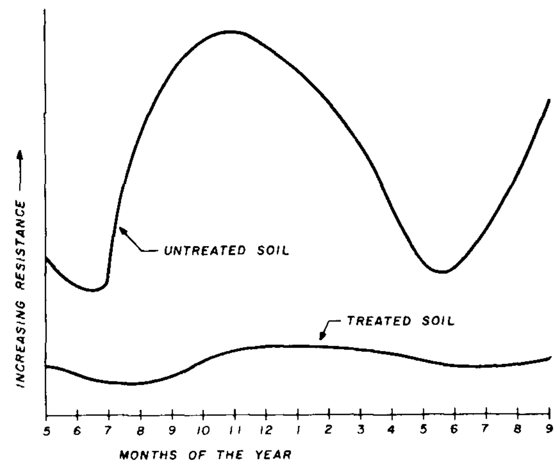

fig. 7. Seasonal variation of ground resistance.

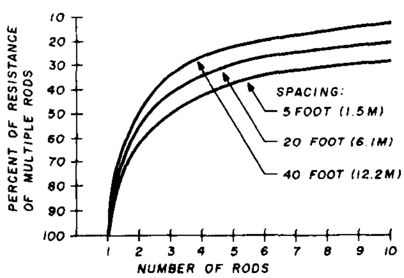

fig. 8. Resistance reduction of multiple rod ground over single rod ground.

*Use extreme caution in applying chemicals that may pollute ground water, wells, or soil. **Editor.**

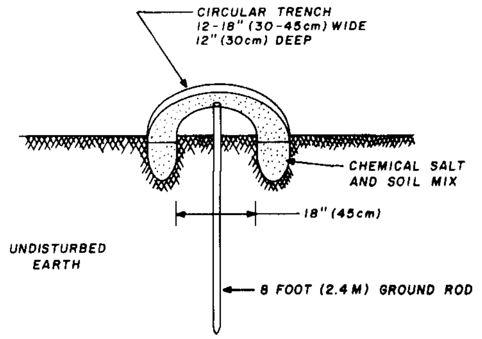

fig. 9. Typical ground rod set-up.

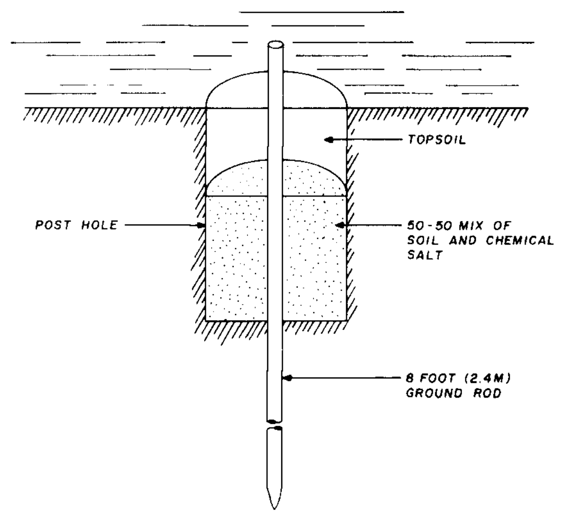

fig. 10. Ground rod with treated soil for confined areas.

The proper construction of a low resistance earth ground system is a relatively simple task. It can eliminate the problem of "rf in the shack," reduce your TVI potential, and improve the performance of low band antennas — not a bad trade-off for several hours of work.

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ham radio

locate orbiting satellites

The motion of satellites around the earth is explained to help you find and use Amateur satellites

For the beginning satellite chaser, probably the most perplexing question is, how do I find out when I can hear it? Although there are now numerous ways of finding the answer to that question, the newcomer — and possibly some old-timers — will find it very helpful to understand the spatial relationships that exist between satellites and the earth. With the aid of a simple globe of the earth and some basic information on satellite behavior, a clearer picture of how to find satellites emerges.

Look at a globe of the earth and visualize it divided exactly in half by a flat planar surface. Imagine this plane at a slight angle to the polar axis, so that it passes to one side of the north pole and to the other side of the south pole. Now consider this plane to be stationary, with the earth rotating freely through it. Note that twice during each rotation each point on the earth's surface passes through this plane — except for small regions near each pole. At each passage the plane will appear to approach the earthbound observer from the east and disappear to the west, just like the sun and moon.

satellite paths

What does this have to do with satellites? Satellites travel around the earth in a path that stays on a flat plane of this kind, and the planes of the various satellites are completely independent of one another. Much of the apparent movement of the satellites is merely the movement of the earthbound observer being carried toward and away from the orbital plane.

The problem of discovering when a given satellite comes within useful distance is then really the problem of finding out where the orbital plane is when the satellite is near your latitude. Since this information is different for every station, a convention is used that identifies the time and location of the satellite's equatorial crossing. From that information you can derive the specific data you need for your own location.

A satellite circling the earth in the orbit previously described crosses the equator twice during each revolution around the earth. The convention for reference data identifies only the northbound equator crossing. Information on the longitude and time of the first northbound equatorial crossing for the UCT (Greenwich) day is published and broadcast by ARRL, AMSAT, and others. In addition to this information, we must also know certain other facts about the satellite's orbit. The time it takes a satellite to revolve exactly once around the earth is called its *period*. The angular distance, measured at the equator, between successive northbound equator crossings is called the *increment*; measured in degrees of longitude, and mainly related to the earth's rotation. It is also important to know the *inclination angle*, the angle between the orbital plane and a plane through the earth's equator. All these orbital characteristics are unique to each satellite and are published in various Amateur magazines.

For the ham who really wants to get serious about tracking satellites, there is another item of information I can recommend. That is something that's not published but must be calculated by the individual for his own location. I have called it the *index point*, and I define it as the longitude of the intersection of the orbital plane with the equator that causes the satellite to pass directly overhead. These index points are different for each satellite, and, in fact, there will be two: one for northbound satellite movements (ascending orbits) and one for southbound move-

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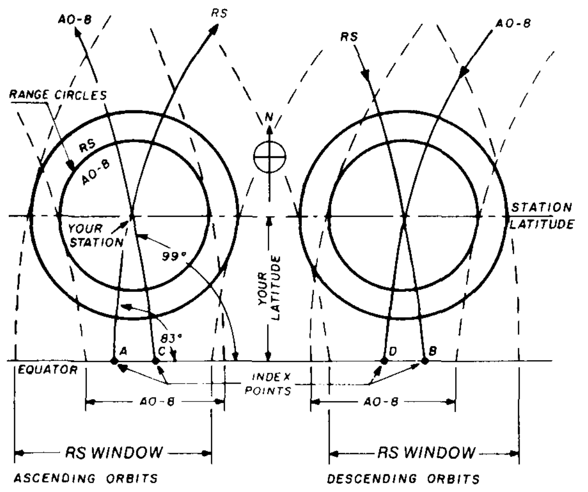

The "windows": Satellites will pass within range of your station if they cross the equator inside your window. Points A and B mark the center of the windows for RS birds, points C and D for OSCAR 8. Northbound equator crossings will be farther west from points D and B, which mark the window centers for southbound crossings by 180 degrees minus ½ increment. At stations located on the equator, the window widths are 75 degrees for RS birds and 58 degrees for OSCAR 8. For station locations at other latitudes, the window will widen by the reciprocal of the cosine of the station latitude (up to about 50 degrees either north or south). NOTE: Stations in the southern hemisphere should invert this figure and interchange the terms "ascending" and "descending."

fig. 1. "Window" determination for OSCAR 8 and RS satellites.

ments (descending orbits). Let's take a closer look at these index points.

If the orbital plane had an inclination angle of 90 degrees (perpendicular to the equator), one might predict that the index point would have the same longitude as the ground station. That is not quite true, however, because it takes time for the satellite to move from the equator to the station and the rotation of the earth during this interval has moved the station eastward by one degree longitude for each four minutes. Thus the orbital plane must be positioned east of the station longitude to accommodate this fact.

Since the inclination angle of the orbital plane is not 90 degrees for any of the satellites now in orbit, there will be a difference between the longitude of the equator crossing point and the ground station because of this "leaning" of the plane. An effective way to visualize this is to stretch a rubber band around the globe, making a great circle. Position this great circle so that it passes through the ground station location, and make the northernmost and southernmost points tangent to latitude parallels equal to the inclination angle. For OSCAR 8 this angle is 99 degrees, so the great circle will come tangent to 81 degrees, passing to the left of the north pole (as you view your station's location) and to the right of the south pole. For the Russian satellites (RS-3 through RS-8) the inclination angle is 83 degrees, which makes the tangency points nearly the same, but on opposite sides of the earth's poles.

With the assistance of this great circle it's apparent that for inclination angles of less than 90 degrees, the plane crosses the equator slightly west of the ground station's longitude; for inclination angles greater than 90 degrees, it crosses slightly east. The contribution to the displacement due to the earth's movement is always toward the east; thus these two effects almost cancel one another for the RS birds. They add for OSCAR 8.

For ground stations with latitudes of not greater than about 60 percent of the inclined orbital plane's northernmost (or southernmost) latitude, it's possible to calculate the location of the index points without resorting to spherical geometry and still get accurate enough results for Amateur communications. For example, consider a ground station at 40 degrees north latitude and 80 degrees west longitude. And let us use the data for the RS-8 satellite, because it provides some easily understood calculations (see **fig. 1**). RS-8 has a period of just under two hours, an increment of almost exactly 30 degrees of longitude, and an inclination angle of 83 degrees. Its height above the earth's surface is 1680 kilometers, a value we will also need.

The first value we will need to derive is the displacement caused by the earth's rotation. Since the satellite travels at a velocity of 3 degrees per minute, it will take 13.3 minutes for it to travel north from the equator to the station's latitude. Meanwhile, the earth turned 3.33 degrees (13.3 divided by 4).

The *inclination factor* is the latitude multiplied by the cosine of the inclination angle. That is 4.9 degrees, but since it's west and the 3.33 degrees is east, they partially cancel, making the index point 81.47 degrees west longitude. The significance of this is that every orbit of RS-8 that ascends across the equator at 81.5 degrees will pass over the ground station 13.3 minutes later.

A similar index point can be found for satellite passes which ascend on the other side of the earth and descend over the station. The arithmetic for determining this index point has almost all been done, since the satellite now passes the station before it reaches the equator by 13.3 minutes. Both the previous displacements change direction, and the equator crossing on descent becomes 78.5 degrees west.

It's more useful to learn where the ascending equator crossing must be to produce the desired descending longitude. One might expect it to be exactly opposite (i.e. 180°), however, that is not correct since the earth has been turning during the intervening half-orbit. Therefore, the required longitude of ascension will be east of a point opposite by an amount proportional to the time required for this half-orbit transit. Since all satellite locations are expressed in longitude degrees west of zero, this point is most easily obtained by adding 180 degrees minus

one-half the increment. (Should the result be greater than 360 degrees, the correct value is obtained by subtracting 360.) For the example we've been using, this ascending crossing will be at 243.5 degrees west. It's useful to note that the 'bird' will arrive over the station 46.5 minutes after this crossing: one-half the period minus the time from the station to the equator.

So much for passes which are overhead. But what about the ones that come by without being that high in the sky? To find out when and where these occur, we must take up the question of range. When the satellite is just on our horizon (unless the horizon is obscured by a mountain or building) the ground station is at the 90-degree corner of a right triangle, the other two corners of which are the center of the earth and the satellite. The useful information to be drawn from this triangle is the angle between the lines joining the center of the earth with the other two corners. This angle defines the maximum range at which the satellite is visible on the horizon, and its value can be used to calculate the equator crossing longitudes of orbits that will carry the satellite inside a "range circle" that's centered on the ground station and has a radius of that dimension.

If the ground station were on the equator, we could merely add and subtract the range angle to the index points to derive the "window" through which every satellite would have to pass to come into ground station range. For ground stations off the equator — at latitudes greater than zero — the range window widens. Without getting into complicated spherical geometry, it's possible to estimate the width between eastern and western equator crossings at the range limits by dividing the range angle by the cosine of the station latitude, and adding and subtracting the resulting value to the previously calculated index points.

Using the RS-8 satellite and the ground station of the earlier example, the range angle is 37.7 degrees.* Dividing this by the cosine of 40 degrees widens this angle to 49.2 degrees. Adding and subtracting this gives limits of 32.3 degrees and 130.7 degrees, and provides a fair approximation of where ascending equator crossings will bring the satellite within range of this ground station. The same operation on the other index point gives a set of limits for descending orbits in terms of the longitude of ascension. For this station they are 194.3 degrees and 292.7 degrees west longitude.

The true boundaries of equator crossings are slightly beyond these calculated values, but the mathematics becomes too involved to make their determination worthwhile. Also, this simple scheme develops gross inaccuracies as the location of the ground station exceeds latitudes greater than about 60 percent of the maximum satellite latitude. Stations in higher latitudes need to use a different approach.

*The angle is equal to arc cosine $[R/(R + H)]$, where $R = 6371$ km and $H = 1680$ km.

which satellites are in range?

