$1.50

ham radio magazine

JUNE 1978

RTTY SELCOM

HALF A CENTURY OF SERVICE

Fifty years ago in 1928, Henry Radio first offered to help amateur radio operators solve their communications problems. Today Amateurs, not only in the United States but throughout the free world, still look to Henry Radio as their pre-eminent supplier of fine communications equipment.

Fifty years is a long time in the life of an individual. It is a long time in the history of amateur radio. So we are proud to be celebrating our fiftieth anniversary of service to Amateur Radio. We believe it says something important about Henry Radio and about the pioneering contributions we have made to our industry.

From the begining, we offered personalized service. Service that recognized that every person's needs were as individual as each person is unique.

We were the first to offer low cost time sales of Amateur equipment. We were among the first to trade for used equipment. Even then we had an expert service department to assure that each piece of equipment operated the way it should. We pioneered "satisfaction guaranteed" and the ten day free trial policy. Then as now we recognized our obligation to provide amateurs everywhere with fine equipment and good service.

At Henry Radio we don't know any other way of doing business. Since we have been active amateurs for all these years, we know the correct answers when we ask ourselves, "Is this the way I would want to be served if I were a customer of Henry Radio?".

Looking back, 50 years seems a long time. Looking ahead we feel like eager youngsters impatient to know the exciting new experiences that the next 50 years will bring. Eager to help our amateur friends all over the world share the unique communication thrills that only amateur radio can provide.

May we help you?

Ted Henry

Mary E. Silva
W6VWL

Meredith Henry
W6WNE

Bob Henry
W0ARA

Ted S Henry
W6YEY

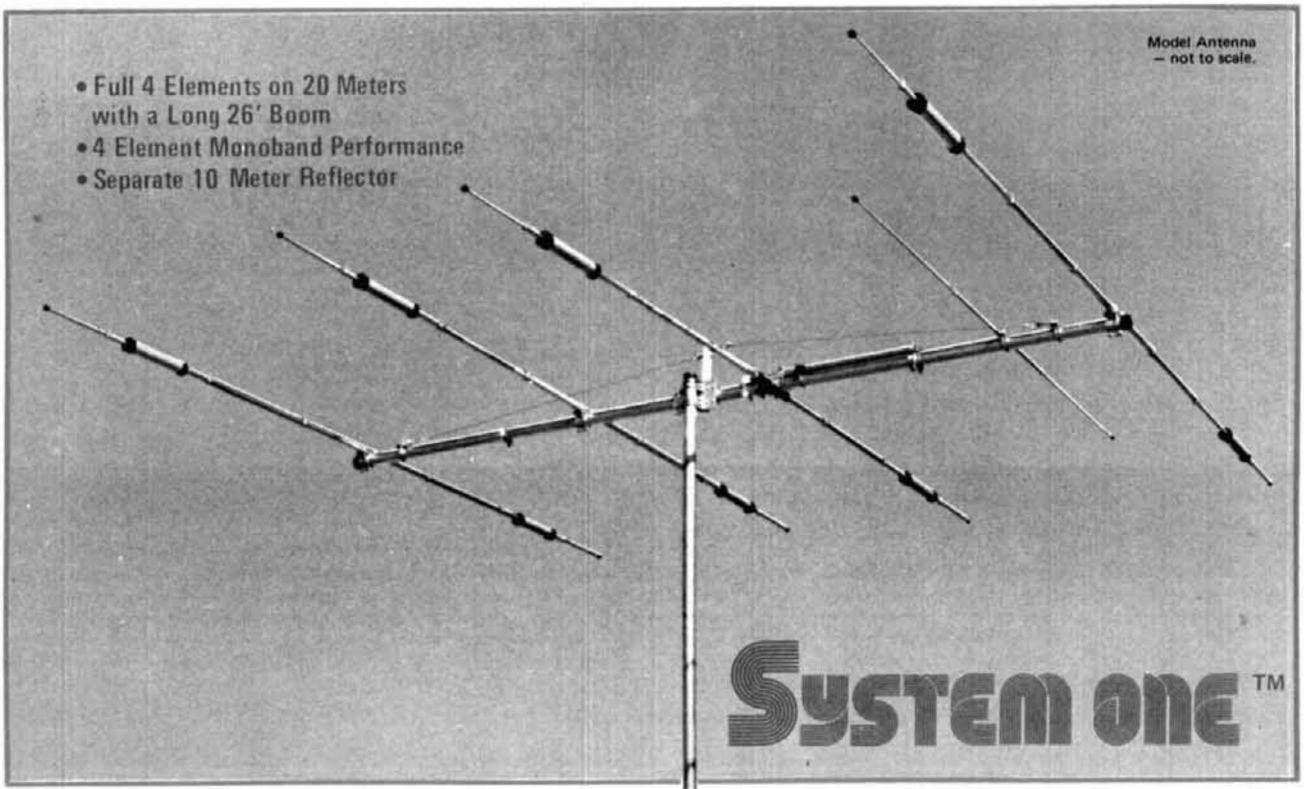
Walt Henry
W6ZN

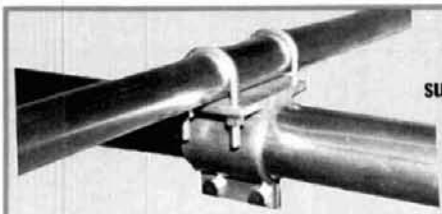
Henry Radio

11240 W. Olympic Blvd., Los Angeles, Calif. 90064 213/477-6701
931 N. Euclid, Anaheim, Calif. 92801 714/772-9200
Butler, Missouri 64730 816/679-3127

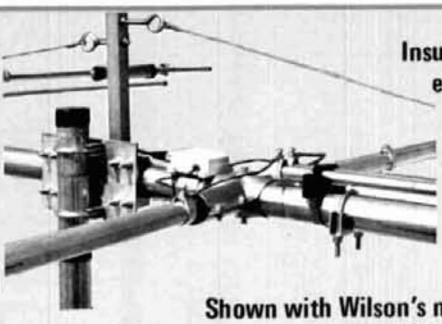
THE NEW INDUSTRY STANDARD OF PERFORMANCE . . . IS THE Wilson SYSTEM ONE!

A DX'ers delight operating 20 meters on a full 26' boom with 4 elements, 4 operational elements on 20-15-10, plus separate reflector element on 10 meters for currect monoband spacing. Featured are the large diameter High-Q traps, Beta matching system, heavy duty taper swaged elements, rugged boom to element mounting . . . **and value priced!** Additional features: • SWR less than 1.5 to 1 on all bands • 10 dB Gain • 20-25 dB Front-to-Back Ratio.





The mechanically superior construction uses heavy duty boom to element extrusion.



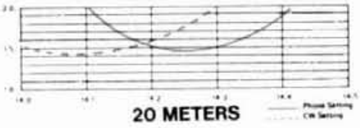
Insulated driven element with precision Beta match and heavy duty element mounts.

Shown with Wilson's new optional Toroid Core BN-50-A Balun.

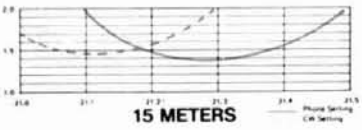
Advanced design large diameter High-Q Traps for minimum loss and maximum power capacity

SPECIFICATIONS: SY-1

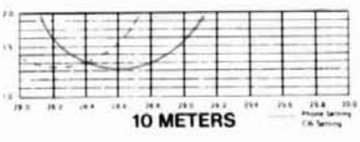
Matching Method	Beta	**Boom Length**	26'	**Required**	
Band MHz	14-21-28	**Boom Diameter**	2" O.D.	**Mast Diameter**	2" O.D.
Maximum Power Input	Legal Limit	**No. of Elements**	5	**Surface Area**	8.6 sq. ft.
VSWR (at Resonance)	1.5 to 1	**Longest Element**	26' 7"	**Windload at 78 mph**	215 lbs.
Impedance	50 ohms	**Turning Radius**	18' 6"	**Shipping Weight**	65 lbs.
Gain	10 dB	**F/B Ratio**	20-25 dB	**UPS Shipment in 2 Cartons**	



20 METERS



15 METERS



10 METERS

DEALERSHIPS AVAILABLE!!!

We are looking for new Dealers for certain areas of the country. If you are interested, contact us for details.

Wilson Electronics Corp.

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Phone (702) 739-1931 • Telex 684-522

This NEW MFJ Versa Tuner II . . .

has SWR and dual range wattmeter, antenna switch, efficient airwound inductor, built in balun. Up to 300 watts RF output. Matches everything from 160 thru 10 Meters: dipoles, inverted vees, random wires, verticals, mobile whips, beams, balance lines, coax lines.

BRAND NEW

$79.95

Antenna matching capacitor. 208 pf. 1000 volt spacing.

Sets power range, 300 and 30 watts. Pull for SWR.

Meter reads SWR and RF watts in 2 ranges.

Efficient airwound inductor gives more watts out and less losses.

Transmitter matching capacitor. 208 pf. 1000 volt spacing.

Only MFJ gives you this MFJ-941 Versa Tuner II with all these features at this price:

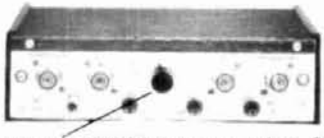
A SWR and dual range wattmeter (300 and 30 watts full scale) lets you measure RF power output for simplified tuning.

An antenna switch lets you select 2 coax fed antennas, random wire or balance line, and tuner bypass.

A new efficient airwound inductor (12 positions) gives you less losses than a tapped toroid for more watts out.

A 1:4 balun for balance lines. 1000 volt capacitor spacing. Mounting brackets for mobile installations (not shown).

With the NEW MFJ Versa Tuner II you can run your full transceiver power output — up to 300 watts RF power output — and match your transmitter to **any** feedline from 160 thru 10 Meters whether you have coax cable, balance line, or random wire.



ANTENNA SWITCH lets you select 2 coax fed antennas, random wire or balance line, and tuner bypass.

You can tune out the SWR on your dipole, inverted vee, random wire, vertical, mobile whip, beam, quad, or whatever you have.

You can even operate all bands with just one existing antenna. No need to put up separate antennas for each band.

Increase the usable bandwidth of your mobile whip by tuning out the SWR **from inside your car.** Works great with all solid state rigs (like the Atlas) and with all tube type rigs.

It travels well, too. Its ultra compact size 8x2x6 inches fit easily in a small corner of your suitcase.

This beautiful little tuner is housed in a deluxe eggshell white Ten-Tec enclosure with walnut grain sides.

SO-239 coax connectors are provided for transmitter input and coax fed antennas. Quality five way binding posts are used for the balance line inputs (2), random wire input (1), and ground (1).

$59.95

BRAND NEW

MFJ-901 VERSA TUNER

New efficient air wound coil for more watts out.

Only MFJ uses an efficient air wound inductor (12 positions) in this class of tuners to give you more watts out and less losses than a tapped toroid. Matches everything from 160 thru 10 Meters: dipoles, inverted vees, random wires, verticals, mobile whips, beams, balance lines, coax lines. Up to 200 watts RF output. 1:4 balun for balance lines. Tune out the SWR of your mobile whip **from inside your car.** Works with all rigs. Ultra compact 5x2x6 inches. SO 239 connectors. 5 way binding posts. Ten Tec enclosure.

$49.95

BRAND NEW

MFJ-900 ECONO TUNER

Same as MFJ-901 Versa Tuner, but does not have built-in balun for balance lines. Tunes coax lines and random lines.

