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ham radio magazine

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- VFOs tuned by cylinder and disc
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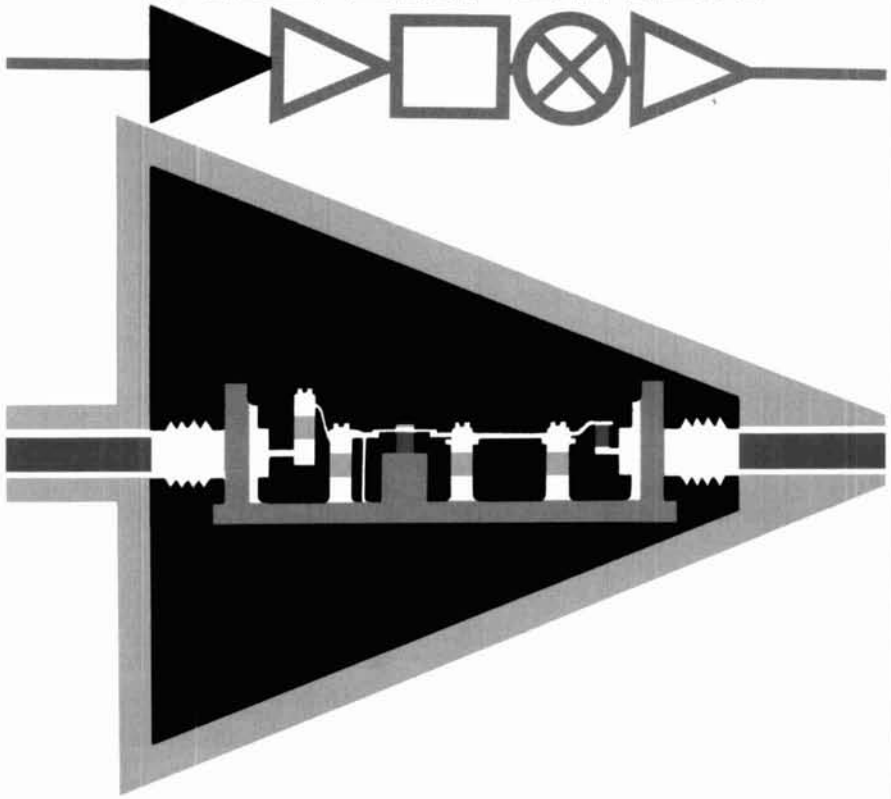

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Transceiver Unit

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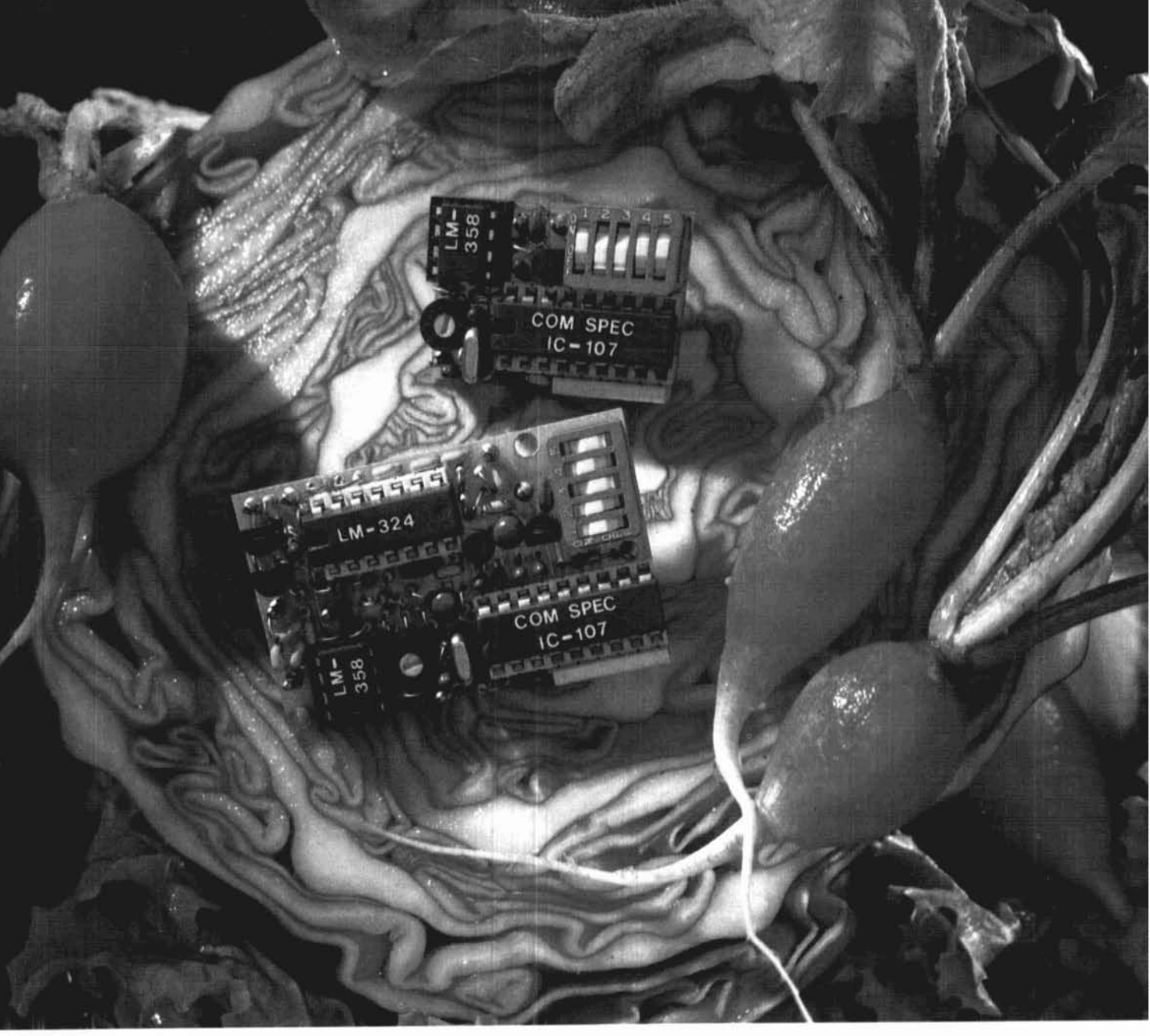

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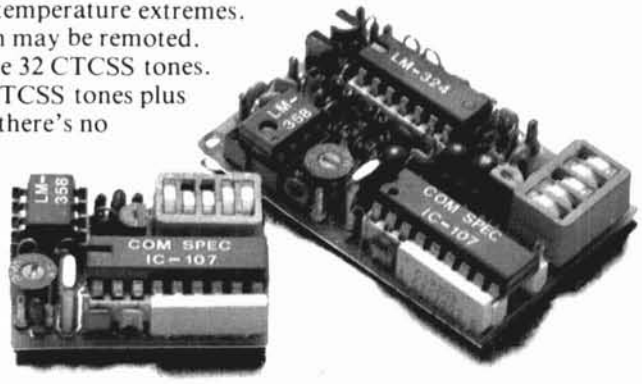

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R-600 FEATURES:

- 150 kHz to 30 MHz continuous coverage, AM, SSB, or CW.
- 30 bands, each 1 MHz wide, for easier tuning.
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- Up-conversion PLL circuit, for improved sensitivity, selectivity, and stability.
- Communications type noise blanker eliminates "pulse-type" noise.
- RF Attenuator allows 20 dB attenuation of strong signals.
- Tone control. • Front mounted speaker.
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- Coaxial and wire antenna terminals.
- 100, 120, 220, and 240 VAC, 50/60 Hz. Selector switch on rear panel.
- Optional 13.8 VDC operation, using DCK-1 cable kit.
- Other features include carrying handle, headphone jack, and record jack.

Optional accessories for R-600 and R-1000:

- DCK-1 DC Cable kit. • SP-100 External Speaker.
- HS-6, HS-5, HS-4 Headphones.
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High performance, easy tuning, digital display

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- Effective noise blanker. • Tone control.
- Built-in 4-inch speaker. • Dimmer switch.
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TS-130SE FEATURES:

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- Digital display, built-in.
- IF shift circuit.
- Speech Processor, built in.
- Narrow/wide filter selection on CW and SSB with optional filters.
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- RF attenuator, built-in.
- Effective noise blanker.
- Final amplifier protection circuit assures maximum reliability. Output power is reduced if abnormal operating conditions occur. For very severe operations, optional cooling fan, FA-4, is available.
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Optional accessories:

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- KPS-21 power supply (TS-130SE
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- SP-120 external speaker.
- VFO-120 remote VFO.
- FA-4 fan unit (TS-130SE).
- YK-88C (500 Hz) and YK-88CN (270 Hz) CW filters.
- YK-88SN (1.8 kHz) narrow SSB filter.
- AT-130 antenna tuner.
- MB-100 mobile mounting bracket.

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contents

REFLECTIONS

The Battlefield

It's 0600 hours UCT. Most sensible people on this side of the Atlantic have turned in for the night. Europe is waking up to a new day. The place is 75 meters and we are greeted with a mixture of howls that sound like the sound track from a horror movie. Upon closer examination human voices become recognizable, along with radioteleprinter signals, several unmodulated carriers, and the ever-present and pervasive noise.

During a brief lull in the hostilities, a crisp, British-accented voice is heard, announcing that he is listening for any stateside station, preferably Midwest or West Coast. His 10 over 9 signal attracts quite a bit of attention and the melee begins. As if the entire FCC roster were being called, one-by-twos, one-by-threes, and two-by-ones line up, each in their own turn, to shout their calls in the hope of attracting the British station.

A second pause, and a confirmation by the G station is heard. How delightful! His signal is strong, the band is wide open, and the noise level is down. But what's this? A 30 dB over S9 carrier sweeps back and forth, the work of a disgruntled Amateur who feels that he must get even — and, for most listening, he's accomplished his task. For them, he's turned what might best have been described as merely a headache-producing operating experience into one that sends the blood pressure up and poisons the bile. Others, however, accept it as inevitable, switch to their Beverage antenna, narrow their passband, and insert rejection. For those few, communications technology has moved on and they're riding with it.

Six years have passed since I left the East Coast. How simple it all seemed then. A trap vertical, four quarter-wave radials, and 25 kHz of band on which to meet our overseas partners leisurely and on an equal footing. The exceptionally well-equipped station had a pair of phased verticals, twenty radials under each, and maybe even a Beverage antenna for listening. Today, during *non*-contest periods, even that station will not necessarily produce a response on the first call. More and more we hear of the four-square (four phased verticals in a square configuration) with radial systems measured in miles not feet, 1200-foot rhombics on a leg, and three-element Yagis, most fixed, some rotary.

So what's the complaint? This is progress, isn't it? Perhaps it's the fact that this all occurs on 3799 ± 0.000 . . . 1 kHz; as if some magical gentleman's agreement has been made by the unseen multitudes.*

We must love this band. What other word could describe the rush of emotion while working DX, could explain the reason we put up with operating conditions that would make the military C^3 (Command, Control, and Communication) people wince, the sore muscles, the strained wallet, and lost sleep?

Is it possible — not in a world far, far away but right here, on the dial between 3777 (remember LSB) and 3800 — to improve our act, show a little more patience, cut back on the processing, and listen a little more? If not, I suppose I'll have to put in an order for 20,000 more feet of radial wire, 500 feet of six-inch irrigation tubing, solid-state commutating for my Beverage farm.

Might the hostilities, if not cease, perhaps slacken?

Rich Rosen, K2RR/1
technical editor

**SSB DXers from Europe, Africa, Asia, the U.S., and elsewhere have gravitated toward 3799 for several reasons. It's there that one finds the greatest commonality of nationally regulated Amateur frequencies and the least interference from worldwide commercial broadcast stations. Japanese Amateurs, for example, can operate only between 3793 and 3802, and Australians between 3794 and 3800, while Europeans and many others can go no higher than 3800 kHz. With strong commercial and military broadcasts from Regions 1 and 3 below 3795, and with three daily domestic nets in Region 2 also operating below 3795, 3797-3799 has become the 75-meter DXers' common ground.*

But what about the Extra Class Amateurs who don't want to chase DX and yet who operate in the "window"? They of course have every legal right to use it. If only they would bear in mind that there is a difference of up to 70 dB in signal level between their signals and those of the DX stations! That's quite a bit of filtering, directive antenna gain, and rejection that's needed to even come close to equalizing. Also, communicators are supposed to use the minimum *necessary power to establish and maintain contact. Rarely is a kilowatt needed to communicate across town. By using a 10-dB-step power attenuator (from 0 dBm to +60 dBm in six steps), contact with several hams over 500 miles away has been accomplished at the 10-*milliwatt *level on 3795. If most Amateurs followed this rule (minimum necessary power) we might be pleasantly surprised by how much nicer 75 meters would sound.*

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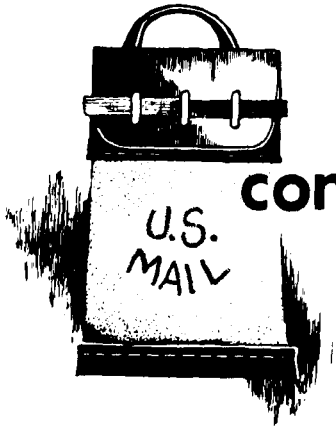

comments

filters

Dear HR:

The FCC Rules and Regulations of January, 1979, Part 97, Amateur Service, state that the second harmonic from an Amateur transmitter must be down from the fundamental by 40 dB. The responsibility to comply falls directly upon the Radio Amateur. But few have the equipment to make this measurement accurately, and even the inspectors who recently cited a local Amateur had to first obtain the equipment to make the measurement.

One might assume that an AB-1 or AB-2 amplifier is operating linearly if it is not being over-driven and the bias is set right. One might assume that the lowpass filter will take care of the problem — it's easy to forget that it cuts off at 30 MHz, and that your station might be measured at 7 MHz.

The best solution for the Amateur is to use a band cut-off filter as described by *GE Ham News*, June, 1957, Vol. 12 No. 2. The mica capacitors, however, are located in the form of an inductance, which throws the cut-off frequency off. If you use the small ceramic type, any high power will make popcorn out of them. The only capacitors I have found to be satisfactory are the Ceramic TVL Centralab, but they are expensive. They cost $10.00, and you need four per band.

Amateurs do not realize that the FCC is *not* talking about TVI; they are talking about the second harmonic output from the 160-80-40-20 meter bands. No one seems to care and the regulation is being ignored — except when an Amateur is cited and finds that he has to get a letter of certification from someone saying that his rig is OK. That's a service and shipping cost of several hundred dollars. All I can say to those who do not have a filter is, good luck!

Ed Marriner, W6XM
La Jolla, California

autodialer

Dear HR:

A source for drilled and plated printed-circuit boards for my August, 1982, *ham radio* article, "A Portable Touch-Tone Autodialer," is now available. Dynaclad Industries, P.O. Box 296, Meadow Lands, Pennsylvania 15347, will make them available at $8.00 per board plus $1.50 shipping.

Alan Lefkow, K2MWU
Thiells, New York

ultimate tone information

Dear HR:

In regard to my article, "The Ultimate Tone Decoder," in the September, 1982, issue of *ham radio*, please note that our chips were purchased from Seiger Associates, 1885 Hicks Road, Rolling Meadows, Illinois 60008. Also note that the capacitors connected to pin 2 and pin 11 of the 8865 chip are 20 picofarad capacitors.

E.M. Dean, WD9EIA
Machesney Park, Illinois

Q signals

Dear HR:

I don't know where the idea that the Q signals are only for CW got started, but I've seen it many times, as in the N4AGS letter in the April issue. The facts follow:

Q signals are a part of the International Radio Regulations, a multi-partate treaty signed by the U.S.A. They are set forth in Appendix 13 (1968 edition). Section I, paragraph 1, specifies that the signals QRA to QUZ are for the use of all services. (QAA to QNZ are for the aeronautical service and QOA to QQZ are for the maritime services.)

A useful exercise is to look up the meaning of QRJ, QSU, and QUE. Note also the phrase, in Appendix 13A, Section I, paragraph 3: "in radiotelephony spoken as CHARLIE or NO." And further, in Section II: "When used in radio-telegraphy a bar over the letters composing a signal denotes that the letters are to be sent as one signal," as in $\overline{AS}$, wait.

With respect to the use of a phonetic alphabet, the Radio Regulations, Appendix 16, paragraph 1, specifies that the Alfa, Bravo . . . phonetics shall be used when necessary to spell out call signs, service abbreviations and words. Amateur regulations are at variance with this, however, in that paragraph 97.84(g) only "encourages the use of a nationally or internationally recognized standard phonetic alphabet."

There are important practical reasons behind the International Regulations. The Q code is the same in all languages. Consequently, a real QSO can be completed without the participants knowing a word of each other's language. It's easy on phone, too — the International alphabet words were selected to be easy to pronounce and hear in most languages.

I have called on the ARRL to work to correct the current misuse which is so common (see the correspondence column, August, 1981, *QST*, page 61).

R.P. Haviland, W4MB
Daytona Beach, Florida

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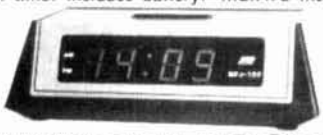

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More Details? CHECK—OFF Page 98

presstop de W9JUV

THE WARC 79 TREATY WAS FINALLY RATIFIED by the U.S. Senate Tuesday, December 21. Though ratification won't have any immediate effect on the U.S. Amateur community, it does mean that the FCC can now begin the regular rule-making procedures leading to permanent assignment to the Amateur service of the new 10, 18, 24, and 902 MHz WARC bands.

A "NO-CODE" AMATEUR LICENSE is almost certain to be proposed by the FCC early this year, very likely by the time this Presstop sees print. The alternatives still seem to be either dropping the code requirement from the current Technician license or adopting a new "digital" class license, such as is offered in Canada.

Within The FCC The Modified Technician License probably has the strongest support, as it would cost the least and require little staff effort to implement. It's also the course most vehemently opposed in the Amateur community, since it would not only permit individuals with no CW capability at all to become Amateurs but would also give them access to the HF bands. It is possible that some form of CW capability could still be required before a "no-code" tech could legally operate on an HF band, for example a "certification" by a General Class or higher Amateur that the individual can send and receive Morse code.

But The Strong Opposition To A No-Code Tech License already demonstrated by the ARRL and many individual Amateurs may very well lead the Commission to lean toward the "digital" type license, with a difficult technical exam like the Canadians'. Since that license has not proven popular in Canada, it could very well flop here too.

The Present FCC CW Tests May No Longer be nearly as effective a part of the Amateur exam process as most Amateurs believe. Some FCC Field Offices report an increasing number of applicants have apparently memorized the answers to at least one of the CW exams. They sit through the transmission, then answer the questions—though sometimes the answers will be for a tape other than the one they just heard! When lucky they pass the CW exam; if not, they return every month until they do.

THE 900-MHZ "PRIVATE RADIO COMMUNICATIONS SERVICE" is also quite certain to be proposed in a January Notice of Proposed Rule Making. Latest stories out of Washington say it won't be just a UHF CB service, but more a land mobile service readily available to anyone wishing to use it. Amateur Radio will not be connected in any way with the new service, despite some earlier rumors that it might.

Amateur Access To The New 902-928 MHz WARC Band seems to have received very little attention as yet, though signing of the WARC Treaty may now give it a push forward.

CORDLESS TELEPHONES ARE MAKING QRM for some 80-meter CW operators. The telephones use 1750 kHz for one side of the two-way circuit, and harmonics of the 1750-kHz carrier-current transmitter fall right into the low end of 80 CW. Though not confirmed, it's also likely that some 160-meter Amateurs are causing problems to neighbors' phones.

The Other Side Of The Phone Circuit, 49 MHz, may soon also be creating similar difficulties. Some makers of cordless phones have petitioned the FCC to extend their band edge up to 50 MHz, and with the questionable quality of some consumer electronics it is likely that phone interference to and from 6-meter users may become a problem as well.

Some "Long-Range" Cordless Phones, brought into the country by travelers or even smuggled in by people with little interest in or knowledge of frequency use, have also been showing up. These units operate at VHF and run considerable power. One,whose frequency capability includes the 2-meter band, promises 100-km range with an appropriate antenna and accessory power amplifier! Anyone hearing such a unit in operation should alert the nearest FCC monitoring station immediately.

RUSSIA'S ISKRA 3 SATELLITE HAS APPARENTLY FAILED for good. Though its beacon and 15 to 10 meter transponder were both heard early in December, by the middle of the month the over-temperature problem that had plagued the new bird seems to have shut it down.

Better News Is The Apparent Coming To Life of RS1, one of the two Russian satellites launched back in 1979. Several listeners have reported hearing noise and signals in its 29.35-29.40 MHz downlink passband, and at least a couple of satellite-relayed contacts have been made on RS1's frequencies when none of the other active birds were accessible. Its 29.4 MHz beacon has not been heard and is probably not functioning.

Asia Thanks To UAOBBN Has Been Worked by WØCY and W8DX via RS6. Though the window to the Siberian station is short, it does provide a rare satellite WAC opportunity for many.

"AMATEUR RADIO'S NEW FRONTIER" is the tentative title of a new Amateur Radio video tape promotion that's to be produced by a group headed by Roy Neal, K6DUE. Sponsored by the ARRL, the new effort will be directed at teenagers and will emphasize space-age communications and computer technology. Locales for the production will include Johnson Space Center in Houston, Kennedy Spaceflight Center, and AMSAT and ARRL headquarters. After funding is approved by the League directors, it will be targeted for completion by September.

THE FEDERAL JUDGE HEARING THE BURBANK TOWER CASE has agreed to take under advisement the city's motion to dismiss the suit filed by Burbank Amateurs. How soon he'll rule on the motion against that suit cannot be predicted at this time. The suit seeks to overturn the city's ordinance prohibiting new tower construction and outlawing RFI.

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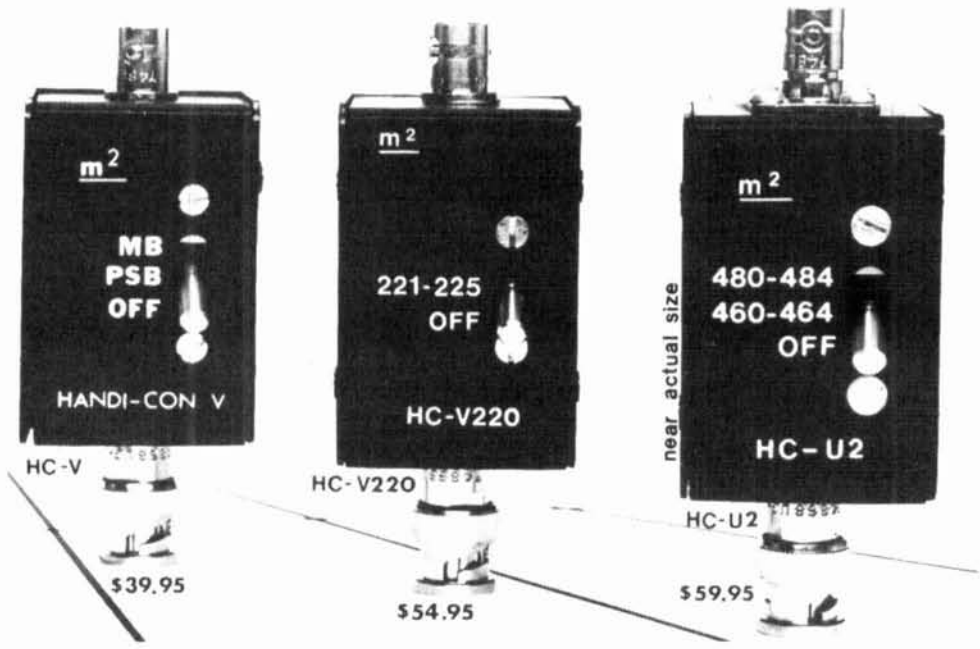

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a low-noise preamplifier for 2304 MHz

0.8-dB noise figure and 16-dB gain in a home-built microwave amplifier

Even though commercial equipment is not available for the 2300-2450 MHz band, weak-signal operation at 2304 MHz is undergoing great growth: The W2SZ/1 contest station worked only four other stations in four sections (including one station in eastern Pennsylvania, over 250 miles away) on this band in the June, 1981, VHF contest; in the June, 1982, VHF contest, eleven stations in eight sections were worked (including two stations in eastern Pennsylvania). Additional stations were known to be available, but were not worked because of a transmitter high-voltage relay problem.

The first requirement for a 2304-MHz station is a receiving converter. Many designs exist.[1] If low-noise preamplification and proper filtering are used in front of a subsequent mixer, then even a simple 3-dB hybrid-coupler mixer,[2] etched on a G-10 printed circuit board and using low-cost Schottky diodes (such as the HP 5082-2810), is adequate. **Fig. 1** shows a block diagram of a receiving converter, along with stage noise figures and gain/loss values. The 27 dB of gain in front of the mixer is more than adequate to overcome the 8-10 dB noise figure of the mixer. The bandpass filter[3] is used to reject noise and image signals at the mixer image frequency, aiding the relatively broadband preamplifiers. The i-f amplifier[4] may or may not be necessary, depending on the sensitivity and noise figure of the receiver at the selected i-f.

Because all these requirements have been previously discussed in other articles,[5] as have been the formulas necessary to obtain the overall converter gain (about 40 dB) and noise figure (approximately 1.0 dB), this article concentrates on the low-noise GaAs fet first-stage amplifier. The rf amplifier used in the second stage is a well-known microstrip design[6] using a bipolar NE64535 transistor (which costs about $7).

The device selected for the LNA is a Mitsubishi MGF-1402 GaAs fet, presently priced at about $15. The LNA circuit is shown in **fig. 2**. On the basis of past experience, I selected a π section to impedance-match the device output to a 50-ohm load. The length and width of output inductor L2 are determined by the required inductance and the height of the supporting portion of the π network tuning capacitors C3 and C4. The best information available, at the time, indicated that the optimum noise impedance to be presented to the gate of the device is between about $85+j60$ ohms and about $110+j90$ ohms. The input circuit was designed to provide an acceptable range of impedances, around these desired values, to accommodate variations between devices. Source self-bias is used; effective series-resonant chip bypass capacitors (C_S) are an absolute necessity. Fortunately, a set of five chip capacitors are available, at a reasonable price, from the same source[7] that supplies the GaAs fet device. These chip capacitors, the variable capacitors, and the device itself are all relatively small. Use of sharp-pointed tweezers is advisable for careful handling of these parts. While only four chip capacitors are needed, the fifth chip capacitor is insurance, as the little beasties are easily destroyed or lost. I did all soldering

By Geoff Krauss, WA2GFP, 16 Riviera Drive, Latham, New York 12110

with a 23-watt pencil line, while observing special grounding techniques for handling the device.

construction

The LNA is built from the output forward. Refer to **fig. 3**. A base of copper-clad printed circuit board is cut to a width of about 1-1/2 inches (40 mm) and a length in excess of 3 inches (80 mm). End plate 1 is formed from a piece of double-sided printed circuit board, cut to a width of 1-1/2 inches and a height of 1 inch. Only the outside copper cladding of the end piece 1 is initially soldered to the base piece. A hole is now formed in the end piece 1 to pass the threaded portion of a gold-flashed, square-flange SMA connector, J2. The hole is positioned so that the edge of the connector's flange rests on the surface of the base, inside the angle formed by the base and end piece 1, when the threaded portion extends through the end piece hole. The gold flashing on the connector readily accepts solder, allowing the flange to be soldered to the end plate and base plate along all four edges with a minimum of heat. The pin of the connector lies along the center line of the base — almost all of the components are mounted along the center line. The rest of the inner angle between the end piece and the base is soldered after J2 is installed.

The output tuning capacitors C3 and C4 are mounted next. First, form the C4 lead nearest to the tuning screw to extend over the output connector J2 center pin. A chip capacitor, C5, is placed between the pin and the lead at a later time. When the lead is formed and properly placed, solder the base of tuning capacitor C4 to the copper foil of the base. Use of a silver-bearing, low-temperature solder and appropriate flux is highly recommended for soldering all components, and is a must for chip capacitor soldering. The small circular formations about the screw end of capacitors C3 and C4 provide buttresses upon which output inductance L2 is later mounted. Therefore, solder capacitor C3 in place along the center line, at a distance from capacitor C4 such that it can receive the strip inductor, and with the C3 lead pointing along the center line and away from the inductor position.

After C3 and C4 are mounted, solder inductor L2 between the variable capacitors. This soldering to the capacitors should be carefully done, and preferably from the underside of the inductor, to prevent solder from flowing into the tuning screw mechanism of the capacitors. Be aware that, if different capacitors are used for C3 and C4 with different buttress heights above the copper groundplane of the base, the width of inductor L2 may have to be adjusted to compensate.

Next, form the X support from a piece of copper plate or foil, as shown in **fig. 5**. Mount the two source lead chip capacitors (C_S) on the top of the support, with their inner surfaces about 1/8 inch (3 mm) apart. The height of the X support is such that the top of the chip capacitors is approximately in a plane with the leads of capacitors C2 and C3, when the support is soldered to the copper base covering. When the support has been properly formed and placed, solder the lower tabs A to the base.

Now move the input shunt capacitor, C2, into place, with its lead extending along the center line toward the output connector; trim the lead to extend along a line between the two chip capacitors on support X. The distance, D, between the center line of

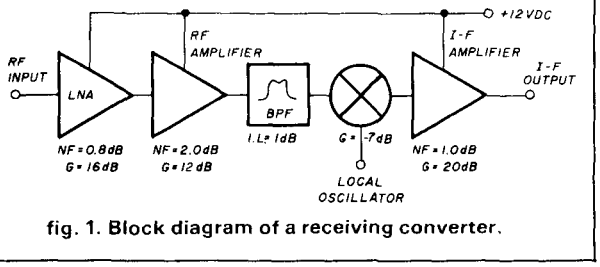

fig. 1. Block diagram of a receiving converter.

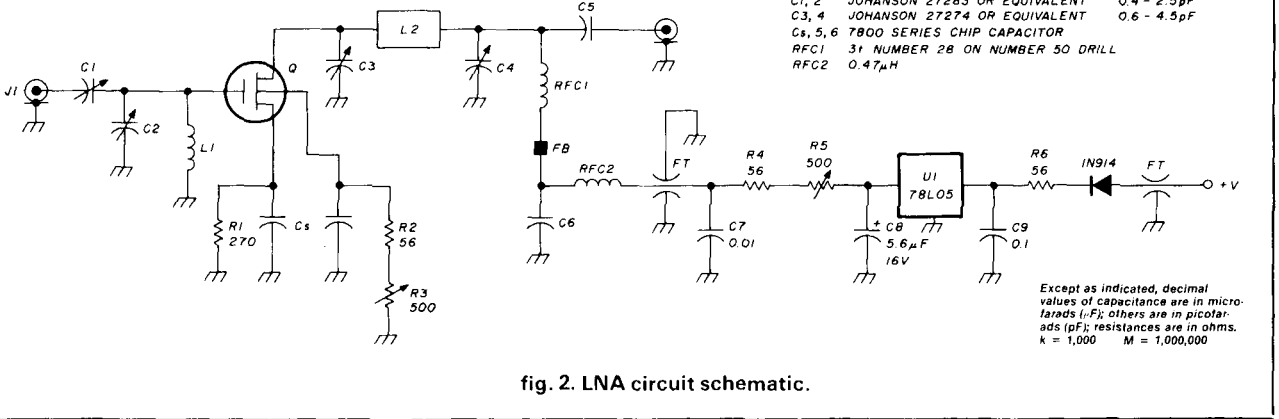

fig. 2. LNA circuit schematic.

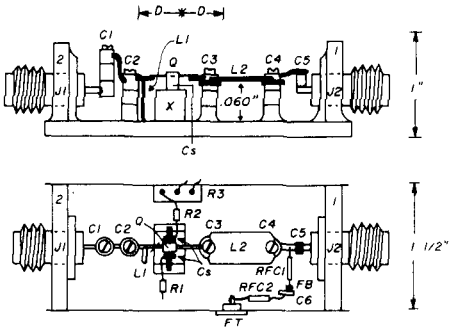

fig. 3. Construction details of the low-noise amplifier.

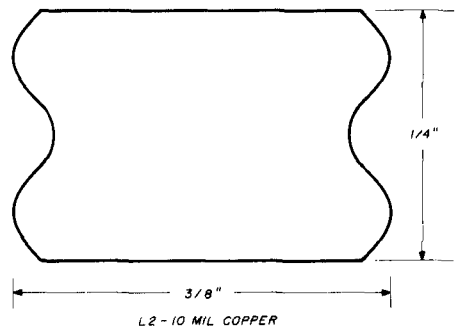

fig. 4. Output pi-inductance, L2.

the chip capacitors and the center lines of each of capacitors C2 and C3 should be between about 3/16 of an inch (4.5 mm) and 1/4 inch (6.5 mm). Solder the base of capacitor C2 in place. Now solder the base of capacitor C1 to the center pin of the input SMA connector J1, and form the lead from the other end of C1 over the shortest possible distance to the top of capacitor C2. Place connector J1 and capacitor C1 along the center line and tack the connector flange to the base.