Having established the edges of our own personal index windows, we now need a list of all the satellite equator crossings to see which of them will be in range. Lists showing all equator crossing longitudes and times for ascending orbits are available, but they are predictions, made months into the future, and tend to require corrections when the actual date arrives. Here is a simple technique, using an ordinary pocket calculator, for getting the same information from more correct reference orbit data broadcasts by W1AW and the AMSAT nets. If your calculator has a memory capable of storing an eight-digit constant, it can handle this procedure.

The idea is to combine the two values — time and longitude — into a single multiple digit value that can be repeatedly added to the initial reference data to yield successive orbital data. Again using data for RS-8, the satellite has a period of 119.7 minutes and an increment of 30.07 degrees. Combine these two values into a single expression and enter it into the calculator's memory. Make this value 199.70301 (why it's not 119.70301 will be explained later — see **calculator values**). Note that the increment has been rounded off to stay within eight digits.

Assuming that the reference data for RS-8 this day is 00:42:36 (hours:minutes:seconds) at longitude 260.4 degrees west, enter these two items as a single value (42.62604) and add the constant to get 242.32905. This can be mentally separated to be 2 hours, 42.3 minutes at longitude 290.5. Add the constant again and get 442.03206, 4 hours, 42.0 minutes at 320.6 degrees longitude. Add the constant once more and get 6 hours, 41.7 minutes at 350.7 degrees west longitude. The next addition comes to 841.43808, but since the longitude portion exceeds 360 degrees, merely subtract 0.036 and you find that this orbit ascends the equator at 8 hours, 41.4 minutes at 20.8 degrees west. You can continue to develop data for each successive orbit. Should the minutes value of the time come out between 60 and 99, merely subtract 40.0 and you have a correct value and can continue. In fact, you can even subtract 2400.0 when the time exceeds 2359 and continue on into the next day if you don't have new reference data for that day. If you go on too far, of course, the inaccuracies of rounding will build up.

By comparing the longitudes of equator crossings with the limits you have computed for your two index windows, you can select those which will pass within the range of your station and establish the time that each will pass your latitude. The elapsed time from equator crossing to arrival at your latitude will be the same whether the equator crossing is such that the bird passes overhead or only out near the limits of your range. When the pass is directly overhead, you can expect the duration of visibility to be twice the range (degrees) divided by the velocity (degrees per minute). For OSCAR 8 this is 16.7 minutes ($2 \times 29.1 \div 3.49$). For the RS birds this duration is 25 minutes ($2 \times 37.7 \div 3.0$). When the pass is halfway between the station and the range limit, the duration is 85 percent of the overhead value; at the range limit, it may be only a minute or less.

A helpful exercise in developing your understanding of how the satellite moves through any portion of your range circle is to place your great circle marker on your globe at various longitudes within the index window and note the path it defines as it comes into and leaves your range circle. For stations in the Northern Hemisphere this track causes the RS birds to depart off to the northeast on ascending orbits and to arrive from the northwest on descending orbits. For OSCAR 8 the opposite relationship results from the difference in inclination angle, its having an angle of inclination 9 degrees greater than 90, while the Russian orbits are 7 degrees less than 90 (see **fig. 1**). By attaching a length of string to your globe at the station location and tying a knot at a distance representing the range limit, you can obtain an excellent graphical representation of your range limit. Note that the length to the knot can be measured in either latitude degrees or in longitude degrees at the equator.

calculator values

By making the constant for the period and increment that value given earlier, you are simultaneously adding two hours and subtracting a few minutes to the mixed hours and minutes expression. Occasionally, when the minutes value is small, the result comes out a few minutes less than 99 when it should be the same number of minutes less than 59. Subtracting 40 minutes fixes it up.

No doubt a home computer with satellite locating programs can provide more exact information, but satisfactory operation can be achieved using the simple methods described here. For almost ten years I have tracked the satellites — and had hundreds of QSOs — using only my globe, a rubber band, some string, and a hand calculator.

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✓ 110

working W5LFL from space

All you'll need is ten watts and an antenna — and lots of luck.

So you want to work an astronaut from space? You'll have your chance when Dr. Owen Garriott, W5LFL, begins transmitting from the space shuttle *Columbia* on the third day of the nine-day mission scheduled for launch September 30.

Details of the flight plan, are still being worked out. As of this writing, transmission is expected to be within the range of 145.51 to 145.77 MHz, with 145.55 the primary channel (downlink). Using split operation, W5LFL will listen between 144.91 and 145.09 MHz, stepping in 20 kHz increments. (Stay tuned to AMSAT nets and W1AW for specifics. Newsletters will also provide details as the launch date approaches.)

NASA has mapped out a flight path that takes the *Columbia* over the most heavily populated areas of the earth. In ascending orbit, the ship will appear over the southwest horizon of the United States and follow a gentle curve towards the northeast, its path dividing the contiguous United States into four areas corresponding roughly to the time zones. Tracking data is being compiled for release by AMSAT.

Flying at 17,000 miles per hour at an altitude of approximately 200 statute miles, Garriott will have line-of-sight for about 1,000 miles. He'll be radio-visible for a *maximum* of eight minutes over any given point.

Based on experience with OSCAR, AMSAT tells us we can expect to receive full quieting signals while the ship is passing overhead — even on a hand-held radio with a rubber-duckie antenna. Transmission may not be as simple; you'll need ten watts and a gain antenna — and lots of luck — to stand a chance of being herad by W5LFL.
ing heard by W5LFL.

Garriott will operate from the aft flight deck of the *Columbia*, using a specially-built transceiver operating at 5 watts. His split-ring antenna, housed in a window overlooking the European-built Space Lab, will give him line-of-sight perspective to earth during most of the flight.

Astronauts work a schedule of twelve hours on, twelve hours off. Garriott has NASA's OK to operate up to one hour per day during his free time, most likely on either end of his eight-hour sleep; he'll tell Mission Control when he's ready to operate. Club stations at each NASA site will pass the word to other Amateurs; those of us on earth can expect about 35 to 40 minutes' notice.

Once he begins operating, Garriott will transmit on the even minutes and listen on the odd minutes. During transmission, he'll state his location, then identify call areas for which he'll be standing by, and finally begin acknowledging calls he's been able to log.

NASA recommends that amateurs wishing to contact W5LFL transmit *only* their calls during the odd minutes. Just fifteen to twenty orbits at most are expected to be effective, and on each pass, no more than a few dozen earth stations can be worked. If you call but are not acknowledged, don't give up hope: Garriott will tape record all Amateur activity and the resulting tapes will be used as a log for QSLing after completion of the mission. (Attention DX'ers: W5LFL does *not* count as another country!)

September is a good time to clean up that 2-meter equipment. So clean it up, follow the news closely, and get ready to make history . . . as one of the lucky ones to make contact with "W5LFL from Columbia" this fall.

ham radio

by Roy Neal, K6DUE, Senior Correspondent, NBC Network News.

technical forum

Have a technical question? Ask your fellow Amateurs through Technical Forum. You'll reach knowledgeable readers ready to help you find the answer you're looking for. *Have an answer?* Send it in. Every month we'll award a specially selected book from Ham Radio's Bookstore to the writer of the best response to a question previously posed in this column. Address your questions and answers (typewritten, if possible) to Technical Forum, *ham radio magazine*, Greenville, New Hampshire 03048.

efficient matching

Joe Czerniak, W8NWU, asked for "the most efficient way" of feeding a 432 MHz helical antenna with 70 ohm cable from a 50 ohm source (Technical Forum, March, 1983). I assume that by "most efficient way" he meant the way resulting in the least power loss, not the way representing the best possible ratio between personal effort extended and the result achieved.

It seems to me that with the system having a relatively narrow bandwidth, then if effort is not a consideration, a 1/4 wave section of air-spaced coaxial should be constructed to match the unbalanced 140 ohm antenna to the unbalanced line. This should be constructed in the form of a trough, using the jacket of the 70 ohm cable as the outer strips to avoid having a connector (**fig. 1A**). The impedance of the trough section should be 99 ohms (the square root of the product of 140 and 70).

At the equipment end, the matching is best done in the converter, by arranging it to match directly to a 70 ohm feedline.

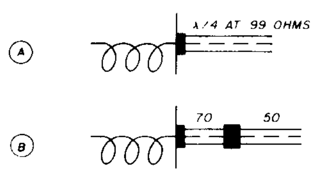


fig. 1. Two methods of matching to a 140-ohm impedance helical: (A) Using a quarter-wave 99 ohm trough, (B) Using successive sections of quarter-wave lines (70 to 50 ohms, respectively).

A more conventional way, using the connectors (while acknowledging their possible future problems), would be to match the antenna to the cable with two successive 1/4-wave sections (**fig. 1B**). It is a fortunate coincidence that a section of 70-ohm coaxial would transform from 140 to 35 (70 is the square root of the product of 140 and 35) and a section of 50 ohm coaxial would transform from 35 to 70 (50 is the square root of the product of 35 and 70). If the helical were a balanced antenna it would be interesting to note that a 140/balanced to 35/unbalanced balun could be built from the same cable used for the feedline.

If the idea of changing the converter input is not acceptable, a pair of nonsynchronous sections, one of 50 ohms and the other of 70 ohms, as described by K1XX in *ham radio* (September, 1978) would be nice. In the same issue, W7VK shows how to put a standard connector on the hardline cable. — **Bob Eldridge, VE7BS**

rain static resolved

HB9FU's letter in July, 1983, Technical Forum recalls difficulty of reception of radio signals aboard aircraft flying through rainstorms. About 1948 an "anti-precipitation static" (APS) wire system began to appear on aircraft.

The wire for the antenna was single-strand copperweld covered with a tough insulation, much like the dielectric in RG-59/U. (In fact, take the outer cover and braid off RG-59/U and you have APS wire.)

While the system on aircraft uses special nylon insulators to grip the wire or to tap off in a "Tee," the main idea is that no rain be allowed to get to the *wire conductor*. Simply stated, the conductor(s) are totally encapsulated.

The static is apparently caused by the charge a wire antenna picks up and the changing charges as the rain drips off.

If HB9FU can get to an airport and see a high-frequency antenna on an overseas aircraft, he'll get the picture — maybe he can also find out where he can obtain that kind of wire and insulators.

Anyway, as long as no part of the conductor is exposed, APS will almost totally disappear. — **Dave Walsh, W1FYX**

LED puzzle

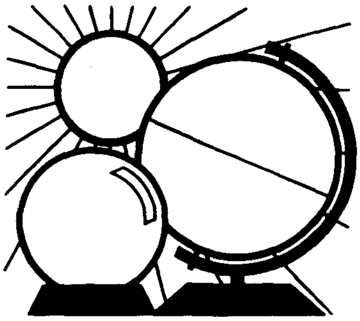
Can anyone tell me what's wrong with the first LED in my Kenwood TS590SE's digital display. It reads *1* on 80 to 40, *2* on 20 and WWV, and *3* on 15 or 10. Can you help? — **John E. Dunn, WB9JKV.**

"hidden" antenna

I would like to correspond with anyone who has used, or is successfully using a "hidden antenna." — **Michael H. Landwehr, KE7T**, P.O. Box 4502 Huachuca City, Arizona 85616.

Heath HX1681

I want to modulate my Heath HX1681 CW transmitter. Is a kit (or circuit) available? — **Robert Miller, W2UWO**



Garth Stonehocker, KØRYW

DX FORECASTER

last-minute forecast

The forecast for September emphasizes the end of summertime DX conditions with its longer daylight hours, increased short-skip openings during the sporadic-E season, and evening thunderstorm QRN. Fall DX conditions are quite different.

In the band-by-band summary below look for geomagnetic-ionospheric disturbances to increase (especially during 1983 and 1984); transequatorial openings to begin again; transpolar openings (gray-line DX) to occur near twilight; maximum usable frequencies to increase; and thunderstorm activity to change from airmass to frontal, with related QRN changes. Accompanying these changes, the lower hf bands (30, 40, 80, and 160 meters) are forecast to be best during the first two weeks of the month. Then the higher bands (30, 20, 15, and 10 meters) are expected to take over, providing excellent conditions considering this point in the 11-year sunspot cycle. Disturbed geomagneticionospheric conditions are probable on September 2-5th, 10-13th, 16-19th, and 23-25th.

The full moon will occur on September 22nd and its perigee on the 6th. The autumnal equinox will be on the 23rd at 1442 UT. No significant meteor showers are expected in September.

solar cycle

It's time to check the decline of this solar cycle. April 1982's lower solar flux and sunspot number (SSN) values confirmed that the gradual downward trend of the cycle from the peak had begun (in February for SSN and April for solar flux). In September 1982 the SSN was recorded at 100.6. At present (June, 1983) a plateau has been reached where it levels off before descending at a more leisurely rate to the minimum years of 1985 and 1986. The plateau is at approximately a SSN of 62 or flux value of 110. It is expected to remain constant through the winter months before decreasing again.