$39.95

MFJ-16010 RANDOM WIRE TUNER

Operate 160 thru 10 Meters. Up to 200 watts RF output. Matches high and low impedances. 12 position inductor. SO-239 connectors. 2x3x4 inches. Matches 25 to 200 ohms at 1.8 MHz.

$39.95

BRAND NEW

MFJ-400 8043 ECONO KEYER

MFJ brings you a reliable, full feature economy keyer using the famous CURTIS-8043 keyer-on-a-chip.

Panel Controls: Speed (8 to 50 WPM), pull-to-tune; volume, on-off; 3 conductor, ¼ inch phone jack for keying output and key paddle input.

Internal weight control lets you adjust dot-dash-space ratio for a distinctive signal to penetrate QRM for solid DX contacts. Sidetone and speaker. Internal tone control.

Iambic operation with squeeze key. Dot memory. Instant start. Self completing. Jamproof spacing. Reliable solid state keying: grid block, cathode, solid state transmitters (−300V, 10 ma. max. and +300V, 100 ma. max.).

For Orders Call toll-free 800-647-8660

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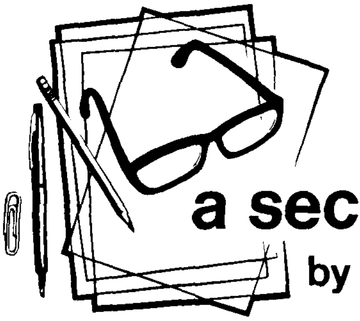

a second look

by Jim Fisk

A group of atomic physicists at Western Washington University has predicted that sometime this year the first message through the earth, rather than around it by way of the ionosphere, will be transmitted along a beam of neutrino particles from a particle accelerator. The neutrino is one of the fundamental subatomic particles, but one of the more elusive ones — Wolfgang Pauli first proposed its existence on theoretical grounds in 1930; Enrico Fermi christened the new particle the neutrino (for "little neutral one"), but it wasn't until 26 years later, in 1956, that it was first detected by scientists.

The interaction of neutrinos with ordinary matter is so weak that, according to classical theory, a neutrino could pass through a block of lead that stretched from here to the nearest star without disturbing any of the atoms in its path. Since the neutrino carries no charge and has no mass (or nearly no mass, scientists aren't sure), it evaded traditional particle detection methods simply by passing through them without affecting them in any way. Billions of neutrinos from the sun pass through your body every second, day and night, but it's estimated that a neutrino interacts with one of the atoms in your body only about once every ten years. It's no wonder it took 26 years to detect the neutrino's presence!

While the average neutrino is capable of passing through most of the matter of the universe without slowing down or losing any of its energy, it's been found that neutrinos fired in eight-second bursts from a high-energy particle accelerator occasionally collide with other particles, at the rate of about one collision for every 17 tons of matter that the beam penetrates. Although neutrinos cannot be detected directly, the particle debris, light, and noise generated by their collisions can be. When a beam of neutrinos is passed through a large volume of water, all along its path some of the collision products emit a forward cone of Cerenkov photons which can be detected by a light collector-phototube system. Prototype experiments using Cerenkov detectors to intercept cosmic neutrinos 1000 meters below the ocean's surface have already been carried out.

In experiments at the 400-billion-electron-volt proton accelerator of the Fermi National Accelerator Laboratory in Illinois, a 20-microsecond pulse of protons is directed into a bar of aluminum — the resulting atomic collisions produce about 10-billion neutrinos per pulse. The beam of neutrinos generates about one reaction per pulse in a bubble chamber containing 25 tons of liquid neon one kilometer away. With a grid of Cerenkov detectors in a large body of water it's predicted that a greater number of reactions per pulse would be detected. If information could be encoded into pulses of the neutrino beam, theoretically a message could be received and decoded virtually any distance away.

In the experiment suggested by the group in Washington, a pulsed neutrino beam from the Fermi Lab accelerator would be directed downward at an angle of about 12 degrees so the beam would pass through the earth and emerge in Puget Sound, nearly 3000 kilometers away. The detector-target would consist of the approximately one-million tons of water in Puget Sound where showers of particles would be recorded with each neutrino collision. The tiny flashes of light from the Cerenkov photons would be recorded and translated into the original message. Funding for the experiment is being considered by a number of government agencies, including the Navy, which is interested in applications of the technique for deep-water communications with nuclear submarines.

An analysis by the Naval Research Laboratory has shown that, if the energy level of the Fermi accelerator was increased to 1000-billion electron volts, with improved beam focusing, the neutrino event rates could be increased by a factor of 10. By using synchronous detection techniques and Cerenkov photo detectors 3000 meters below the surface of the ocean (where they're not bothered by ambient light), it is expected that one 15-bit message per pulse could be transmitted with very low error rates. With one neutrino pulse every 8 seconds, this represents a message rate of 6750 bits per hour. Compared with other methods of communications, this is slow, but unlike radio communications, neutrino beams can't be blocked, they're not affected by solar storms nor dependent on the ionosphere, and they travel great distances with no loss of power.

Jim Fisk, W1HR
editor-in-chief

IC-211, the 2meter Maximizer

COMPUTER-COMPATIBLE 4 MHz TRANSCEIVER WITH 2 VFO'S

ICOM's **IC-211** maximizes band coverage, speed, performance and convenience like no other transceiver in the 2 meter world. This Maximizer's single-knob dial provides all 4 MHz in a flash, right to your single fingertip! The **IC-211** maximizes read-out speed with positively no time lag or backlash in display stability, even in modes using 100 Hz steps. The **IC-211**'s freewheeling dial, with its superb inertia clutch, is instantly coordinated with the high speed, computer circuitry controlled synthesizer's seven digit read-out using an optical chopper. There is absolutely no mechanical connection between the smooth, bearing mounted flywheel knob and the **two dual-tracking VFO's,** which come built into your **IC-211.**

- **Single knob frequency selection:** The **IC-211** is synthesized with convenient single knob frequency selection over the entire 4 MHz. No more fussing with two or more knobs just to check what is going on around the band. One easy spin of the dial does it all.
- **Two VFO's built in:** The second VFO, which is an optional tack-on with most other transceivers, is an integral feature in every **IC-211.**
- **Variable offset:** Any offset from 10 KHz through 4 MHz, in multiples of 10 KHz, can be programmed with the LSI synthesizer.
- **Remote programing:** The **IC-211** LSI chip provides for input of touch tone and programing data from an external source, such as the microprocessor controlled accessory which will also provide scan and other functions (available summer '78). Computer control from a PIA interface is also possible (data available on request).
- **FM stability on SSB and CW:** The **IC-211** synthesis of 100 Hz steps makes SSB as stable as FM. This extended range of operation is attracting many FM'ers who have been operating on the direct channels and have now discovered SSB.

The **IC-211** is the very best and most versatile 2 meter transceiver made: that's all. For more information and your own hands-on demonstration, see your ICOM dealer. While maximizing performance, the **IC-211** minimizes impatience: yours is ready for delivery now.

Maximize the new repeater band: both the **IC-211** and the **IC-245/SSB** operate the the new FCC repeater spectrum with no modification.

All ICOM radios significantly exceed FCC specifications limiting spurious emissions.

Specifications: ☐ Frequency Coverage: 144.00 to 148.00 MHz ☐ Modes: SSB (A3J), FM (F3), CW (A1) ☐ Supply Voltage: DC 13.8V ± 15%, AC 117V ± 10% ☐ Size: 111mm(h) x 241mm(w) x 264mm(d) ☐ Weight: 6.8 Kg ☐ TX Output: A3J, 10W (PEP), A1 & F3, 10W ☐ Spurious Radiation: 60 dB below Carrier ☐ Microphone Impedance: 600 Ohms ☐ Sensitivity: A3J & A1, 0.5 microvolt 10 dB S + N/N; F3, 0.6 microvolt for 20 dB quieting ☐ Spurious Response: 60 dB or better ☐ Synthesizer Frequency Range: 144.00 MHz to 148.00 MHz ☐ Synthesizer Step Size: 100 Hz or 5 KHz for SSB, 5 KHz for FM

Supplied with hand held microphone, AC cord, DC cord, fuses and owner's manual

Specifications are subject to change without notice

HF/VHF/UHF AMATEUR AND MARINE COMMUNICATION EQUIPMENT

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presstop

SERIOUS QUESTIONS ABOUT AUTOPATCHES and the apparent increase of business-type communications on the Amateur bands were raised in an April FCC release, which likened "telephone interconnection at Amateur stations" with "the situation in the Personal and Business Radio Services." Though there were some text problems with the release as issued — the Personal Radio Division has requested that it be corrected and re-released — it strongly points up growing Commission concern with this area of Amateur Radio.

Autopatches And Reverse Autopatches in particular were discussed at some length in the FCC document. For example, it pointed out that the regulations require a control operator be on duty whenever autopatching or reverse autopatching occurs, effectively prohibiting autopatch use when a repeater is operating in "automatic control." It further stated that "all calls not initiated at an amateur station had to be screened by the control operator before being placed on the air." Though a revised release is to be issued shortly, it's obvious that autopatch operators and users should start now to tighten up their operations.

Autopatch Financing could raise still another sticky question with respect to ITT tariffs, W0MKZ points out in Boulder QSP, if money is collected from users specifically to pay for their use of the autopatch. It appears clubs or other groups with autopatch repeaters would be on firmer ground if autopatch costs were to be covered as just another expense item financed from club revenues.

THE FCC'S COMPUTER has mistakenly issued duplicate licenses to approximately 3000 new amateurs. Some of those who received the dual licenses received two call signs, others received two licenses with the same call letters. To end the confusion, the FCC has ruled that amateurs with two tickets are to use the license with the later date, and set aside the one with the earlier date until informed by the FCC what is to be done with it.

Two Sets Of "Doubles" were mailed out. The first sets are dated February 28 and March 3, the second pairs are dated March 17 and 21. The FCC should have been in touch by letter with all amateurs who received two licenses.

THE 3-CM AMATEUR BAND IS THREATENED by "Amateur Radio" manufacturers who are planning to make and market police-radar jammers under the "Amateur Radio" label. The March issue of Communications Retailing described one such unit being sold as a "radar calibrator," quotes a company official as saying they may designate their jammer as amateur equipment to escape FCC's controls on such items and it should be on the market in May.

Whatever The Result of all this, amateurs seem likely (as with the 10-meter linear ban) to be the losers in the end. Even the radar detector manufacturers oppose the jammers, according to Communications Retailing, on the grounds that they're almost certain to generate legal sanctions that would include detectors.

NEW CHIEF OF THE FCC'S Safety and Special Services Bureau is Carlos Roberts, replacing Charley Higginbotham whose retirement became official April 7. Roberts comes to Safety and Special Services from the FCC's Office of Plans and Policy, where he's been Chief since July, 1975. He's been with the FCC since graduating from college in 1970, starting with the Field Operations Bureau. In 1973 he supervised a Special Enforcement Facility for CB rules, so he's no stranger to either CB or Amateur Radio.

R. L. DRAKE HAS OPPOSED FCC'S ban on 10-meter linears with a Petition for Reconsideration filed near the end of April. The thrust of Drake's objection to the ban is that compliance with the Type Acceptance requirements will effectively prevent an amateur amplifier's use by a CBer, so the ban unnecessarily penalizes Amateurs and those who serve the Amateur market. Several other major amplifier manufacturers were actively considering similar action, with ETO also filing a Petition for Reconsideration.