At this point, make up another end plate with a hole to pass the threaded end of J1. Place end plate 2 over J1, solder the outside foil of end plate 2 to the base, and then solder the four flanges of connector J1 to the inner foil of the end plate and the base. Now solder the top lead from capacitor C1 to the top of capacitor C2. Form the input inductor, L1, as shown in **fig. 6** and solder from the top of capacitor C2 to the base foil.

The output chip capacitor, C5, is now soldered between the C4 lead and the output connector center pin. This is most easily accomplished by pre-tinning the center pin and soldering one end of chip capacitor C5 to that pin, before pressing the C4 capacitor lead down onto the other end of chip capacitor C5 for soldering. Add choke RFC 1, the ferrite bead, and the chip bypass capacitance C6 (having one end soldered to the base plate).

A printed-circuit-board piece is now added to each side of the base after forming a hole in one side for the feed-through capacitance, FT. After the sides have been added, solder in capacitor FT and RF choke RFC 2 between the feed-through and chip C6 capacitors. Solder the 270-ohm, 1/8-watt resistor R1 between ground and the free end of one of the source chip capacitors, C_S. Mount variable resistor R3 and then connect the 56-ohm R2 to the free end of the remaining source chip capacitor. The drain supply network of C7-C10, R4-R6, U1, and the 1N914 diode, can be mounted outside the LNA box (either on the surface or in a separate box section), but with no connection between U1 and R5. Only device Q remains to be mounted. While carefully holding one of the source leads with a grounded tweezer, use a low-wattage, grounded soldering iron to solder each of the source leads to the associated chip capacitor. The full length of the source lead is allowed to remain, as it serves as a convenient connection point for measuring bias voltages. Carefully cut the drain and gate leads to size and solder to the leads of capacitors C3 and C2, respectively. Construction is now complete.

tune-up

Adjust resistors R3 and R5 for maximum resistance. Apply a voltage, between 8 and 15 volts, to the power input and check for 5 volts at the output of integrated circuit regulator U1. After checking, connect the regulator output to variable resistor R5. Connect a voltmeter from ground to one of the source leads and, after again applying power, note a positive voltage of between 0.5 and 1.3 volts. Apply a relatively weak (less than −30 dBm) signal to input connector J1 and monitor the output signal at connector J2. Adjust resistor R3 for maximum gain, while adjusting resistor R5 to keep the drain source voltage (measured between a source lead and the top of chip capacitor C6) between 2.5 to 3.0 volts.

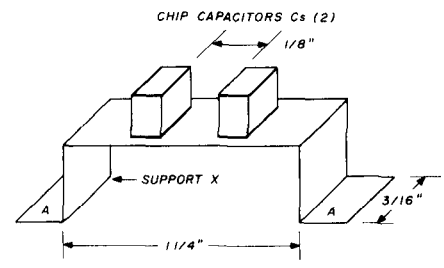

fig. 5. The X support, constructed from a piece of copper plate or foil.

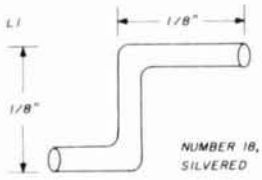

fig. 6. Input inductance, L1.

Now adjust capacitors C1 through C4 for maximum gain. Adjustment of drain current (with resistor R3) and drain voltage (with resistor R5) can be touched up for maximum gain. Using this maximum gain tuning procedure, a gain of about 20 dB with a noise figure of less than 2 dB is obtained. For minimum noise figure (measured to be about 0.8 dB, with an associated gain of about 16 dB), a noise source or weak-signal tuning method must be used. Do not change the tuning of output capacitors C3 or C4, but tune only input capacitors C1 and C2 for minimum noise figure or best weak-signal-to-noise ratio.

conclusion

A low-noise, high-gain amplifier for the 2304-MHz band can be built with a noise figure of under 1 dB for a cost less than $50 (dependent upon the state of your junk box). Outstanding reception is therefore possible on the 13 cm band.

See you there, next contest?

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ham radio

CB to 10 fm
one group's approach

An ingenious conversion that will quickly put you on the air on 10 meters

Recent articles in the ham journals,[1,2,3] regarding the conversion of CB rigs and circuit boards to 10-meter fm have caused quite a stir of activity. Here in the Toronto area, 10 fm is growing daily.

Our group decided to get on 10 fm by going the surplus route. Circuit boards made by the Japanese Cybernet company for Hy-Gain and several other manufacturers seemed to offer the best promise. They are essentially complete transceivers except for the addition of volume and squelch controls, microphone, speaker, channel selector switch, and housing. Several boards and forty channel switches were purchased from a surplus outlet,[4] crystals were ordered, and construction commenced. VE3FIT was fortunate enough to pick up a used forty-channel Hy-Gain CB rig for $10. This unit became the test bed.

initial set-up

First, make a visit to your public library and take a look at a copy of *Sams Photofact #148*. This book covers several of the Hy-Gain CB rigs that use the Cybernet PC board. Wire the controls and connections mentioned above as per the Sam's schematics. At this point it is probably best to leave off features such as RIT and ANL and concentrate on getting the basic rig operational on the CB channels.

Locate IC 101, the phase lock loop (PLL) chip. The leads from the channel connect to IC 101, but for now we'll just hard-wire them. Make sure that pins 8, 9, and 10 are joined, floating free of any components. Likewise for pin 7. Pick up +5 volts from pin 1 of IC 101 and temporarily jumper it to pins 7 and 14 of IC 101. Don't worry about the other input pins of the PLL chip. They have on-board pull-down resistors. This will program the rig to an output of 27.305 MHz (CB channel 30).

Go through the transmitter section, peaking each coil in turn. A General Cement Electronics alignment

By Ian MacFarquhar, VE3AQN, and **Ken Grant, VE3FIT,** 46 Merryfield Drive, Scarborough, Ontario, Canada M1P 1J9

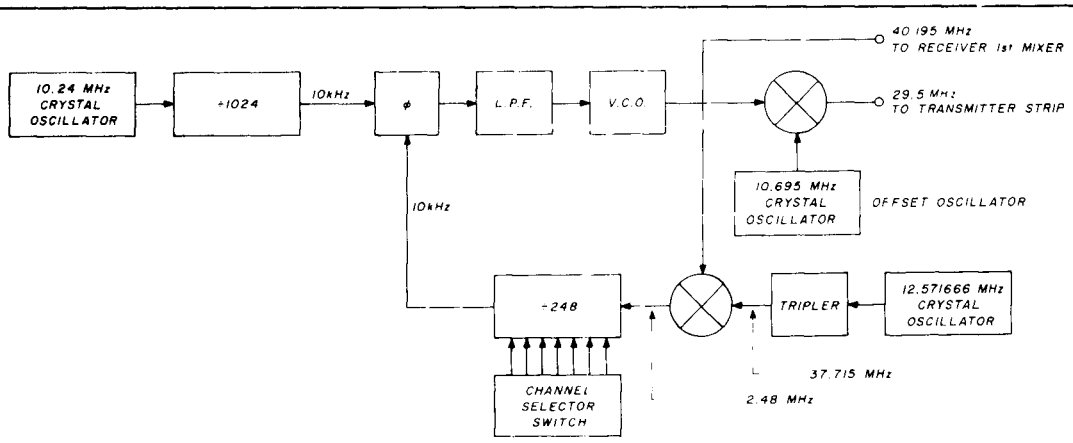

fig. 1. Mixing scheme.

tool kit (#18-530) is all you need. Use a #47 pilot lamp as a dummy load. If things are out of alignment, a general coverage receiver with an antenna close to the CB rig will provide an excellent output indicator. Simply tweak for maximum S-meter indication on the receiver.

The Cybernet receiver section is essentially prealigned. You may, however, wish to peak T104 and T105 in the rf amplifier stage. Use a signal generator as a signal source, or peak on a local CB conversation. Besides setting up the receiver, this will remind you of why you're glad to be a ham.

Once you are satisfied that the transceiver is operational, it's time to begin the conversion to Amateur use.

transmitter modifications

Remove crystal X101 (11.806 MHz) and replace it with a unit specified at 12.571666 MHz, HC18/U holder and 30 pF load capacitance. Notice the 6s at the end of the frequency. Leaving them off could ultimately put you as much as 2 kHz off frequency.

With the crystal now changed, power up the board and listen for the transmitter output on your main station receiver at 29.6 MHz, the center frequency of fm activity. Adjust T101 until the voltage at TP8 reads +2.1 volts. Peak T111, L104, T102, T103, L106, L109, and L110 for maximum output as shown on the lamp dummy load.

Once it had been "tweaked and peaked," our rig put out enough power to light a #47 lamp dummy load to about half brilliance. But prior to conversion, while still on CB, it had been very bright indeed! Obviously something was amiss.

The rig had originally been equipped with a pi-section lowpass filter composed of C604, C605, (330 pF each), and L600 (0.18 μH). Unfortunately, this combination cuts off somewhat below the fm operating

table 1. Scope readings.

test point		waveform (*)
Q101	base	0.10
	collector	0.35
Q105	emitter	1.20
Q108	base	0.10
	collector	0.20
Q109	emitter	1.00
Q110	collector	1.00
Q111	base	0.20
	collector	4.00
Q112	base	1.90
	collector	8.50
Q113	base	2.00
	collector	17.0
ant.	connector	across 50 ohms 26.0 (loaded down by probe)

*All voltages are ac peak-to-peak and measured with a high-impedance scope probe unless otherwise noted.

table 2. Crystal oscillator test points.

oscillator frequency	test point
10.24 MHz	pin 3, IC 101
12.571666 MHz (X3 = 37.715 MHz)	emitter Q105
10.695 MHz	emitter Q109

frequencies. When the pi net was removed and replaced with a piece of wire and a good outboard lowpass filter, output increased noticeably but was still far short of the original level. The original three-component design just doesn't have enough harmonic attenuation to justify reworking it for 10 meters.

Next, C603 was reduced from 220 pF to 200 pF and L109 and L110 were readjusted for maximum output. This helped a bit.

Luckily, enough voltage measurements had been taken at various points in the transmitter stage (while still on CB) to enable us to determine where we were losing out. These readings are given in **table 1**.

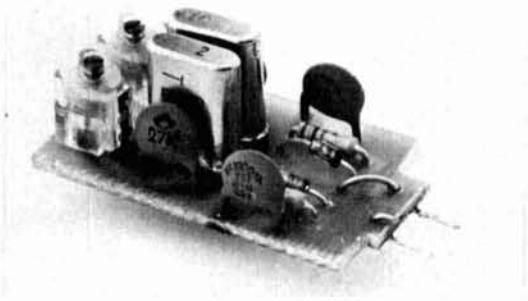

fig. 2. PC board making use of diode switching.

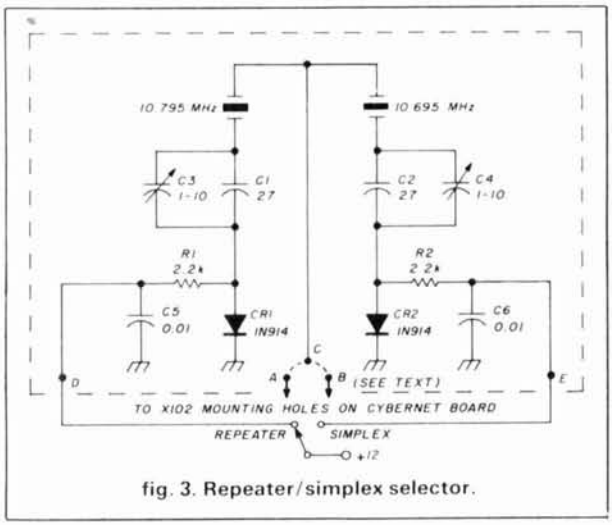

fig. 3. Repeater/simplex selector.

For maximum output, L106's slug had to be completely removed from its windings: that is, it was at minimum inductance and wouldn't go any lower. Removing a turn or two from L106 was impracticable because of the way the coil is built. To solve this problem, we simply broke one of the circuit paths from L106 and added a 270-pF capacitor in series. This change permits L106 to properly match Q112 and Q113. Setting L106 was now possible. We were getting closer.

Ultimately, the trouble was traced to the base of Q110, where the VCO and offset oscillator signals are mixed. The offset oscillator output level hadn't changed, and so it was assumed that, for whatever reason, the VCO level had changed. Changing C136 from 150 pF to 82 pF restored full drive to Q110 and to the rest of the transmitter chain. A full 5 watts of power was now available at the transmitter output. By the way, the output power is very sensitive to supply voltage. We normally run the rigs with 13.5 volts.

crystals

On our boards the crystals were all presented with too high a load capacitance. That is, C118, C127, and C178 were all 56-pF ceramic disks. A check of the oscillator output frequencies (at the points shown in **table 2**) confirmed that all crystals were oscillating slightly low in frequency. Changing the capacitors to 33 pF brought all the oscillators very close to the correct frequencies. If you can install trimmer capacitors, so much the better.

The mixing scheme used on the Cybernet boards is shown in block diagram form in **fig. 1**. Note that the rig is shown receiving and transmitting on 29.6 MHz simplex. The receiver's local oscillator signal is 10.695 MHz above the transmit frequency. In the repeater mode (input 100 kHz below repeater output), the receiver LO frequency stays the same but the transmitter frequency is now mixed down another 100 kHz.

Our group is contemplating repeater operation, so a PC board was designed to provide diode switching of X102 between 10.695 MHz (simplex) and 10.795 MHz (repeater). This board is shown in **figs. 2, 3,** and **4**. Diode switching was used because of the long distance between X102 and the nearest point on the front panel (about 5 inches). In the testbed rig, the ANL switch was used to provide the simplex/repeater selection.

This circuit board is installed vertically in the holes

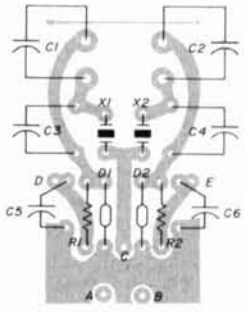

fig. 4. Offset oscillator parts layout.

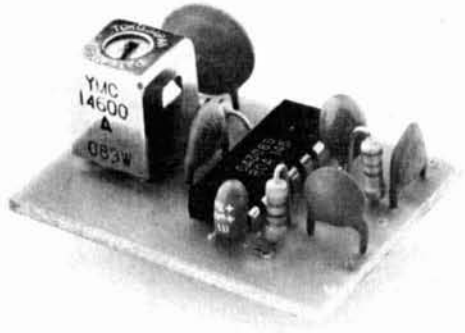

fig. 5. The fm demodulator board.

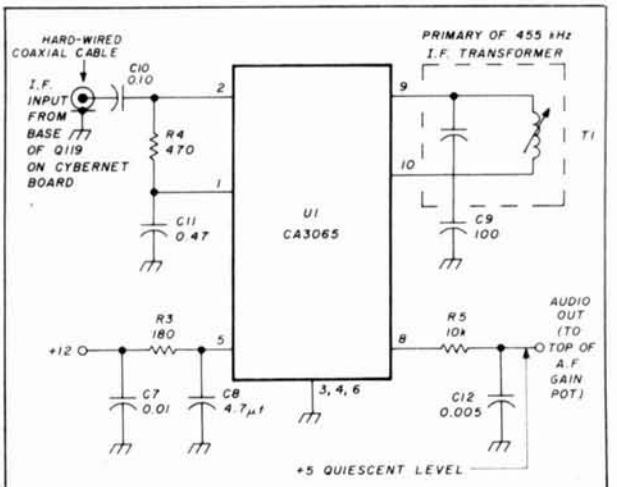

fig. 6. Fm demodulator.

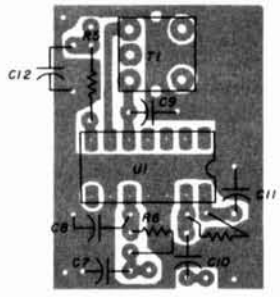

fig. 7. Fm demodulator board.

provided for X102 and secured with a drop of epoxy. Remove C127 and jumper its PC board holes. The lead coming from the common point of the two crystals, point C, can be jumpered to either terminal A or B. If A is the hot lead, ground B. If B is hot, ground A. This allows you to mount the board with the components facing inward, where you can adjust them. One of the subtle differences between the Hy-Gain and Cybernet boards is the placing of X102 and C127.

fm demodulator

The fm demodulator board shown in **figs. 5, 6,** and **7** is extremely compact and has been designed for operation at 455 kHz. A solder lug is soldered to the ground plane. This solder lug is then secured to the Cybernet board with a 4-40 (M3) screw and nut through the uppermost mounting hole in the audio amplifier's IC heatsink. Be sure to use shielded cable or Subminax (RG174/U) to feed the demod board from the base of Q119. Believe us, it's necessary! The bottom of the volume control is grounded and the wiper goes to pin 21 on the Cybernet board.

The i-f transformer appears to be a common Japanese transistor radio item. Ours measures about 0.4 × 0.4 inch (10 × 10 mm) and has a yellow core. It cost 50 cents at a local surplus store. The primary inductance is variable between 500 and 900 μH, and it resonates with an extremely tiny 180-pF tubular capacitor contained within the base of the i-f can. Initially, set the core about two turns from the maximum counter-clockwise rotation. Tune in a fairly weak signal (off the air or from a signal generator) and adjust the core for maximum undistorted audio output. This point is also coincident with maximum a-m rejection.

The CA3065 chip[5] contains an extremely sensitive i-f amplifier-limiter (200 μV for limiting), a differential peak detector (demodulator), and an audio output buffer. It will deliver over 4 volts peak to peak of clean audio. The demod section is shown in **fig. 8**. This circuit has also been referred to as a time delay differentiator.[6] What happens is that, at resonance, the tuned circuit impedance becomes purely resistive. This is shown in **fig. 8** as R. For our i-f transformer, R turned out to be about 70 kilohms. R and Cp must provide a phase shift of approximately −90 degrees. The required value of Cp at 455 kHz is about 100 pF. The output of the demod board goes to the top of the volume control.

fm modulator

To convert the rig to fm is fairly simple. The a-m

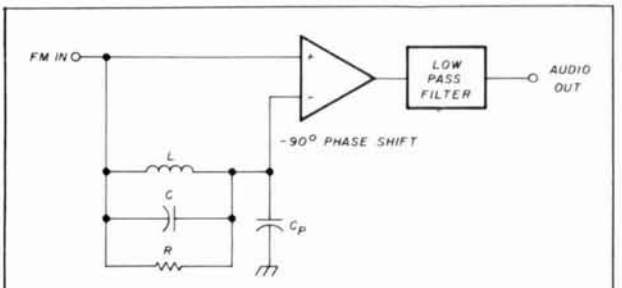

fig. 8. The fm demodulator, principle of operation.

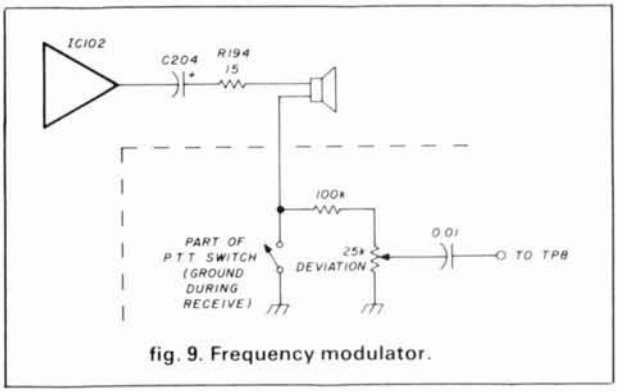

fig. 9. Frequency modulator.

modulation transformer T110 and RV102 are discarded. The B+ is restored to the final amplifier by joining points 18 and 20 on the Cybernet board. The output of the audio amplifier, IC 102, is routed from the positive side of C204 through R194 to the hot side of the speaker. The cold side of the speaker is grounded during receive through one of the contacts of the PTT switch.

During transmit, the amplified microphone audio is available at the cold side (now floating) of the speaker. The circuit shown in **fig. 9** taps off part of this audio and applies it to the VCO control voltage at TP8, thus frequency modulating the signal. Setting the rig's deviation is done by monitoring the transmitter output on the general coverage receiver (a-m mode) using slope detection. Adjust the deviation control until clean audio is heard. On-the-air comments have been positive. If a deviation meter is available for this adjustment, so much the better.

forty-channel switch

If you were fortunate enough to obtain the forty-channel switch made for the Cybernet board you can use it directly. This switch is 1-1/2 × 1-1/2 × 5/8 inches thick (37 × 37 × 15 mm) and has a small printed circuit board on top. It's manufactured by Standard Grigsby. You may wish to reprogram the switch to another band plan, as will be described later. There is a very similar switch, also made by Standard Grigsby but without the PC board on top. This switch is meant for use with a circuit completely different from ours, and is almost useless to us. It also happens to be the switch we had purchased with our boards at three dollars a shot and were absolutely determined to use. Fortunately it can be modified to our specifications.

The switch is a marvel of mechanical design. It consists of two sections, a front-mounted detent mechanism and a rear-mounted printed circuit switch (see **fig. 10**). The sections are held together by two metal retainer pieces which are inserted from the rear. To remove them, slightly crimp the two metal tabs on the front of each retainer. Then, using a pair of pliers, pull the retainers out from the rear. The two sections will now separate.

The printed circuit section is held together by a bead of fairly soft epoxy, which also secures the terminals. Chip away at the epoxy (watch those terminals!) until you can separate the two halves. This will expose the removable printed circuit switch disk. This disk provides the coding to the PLL via ten finger contacts riding on the PC traces. The board etching dictates which fingers make contact with the common line (giving a digital "1"). This disk will be replaced with one custom-encoded to our needs, as discussed in the next section. Reassemble the sections and check for smoothness of operation.

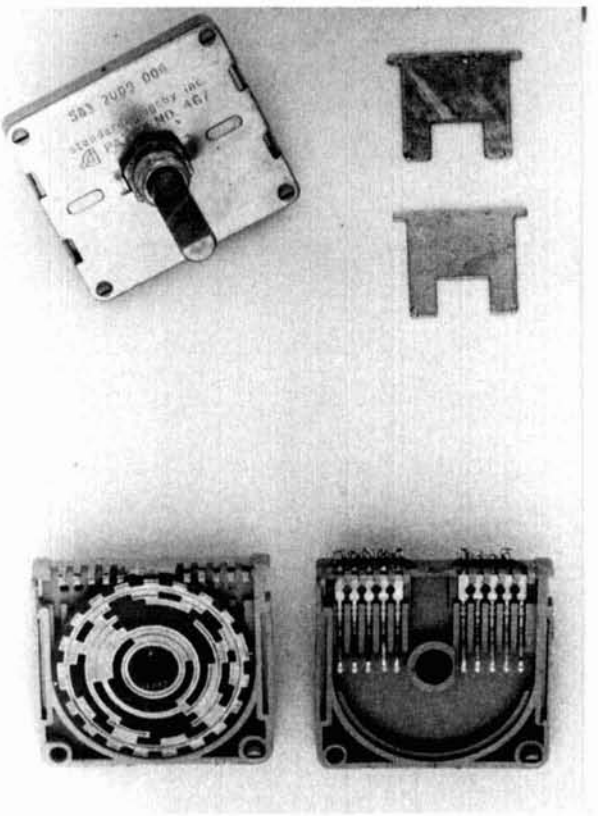

fig. 10. Forty-channel switch.

For the sake of convention we have numbered the switch terminals from 1 to 9, left to right, when viewing the switch assembly from the front. Wire these terminals to the appropriate points on the Cybernet board as per **table 3**.

The switch provides the PLL chip with a seven-bit word representing the division ratio necessary to place the transceiver on the desired frequency. The switch is directly connected to the PLL inputs to control the division factor. **Table 4** gives this information. In the example shown, illustrating the mixing scheme (**fig. 1**), the channel selector switch provides the correct code to the PLL for division by 248.

Fig. 11 illustrates the internal finger contact arrangement of the switch. Note that each adjacent connection makes contact with every other switch

table 3. Wiring directions.

switch pin #	IC 101 pin #	division ratio
1	15	1
2	14	2
9	13	4
3	12	8
8	11	16
4	8,9,10	224
7	7	256
5,6	1	common (+5)

table 4. Division ratios.

channel number	switch pin # 7483921	division ratio	frequency MHz
01	0100100	228	29.300
02	0100101	229	29.310
03	0100110	230	29.320
04	0100111	231	29.330
05	0101000	232	29.340
06	0101001	233	29.350
07	0101010	234	29.360
08	0101011	235	29.370
09	0101100	236	29.380
10	0101101	237	29.390
11	0101110	238	29.400
12	0101111	239	29.410
13	0110000	240	29.420
14	0110001	241	29.430
15	0110010	242	29.440
16	0110011	243	29.450
17	0110100	244	29.460
18	0110101	245	29.470
19	0110110	246	29.480
20	0110111	247	29.490
21	0111000	248	29.500
22	0111001	249	29.510
23	0111010	250	29.520
24	0111011	251	29.530
25	0111100	252	29.540
26	0111101	253	29.550
27	0111110	254	29.560
28	0111111	255	29.570
29	1000000	256	29.580
30	1000001	257	29.590
31	1000010	258	29.600
32	1000011	259	29.610
33	1000100	260	29.620
34	1000101	261	29.630
35	1000110	262	29.640
36	1000111	263	29.650
37	1001000	264	29.660
38	1001001	265	29.670
39	1001010	266	29.680
40	1001011	267	29.690

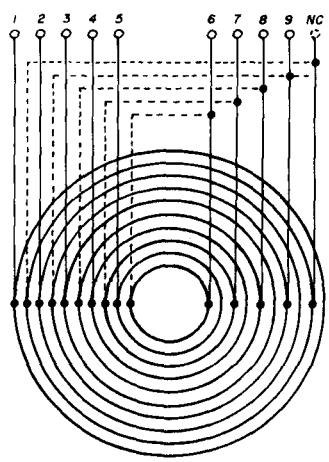

fig. 11. Internal finger contacts arrangement.

"track" of the PC board with a total of ten fingers. In the switch used, finger 10 had no external connection; that track was employed to make electrical connection to the outside track. The dashed lines show the effective position of the second set of fingers, 180 degrees from their true electrical position. It should be evident that, while encoding any particular division factor, it is necessary to alternate between the left and right side of the disk to assemble a digital word. This is a result of the interleaving contact arrangement used in these switches.

fm band plan

When considering how to "channelize" these boards, we tried for as rational an approach as possible. Initially we considered the original CB channel scheme. The channels are nominally spaced at 10 kHz, but there are several 20-kHz gaps, notably between channels 7 and 8, 11 and 12, 15 and 16, and 19 and 20. There was also a 30-kHz gap between channels 22 and 23. These gaps are presumably there to protect established users in the old pre-CB 11-meter band. When channels 24 through 40 were added, 24 and 25 were used to fill the gap between 22 and 23. The rest remained the same. Confusing, eh?

Since the switch used a printed circuit disk, it seemed possible to reprogram the switch to channelize our rigs as we desired. Thus we could eliminate the oddball frequency shifts one would experience when using a standard CB switch. The possibilities seemed endless, and numerous evenings were spent trying to establish a plan that seemed logical.

Since one cannot transmit fm on 29.7 MHz without having one's sidebands spilling out of the band, the top channel would have to be 29.69 MHz (channel 40). This fact seems to have been overlooked in the band schemes we have seen to date. If your rig can operate on 29.7 MHz, we recommend you not use that channel.

The first disk produced did not permit operation on the frequencies between 29.4 and 29.5 MHz. This was done to prevent interference to OSCAR Mode A downlink signals. This scheme made possible nineteen channels above 29.5 and twenty-one channels below 29.4 MHz. But 29.5 MHz, for some unknown (and apparently quite foolish) reason, is used as a calling channel. Transmitting on this frequency could cause severe interference to satellite beacon signals. We suggest a different channel be used as a calling frequency. Any suggestions?

Information available to us when the band plan was being worked out indicated that the present OSCAR 8 satellite was to be the last with a Mode A downlink. Since OSCAR 8 was then over three years old, it was reasonable to assume that three years hence it would be out of service. On that basis we fi-

fig. 12. Disk PC layout.

nally decided on forty continuous, 10-kHz-spaced channels between 29.30 and 29.69 MHz. We simply would not use the channels in the satellite band until Mode A was no longer in use.

Then, long after the switches were designed and made, along came the new Russian satellites that not only use 29.4 to 29.5 MHz but frequencies between 29.3 and 29.4 MHz as well. Coordination began to seem impossible. All we can suggest is that prudence regarding use of transmitting frequencies be exercised.

Fig. 12 shows a 1:1 positive of our disk PC layout. The artwork should be 1.32 inches (33.5 mm) in diameter. It will be necessary to make a negative mask from this artwork. Be very precise when producing your disk, as the switch tracks are only 0.05 inch (1.25 mm) apart. Use 1/16-inch thick, 35-mm diameter, glass epoxy PC board and, if possible, tin plate the copper. The hole for the switch shaft can be made with a small file, using the original disk as a template.

in summary

These modifications and suggestions have all worked out quite nicely and helped several fellow hams get on the air sooner than might otherwise have been the case. See you on 10 fm!

acknowledgment

The idea of reprogramming the channel selector switch was proposed and developed by Ian Campbell, VE3IEO, to whom much credit is due.

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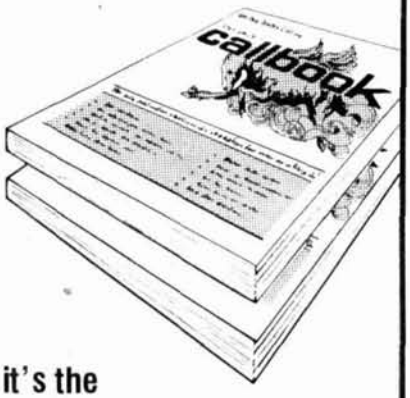

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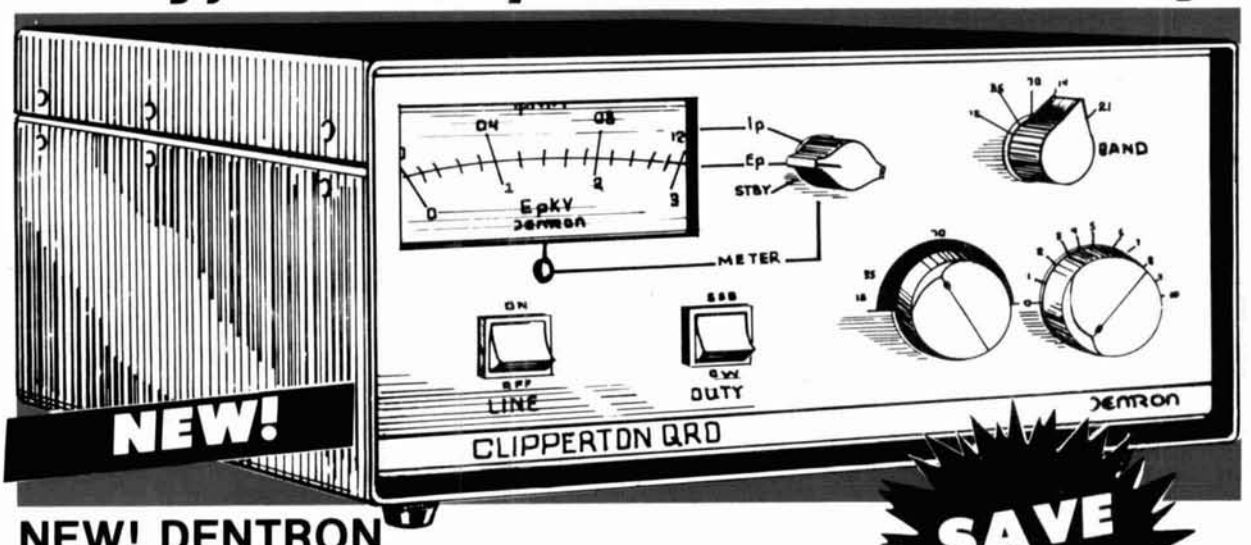

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More Details? CHECK—OFF Page 98

design notes on a panoramic adaptor/ spectrum analyzer

Double-conversion superheterodyne with a 55-dB skirt filter, doubly balanced mixers, and a log detector

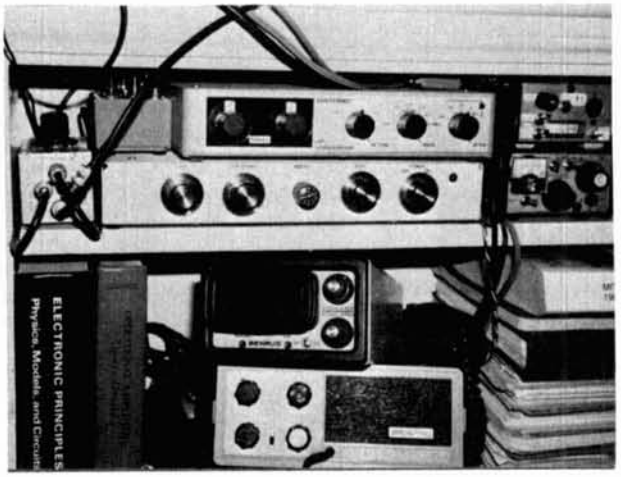
Human beings cannot see the radio signals that are everywhere around them. Hams spend much of their time listening to this or that signal, but their receivers let them hear only one at a time. Wouldn't a new dimension open up if you had a way of seeing those signals your radio wasn't tuned to — if you could see all the signals over a whole band of frequencies, rather than listen to just one of them?