In July I mentioned that the critical frequency, foF2, the main variable of the maximum usable frequency (MUF), was nearly a linear function of SSN or radio flux and gave three representative values at mid-latitude. The foF2 (MUF equals approximately 2.5 × foF2) variation is 0.0485 MHz per SSN value or 0.0557 MHz per flux value, ϕ. The equations are:

$$foF2 = 0.0475\,SSN + 5.25$$
$$foF2 = 0.0557\,\phi + 1.8$$

where *SSN* is the 12 month smoothed sunspot number and ϕ is the monthly mean solar flux. The 2.5 (in the parentheses) is the MUF factor, a geometric angular relationship formed by the distance between the transmitter and the receiver and the height of the ionosphere.

Daily foF2 show greater variation with daily solar flux values or five-day running mean SSN. These relationships will be provided in a future column.

band-by-band summary

Ten and fifteen meters will be open to many areas of the world from morning until early evening hours many days. Geomagnetic disturbances will limit the number of signals heard, but listen carefully—they can be from very unusual places, particularly one-long-hop transequatorial DX. Fifteen meters should stay open later in the day than 10 meters. Operate 10 first and then move down to 15.

Twenty meters will be the main daytime DX band, as it is almost always open to some part of the world. It opens to the east as the sun rises and extends into the late evening hours to the west. Geomagnetic disturbances do not affect this band as much as 10 and 15 meters, but look for unusual transequatorial DX of 5,000 to 7,000 miles (8,000 to 11,200 km). These paths may be possible in the late evening hours during some of these unusual conditions.

Thirty meters is a day and night band. The day portion should be like 20 meters except that signal strengths may decrease during some middays. Days of decreasing strength are related to those having high solar flux values. This band can also be used well into the night, and often through the night; nights in which this doesn't hold true will most likely be those that follow very high solar flux days. The questionable periods are usually the hour or so before dawn. The workable distance may be expected to be greater than 80 meter DX at night and less than 20 during the day.

Forty and eighty meters will exhibit short skip conditions during daylight hours and lengthen after dark. The bands will open for DX to the east just before your sunset, swing more to the south toward Latin America about midnight, and end up in Pacific areas during the hour or so before dawn. On some nights these bands will have low QRN similar to the winter DX season conditions. Coastal regions usually have the edge for working rare DX on these bands. Look for transpolar openings on these bands. (See *ham radio*, September, 1982, p. 56.)

One sixty meters will probably have many nights that will remind you of last summer's noise. However, useful nighttime conditions aren't too far off. Propagation on 160 meters will approximate a shortened 80-meter condition.

ham radio

SEPTEMBER

WESTERN USA

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

MID USA

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

EASTERN USA

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

*Look at next **higher** band for possible openings.

product REVIEW

TH5MK-2 broadband thunderbird

Over the past three years I have been using the Hy-Gain TH5DX triband beam. The performance overall has been excellent with no problems experienced. I had no intention of replacing the antenna — that is until Alan Caplan, WØRIC, of Hy-Gain called and told me about a new version of the TH5 they were getting ready for release. The new antenna is called the TH5MK-2 and is based upon a dual-driven element design. This design facilitates operation from band edge to edge with low SWR and high performance.

For years, broadbanding antennas was not as important as it is now. But today's solid-state radios and amplifiers are much more sensitive to antenna mismatches. To achieve maximum equipment performance, it is imperative to keep VSWR levels below 2 to 1. Otherwise, protective circuits will start shutting the power amplifier down. Another limitation of older antenna designs is that the user usually had to make a choice of either CW or SSB subbands when assembling the antenna. Hy-Gain's solution for broadbanding was the TH5MK-2 — And, its's quite a solution.

construction

My first feeling upon opening the two shipping boxes was that I was looking at a hardware store's inventory. I was overwhelmed by a lot of parts. Before you touch *anything*, grab the instruction manual and read it thoroughly. Hy-Gain has carefully researched instruction manuals and found that when owners read through the instructions several times, assembly problems are drastically reduced. This is a sound recommendation that should be adhered to — without exception. Hy-Gain went to quite a bit of time and expense to write an accurate and precise instruction manual. You'll save yourself time and hassle if you're familiar with the instructions before you start.

Parts are in poly bags so it will also be worth your time to segregate all the different clamps, bolts, nuts, screws, and tubing prior to putting the antenna together. This saved me time and eliminated frantic searching while putting the antenna together. One word of warning. Make sure you carefully measure tubing lengths as you assemble the elements. (I didn't. Well, so much for my advice about reading the manual!)

One place where I did divert (again, not following my own recommendation . . .) from Hy-Gain's instructions was in the assembly of the elements. Hy-Gain suggests that you first build the boom and then assemble the elements on the boom. Not having the time on weekends to sit down and assemble the antenna from start to finish, I decided to assemble the elements first and then mate them to the boom. This allowed me to put the antenna together over several evenings. Other than investing a bit of extra diligence, I didn't have any additional problems using this method. I also didn't have to worry about losing element parts. It took less than two hours to mate all the elements to the boom assembly and assemble the beta match.

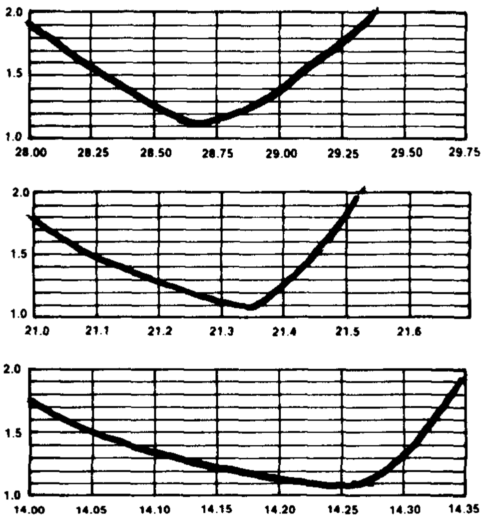


fig. 1. VSWR on 10, 15, and 20 meters (Hy-Gain TH5MK-2).

performance

Initial results have been most favorable with the new TH5MK-2. Not being a "hot and heavy" high band DXer, I can't give a day-by-day summary of its performance. However, in casual DXing and in several contests, it has performed admirably well. In comparing the TH5MK-2 to my TH5DX, my gut feeling is that the TH5MK-2 has a slight edge. The big plus, however, is that the MK-2 operates efficiently from band edge to band edge.

specifications

The TH5MK-2 is a five-element broadband antenna designed to operate on 20, 15, and 10 meters. A big plus for the MK-2 is that all hardware is stainless instead of plated steel. This eliminates (or reduces) the problem of hardware oxidization. Hy-Gain also supplies a BN86 balun with the antenna. The TH5MK-2 weighs 57 pounds and has a wind surface area of 7.4 square feet and is designed to survive a 100 mph maximum wind. Each band has one director and one reflector, as well as the two driven elements. The boom is 19 feet long (one foot longer than the TH5DX) and the longest element is 31 feet 6 inches. Hy-Gain rates the antenna at 7.8 dBi gain for 20 meters, 8 dBi for 15 meters, and 9 dBi for 10 meters. Since the antenna employs a Beta match and balun, the antenna is at dc ground for lightning protection. For more information contact Hy-Gain, 9100 Aldrich Avenue, Minneapolis, Minnesota 55420.

N1ACH

Triplett model 3500

The Model 3500 is a compact, portable autorange manual digital multimeter designed to be easy to operate and read and also be able to withstand rough handling. The autorange feature eliminates the need for manual selection of range; you can select the ranges manually if you desire. All measurements except 10 amperes are made from two jacks, eliminating the need to switch test leads as different ranges are selected. The Model 3500 is fully overload-protected with a special 0.3A/250V and 2A/600V fuse arrangement.

The Model 3500 measures ac/dc volts, ac/dc current and high or low power ohms. Accuracy is guaranteed for one year. Protection from overload is up to 1000 Vdc and 750 Vac without fuseblow. The 3500 also features a tilt stand to facilitate greater visibility on the test bench. The case is ribbed to provide a stable, non-slip grip for the user. Battery life is approximately one year in occasional service but less in daily use. The low-battery indicator will alert the user when battery life remaining falls to approximately 50 hours.

We found the Triplett Model 3500 simple to use, handy to have, and rugged enough to stand up well in most ham shacks. Its large LCD display is readable under a variety of lighting conditions. Packaged in a high-impact plastic case, the Model 3500 measures 3-1/2 × 6 × 1-5/8 inches (88 × 155 × 34 mm). It weighs 12.5 ounces (0.35 kg) with battery installed. The suggested retail price ($140) includes the unit itself, 36 inch test leads with alligator clips, and two 1-1/2 volt batteries. Contact your local distributor or Triplett Corp., One Triplett Drive, Bluffton, Ohio 45817 for further information. RS#301

N1ACH

NEW products

1.2 GHz mobile transceiver and receiver

ICOM's new IC-120 is a 1.2 GHz fm mobile transceiver, covering 1260 to 1300 MHz. This unit is styled similarly and has features similar to the IC-15A/H series of 2-meter transceivers, and has many equivalent features. Duplex split is variable, but is initiated at 20 MHz when the unit is first turned on. Duplex up and down as well as scanning features are offered. Power output is 1 watt. ICOM is the first to offer a full-featured mobile transceiver for this mostly unused band.

To complement ICOM's entry into the 1.2 GHz Amateur band with its IC-120 mobile transceiver, ICOM has also announced the release of a 1.2 GHz repeater with a power output of 10 watts, CTCSS capability, IDER, and DTMF control. The RP1210 is synthesized to be complementary to the IC-120 transceiver, and has a duplex split of 20 MHz.

For further information, contact ICOM America, Inc., 2112-116th Ave., NE, Bellevue, Washington 98004. RS#302

programmable linear amplifier

The ETO Alpha 85 features a microprocessor control circuit that eliminates manual tune-up and ensures maximum output and performance. Using the new Eimac 3CX800AF ceramic metal triodes, the Alpha 85 is designed to cover 1.8-2 and 3-22 MHz and is rated at 1500 watts PEP rf output SSB, 1500 watts CW and 1000 watts RTTY and SSTV. (Export and government models tune to 30 MHz. U.S. licensed Amateurs can modify their unit to tune to 29.7 MHz.)

NEW products

The microprocessor is factory-programmed to tune each Amateur band except for 10 meters. Five band-segment pushbuttons can be field programmed to any frequency for rapid band changes and ease of use. The unit can also be manually tuned. To ensure maximum output on all high-frequency bands, a tuned input circuit has been incorporated.

The Alpha 85 measures 7-1/2 × 17-1/10 × 17 inches and weighs 60 pounds.

For more information, contact Ehrhorn Technological Operations, Inc., Canon City, Colorado 81212.

handheld transceiver

The new 2-meter handheld transceiver, model 2591, from Ten-Tec was designed in collaboration with Motorola. Its advanced microprocessor provides features that include a key pad, ten memories, memory scan, and programmable band scan. Any section of band within user-selected upper and lower limits may be scanned in steps of 5, 10, 15, 25, or 30 kHz. Either step size, upper limit or lower limit can be changed independently without complete reprogramming. User selectable HOLD or SKIP is also included. Manual scan is possible — up or down in 5 kHz steps.

A new memory lockout feature allows the scanner to temporarily bypass channels while retaining memory and provides quick lockout of busy frequencies yet returns to normal operation on command.

Other features include selectable power level and extended frequency coverage from 143.500 to 148.995 MHz. A dual function LED shows battery status and indicates transmit mode. A quick-release Ni-Cad pack provides heavy duty 450 mAH rating at 8.4 volts. Standard accessories include rubber flex antenna with BNC connector and wall charger.