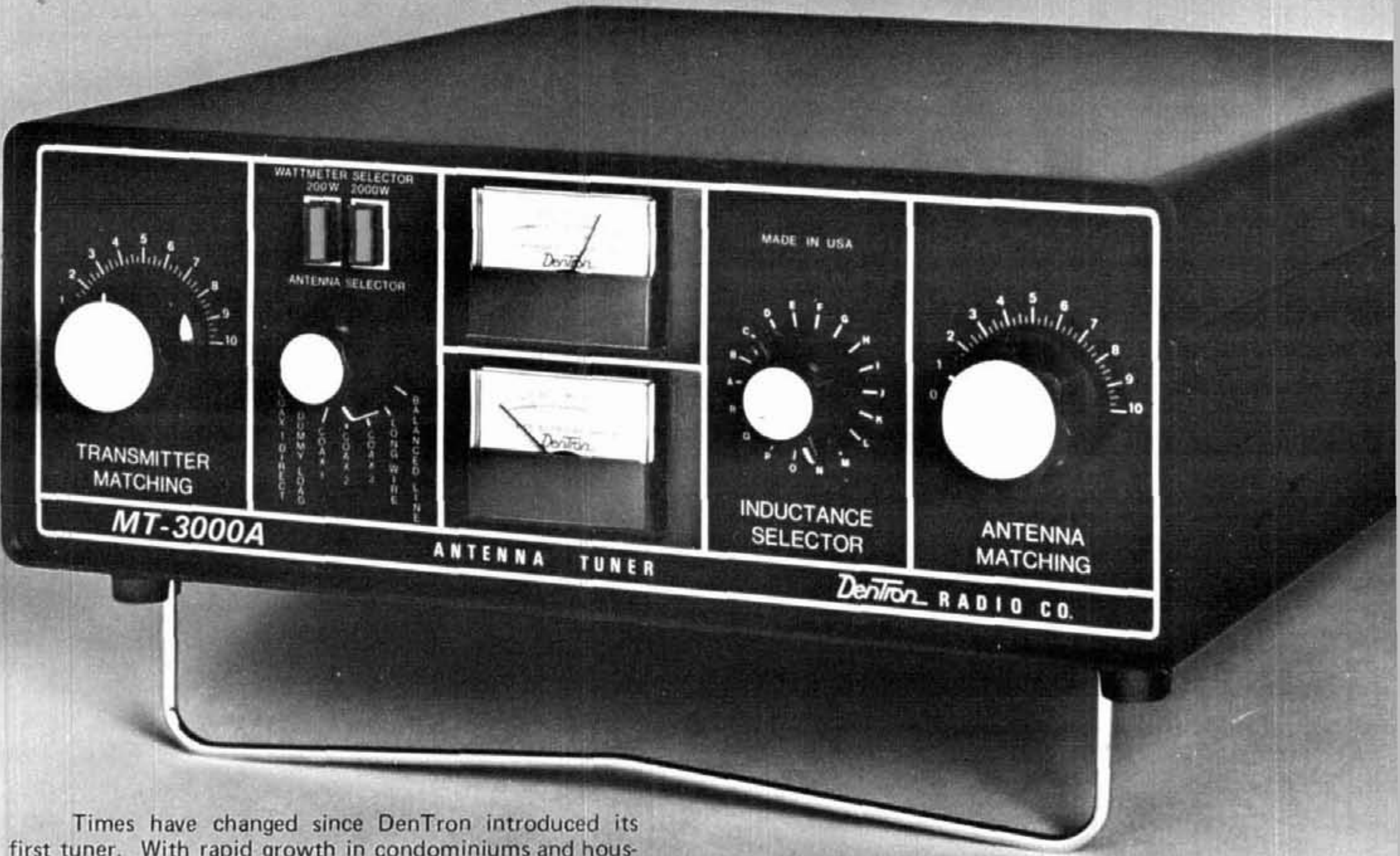
HY-GAIN HAS BEEN PURCHASED BY TELEX and planned to be back in production May 1 as a division of the Telex Corporation. The product lines will include amateur antennas and electronics, marine antennas and gear, government and commercial antennas, and CB antennas. Notably lacking will be the CB electronics that caused so many of their problems in recent months.

FIRST 2-METER E-M-E contact between North and South America was logged the end of March by W4WD and YV5ZZ. Fine signals were reported at both ends. K1WHS worked YV5ZZ an hour later.

Rare States On 70 cm E-M-E (ND, SD, WY, MT, ID) will be provided by K2UYH during a mid-June cross-country trek. Al will appreciate set-up and operating help — write Dr. Allen Katz, Department of Engineering Technology, Trenton State College, Trenton, New Jersey 08625.

THE SMITH CHART ARTICLE in the March ham radio quoted an incorrect price for packages of 100 charts. The correct price is $6.50 per hundred from Analog Instruments Company, Post Office Box 808, New Providence, New Jersey 07974.

Look closely at the new MT-3000A. You've never seen anything like it.



Times have changed since DenTron introduced its first tuner. With rapid growth in condominiums and housing developments, we have new problems that require new solutions.

DenTron decided to rethink the tuner and what its total capabilities should be.

The MT-3000A is a capsulized solution to many problems. It incorporates 4 unique features to give you the most versatile antenna tuner ever built.

First, as a rugged antenna tuner the MT-3000A easily handles a full 3KW pep. It is continuous tuning 1.8-30mc. It matches everything between 160 and 10 meters.

Second, the MT-3000A has built-in dual watt meters.

Third, it has a built-in 50 ohm dummy load for proper exciter adjustment.

Fourth, the antenna selector switch; (a) enables you to by-pass the tuner direct; (b) select the dummy load or 5 other antenna systems, including random wire or balanced feed.

The compact size alone of the MT-3000A (5½" a 14" x 14") makes it revolutionary. Combine that with its four built-in accessories and we're sure you'll agree that the MT-3000A is one of the most innovative and exciting instruments offered for amateur use.

At **$349.50** the MT-3000A is not inexpensive. But it is less than you'd expect to pay for each of these accessories separately.

As unique as this tuner is, there are many things it shares with all DenTron products. It is built with the same meticulous attention to detail and American craftsmanship that is synonymous with DenTron.

After seeing the outstanding MT-3000A, wouldn't you rather have your problems solved by DenTron?

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(216)425-3173

KENWOOD

...pacesetter in amateur radio

IT'S NEW ... IT'S UNIQUE ... AND IT'S TRULY USEFUL. IT'S KENWOOD'S SM-220 STATION MONITOR. THE SM-220'S UNEXCELLED VERSATILITY ALLOWS YOU TO MONITOR YOUR TRANSMISSIONS, MONITOR INCOMING SIGNALS, AND MONITOR THE AMOUNT AND STRENGTH OF BAND ACTIVITY* AND PERFORMS AS A GENERAL-PURPOSE 10 MHz OSCILLOSCOPE, AS WELL.

Kenwood offers this totally unique unit as a perfect compliment to your TS-820S or TS-520S station.** The SM-220, based on a wideband oscilloscope (2 Hz to 10 MHz), permits you to monitor your transmitted signals, thus assuring optimum linearity and maximum performance. With the addition of the BS-5 or BS-8 Pan Display option you will be able to determine visually the location and strength of adjacent signals without tuning your receiver off frequency. The choice of options allows you to adapt the SM-220 to either the TS-820S or TS-520S.

The SM-220 has a built-in two-tone audio generator with full provisions for tuning your exciter and linear amplifier (160 m through 2 m).

All this costs little more than a general-purpose oscilloscope. And, of course, it's pure Kenwood quality.

*With BS-5 or BS-8 option

**For other models check with appropriate manufacturer for compatibility.

SM-220

Function: Selects operation mode. OSC/RTTY: General testing of station equipment, experimental design of new equipment, or troubleshooting; display of receiver IF output allows you to give "signal quality reports".

Power ON indicator.

Power switch.

Intensity: Controls brightness of 'scope display.

Band Scope: (Pan Display) With BS-5 or BS-8 option, allows you to "see" the signals on both sides of your operating frequency without tuning your receiver off frequency. Useful for determining "band conditions", band crowding, source of interference from adjacent stations ... a visual display of what you would hear if you tuned across the band, without having to touch your receiver's dial.

Focus: Controls sharpness of 'scope display.

Vertical Attenuator: Precision step attenuator (gain control) switch adjusts vertical input level.

Vertical Input: Accepts IF input, RTTY input or oscilloscope input.

Vertical Gain: Potentiometer to fine-adjust vertical input level.

↕ Adjusts display along vertical axis.

RF Attenuator: Level control used in MONI/TRAP mode.

Tone: Step switch selects Wien bridge tone generators: 1000 Hz, 1575 Hz or both tones simultaneously.

Out: Output of the audio generator can be connected to the transceiver's microphone input for "two-tone test". Also for trapezoidal test of transceiver linear amplifier.

Synchronization Marker: Selects internal or external sync (similar to horizontal hold on TV. Turns On or Off the built-in marker which shows operator where his receiver is actually tuned.

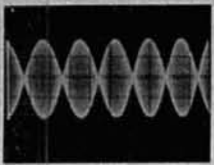
Scan Width: Selects width of "window" or receive band display when using the Pan Display option. (100 kHz or 20 kHz)

Variable sweep control/External gain: Controls (1) sweep speed of display in any sweep range, (2) optional Pan Display (Band Scope) speed of display, (3) level of horizontal input/external syncronization input when sweep range is in RTTY/Ext or Trap.

Horizontal Input/External Sync: Accepts either (1) RTTY input for tuning, (2) external sync input for test (oscilloscope functions), (3) external oscillator for Lissajous display.

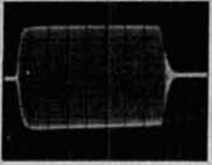
↔ Adjusts display along horizontal axis.

Sweep Range: Step switch controls sweep band width or switches horizontal input/external sync terminal "ON".

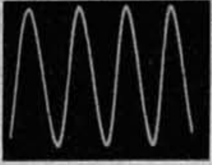


Two-Tone Wave Envelope For "performance" tune-ups or checking proper tranceiver operation.

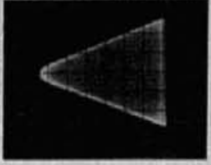
Pan Display Use to check source of interference during "QSO" without moving off-frequency. Also determines location and strength of adjacent frequencies. (Requires BS-5 or BS-8 option)



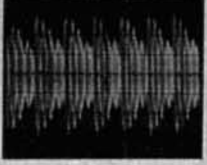
Keyed Waveform Shows detail of CW keying. Use to monitor the quality of your CW note. (Photo shows ideal waveform produced by TS-820S.)



Oscilloscope Operation (1 kHz) Oscillator function allows Sine, square wave, Lissajous patterns for testing or design work.



Trapezoid (TS-820S w/ TL-922) Shows linearity of power amplifier. Used primarily for testing.



Wave Envelope shows full SSB voice modulation, with processor on (full compression), and "clean signal" at full power.