A panoramic adaptor — a spectrum analyzer for engineers — can be built quite reasonably as a most useful accessory for the shack. Once connected to your receiver, the panoramic adaptor will give you rf vision.

A panoramic adaptor or spectrum analyzer will display the frequencies and magnitudes of all signals within some bandwidth (generally much wider than the bandwidth of your receiver) on an oscilloscope screen. For example, if your receiver is tuned to 14.200 MHz and the panoramic adaptor is set to scan plus or minus 50 kHz of your center-tuned frequency, all signals on 20 meters from 14.150 to 14.250 MHz will appear on the scope display. If someone on

By Rick Ferranti, WA6NCX/1, P.O. Box 350, MIT Branch P.O., Cambridge, Massachusetts 02139

14.175 MHz gets on the air, his signal will suddenly appear as a pip on the screen, 25 kHz away (¼ the screen width), with a height proportional to the strength of his signal.



A view of the panadaptor. The white box is the actual unit with the display scope below; its power supply is on the right. A commercial general coverage receive-converter sits on top of the analyzer, with its power supply also at the right.

By adjusting the sweep-width for a plus or minus 10 kHz display, you can easily see dead spots on the band and plop your signal there for a schedule or CQ. Narrowing the sweep even further, you can analyze the modulation characteristics of the station you're receiving — such as upper or lower sideband, DSB, or a-m, fm, or even the shift or spacing between tones of an RTTY signal. For instance, a station running SSB with carrier injected — and telling his friends he's on a-m — can easily be distinguished from the full double-sideband a-m signals!

You can also see splattering, or readily identify the kilowatt station who's desensing your receiver's front end — he's the one up the band 30 kHz with the pip height almost off screen! You can get classical modulation patterns of a-m and fm signals, showing sidebands and odd order products. If you're a utility station listener (someone who likes to snoop on non-Amateur and non-broadcast high-frequency communications, like the strategic air command, coast guard, search and rescue, etc.), you can tune your receiver to an active band of frequencies, with the panoramic adaptor set for wideband scan, and zoom in on fleeting signals as soon as they pop up on the display. I've found dozens of hidden high-frequency signals normally missed when you're limited to the 2.1 kHz window of the basic receiver. With a VHF converter ahead of your high-frequency rig, the adaptor similarly lets you see and tune to those signals you'd usually miss if your receiver were just sitting at 50.110 MHz or 144.200 MHz.

history

The history of the panoramic adaptor, or spectrum analyzer, goes back to the 1930s and possibly earlier, when one could read in the *Proceedings of the IRE* (precursor to the IEEE) about various equipment designed to plot, on a crt or on paper, a magnitude versus frequency graph of the signals applied to its input. One such Fourier Analyzer (as they were sometimes called) had a motor-driven variable oscillator which slowly swept back and forth across its frequency range as the operator watched the output plot on the screen of a long-persistence cathode ray tube. Earlier models of spectrum analysis machines were actually mechanical devices devised to break a complex waveform into its Fourier (sine and cosine) components. They were full of gears and wheels. Some photos show them being operated by a hand crank.

Fortunately, modern-day spectrum analyzers don't need motors or even hand cranks, if you don't count an occasional knob-tweak as a cranking operation. In fact, the panoramic adaptor/spectrum analyzer to be described has some of the nicest modern devices at its heart: double-balanced mixers, wideband power amplifiers, a varicap diode-tuned oscillator, and an IC logarithmic detector.

basics of spectrum analysis

A spectrum analyzer is basically a narrowband filter swept through a band of frequencies with the resultant output plotted versus the frequencies you just swept through. Imagine that you had a tunable bandpass filter, and you tuned it, slowly, through the 20-meter band. As you proceeded up the band, the filter's output would increase every time you tuned through a signal, and then drop down when you went through an unoccupied part of the band. Now imagine that you hooked the output to the vertical plates of an oscilloscope, and, at the same time, you had the horizontal plates of the scope connected to the tuning knob of the filter, so that as you went up in frequency you'd move the spot from left to right. Now you've got a magnitude versus frequency display of 20 meters — a panoramic adaptor.

There are problems with this simple model. First, we want to be able to separate nearby stations, so the filter has to be very narrow. And it must be tunable, which makes it technologically almost impossible to build. Further, you would need a very high-

frequency scope to register the filter's output at 14 MHz; these are expensive, so we need to rectify the output and apply this dc signal to an inexpensive low-frequency scope. Finally, you don't want to sit and turn knobs all day to use the panadaptor; some kind of sweep generator is needed to do the work for you.

". . . the spectrum analyzer shouldn't interfere with the receiver. This may seem obvious . . ."

The solution is to build a superheterodyne spectrum analyzer, where we keep the filter fixed at some i-f frequency and, using a mixer, sweep the signals of interest through it with a scanning local oscillator. In fact, the model to be described is a double-conversion superhet, but that doesn't change the operational principle. As far as a detector or rectifier goes, an IC takes care of that in a single stage, with an excellent added feature to boot. The sweep generator is also fabricated from an IC, which drives a voltage-controlled local oscillator, nicely freeing the operator from strained wrists.

design goals

Getting down to the actual design goals of a modern panoramic adaptor: first, the device should have good dynamic range, displaying signals just above the noise floor of your receiver to those that nearly knock the S-meter off its pin. This makes a logarithmic detector a necessity, for it compresses a very wide linear voltage range (the 0.1 to 1000+ microvolts at your receiver's input) to a log scale that is easily viewed on one vertical scale on the oscilloscope. In addition, the analyzer itself should have wide dynamic range — not be susceptible to signal overloads. This design incorporates passive double-balanced mixers with fairly high-level injection and intercept points so these weak-links in the superhet circuit are practically overload-proof.

Next, the panoramic adaptor should have good resolution, the ability to separate signals from one another in a crowded band. This design incorporates a very narrow single crystal filter which is easy to build and which gives at least 55 dB skirts, and is inexpensive. Several options are available to those who want even better performance.

The adaptor should also have variable sweep width and rate, and some means to control its gain. It shouldn't respond to signals outside its bandwidth, and should give a linear frequency sweep out to about plus or minus 100 kHz. The display shouldn't cost a fortune; here the adaptor will work with any old clunk of an oscilloscope, as long as it has dc-coupled vertical and horizontal inputs. The scope's own sweep generator isn't even used; I bought my 3-inch display for $20 at a flea market and removed the sweep circuit tubes to save on heat generation. Vertical and horizontal amplifier frequency response is also unimportant — the adaptor essentially puts out dc.

Finally, the spectrum analyzer should not interfere with the receiver it's connected to. This may seem like an obvious requirement, but if you're interested in receiving signals from dc to 30 MHz, you don't want any local oscillator (LO) energy in that band of frequencies — any amount of LO leakage would be picked up by your receiver.

This panoramic adaptor was designed to work with the author's aging FT-101B which has a general coverage receive converter ahead of it. A simple modification of the LO and filtering will make this design work with any rig; all other components are broadbanded.

the circuit

The block diagram (**fig. 1**) shows the basic circuits used in this adaptor and gives figure numbers for each of the individual stages, **figs. 2** through **13**. For sake of simplicity let's say the receiver to be used has an i-f of 3 MHz, and that you tap into it before the narrow receiver's filter, and that this wider-band part of the receiver i-f amplifier is about plus or minus 100 kHz wide.

The i-f signals go into a wideband amplifier with about 20 dB of gain, and then into the first double-balanced mixer (DBM). Here the signals are mixed with an amplified and filtered signal from the first local oscillator; this LO is voltage tuned and is connected to a sweep oscillator so the original 3-MHz signals are translated up to about 36 MHz. The image at 30 MHz is filtered, then the 36-MHz signals are amplified with another wideband amplifier with variable gain. Here another mixer is employed to beat the signals down to 5 MHz, using a crystal-controlled LO with amplifier and filter. At this 5-MHz i-f we have the narrow-crystal filter, which sets the resolution of the instrument, and feeds into a high-gain 5-MHz amplifier and log-detector IC. Power supplies and some op-amps around the sweep circuit complete the block description of the panoramic adaptor.

Everything is in modules or blocks which can be in-

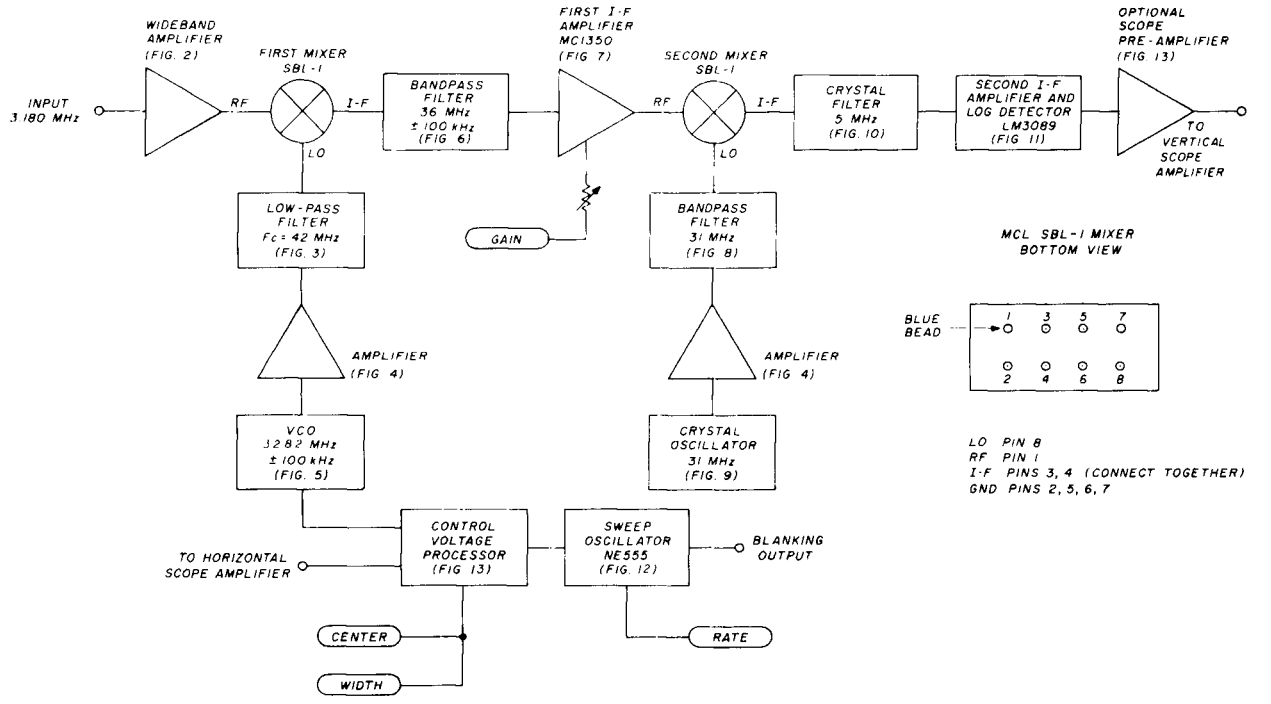


fig. 1. Block diagram of the panoramic adaptor. Interconnections are made with subminiature coax (RG-174/U or equivalent). The optional scope pre-amp is useful if the vertical sensitivity of your oscilloscope is marginal; it comes free as one of the op-amps in the LM324 control voltage processor.

dividually built and tested. A circuit of this complexity can't be thrown together all at once in a weekend; each sub-assembly needs check-out before it all goes together. In fact, the author's unit worked the first time around (save for one problem to be mentioned) once all the modules were built and operating individually. Of course, each module can be constructed and tested in a weekend; this spreads the project out and makes for an interesting diversity of circuits to explore over a couple of months.

The output from your receiver's i-f goes to a wideband preamplifier which provides some gain and essentially sets the noise figure of the panadaptor (the noise figure of the whole system is, of course, set by the front end of your receiver). Any wideband design will work satisfactorily here, since the inherent selectivity of the associated receiver's front-end and wideband i-f coupling will keep spurious signals from this amp. I used a commercially available amplifier; I provide a schematic of another design that works as well.

The signal now goes into the first mixer. Here you should use a passive double-balanced mixer, as mentioned above, for greatest dynamic range. The least expensive of these come from MCL (Mini-Circuits Lab, 2625 E. 14th St., Brooklyn, New York 11235) and will perform well; typical cost is $4-$5 each, which is what one vacuum-tube mixer would cost nowadays, anyway.

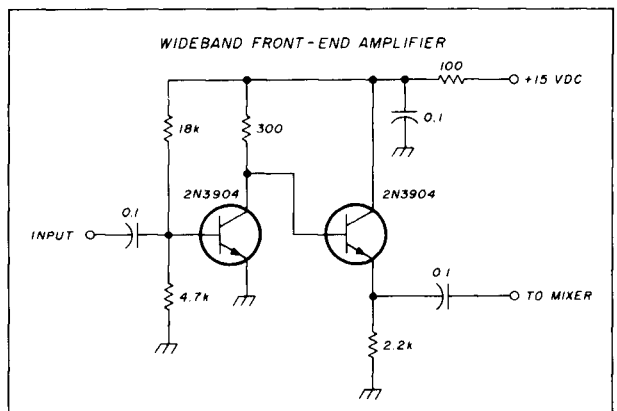


fig. 2. Wideband amplifier.

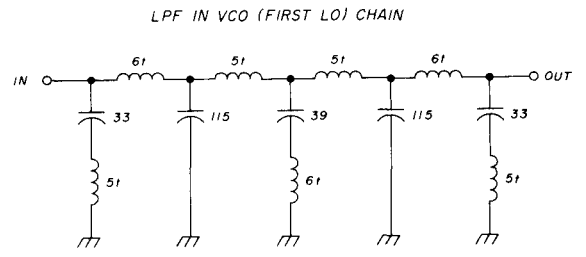


fig. 3. Low-pass filter, F_C = 42 MHz.

One of the most important design parameters of any superheterodyne receiver is LO purity; that is, you want the LO to put out just one signal and nothing else — no spurs, harmonics, or such. The first LO in the panadaptor is voltage tuned and free-running, using a varicap diode and FET as the active element. It's remarkably stable, within a kilohertz or so of its 33 MHz center frequency, and sweeps linearly over a plus or minus 100 kHz range. Following this LO is a power amplifier stage using broadband toroids and feedback; I modified the design from the *ARRL Handbook*. Here we get at least enough power to drive the first mixer, which requires +7 dBm input. But before we run this into the MCL mixer we filter it with a low-pass filter of conventional design. This filter was built without test equipment and later found to be non-critical as to exact components, as long as you're within a few percent of the values listed. Computer-aided analysis showed the theoretical and actual performance of the unit to be nearly identical. The cut-off frequency of this low-pass filter is about 42 MHz, and it does the job of rejecting all significant harmonics of the first LO and amplifier chain nicely.

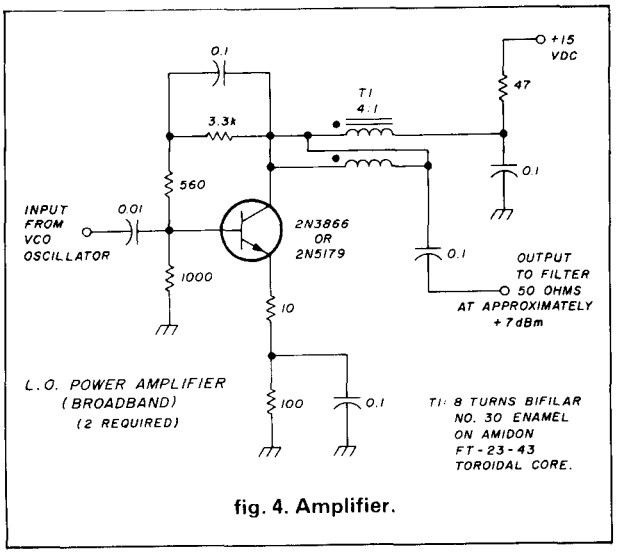


fig. 4. Amplifier.

The i-f port of the DBM runs into a bandpass filter of conventional handbook design, scaled to the frequency of interest. Here, we want a center frequency of 36 MHz, with a passband flat over plus or minus 100 kHz of that frequency. The filter needs to reject the image at 30 MHz (29.64 ± 0.1 MHz) and this design provides some 40 dB of rejection. This topology was also checked on a computer analysis program and its performance is nearly as predicted. The 9 dB or so of passband loss it exhibits is mainly due to the finite Q of the inductors (which the computer can take into account), but this is not a serious problem since there's ample gain before and after this stage.

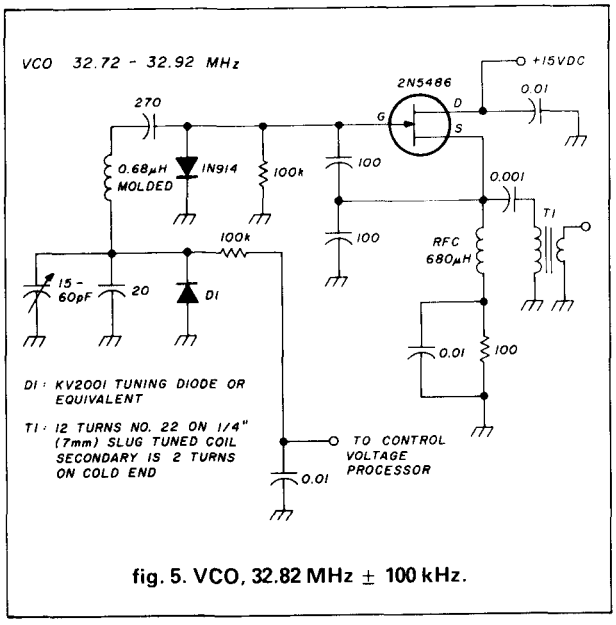


fig. 5. VCO, 32.82 MHz ± 100 kHz.

The filtered 36-MHz signals are now amplified by a wideband MC1350P i-f stage which is easy to build and get working. The input and output transformers can be homebrewed like the ones in the LO drivers, or a pair of MCL transformers can be used — or you can leave them out and only lose 3 dB or so of gain. This amplifier is capable of 36 dB of gain, and more importantly, can be cranked down to give about 30 dB of loss if necessary. Hence, it becomes the gain-controlled stage in the panadaptor, with a variable control on the front panel to change its gain as required.

These now-amplified signals run into the second mixer, another MCL DBM, which is driven by a crystal-controlled LO, another power-amp, and a narrowband filter. The LO and power amp are of conventional design, with the power amp identical to the one in the first LO chain. A 31-MHz crystal oscillator provides signals which, after amplification, go to a

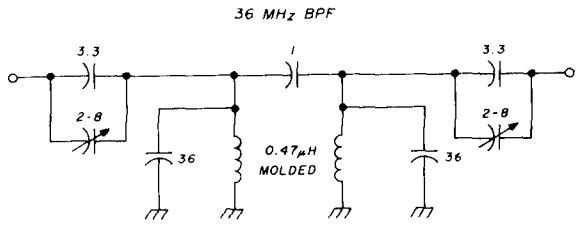


fig. 6. Bandpass filter, 36 MHz ± 100 kHz.

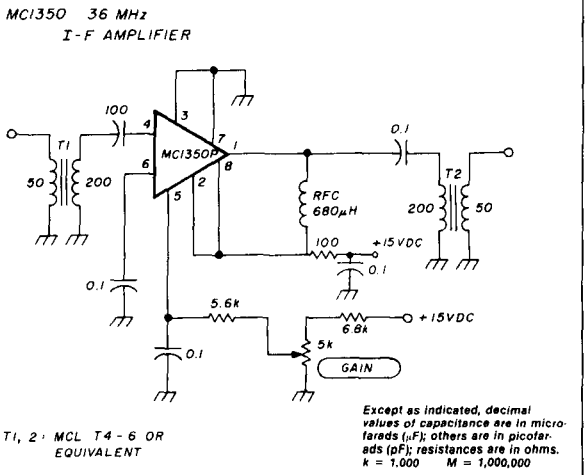


fig. 7. First i-f amplifier, MC1350P.

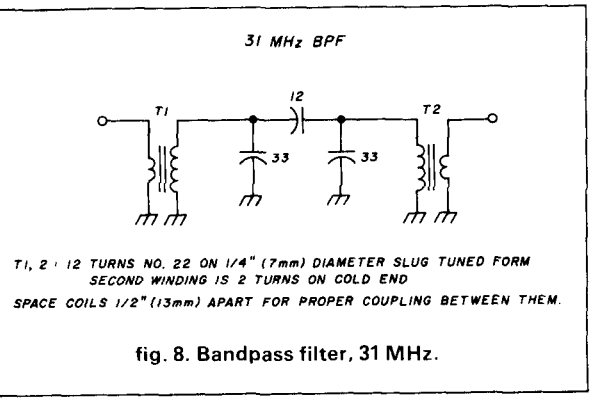


fig. 8. Bandpass filter, 31 MHz.

magnetically/capacitively coupled filter. This filter provides a very narrow passband to let only the 31 MHz signal through with about 1 dB of loss; it has a steep notch at approximately 41 MHz which nicely attenuates a spur there, and thereafter kills all other higher-order harmonics. The filter also has excellent return loss (good match to 50 ohms) at 31 MHz, which aids the stability of the preceeding amplifier.

The output of the second DBM, now at about 5 MHz, runs into a single crystal filter built from an article in *73 Magazine*. This unusual design has the crystal embedded in a two-transistor amplifier circuit, providing 15-dB gain at center frequency, with a 300-Hz bandwidth and skirts down to 55 dB below the peak. As mentioned above, this stage sets the resolution of the spectrum analyzer. Use a crystal with wire leads (any small unit will work — these are often available as surplus or microprocessor crystals) to minimize holder capacitance, and simply adjust the variable capacitor for equal skirt attenuation on either side of resonance. A sweep generator/scope arrangement is helpful for this adjustment.

Following the crystal filter is a surprising IC — the LM3089 fm i-f chip. This chip has a beautiful feature that makes it ideal for a panoramic detector. One of the pins is a tuning-meter output which, if you look at the spec sheet, gives an almost ideal logarithmic response to its input signals. This is the whole amplifier/detector circuit! There are no adjustments at all; the 5-MHz signal from the crystal filter goes in, gets amplified by the three i-f stages in the chip, then logarithmically detected. The rest of the IC (fm demodulator, muting, etc.) is not used and thus left unconnected. Though the chip is designed for 10.7 MHz service, it works fine at 5 MHz. At $3 a crack, the log detector feature (buried in its tuning-meter output) compares with commercial log-amps costing several hundreds of dollars.

The remaining circuitry is for the sweep generator and controls; here an ubiquitous NE555 timer IC plus a transistor makes for a very nice linear ramp generator, with rate variable from a few Hertz to a hundred Hertz or so. The generator is self-triggering, thus reducing circuit complexity from conventional designs which have two timers in series. Following this stage is a buffer (so circuit loading won't spoil ramp linearity), and two subtractors so the ramp signal to the VCO can be adjusted in amplitude about some adjustable dc value, thus giving you variable-sweep width and centering. The ramp is tapped off before these controls so it can be fed as a constant sweep source to the scope's horizontal plates.

Finally, the power supply is of straightforward design, using two three-terminal regulators and a full-wave center-tapped arrangement for the plus and minus 15 volts. The positive supply draws some 200 mA, while just a few mils are needed for the − 15 volt bus. A word of caution: the author had no trouble getting the whole adaptor working once each module was built and tested, except for the power sup-

ply. The analyzer worked fine, but a horrible wideband racket was heard in the receiver at certain frequencies every time the unit was powered up. At first I suspected the wideband amplifiers in the local oscillator chains, but a resistor connected across the 15-volt line produced the same receiver noise, with the adaptor completely disconnected! I then shunted the regulators right at their input and output pins with bypass capacitors (0.001, 0.1, and 33 μF). Thankfully, this cured the problem.

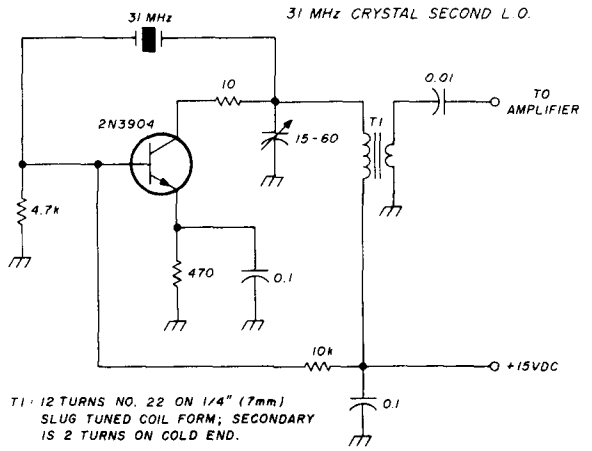


fig. 9. Crystal oscillator, 31 MHz.

a word on frequency scaling

Before I launch into some hints on building and adjusting each module, I should say something about adapting this design to other receiver i-f frequencies. Most receiver i-f's are below 9 MHz or so, and you can make the first and second local oscillators kick that up to some higher i-f in the analyzer, then back down to 5 MHz in its second i-f. In fact, most of the components are broadband at least up to 42 MHz (where the lowpass filter in the first LO cuts off), so no amplifiers need be redesigned. You will have to scale the filter components, which should not be difficult if you use a sweep generator/detector/scope arrangement to tune things up. There's nothing sacred about the 5-MHz crystal filter either; any fundamental crystal from about 4-8 MHz will work in the circuit, giving you even more flexibility. The important thing is to watch where you put your oscillator signals so they won't cause unwanted responses either in the analyzer or in your receiver.

For example, if you have a 9 MHz receiver i-f, use a

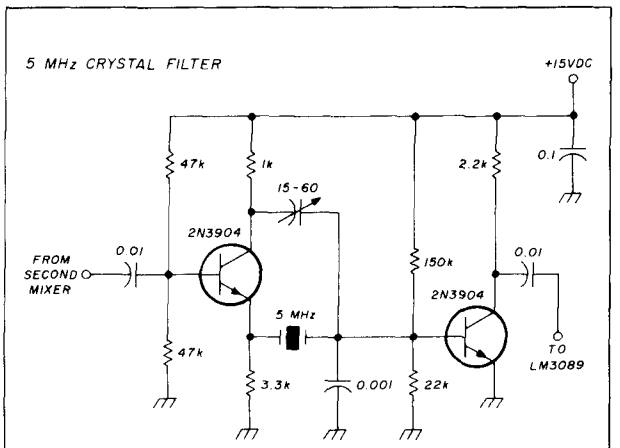


fig. 10. Crystal filter, 5 MHz.

voltage-tuned first LO at 32 MHz, filter the image and amplify at a first i-f of 41 MHz, then beat this down to 5 MHz with the second LO at 36 MHz. Here just the second LO filter, the 36 MHz bandpass filter, and a few tuned circuits in the oscillators need be scaled accordingly.

construction and tuning

My unit was built ugly style (no pc boards, just solder each component to a double-sided piece of copper-clad material), with small-diameter coax used to connect each module to one another. I even soldered the modules to a large piece of copper-clad board as a means of mounting them. The power supply was built in a separate box; a connector was used to lead power in and scope voltages out of the panadaptor chassis. Five controls on the front panel are gain, centering, width, rate, and power; the centering and

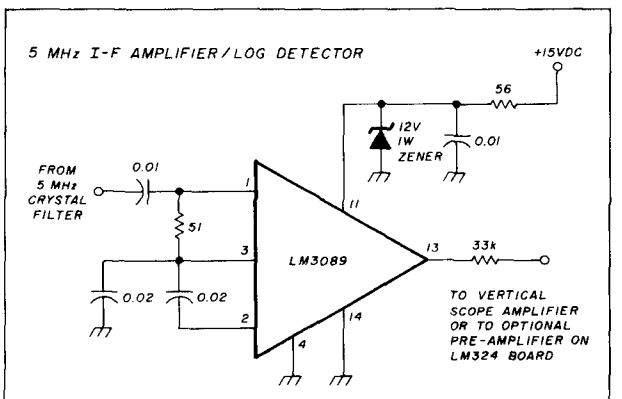


fig. 11. Second i-f amplifier and log detector, LM3089.

width controls are multi-turn for ease of use (the width control has a dial that can be calibrated if you wish).

To tune things up, note that only the filters and the LOs need be touched; all else is broadbanded. Tune each unit individually; when you hook all of them together you won't have to adjust anything.

For the first voltage-tuned LO, try to choose the LC network and the varicap diode so that several volts will swing the frequency over the desired 200 kHz of total spread. I padded down the tuned circuit until it did this — it's desirable because the LO won't be so sensitive to small pick-up voltages on the control line from hum or other sources. Using the values shown, I got the LO to cover 32.82 MHz plus or minus 100 kHz with a voltage swing from 5 to 9 volts. Don't make the swing too large as the ramp generator puts out a maximum of 5 volts peak-to-peak. The trimmer across the tuned circuit can be adjusted for center frequency (here 32.82 MHz to beat with the center of the FT-101B's i-f at 3180 kHz giving 36 MHz) with 7 volts on the tuning voltage input.

As mentioned above, the filters are best tuned with a sweep generator, scope, and detector. The 36-MHz bandpass is tweaked for flattest response over 36 MHz, and best rejection of 30 MHz. If you keep the frequency conversion scheme close to mine you'll not have to touch the 42-MHz low-pass filter in the first LO chain at all. The 31 MHz second LO filter is simply tweaked for maximum power out of the oscillator-amplifier stages, loaded into 50 ohms.

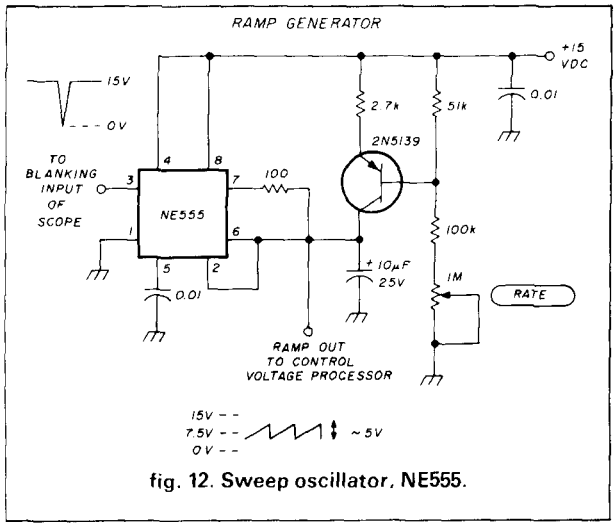


fig. 12. Sweep oscillator, NE555.

The two variable capacitors on the 31-MHz oscillator should be tuned for maximum power-out consistent with reliable starting. This LO, the power amp, and its narrow-band filter should be tuned as one unit.

As a check of the output power of the two LOs, you should use a vtvm with rf probe and measure the voltage across a 50-ohm resistor. For +7 dBm you should read 0.5 V rms, plus or minus 20 percent. You could also use the DBM as the load, as they are nominal 50-ohm devices and will be the actual load of the LO in use.