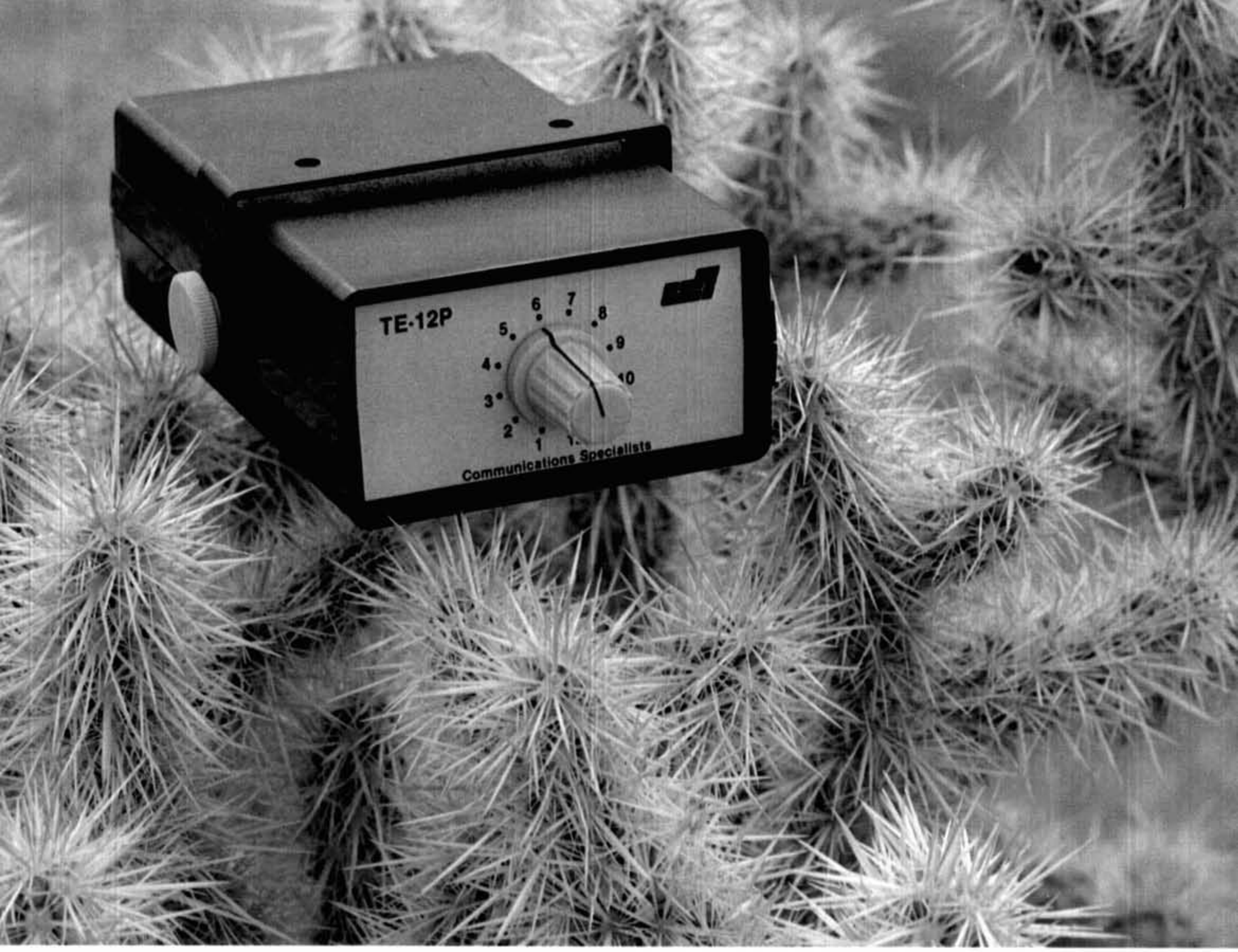
The price of Model 2591 is $319.00.

For more information, contact Ten-Tec, Inc., Sevierville, Tennessee 37863.

computer patch™ interface

Now you can convert your personal computer and transceiver into a full-function RTTY station with the new CP-1 Computer Patch™ interface by AEA and appropriate AEA software and cabling. Software packages include split screen operation and large type-ahead and message (brag) buffers at all the common RTTY and CW speeds. No computer programming knowledge is required to use the CP-1.

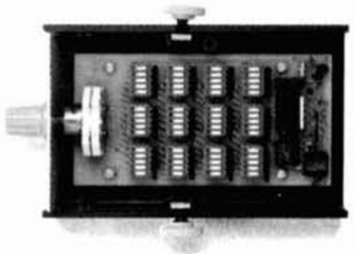
The CP-1 demodulator is said to provide improved performance compared to single channel RTTY detectors. An easy-to-use AEA



Stuck with a problem?

Our TE-12P Encoder might be just the solution to pull you out of a sticky situation. Need a different CTCSS tone for each channel in a multi-channel Public Safety System? How about customer access to multiple repeater sites on the same channel? Or use it to generate any of the twelve tones for EMS use. Also, it can be used to access Amateur repeaters or just as a piece of versatile test equipment. Any of the CTCSS tones may be accessed with the TE-12PA, any of the audible frequencies with the TE-12PB. Just set a dip switch, no test equipment is required. As usual, we're a stickler for 1day delivery with a full 1 year warranty.

- Output level flat to within 1.5db over entire range selected.
- Immune to RF.
- Powered by 6-30vdc, unregulated at 8 ma.
- Low impedance, low distortion, adjustable sinewave output, 5v peak-to-peak.
- Instant start-up.



TE-12PA

67.0 XZ	85.4 YA	103.5 1A	127.3 3A	156.7 5A	192.8 7A
71.9 XA	88.5 YB	107.2 1B	131.8 3B	162.2 5B	203.5 M1
74.4 WA	91.5 ZZ	110.9 2Z	136.5 4Z	167.9 6Z	
77.0 XB	94.8 ZA	114.8 2A	141.3 4A	173.8 6A	
79.7 SP	97.4 ZB	118.8 2B	146.2 4B	179.9 6B	
82.5 YZ	100.0 1Z	123.0 3Z	151.4 5Z	186.2 7Z	

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

TE-12PB

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

$89.95

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✓ 126

NEW products

magic-eye bargraph tuning indicator gives the closest thing to scope tuning, but separate Mark/Space scope output jacks are also provided. A state-of-the-art multi-usage active filter is incorporated offering pre- and post-limited filtering. Floating comparator (automatic threshold) circuits give the best possible copy under fading and weak signal conditions.

Additionally, the CP-1 offers a variable receiver shift capability for any shift from 100 to 1000 with a NORMAL/REVERSE tone selector switch on the front panel.

A function generator chip is utilized for clean, stable sine wave AFSK tone output to the transmitter. Both plus (+) and minus (−) keyed output jacks are provided for CW keying of virtually any popular transceiver. Automatic transmit/receive switching is available under computer control or from a front panel manual transmit button. Output and computer control signals are available in the usual TTL levels (or RS-232 format with an optional low-cost RS-232 kit).

For complete information, contact Advanced Electronic Applications, Inc., P.O. Box C-2160, Lynnwood, Washington 98036. RS#304

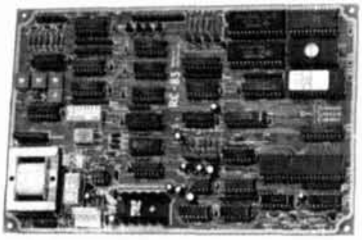
low-cost repeater control

The RC-85 low-cost repeater controller board from Advanced Computer Controls, Inc., is a scaled-down, simplified version of the RC-850 controller. The microcomputer-based control board offers built-in speech synthesis, Touch-Tone remote programming, and a full-featured autopatch at a cost comparable to a collection of "dumb" repeater control boards. It provides the complete interface between the repeater's receiver and transmitter.

The autopatch features autodial, long distance protection, optional phone number readback, DTMF or dial pulse regeneration, and reverse patch.

Some operating parameters of the RC-85 control board may be changed remotely with Touch-Tone commands, including ID and tail messages (with its built-in Touch-Tone activated message editor), command codes, and autodial numbers. Storage is in write-protected RAM. An optional fully documented Personality EPROM allows the repeater owner to define a backup set of parameters independent of the firmware for use in case power is lost. Built-in diode switching allows easy battery backup.

High quality, natural sounding speech synthesis, including a portion of ACC's custom repeater vocabulary, is built in. Together with the control board's Touch-Tone activated message editor, ID and tail messages can be made informative, reminding users of nets, meetings,



and special events, or informing users of repeater status. An alarm logic input provides the repeater owner with a site alarm to enhance security of the installation. The RC-85 uses CMOS circuitry (no TTL) for low-power consumption from a single +12 volt supply. All ICs are socketed in high reliability machine contact sockets. The control board is a compact 6″ × 9″ for easy integration into any repeater. The price is $849.

For more information, contact Ed Ingber, WA6AXX, at Advanced Computer Controls, Inc., 10816 Northridge Square, Cupertino, California 95014. RS#305

dual band radio

Trio-Kenwood has recently announced a new model, the TS-780 All-Mode "Dual-Bander," a combination of 2-m/70-cm (144-148 MHz/430-440 MHz) radio designed to meet the needs of the Amateur Radio enthusiast active on both bands. Important features included in the TS-780 are USB, LSB, CW, and FM operation, dual digital VFO's, cross-frequency operating capability, 10 memories that store frequency and band data, internal battery memory back-up, band scan, memory scan, i-f shift, fluorescent tube digital display, 2-m offset switch, and 10 watts of rf output. VOX and

CW semi break-in are built in. An optional TU-4C two frequency tone encoder unit is available.

Additional information is available from Trio-Kenwood Communications, 1111 West Walnut Street, Compton, California 90220. RS#306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QSL CARDS: $17.50/500 ppd. Free catalog. Bowman Printing, 743 Harvard, St. Louis, MO 63130.

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CABLE TV EQUIPMENT, Channel 3 or 4 notch filter $20.00. Information $1.00. Goldcoast, P.O. Box 63/6025G, Margate, FL 33063. (305) 752-9202.

SATELLITE, Microwave, video, audio components and equipment. Send $1 for 1983 catalog. DSCo, Department C, 3110 Evelyn Street, Roseville, MN 55113.

KLM PA15-80BL 2 meter amplifier. 10W-in/80W-out, multimode, mint condx. $100. MO, bank check. Rich Tashner, N2EO, 163-34 21 Road, Whitestone, NY 11357.

CHASSIS and cabinet kits. SASE K3IWK.

TENNATEST — Antenna noise bridge — out-performs others, accurate, costs less, satisfaction guaranteed. Send stamp for details. W8URR, 1025A Wildwood Road, Quincy, MI 49082.

ELECTRON TUBES: Receiving, transmitting, microwave . . . all types available. Large stock. Next day delivery most cases. Daily Electronics, 14126 Willow Lane, Westminster, CA 92683. (714) 894-1368.

LINEAR GANTT — A new scheduling tool for project engineers and the like. Written in BASIC and easy to use. Send $9.95 to Howe Associates, 3223 Stimson Way, San Jose, CA 95135.

BUY SELL TRADE — Next 6 issues $2.00. WA4OSR's Rigs & Stuff, Box 973-H, Mobile, AL 36601.

VLF-LF preamps, coupler, Loran-C boards. SASE. Burhans Electronics, 161 Grosvenor St., Athens, Ohio 45701.

WANTED: Kenwood TS-700SP transceiver and MARS-7600 adapter. C. T. Huth, 146 Schonhardt, Tiffin, OH 44883.

ROHN TOWERS — Wholesale direct to users. All products available. Write or call for price list. Also we are wholesale distributors for Antenna Specialists, Regency, Hy-Gain and Wilson. Hill Radio, P.O. Box 1405, 2503 G.E. Road, Bloomington, IL 61701-0887. (309) 663-2141.

PRE-1946 TELEVISION SETS wanted for substantial cash. Finder's fee paid for leads. Also interested in spinning disc, mirror in-the-lid, early color sets, 9AP4 picture tubes. Arnold Chase, 9 Rushleigh Road, West Hartford, Conn. 06117 (203) 521-5280.

FOR SALE: Heathkit DX-100 (160/10 meters), $75.00. Technical material GPR-90. General coverage receiver, $150.00. National NCX-5 transceiver with remote VFO, power supply/speaker and Heath mobile power supply $375.00. All with manuals. K3UWO, Route 1, Box 201-A, Bridgewater, VA 22812. (703) 828-3723.

MUSEUM now open for radio historians and collectors. Free admission. Old time Amateur (W2AN) and commercial station exhibits, 1925 replica store and telegraph displays. 15,000 items. Write A.W.A. for details: Bruce Kelley, W2ICE, Holcomb, NY 14469.

LOW VOLTAGE POWER SUPPLIES: 5/12V at 2A each. Ideal for IC's. $45.00 — Hollan Electronics, P.O. Box 18632, Austin, TX 78760.

MOBILE IGNITION SHIELDING. Estes Engineering, 930 Marine Dr., Port Angeles, WA 98362.

OLD TIMERS: Collector looking for old bugs and Spark keys. Vibroplex, McElroy, Marconi, DeForest, etc. K5RW, Neal McEwen, 1128 Midway, Richardson, TX 75081.

CABLE CONVERTERS, decoders. Catalog $1 refundable. APS, POB 263 HR, Newport, RI 02840.

IBM-PC RTTY & ASCII. SASE for full details. E. Alline, NE5S, 773 Rosa, Metairie, LA 70005.

HAM HOLIDAY Sri Lanka. Write to Spangles Travels, 84 Templers Road, Mount Lavinia, Sri Lanka. Enclose 5 IRCs.

SELL COLLECTION of 40 years receiving tubes only one dollar each. Drake R4C $275, T4XC $275 plus DC4 P.S. MS4 Speaker $25. Drake 1A $100. Wanted machinist tools from retired machinists. Reasonable. W5QJT, 314 N. Resler Drive, El Paso, TX 79912. (915) 581-2017.

RTTY-EXCLUSIVELY for the Amateur Teleprinter. One year $7.00. Beginners RTTY Handbook $8.00 includes journal index. PO Box RY, Cardiff, CA 92007.

6 NEW CHAPARRAL "Super" feed horns $20 each, 9 new regular circular feed horns $8 each, Force AMU-150T 2 ch. UHF mobile with factory CTCSS, adjustable $250. Heath IG-102 signal generator, new tubes/clean $40. GE 4ER25C2 VHF Rx $25. (2) GE 4EP3A1 rack mount power supplies $30 each. RCA senior volt ohmyst $35. Dave Fant, Rt. 2, Box 381, Ozark, Arkansas 72949. (501) 667-4743.