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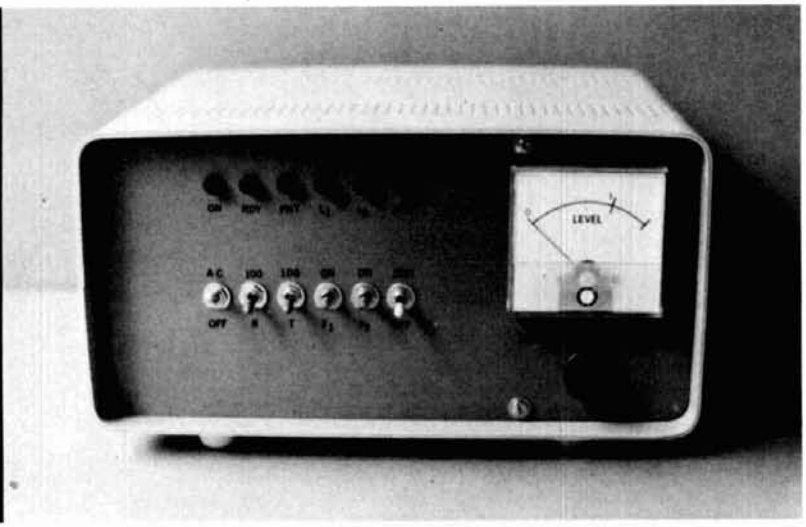


RTTY SELCOM

Discussion of the RTTY SELCOM — an advanced TTL design, providing selective character recognition

One of the first applications of digital logic to RTTY was the RTL SELCAL described by Lamb.[1] Capable of recognizing a single sequence of four characters, it proved very laborious and costly, since there were over 300 wired connections to be made in the basic unit. This concept, however, was expanded and translated into TTL form in the TTL SELCAL described by Branscome.[2] Although this unit was constructionally simpler, even with expanded capabilities, it still did not overcome the cumbersome decoding process, or provide for easy expandability.

Shortly after the TTL SELCAL was introduced, the CATC group[3] tackled the problem of sequential character recognition, hoping to overcome the two main problems presented by the TTL SELCAL. By 1972 the objectives had been met, and circuit boards were fabricated for what was known as SELCOM I. This unit dramatically expanded the flexibility to decode all 32 Baudot characters and could recognize nearly unlimited strings of characters. Many of the sequences were to be used as *sel*ective station control *com*mands, hence the name.

Probably the most powerful discrete logic sequential decoder ever developed, the SELCOM was also far easier to program than the earlier SELCALS since only one connection, instead of five, was required per character. This ease in decoding had been achieved by the use of a 1-of-32 decoder. In this manner, the Baudot character set was decoded, providing access to characters, rather than the bits as in the SELCAL versions. And, to provide expandability, a 32-character bus was connected to every sequential decoder board. This bus could be expanded as desired since each line of the bus was capable of handling up to 500 TTL loads.

In May, 1973, the discrete bus drivers were replaced with TTL buffers, lowering the drive to 30 instead of 500 loads. Even with this change, SELCOM II still retained the versatile bus structure of the original version.

Version III of the SELCOM incorporated a MOS UAR/T. This chip, a natural for the SELCOM, had already been in use for several years by various computer manufacturers, but the single quantity price was prohibitively high for amateur work until about December, 1973. Offering significant simplification, the UAR/T provided all functions except those of the clock and character decoders, and in addition, offered new functions not available in earlier versions of the SELCAL or SELCOM. They included regeneration of the received RTTY signal, speed conversion, and the ability to handle any code of 5 through 8 bits with only a simple jumper change.

By Robert C. Clark, K9HVW, Archie Lamb, WB4KUR, and Fred R. Scalf, K4EID. Mr. Clark may be reached at 930 Chestwood Avenue, Tallahassee, Florida 32303.

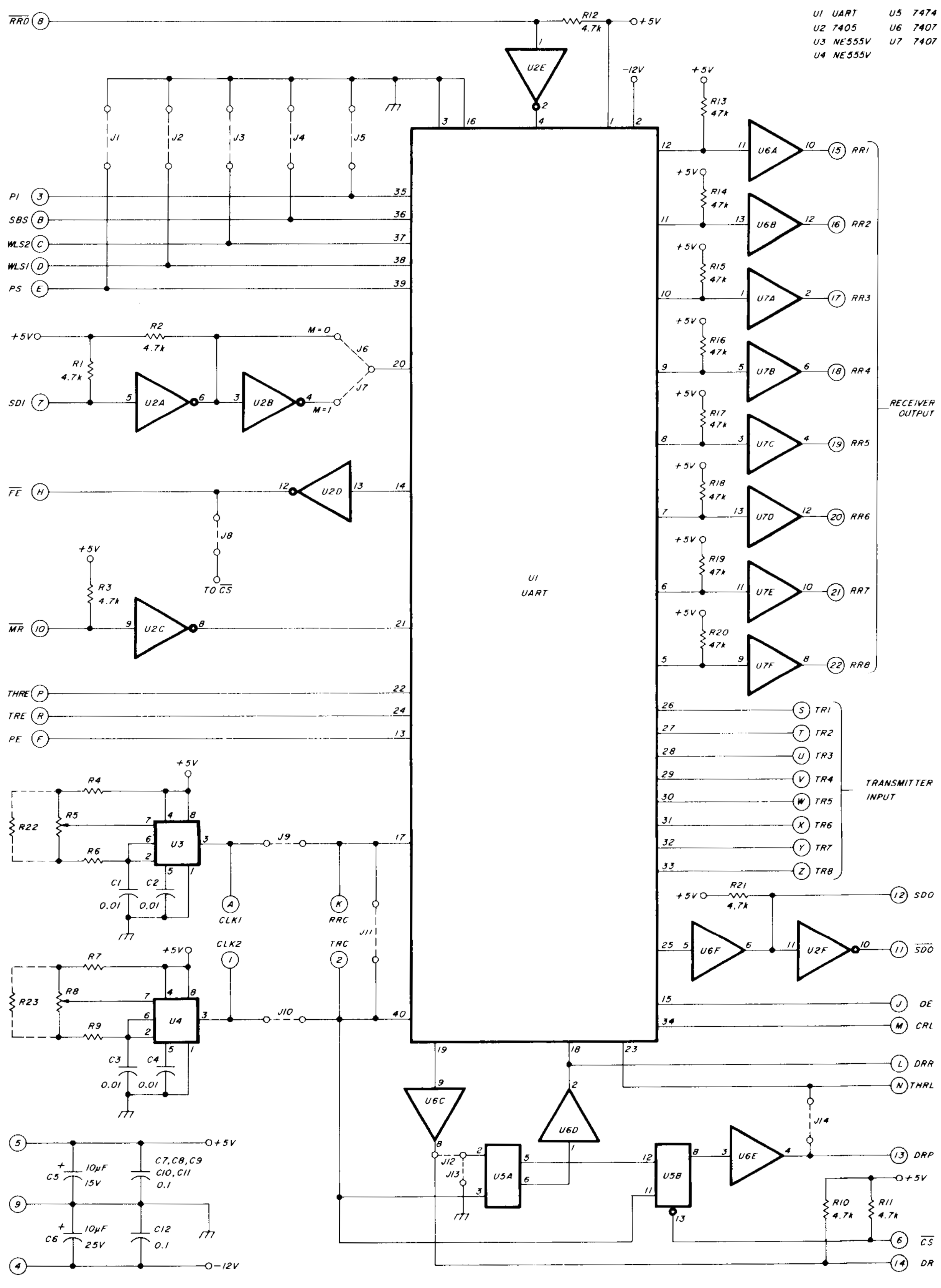


fig. 1. Schematic diagram of the DU-200 Universal UAR/T module. The jumper placement is explained in the text and also *table 1*. The UAR/T is available from either Texas Instruments or General Instruments. The buffers for the receiver output and flag lines can be eliminated if the lines are used for feeding only one TTL load.

In early 1974, an attempt was made to eliminate the mechanical problems presented by the double-width cards used in earlier SELCOMs. To do this, the versatile bus structure was abandoned in favor of a functional module approach. These modules provided a versatility not possible in the earlier versions of the SELCOM. With the change to single-width cards, the modules of SELCOM IV are now the same physical size as the DT-500[4] and DT-600 boards.

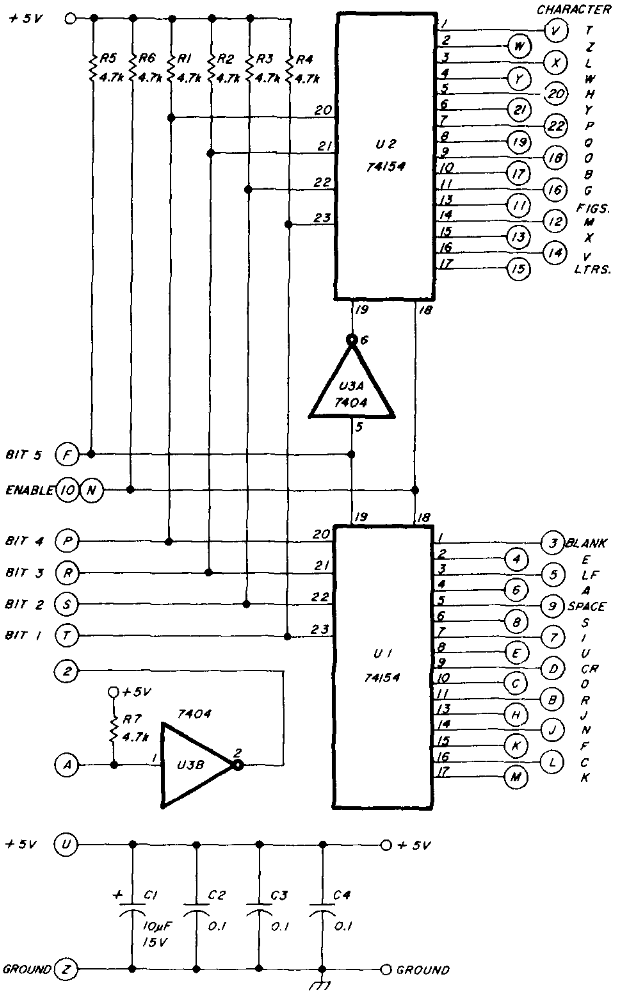


fig. 2. The DU-210 character decoder uses two 1-of-16 decoders as a 1-of-32 decoder. Both 74154s receive bits 1 through 4, while bit 5 is used to select the appropriate 74154. The single inverter is provided if more than one DU-210 decoder is used.

The group of modules to be described form SELCOM IV, or individual modules may be used in other applications. The modules include:

1. DU-200 Universal UAR/T
2. DU-210 Expandable 1-of-32 Character decoder
3. DU-220 Sequential Decoder
4. DU-300 Mini-SELCOM

SELCOM IV may be used with 5, 6, 7 or 8 bit codes at speeds up to 9600 bits per second. The following description is for the five-bit Baudot code used for amateur RTTY at 45.45 and 74.2 baud, but the unit is designed for expansion to the full 64-character ASCII code group.

SELCOM features

DU-200 Universal UAR/T. The DU-200 (**fig. 1**) is *not only the heart of the SELCOM system, but also* provides a powerful functional module for many other applications as well. It may be used for teleprinter signal regeneration, speed conversion, serial-to-parallel data conversion, parallel-to-serial data conversion, code conversion (Baudot to ASCII, ASCII to Baudot, Baudot to Morse, etc.), and many other ways. All the features of the UAR/T have been made available in the DU-200, either through hard-wired jumpers or through external control. In this way, the same board may be configured as a Baudot or ASCII regenerator, an interface between a serial RTTY station and a parallel I/O port of a microprocessor, a SELCOM, or a wide variety of other applications.

The DU-200 consists of the UAR/T, interface (buffering), control, and clock functions. The UAR/T IC (U1) functions as two nearly independent circuits, a digital receiver and a digital transmitter. The receiver accepts serial data in a particular format (selected by the user), checks for format errors (parity error, missing stop bit, etc.), and outputs the data in a parallel form. The transmitter accepts parallel data, adds start, stop, and parity bits, and sends the data in a serial format at the data rate selected. If the parallel output of the receiver is connected to the parallel input of the transmitter, the unit functions as a regenerator. The two sections may be used independently, but the data format for both sections must be the same. That is, both the receiver and transmitter must operate with the same code, parity, and so on. Under certain conditions they may operate at different speeds.