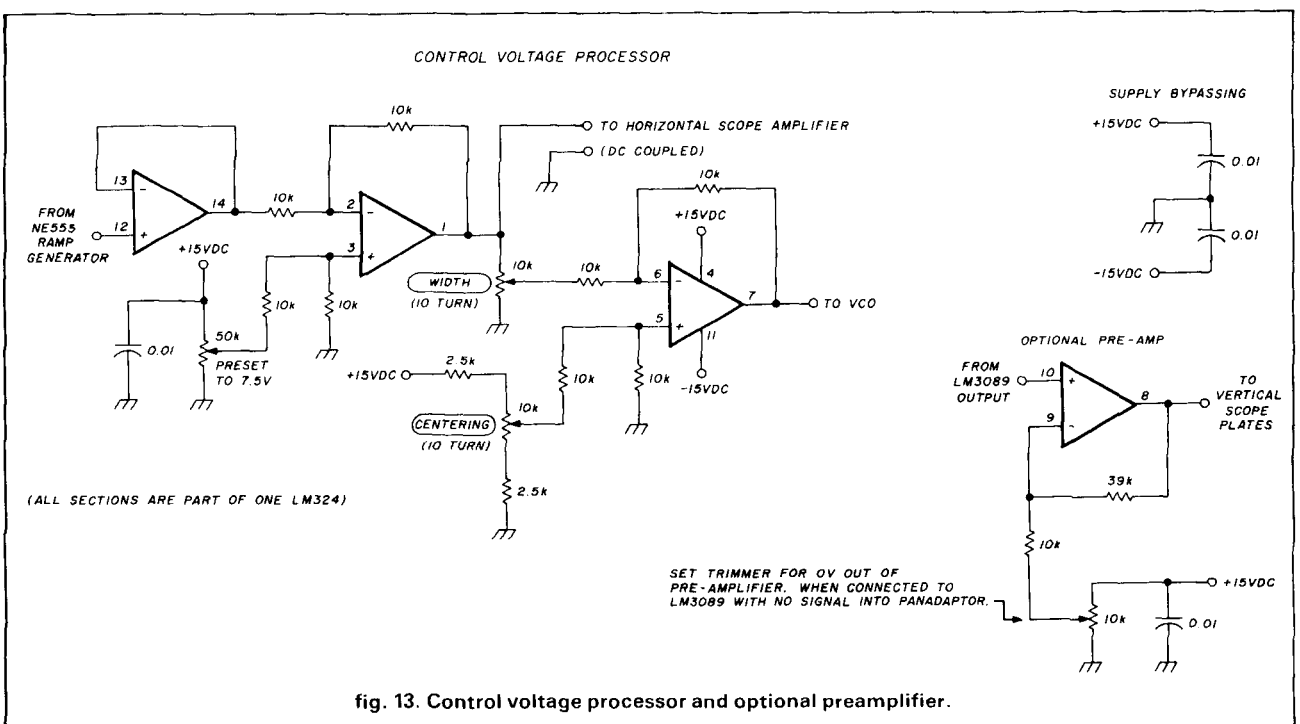


fig. 13. Control voltage processor and optional preamplifier.

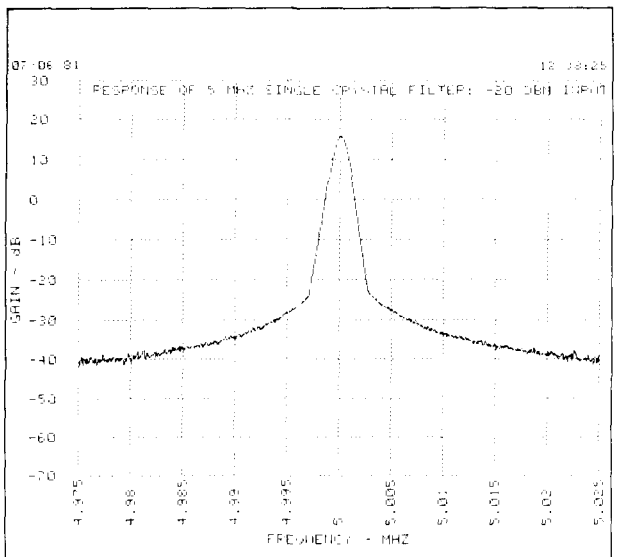


fig. 14. Measured bandpass characteristics of the 5-MHz crystal filter. Note ultimate attenuation is greater than 55 dB; the 3-dB bandwidth is less than 300 Hz.

The trimpot on the LM324 op-amp board should be set so that you get +7.5 volts at the slider contact. This will help keep the pip centered on the screen as you decrease the sweep width for a closer look at some signal. It can be fine-adjusted after the unit is working as a whole.

Needless to say, you should always use short leads and bypass all power going to the various modules. The ugly method of construction makes it easy to use short connections since ground is all around on the board. My unit was assembled into a chassis with no shielding of any module from any other. It works fine this way, with no spurious pips on the display. However, another frequency conversion scheme may require some shielding, though the narrow range of the device (plus or minus 100 kHz) helps keep the possible spurs out of the tuning range.

hooking it up

If your receiver has an i-f output jack on the back, as many modern transceivers do, you merely run a shielded cable from that jack to the input of the pan-adaptor. If you notice that the unit is loading down the receiver, try a 4:1 transformer in the line, or put two in series to match the impedances.

Receivers without an i-f output jack can be connected by running a cable to the last i-f stage in the receiver before its narrow-band filter stages; this is usually after the receiver's last mixer. A small value coupling capacitor should be used at the tap-off point to avoid loading down or detuning the receiver's i-f amplifier.

The oscilloscope should be connected to the horizontal/vertical outputs of the analyzer; dc couple the scope's amplifiers and set them to approximately 1-volt/division. The blanking output of the adaptor sits at 15 volts and produces a narrow spike to ground upon retrace; my scope blanks almost completely with this input to its external blanking terminals. If you can't find your scope's blanking input it's not a big deal; the retrace is so fast compared to the forward sweep speed that you barely see the retrace under normal intensity settings anyway.

using the spectrum analyzer and some options

When you first turn things on, you've got the scope gain controls plus the four controls on the pan-daptor to play with. Start with the gain high enough to see noise (grass in spectrum analyzer jargon) on the scope baseline, and adjust sweep rate and width to about center of rotation. Now turn on the 100 kHz calibrator in the receiver (or 1 MHz calibrator, or any strong locally-generated signal) and tune the receiver so you can hear this signal. Somewhere on the display you should see a large pip — if not, tune the

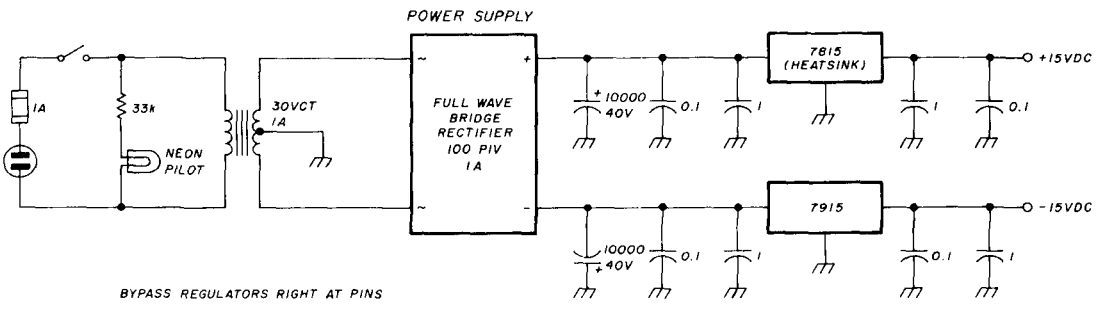


fig. 15. Power supply.

FILAMENT TRANSFORMERS

PRI V.	SEC V.	SIZE	WT	PRICE
117	5 @ 9.75 A 29 KV Ins.	6x5x8	10	$29.95
115	6.6 @ 25 A	4x5x6	15	$19.95
115	6.6 @ 18 A	4x5x6	12	$13.95
115	6.6 @ 10 A	3x4x6	8	$ 9.95
230	6.3 @ 30 A	4x4x6	10	$15.95

PLATE TRANSFORMERS

120	1510 @ 382 Ma	4½x4½x8	15	$39.00
208	3 phase with taps to allow sec. to be varied from 5900 to 7700 VDC @ 600 Ma out of rect.	11½x11½x13	100	$175.00
115	#1-600 CT @ 450 Ma #2-580 CT @ 220 Ma	5x4½x8	12	$19.95
208/ 230/ 240	5700 @ 1.2 A	9½x9½x13	75	$175.00
215/ 230/ 245	4,000/4,450 @ 26 KVA	38x16x24	845	$575.00
115	690 @ 450 Ma (Production quantities in stock)	4x5x6	12	$ 9.95
115/ 230	803 @ 735 Ma. Hypersil core. (Use two of these for a cool KW)	6x5x6½	17	$59.00

POWER TRANSFORMERS

115	#1-1,000 CT @ 220 Ma #2-5.1 @ 2 A #3-5.1 @ 4 A	4x5x6	15	$ 9.95
115	#1-840 CT @ 230 Ma #2-620 CT @ 25 Ma #3-5 @ 2 A #4-6.3 @ 5.5 A #5-6.3 @ 5 A #6-6.3 @ 5 A	5x6x7	10	$19.95
115	#1-45 @ 50 Ma #2-68 @ 3 A #3-34 CT @ 25 A #4-20 CT @ 2 A	7x6x6	43	$24.50
115	#1-105 @ 75 Ma #2-475 @ 200 Ma #3-6.5 @ 9 A #4-6.3 @ 3.3 A #5-6.3 @ 2A	4x5x3	7	$ 9.95

FILTER CHOKES

25 H @ 770 Ma, DC resistance 70 ohms, 13 KV insulation		8x10x9	50	$69.00
4.5 H @ 950 Ma, 25 KV ins.		10½x12x15	150	$125.00
2 H @ 130 Ma, DC resistance 155 ohms, 2,000 V ins. (Production quantities in stock)		1x1½x3	1	$2.95
5 H @ 500 Ma, 700 V ins.		4x5x6	15	$22.00
4 H @ 350 Ma, Collins		3x3x4	4	$3.95
1 to 1.5 H @ 1.2 A swinging choke, 18 KV insulation.		13x17x17	248	$125.00
2 H @ 1.6 A, 15 KV insulation (Production quantities in stock)		6x7x10	45	$49.00

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10	660 AC (2000 DC)	2x3x4	1	$ 6.95
45	330 AC (1000 DC)	2x3½x7	2	$ 5.95
4	4000	4x4x11	6	$ 29.95
2	10,000 Aerovox	13¼x4x17½	40	$ 29.00
.026	32,000 GE	16x7x20	40	$ 49.00

.01	1200 V mica	$1.95
.01	2500 V mica	$2.95
50 pf 15 KV or 40 pf 15 KV ceramic, Centralab type 857		$2.95

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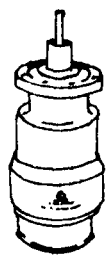
Jennings UCSXF-1200, 10 KV, 5" diam, 9" long $375.00



Energy Labs 7-200 pf, 7.5 KV. ¼ inch shaft. 3" diam., extends 5½" behind panel. Equivalent to Jennings CHV1. (Production quantities in stock)

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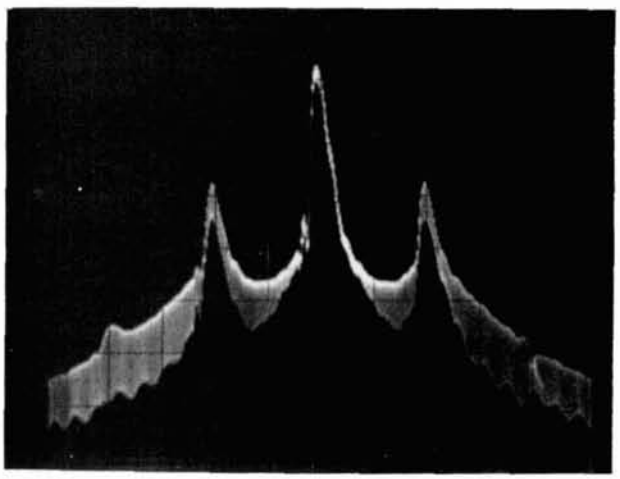
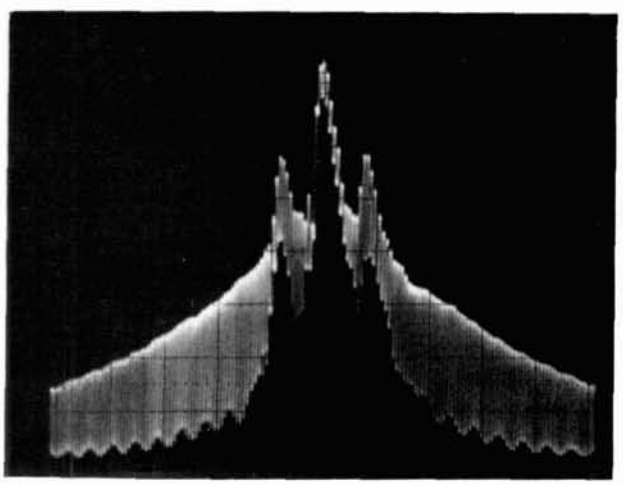
Fil. transformer $110.00

More Details? CHECK—OFF Page 98

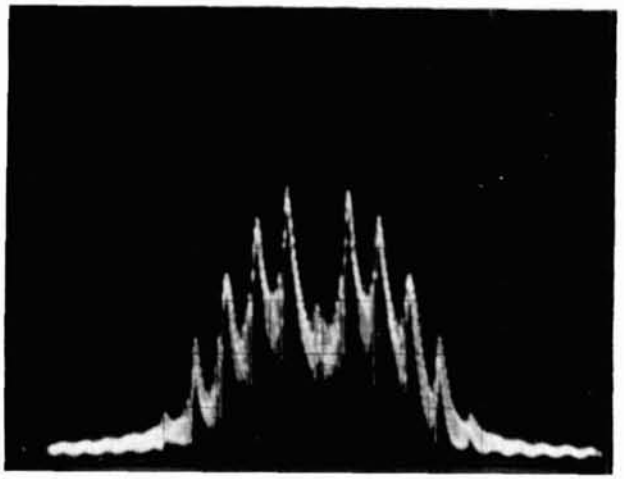
centering control until you do. Now set the gains on the adaptor and scope (the scope controls seldom need readjustment once set) for a presentation similar to those in the photographs. If you have a 25-kHz calibrator, flip that on and see the spectrum of signals displayed. In fact, this will calibrate the horizontal axis as you change the sweep width; you can set the center pip to the center, and the ones on either side to the edges of the display, for instance, to give you plus or minus 25 kHz of scan width. From here on, you will quickly learn what gain, width, and sweep speeds give the best display for a particular signal.



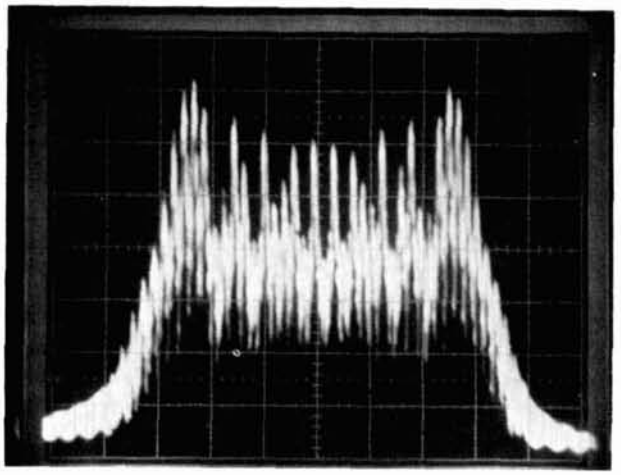
Panadaptor display with a 3180 kHz a-m signal at its input, 90 percent modulated at 1 kHz. Note the generator's intermod visible as another sideband set 2 kHz from the carrier.



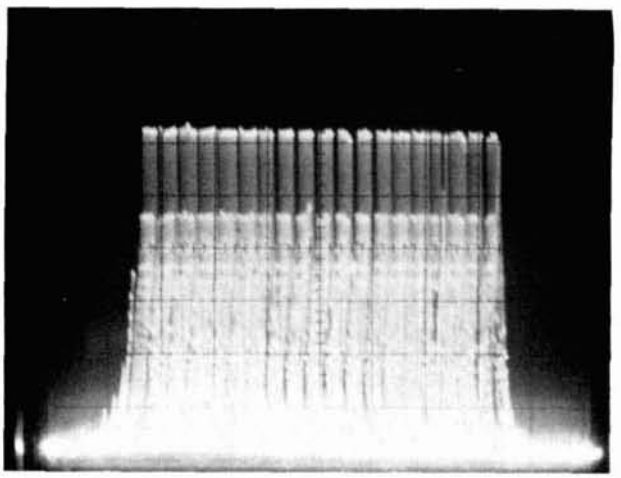
Same as photo 2, but with 400-Hz modulation. The sidebands are easily seen, demonstrating the instrument's 300 Hz or better resolution capability.



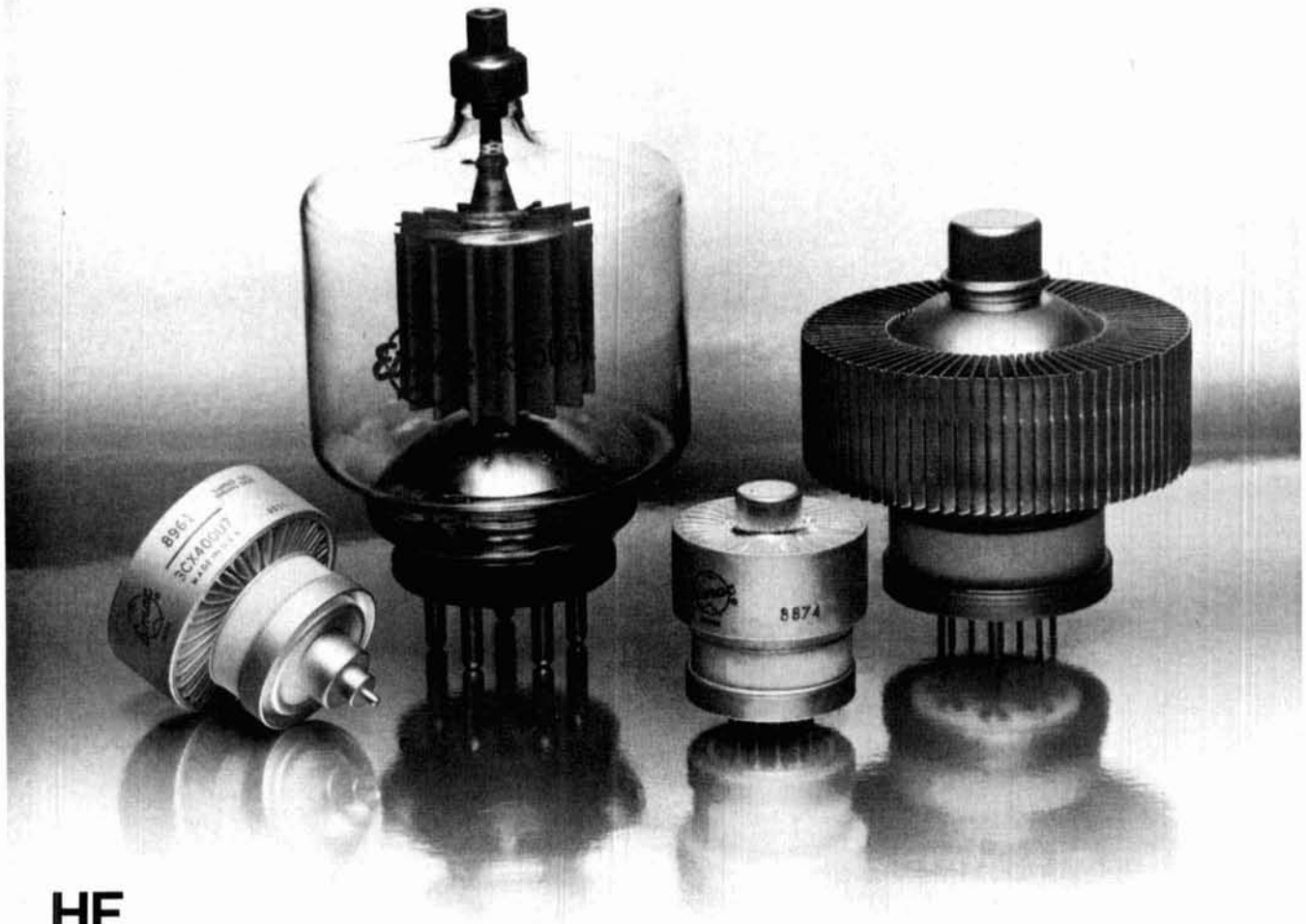
A classical fm waveform. Here at 2.3 kHz deviation with 1 kHz modulation. Note the carrier has almost disappeared, due to the Bessel-function character of fm for this particular modulation index.



A wideband fm spectrum, 15 kHz deviation with 1 kHz modulation.



Sweeping ±50 kHz around the panadaptor's center frequency shows its excellent amplitude flatness over the band.



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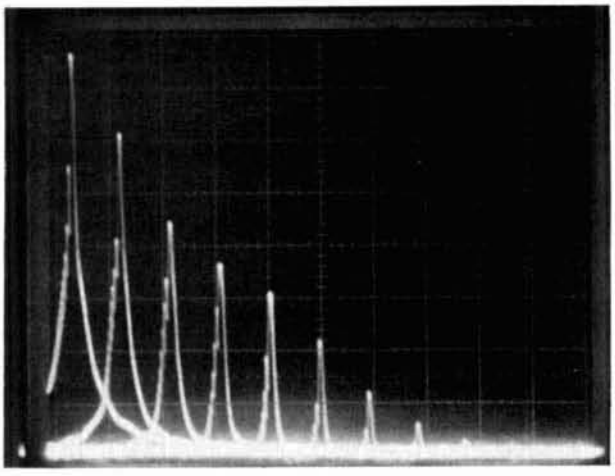
Note that if you increase the sweep rate too much, the pips get broader at the base and you lose resolution. Try to keep the rate slow enough to have good resolution yet fast enough so flicker is not bothersome. You may also notice that the resolution increases for narrower sweep widths, approaching 300 Hz as you get to very narrow sweeps. This is handy, for example, in checking the spacing of two tones in an RTTY signal, providing they're spaced further than 400 Hz or so.



A multiple-exposure photograph showing the analyzer's good frequency and amplitude linearity. Amplitude steps are in 5-dB increments and frequency steps in 5-kHz increments across the screen. Greater than 40 dB of range is displayed here.

No project is complete without some options; here you could get better than the 55-dB skirts of the simple crystal filter by substituting a crystal lattice unit as used in commercial transceivers. Surplus Atlas filters are available for about $15 with center frequencies near 5 MHz; a narrow-band version of one of these would probably give very good performance. However, the band-edge roll-off of these lattice designs is very steep and could necessitate slow sweep speeds so the filter won't ring as signals move through them. Try it and see.

Another option would be a linear detector (as on a commercial spectrum analyzer), useful for some applications. Here the LM3089 comes in handy; it provides an amplified i-f output port that can be rectified in a linear detector circuit for later application to the scope's vertical channel. A switch could select between the log and linear displays.

This modern spectrum analyzer is an updated and improved version of the older panoramic adaptor, and besides the applications mentioned earlier in the article, will find other uses around the shack. With the rf vision it provides, a new facet of radio communication monitoring becomes possible, with rapid signal detection, modulation analysis, and band-condition assessment all easily accomplished. Soon you'll feel quite blind without its help, and you will switch it on every time you fire up the station receiver for a simple ragchew or just to snoop around the spectrum.

bibliography

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Williams, Everard M., "Radio Frequency Spectrum Analyzers," *Proceedings of the IRE*, January, 1946.

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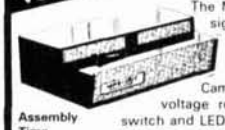

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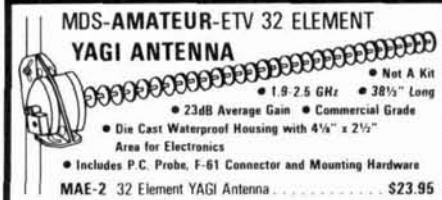

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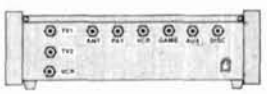

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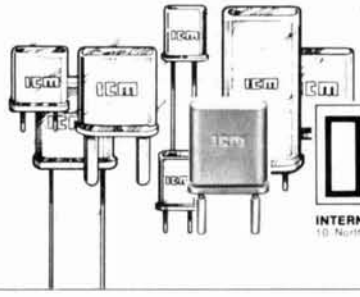

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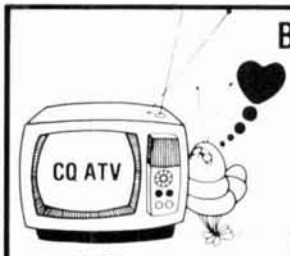

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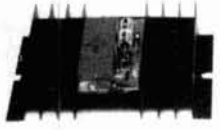

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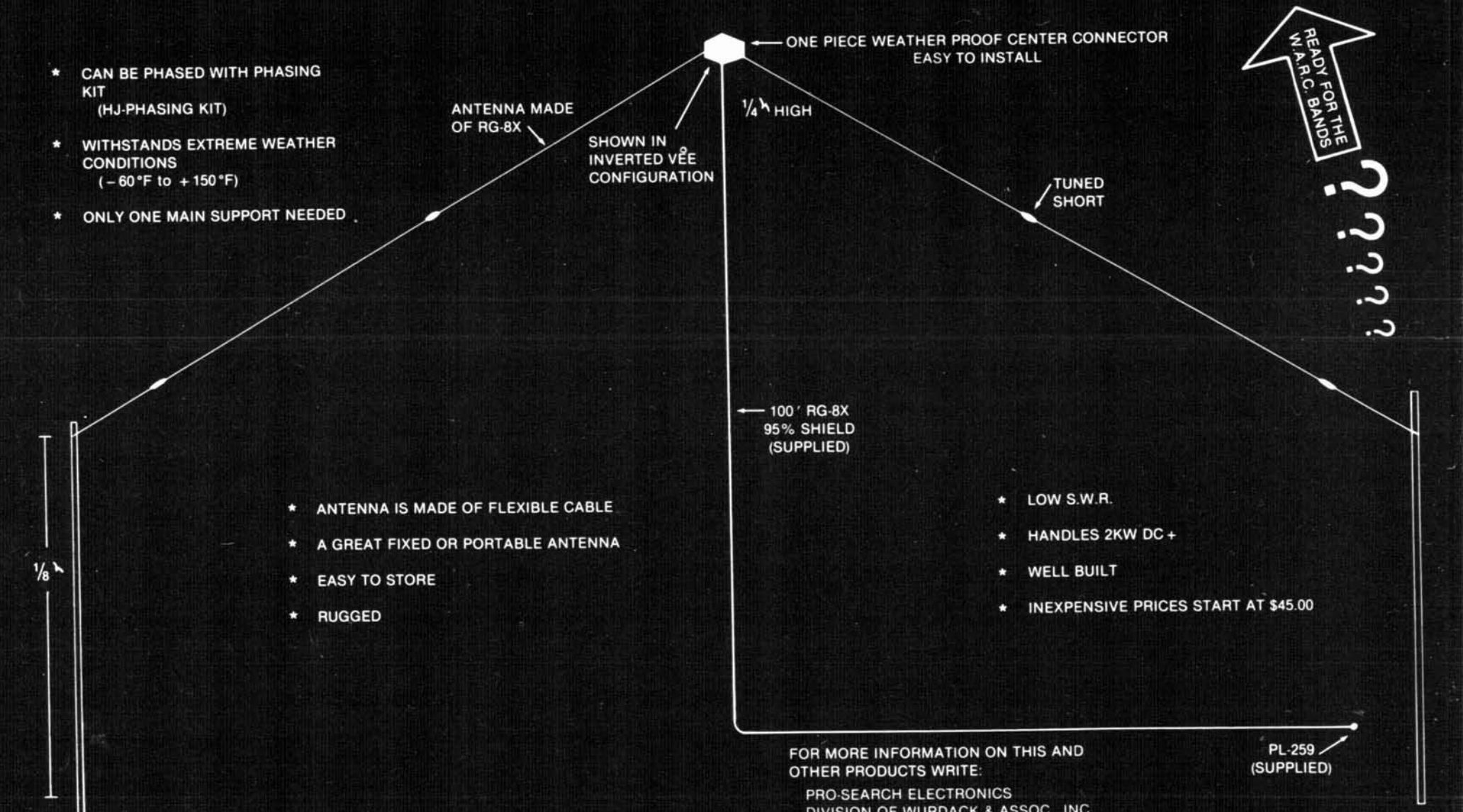

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the Bragg-cell receiver

New uses for an old technology

The year is 1932 and radio as a technology is just beginning. A French physicist by the name of Louis-Marcell Brillouin is establishing grounds for what we today call the Bragg-Cell Receiver.

He notes the phenomenon of interaction between sound and light and proves that monocromatic light can be defracted in the presence of sound. The 1932 experiment involved a source of filtered light that illuminated a column of water into which sound was coupled. By properly adjusting the angle of incidence of the light source, the first-order diffraction line was observed to become more intense while the other lines were cancelled, presenting a graphic representation of this interaction. This angle of incidence was later called the Bragg angle, and the phenomenon became the basis for what we today call the Acousto-Optical (A/O) receiver, or, the Bragg-Cell Receiver.

The block diagram of a modern Bragg-Cell receiver is shown in **fig. 1**. It resembles a single-conversion receiver with a very wide i-f (40 MHz) centered at 70 MHz. Many rf signals are processed at the same time, as the passband of the front end is also 40 MHz wide.

Extreme care must be exercised in designing a system with a wide dynamic range, as there are no preselectors or narrow-band filters in this approach. The i-f amplifier is also a very high-dynamic-range power device providing about three watts of wide-band video signal to the Bragg-Cell transducer, which acts as a launcher or transmitter. A modern Bragg-Cell transducer and medium is a block of very pure crystalline material such as quartz or lithium niobate, which is approximately 1 cm × 1 cm × 1 cm. A pair of tuned electrodes are bonded to the side of this material. This is where the i-f signal is applied, as shown in **fig. 1**.

When excited with signals within the passband of the receiver, rf wavefronts are launched (or propagated) through the medium, changing its refractive characteristics accordingly (a form of spatial phase modulation). If a beam of monocromatic light is introduced at the Bragg angle, a panoramic display of all the signals within the i-f passband can be obtained on a projection screen. A helium-neon laser is used as the source of monocromatic light.

The deflection angle (the displacement from the center of the screen) viewed on the screen, and the intensity of the light spots, are directly proportional respectively to the frequency and the power of the

By Cornell Drentea, WB3JZO, 7140 Colorado Avenue, N., Brooklyn Park, Minnesota 55429

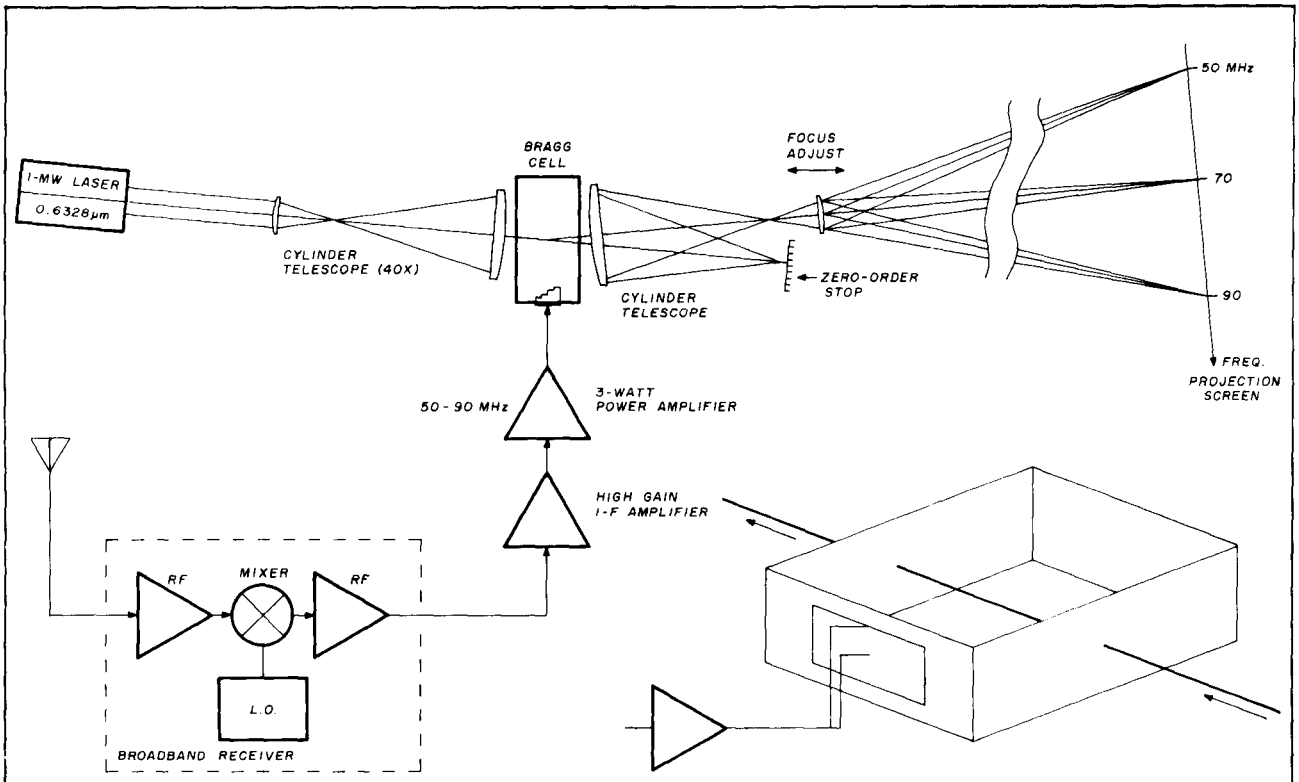

fig. 1. Block diagram of a modern Bragg-Cell receiver.

received signals. Post-detection demodulation can be accomplished by an array of closely spaced PIN photodiodes. The position of each photodiode corresponds to a specific frequency within the passband of the receiver's input, providing instantaneous reception of many signals, without sweeping or scanning.