APPLE COMPUTER OWNERS — Announcing "The Logger" — A very sophisticated, full-featured disk-based log book for ham radio operators. "The Logger" manages over 1900 log entries per standard DOS 3.3 diskette with sixteen separate functions including personalized QSL cards for less than 2 cents each! Unlocked program diskette and User's Guide $35. pd. U. S. Large SASE for more information. Bob Jackson, Dept. HR, Box 57304, Webster, TX 77598.

RS303/U AND FERRITE BEADS for W2DU's balun (QST March '83) HF $8, VHF $6 ppd. Copperweld™ 30% - 18 ga 3¢, 14 ga 6¢. All Amateur wire and cable (Belden & generic); Larsen, Unadilla, Janel, custom QSL's, crystals. All from Certified Communications, "the CB to 10 meter people", 4138 S. Ferris, Fremont, MI 49412.

HALLICRAFTERS $$$ Serious collector needs Hallicrafter and other Ham equipment manufactured before 1940 for restoration and eventual museum exhibit. Need Hallicrafters, National, Hammarlund, Patterson, RCA, RME, Grebe, etc. Condition not important. Also need QST mags Vols. I & II and old tubes. All letters answered. Write Dave Medley, WA5YXA, 6621 Duffield Drive, Dallas, Texas 75248.

DRAKE R-4C, FL1500, FL500, 10.0-10.5 MHz xtal. Excellent, UPS prepaid. $325. W7BDO.

WANTED: Schematics-Rider, Sams or other early publications. Scaramella, P.O. Box 1, Woonsocket, RI 02895-0001.

WANTED, MILITARY SURPLUS RADIOS. We need Collins 618T, ARC-94, ARC-102, 718F-1/2, MRC-95, MRC-108, RT-980/GRC-171, RT-712/ARC-105, RT-804A/APN-171, ARC-114, ARC-115, RT-823/ARC-131 or FM-622, RT-857/ARC-134 or Wilcox 807A, ARC-159, ARC-164, RT-859/APX-72, APN-153, Antenna Couplers 490T, CU-1658A, CU-1239/ARC-105, CU-1669A, ARC-105, Sperry Rand 3226A1, 3226B1, 490B-1, 690D1. Top dollar paid or trade for new amateur gear. Write or phone Bill Slep, 704-524-7519, Slep Electronics Company, Hwy. 441, Otto, NC 28763.

WANTED: Cash paid for used Speed Radar equipment. Write or call: Brian R. Esterman, PO Box 8141, Northfield, Illinois 60093. (312) 251-8901.

COLOR COMPUTER OWNERS — Free hardware and software catalog. Spectrum Projects, 93-15 86 Drive, Woodhaven, NY 11421.

WANTED: Early Hallicrafter "Skyriders" and "Super Skyriders" with silver panels, also "Skyrider Commercial", early transmitters such as HT-1, HT-2, HT-8, and other Hallicrafter gear, parts, accessories, manuals. Chuck Dachis, WD5EOG, The Hallicrafter Collector, 4500 Russell Drive, Austin, Texas 78745.

RUBBER STAMPS: 3 lines $4.50 PPD. Send check or MO to G.L. Pierce, 5521 Birkdale Way, San Diego, CA 92117. SASE brings information.

RADIO WEST! High quality coverage communications receivers with Collins filters and other DX modifications! Catalog 50¢ (refundable). Radio West, 3417 Purer Rd., Dept HR, Escondido, CA 92025 (619) 741-2891.

VERY in-ter-est-ing! Next 4 issues $2. Ham Trader "Yellow Sheets", POB356, Wheaton, IL 60189.

SUPER CQWW CONTEST programs. TRS-80 Model I, III, (IV in III mode) Completely machine language. Logs 3200+ contacts per band. Automatic identification of country and zone from call letters. Dupe Speed 12000+ contacts per second. Screen displays zones still needed, total points, zones, countries, etc. Automatic cw generator with 2 buffers. Log Print program prepares logs and dupe sheets. $39.95 Log Preparation program for hand logs. Similar features to above. $29.95 Free fact sheet and sample printouts. K4SB, 3496 Velma Dr., Powder Springs, Georgia, 30073.

VARIABLE VOLTAGE SUPPLY, 0-25V, 3A. Kit $50, Assembled $65. (+$3.00 shipping.) Hollan Electronics, P.O. Box 18632, Austin, TX 78760.

CUSTOM P/C BOARDS. Send schematic for quotes. 1-4 transistors and/or IC's, $15 single board. Orders of 1-10 please enclose payment. Hollan Electronics, P.O. Box 18632, Austin, TX 78760.

flea market

Coming Events
ACTIVITIES
"Places to go..."

CALIFORNIA: Sonoma County Radio Amateurs giant indoor flea market, Saturday, September 17, 9 AM to 3 PM, Sebastopol Community Center, 390 Morris St., Sebastopol, 5 miles west of Santa Rosa. Free admission and parking. Indoor flea market space $3 ($6 with table) at the door. Advance $2.50 and $5. Vendor set up 8 AM. Radio clinic, refreshments, auction in afternoon. Talk in on 146.13/73. For tickets and information: SCRA, Box 116, Santa Rosa, CA 95404.

CONNECTICUT: The Natchaug ARA will hold a giant flea market, Sunday, September 25, 9 AM to 4 PM, Elks Home off Rt. 32, Willimantic. Indoor/outdoor, rain or shine. Dealers set up 8 AM. Refreshments, free parking. Tables $5 advance, $7 at door. Admission $2.00. Under 16 free. For information: Edward C. Sadeski, KA1HR, 49 Circle Drive, Willimantic, CT 06226, (203) 423-7137; or Clifton Pease, KA1HYW, 268 Main Street, Willimantic, CT 06226, (203) 456-1432 after 4 PM.

COLORADO: The Boulder Amateur Radio Club's "Barcfest", September 25, National Guard Armory, 4750 N. Broadway, Boulder, 9 AM to 3 PM. Admission $3.00 per person or $3.00 per family. Free parking. Refreshments. Talk in on 146.10/70 and 146.52 simplex. For information: Tim Groat, KRØU, 1000 East 10th Avenue, Broomfield, CO 80020. (303) 466-3733.

FLORIDA: The Platinum Coast Amateur Radio Society's 18th annual Hamfest and indoor swap-and-shop, September 10-11, Melbourne Auditorium, Melbourne. Admission $3.00 advance, $4.00 door. Swap tables and tailgating space available. Free parking. Awards, forums and meetings. Talk in on .25/.85 and .52/.52. For reservations, tables and information: PCARS, P.O. Box 1004, Melbourne, FL 32901.

GEORGIA: The 10th annual Lanierland ARC Hamfest, September 25, 9 AM, Holiday Hall, Holiday Inn, Gainesville. Free tables and inside display for dealers. Large flea market, boat anchor auction. Free admission. Talk in on 146.07/.67. For information: Phil Loveless, KC4UC, 3574 Thompson Bend, Gainesville, GA 30506. (404) 532-9160.

IOWA: The 9th annual Cedar Valley ARC Hamfest, Sunday, October 2. Doors open 7 AM, Hawkeye Downs Exhibition Building, Cedar Rapids. Tickets $2.00 advance, $3.00 door. First table $5.00 others $7.00. Overnight camping area, picnic facilities, airport nearby. Collins surplus store will be open 9 AM to 2 PM. Talk in on 146.16-.76, .52, 223.34-.94. For tickets and information: CVARC Hamfest, P.O. Box 994, Cedar Rapids, IA 52406.

ILLINOIS: The Sangamon County Fair and Agricultural Association's 8th annual New Berlin Hamfest, Sunday, September 25, Sangamon County Fairgrounds, New Berlin, rain or shine. Camping available. A model railroad train meet will also be held that day. For details: K9QFR, Box 2, Pleasant Plains, IL 62677.

ILLINOIS: The Peoria Area ARC Superfest '83, September 17 and 18, Exposition Gardens, W. Northmoor Road, Peoria. Gate opens 6 AM. Commercial building 9 AM. Admission $3.00 advance, $4.00 gate. Amateur Radio and computer displays, huge free flea market, free transportation to Northwoods Mall on Sunday. Camping facilities on grounds. Talk in on 146.16/76, W9UVI. For information and reservations SASE to: Superfest '83, 5808 N. Andover Ct., Peoria, IL 61615.

KANSAS: The Sandhills ARC's annual Eye-Ball QSO Party, September 25, Finney County Fairgrounds, Garden City. Doors open 9 AM. For information SASE to S.H.A.R.C., P.O. Box 811, Garden City, KS 67846.

INDIANA: The 4th annual Grant County ARC Hamfest, Saturday, Septmeber 10, McCarthy Hall, St. Paul's Catholic Church, Marion. Doors open 8 AM. Donation $2.00 advance, $3.00 gate. Table reservations $2.00 per 8 ft. table. Refreshments, free parking. Talk in on 146.19/79 or 146.52 simplex. For information/tickets SASE to: KA9DLJ, Jerry Richards, P.O. Box 1146, Marion, IN 46952.

MARYLAND: The Columbia Amateur Radio Association's 7th annual Hamfest, Sunday, October 23, 8 AM to 3:30 PM, Howard County Fairgrounds, 15 miles west of Baltimore. Admission $3.00. Indoor tailgating and tables $6.00 additional. Outdoor tailgating $3.00 additional. Talk in on 147.735/135, 146.52/52. For reservations and information: Ed Wallace, K3EF, 9905 Carillon Drive, Ellicott City, MD 21043.

MASSACHUSETTS: The 19-79 ARA's annual fall flea market, Sunday, October 16, 11 AM to 4 PM, Beachmont VFW Post, 150 Bennington St., Revere. Sellers 10 AM. Admission $1.00. Sellers tables $6.00 advance, $8.00 at door if available. Talk in on 19-79 and 52 direct. For table reservations send check to 19-79 Amateur Radio Association, P.O. Box 171, Chelsea, MA 02150.

MICHIGAN: The Grand Rapids ARA's annual Swap and Shop, Saturday, September 17, Hudsonville Fairgrounds. Dealers. Refreshments. Indoor sales area and outdoor trunk swap area. Gates open 8 AM. Talk in on 146.16/76. For information: Grand Rapids ARA, P.O. Box 1248, Grand Rapids, MI 49501.

MICHIGAN: The L'Anse Creuse Amateur Radio Club's 11th annual Swap and Shop, Sunday, September 18, 9 AM to 3 PM, L'Anse Creuse High School on Reimold. Admission $1.00 advance, $2.00 at door. Good food, free parking. Talk in on 147.69/.09 and 146.52. For information and tables SASE to William Chesney, N8CVC, 215 Elizabeth @ Mt. Clemens, MI 48043. (313) 463-1412.

NEW ENGLAND: The Hosstraders will hold their annual autumn swapfest, Saturday, October 8, rain or shine, Deerfield, New Hampshire, Fairgrounds. Admission $1.00, tailgating included. Friday night camping for self-contained rigs, after 4 PM. Profits benefit Shriners' Boston Burns Hospital. Last May's donation $2,702.00. For information/map SASE to Norm, WA1IVB, RFD Box 57, West Baldwin, ME 04091; or Joe, K1RQG, Star Rt. Box 56, Bucksport, ME 04416; or Bob, W1GWU, 105 Walton Rd., Seabrook, NH 03874.

NEW JERSEY: The De Vry Technical Institute ARC's annual flea market, October 1, 9 AM to 4 PM, school parking lot at 479 Green Street, Woodbridge. Buyers free admission. Sellers $3.00. No electricity. For information contact WB2JKU.

NEW HAMPSHIRE: The Connecticut Valley FM Association's 6th annual Hamfest and Flea Market, September 25, 9 AM to 5 PM, King Ridge Ski Area, Sutton, rain or shine. Admission $2.00. Dealers and flea marketeers $5.00. Refreshments available. Overnight camping for self-contained RV's. No hookups. Talk in on 146.16/76 or 146.52 simplex.

NEW YORK: The Yonkers electronics fair and giant flea market, Sunday, October 2, 9 AM to 4 PM, Yonkers Municipal Parking Garage, Corner of Nepperhan Avenue and New Main Street. Rain or shine. Live demonstrations, Amateur Radio, computers, electric car, satellite TV, SSTV, Hi-Fi/audio. Refreshments, free parking. Unlimited free coffee all day. Admission $2.00, children under 12 free. Sellers $6.00 per space, bring tables. Sponsored by the Yonkers ARC. For information (914) 969-1053.

NEW YORK: The Radio Amateurs of Greater Syracuse, RAGS, annual Hamfest and Computer Display, Saturday, October 1, 9 AM to 6 PM, Art and Home Center, New York State Fairgrounds, Syracuse. Commercial exhibitors, large indoor/outdoor flea market, tech talks, ARRL booth, contests and entertainment. Refreshments. Admission $3.00. Talk in on 90/30, 31/91 and 52 simplex. For information: RAGS, Box 88, Liverpool, NY 13088.