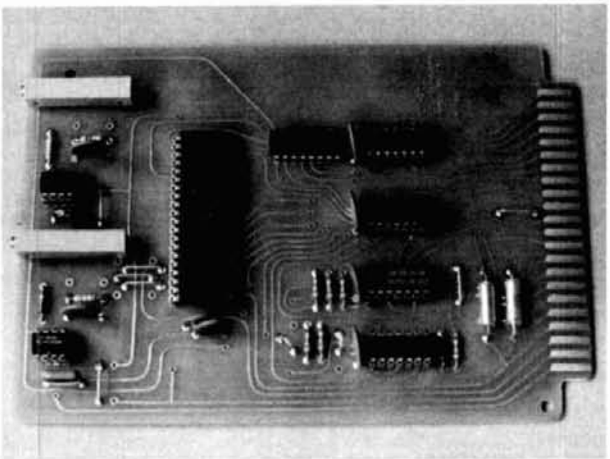
The UAR/T is capable of accepting data with up to 43 per cent distortion (more in some cases) and resending it with less than 1 per cent distortion. Typical teleprinters are capable of accepting less than 30 per cent distortion, while many keyboards and transmitter distributors generate signals with large amounts of distortion. As machines age, their ability to accept distortion is diminished and their ability to produce it is increased. The use of the DU-200 as a regenerative repeater offers improvements to all mechanical teleprinters, keyboards, and transmitter distributors.

Under marginal conditions several undesirable situations may exist with the mechanical teleprinter. Typically, high-frequency propagation phenomena tend to add distortion to that which already exists on the transmitted signal. For this reason, it is highly desirable that the transmitted signal have a minimum of distortion. If the DU-200 is used to process the transmitted signal, then this criteria will be met. Even if the transmitted signal is perfect, distortion will be added by the time the signal reaches the receiver.

Another problem that exists with a mechanical teleprinter is that a short noise pulse may be read as a *start*. When this happens, a clutch is released, beginning the sequence of events which decode and print a character. The teleprinter shaft must complete one full revolution before it can recover from this premature start. If the real start bit is received during this revolution, the printer will not be able to get back in synchronization with the sending station. In such a situation, the printer may print *garbage* for several characters. Most brands of the UAR/T though, after receiving what appears to be a start bit, recheck to determine that the start bit is still at the appropriate level in the middle of the bit. If the start bit is not valid, then the UAR/T is immediately reset. Thus, the probability of the receiving station staying in synchronization with the sending station is greatly improved.

Another undesirable condition exists when the received signal drops below the noise level and garble is printed. If the signal is not capable of providing the necessary information for character recognition, then it is quite likely that the appropriate level will not be maintained during the stop bit. This is termed a Framing Error and the UAR/T provides a flag to indicate this error. The flag may be used to suppress the transfer of the character to the transmitter section. If this feature is selected, the mutilated character will not be printed. A similar feature is available for parity errors on received characters.

The UAR/T will respond only to those characters that appear to be valid RTTY. It will not respond to a steady space (a single *blank* character will be transferred to the transmitter section unless the Framing Error flag has been used to suppress the transfer) while most noise and CW will transfer fewer characters to the printer than if the UAR/T were not present. With the DU-200 on-line, the appearance of the page is dramatically improved, with any demodulator.



Photograph of the DU-200 Universal UAR/T board.

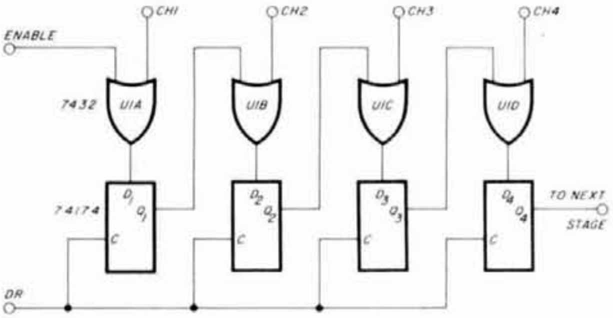


fig. 3. Diagram of the DU-220 sequential decoder. Several similar sections are on each board. Each channel input is connected to the desired character output from the DU-210 decoder.

If the clock applied to the transmitter and receiver sections of the UAR/T are set for different rates, the UAR/T will function as a speed converter. For example, if a 100 wpm (74.2 baud) printer is used, it's possible to receive any speed up to 100 wpm without expensive and noisy gear shifts. By providing a buffer memory between the receiver and transmitter sections, the DU-200 can function as a down converter. Of course, if the size of the buffer is finite, then the UAR/T receiver will deliver characters to the buffer faster than the transmitter section clears them, causing the buffer to overflow. In the case of overflow, the UAR/T provides an Overrun Error flag which may be used to signal an external device to withhold further characters.

DU-210 Character Decoder. The DU-210 (**fig. 2**) recognizes which one of 32 possible characters has actually been received by the UAR/T in the DU-200. Several DU-210 boards may be used to recognize characters from larger character sets. Two DU-210 boards may be used to recognize the 64 characters of the ASCII-6 subset and four may be used to recognize the 128 characters of the full ASCII set. In fact, the DU-210 may be used in many applications where one particular binary code must be recognized.

Sequential Decoder. The DU-220 (**fig. 3**) works with the DU-200 and DU-210 to recognize sequences of characters. It might be wired to recognize the station call, setting a latch when the call is received. This latch could be used to prevent the station printer from operating until the call was received. In fact, the DU-220 is capable of detecting a number of sequences, each of which may control some event such as:

1. Turn on reperforator.
2. Turn off reperforator.

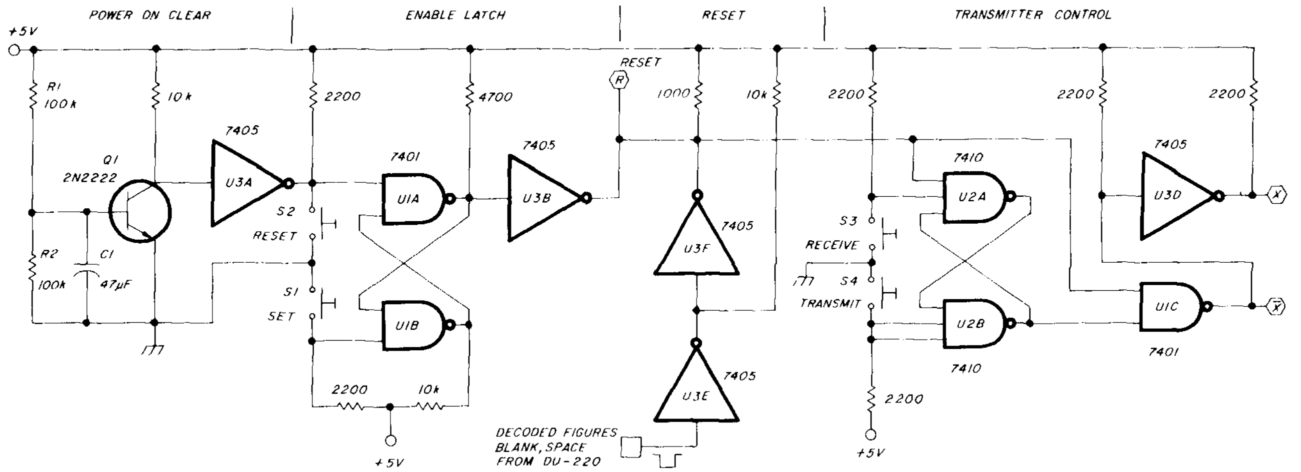


fig. 4. Schematic diagram of the power-up clear and latch circuitry. By using open-collector inverters, the reset line can be fed from several diferent sources. This circuit ensures that the transmitter control will come up in the transmitter off condition.

3. Start CW identification.
4. Turn transmitter on.
5. Turn transmitter off.

If necessary, these control sequences may be configured so that they will be recognized only when the source is the local keyboard.

The DU-220 is quite versatile in that it may be used to detect a sequence of events independent from the SELCOM system. For instance, the DU-220 might be used to recognize a sequence of digits from a *Touch-Tone** decoder. Certain sequences could be prevented from reaching the telephone lines, with others being used to control repeater functions. In addition, the DU-220 could also be used to recognize a sequence of switch closures in an electronic lock.

circuit description

DU-200 UAR/T Board. Serial data for the UAR/T is first applied to pin 5 of U2A. The input to pin 20 (*S*erial *D*ata *I*nput) of U1 is jumpered to either pin 4 or pin 6 of U2 depending on the sense of the data (mark low or mark high). The UAR/T is programmed, by either hard wiring or external devices, as shown in **table 1**.

table 1. UAR/T programming information.

function	format	conditions (UART pins)
Code Length	5 bit	pin 37 low, pin 38 low
	6 bit	pin 37 low, pin 38 high
	7 bit	pin 37 high, pin 38 low
	8 bit	pin 37 high, pin 38 high
Parity Selection	Parity	pin 35 low
	No Parity	pin 35 high
Odd/Even Parity	Odd Parity	pin 39 low
	Even Parity	pin 39 high
Stop Bit Select	One Stop Bit	pin 36 low
	Two Stop Bits	pin 36 high (for some manufacturers, a 1.5 bit stop is provided for 5 bit codes).

The speed of the received data is selected by an external clock set to sixteen times the baud rate. For 60 wpm, the clock would be set to *45.45 Hz x 16 = 727.27 Hz*. On the first mark to space transition, an internal counter is reset and allowed to count clock pulses. Each brand of UAR/T has some provisions for verifying that the mark to space transition was a valid start bit. If the start is verified, the counter continues, in turn controlling a serial-shift register, so that each received bit is stored in the shift register. At the time of the expected stop bit, another check is performed. If the stop (a mark) is not present at the required time, the Framing Error (FE) flag is raised to indicate an invalid condition. In the same manner, if a parity check has been requested, and the proper parity is not verified, the Parity Error (PE) flag is raised. The Overrun Error (OE) flag is available to indicate that one character has not been removed from the receiver holding register before the next character took its place. These flags may be used to control indicators, keep the character from being printed, or control error-correction schemes.

When a complete character has been received and transferred to the receiver-holding register (only complete characters appear at the receiver holding register output), pin 19 of the UAR/T (*D*ata *R*eady) goes high to indicate that the character is available in parallel form on pins 5 through 12 of U1. U5 is a two-stage shift register clocked by the receiver clock. The high from pin 19 of U1 (DR) is transferred through U5 after the next two successive clock pulses. The out-

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**Touch-Tone* is a registered trademark of the American Telephone and Telegraph Company.