The Bragg-Cell receiver can be viewed as a parallel processing device which converts radio-frequency energy to individual light spots positioned in the frequency domain on a dial-like base line.

While not completely understood from an application point of view, this receiver can be used as a wideband (non-sweeping) spectrum analyzer which can identify the presence of active frequencies. High-resolution programmable receivers can then analyze the particular signals.

The instantaneous nature of the Bragg-Cell receiver allows for a high probability of intercept (POI), since many signals can be observed at the same time. This, in turn, would make an ideal addition to a radio telescope which is searching many frequencies for extra-terrestrial signs of life.

The main disadvantages of the Bragg-Cell receiver are its limited dynamic range (typically 40 dB) and its frequency resolution, which is limited by the mechanical arrangement of the photo-detectors.

For readers interested in experimenting with such a receiver, helium-neon lasers are available today from a variety of sources, and Bragg-Cells can be purchased commercially from Intra-Action Corporation, 3719 Warren Avenue, Bellwood, Illinois 60104.

This article was adapted from the author's book, "Radio Communications Receivers," No. 1393, by TAB Books Inc., Blue Ridge Summit, Pennsylvania 17214: $13.95 soft-bound, $19.95 hard-bound.

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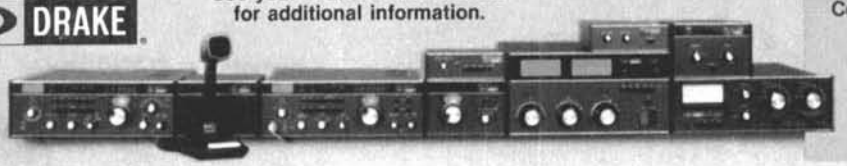

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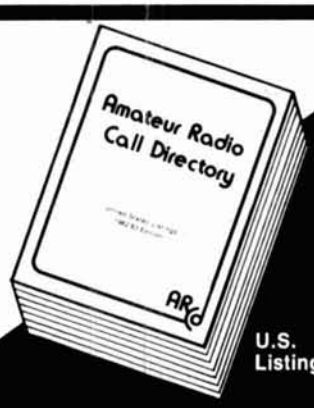

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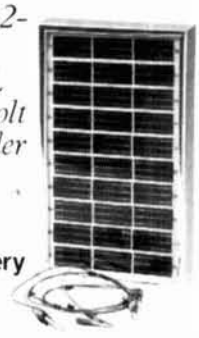

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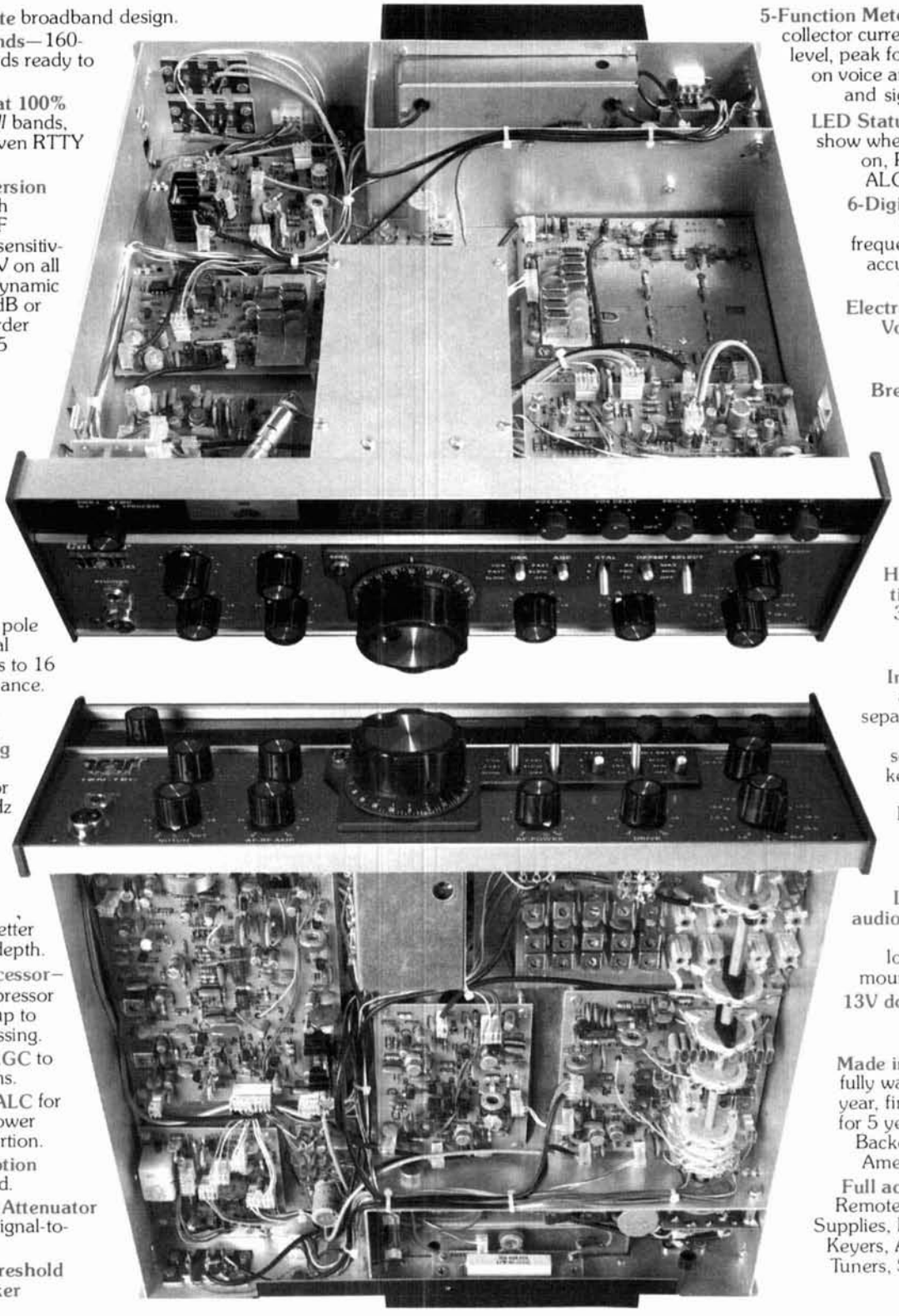

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Welcome to the *ham radio* Technical Forum. The purpose of this new feature is to help you, the reader, find answers to your questions, and to give you a chance to answer the questions of your fellow Radio Amateurs. As a new feature, the Technical Forum will be shaped by the type and number of letters we receive from you. Do you have a question? Send it in!

Have you ever published a circuit, or do you know of a circuit, that can be used to test Zener diodes? The circuit should test the voltage rating of the Zeners. — Pete Hons, W3PKH.

Yes. Quite a few articles over the years have been published in the Amateur journals. Here are three:

"Low Voltage Zener Tester," *ham radio*, November, 1969, page 72: The circuit measures Zener voltages up to 10 volts and makes it possible to check voltages of unmarked and surplus devices.

"Two Methods of Testing Unknown Zener Diodes," *CQ*, August, 1972, page 38: The first circuit uses a 250-volt power supply, one fixed and one variable resistor, and any VOM or VTVM. It determines the breakdown voltage or a short or open condition. The second method feeds an audio signal to the Zener. The diode's characteristics are then read off a scope display.

"Bargain Zener Classifier," *73*, August, 1979, page 46: A method similar to that described above places an increasing voltage across the unknown Zener until breakdown occurs.

Has anyone designed an inductance meter that is fairly accurate at inductances of 20 μH on down to 0.01 μH? I built one that is used in conjunction with a digital volt-ohmmeter. However, its accuracy at 10 μH and down is very poor. — Gustave C. Budina, K9EBA.

When I first sat down to research your question, I thought finding the answer would be quite simple. But I found that most of what's been written has been devoted to L-measuring devices that go only as low as 20 to 50 μH. Below 20 μH very little has been done. One possible solution to your problem is discussed in the February, 1981, issue of *QST*. There, WA2TNG wrote of an inductance meter and frequency counter he designed that would measure values from 1 mH to 0.05 μH. When he started, he found that his design would work down to 1.4 μH. Below that, his inductance meter would not perform accurately. His design is basically a Colpitts oscillator fed into a frequency counter. Inductance is measured by determining resonant frequency and then calculating inductance using this formula:

$$L_{\mu H} = (15.915/f_{MHz})^2 - L_o$$

L_o being derived from the Handbook LC chart for resonant frequencies above 5 MHz. Basically it is a correcting subtraction.

In looking into the reasons why the counter would not measure below 1.4 μH, the author found that the ceramic disc capacitors he was using had too much internal resistance (in excess of 7 ohms) and that this resulted in excessive loss in the tank circuit. Replacement of all capacitors with those of polystyrene design (internal resistance of 1 ohm) reduced series resistance. This resulted in an ability to measure inductance to values as low as 0.05 μH.

My suggestion is to look closely at your capacitors and replace them with the polystyrene type. That should give your inductance meter a greater range and give you a much more useful instrument.

ham radio

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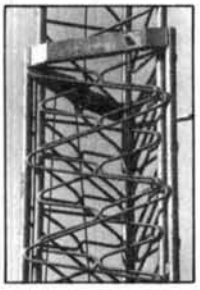

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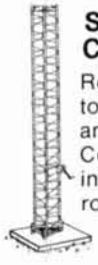
	HG-37SS	2	37 ft. 11.3 m	20.5 ft. 6.2 m	13.75 in. 349.3 mm	9.5 sq. ft.-50 mph .88 sq. m-80 km/h	265 lbs. 120 kg
	HG-54HD	3	54 ft. 16.5 m	21.5 ft. 6.6 m	19.53 in. 496.1 mm	16 sq. ft.-60 mph 1.5 sq. m-96 km/h	575 lbs. 261 kg
	HG-70HD	4	70 ft. 21.3 m	21.5 ft. 6.6 m	22.63 in. 574.7 mm	16 sq. ft.-60 mph 1.5 sq. m-96 km/h	1100 lbs 499 kg
SIDE-SUPPORTED	HG-33MT2	4	33 ft. 10.1 m	11.5 ft. 3.5 m	13.75 in. 349.3 mm	8.5 sq. ft.-50 mph .79 sq. m-80 km/h	210 lbs. 95 kg
	HG-50MT2	3	50 ft. 15.2 m	21 ft. 6.4 m	11.5 in. 292.1 mm	6.0 sq. ft.-50 mph .56 sq. m-80 km/h	290 lbs. 132 kg
	HG-35MT2	2	35 ft. 10.7 m	20.5 ft. 6.2 m	9.25 in. 235 mm	9.5 sq. ft.-50 mph .88 sq. m-80 km/h	187 lbs. 85 kg



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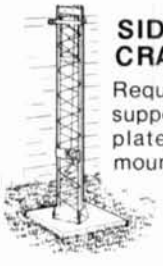

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More Details? CHECK—OFF Page 98

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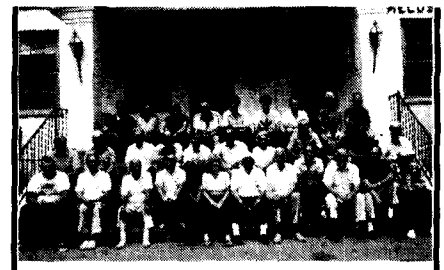

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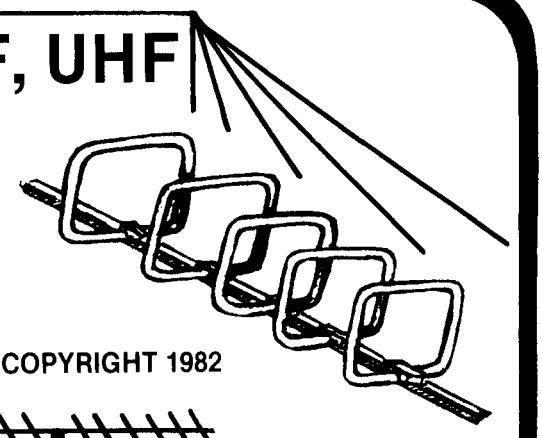

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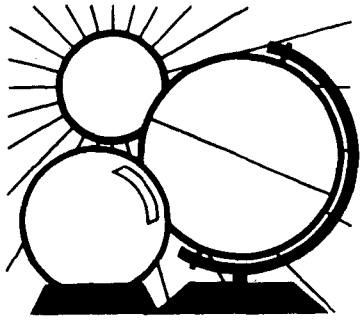

DX FORECASTER

Garth Stonehocker, KØRYW

last-minute forecast

Excellent DX conditions on the higher frequency bands (10-20 meters) during the third week and on into the beginning of the fourth week of February are expected, after a slow beginning the first two weeks. In fact, during these first two weeks of the month it may be better to try nighttime DX on the lower frequency bands. Those bands should be very good throughout the month unless disturbances prove particularly severe, which may be the case on the 1st, 11th, 19th, or 28th. Disturbances on the 1st and 28th should be less severe but four to six days in length.

No significant meteor showers occur during February. The full moon is on the 27th and lunar perigee the 25th. February is often the month of the highest mean solar flux values of the year, which results in very high maximum usable frequencies (MUFs). The ionization responsible for these MUFs moves toward the sides of the geomagnetic equator, giving trans-equatorial (TE) one-long-hop propagation. Geomagnetic disturbances, however, can enhance TE and lower mid-latitude MUFs. These disturbances result from particles in the solar wind traveling to earth and spiraling down into the polar regions. High solar winds result from solar flares and thin spots in the sun's corona.

Geomagnetic disturbances associated with thinning of the solar corona (coronal holes) should be increasingly affecting radio propagation. The reason is that the solar flux has rounded off the eleven-year peak and it has started its maximum rate of decrease; also, with decreasing flare output, the solar pressure on the earth's magnetosphere has decreased. This leaves the geomagnetic field sensitive to the solar wind (particles radiating from the sun) streaming through coronal holes. Geomagnetic disturbances from these holes are weaker (A of 20-30), longer (four to six days), and build up gradually. This is in contrast to disturbances following flares, which are intense (A often above 50-60), short (two to three days), and start suddenly. Coronal hole disturbances tend to recur in twenty-seven-day cycles similar to those of flares, but they tend to occur around the twenty-seven-day solar minimum rather than the time of maximum flare activity and flux.

Coronal hole disturbances reoccur so regularly that they have been labeled recurrent geomagnetic disturbances. In certain years they can be observed for as many as four to six consecutive twenty-seven-day cycles, and with as many as two to three distinct groups within a twenty-seven-day period. That's a lot of disturbance. Expect these recurrent disturbances to become more frequent soon and last through most of 1986 until the solar cycle, at minimum flux in 1986/7, begins to turn upward. The maximum disturbance is expected in the later part of 1984.

What does all this mean in terms of propagation and DXing? Well, simultaneous with the decreases in MUF toward sunspot minimum (see October, 1982, "DX Forecaster") will be 2½ years of increase in long-duration (four to six day) disturbances. When disturbed, the ionosphere becomes depleted south of the auroral zone (60° to 70° north or south latitude) in a region known as the trough. Where has the ionization gone? It has diffused up the geomagnetic lines of force to the geomagnetic equator. The more and longer the disturbance, the wider the trough becomes. This affects east/west paths from mid-latitudes (U.S.-Europe) by lowering the MUF while at the same time raising the MUF for TE paths.

band-by-band summary

Ten and fifteen meters will be open for worldwide DX from sunrise until after sunset during the twenty-seven-day solar flux maximums. Skip of 2500 miles (or multiples) is possible, and will follow the sun across the earth.

Twenty meters will be open to some area of the world for the entire twenty-four-hour period on many days of the month. The band should peak in all directions just after local sunrise, and again toward the east and south during late evening hours. During hours of darkness the band will peak toward the west in an arc from southwest through northwest, encompassing Pacific areas.

Forty and eighty meters will be the most usable nighttime DX bands. Most areas of the world will be workable from dusk until sunrise. Hops shorten on these bands to about 2000 miles for 40 meters and 1500 miles for 80 meters, but the number of hops can increase because signal absorption in the ionosphere's D-region is low during the night. The path follows the direction of darkness across the earth, similar to the way in which the higher bands follow the sun.

One-sixty meters will be similar to 80 meters, providing good working conditions for enthusiastic DXers who like to work the nighttime and early morning hours, especially at local dawn.

ham radio

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

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

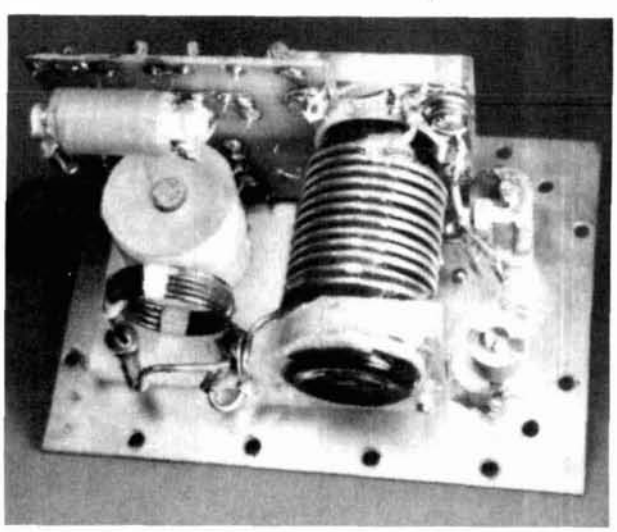
VFOs tuned
by cylinder and disc

Inductive tuning provides tailor-made frequency coverage and temperature stability

This article describes further results in my search for simple, reliable, variable-frequency oscillators (VFOs) reported in the July, 1980, issue of *ham radio*.[1] I feel there is a need for low-current-drain, stable VFOs of simple construction, especially for portable use. Also, the alternative of inductance-tuning techniques, rather than reliance on increasingly scarce, bulky, precision variable capacitors, offers great advantage.

Although the VFOs described here are simple, one could control them from a synthesizer output.[2]

When the VFO is to be used in communications equipment, one must avoid generating unwanted frequencies, which would have to be filtered out. This can be a problem with synthesizers. For Amateur use, simplicity may be the best approach. As a



An example of a cylinder-tuned VFO.

By Richard Silberstein, WØYBF, 3915 Pleasant Ridge Rd., Boulder, Colorado 80301

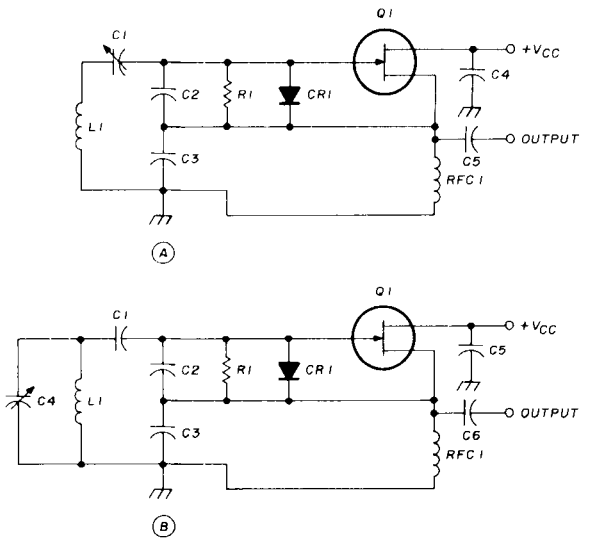


fig. 1. The well-known series-Colpitts oscillator is shown at A. C1, for tuning, can be placed at the other end of the coil. A basic Seiler oscillator, B, is adapted from the series-Colpitts. C1 is now a coupling capacitor and C4 is generally used for tuning. If L1 is tuned, C4 can be used for frequency calibration.

home experimenter, I build only analog frequency sources, and use only one frequency conversion in receivers. I plan to have the local oscillator on the high side of the received frequency, where possible, so as to place image frequencies and harmonics as far out of reach as possible.

This text begins by presenting the next development after those covered in reference 1: a Seiler oscillator in which incremental inductance tuning is done by means of a metal-foil triangle on a rotatable insulating cylinder adjacent to a coil.

The next development is a successful venture into frequencies higher than those usually used in a simple VFO. A 30-MHz VFO is tuned by means of a disc with a metal pattern, rotated close to the ground end of a high-*Q* inductor. Here, I returned to the Hartley circuit; a modification dispelled my earlier objections and left me with a very good, simple oscillator circuit.

Finally, I discuss temperature effects and rectify some wrong guesses made in the earlier article.

the cylinder-tuned oscillator

The Seiler circuit used in this oscillator is an outgrowth of the well-known series-Colpitts circuit illustrated in **fig. 1A**. C1 is conventionally the tuning capacitor, and C2 and C3 provide feedback. The value of frequency is determined essentially by L1 and a capacitance which has the value of C1, C2, and C3 in series.

In the interest of stability, it is desirable to have a high-*Q*, stable, frequency-determining circuit isolated as much as possible from the semiconductors. The Seiler circuit, **fig. 1B**, is an attempt to provide these conditions. Here, C2 and C3 are still the feedback capacitors, but C1 is now a coupling capacitor. There is a new capacitor, C4, which, in parallel with L1, would determine the oscillator frequency if C1 were small enough. In a practical circuit, if C1 is too small the drain current becomes excessive, and a still smaller value of C1 causes normal oscillation to cease. However, the advantage of the circuit to the experimenter is that he can adjust C1 to a practical, limiting value for at least partial isolation of L1C4. The higher the *Q* of this *LC* combination, the greater the possible isolation.

In the usual Seiler oscillator, C4 of **fig. 1B** is used for tuning. In my inductance-tuned version, useful only for a relatively small band of frequencies, there is a small pickup coil in series with the ground end of L1. The coil is coupled to a rotatable acrylic cylinder around which is glued a metal-foil triangle. This is shown in **fig. 2**. Because the magnetic field of the pick-up coil produces eddy currents in the foil, an opposing magnetic field is generated which reduces the inductance of that coil. This effect increases as the area of metal coupled to the coil increases, up to an area a little greater than that encompassed by the coil cross-section. Thus, as the larger end of the triangle is rotated into the field of the coil, inductance decreases and the frequency goes up.

Other designs may produce the same effect by using a fixed-metal surface or object and varying its distance from the concentrated magnetic field of the coil, or by varying its angle, or both. The copper-vane tuning element is one form of such a tuning device where a sickle-shaped rod made of a tube or wire is rotated into a half-toroid coil.[1] The cylinder and the disc, to be described later, have two advantages over the copper vane:

1. The useful tuning range is at least 270 degrees.

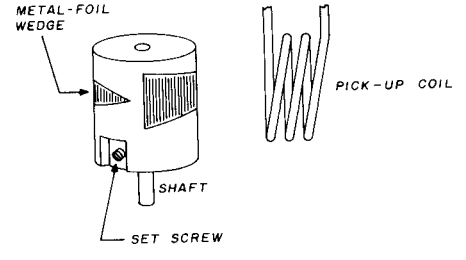


fig. 2. The cylindrical acrylic-spool tuning element.

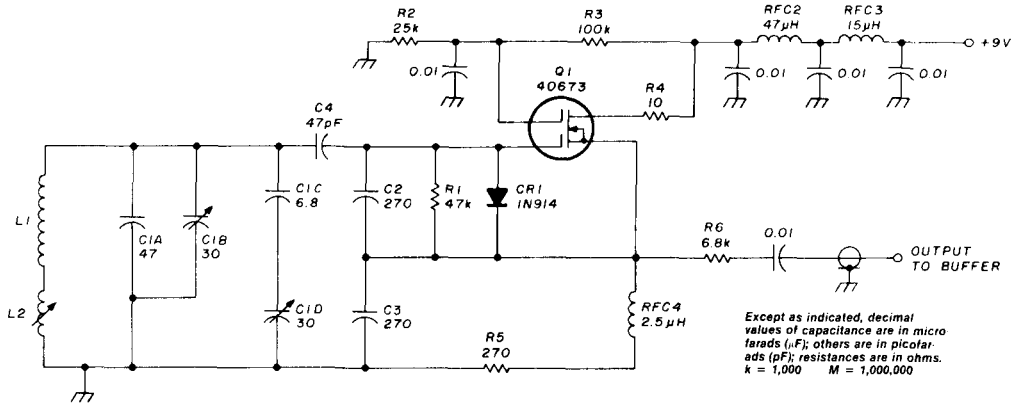


fig. 3. A 9-MHz cylinder-tuned VFO. Variable capacitors are air trimmers; C1B is used for coarse calibration and C1D for fine calibration. Tuning is done in the manner of *fig. 2*. L1 = 11-1/4 turns No. 16 tinned wire on a glass vial 1.04 inches (26.4 mm) in diameter and 1-1/4 inches (28.6 mm) long. L2 = 3-3/4 turns No. 16 enameled wire, close wound, 7/8 inch (19.4 mm) in diameter.

2. No detent (stop) is needed; the dial can be rotated continuously.

Fig. 3 shows a practical form of a cylinder-tuned Seiler for 9 MHz. Because the cylinder provides only the variable part of the tuning, it is necessary to provide means for setting a calibration point against a standard. C1B provides coarse initial calibration, and C1D, in series with a small capacitor, C1C, provides fine adjustment. This last function could also be performed by electronic means.

Fixed frequency-determining capacitors in this oscillator were originally polystyrene capacitors. The adjustable capacitors are air-dielectric trimmers.

The acrylic cylinder is 1 inch (25.4 mm) in diameter. The metal-foil triangle is made of 0.006 inch (0.15 mm) thick copper, 1 inch (25.4 mm) wide at the widest point. Heavy-duty household aluminum foil works almost as well as the copper.

I built the main inductor, L1, as an air-core solenoid with the same inductance as the 38-1/2 turn air-core toroid described in reference 1, since I believed at that time that the toroid was a source of positive frequency drift with increasing temperature. The coil consists of 11-1/4 turns of No. 14 tinned wire spaced on a glass (not plastic) medicine vial 1.04 inches (26.4 mm) in diameter for a total length of 1-1/8 inches (28.6 mm).

To make the coil, I first wound the wire on a dowel suspended between a lathe chuck and a "steady rest." This can be done manually, if you have help. I got just the right diameter of dowel by applying masking tape to a dowel which was a little too small. The coil, which slid off the dowel, was just a bit narrower than the glass vial but could be sprung and slipped onto the bottle so the turns could be spaced and would exert a clinching force. I had previously made end mounts by using a fly cutter on square pieces of acrylic to make holes the same diameter as the bottle. I placed terminals and mounting brackets at the corners and cemented the mounts to the bottle. Finally I anchored the coil to the vial surface by laying on strips of epoxy glue. I avoided coating the whole coil because of the tendency of most adhesives to absorb moisture or otherwise lower the *Q* of the coil.

The *Q* of this coil measured at 12 MHz was approximately 290. Partly because of the high *Q*, it was possible to have an oscillator current drain of only 1.8 milliamperes.

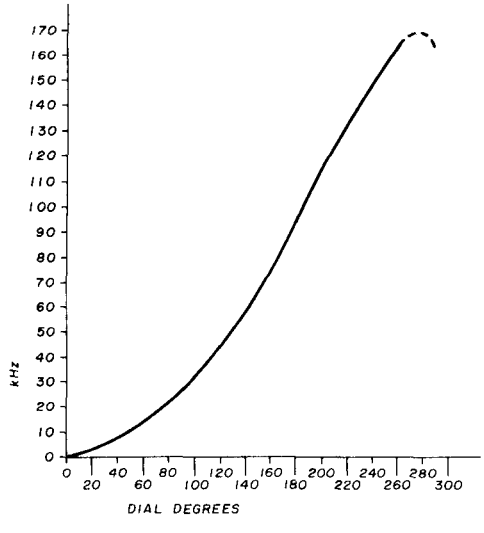
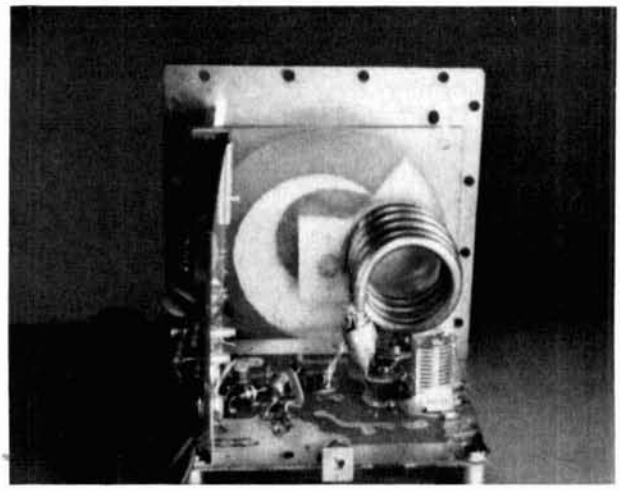


fig. 4. Incremental frequency calibration of the 9-MHz cylinder-tuned VFO.



A disc-tuned VFO.

RFC4 in the source circuit is a 4-section 2.5-mH air-core choke, used to minimize temperature-change effects on the oscillator frequency, which might occur with a simpler choke. The 270-ohm resistor, R5, isolates the choke, and may also prevent low-frequency oscillations. Resistor R6, 6800 ohms, helps to isolate the output cable and other output-circuit elements which might influence the oscillator frequency.

Fig. 4 is a plot of frequency change against angular shaft rotation for the 9-MHz cylinder-tuned oscillator. The useful tuning range is seen to be about 165 kHz, reasonably linear over most of its coverage.

the disc-tuned oscillator

Development of this oscillator coincides with a return to the Hartley configuration, as a result of a simple modification which eliminated some problems. Of course, any inductance-tuning method will work with any oscillator in which an inductance is a frequency-determining element.

In the simple Hartley oscillator of **fig. 5A**, feedback is produced in the coil. The alternating FET drain current through turns B-O on L1 induces a voltage on turns O-A, exciting the FET gate in the correct phase to sustain oscillations. The frequency is largely determined by L1C1, but instability can be introduced by the attached circuitry. The tapped-coil Hartley of **fig. 5B** is an attempt to isolate L1C1 from relatively unstable parameters. Tapping down the coil performs the same isolation function as adjusting C1 in the Seiler oscillator of **fig. 1B**.

Previous experiments had demonstrated a tendency of the circuit to break into parasitic oscillations as the taps A and O were moved down the coil. At the higher frequencies the turns between A and A' act as a choke, isolating C1. Then the turns A-O-B, plus incidental capacitances and inductances of the etched conductors (or wiring), plus what is contained in all the attached circuit elements, are probably what produce these VHF parasitic oscillations. In **fig. 5B**, the area of greatest concern is enclosed by a dashed line.

In the modified Hartley of **fig. 5C**, the inserted resistor R2, of the order of 10 ohms, breaks up the loop which might resonate at a parasitic frequency. The oscillator I built using this circuit produced the desired results. Now, the rf choke in the FET source circuits of **fig. 1**, (RFC4 of **fig. 3**), was no longer needed and the feedback capacitors C2 and C3 were also eliminated. Relative isolation of the frequency-determining elements could be increased by moving taps A and O down the coil (until drain current became excessive).

In the usual Hartley oscillator, tuning is done by capacitor C1. In this oscillator, inductance tuning is accomplished by means of a rotatable insulated disc bearing a metal plate of such configuration that the ground end of a coil coupled to the disc is exposed to a varying area of metal as the disc is rotated. The

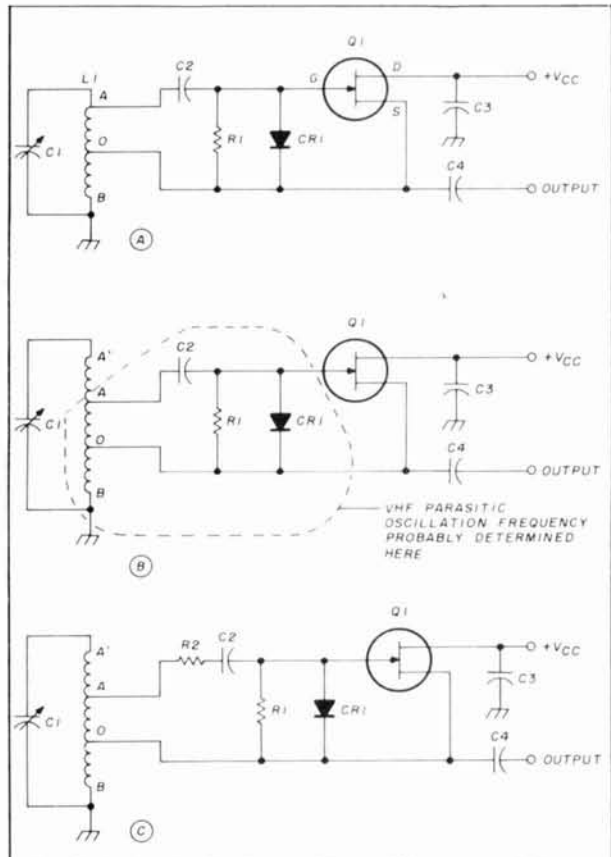


fig. 5. A simple Hartley oscillator (A); a tapped-down Hartley, (B), showing probable source of parasitics; introduction of resistor R2 in (C) breaks up parasitic resonances in the tapped-down Hartley.

simple geometric design I used was a triangle similar to that of the cylindrical tuner, except that I transposed the triangle to the polar coordinates of the disc. **Figs. 6A** and **6B** illustrate how I laid out the disc pattern.