NEW YORK: The Elmira International Hamfest, September 24, Chemung County Fairgrounds, gates open 6 AM. Free flea market, dealers, tech talks. Refreshments available. Talk in on 147.96/36, 146.10/70 and 146.52/52. Advance tickets $2.00 from John Breese, 340 West Avenue, Horseheads, NY 14845. Tickets at gate $3.00.

NEW YORK: Seaway Valley Hamfest, Saturday, September 10, 9 AM to 4 PM, Louisville Firemen's Arena, Louisville. ARRL forum, tech programs, demos, entertainment, flea market, snack bar. Tickets $3.00 at door, $2.50 advance. For information/tickets: SASE to Lois Ierlan, WA2RXO, 725 Proctor Avenue, Ogdensburg, NY 13669. (U.S. funds only please).

NEW JERSEY: The South Jersey Radio Association's 35th annual Hamfest, September 18, Pennsauken Sr. High School, Hylton Road, Pennsauken, 8 AM to 4 PM. Advance tickets $2.50. $3.50 at gate. Tailgaters $5.00. Refreshments available. Talk in 22/82 and 52. For information: Fred Holler, W2EKB, 348 Bortons Mill Road, Cherry Hill, NJ 08002. (609) 795-0577.

OHIO: The Cleveland Hamfest and ARRL Great Lakes Division Convention, Saturday, September 24, banquet. Sunday, September 25, Hamfest, 8 AM to 5 PM. NEW LOCATION: Cleveland Aviation High School, North Marginal Road, Cleveland. Exhibits, refreshments, overnight parking available. Flea market open 6 AM, $2.00 per space. General admission $3.00. Talk in on 146.52, W8QV. For advance tickets send check or MO for $2.50 before August 31 to: Cleveland Hamfest Association, P.O. Box 93077, Cleveland, OH 44101.

WASHINGTON: The Walla Walla Valley Radio Amateur Club's 37th annual Hamfest, September 24 and 25, Milton-Freewater, Oregon Community Building. Doors open 8:30 AM. Swap shop, crafts, Tesla coil and spark gap demo. Antique, homebrew contests. Bazaar Sunday. Potluck dinner Sunday noon. For information: W7DP, P.O. Box 321, Walla Walla, WA 99362.

PENNSYLVANIA: 1983 A-5 Magazine/USATVS 4th annual fall ATV Conference, September 23-25, to be held concurrent with York, PA Hamfest. Seminars Friday 6-10:30 PM. Saturday 9 AM to 10 PM with banquet. Sunday 7 AM to noon. FSTV and SSTV to be fully covered with excellent speakers. SASE to W3SST or ATV Magazine, P.O. Box H, Lowden, IA 52255.

PENNSYLVANIA: The Skyview Radio Society's annual Hamfest, Sunday, September 18, noon to 4 PM, club grounds on Turkey Ridge Road, New Kensington. Talk in on 04-64 and 52 simplex. Registration fee $2.00. Vendors $4.00.

PENNSYLVANIA: The Pack Rats (Mt. Airy VHF ARC) invites all Amateurs and friends to the 7th annual Mid-Atlantic VHF Conference, Saturday, October 1, Warrington Motor Lodge, Route 611, Warrington; and Sunday, October 2, Hamarama, Bucks County Drive-In Theater, Route 611, Warrington. Flea market admission $3.00. Selling space $5.00 each. Bring own tables. Gates open 7:30 AM. Rain or shine. Advance registration $4.00 for conference and Hamarama. Send to Hamarama '83, P.O. Box 311, Southampton, PA 18966 or Lee A. Cohen, K3MXM, (215) 635-4942.

SOUTH CAROLINA: 32nd annual Rock Hill Hamfest, October 2. For information: YCARS, Box 4141CRS, Rock Hill, SC 29730.

SOUTH DAKOTA: The ARRL Dakota Division Convention, September 23-25, Howard Johnson Motor Lodge, Sioux Falls. Friday evening registration and entertainment. Saturday forums, exhibits, flea market, contests, luncheon. ARRL forum lead by Vic Clark, President. Sunday 2 meter transmitter hunt. Convention pre-registration prior to September 1 is $5.00. $6.00 at door. Convention and banquet $15, $16 at door. Banquet only $10. Talk in on 16/76 and 52/52. For information, Sioux Falls ARC, P.O. Box 91, Sioux Falls, SD 57101.

RADIO EXPO: Sponsored by the Chicago FM Club, Saturday and Sunday, September 24 and 25, Lake County Fairgrounds, Routes 120 and 45, Grayslake, Illinois. Flea market opens 6 AM. Exhibits open 9 AM. Indoor flea market tables available at $5.00 per day. Tickets $3.00 advance, $4.00 at gate, good for both days. Seminars, tech talks, ladies' programs. Talk in on 146.16/76, 146.52 and 222.5/224.10. For information: SASE to Radio Expo 83, Box 1532, Evanston, IL 60204 or (312) 582-6923.

TENNESSEE: The Memphis Hamfest, Saturday and Sunday, October 8 and 9, Memphis Fairgrounds, Mid South Building. Radio and computer displays and forums. Hospitality party Saturday night. Dealer and flea market setup Friday evening til 9 PM. Tables on site. Talk in on 28/88 and 34/94. For information/reservations: Clayton Elam, K4FZJ, 28 No. Cooper, Memphis, TN 38104. (901) 274-4418 days or (901) 743-6714 evenings.

TEXAS: The Wichita ARS's second annual Hamfest, September 24 and 25, National Guard Armory, Wichita Falls. Saturday 8 AM to 6 PM. Sunday 8 AM to 2 PM. Dealer displays, computers, large inside flea market, refreshments, free RV parking no hookups. Nearby shopping malls. Air Force MARS, QCWA meeting and more. Preregistration by September 21, $4.00. $5.00 at door. Talk in on 146.34/94 and 147.75/15. For information/tickets: WARS HAMFEST, P.O. BOX 4363, Wichita Falls, TX 76308.

VIRGINIA: The 8th annual Tidewater Amateur Radio Hamfest, Computer Convention, Electronic Flea Market, Saturday and Sunday, October 8 and 9, Virginia Beach Pavillion, 9 AM to 5 PM. $4.00 admission good for both days. Flea market tables $5.00 one day, $8.00 both days. Dealers, displays, forums, computers, satellite equipment. Beautiful Virginia Beach nearby. Visit Norfolk Waterfront Festival Marketplace. For information/tickets: Jim Harrison, N4NV, 1234 Little Bay, Norfolk, VA 23503. (804) 587-1695.

WISCONSIN: The St. Croix Valley Repeater Association's 7th annual Hamfest, Saturday, September 24, 9 AM to 2 PM, American Legion Hall, Baldwin. Admission $2.00. Talk in on 147.93/.33 and 146.52 simplex. For information: Bruce Olson, N9BLU, Box 91, St. Croix Falls, WI 54024.

OHIO: Lima Hamfest, Allen County Fairgrounds, October 9. Gates open 6 AM. Advanced tickets $3.00; at gate $3.50. Tables $6.00 each; half tables $3.50. For information/reservations: N.O.A.R.C., Box 211, Lima, Ohio 45802.

OPERATING EVENTS

"Things to do..."

SEPTEMBER 3 AND 4: The Independence FM Radio Association will operate a special event station celebrating Santa Caligon Days in Independence. Frequencies: 10-30 kHz from lower General and Novice band edges. Certificate for large SASE to KD0FW, Mike Bogard, 608 Concord Circle, Independence, MO 64056.

SEPTEMBER 13-17: The Southern Counties ARA will operate a special events station at the Miss America Pageant, Caesars Hotel Casino on the boardwalk in Atlantic City on a 24-hour basis. Frequencies: Phone - 25 kHz inside General band. CW 65 kHz from bottom of General band. 80-10 meters. Novice contacts 15 and 40 meters in the middle of Novice band. Local SCARA repeater K2BR at 146.745, output/input down 600. A special QSL available for SASE to: SCARA, K2BR, Box 121, Lynwood, NJ 08221.

SEPTEMBER 17: The Sweetwater ARC will operate special event station WA7USI from an historic site in southwestern Wyoming from 1800Z Sept. 17 to 1800Z Sept. 18. Frequencies: Up 40 kHz on General phone bands. Also Novice.

SEPTEMBER 17-19: Kansas State QSO Party sponsored by Boeing Employees' ARS of Wichita. Sept. 17 - 0100 UTC to 0700 UTC. Sept. 17 1300 UTC to 0700 UTC Sept. 18. Sept. 18 1300 UTC to 0100 UTC Sept. 19. All Amateurs are invited to participate. All bands and modes may be used. Kansas stations send QSO number, RS(T) and county. All others send QSO number, RS(T) and state, Province or foreign country. Logs must show dates, times in UTC, stations worked, exchanges, bands, modes and scores claimed. Log and summary sheets available for SASE. Must be postmarked NLT October 20, 1983 and sent to: Boeing Employees' ARS of Wichita, c/o Mike Thornton, WA0TAH, 1001 Munnell Avenue, Wichita, KS 67213.

SEPTEMBER 18: The Wisconsin Valley Radio Association will operate a special event station from Marathon County in north central Wisconsin at the intersection of 45 degrees North Parallel and 90 degrees West Meridian, near the city of Wausau, exactly halfway between the North Pole and the Equator and halfway between the Zero Meridian at Greenwich, England, and the International Dateline. Listen for club call W9SM. 7 AM to 7 PM CDT. Frequency (depending on band conditions) will be 25 kHz up from bottom of General phone portion of band(s) used. For a QSL card SASE with $1.00 to Wisconsin Valley Radio Association, Box 363, Wausau, WI 54401.

SEPTEMBER 23 AND 24: The Smithfield (Ohio) Apple Festival is sponsoring a special event station. 2300 UTC to 0400 UTC. Frequencies: SSB, 3.900 ± 5 MHz. Novice 7.110 ± 5 MHz. Station call N8CUX. For a special certificate SASE to Robert Carson, N8CUX, 259 Hill Street, Smithfield, Ohio 43948.

SEPTEMBER 22-24: The Fisher Body Lordstown ARC will operate W8KKZ from 1200Z to 0300Z daily to commemorate the 75th anniversary of General Motors. Operations lower portion of 20 and 40 meter General phone band and lower portion of 15 and 40 meter Novice CW bands. QSL information will be given on the air.

OCTOBER 1 AND 2: Oregon QSO party sponsored by the Hermiston Amateur Radio Club. Oct. 1 1700Z to 0800Z Oct. 2. 1500Z Oct. 2 to 0000Z Oct. 3. Exchange: OR stations signal report and county. Others signal report and state/province/country. A station may be worked once per band and mode. Mixed mode or CW only. All entries must have log and summary sheet. Summary sheet available from KA7IXH for SASE. Logs must be received by November 4, 1983. Mail to Bob Franklin, KA7IXH, Rt. 3, Box 3783, Hermiston, OR 97838.

OCTOBER 1-9: Special events station KN5D will operate throughout the 12th annual International Hot Air Balloon Fiesta, Albuquerque, New Mexico. 1400 to 1800 UTC daily. Frequencies: 15-25 kHz above low end of General phone bands. For a special QSL card and Balloon Fiesta certificate SASE to KN5D, P.O. Box 997, Corrales, NM 87048.

OCTOBER 1,2 & 8,9: VK/ZL/Oceania Contest. The WIA and NZART invite worldwide participation in this year's VK/ZL DX contest. Phone: From 1000 GMT, Saturday, October 1 to 1000 GMT, Sunday, October 2. CW: From 1000 GMT, Saturday, October 8 to 1000 GMT, Sunday, October 9. Logs overseas stations: Show date, time in GMT, call sign of station contacted, band, serial number send, serial number received. Underline each new VK/ZL contact. Separate logs must be submitted for each band. Summary sheet to show call sign, name and address, equipment used, QSO points for each band, VK/ZL call areas worked on that band. WIA VK/ZL Contest Manager, VK3BGW, 1 Noorabil Court, Greensborough, Victoria 3088, Australia by January 31, 1984.

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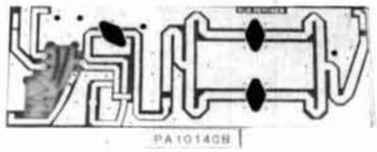

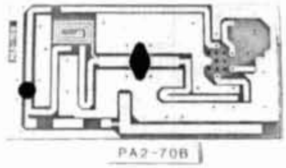

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MRF304	43.45	MWA210	7.80	40290	POR
MRF315	23.00	MWA220	8.25	RF110	25.00
MRF420	20.00	MWA230	8.65	SCA3522	POR
MRF421	36.80	MWA310	8.25	SCA3523	POR
MRF422	41.40	MWA320	8.65	SD1065	POR
MRF427	16.10	MWA330	9.50	SS43	POR
MRF428	46.00	NEC57835	5.30	TP1014	POR
MRF450/A	13.80	ON382	5.00	TP1028	POR
MRF453/A	17.25	PPT515-20-3	POR	TRW-3	POR
MRF454/A	19.90	PRT8637	POR	UT0504 Avantek	70.00
MRF455/A	16.00	PSCQ2-160	POR	UT0511 Avantek	75.00
MRF458	19.90	PT3190	POR	V15	4.00
MRF463	25.00	PT3194	POR	V33B	4.00
MRF472	1.00	PT3195	POR	V100B	4.00
MRF475	2.90	PT3537	POR	VAB801EC	25.00
MRF477	11.50	PT4166E	POR	VAB804EC	25.00
MRF502	1.04	PT4176D	POR	VAS21AN20	25.00

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More Details? CHECK—OFF Page 110

COAXIAL RELAY SWITCHES SPDT

Electronic Specialty Co./Raven Electronics FSN 5985-556-9683 $49.00
Part # 25N28 Part # SU-01
26Vdc Type N Connector, DC to 1 GHz.