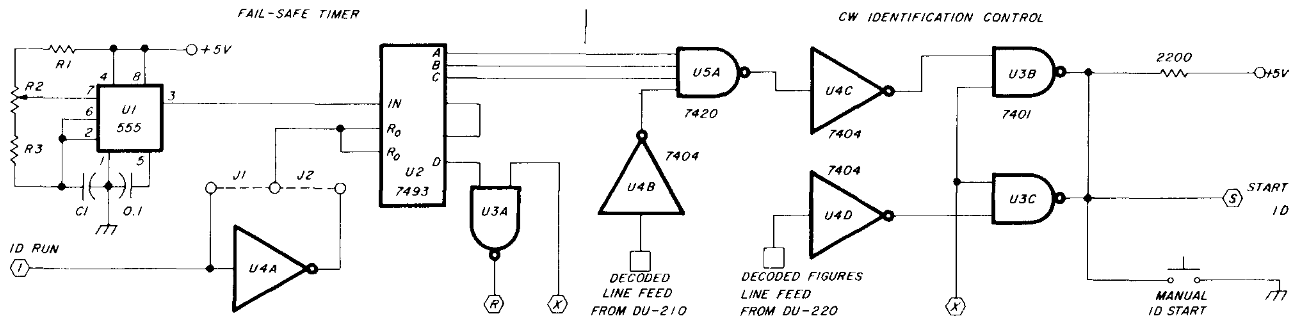

fig. 5. By using this fail-safe timer, the transmitter will be turned off if an identification is not sent every 10 minutes. As with all other diagrams, the power supply connections have not been shown. If the return line from the identification unit is low when the ID is running, J1 should be connected; if high, J2 is connected.

put of the first stage (U5A pin 6) is applied to the *D*ata *R*eady *R*eset (DRR) of U1, resetting the DR line. In addition, the $\overline{Q}$ output of the second stage feeds the *T*ransmitter *H*olding *R*egister *L*oad (THRL) line of U1, loading the parallel data from the receiver into the transmitter holding register. This action of U5 guarantees that DR stays high for exactly one clock period. Some brands of UAR/T require a rising edge for THRL, while others require a falling edge. The DU-200 provides both a rising and a falling edge, and hence will function with most of the UAR/Ts on the market. The direct clear for the second stage (U5 pin 13) may be used to prevent the character from being loaded into the transmitter holding register. Jumper J8 allows the Framing Error flag to suppress characters with a missing stop pulse. A similar procedure may be used for parity errors and overrun errors.

The UAR/T handles steady spacing in an interesting manner. If J8 is omitted, then a steady space will cause a single blank character to be transferred to the transmitter. No other characters will be transferred to the transmitter until the data line returns to mark and a valid start pulse is detected. If jumper J8 is installed, then no characters will be transferred to the transmitter. Hence, it is not possible for the printer to run open. This action is superior to the antispace offered on the ST-6 and DT-600.

The character transferred to the transmitter holding register will in turn be transferred to the transmitter register when empty. Notice that the UAR/T may be simultaneously processing 3 characters, sending one character, holding a second character, and receiving a third character. The status of the transmitter registers is indicated by pins 22 (*T*ransmitter *H*olding *R*egister *E*mpty) and 24 (*T*ransmitter *R*egister *E*mpty) of U1. When a character reaches the transmitter register it is clocked out in serial form (at pin 25 of U1, *S*erial *D*ata *O*ut) according to the format previously selected, at a speed determined by the transmitter-register clock. If this clock is the same one used for the receiver, then the unit operates as a regenerative repeater. If the clocks are of different frequencies, then the DU-200 operates as a speed converter. If the receiver speed is higher than the transmitter speed, the characters may arrive at the transmitter holding register faster than they may be accepted and a buffer memory must be provided to avoid overrun.

Two clocks are installed on the DU-200 board. In addition, jumpers are provided so that one clock may be used to operate both the receiver and transmitter, or a separate clock may be provided for each. It is also possible to supply clock signals from an external source. A crystal-controlled clock, supplying multiple baud rates, has been designed as part of the CATC line. The 555 IC (U3 and U4) has proven to be adequate as a clock, as long as the ambient temperature is relatively stable. Wide frequency excursions can be expected with wide temperature variations. Most of this frequency shift can be attributed to the thermal characteristics of the resistors and the capacitor which form the RC timing portion of the oscillator. Choice of components, to minimize this shift, will improve the drift characteristics of the oscillator. A polystyrene capacitor is recommended. Also, metal-film resistors will show a significant improvement over the carbon composition types. The configuration of the timing resistors (R4, R5, and R6 for U3) was chosen for stability and is superior to most shown in other articles.

Oscillator frequency is the only adjustment required for the DU-200. The frequency should be set in accordance with **table 2**, while measuring at pin 3 of the 555.

Since the UAR/T is only capable of sinking one TTL load, buffering has been provided on the output and flag lines. If only one load is to be connected to any

table 2. Oscillator frequency of the 555 timer.

speed	baud rate	clock frequency
60 wpm	45.45	727.273 Hz
European	50.00	800.00 Hz
75 wpm	56.83	909.280 Hz
100 wpm	74.18	1186.880 Hz

UAR/T output, and none of the flags or control signals are to be used externally, then U6 and U7 may be eliminated and a jumper used to complete the circuit.

The UAR/T is available from a number of manufacturers. The Texas Instruments TMS-6011NC, General Instrument AY-5-1013, and the Western Digital TR-1602A have all been tested in the DU-200. Difficulties have been experienced with the TR-1602A when the received data did not have a stop bit. Therefore, only the TMS-6011NC and AY-5-1013 are recommended.

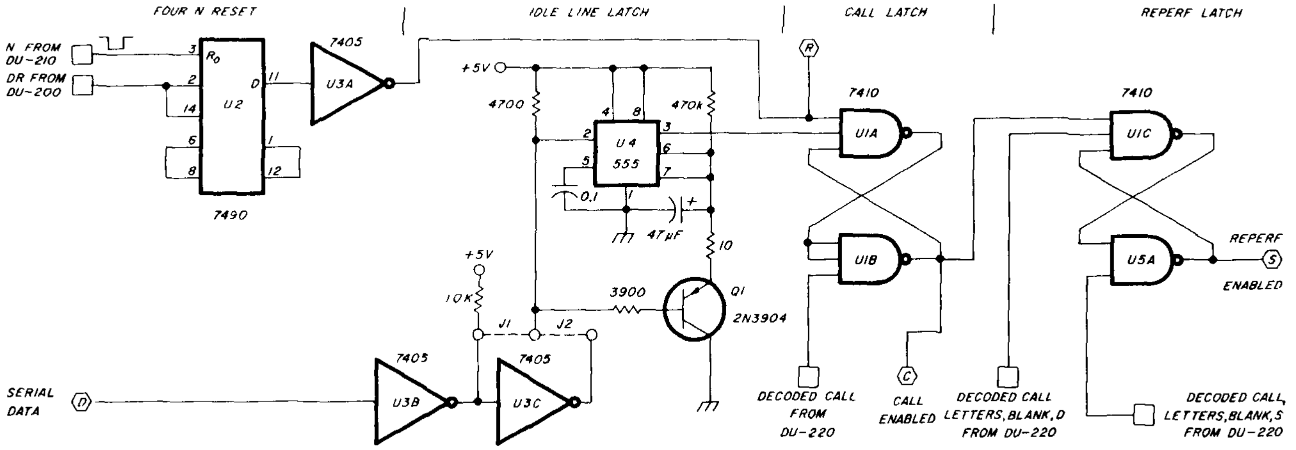

fig. 6. The printer-control portion prevents the printer from operating until the correct sequence of letters is received and the call latch is set. This latch is reset by a four N reset, the idle line reset, or by the normal reset line. The serial data for the idle line reset can be either high or low, with the appropriate jumper connected. For a mark low, use J1 and for mark high, use J2.

The DU-210. The buffered outputs of the UAR/T receiver-holding register (RR1 through RR8 on the DU-200 board) are connected to the one-of-32 decoder on the DU-210 board. Two 74154 (U1 and U2) decoders are used. The first four bits of the received character are used to address the two decoders, while the fifth bit is used to select one of the decoders. When a decoder is selected (pins 18 and 19 low) only one of the output pins will be low. Hence, if the enable line of the DU-210 is held low, then only one of the 32 output lines will be low for any five-bit binary code on the input lines. The characters of the Baudot set have been shown on the output lines in **fig. 2**.

Because of the nature of the UAR/T, it is permissible to leave the DU-210 enabled at all times, since only complete characters are available at the output lines of the receiver holding register. There is no need to worry about glitches at the output of the DU-210 as one character replaces another in the DU-200.

Several DU-210 boards may be used for a character set larger than the 32 characters in the Baudot set. In such a case, only one enable input at a time may be allowed to go low. The extra section of U3 has been provided to facilitate such connections.

The DU-220 Sequential Decoder. As shown in **fig. 3**, selected character lines from the DU-210 are connected to the inputs of the DU-220. Suppose that the enable line of the DU-220 is low and that characters A, B, C, and D from the DU-210 have been connected to CH1, CH2, CH3, and CH4 respectively of the DU-220. When the DU-200 receives an A, it is recognized by the DU-210, and the CH1 line of the DU-220 pulled low. Only when both inputs of U1A are pulled low does the output go low. This low is presented to the D input of U2A. Shortly after the character is recognized, the DU-200 DR line goes high, indicating that a character has been received and is stable in the receiver holding register. The leading edge of the DR line pulse clocks the D level through to the Q output of the flip flop. Since the other character lines are not low, all other flip flops in the chain will be reset producing a 1 on the Q output. The high from the output of the first D flip flop is used to enable U1B. If the next character is a B, then the other input of U1B is pulled low (the output of U1A will not change until the next DR pulse is received). This output is applied to the D input of U2B and is transferred to the output when the DR line goes high. If the next two characters are C and D, this sequence is continued through to U2D. The low on the output of U2D indicates that A, B, C, and D have been received in that order. If at any time a different character is received, or the characters are not in the right order, the sequential decoder is reset. It will respond *only* to the right characters in the right order. The output of this sequential decoder may then be used to control a number of station control functions.

station control

Power-up Circuitry. When digital equipment is first turned on, latches and flip flops come up in random states. The portion of the station control logic shown in **fig. 4** is a power-up reset which resets all control functions when the power is first turned on. It also guarantees that automatic features are enabled only when desired by the operator.

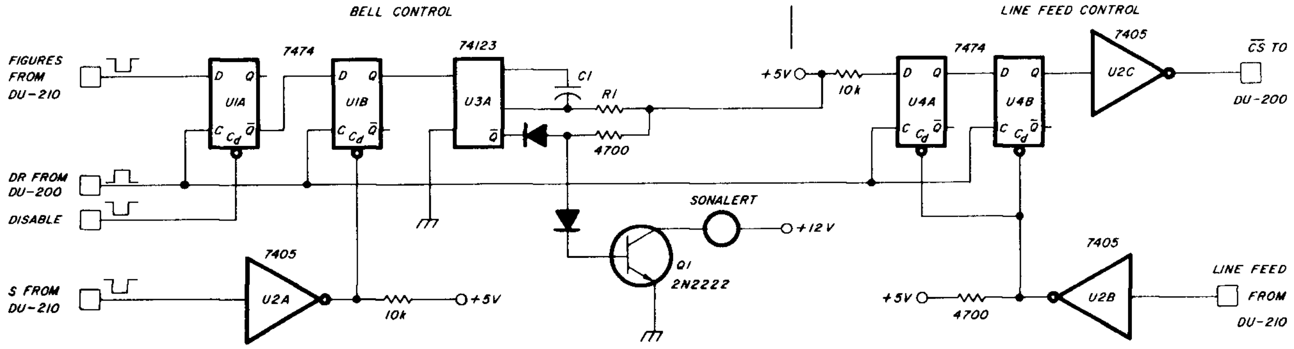

fig. 7. Bell and line-feed control. This circuit prevents the excessive ringing of the bell and the excessive line feeds.

The latch formed by U1A and U1B is used to enable any automatic functions. The operator may set or reset this latch with S1 and S2. Q1 and U3A form the power-on clear portion of the circuit. As the five-volt supply starts up from zero, the base of Q1 is held low by the $47\mu F$ capacitor. The capacitor begins to charge slowly through R1, but the voltage on the capacitor will not turn on Q1 for several seconds. By this time the five-volt supply has stabilized and the U1A latch is reset. The *R* output is low any time the latch is reset, and is used to disable or reset other circuits in the station control. The 7405 open collector hex inverter allows the output of the enable latch to be "QR tied" with other resets, in this case from U3F. U3E and U3F provide an additional reset from the DU-220, resetting all latches.