I made the disc 3 inches (76.2 mm) in diameter, using single-side plated Fiberglas® epoxy-resin circuit board upon which I etched the pattern. Note that the pattern as transposed to the disc in **fig. 6B** is centered toward the outside of the disc, since the center of the pattern must rotate past the center axis of the coil, and the coil must be positioned so that one edge must clear the shaft and its support bearing. Refer to **fig. 8** for details.

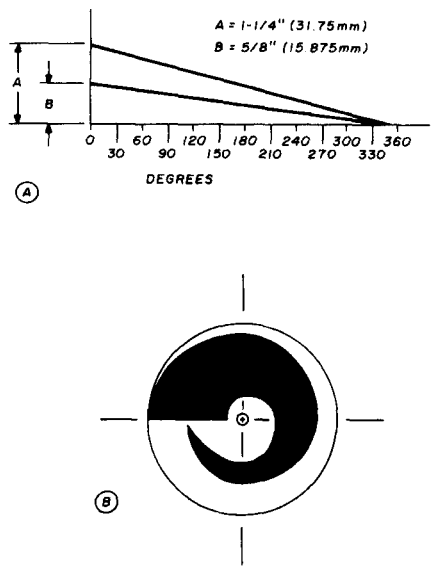


fig. 6. Scaling diagram for generating the tuning-disc pattern, (A); the pattern as etched on the disc, (B).

To fasten the disc to its shaft, I made a simple, square acrylic hub. At the expected velocities of hand rotation, a dynamically balanced hub was not needed. I drilled and tapped two edges of the hub for set screws, and cemented it to the disc. To ensure a snug fit, I glued the hub to the disc and then drilled the final shaft hole after everything was cemented. To avoid heat flow of the plastic, and distortion of the hole, drill at slow speed, perhaps with the aid of a coolant such as cutting oil.

Fig. 7 shows the circuit of a modified, tapped-down 30-MHz Hartley VFO with buffer for 15-meter operation using a 9-MHz i-f.

The inductor, L1, is an air-core solenoid wound with 4-3/4 turns of No. 6 copper wire, 1-1/4 inches (32 mm) in outside diameter and the same length, with a *Q* of 260 measured near 25 MHz. The gate tap A is 1-3/4 turns above ground, and the source tap O is 3/4 turn above ground, which is at B.

Capacitor C1, a small air trimmer, is used for coarse calibration; I had planned to do fine calibrating electronically. Originally, C2 was a single polystyrene capacitor with the parallel combination of C1 and C2 capable of reaching 70 or 80 pF. The series-parallel modification of C2 shown in **fig. 7** resulted from a need for temperature compensation.

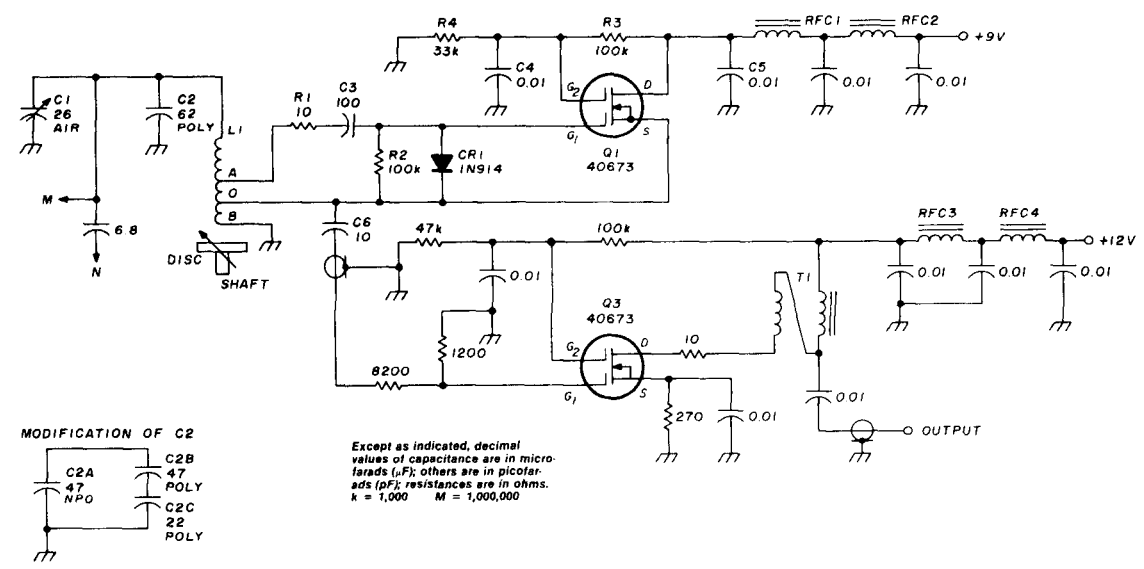


fig. 7. A disc-tuned, 30-MHz Hartley VFO and buffer for 15-meter use. L1, see text, T1 = 4:1 bifilar transformer, 6 turns of No. 26 enameled wire on Amidon FT 37-63 core. Points M and N, see text. Most of the labeled components appear in mechanical layout of *fig. 8*.

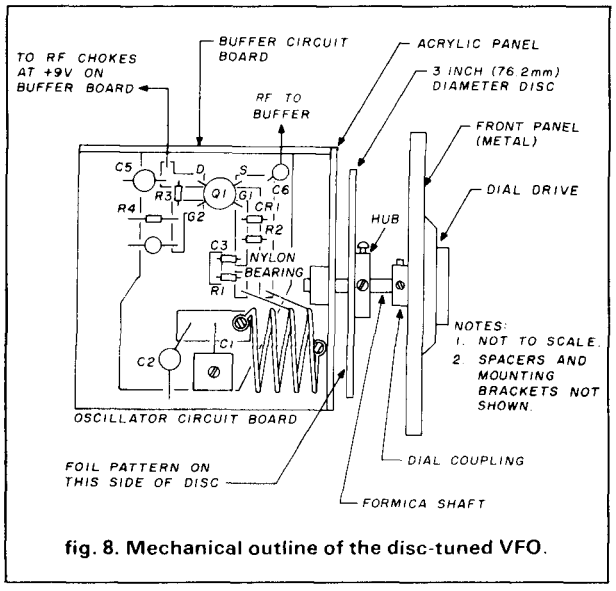


fig. 8. Mechanical outline of the disc-tuned VFO.

For the circuit layout, I used a single-side Fiberglas® epoxy-resin board. I prefer the etched circuit to free-style wiring because of the precision with which a layout can be planned and its mechanical stability. As for any objection concerning the relatively poor insulating properties of the board, I always etch the high-impedance conductors of an rf circuit with plenty of space between them and other conductors or ground. For stability during initial tests, and even in the shield box, a ground plate on spacers is a good idea.

In **fig. 7**, a tap-point M is where auxiliary capacitors can be switched in to make the oscillator run at 23 MHz for 20-meter operation. This entails a separate dial calibration, but for home construction, the method is much simpler than having a VFO with a single calibration, using an extra mixer, and switched-crystal oscillators to provide local-oscillator injection for each frequency band.

Tap-point N comes after a small coupling capacitor 6.8 pF. It is intended to be used for frequency slewing with varactors in the conventional manner. Possibilities include using a number of potentiometers, one for a shift of the VFO frequency in transmitting CW, one for vernier tuning in the receive position, and one for vernier frequency calibration adjustment.

Fig. 8 shows mechanical details of the VFO. Note that the buffer is mounted on a separate board at right angles to the main board and away from the coil. In its box, the outside dimensions of the unit measure 4 inches (101.6 mm) wide, 4 inches (101.6 mm) high, and 4-1/2 inches (114.4 mm) deep. The shielded box is actually intended to go inside the enclosure of a transceiver, instead of being tuned as shown in **fig. 8**, thus affording extra shielding.

The frequency calibration of the VFO is shown in **fig. 9** for two spacings of the disc from a reference point on the ground end of the coil. It should be easily possible to achieve band-spread tuning in excess of 1000 kHz, or as narrow as desired. Linearity is acceptable, but could be improved by tailoring the disc pattern.

The current to the VFO is 2.3 to 2.4 milliamperes as the disc is turned. The buffer draws 2 milliamperes.

temperature effects

In my early VFO work, I relied upon polystyrene rf capacitors and was wrongly inclined to blame a positive drift of frequency with temperature upon the air-core toroidal inductors I had developed.[1] Publication of careful work by other experimenters has since revealed that the polystyrene capacitors have a high negative temperature coefficient.[3,4] The type of capacitor recommended as an alternative is the NPO ceramic; these are available through the large mail-order wholesalers. At the time of this writing, I learned from W7ZOI that they could be obtained from at least one distributor: Mouser Electronics, 11433 Woodside Avenue, Santee, California 92071. Actually, I found that just inserting an NPO ceramic capacitor as C2 of **fig. 7** in my experimental unit was not satisfactory, since a negative coefficient of temperature with frequency resulted. I found it was not hard to compensate for frequency drift with temperature by mixing NPO ceramic and polystyrene capacitors, substituting the series and parallel combination shown in **fig. 7** as "Modification of C2."

The heat run shown in **fig. 10** was accomplished with the same plate warmer and 40-volt ac source as

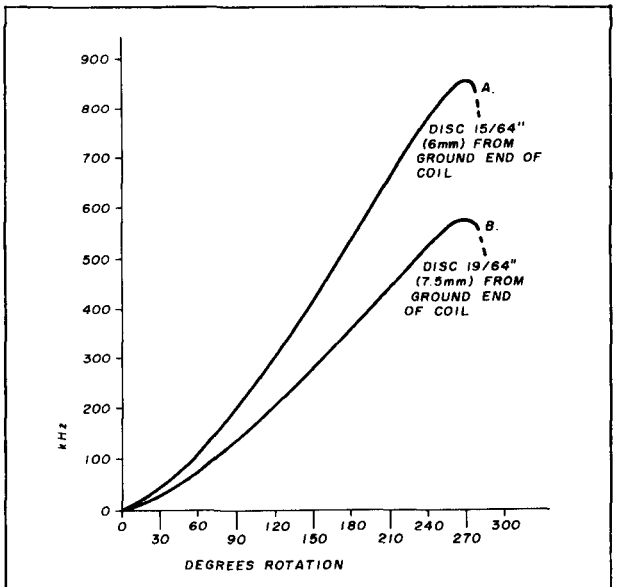


fig. 9. Incremental frequency calibration of 30-MHz disc-tuned VFO.

in reference 1. Results are not directly comparable, however, because of a different physical configuration and shield-box shape, with its obviously longer thermal time constant and greater heat losses than in the earlier case. Nevertheless, it is estimated that the temperature rise near the critical circuit elements approached 16 degrees C (29 degrees F).

The data for **fig. 10** were obtained by using 47 pF NPO for C2A; 47 pF polystyrene for C2B; and 22 pF polystyrene for C2C. The small dip in the curve for the first hour could indicate that the temperature transient reached C2A before C2B and C2C. It would have been interesting to make C2C an NPO capacitor.

In **fig. 10**, the frequency of the 30-MHz VFO has increased only 4300 Hz in fourteen hours on the plate warmer. The same VFO at constant room temperature for one hour did not appear to depart from its initial frequency by as much as 20 Hz.

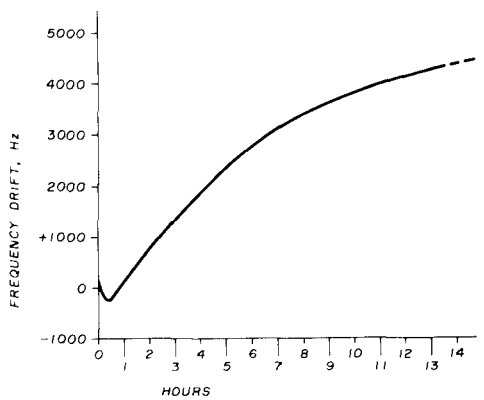


fig. 10. Frequency drift of the 30-MHz VFO during a heat test.

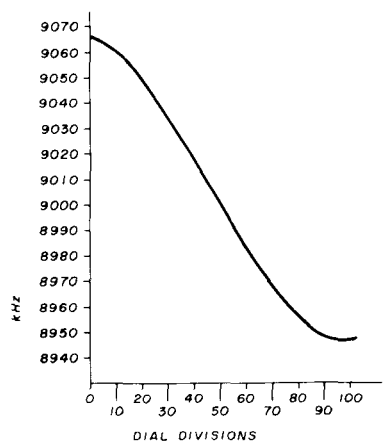


fig. 11. Corrected frequency calibration of copper-vane VFO. (See *ham radio* magazine, July, 1980, fig. 14, page 57.)

conclusions

The experiments reported here have shown that small, stable, low-current VFOs can be built at frequencies up to at least 30 MHz, using new versions of older inductance-tuning methods, eliminating the bulky and expensive variable capacitor, and now with cylinder- or disc-tuning, extending the useful tuning range beyond 270 degrees. Also, the wiping contacts found in most variable capacitors are eliminated.

The oscillators shown here could be made smaller. For the disc-tuned unit, one easy way to cut down on size would be for part of the disc to protrude through a slot in the shield box. Perhaps the ultimate compact oscillator would be a cylinder-tuned type using a Hartley circuit and perhaps a single closely-placed coil of the solenoid type near the circuit, operating at 30 MHz or higher.

One foreseeable problem with a 30-MHz VFO, especially the disc-tuned type, would be that of microphonics, especially if a loudspeaker were close by, or perhaps from vibration caused by keying a transmitter. One recalls the all-wave broadcast receivers of the 1930s, in which the tuning capacitors were mounted on rubber shock absorbers.

Appendix I demonstrates how the band-coverage capabilities of any inductance-tuned local oscillator go up with frequency. With stable, inductance-tuned VFOs of high enough frequency to be capable of a 500- or 1000-kHz tuning range, it should be possible to design very simple, general-coverage high-frequency receivers of fairly high quality.

appendix I

Here is a little mind sharpener for budding future engineers to demonstrate that mathematics is a useful and fascinating tool, and for over-the-hill engineers to convince themselves that they are still with it.

The oscillators I have described all tune through a band of frequencies by shifting the frequency of oscillation an incremental amount. The shift is accomplished by making incremental changes in the inductance of the tuned circuit. The question is: Assuming that the total inductance of the frequency-determining circuit is shifted by a certain small, proportionate amount, what is the relationship of the frequency change to the frequency itself?

First there is the fundamental equation relating frequency to inductance and capacitance:

$$f = 1/2\pi\sqrt{LC} \qquad (1)$$

where f is frequency in Hz, L is inductance in henrys, and C is capacitance in farads. Any other units are taken care of by the use of appropriate constants. Now, squaring **eq. (1)**:

$$f^2 = 1/4\pi^2 LC$$

If we keep the capacitance constant and change the inductance by a small amount, dL, the frequency changes by a small amount df, so we can write:

$$(f + df)^2 = 1/4\pi^2 C\,(L + dL)$$

Then expanding:

$$f^2 + 2f\,df + df^2 = 1/4\pi^2LC \times 1/(1 + dL/L)$$

Substituting f^2 from above for $1/4\pi^2LC$, and dropping the higher-order term df^2, which we can do for small increments:

$$f^2 + 2f\,df = f^2/(1 + dL/L) \quad (2)$$

Now for small dL/L:

$$1/(1 + dL/L) = 1 - dL/L$$

so, from **eq. (2)**:

$$f^2 + 2f\,df = f^2(1 - dL/L),$$
$$2f\,df = -f^2dL/L$$

and:

$$df = -f/2 \times dL/L \quad (3)$$

This equation says that, for small changes, if the change in the inductance is a fixed proportion of the inductance itself, dL/L constant, then the frequency change is proportional to the frequency being changed but in the opposite direction. This may be a fairly useful relationship when one is striving for the maximum achievable frequency shift. An analogous relationship is easily derived for capacitance tuning.

As the frequency-changing surface or object is brought closer to the inductive circuit, the inductance becomes smaller, but so does the Q, because the eddy-current paths in the metal are resistive as well as inductive. As noted before, when the Q is lower, oscillation eventually ceases, but before this happens, the oscillator may become a selective noise generator. Even when the oscillator appears to be acting normally, if the Q is too low there may be excessive noise modulation, making adjacent-channel signals audible with noise modulation.[5] This may be one kind of limit on the maximum achievable frequency shift. With cylinder tuning, the limit may sometimes be the fact that the cylinder's curvature does not allow close enough coupling to the coil.

The limitation on how big an incremental band can be covered by the methods outlined, and its relationship to frequency, may be more complex than indicated by **eq. (3)**. However, in general, the higher the local oscillator frequency the larger the band one can cover. If **eq. (3)** holds, then the 165-kHz available bandspread of the 9-MHz cylinder-tuned VFO of **fig. 4** could be scaled up to 3-1/3 × 165, or 550 kHz for a 30-MHz oscillator. Actually, I have converted the 40-meter direct conversion receiver that I described in the January, 1977, issue of *ham radio* to 15 meters, using a cylinder-tuned local oscillator. This oscillator could easily be made to function at 21 MHz with well over 1 MHz bandspread, because I coupled the entire oscillator inductor to the cylinder.

appendix II

Fig. 11 is a corrected version of **fig. 14** in reference 1. It should be noted by examining the new figure that the correct tuning range of the 9-MHz copper-vane VFO was about 120 kHz.

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1. Richard Silberstein, WØYBF, "Variable-Inductance Variable-Frequency Oscillators," *ham radio*, July, 1980, pages 50-59.
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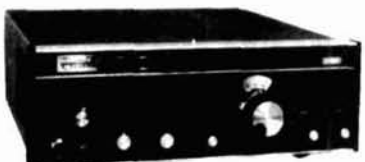

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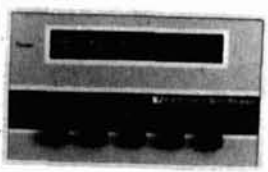

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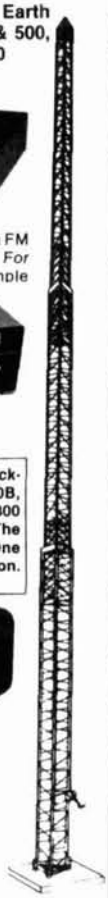

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low-power keyer and interface

CMOS and MOSFETs in a keyer and switch that runs for two years off a small battery

By Dr. R.A. Reiss, K1HOP, 41 School Road, Bolton, Connecticut 06040

A number of excellent, low-power, CMOS keyers have appeared in the literature in the past few years. Nearly all consume negligible power in the quiescent state, and would seem ideal for portable use or extended operation from a small battery, except for one problem. The interface between the keyer circuitry and the transmitter has always been implemented with either bipolar transistors or (reed) relays. These devices require more current to turn them on than the rest of the keyer circuitry.

I have been using a very simple, three-chip CMOS keyer (called HOPKEY MARK-IV) for over four years. This circuit has been duplicated by many hams who were intrigued by its simplicity and low-power consumption. As you can see from **fig. 1**, this keyer represents almost ultimate simplicity. It has no memory, iambic operation, or other frills. It just provides the basic requirements of self-completing dots, dashes, and spaces, and instantaneous operation on key closure (that is, gated oscillator). A side-tone oscillator was included, since, even with only three chips, enough gates were left over to make this a no-cost feature.

Before adding the required transmitter interface circuitry, the quiescent current drain of this keyer is unmeasurable on my equipment (less than 100 nanoamps). At 50 WPM, with the side-tone oscillator driving a high-impedance crystal earphone, it draws only 100 μA from a nine-volt transistor battery. This circuit keeps on working down to almost three volts, where it draws only 20 μA. Resistor values could be increased by an order of magnitude or more if even less current drain is desired. However, susceptibility to rf pick-up would increase. It is estimated that the battery would last its shelf life (two years or so) with such a light load. However, until recently, I have been plagued by an additional one to ten milliamps of current drain, just to drive the transmitter keying transistors. The recent development of power MOSFET transistors has changed that.

conventional keying circuits

Conventional bipolar transistors (and relays), when operated as switches, exhibit current gain. In other words, only a small amount of current is required for them to switch a larger current. For keying a transmitter with a positive (open circuit) potential at the key leads, a simple interface (**fig. 2A**) is normally used. The keyer power supply must furnish sufficient current through the base resistor to ensure that the

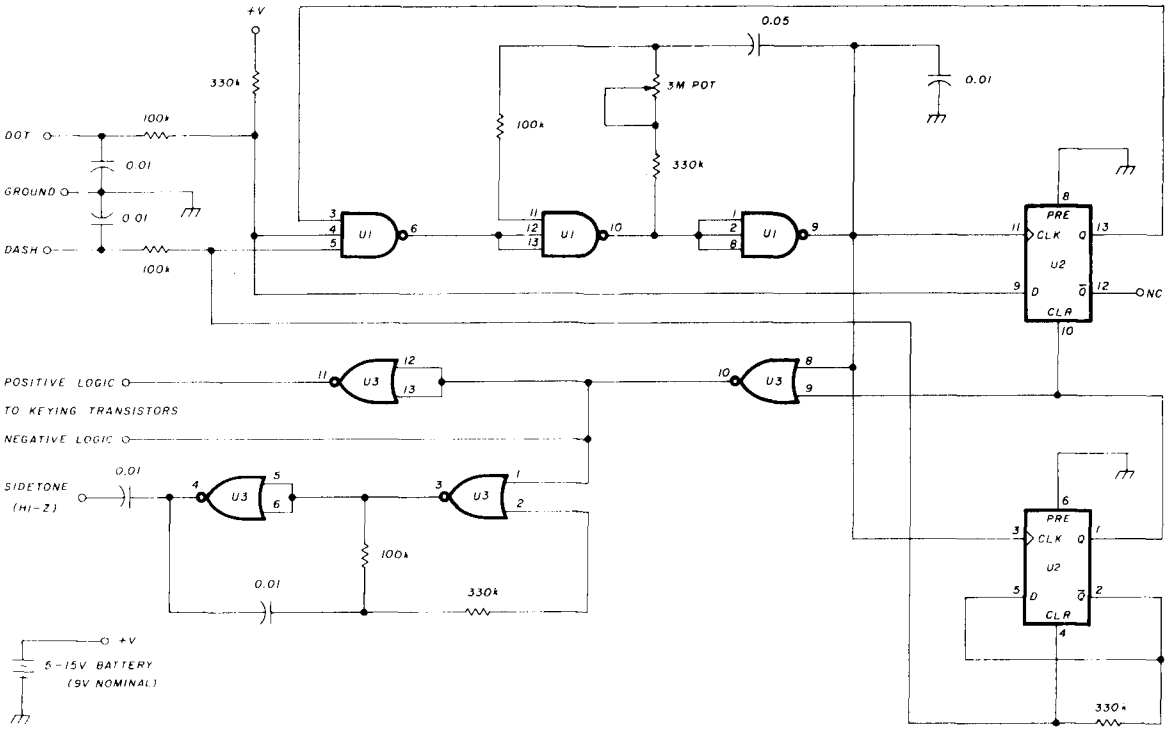

fig. 1. HOPKEY-MARK IV-A low-power CMOS keyer.

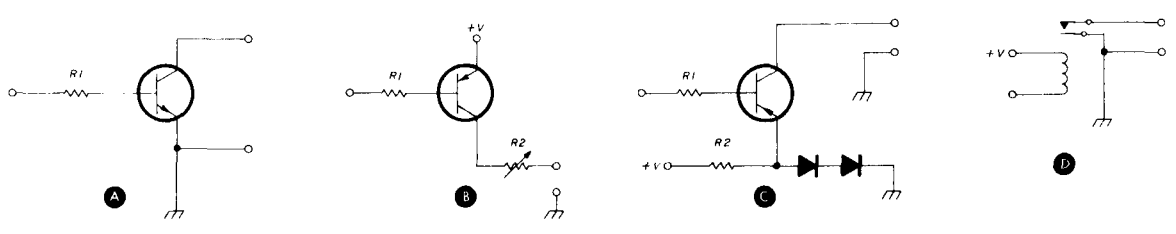

fig. 2. Conventional keying circuits. All draw considerable current from the keyer battery.

transistor turns on fully (saturates) with whatever collector current the transmitter presents in a key-down condition. This requires an additional 1 to 10 mA of current from the keyer battery.

For negative potential keying (grid-block), variations of the circuits shown in **figs. 2B** and **2C** are often used. These require a low-going input from the keyer, which sinks current from the base and turns on the transistor. Circuit 2B requires that R2 be adjusted for each particular transmitter in order to keep the key-down voltage near zero. The PNP transistors for grid-block keying normally have a high-voltage rating. Very often, 2N4888 or 2N5416 types are used since they will withstand −300 volts.

The simple relay interface of **fig. 2D** generally requires the highest amount of drive current, but offers the advantages of positive or negative keying, transmitter isolation, and relatively high-voltage operation.

All the above circuits draw current from the keyer power supply. While this can be as low as 1 mA in some cases, it varies with the type of transmitter to be keyed, and is generally many times greater than the current required to run the keyer logic. Battery life is severely shortened.

N-channel MOSFET keying circuits

Power MOSFET transistors, on the other hand, are almost perfect switches. A voltage rather than a current is required at the gate to turn them on. Their extremely high gate resistance draws only 1 to 100 nanoamps from the keyer. Recent power MOSFETs

table 1. N-channel power MOSFETs. Those marked with an asterisk contain internal gate-source diode.

manufacturer	type	BV_{DSS} (volts)	I_{DP} (amperes)	R_{DS}(on) (ohms)	V_{GS}(th) (volts)
Ferranti	ZVN0106A	60	0.38	4	2.4
	ZVN0120A	200	0.18	16	2.4
	ZVN0335B	350	1.04	3	3.5
	ZVN0365M	650	3.04	6	4.0
	ZVN0465M	650	6.4	2	4.0
	ZVN12A3M	30	16	0	2.4
	ZVN1304A	40	0.23	10	2.4
	ZVN1314A	140	0.16	20	3.0
International Rectifier	IRF123	60	5.0	0.4	4.0
	IRF220	200	4.0	0.8	4.0
	IRF322	400	11.0	2.5	4.0
	IRF420	500	2.0	3.0	4.0
	IRF450	500	10.0	0.4	4.0
	IRF513	60	2.5	0.8	4.0
	IRF710	400	1.2	3.6	4.0
	IRF820	500	1.5	3.0	4.0
Intersil	VN10KM*	60	0.30	4 (est)	2.5
	VN67AF*	60	0.60	8 (est)	1.2 (typ)
	IVN5000ANE	60	0.70	2.5	2.0
	IVN5200TNH	100	2.00	0.5	2.0
	IVN6000CNU	500	1.75	4.0	5.0
	IVN6200KNX	800	2.50	6.0	5.0
RCA	RCA9213A	100	1.0	2.50	?
	RCA9212B	150	5.0	0.30	?
	RCA9195B	150	10.0	0.15	?

(called VMOS, HEXFET, DMOS, SIPMOS, and TMOS by various manufacturers) are enhancement mode devices. Unlike their familiar linear MOSFET cousins used as rf amplifiers, these devices are normally off and turn on when the gate is biased in the direction of the drain potential. In this respect, they look more like bipolar devices, but consume (almost) no current. **Fig. 3** shows the sheer simplicity of a positive-potential MOSFET keying stage. All that is required is an N-channel MOSFET transistor. (The capacitor across the output simply keeps rf from getting back into the keyer.) However, a few precautions must be observed.

When not turned on, the transistor must be capable of withstanding the open-circuit potential presented by the transmitter. This is no great problem since transistors are available with BV_{DSS} breakdown ratings of 20 to 650 volts. When conducting, the transistor must handle the key-down transmitter current. Even small, inexpensive devices have I_{DP} practical current-handling capacities of many hundred milliamperes. Larger devices can switch over 4 kW. More serious concerns are the devices' on-state resistance and threshold voltage.

power MOSFET characteristics

A power MOSFET essentially acts like a variable resistor (or triode tube) and is characterized by a forward transconductance, g_{fs}. This is the ratio of drain-source current versus gate-source voltage. Fortunately, power MOSFETs have high g_{fs} (typically 0.2 to 4.0 mhos). This means that very large currents may be switched with low gate voltages. However, there is a limit to how low the on-state resistance, R_{DS}(on), (from drain to source) can be made. This will determine the minimum voltage across the transmitter key leads in a key-down condition. In choosing a suitable device, one must pay attention to the R_{DS}(on) rating at rated transmitter keying current I_K. The key-down voltage V_K will be:

$$V_K = I_K \bullet R_{DS(on)}$$

Another concern is that a minimum gate-source threshold voltage V_{GS}(th) is required to operate a MOSFET. This is normally less than 3 volts and presents no major problem when the keyer is operated from 5 volts or greater. The positive-logic (high-going) output of a CMOS (or TTL) keyer is compatible and may simply be connected directly to the gate.

In some applications, although not here, two other factors become important. These are gate-source breakdown and drain-source breakdown due to voltage spikes. These factors are particularly important when using high-impedance drive circuits and/or switching inductive loads. Reference 3 provides a good discussion of the sources of these problems and effective cures. For resistive switching, simply driving with a relatively low-impedance such as CMOS at less than 20 volts is normally satisfactory. The rf bypass capacitor at the output also limits the rate of change of voltage which offers another measure of protection.

Keep in mind that power MOSFETs are high-impedance devices. Handling precautions similar to those when using CMOS apply. Store in anti-static containers, do not handle by leads, and use grounded soldering equipment.

Table 1 lists a number of N-channel power MOSFET devices suitable for positive keying applications (the references should be consulted for complete listings). It should be noted that some types (marked with an asterisk in **table 1**) have internal reverse diodes from gate to source. With such devices, the gate must never be allowed to go negative with respect to the source; otherwise the device can self-destruct. This situation cannot occur in the present application.

Power rating is generally of little concern in switching applications since we either have high voltage (off) or high current (on), but not both simultaneously.

Some particular devices I have used with great success are the miniature (TO-92) ZVN0106A and VN10KM for keying solid-state QRP transmitters and an ICOM-211. These devices cost less than a dollar. A very low key-down voltage of less than 20 mV is a particular benefit to some modern rigs (such as the IC-211), which balk at more than 0.3 volt across the key leads. The IVN67AF was used to key the emitter of a 10-watt solid-state amplifier. The IVN6000CNT was employed to cathode key an older rig using a pair of 6146s.

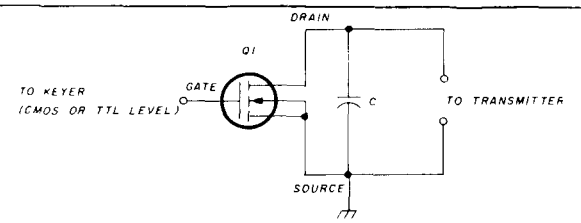

fig. 3. Positive-potential MOSFET keying stage. Capacitor C is 0.001-0.01 μF rf bypass; Q_1 is N-channel MOSFET.

P-channel MOSFET keying circuits

Keying a grid-block transmitter (negative potential) becomes a bit more involved, yet the same benefits may be achieved. Ideally, we would like to use a P-channel rather than an N-channel device. Some suitable P-channel devices are listed in **table 2**. To turn on a P-channel enhancement-mode, MOSFET requires a negative voltage at the gate. Although this would seem to make them incompatible with CMOS keyers, the circuit in **fig. 4** does the trick.

The input to this keying stage is the same positive-logic (high-going) signal from the keyer as was used above. It is inverted and applied to a voltage-converting circuit composed of a capacitor, resistor, and diode. When the keyer is at rest, the capacitor charges to almost the supply voltage (normally 5 to 9 volts). The diode provides a fast charging path. The resistor keeps the gate near ground once the capacitor is charged. When a dot or dash arrives, the inverter output goes low and the (negative) capacitor voltage appears across the gate-source. This turns on the MOSFET which keys the transmitter.