Amphenol
Part # 316-10102-8
115Vac Type BNC DC to 3 GHz.

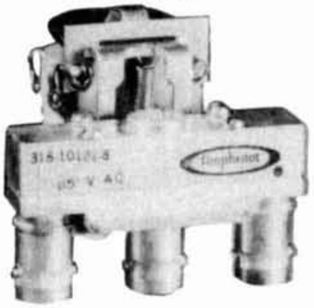
$29.99

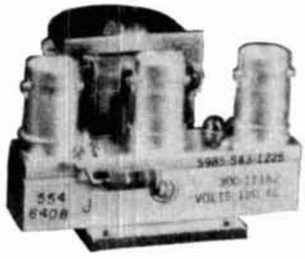
FXR
Part # 300-11182
120Vac Type BNC DC to 4 GHz.
FSN 5985-543-1225

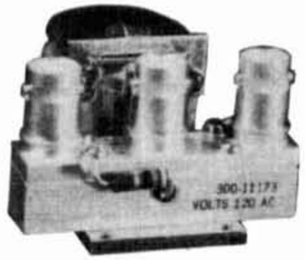
$39.99

FXR
Part # 300-11173
120Vac Type BNC Same
FSN 5985-543-1850

$39.99







BNC To Banana Plug Coax Cable RG-58 36 inch or BNC to N Coax Cable RG-58 36 inch.

$7.99 or 2 For $13.99 or 10 For $50.00 $8.99 or 2 For $15.99 or 10 For $60.00

SOLID STATE RELAYS

P&B Model ECT1DB72 PRICE EACH $5.00	5vdc turn on	120vac contact at 7amps or 20amps on a 10"x 10"x .124 aluminum. Heatsink with silicon grease.
Digisig, Inc. Model ECS-215 PRICE EACH $7.50	5vdc turn on	240vac contact 14amps or 40amps on a 10"x 10"x .124 aluminum. Heatsink with silicon grease.
Grigsby/Barton Model GB7400 PRICE EACH $7.50	5vdc turn on	240vac contact at 15amps or 40amps on a 10"x 10"x .124 aluminum. Heatsink with silicon grease.

NOTE: *** Items may be substituted with other brands or equivalent model numbers. ***

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RECALL PHONE MEMORY TELEPHONE WITH 24 NUMBER AUTO DIALER

The Recall Phone Telephone employs the latest state of art communications technology.It is a combination telephone and automatic dialer that uses premium-quality,solid-state circuitry to assure high-reliability performance in personal or business applications. $49.99

ARON ALPHA RAPID BONDING GLUE

Super Glue #CE-486 high strength rapid bonding adhesive.Alpha Cyanoacrylate.Set-Time 20 to 40 sec.,0.7fl.oz.(20gm.)
$2.00

TOUCH TONE PAD

This pad contains all the electronics to produce standard touch-tone tones. New with data.

$9.99 or 10/$89.99

MITSUMI UHF/VHF VARACTOR TUNER MODEL UVE1A

Perfect for those unscrambler projects. New with data.

$19.99 or 10/$149.99

INTEGRATED CIRCUIT.		1 to 10	11up
MC1372P	Color TV Video Modulator Circuit.	$ 4.42	$2.95
MC1358P	IF Amp.,Limiter,FM Detector,Audio Driver,Electronic Attenuator.	5.00	4.00
MC1350P	IF Amplifier	1.50	1.25
MC1330A1P	Low Level Video Detector	1.50	1.15
MC1310P	FM Stereo Demodulator	4.29	3.30
MC1496P	Balanced Modulator/Demodulator	1.50	1.25
LM565N	Phase Locked Loop	2.50	2.00
LM380N14	2Watt Audio Power Amplifier	1.56	1.25
LM1889N	TV Video Modulator	5.00	4.00
NE564N	Phase Locked Loop	10.00	8.00
NE561N	Phase Locked Loop	10.00	8.00

FERRANTI ELECTRONICS AM RADIO RECEIVER MODEL ZN414 INTEGRATED CIRCUIT.
Features:
1.2 to 1.6 volt operating range.,Less than 0.5ma current consumption. 150KHz to 3MHz Frequency range.,Easy to assemble,no alignment necessary. Effective and variable AGC action., Will drive an earphone direct. Excellent audio quality.,Typical power gain of 72dB.,TO-18 package. With data. $2.99 or 10 For $24.99

NI CAD RECHARGEABLE BATTERIES

AA Battery Pack of 6 These are Factory New. $5.00

SUB C Pack of 10 2.5Amp/Hr. $10.00

Gates Rechargeable Battery Packs

12vdc at 2.5Amp/Hr. $11.99
12vdc at 5Amp/Hr. $15.99

MOTOROLA MRF559 RF TRANSISTOR

hfe 30min 90typ 200max.
ft 3000mhz
gain 8db min 9.5typ at 870mhz
13db typ at 512mhz
output power .5watts at 12.5vdc at 870mhz.

$2.05 or 10/$15.00

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"SOCKETS AND CHIMNEYS"

EIMAC TUBE SOCKETS AND CHIMNEYS

SK110	Socket	$POR
SK300A	Socket For 4CX5000A,R,J, 4CX10,000D, 4CX15,000A,J	$520.00
SK400	Socket For 4-125A,250A,400A,400C,4PR125A,400A,4-500A,5-500A	260.00
SK406	Chimney For 4-250A,400A,400C,4PR400A	74.00
SK416	Chimney For 3-400Z	36.00
SK500	Socket For 4-1000A/4PR1000A/B	390.00
SK600	Socket For 4CX250B,BC,FG,R,4CX350A,F,FJ	51.00
SK602	Socket For 4CX250B,BC,FG,R,4CX350A,F,FJ	73.00
SK606	Chimney For 4CX250B,BC,FG,R,4CX350A,F,FJ	11.00
SK607	Socket For 4CX600J,JA	60.00
SK610	Socket For 4CX600J,JA	60.00
SK620	Socket For 4CX600J,JA	66.00
SK626	Chimney For 4CX600J,JA	10.00
SK630	Socket For 4CX600J,JA	66.00
SK636B	Chimney For 4CX600J,JA	34.00
SK640	Socket For 4CX600J,JA	36.00
SK646	Chimney For 4CX600J,JA	71.00
SK700	Socket For 4CX300A,Y,4CX125C,F	225.00
SK711A	Socket For 4CX300A,Y,4CX125C,F	225.00
SK740	Socket For 4CX300A,Y,4CX125C,F	86.00
SK770	Socket For 4CX300A,Y,4CX125C,F	86.00
SK800A	Socket For 4CX1000A,4CX1500B	225.00
SK806	Chimney For 4CX1000A,4CX1500B	40.00
SK810	Socket For 4CX1000A,4CX1500B	225.00
SK900	Socket For 4X500A	300.00
SK906	Chimney For 4X500A	57.00
SK1420	Socket For 5CX3000A	650.00
SK1490	Socket For 4CV8000A	585.00

JOHNSON TUBE SOCKETS AND CHIMNEYS

124-111/SK606	Chimney For 4CX250B,BC,FG,R, 4CX350A,F,FJ	$ 10.00
122-0275-001	Socket For 3-500Z, 4-125A, 250A, 400A, 4-500A, 5-500A	(pair)15.00
124-0113-00	Capacitor Ring	15.00
124-116/SK630A	Socket For 4CX250B,BC,FG,R, /4CX350A,F,FJ	55.00
124-115-2/SK620A	Socket For 4CX250B,BC,FG,R, /4CX350A,F,FJ	55.00
	813 Tube Socket	20.00

TUBE CAPS (Plate)

HR1, 4	$11.00
HR2,3, 6 & 7	13.00
HR5, 8	14.00
HR9	17.00
HR10	20.00

CHIP CAPACITORS

.8pf	10pf	100pf*	430pf
1pf	12pf	110pf	470pf
1.1pf	15pf	120pf	510pf
1.4pf	18pf	130pf	560pf
1.5pf	20pf	150pf	620pf
1.8pf	22pf	160pf	680pf
2.2pf	24pf	180pf	820pf
2.7pf	27pf	200pf	1000pf/.001uf*
3.3pf	33pf	220pf*	1800pf/.0018uf
3.6pf	39pf	240pf	2700pf/.0027uf
3.9pf	47pf	270pf	10,000pf/.01uf
4.7pf	51pf	300pf	12,000pf/.012uf
5.6pf	56pf	330pf	15,000pf/.015uf
6.8pf	68pf	360pf	18,000pf/.018uf
8.2pf	82pf	390pf	

PRICES: 1 to 10 - .99¢   101 to 1000 .60¢   * IS A SPECIAL PRICE: 10 for $7.50
11 to 50 - .90¢   1001 & UP .35¢   100 for $65.00
51 to 100 - .80¢   1000 for $350.00

WATKINS JOHNSON WJ-V907: Voltage Controlled Microwave Oscillator $110.00

Frequency range 3.6 to 4.2GHz, Power ouput, Min. 10dBm typical, 8dBm Guaranteed. Spurious output suppression Harmonic (nf_o), min. 20dB typical, In-Band Non-Harmonic, min. 60dB typical, Residual FM, pk to pk, Max. 5KHz, pushing factor, Max. 8KHz/V, Pulling figure (1.5:1 VSWR), Max. 60MHz, Tuning voltage range +1 to +15volts, Tuning current, Max. -0.1mA, modulation sensitivity range, Max. 120 to 30MHz/V, Input capacitance, Max. 100pf, Oscillator Bias +15 +-0.05 volts @ 55mA, Max.

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TUBES

TYPE	PRICE	TYPE	PRICE	TYPE	PRICE
2C39/7289	$ 34.00	1182/4600A	$500.00	ML7815AL	$ 60.00
2E26	7.95	4600A	500.00	7843	107.00
2K28	200.00	4624	310.00	7854	130.00
3-500Z	102.00	4657	84.00	ML7855KAL	125.00
3-1000Z/8164	400.00	4662	100.00	7984	14.95
3B28/866A	9.50	4665	500.00	8072	84.00
3CX400U7/8961	255.00	4687	P.O.R.	8106	5.00
3CX1000A7/8283	526.00	5675	42.00	8117A	225.00
3CX3000F1/8239	567.00	5721	250.00	8121	110.00
3CW30000H7	1700.00	5768	125.00	8122	110.00
3X2500A3	473.00	5819	119.00	8134	470.00
3X3000F1	567.00	5836	232.50	8156	12.00
4-65A/8165	69.00	5837	232.50	8233	60.00
4-125A/4D21	79.00	5861	140.00	8236	35.00
4-250A/5D22	98.00	5867A	185.00	8295/PL172	500.00
4-400A/8438	98.00	5868/AX9902	270.00	8458	35.00
4-400B/7527	110.00	5876/A	42.00	8462	130.00
4-400C/6775	110.00	5881/6L6	8.00	8505A	95.00
4-1000A/8166	444.00	5893	60.00	8533W	136.00
4CX250B/7203	54.00	5894/A	54.00	8560/A	75.00
4CX250FG/8621	75.00	5894B/8737	54.00	8560AS	100.00
4CX250K/8245	125.00	5946	395.00	8608	38.00
4CX250R/7580W	90.00	6083/AZ9909	95.00	8624	100.00
4CX300A/8167	170.00	6146/6146A	8.50	8637	70.00
4CX350A/8321	110.00	6146B/8298	10.50	8643	83.00
4CX350F/8322	115.00	6146W/7212	17.95	8647	168.00
4CX350FJ/8904	140.00	6156	110.00	8683	95.00
4CX600J/8809	835.00	6159	13.85	8877	465.00
4CX1000A/8168	242.50*	6159B	23.50	8908	13.00
4CX1000A/8168	485.00	6161	325.00	8950	13.00
4CX1500B/8660	555.00	6280	42.50	8930	137.00
4CX5000A/8170	1100.00	6291	180.00	6L6 Metal	25.00
4CX10000D/8171	1255.00	6293	24.00	6L6GC	5.03
4CX15000A/8281	1500.00	6326	P.O.R.	6CA7/EL34	5.38
4CW800F	710.00	6360/A	5.75	6CL6	3.50
4D32	240.00	6399	540.00	6DJ8	2.50
4E27A/5-125B	240.00	6550A	10.00	6DQ5	6.58
4PR60A	200.00	6883B/8032A/8552	10.00	6GF5	5.85
4PR60B	345.00	6897	160.00	6GJ5A	6.20
4PR65A/8187	175.00	6907	79.00	6GK6	6.00
4PR1000A/8189	590.00	6922/6DJ8	5.00	6HB5	6.00
4X150A/7034	60.00	6939	22.00	6HF5	8.73
4X150D/7609	95.00	7094	250.00	6JG6A	6.28
4X250B	45.00	7117	38.50	6JM6	6.00
4X250F	45.00	7203	P.O.R.	6JN6	6.00
4X500A	412.00	7211	100.00	6JS6C	7.25
5CX1500A	660.00	7213	300.00*	6KN6	5.05
KT88	27.50	7214	300.00*	6KD6	8.25
416B	45.00	7271	135.00	6LF6	7.00
416C	62.50	7289/2C39	34.00	6LQ6 G.E.	7.00
572B/T160L	49.95	7325	P.O.R.	6LQ6/6MJ6 Sylvania	9.00
592/3-200A3	211.00	7360	13.50	6ME6	8.90
807	8.50	7377	85.00	12AT7	3.50
811A	15.00	7408	2.50	12AX7	3.00
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NOTE * = USED TUBE