Fig. 4 also shows the transmit/receive latch. In addition to being set or reset manually by S3 and S4, the latch is reset from the reset line. This means that the transmitter will be turned off by the power-up reset, a manual reset of the enable latch, or by the reset function (figures, blank, space). The provision for a reset function allows the transmitter to be turned off by a code typed on paper tape. Thus, the operator may cut a tape (concluding with the reset sequence) and then look for something more interesting to do than sit and watch the tape play. At the end of the tape, the reset sequence will turn the transmitter off.

Identification and fail-safe timer. The fail-safe timer (**fig. 5**) guarantees that the transmitter does not stay on the air for an unintentional extended period of time (as when the tape tangles and tears). U1 is another 555 which is enabled only when the transmitter is on the air. The timing components have been chosen so that the period of the oscillator is 1.25 minutes. The pulses from the 555 are applied to the input of U2, a 7493 four-stage binary counter. When the 7493 has counted eight clock pulses (10 minutes) the D output goes high. This high is inverted by U3A and the resulting low is used to pull the reset line down, resetting the transmit/receive latch.

The counter may be reset to zero at any time by starting the CW identification device. A line from the identification device resets the 7493 when the ID starts. Options are provided so that the CW run line may be active low or active high.

If the 7493 reaches a count of seven without being reset, then pins 12, 9, and 8 are all high. When the next line feed is received, U5A is enabled, and if the transmitter is on, U3B provides a low, starting the CW identification device. The keyboard and transmitter distributor must be inhibited though while the CW device is running.

It should also be possible for the operator to start a CW identification earlier than 8 minutes and 45 seconds into the transmission. In my case, the sequence figures, line feed is used to insert a CW identification at any time the transmitter is on. The outputs of U3B and U3C are OR tied to provide both automatic and semi-automatic identification. A manual push button is also provided to start the identification.

Printer control. The call latch (**fig. 6**) is mainly used to prevent the station printer from operating until the correct sequence is received. When the DU-220 has recognized the four-character sequence (in my case letters H, V, W) the call latch is set. It may be reset in any of the three different ways: by the sequence N, N, N, N, by a lack of activity on the serial data line, and by the enable latch.

The four N counter (U2) counts DR pulses as long as the N line from the DU-210 is low. When the counter reaches four it is forced to a count of nine. The resultant high on pin 11 is inverted and used to reset the call latch. A unique feature of this counter is that it will automatically reset on the first character after the fourth N.

As all stations have not developed the procedure of sending four Ns at the end of each transmission (or they might be sent, but not received) another method of resetting the call latch is desired. The method chosen is to monitor the serial data line for mark/space transitions. If no transitions are detected for thirty seconds, the call latch will be reset by the action of U4. This 555 is configurated as a monostable with a period of thirty seconds. Each time the serial data line goes to the space level, the 47 μF capacitor is discharged through Q1 and the sequence begins again. Pin 3 of the 555 goes low after thirty seconds of no transitions and resets the call latch.

Another latch (U1C and U5A) is used to control a reperforator. The sequence letters, H, V, W, letters, blank, S sets the latch and turns the reperforator on (the call and reperforator latches are used to enable and disable the DD-350 selector magnet driver and motor control). The reperf latch is reset by the sequence letters, H, V, W, letters, blank, D or any sequence or event that resets the call latch.

At times it is helpful to control machine functions to save wear and tear both on the operator and machine. One function that is not always valuable is the bell. The operation of the bell on random noise is irritating and the excess use of the bell by some operators is infuriating. **Fig. 7** shows one method of controlling the bell function. Initially, the printer bell is disabled and replaced by a Mallory *Sonalert*. U1A and U1B form a 2-bit shift register. The first stage is enabled by a figures function and the count is allowed to continue if the next character is an S. The output of U1B goes high when the sequence figures, S has been received, triggering U3A which controls the time the *Sonalert* is on. The reset input of U1A may be used to inhibit the operation of the bell. One way to use this would be to connect the disable pin to the output of the call latch in **fig. 6**. In this way, the bell will ring only when the station call has been sent and then the sequence figures, S is received. This should eliminate all bells directed at someone else and the repeated ringing of the bell.

In a similar manner, the machine may be prevented from responding to a sequence of line feeds. U4A and U4B count DR pulses as long as the received character is a line feed. When two consecutive line feeds are received, the output of U4B goes high, is inverted, and the character suppression input of the DU-200 is pulled low, preventing the character from being transferred to the printer. As long as line feeds are sent, no characters will reach the printer. When a character other than a line feed is received, the U4A/U4B counter is reset and characters will again reach the printer. If the operator wishes to double space, a sequence of carriage return, line feed, letters, line feed, letters will circumvent the line feed counter and allow two lines to be turned up.

Many other station control functions may be provided for with the SELCOM system. Another possibility would be to establish two frequencies within the same band, one for general calling and the other for third-party traffic. Station **A** may call station **B** on the general calling frequency and send a code to switch station **B** to the traffic frequency. Station **A** then sends traffic to station **B** on the second frequency, resetting station **A** to the calling frequency at the termination of the traffic. The SELCOM can control almost any function that the operator can dream of.

summary

The SELCOM is a powerful digital building block which may be used to implement a wide range of station control applications. In a subsequent article, the DU-300 will be presented. The DU-300 Mini-SELCOM is a single board which provides many of the functions of the DU-200, 210, 220, and the station control board. The DU-300 provides regeneration, speed conversion, call-letter recognition, four N turn-off, printer control, and two other (user defined) functions for station control. Also, the trade-offs between the SELCOM and the Mini-SELCOM will be discussed.

All correspondence should be addressed to Robert Clark at the address indicated at the beginning of this article. All inquiries with a self-addressed stamped envelope will be acknowledged.*

acknowledgements

W0RQI, K4OAH, and W6DNT were very helpful in the design of the early versions of the SELCOM. WA4SNL did the layout for versions II, III, and IV. W8IDJ assisted in preparing tables and parts lists. K4TKU was instrumental in the preparation of high-quality drawings as he has done for other CATC project efforts. WA5IAT was particularly helpful with his work on the control section of the DU-200 and in providing comments on the draft article. We extend our appreciation to each of these who have helped, hoping we have not overlooked anyone.

references

1. Tom Lamb and Bill Malloch, "The SelCal," *73*, May, 1968, page 58.
2. Kenneth Branscome, "The TTL SelCal," *The RTTY Journal*, December, 1971, page 7.
3. Robert C. Clark, K9HVW et al, "DT-600 RTTY Demodulator," *ham radio*, February, 1976, page 8.
4. Robert C. Clark, K9HVW, et al, "The DT-500 RTTY Demodulator," *ham radio*, March, 1976, page 24.

ham radio

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*As with the DT-500, DT-600, DI-70, and DD-350, boards are being produced by Data Technology Associates, Box 431912, Miami, Florida 33143. The DU-200 board is available with construction notes for $12.50 plus $.75 for first-class postage. The format is the same as the DT-600.

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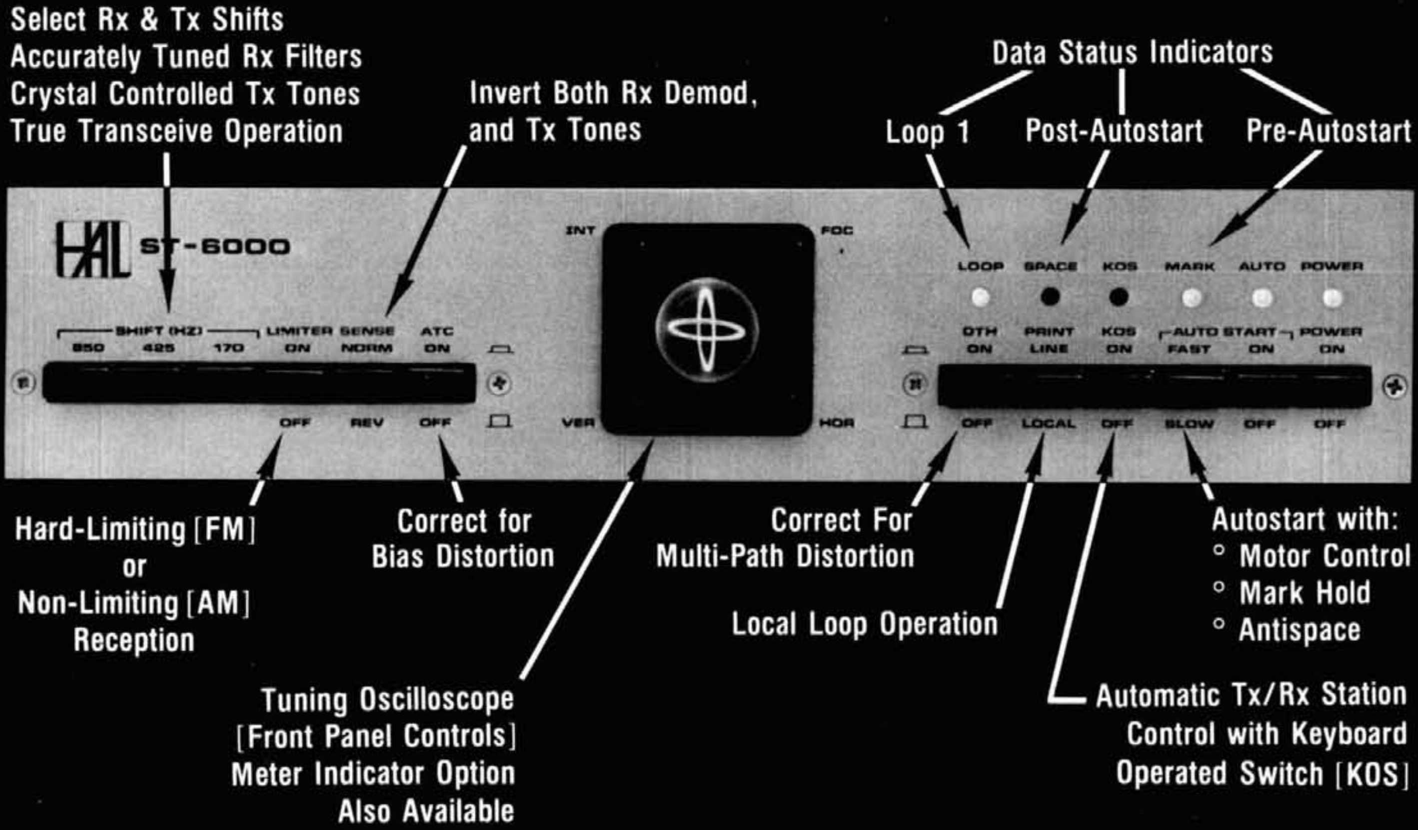

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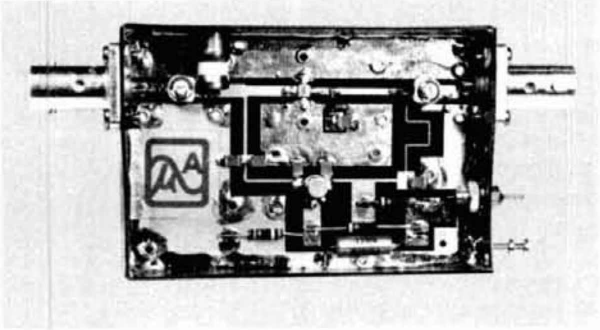
receiving preamplifier for OSCAR 8 Mode J

Amateurs who have designed and built vhf and uhf transistor circuits in the past are well aware of the fact that high performance often seems to be more art than science; however, the "art" involved in the design of vhf/uhf amplifiers is rapidly giving way to science with the utilization of *S* parameters and computer optimization. Using these techniques, an engineer can design a multi-stage vhf or uhf amplifier in a few hours with the aid of a computer and be highly confident of the results. The low-noise 435-MHz preamplifier described in this article is a good example of the combination of the manufacturer's transistor *S*-parameter data, engineering judgment, and computer optimization.

design approach

Virtually all manufacturers of transistors intended for vhf, uhf, and microwave applications now utilize *S* parameters to characterize the performance of their high-frequency transistors. This fact alone attests to the usefulness of this parameter set in the design of high-frequency amplifiers.[1,2] In conjunction with specific noise figure data and bias point considerations, the addition of a computer analysis and optimization program, and sound engineering judgment, you have all the ingredients necessary for a successful design.