A small amount of charge is removed from the capacitor during key-down time. However, the RC time constant is made very large compared to the longest dash. This ensures that the transistor stays on during the entire dash. When a space occurs, the capacitor rapidly regains its previous charge and is ready for the next cycle. With the values shown, the transistor can be kept on for over 5 seconds. For long tune-up

table 2. P-channel power MOSFETs. Fewer types are available than with N-channel, yet they cover a wide range of operating characteristics.

manufacturer	type	BV_{DSS} (volts)	I_{DP} (amperes)	$R_{DS}(on)$ (ohms)	$V_{GS}(th)$ (volts)
Ferranti	ZVP0110A	−100	−0.20	16	−3.5
	ZVP0120A	−200	−0.13	40	−3.5
	ZVP0330B	−300	−0.68	8	−4.5
	ZVP0345B	−450	−0.68	8	−4.5
	ZVP0530A	−300	−0.06	200	−4.5
	ZVP12A3M	−30	−12	0.4	−3.5
International Rectifier	IRF9520	−100	−4.0	0.6	−4.0
	IRF9530	−100	−7.0	0.3	−4.0

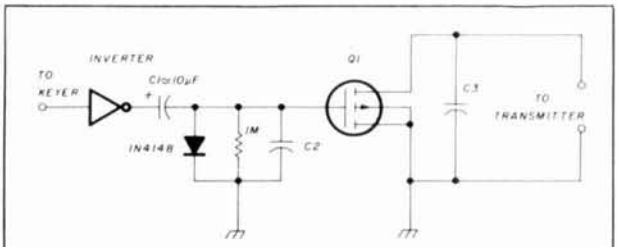

fig. 4. Negative-potential MOSFET keying stage. Q1 is P-channel MOSFET. C_1 should be low leakage. C_2 and C_3 are 0.001-0.01 μF rf bypass.

periods of greater duration, the key leads should be shorted directly rather than using the keying transistor to hold the transmitter on. The value of C_1 may also be increased to permit longer on time. Be sure that C_1 is a low-leakage type. A small capacitor (0.001-0.01 μF) from gate to ground may be required when operating with large amounts of rf (high SWR). This prevents the voltage-inverting circuit from acting as a positive peak-clipping rectifier which would keep the transistor turned on due to rectified rf. Very little energy is used in charging the capacitor since the high gate resistance drains off very little charge during key-down. Therefore, the power consumption of this circuit is only slightly greater than that of the one in **fig. 3**.

Use of a small (TO-92) type ZVP0120A permits keying up to −200 volts at 25 mA with less than 1 volt across the key leads in the on state. Only 20 mV appears across the key leads of my HW-100 with this circuit. ZVP0345B (TO-39 package) will key −450 volts at 100 mA with less than 0.8 volt across the key leads.

At last the ideal electronic switch seems to have arrived in the form of power MOSFET transistors. You can now run your keyer from a tiny battery for two years. Anyone for a solar-powered keyer? Or how about using rectified rf from the transmitter for power?

As you explore the benefits of these devices, you are sure to find many other applications for them. I have found that they even work quite well at rf as oscillators and power amplifiers. Why not get a few and experiment?

references

1. *VMOS Data Book*, 1981, Ferranti Limited. Available for $5.00 from Sales Offices and Franchised Distributors. Or, contact Ferranti Electric, Inc., Semiconductor Products Group, 87 Modular Avenue, Commack, New York 11725.

2. *Power MOS Handbook*, 1981, Intersil, Inc. 10710 N. Tantau Avenue, Cupertino, California 95014.

3. *HEXFET Data Book*, 1981, International Rectifier, 233 Kansas Street, El Segundo, California 90245. Available for $3.50.

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WANTED: Military surplus radios. We need Collins 618T, ARC-94, ARC-102, MRC-95, HF105, VC102, RT-1299/ARC-186, RT-712/ARC-105, ARC-164, ARC-114, ARC-115, RT-823/ARC-131 or FM622, RT-859/APX-72, Wilcox 807A or RT-857/ARC-134, 313V-1 control, TRC-146, antenna couplers Collins 490T, CU-1658A, CU-1669A, 490B-1, 690D-1. 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.

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.

FREE ELECTRONICS CATALOG: Resistors, Capacitors, ICs, EPROMs, Transistors, Diodes, Sockets . . . thousands of hard to find parts. RamPart, Room 701, Box 988, Evergreen, CO 80439.

PROFESSIONAL QUALITY Ham Radio, QST circuit boards at ham prices. Catalog $1.50 postpaid. Dynaclad Industries, Box 296, Meadowlands, PA 15347.

RTTY FOR SALE— 28KSR, 28 keyboard typing reperforator, 28 self-contained TD, 34ASR, 33KSR, 35KSR, Model 15, Model 19, Dovetron MPC-1000R demodulator — as NEW, ST-5 demodulator, 3-speed 28RO compact printer, 28 underdome typing reperforator for 28ASR, RTTY video display, 19" video monitor-TV, MORE — Send SASE for list and prices. Lawrence R. Pfleger-K9WJB, 2600 S. 14th Street, St. Cloud, MN 56301. (612) 255-9794.

RTTY AND ASCII for Atari. Plans and a drilled PC board to build your own modem. ASCII and RTTY programs on disk all for $25. Robert Holsti, K7ZJD/KH2, Box 4426, AAFB Br. Yigo Guam 96912 (USA).

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SIGNAL GENERATORS — URM-25 F, 15 kHz - 50 MHz AM $120.00; TS-497, 2 - 400 MHz. $100.00; Advanced Measurement Instrument 303A, 200 - 410 MHz FM $120.00. All in working condition. N. E. Litsche, P. O. Box 191, Canandaigua, NY 14424.

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SATELLITE TELEVISION INFORMATION. Build or buy your own earth station. $4.00 to Satellite Television, RD #3, Oxford, NY 13830. Parabolic antenna construction book also available. Send SASE for details.

Coming Events

ACTIVITIES

"Places to go..."

INDIANA: The LaPorte Amateur Radio Club's Winter Hamfest, Sunday, February 27, LaPorte Civic Auditorium. Donation $2.50 at door; tables $1.00 each. Talk in on 52 simplex. For information/reservations SASE to: PO Box 30, LaPorte, IN 46350.

ILLINOIS: The Sterling/Rock Falls Amateur Radio Society's 23rd annual Hamfest, March 20, Sterling High School Fieldhouse, 1608 Fourth Avenue, Sterling. Tickets $2.00 advance; $2.50 door. Distributors, dealers and large flea market. Free parking and space for self-contained campers overnight. Doors open 7:30 AM. For tickets, tables and information: Sue Peters, 511 8th Avenue, Sterling, IL 61081 or call (815) 625-9262. Talk in W9MEP 146.25/85.

KENTUCKY: The annual Glasgow Swapfest, Saturday, February 26, 8 AM, Glasgow Flea Market Building, 2 miles south of Glasgow off highway 31E. Heated building, free parking, free coffee, large flea market. Admission $2.00, no extra charge for exhibitors. One free table per exhibitor, extra tables available at $3.00 each. Talk in on 146.34/94 or 147.63/03. For additional information: WA4JZO, 121 Adairland Ct., Glasgow, KY 42141.

MINNESOTA: The Midwinter Madness Amateur and Computer Fest sponsored by the Robbinsdale Amateur Radio Club, KØLTC, February 26, Sacred Heart Church School Auditorium, 4087 West Broadway, Robbinsdale. Public admission 8:30 AM. Seminars on antennas, towers, computer interfacing and a slide presentation on the voyage of the Viking ship, Hjemkomst. General admission $2.00 advance, $3.00 door. Commercial space $15.00 per table. Contact Bob Reid, NØBHC, 19725 Jackie Lane, Rogers, MN 55374. Flea market $3.00 per space. Contact Barry Blazevic, WBØFBN, 5437 Virginia Ave., N. New Hope, MN 55428.

MICHIGAN: The 21st annual Michigan Crossroads Hamfest sponsored by the Southern Michigan ARS and the Calhoun County Repeater Association, March 19, Marshall High School, Marshall. Doors open 7 AM for exhibitors and 8 AM for buyers and lookers. Tickets $1.50 advance; $2.00 door. Tables 50¢ per ft. For tables or tickets: SMARS, PO Box 934, Battle Creek, MI 49016 or call Chuck Williams (616) 964-3197.

MICHIGAN: The 13th annual Livonia Amateur Radio Club's Swap 'n Shop, Sunday, February 27, from 8 AM to 4 PM, Churchill High School, Livonia. Refreshments and free parking. Reserved 12 ft. table space available. Talk in on 144.75/5.35 and 52 simplex. For information SASE to Neil Coffin, WA8GWL, c/o Livonia Amateur Radio Club, PO Box 2111, Livonia, MI 48151.

NEW JERSEY: The Old Bridge Radio Association's third annual electronic equipment auction, K of C Hall, Pine Street, off Route 18, Old Bridge. NEW LOCATION, plenty of seats and free parking. Doors open for registration and inspection at 9:00 AM; sale begins at 10:00. Admission $2.50. Club commission, successful sales only, 10% on first $100 of sale price; 5% on remainder. Refreshments available. Talk in on .72/.12, .34/.94 and .52. For information call Fred, WA2BJZ. (201) 257-8753.

NEW JERSEY: Shore Points ARC invites everyone to Springfest '83, Saturday, March 12, 9 AM to 3 PM, Atlantic County 4-H Center, Route 50, Egg Harbor City (near Atlantic City). Large heated building for buyers and sellers. Covered outside tailgating spaces. Admission $3.00 at gate; $2.50 advance. Sellers $5.00 per space (bring own table). XYL's and children free. Refreshments available. Talk in on 146.985 and .52. For info and reservations: SPARC, PO Box 142, Absecon, NJ 08201.

NEW JERSEY: The Split Rock Amateur Radio Association's sixth annual electronics auction, Friday, March 4, V.F.W. Post #3401, State Route 53, Morris Plains. Doors open at 7 PM for unloading and inspection. Auction starts at 8 PM. Admission $1.00. Club commission 10% on first $50 of each sale, above which a flat fee of $5 will be charged. Commissions cash only. Refreshments available. Talk in on WR2ADE, 146.385/146.985 or 146.52 direct. For information: SARA, PO Box 3, Whippany, NJ 07981.

NEW YORK: LIMARC, The Long Island Mobile Amateur Radio Club's indoor Hamfest, February 20, Electricians Hall, 41 Pinelawn Road, Melville, L.I., 9 AM to 5 PM. General admission $3.00. Advance sellers table only $10.00 to Hank Wener, WB2AIW, 53 Sherrard Street, East Hills, NY 11577 or 10 PM to Midnight (516) 484-4322. Refreshments available. For information: Sid Wolin, K2LJH (516) 379-2861 nights.

OHIO: The Mid Winter Hamfest/Auction and Flea Market, Sunday, February 13, Richland County Fairgrounds, Mansfield. Doors open 8 AM. Advance tickets $2.00; $3.00 at door. Advance tables $5.00; $6.00 at door. Talk in on 146.34/94. For information or tickets: Harry Frietchen, K8HF, 120 Homewood Road, Mansfield, Ohio 44906. (419) 529-2801 or (419) 524-1441.

OHIO: The Cuyahoga Falls ARC's 29th annual Electric Equipment Auction and Hamfest, Sunday, February 27, North High School, Akron, 8:30 AM to 4:00 PM. Tickets $2.50 advance; $3.00 door. Sellers bring own tables. Some available for $2.00. Talk in on 147.87/.27 or 146.04/.64. Details from CFARC, PO Box 6, Cuyahoga Falls, Ohio 44222 or phone K8JSL (216) 923-3830.

PENNSYLVANIA: The R.A.E. Eyeball QSO Party sponsored by the Radio Association of Erie, March 19, Perry Highway Hall south of I-90 on west side of Rt. 19. FCC exams. Send Form 610 to FCC Buffalo office by February 22. QSL drawing, bring your card. Reserved tables only, $3.00 per 8 ft. table. Admission $2.00. Talk in on 01-61-22-82. Refreshments available.

PENNSYLVANIA: The Lancaster Hamfest, Sunday, February 20, Guernsey Sales Pavilion, U.S. Route 30 East, Lancaster, 0800 to 1600. Dealer set up 0600 by reservation. Tables $10 in main display area, $6 in annex. General admission $3.00. Tailgating weather permitting. Talk in on 146.01/61, 147.615/015, 146.52. Send reservations to Hamfest Committee, RD #1, Box 56V, Blue Ball, PA 17519. Checks payable to SERCOM, Inc.

VIRGINIA: The 10th annual WINTERFEST '83 celebrating the 20th anniversary of the Vienna Wireless Society, February 27, 8 AM, Community Center, 120 Cherry Street, Vienna. CW contest, manufacturers and dealers, indoor flea market, outdoor Frostbite tailgating. Tables $5 and $10. Free parking. Tickets $4.00. Good food available. Talk in on 146.31/91 and 146.52 simplex. For information SASE to Winterfest '83, PO Box 418, Vienna, VA

22180 or call Jeff Wilkes, W4NFA (703) 281-4249 or on Virginia Sideband Net.

OPERATING EVENTS

"Things to do..."

FEBRUARY 12: YL-OM Contest, Saturday, February 12, 1800 UTC to Sunday, February 13, 1800 UTC and Saturday, February 26, 1800 UTC to Sunday, February 27, 1800 UTC. OMs call "CQ YL" — YLs call "CQ OM". All bands may be used. No cross band operation. EXCHANGE: Station worked, QSO number, RS(T), ARRL section or country. Phone and CW scored as separate contests. Submit separate logs. Score one point for each station worked. Multiply number of QSOs by total number of different ARRL sections and countries worked. Contestants running 150 watts or less on CW and 300 watts PEP or less on SSB at all times may multiply the results of (C) by 1.25 (low power multiplier). Logs must be signed by operator and postmarked by March 15, 1983. No logs will be returned. For further information contact WA6WZN.

MARCH 12, 13, 14: Idaho QSO Party sponsored by the Kootenai Amateur Radio Society, 0000Z through 2359Z. Exchange RS(T) and county for Idaho stations; state and country for all others. Idaho stations score one point for each QSO multiplied times Idaho counties, states, VE provinces and countries worked. Others score one point for each Idaho QSO multiplied times total Idaho counties worked. Frequencies: CW - 50 kHz up from lower band edge. Novices 25 kHz up from their lower band edge. SSB: 3.920, 7.260, 14.250, 14.325, 21.325, 21.380 and 28.550. No net frequencies. Awards will be issued to top scorer in each Idaho county, state, VE province and country. USA mailing deadline for all entries is April 16, 1983. DX countries and Canada deadline is May 1, 1982. Send to Vladimir J. Kalina, KN7K, South 1555 Signal Point Road, Post Falls, Idaho 83854.

FEBRUARY 5, 6: Vermont QSO Party sponsored by the Central Vermont Amateur Radio Club (W1BD). 2100Z February 5 to 0700Z, February 6. 1100Z to 2400Z, February 6. Send SASE for official log and score sheets. SASE for results. Send logs/facsimiles, name, class of license, address, NLT March 1, 1983 to: D. Nevin, KK1U, W. Hill, Northfield, VT 05663.

FEBRUARY 13: The Oregon Tualatin Valley Amateur Radio Club will operate a commemorative special event station celebrating the 124th birthday of the state of Oregon, the 33rd state to be admitted to the Union on Valentine's Day in 1859. KA7CPT will operate from 1700Z to 0300Z on or near 14.280, 21.360 and 28.510. An attractive certificate QSL will be awarded to Amateur contacts who qualify. Send 9 × 12 SASE or $1.00 to Marshall D. McKillip, 1175 NW 128th Street, Portland, Oregon 97229.

FEBRUARY 15, 16: International DX Contest sponsored by the America Radio Club. Contacts with a Club DX Group member must be made during 0400 UTC, February 15 to 2400 UTC, February 16. Suggested frequencies: All authorized frequencies 10, 15, 20 and 40 meters, phone and CW. For a special award send QSL and $2.00 U.S. or 3 IRCs to America Radio Club QSO Contest, PO Box 3576, Hialeah, FL 33013.

PROJECT OSCAR, Inc. is preparing a new set of orbital predictions for the period covering the calendar year 1983. The predictions will provide the UTC times and longitude for all south to north equatorial crossings of AMSAT OSCAR 8 (AO8) and the 4 Russian satellites carrying transponders (RS5, RS6, RS7 and RS8). Minimum donation of $10.00 for mailings to the US., Canada and Mexico ($12.00 overseas). Send your name and address along with a check or money order payable to Project OSCAR, Inc. The donation covers the cost of first class mailing within the U.S., Canada and Mexico and airmail printed matter to overseas destinations. Project OSCAR, Inc., POB 1136, Los Altos, CA 94022.

WOULD LIKE TO GET IN TOUCH with other hams who are involved in emergency services, paid or volunteer, particularly those in emergency medical services (EMS) or those who are EMTs or Paramedics or equivalent. Please contact Jeff Howell, EMT, WB9PFZ, PO Box 463, Madison, IN 47250.

FORMING A NATION-WIDE NETWORK of motorcycling Amateur Radio operators. Anyone interested please check in on 3967 kHz at 0300Z Thursday evenings. Everyone welcome. Please SASE for details. Gary McDuffie, AGØN, Route 1, Box 90-A, Bayard, Nebraska 69334.

WORKSHOP: Personal Microcomputer Interfacing and Scientific Instrumentation Automation. March 21-24, 1983. $595.00. The workshop is hands-on with participants designing and testing concepts with the actual hardware. For more information, call or write Dr. Linda Leffel, C.E.C., Virginia Tech, Blacksburg, Virginia 24061. (703) 961-4848.

ham radio TECHNIQUES

Bill Orr W6SAI

Welcome to the new 10-MHz band! For those contemplating operation on this new portion of the spectrum opened in late 1982 to Radio Amateurs, here's some information that may be of interest.

experimental tests run in 1982

During 1982, several U.S.A. Amateurs had the privilege of conducting tests on the 10-MHz band using experimental licenses. The license is granted under Part 5 of the FCC rules for the Experimental Radio Service. This was not an Amateur license, and communications between experimental stations and Amateur stations were not permitted. Licenses were granted by the Office of Science and Technology of the FCC on proof of necessity, with strict requirements concerning frequency, power output, and operating practices (**fig. 1**).

The purpose of the ensuing tests conducted over a period of a year was to determine the characteristics of the 10-MHz band, to test various antenna designs for the band, and to see if Amateur-style operation was feasible among the various commercial stations occupying the band. Power limit for the experimental stations at first was very low, but was gradually raised as I gained operating experience. Now that the band is open for general operation in the United States, the need for the experimental 10-MHz transmissions has ceased and plans are afoot for investigation of the future 18 and 24 MHz Amateur assignments.

A formal report on 10-MHz experiments will be filed with the FCC, but the investigations of KM2XDW (W6SAI) may be of general interest to the readers of this column.

10-MHz operating conditions

After conducting tests across the United States and receiving overseas reception reports from Europe, Africa, and Australia, aided by hundreds of hours of monitoring the band, I've come to the conclusion that 10 MHz resembles 7 MHz more than it does 14 MHz. Long-distance DX is workable on 10 MHz much as it is on forty. Some mouth-watering signals have been logged: FB8WG, VK9YC, ZS, VK, and ZL, plus stations in Malta, Greenland, the Philippines, Japan, Indonesia, and South America. Over forty-five countries were noted as the year progressed and Amateur activity increased.

Even so, there were long periods of time during daylight hours, particularly in summer, when no signals were heard, aside from the 40-kW RTTY signal of NAA (Cutler, Maine) on 10.130 MHz. Summer static levels were high (compared with 20 meters), and only during hours of darkness was the band open for long-distance communications.

During the winter months, on the other hand, the 10-MHz band opened to Europe, Africa, and South America as early as 2200Z in the afternoon (in California). Most signals were weak, as the DX stations seemed to be running 100 watts or less into makeshift antennas. On the other hand, VK9YC, using 100 watts into

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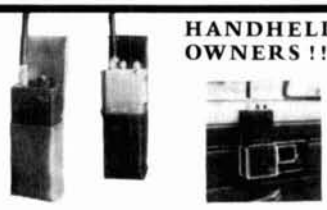

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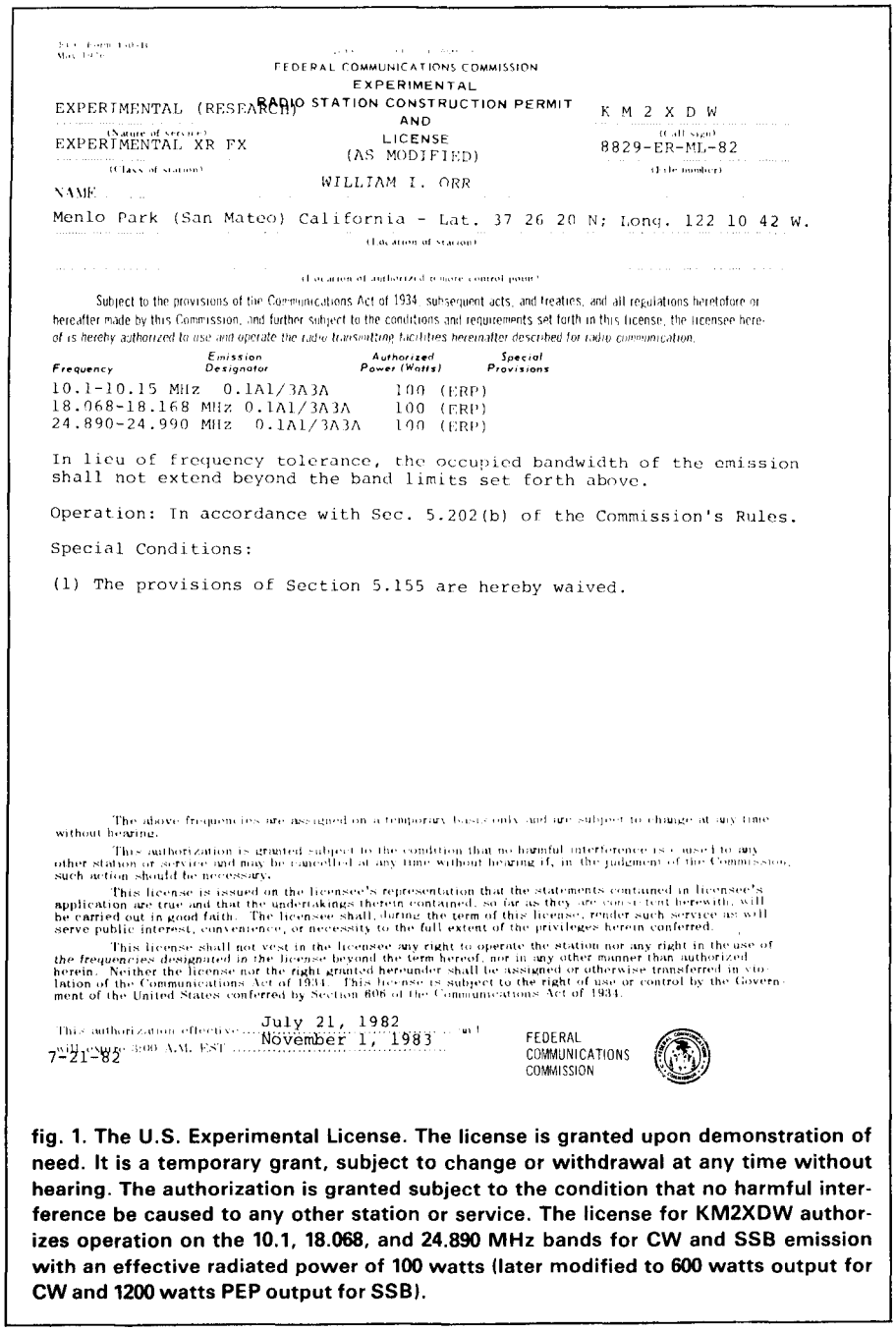

FEDERAL COMMUNICATIONS COMMISSION

EXPERIMENTAL RADIO STATION CONSTRUCTION PERMIT AND LICENSE (AS MODIFIED)

EXPERIMENTAL (RESEARCH) (Nature of service)

EXPERIMENTAL XR FX (Class of station)

K M 2 X D W (Call sign)

8829-ER-ML-82 (File number)

NAME WILLIAM I. ORR

Menlo Park (San Mateo) California - Lat. 37 26 20 N; Long. 122 10 42 W. (Location of station)

(Location of authorized control point)

Subject to the provisions of the Communications Act of 1934, subsequent acts, and treaties, and all regulations heretofore or hereafter made by this Commission, and further subject to the conditions and requirements set forth in this license, the licensee hereof is hereby authorized to use and operate the radio transmitting facilities hereinafter described for radio communication.

Frequency	Emission Designator	Authorized Power (Watts)	Special Provisions
10.1-10.15 MHz	0.1A1/3A3A	100 (ERP)	
18.068-18.168 MHz	0.1A1/3A3A	100 (ERP)	
24.890-24.990 MHz	0.1A1/3A3A	100 (ERP)	

In lieu of frequency tolerance, the occupied bandwidth of the emission shall not extend beyond the band limits set forth above.

Operation: In accordance with Sec. 5.202(b) of the Commission's Rules.

Special Conditions:

(1) The provisions of Section 5.155 are hereby waived.

The above frequencies are assigned on a temporary basis only and are subject to change at any time without hearing.

This authorization is granted subject to the condition that no harmful interference is caused to any other station or service and may be cancelled at any time without hearing if, in the judgement of the Commission, such action should be necessary.

This license is issued on the licensee's representation that the statements contained in licensee's application are true and that the undertakings therein contained, so far as they are consistent herewith, will be carried out in good faith. The licensee shall, during the term of this license, render such service as will serve public interest, convenience, or necessity to the full extent of the privileges herein conferred.

This license shall not vest in the licensee any right to operate the station nor any right in the use of the frequencies designated in the license beyond the term hereof, nor in any other manner than authorized herein. Neither the license nor the right granted hereunder shall be assigned or otherwise transferred in violation of the Communications Act of 1934. This license is subject to the right of use or control by the Government of the United States conferred by Section 606 of the Communications Act of 1934.

This authorization effective July 21, 1982

will expire 3:00 A.M. EST November 1, 1983

7-21-82

FEDERAL COMMUNICATIONS COMMISSION

fig. 1. The U.S. Experimental License. The license is granted upon demonstration of need. It is a temporary grant, subject to change or withdrawal at any time without hearing. The authorization is granted subject to the condition that no harmful interference be caused to any other station or service. The license for KM2XDW authorizes operation on the 10.1, 18.068, and 24.890 MHz bands for CW and SSB emission with an effective radiated power of 100 watts (later modified to 600 watts output for CW and 1200 watts PEP output for SSB).

an inverted-V at about 40 feet, was as regular as clockwork almost every afternoon on the West Coast via the long path. Sometimes he was accompanied by VK6 signals from Western Australia. And these DX catches were mixed in among plenty of signals coming short path from Europe!

In the morning hours, around sunrise, the 10-MHz band was wide open to the Orient. When the Japanese Amateurs were finally allowed on the band, several were heard running only 10 watts into a loaded 20-meter dipole. And a few signals from Indonesia and Australia banged in, too.

Just below the 10-MHz band several out-of-band broadcasting stations in Vietnam could be heard. These served as excellent propagation check points for the Asian opening.

10-MHz antennas

Most of the 10-MHz Amateur stations heard during 1982 used simple makeshift antennas — center-fed antennas, inverted-Vs, long wires, and the like. One Scandinavian Amateur had a large V-beam (intended for 40-meter operation) aimed at the United States, and his signal was an outstanding one from Europe. No doubt some DXer will come up with a 30-meter rotary beam one of these days!

The experimental license afforded me an interesting opportunity to check simple antennas, as there was no interference if the operating frequency was carefully picked. During good conditions, contact could be established from California to New York on 10.125 MHz at almost any hour of the day or night.

Each station had two antennas that could be quickly interchanged — KM2XDW in California had an inverted-V with the apex at about 50 feet and a quarter-wave ground plane whose base was about 12 feet above ground. The ground plane had eight radial wires. These specific antennas were chosen as representative of typical, inexpensive types that were well-suited for 10-MHz service. KM2XDU (W2LX) in New York had a dipole at about 45 feet and a similar ground plane at the same base elevation as that of KM2XDW.

Over the California/New York path the inverted-V and the dipole were invariably better than the ground planes by 3-6 dB. In addition, man-made noise was appreciably lower on the horizontal antennas than the verticals. KM2XDW ran listening tests on European signals and also on VK9YC (Cocos-Keeling Island), and in all instances the inverted-V provided a more readable signal than the ground plane. The conclusion I reluctantly reached was that a ground plane antenna is satisfactory, but a simple dipole or inverted-V whose center is a half-wavelength high, or more, is a better antenna.

Ground conductivity in the vicinity of the station appeared to enter the

picture. KM2XDU (W2LX) seemed to feel that his ground plane was on a par with the dipole as far as reception went. His ground conductivity was very good, with the water table just below the surface. At my station, where ground conductivity is poor, results obtained with my ground plane were not impressive. This points up the interesting idea that good ground conductivity may play a large part in cases where a DXer has had above-average results with a vertically polarized antenna.

point-to-point operation

The frequent schedules between KM2XDU, KK2XJM (Florida), and KM2XDW reminded me that Amateur communications is generally a random operation. It is usually possible to contact somebody somewhere, unless the band has dropped out. Point-to-point operation is entirely different. The stations are locked in a specific route and if that propagation path isn't open, no communication exists, as there isn't anyone else to talk to.

High power and beam antennas can make a questionable path worthwhile. Many times the 100-watt-plus dipole signal of KM2XDU would be running S-zero in California and the 40-kW-plus-beam signal of NAA in Cutler, Maine (not many miles from KM2XDU), would still be very clear at S7 to S9.

Monitoring other foreign Amateurs pointed up the fact that 100 watts and a dipole antenna were sufficient for plenty of good DX operation on 10 MHz, and KM2XDW in California received good reception reports from Europe when running that power level during his one-way transmissions.

SSB or CW on 10 MHz?

The experimental stations had the luxury of running SSB transmissions back and forth, and no problems were encountered. But the practicality of SSB could come into question when the 50-kHz-wide band becomes more populated. How much of the band can be allocated to SSB transmissions? During daylight hours, there's no reason why the whole band can't be opened to SSB as the DX opportunities are few. But at night, when long distance contacts (and long distance QRM) abound, SSB transmission doesn't seem very practical. Perhaps a temporary U.S.A. authorization of SSB transmission from, say, 1400Z to 2200Z may be the answer. Amateurs have never had a general time restriction on a band, and perhaps this is the ideal chance to try one out. In any event, it might be a good idea to avoid contest-style operation on this band, at least until Amateurs get a feel for the operating conditions in this narrow sliver of the spectrum.

the Swiss cheese effect

An interesting "operating hazard" became apparent shortly after the 10-MHz point-to-point tests were started; it was immediately called the Swiss cheese effect. It had been noted before on other bands, but not to the degree apparent at 10 MHz. The effect was simple — during a contact signals would rapidly drop out for a period of seconds or minutes, then build up to normal strength again. The Swiss cheese effect was different from the type of fading normally encountered; it seemed almost as if a hole had opened in the ionosphere and the signals had somehow fallen into it. Sometimes the ionospheric hole lasted for only seconds, at other times it lasted up to three or four minutes.

It has been suggested that the ionospheric hole could be avoided by moving transmitter frequency a few tens of kilohertz, insofar as the hole may be frequency sensitive. Tests are underway to determine if this is so.

If these ionospheric holes exist, they might explain the mysterious and frustrating situation where a DXer seemingly cannot contact a faraway station, when other Amateurs in his vicinity and with comparable equipment seem to work the station with ease.

putting the Collins KWM-2 and S-Line on 10 MHz

Some of the newer pieces of equipment are ready to go on 10 MHz now, or can be put in the transmit mode by a simple modification. Older equipment, however, may take extensive modification to reach the new band.

The Collins KWM-2 and S-Line, happily, fall between these extremes and can be made operative with only a little effort by the owners. The following data applies to the KWM-2 specifically and to the S-Line generally.

For either model, new conversion crystals are required; one for the KWM-2 and two for the S-Line.* The 20-meter range is used for 10 MHz, and I placed the new crystal in the old WWV position (14.8 to 15.0 MHz). This left the 20-meter ham band intact.

It is a good idea to put a small label marked 10.0-10.2 MHz on the bandswitch so you won't get mixed up changing bands. Once the crystal is installed, the exciter tuning control is adjusted to approximately 3.1 and then peaked for maximum background noise. PA tuning is approximately 3.3.

The transmitter is now ready to be tested. Since the output amplifier had been adjusted for 14 MHz operation, it requires some additional tweaking to permit proper loading at 10 MHz. As is, the amplifier stage may be overcoupled to the antenna at 10 MHz and additional output capacitance in the amplifier pi-network is required for efficient operation (**fig. 2**). The capacitors in question are C-155 and C-152 (see instruction manual). These are mica compression types located on the chassis near the two control relays at the rear of the deck. They may be adjusted either from the top or from under the equipment.