NOTE P.O.R. = PRICE ON REQUEST

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HEWLETT PACKARD SIGNAL GENERATORS

606A	50KHz to 65MHz in 6 bands +-1%.Output level adjustable 0.1uV to 3V into 50 ohms.Built-in crystal calibrator.400 -1000Hz modulation.	$ 650.00
606B	Same as above but has frequency control feature to allow bperation with HP 8708A Synchronizer.	$1100.00
608C	10MHz to 480MHz,0-1uV-1V into 50 ohms,AM,CW,or pulse modulation, calibrated attenuator.	$ 500.00
608D/ TS510	10MHz to 420MHz, 0.1uV-0.5V into 50 ohms,+-0.5% accuracy, built-in crystal calibrator, AM-CW or pulse output.	$ 375.00
608E	Improved version of popular 608C.Up to 1V output.Improved stability,low residual FM.	$1450.00
608F	10MHz to 455MHz in 5 bands +-1% frequency accuracy with built-in crystal calibrator.Can be used with HP 8708A Synchronizer. Output continuously adjustable from .1uV to .5V into 50 ohms.	$1100.00
612A	450-1230MHz ,o.1uV-0.5V into 50 ohms,calibrated output.	$ 750.00
614A	900-2100MHz with many features including calibrated output and all modulation characteristics.	$ 500.00
616A/ * TS403	Direct reading and direct control from 1.8 to 4.2GHz. The H.P.616A features +-1.5dB calibrated output accuracy from -3127dBm to -dBm.The output is directly calibrated in microvolts and dBm with continuous monitoring. Simple operation frequency diad accuracy is +-1% and stability exceeds 0.005%-/ C change in ambient temperature. Calibrated attenuator is within +-1.5dB over entire output band. 50 ohm impedance unit has internal pulse modulation with rep rate variable from 40 Hz to 4KHz,variable pulsewidth(1 to 10usec)and variable pulse delay(3 to 300usec).External modulating inputs increas versatility.	$ 375.00
616B	Same as above but later model.	$ 600.00
618B	3.8 to 7.6GHz range,with calibrated output and selection of pulse-FM or square wave modulation.	$ 600.00
618C	Same as above but later model.	$2200.00
620A	7 to 11GHz range,with calibrated output and selection of pulse-FM or square wave modulation.	$ 750.00
620B	Same as above but later model.	$2200.00
626A	10 to 15GHz,10mw output power with calibrated output and pulse-square wave or FM modulation.	$4200.00
8708A	Synchronizer used with 606B,608F.The synchronizer is a phase-lock frequency stabilizer which provides crystal-oscillator frequency stability to 430MHz in the 608F signal generator.Phase locking eliminates microphonics and drift resulting in excellent frequency stability.The 8708A includes a vernier which can tune the reference oscillator over a range of +-0.25% permitting frequency settability to 2 parts in 10 to the seventh.Provides a very stable signal that satisfies many critical applications. (With HP 606B or 608F)	$ 350.00
	(Without)	$ 450.00
EMC-10	ELECTROMETRICS EMC-10 RFI/EMI RECEIVER Low frequency analyzer covering 20Hz to 50KHz frequency range.Extendable to 500 KHz in wideband mode.	$2500.00
NF-105F	Empire Devices Field Intensity Meter. Has NF-105/TA,NF-105/TX,NF-105/T1,NF-105/T2,NF-105/T3. Covers 14KHz to 1000MHz.	$2100.00

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Perfect for Airplanes , Helicopters , Mobile Radios , or Just the Telephone.

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DELIVERY: Orders are normally shipped within 48 hours after receipt of customer's order. If a part has to be backordered the customer is notified. Our normal shipping method is via First Class Mail or UPS depending on size and weight of the package. On test equipment it is by Air only, FOB shipping point.

FOREIGN ORDERS: All foreign orders must be prepaid with cashier's check or money order made out in U.S. Funds. We are sorry but C.O.D. is not available to foreign countries and Letters of Credit are not an acceptable form of payment either. Further information is available on request.

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INSURANCE: Please include 25¢ for each additional $100.00 over $100.00. United Parcel only.

ORDER FORMS: New order forms are included with each order for your convenience. Additional forms are available on request.

POSTAGE: Minimum shipping and handling in the US, Canada, and Mexico is $2.50 all other countries is $5.00. On foreign orders include 20% shipping and handling.

PREPAID ORDERS: Order must be accompanied by a check.

PRICES: Prices are subject to change without notice.

RESTOCK CHARGE: If parts are returned to MHZ Electronics due to customer error, customer will be held responsible for all extra fees, will be charged a 15% restocking fee, with the remainder in credit only. All returns must have approval.

SALES TAX: Arizona must add 5% sales tax, unless a signed Arizona resale tax card is currently on file with MHZ Electronics. All orders placed by persons outside of Arizona, but delivered to persons in Arizona are subject to the 5% sales tax.

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FOREIGN: Prepaid only, U.S. Funds—money order or cashier's check only

C.O.D.: Acceptable by telephone or mail. Payment from customer will be by cash, money order or cashier's check. We are sorry but we cannot accept personal checks for C.O.D.'s.

CONFIRMING ORDERS: We would prefer that confirming orders not be sent after a telephone order has been placed. If company policy necessitates a confirming order, please mark "CONFIRMING" boldly on the order. If problems or duplicate shipments occur due to an order which is not properly marked, customers will be held responsible for any charges incurred, plus a 15% restock charge on returned parts.

CREDIT CARDS: WE ACCEPT MASTERCARD VISA AND AMERICAN EXPRESS.

DATA SHEETS: When we have data sheets in stock on devices we do supply them with the order.

master charge VISA AMERICAN EXPRESS Cards Welcome

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PHOENIX, ARIZONA 85015

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it has features never before available in one handheld, it's made in the USA and it's priced right!

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Do their handhelds have memory lockout?
Exclusive memory lockout on the TEN-TEC 2591 allows scanner to temporarily bypass channels for quick lockout of busy frequencies yet retain them in memory for normal operation on demand.

Do theirs store transmit offset?
The 10 memories of the 2591 allow stored offset for easiest operation. And memory channel 0 accepts any non-standard offset.

Do theirs offer selectable SKIP or HOLD?
When scanning with the 2591, choose HOLD to stop and stay on a busy frequency. Choose SKIP to stop for several seconds and continue.

Do theirs offer modifiable Band Scan without complete reprogramming?
With the 2591 you can scan any section of the band with user defined upper and lower limits in steps of 5, 10, 15, 25, or 30 kHz. Change step size, upper and lower limits independently. Manual Scan also, up or down, in 5 kHz steps.

Do theirs have Quick-Release NI-CAD Battery Pack?
The 2591 battery pack slides off easily, yet is secure in use, has a heavy duty 450 mAH rating at 8.4v, and the 2591 has capacitive memory retention to permit pack changing without reprogramming.

THE TEN-TEC 2591 HAS ALL THE RIGHT FEATURES...
• **Memory Scanner scans only programmed channels** and has user selectable HOLD or SKIP • **Selectable 2.5 Watts or 300 Milliwatts power,** top panel switched • **Extended Frequency Coverage—143.5 to 148.995 MHz.** Covers full Amateur Band plus some CAP and MARS frequencies. • **4-Digit LCD Readout with Switchable Back Light** —large, easy-to-read digits, selectable for frequency or memory channel number. • **Key-Pad Frequency and Function Control** —16 key dual tone encoder • **Dual Function LED**—shows battery status and transmit mode. • **Electret Microphone** plus separate speaker for superior audio. • **Compact, Lightweight, Complete**—easy to handle and rugged. Standard equipment includes flexible antenna with BNC connector, AC charger, belt clip, connectors for mike and speaker. Options include: adaptor pack for +12 VDC mobile operation, speaker/mike, 25 watt power amplifier, leather case, desk charger, subaudible tone module, and spare NI-CAD pack.

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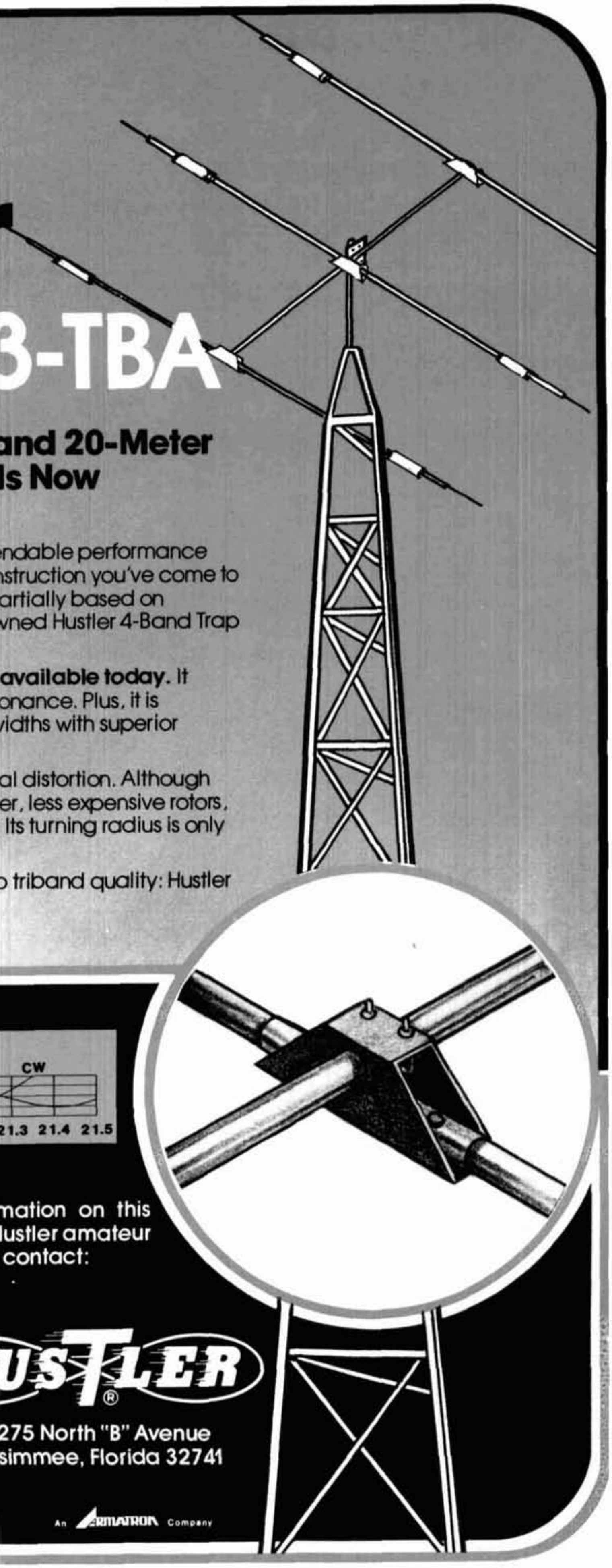

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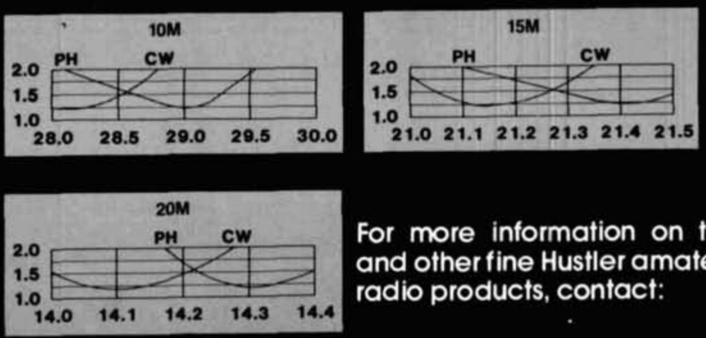

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Specifications:

• Gain	8dB
• F/B Ratio	28dB - (20M)
• Power Rating	1KW at Antenna
• Boom Length	14'
• Longest Element	24'9"
• Turning Radius	14'2-1/2"
• Wind Surface	5.7 Sq. Feet
• Wind Survival	100 MPH
• Weight	40 lbs.

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