Capacitor C-155 is permanently in the circuit and is normally adjusted on the 10-meter range so that the main loading control reads 50 ohms when a 50-ohm load is attached to the antenna receptacle. Capacitor C-152 does the same job on the 20-meter range and is switched into the circuit by

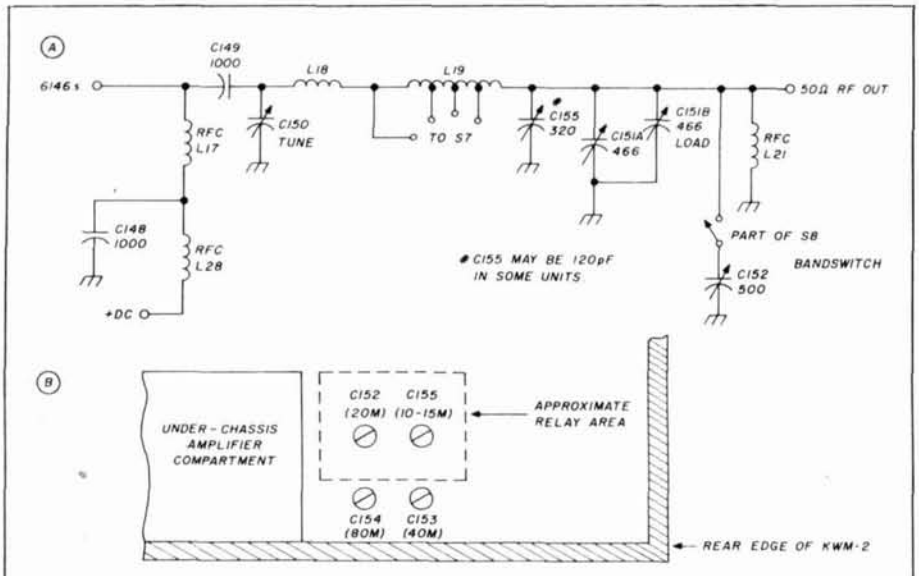

fig. 2. (A) Schematic of the KWM-2 transmitter amplifier stage. (The 32S-3 is similar but component nomenclature may be different, as well as parts placement.) The capacitors to be readjusted for 10-MHz operation are C-152 and C-155, mica compression units mounted on the chassis deck. (B) Under-chassis view of KWM-2 showing placement of compression capacitors near amplifier compartment and rear edge of chassis. Capacitors may be adjusted from above or below the chassis.

segment S-8 of the bandswitch. Note that in some early equipment C-155 may have a maximum value of 120 pF, and in later equipment C-155 may have a capacitance at 320 pF. If yours has the lower value capacitance, it will be very difficult to achieve proper loading on 10 MHz.

In any event, the technique is to increase the capacitance of C-152 to maximum value to achieve proper loading when the equipment is operated on the 30-meter band. If overcoupling still exists, then capacitor C-155 is adjusted to maximum value. (For normal operation on 20, 15, and 10 meters, these capacitors must be returned to their original settings.)

To eliminate the necessity of making these adjustments, an auxiliary loading capacitor may be connected directly across the antenna receptacle of either the S-Line or the KWM-2. A 350-pF broadcast-type capacitor will usually do the job. If additional loading capacitance is needed, a 200-pF, 1-kV mica capacitor can be paralleled with the variable capacitor.

The final stage is to realign the small variable padding capacitors in the receiver rf section for maximum gain at 10 MHz. This may be done by ear. If the 14-MHz setting of these capacitors is marked on the chassis with a pencil, it will be but a matter of seconds to realign the receiver to 14 MHz.

Other equipment, such as Drake, can be placed on the new band with the addition of a conversion crystal. However, it may still be necessary to realign the receiver section for maximum gain at 10 MHz and to determine if the pi-network of the transmitter will load into a 50-ohm system before you go on the new band with your first CQ call.

I'd be pleased to hear from our readers about how they get their equipment working at 10 MHz. If there are any interesting problems, I'll be happy to print them in this column for the benefit of all.

ham radio

*The crystal frequency for the 10.0 to 10.2 MHz range is 13,155.00 kHz (Collins part number 290-9042-000). The crystal can be obtained directly from Rockwell-Collins Service Center, 920 Shaver Road, N.E., Cedar Rapids, Iowa 52498, attention Jim Maccani, WØHUP; telephone 319-395-5391.

the Bobtail curtain and inverted ground plane

part one

History and useful information by the originator of this popular DX antenna

Woody Smith, W6BCX, the originator of the Bobtail Curtain, provides humorous and informative anecdotes on this popular DX antenna, using a Q & A format. Some of our older readers will recognize him as the previous editor of *Radio* (predecessor to *CQ* magazine). This article is well worth reading carefully. **Editor.**

I was flagged down recently at the monthly TRW (Los Angeles) Swap Meet by an old timer I hadn't seen for twenty-five or thirty years.

"Hey, Woody, I'm sure glad you are wearing jumbo call letters. As I recall you used to be pretty sharp on antennas. The wife and I just retired to a place in the country with enough room for me to put up some decent antennas for a change, and I sure need some help.

"Over the last several years I've been reading lots of good things about a 40 and 75 or 80-meter array called the Bobtail Curtain that's supposed to do a real job on DX, and I'm thinking of putting one up for 75 meters. Do you know enough about the Bobtail to answer a couple of questions I haven't found answers to?"

"Well," I replied as I looked away and scraped a circle with my big toe in a futile attempt to feign modesty, "if I can't answer them authoritatively I deserve to be embarrassed. I wrote the original article on the Bobtail, back in 1948."

"Nineteen hundred *what* did you say?"

"It appeared in the April, 1948 issue of *CQ* under my name, with the title 'Bet My Money on a Bobtail Beam,'" I added. Then, seeing as how he was duly impressed with my credentials, I proceeded to answer his questions, all of which I had been asked before at one time or other.

Because certain questions have kept recurring over the years, a recap of those particular questions along with brief answers would seem to be in order. Also included are historical data on the evolution of the Bobtail from the inverted ground plane (IGP). The IGP has not received the recognition and popularity it deserves as a highly effective 40 and 75-meter omnidirectional antenna for long-haul DX. Then, for the benefit of those who always like to know all about the why, some additional details and information will appear in Part II of this article.

basic Bobtail Q & A

Q. My 40-meter Bobtail does an amazing job on DX compared to my old antenna, but I don't have room for a 75-meter Bobtail. What if I put up only half a Bobtail on 75, with two tails instead of three? How should I feed it?

By Woodrow Smith, W6BCX, 2117 Elden Avenue, Apt. 20, Costa Mesa, California 92627

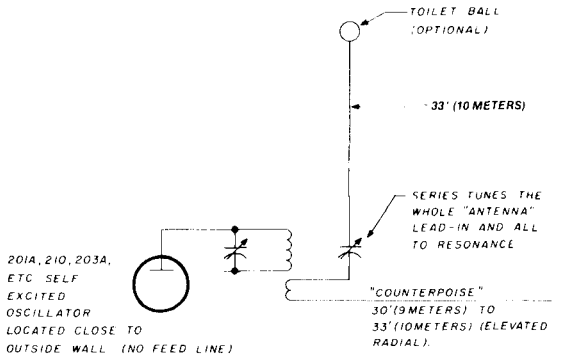

fig. 1. This simple 30 up and 30 out was responsible for lots of real DX on 40 back in the good old days. The copper toilet ball often was employed by the superstitious as a DX talisman (and by the author just for insurance). In 1928 the single-wing radial, then called a counterpoise, frequently was engineered to be about clothesline high (no driers in those days).

A. The three-element version is the elegant version, with better suppression of end-fire high-angle lobes from the horizontal section as compared to a two-element version without end radials. If end radials (extending out beyond the vertical elements) were employed on a two tailer, the horizontal space taken up would be the same as for the standard three-element Bobtail. A two-tailed version, by the way, actually is two-thirds of a three element, not half.

For gain, the two-tailed version without end radials (nowadays sometimes referred to as the half square, per K3BC) is nearly as good as the three tailer if properly fed. I'm partial to feeding the bottom of either leg via a resonant tank. Refer to the answer to the third question regarding coax feed.

Q. I'm going to have trouble getting poles up high enough on 75 meters. Can I cut off 15 or 20 feet from the tails of a 75-meter Bobtail by inserting loading coils in each tail near the bottom? If so, how far up should they be placed?

A. Yes, go ahead. On 75 I would place the coils up about 5 or 6 feet from the bottom. Don't shorten the poles and the tails any more than you have to, or the business part (top) of the vertical radiators won't be able to "see out" as well. Construction of suitable loading coils will resemble good quality trap coils. Any loss in performance other than a slight reduction in bandwidth will be a result of the lower antenna height. There will be very little loss in gain when using coils if the Q is reasonably good.

On 40 meters I see no excuse for loading coils. I would use poles at least 40 feet high so the current loops are well up off the ground, With poles this high on 40, no loading coils are required. If nearby buildings are more than one story, still higher is better yet. Keep in mind that the tops of the vertical elements always like it better when they can see out.

Q. Why can't I just feed one of the current loops of a two-tail Bobtail with coax? How well will it match 50 ohms?

A. You can feed it that way, and it will work, and the VSWR will be tolerable. The coax should be brought down at a 45-degree angle *toward the center*, not to the side or outside, until at ground level. Then take it where you want. There is no way to dress the coax that will avoid completely all undesirable coupling to the far side of the antenna, and this will result in some antenna effect on the coax. Fortunately, it will not be bad enough to cause serious problems. Unfortunately, coax will not work satisfactorily at half or twice frequency.

Q. When three vertical elements are used with bottom feed of the center element, how does the current compare in the three elements? Is it the same in all three, or twice as high in the center element? Or something in-between? I've heard arguments about this.

A. Intuitively one might conclude that the current distribution is 1-2-1 (binomial). But I learned long ago to be wary of deductions that are immediately obvious. What if the complex mutual impedances existing between the various elements should produce a significant effect upon the current distribution? These impedances and the net effect are quite difficult to calculate. The original article stated simply that the current is considerably greater in the center element. Measurements taken subsequently with the aid of a spotting scope confirmed that the distribution in a typical installation *approaches* 1-2-1.

Q. In your *CQ* article and in the description of the Bobtail in your book *The Antenna Manual* you show inductive (link) coupling between the feedline and the parallel resonant matching tank that voltage feeds the driven element. Can't I just use a variable tap instead, or maybe a tapped L-network? It would be easier to adjust than a link.

A. Inductive coupling was chosen primarily to cut down on possible receiver front-end overload and cross modulation. A 40-meter three-element Bobtail looks like a big omniverous Marconi to 160-meter and broadcast-band signals. If you don't have any 160-meter friends nearby or any high power a-m broadcast stations within a few miles, you should have no trouble using a tank or L-network with a variable tap on the coil (in lieu of the inductive link). You can always add a 50-ohm highpass filter designed for about

2500 kHz cutoff if you do happen to come up with a cross-modulation problem.

Q. In your description of the Bobtail Beam in the *Antenna Manual*, but not in your *CQ* article, you mention the use of a small ground screen under the bottom end of the driven element. How important is this? What are the benefits?

A. Such a screen makes a highly effective rf ground, much better than something buried in or driven into the soil, for a ground-independent antenna (meaning one which has little current flowing to ground or ground substitute at the feedpoint). The Bobtail falls in this category. Resonant radials above ground get in the way, are not required for efficient operation of a Bobtail, and may actually upset the pattern under some conditions.

An earth ground is useful primarily for lightning protection, and even if one is employed near the feedpoint for this purpose, a small ground screen in addition is recommended. Grounding considerations are covered in more detail in connection with further discussion of feed methods.

evolution of the Bobtail

The Bobtail may be considered as a broadside array of co-phased quarter-wave radiating elements configured as inverted ground planes. Let's start this Bobtail discussion with a review of the inverted ground plane before progressing to an array using them.

If you have trouble accepting a ground plane with only one radial, don't. Maybe the definition of ground plane has to be stretched a bit, but in the late 1920s (with some still in use in the early 1930s) there was a widely used 40-meter DX antenna often referred to as the 30-30 (**fig. 1**) which could be considered a ground plane flying on just one wing. It used a vertical quarter-wave radiator in conjunction with a neck-high quarter wave horizontal counterpoise which was nothing more than a single above-ground radial.

When the hams moved from 160 meters to 80 and then to 40, the easiest thing to get going in a hurry was a scaled-down antenna-counterpoise arrangement used on the lower bands. Usually the 30-foot radiator and the 30-foot counterpoise were brought in directly to the rig, placed by a window to keep the inside leads short. Feedline? Who needs a feedline? The overall length, with a sum total of about 60 feet outside, was just about right for series tuning to resonance by means of a variable capacitor, more often known in those days as a variable condenser.

Sometimes a copper toilet ball was placed atop the vertical radiator as a combination DX good luck charm and top-loading capacitance that substituted for the multi-wire flat top on a 160-meter Marconi. One big gun DXer claimed it put some kind of DX English on the radiated wave, while the small-caliber crowd always looked to see if he had tongue in cheek. Yes, I used a copper toilet ball. Just in case. No use taking any chances. Besides, nobody had proved yet that the ball did not do any good.

Don't ever pooh-pooh this venerable antenna, because its record of DX worked on 40 speaks for itself. Back in the late '20s a local ham friend worked (QSL confirmed) what was then Madagascar, now Malagasy Republic, on 40-meter CW a half hour before local sunset, running about 50-watts input. Yes, he did it with his trusty 30-30, complete with toilet ball. The rig used a 210 7-1/2 watt triode in a self-excited oscillator, and except for tube type, was typical of perhaps half the CW rigs on the air. Not too shabby from California, even if conditions did happen to be especially good at the moment. From a decent location and with good conditions such results then were commonplace enough with a 30-30 to be considered only slightly amazing.

Actually, the old 30-30 corresponds to a modern trap vertical that uses about 30 feet of effective vertical radiator on 40 meters working against an above-ground resonant radial. The toilet ball, when used, did add to the effective height, but without a loading coil probably not very much.

the center-tapped Windom

While the 30 up and 30 out was popular as a simple yet effective 40-meter DX antenna, the traffic and rag-chewing crowd on 40 had their very own favorite for short- and medium-haul work. This was the single-wire-fed Hertz, oriented horizontally at 30 to 40 feet. Its performance out to several hundred miles was such that its popularity and reputation were well deserved. And it was the ultimate in simplicity.

The antenna first got media attention in an article by Williams, 9BXQ (no W prefix back then), appearing in the July, 1925, issue of *QST*. This was followed by several others over the next few years.

As the name implies, this dipole antenna was fed by a single wire attached to a super-magic point on the dipole between 1/7 and 1/6 of the antenna length from the center. The exact point for minimum VSWR varied with feeder and antenna wire sizes and with surrounding objects, particularly ground.

This does minimize standing waves on the feeder, often bringing the VSWR very close to 1.0 if the dipole length also is correct. But contrary to a misconception widely held at the time (and still somewhat prevalent), unity VSWR does not eliminate radiation from (and pick-up by) the single-wire feeder.

Reduce radiation and pick up? Yes, some. Eliminate it? No. We have simply converted the line to a

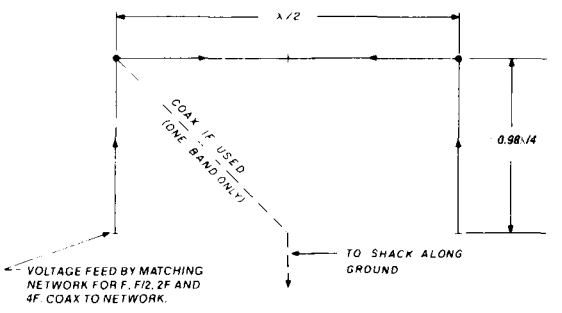

fig. 2. The old 30-30 works even better upside down. When inverted, two can be tied together as shown and voltage fed at one end to make an effective broadside curtain for DX. This elementary Bobtail, or half square did not stir up much interest back in 1948 because it looked too simple, but lately has received a lot of favorable attention.

traveling wave radiator (antenna). Minimizing the VSWR alters the pattern of radiation from the feedline somewhat, and reduces but by no means eliminates the net feedline radiation and pickup.

By 1929, enough conflicting information was floating around on the proper method of arriving at the magic tapping point for the feeder that Loren Windom, W8GZ, was prompted to write what has become a classic article on the subject. The article appeared in the September, 1929, issue of *QST*, and made it unnecessary to fret or argue over the subject any further.

Remember the Yagi-Uda situation, where the English-speaking Mr. Yagi (later Dr. Yagi) made it very clear in his classic 1928 IRE Proceedings paper that he was merely reporting on the work of Professor Uda, who had developed a clever new parasitic array a couple of years before? Well, the same thing happened with the single-wire-fed Hertz. Much of the early work was done at Ohio State University, and W8GZ gave them full credit. W8GZ made it very clear that he was acting solely as a reporter and was claiming no credit for collaborating on the actual development.

Nevertheless, over the years the single-wire-fed Hertz became better known as the Windom. In fact, in Great Britain it was generally referred to as the Windom almost from the day the article by W8GZ first appeared. Dr. Hideji Yagi, meet our Mr. Loren Windom, another reporter on antenna developments. He, too, unwillingly became world famous for an antenna he did not develop or invent.

Back when horizontal Windoms were common, an acquaintance of mine with one at 40 feet kept insisting that he could raise DX easier if he changed the match by sliding the tap a bit toward the center. He wondered if there were some easy way to figure out where the optimum DX tap should be attached without moving it a few inches at a time and comparing results (not too practical).

At first he thought I was kidding when, after getting suspicious as to what actually was going on, I suggested he move the tap to the exact center and see what happened. How about dropping the feeder straight down for about 33 feet, then cut it there and voltage-feed the bottom end with the Zepp feeders he had saved when he converted his Zepp to the Windom?

About a week later he called me breathlessly to announce that the new antenna was working so well that over the weekend he worked some new countries. He would have phoned me sooner except that he was too busy working DX, he explained.

upside down is better

On-the-air tests showed that this inverted configuration of what today would qualify as a two-radial ground plane consistently outperformed typical 30-30 installations on long-haul DX. Subjectively the improvement appeared to be at least a full S unit (then called an R unit).

Tests run more recently confirm that there is only one way to get a regular ground plane to perform as well as an inverted one. That is to get the whole ground plane up in the air where it is well removed from ground and pretty much in the clear. But on 40 and particularly on 75/80 meters this seldom is feasible.

Pat Hawker, G3VA, editor of the RSGB (Great Britain) book *Amateur Radio Techniques*, long ago recognized the advantages of turning a ground plane upside down at high frequency. For years Pat has been hawking (excuse me, *extolling*) the merits of the inverted ground plane for DX in his book.

the Bobtail takes shape

When it came time for me to get something back on the air after WW2, I recalled the results obtained from an inverted ground plane on 40-meter DX, and got to wondering: Is there something I could squeeze on my lot that would do a better job on 40-meter DX than an inverted ground plane? How about two of them in phase (**fig. 2**), oriented so the bidirectional pattern would cover the most important geography? How about using only one radial for each vertical element and bringing the radial ends together so that only two poles would be required? The half-wave spacing would be just right for broadside (in phase) operation of the vertical elements. And the voltage and phase at the tips of the two upstairs radials would be the same and therefore could be joined.

The antenna now would resemble nothing more than a bent fullwave antenna; so it should be possible to get away with feeding only one end (either end). The radiation from the two halves of the horizontal section should cancel well enough that the spurious end-fire lobes from the horizontal section don't represent much wasted power. Receiving, these minor lobes are going to pick up off-axis QRM, but it shouldn't be too high a price to pay for such simplicity.

With the project barely past the bill of materials stage, came an unsurmountable obstacle: I would be moving. There was nothing to do but abandon the project. The trouble was that having gotten all steamed up about the new brainchild, I just couldn't stand not having somebody, *anybody*, put one up to confirm my expectations. So I approached some of the local DX, golf, fishing, and self-styled world-class antenna experts and tried to interest at least one of them in putting up a 40-meter job.

Sad to relate, the very simplicity of the antenna turned out to be my undoing. No takers, even when I offered to help put one up. Their reaction was unanimous. They patiently pointed out to me that, as any fool could plainly see, no antenna that simple could possibly be much good, especially when it is upside down with the counterpoise on top. Obviously, if anything as simple as a bent piece of wire could be all that wonderful on DX, everybody would be using one.

How about enticing them with a more elegant version I had been thinking about. It would perform only slightly better and would require 50 percent more room, but would appear to be more sophisticated, more complicated, and more elegant looking. It definitely would not look like a bent piece of wire. How about adding a vertical element and feeding the bottom of the center one? It would produce only slightly more gain, but a cleaner pattern. More important at the moment, it would certainly be more impressive-looking when sketched.

Fortunately it did turn out to be easier to sell. I quickly got a willing customer who had room for a three-element 40-meter job. Thus, the Bobtail was born (see **fig. 3**).

When he reported back to me on its DX performance, he kept using the words phenomenal, fantastic, etc., ". . . especially beyond 2500 miles when compared to my old antenna."

As a result of his plugging it over the air, I started receiving requests for information. To cut down on this I decided to write an article describing the antenna. When I contacted the editor of *CQ* about a Bobtail article, I recounted my lack of success in stirring up interest in a simple, two-element version. We decided not to include the two-tailer, but possibly make it the subject of a follow-up article.

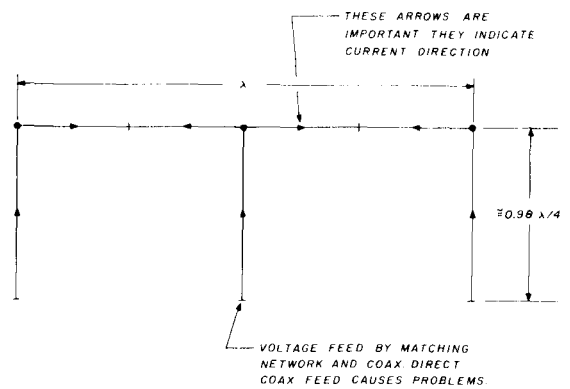

fig. 3. The classic three-element or elegant Bobtail provides better cancellation in the horizontal portion, resulting in less short-haul QRM when trying to receive weak DX. But it takes up more room (usually too much for 75 and 80 meters).

The Bobtail with its three elements looked intriguing enough in the published article to inspire some readers with room to put one up to action. Then among some fan mail and requests for more information appeared a couple of surprises. Two correspondents advised me independently a few days apart that to get a Bobtail to fit their lots they had gone ahead on their own and made it more compact. Both did it by using two instead of three elements, and feeding one end of what was left. Both correspondents were quick to add that their simplified versions worked just great, gave fantastic results, etc., etc. "Just thought you might like to know."

I wrote them indicating I was glad to hear that their chopped Bobtails were doing such a good job, and congratulated them on their ingenuity. Somehow I felt it would appear pretentious of me to write an article on my truncated Bobtail, so never did.

Thanks to Ben Vester, K3BC, for seeing that it finally got some favorable publicity ("The Half-Square Antenna," *QST*, March, 1974). And speaking of the Half Square, Ben's designation certainly is tidier and more descriptive than something like Two-Element Chopped Bobtail Curtain.

Part II will include, among other things, quantitative information on the gain of the Bobtail and Half Square (both free-space theoretical and real world practical DX-signal gain), multi-band operation and performance, more information on feed methods, construction considerations, and some dimensions for 10-MHz Bobtails.

ham radio

learning Morse

When we learned the Morse code, state-of-the-art was memory, and pencil and paper exercises: A- didah; B- dadididit. Over the past few years, records and tapes have come into vogue as learning aids. Now there are microcomputers which do the same. The Morsetalker MMS-1 from Spectrum International is one of these.

This interesting microprocessor-based device is a self-contained random Morse generator that incorporates a speech synthesis system. The MMS-1 has a speed range of 2 to 20 WPM in 2-WPM increments, and character group lengths of one, five, and fifty letters, before talkback. The unit is designed to work at six different learning levels: letters A-F; A-M; A-U; and A-Z; numbers only 0-9; and all letters and numbers combined.

The MMS-1 is designed to use the current teaching philosophy of sending at high speed with long spacing between letters. A crystal oscillator is used as a reference to ensure that all characters are sent and spaced accurately. For the more advanced Amateur, a high speed option is available to increase the speed range of the MMS-1 to 12-48 WPM in 4-WPM increments.

Using the MMS-1 is very easy. Push buttons are used to select character range, group length and speed, with LEDs indicating group length and speed. Once you have made your selection, push the go-stop button and you're all set to start.

There are a few minor drawbacks to the MMS-1. You cannot alter pitch or volume, and the speaker is located on the bottom of the diecast aluminum box. In a noisy environment it is sometimes hard to hear the MMS-1.

The MMS-1 will be particularly interesting to groups and clubs looking for help with code instruction. Students can sit down with the MMS-1 without a teacher's assistance, and program the unit at any level they are comfortable with.

For more information, contact Spectrum International, Inc., Box 1084, Concord, Massachusetts 01742. Reader Service Number 013.

the editors
ham radio

ergonomic comfort chair

Charvoz-Carsen announces the Charvoz Dauphin CRT Chair G1500 for the Amateur Radio, home video game, and computer enthusiast. This new ergonomic chair features five functions for those who spend long hours at play or work in a sitting position. The pneumatic finger-tip controls allow the user to adjust his seated position for maximum comfort with full freedom of movement.

These chairs are designed in Italy for beauty and West German engineered for years of trouble-free enjoyment. Seats move up and down as well as tilting forward; the backrest goes up and down and inclines gently to match your lumbar/lower back needs. The backrest also tilts automatically with your back movement. This chair features the built-in lumbar-comfort support, five point star base and enclosed back-shell for added beauty.

Five fabric colors and open or closed armrests are available. For more information, contact Pat Gusoff, Charvoz-Carsen, 5 Daniel Road East, Fairfield, New Jersey 07006; telephone 201-227-6500. Reader Service Number 084.

coded squelch test unit

Ferritronics, Inc., announces the new TU-100 Coded Squelch Test Unit. The TU-100 is a microprocessor-based instrument designed to aid technicians in testing and troubleshooting sub-audible encoder and decoder circuits.

In addition to EIA CTCSS tones, the test unit works with digital codes compatible with Digital Private Line, Digital Channel Guard, Digital Quiet Channel, Digital Call Guard, etc. Used in conjunction with a monitor receiver, the test unit may be used to police shared repeaters, select unused

codes and identify unknown codes right off the air.

The TU-100 is highly portable in a durable ABS plastic case with retracting carrying handle, has a Ni-Cd battery pack, and weighs in under four pounds. For more information, contact Ferritronics, Inc., 1319 Pine Avenue, Niagara Falls, New York 14301; telephone 800-828-6884/New York: 716-282-7470. Reader Service Number 011.

Guild radio rack

New for hams is the Guild Radio Rack. The Guild Rack comes in fin-

ished solid ash. No assembly is required. Guild's radio rack comfortably holds Kenwood's TS830S/VFO230/SP230 or TS820 series, and any similar rigs. Exact measurements are: overall 16-7/8 × 14-3/4 × 14-1/2 inches, top compartments 7-1/2 × 6 inches, bottom compartment 15-5/8 × 7 inches, and it's fully vented.

The Guild Radio Rack has a suggested retail price of $59.95. For more information, contact Guild Radio Rack, 225 West Grand St., Elizabeth, New Jersey 07202; telephone 201-351-3002. Reader Service Number 086.

low-cost wind power

The TC25WG Helius Rotor Kit was developed as a low-cost battery charger for remote sites. Applications

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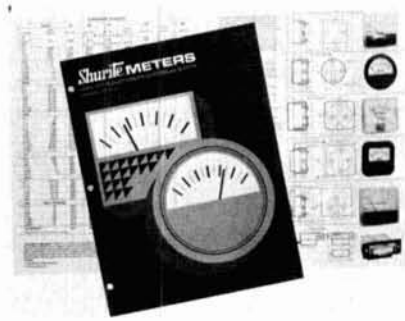
include power for camping, boats, radio operation, RVs, cottages, experimentation, and emergency situations. The patented Helius design responds to winds from any direction and is self-starting. The TC25WG rotor operates at low RPM and avoids overspeed problems common in propeller designs. Virtually no maintenance is required and the tough Lexan vanes resist sun, snow, sleet, and extreme temperatures. Assembly is easy with regular hand tools. The complete rotor kit costs $479, including detailed manuals. A free information package is available from Thermax Corporation, One Mill Street, Burlington, Vermont 05401. Reader Service Number 088.

panel meter brochure

Shurite Meters' free brochure offers a choice of more than 260 standard-range ±5 percent accuracy instruments. A standard-range chart shows range, resistance, and stock numbers in vertical columns, as grouped in five major product categories. The horizontal section of the matrix shows dc microammeters, dc milliammeters, dc voltmeters, ac milliammeters, ac ammeters, and ac voltmeters.



Other contents show specifications, standard options, outline drawings, custom dials and special ranges. Line voltage testers and battery testers round out this catalog.

For further information, write to

Shurite Meters, Inc., 577 Grand Avenue, P.O. Box 1848, New Haven, Connecticut 06508-1848; telephone 203-624-1188. Reader Service Number 087.

small receiver

The Comer Communications R30K is an extremely small general coverage communications receiver, measuring only 2 × 4 × 6 inches. Despite this small size, the R30K performs as well as receivers eighteen times larger. Frequency coverage is from 50

kHz to 30 MHz, and selection is by means of a five-digit push wheel switch giving 1 kHz resolution. A VFO is provided to interpolate between the 1 kHz steps.

Reception modes are AM, LSB, USB, and CW. The receiver operates from a nominal 13.8 Vdc supply and requires an external loudspeaker or headphones. A connector has been provided at the rear of the unit with outputs from the first, second, and carrier oscillators, and also with an input/output of the AGC line.

The receiver is a dual-conversion superheterodyne with a high first i-f. Frequency control is by means of a fully digital dual loop frequency synthesizer. Selectivity is obtained by six-pole crystal filters giving 2.4 kHz on SSB and 6 kHz on a-m. The use of modern high-level integrated circuit mixers give the receiver a very respectable dynamic range while holding the power consumption to a very reasonable level. Normal fast attack fast release AGC is used on a-m, while a fast attack, slow decay, with one-second hold on no signal AGC system is used on SSB. The audio output provides 5 watts at 5 percent distortion to give good results in a

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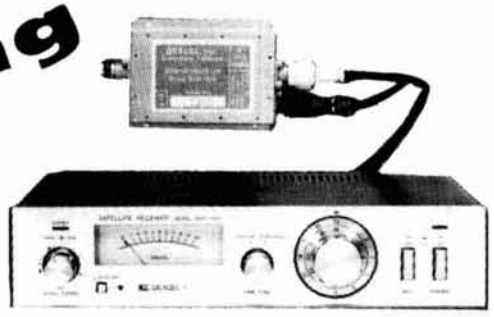

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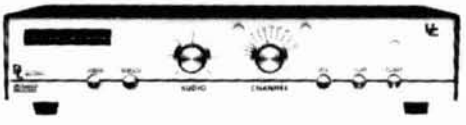

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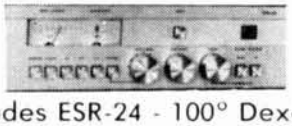

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- **Dual digital VFO's.**
  10-Hz step dual digital VFO's include band information. Each VFO tunes continuously from band to band. A large, heavy, flywheel type knob is used for improved tuning ease. T.F. Set switch allows fast transmit frequency setting for split-frequency operations. A=B switch for equalizing one VFO frequency to the other. VFO "Lock" switch provided. RIT control for ±9.9 kHz.
- **Eight memory channels.**
  Stores both frequency and band information. VFO-MEMO switch allows use of each memory as an independent VFO, (the original memory frequency can be recalled at will), or as a fixed frequency. Internal Battery memory back-up, estimated 1 year life. (Batteries not Kenwood supplied).
- **Dual mode noise blanker ("pulse" or "woodpecker").**
  NB-1, with threshold control, for pulse-type noise. NB-2 for longer duration "woodpecker" type noise.
- **SSB IF slope tuning.**
  Allows independent adjustment of the low and/or high frequency slope of the IF passband, for best interference rejection. HIGH/LOW cut control rotation not affected by selecting USB or LSB modes.
- **CW VBT and pitch controls.**
  CW Variable Bandwidth Tuning control tunes out interfering signals. CW pitch controls shifts IF passband and simultaneously changes the pitch of the beat frequency. A "Narrow/Wide" filter selector switch is provided.
- **IF notch filter.**
  100 kHz IF notch circuit gives deep, sharp, notch, better than -40 dB.
- **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 indicatior 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 intelligibili
- **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 I 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 (tempera ture compensated crystal oscillator). Requires modifications.
- MC-60A deluxe desk microphone with UP/DOWN switch, pre-amplifier, 8-pin plu
- TL-922A linear amplifier (not for CW QSK
- SM-220 station monitor (not for pan-adap
- 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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