This article describes the design of A low—noise 435-MHz receiving preamplifier which is intended for the reception of the downlink communications channel of the OSCAR 8; the preamplifier also provides excellent performance for communications on 432 MHz. Basically, the design approach is developed as outlined below:



The 435-MHz preamp using the Microwave Associates 42141 transistor. The extra chip capacitor, on the collector lead of the bias transistor, is used to ensure a good ac ground. Note the extensive grounding between the two sides of the printed circuit board.

1. Selection of the appropriate transistor.

2. Determination of the terminal impedances (both input and output) required to obtain the specific performance objectives.

3. Synthesis of the appropriate matching networks to present the desired terminal impedances.

4. Computer optimization of network component values.

5. Stability analysis over a broad band of frequencies.

transistor selection

The main criteria in the selection of a transistor for this application is low noise figure coupled with sufficient gain to minimize the second stage contribution to the system noise figure. The intended device should also be completely specified and characterized in terms of *S* parameters and noise figure data. In the absence of such data, extensive analysis of the amplifier circuit is impossible unless, of course, the designer is willing to perform the transistor evaluation and characterization himself.

The Microwave Associates 42140 series of uhf transistors is ideally suited for this application. The devices are completely specified and characterized over a broad range of frequencies. At optimum bias, or dc operating point which results in minimum noise figure ($V_{CE} = 8$ volts, $I_C = 5$ mA), the MA42141 has the following characteristics:

$$\begin{aligned} S_{11} &= 0.64 \angle -112^\circ \\ S_{21} &= 7.70 \angle 111^\circ \\ S_{12} &= 0.046 \angle 41^\circ \\ S_{22} &= 0.72 \angle -35^\circ \\ \Gamma_{os} &= 0.32 \angle 38^\circ \\ NF_{min} &= 1.80\, dB \end{aligned}$$

where Γ_{os} is the source reflection coefficient required for minimum noise figure.

transformation networks

From this data, the design task is to synthesize matching networks which present Γ_{os} to the input of

By Mark Pride, K1RX, and **Kenneth V. Puglia,** Microwave Associates, Inc., Burlington, Massachusetts 01803

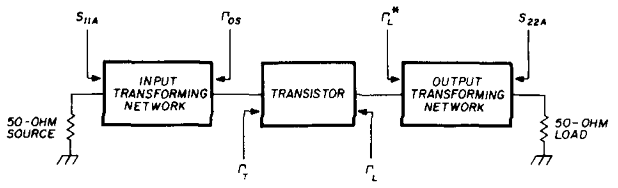


fig. 1. Block diagram of the low-noise preamplifier stage showing the input transformation network, the transistor stage, and the output matching network with applicable reflection coefficients.

the transistor while simultaneously presenting a complex conjugate match at the transistor's output. If low noise figure was not the prime objective, then the design task would be to synthesize input and output networks which would simultaneously provide the complex conjugate impedance to the input and output of the transistor; this would result in maximum gain but not lowest noise figure.

The initial use of the computer is in determining the complex conjugate of the transistor's output impedance. The computer performs this calculation through a program which solves the equation:

$$\Gamma_L = S_{22} + \frac{S_{21}S_{12}\Gamma_{os}}{1 - S_{11}\Gamma_{os}} = 0.35 \angle -54^{\circ}$$

Also of interest is the input impedance of the transistor which may be calculated from:

$$\Gamma_T = S_{11} + \frac{S_{21}S_{12}\Gamma_L{}^*}{1 - S_{22}\Gamma_L{}^*}$$

The asterisk designates the complex conjugate.

The design tasks can be more easily understood by studying **fig. 1** which illustrates, in a block diagram form, a cascade of the input network, the transistor, and the output network. **Fig. 2** is a Smith chart plot *showing the locations of the various impedance* points. The Smith chart will aid in the synthesis of the transforming networks. (Note that a 150-ohm resistor has been added in shunt across the output of the transistor to provide a margin of stability to the amplifier since the initial analysis in determining the complex conjugate of the output impedance indicated that the transistor was potentially unstable when terminated with these impedances.)

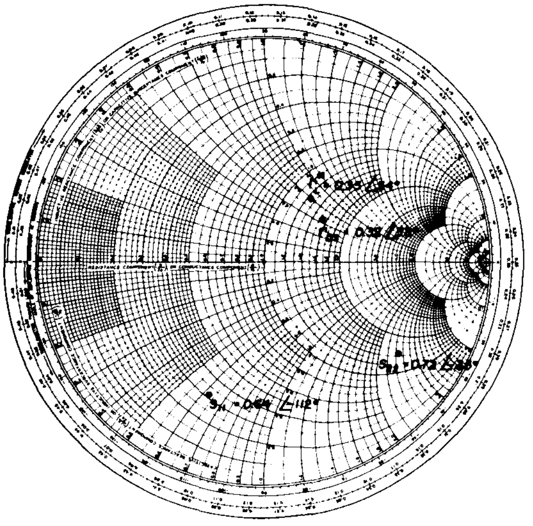


fig. 2. S-parameters for the MA42141 transistor operated at V_{CE} = 8 volts, I_C = 5 mA.

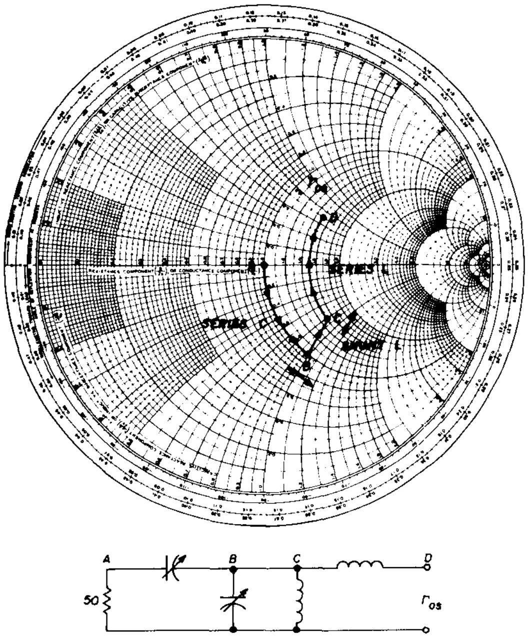


fig. 3. Design of the input impedance transforming network. The Smith chart plot gives preliminary component values which will be optimized with a computer program.

The networks required to transform the 50-ohm source and load to the desired impedances may be designed with the Smith chart. Smith charts are an indispensable tool in the design of impedance transforming networks which use reactive circuit elements and transmission lines. References 3 and 4 provide a clear understanding of Smith charts and their applications.

Figs. 3 and **4** may now be used to determine "ballpark" values for the transformation networks. Variable capacitors have been employed at the input to allow for normal transistor manufacturing variations as well as to extract the absolute minimum noise figure available from the transistor. A single variable *capacitor at the output allows you to peak the gain* and to minimize the output impedance mismatch.

Variable capacitors are recommended for this application because it's doubtful that either the antenna or the receiver used with the preamplifier will provide the desired 50-ohm impedances; in military and commercial designs where the source and termination impedances are known to be 50 ohms, fixed capacitors are usually installed.

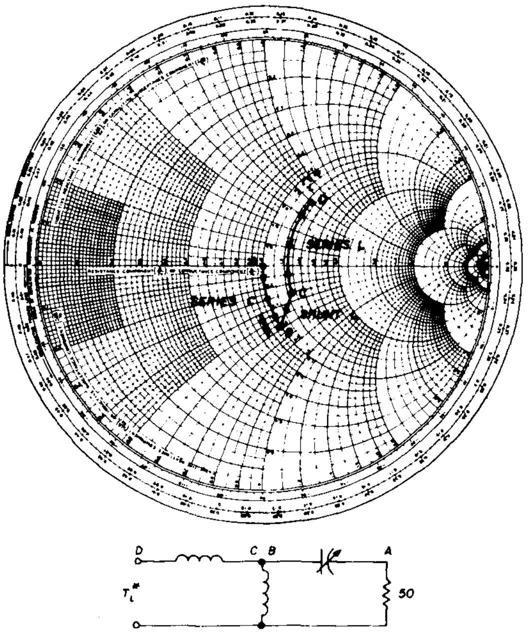


fig. 4. Design of the output matching network with a Smith chart. Component values are optimized with a computer program.

input matching network

At the input of the preamplifier it is necessary to transform the 50-ohm input impedance to the source reflection coefficient required for minimum noise figure (Γ_{os}). This can be accomplished with a T network consisting of a series *capacitance*, *shunt inductance*, and series inductance. Beginning at the 50-ohm point at the center of the Smith chart (which has been normalized to 1.0) at point **A**, the series capacitance moves the impedance to $1.0-j1.0$ (point **B**); the shunt inductance rotates this value to $1.5-j0.9$ (point **C**); the series inductance transforms this to the source reflection coefficient Γ_{os} at $1.5+j0.66$.

The required reactance values for each of the components in the matching network can be read directly away from the Smith chart. Note that the series capacitance rotates the input impedance from $1.0 \pm j0$ at the center of the chart to $1.0-j1.0$ at point **B**. Therefore, the required capacitive reactance is $-j1.0(50)$ or $-j50$ ohms; at 435 MHz this is represented by 7.3 pF.

To determine the reactance of the shunt inductor it's necessary to first convert to admittance (lower case letters designate normalized values).

Point B $z=1.0-j1.0$ $y=0.5+j0.5$
Point C $z=1.5-j0.9$ $y=0.5+j0.3$

The desired transformation requires a *normalized* susceptance of $-j0.2$; in a 50-ohm system this represents −0.004 Siemens (0.004 mho) or +250 ohms. In this circuit this is provided by 37 nH in parallel with 2.2 pF (a 5 pF variable allows adjustment within the limits indicated by the arrows at point **C** on the Smith chart plot).

The series inductance transforms the impedance of $1.5-j0.9$ at point **C** to $1.5+j0.66$ at Γ_{os}. This requires a normalized reactance of $+j1.56$ or 78 ohms (28.5 nH at 435 MHz).

output matching network

The design procedure for the output matching network is similar to that used for the input network. Working from the 50-ohm load back to the collector of the transistor, the series capacitor transforms the load at **A** ($1.0 \pm j0$) to point **B** ($1.0-j0.58$); the shunt inductor rotates the impedance to $1.23-j0.35$ at point **C**. The series inductor then provides the desired reflection coefficient for the load ($\Gamma_L = 0.35 \angle 54°$) at point **D** ($1.23+j0.80$).

For the desired transformation the series capacitor must present a reactance of 0.58×50 or 29 ohms; at 435 MHz this is provided by 12.6 pF. To calculate the value of the shunt inductor, the impedance points are converted to admittance:

Point B $z=1.0-j0.58$ $y=0.75+j0.43$
Point C $z=1.23-j0.35$ $y=0.75+j0.21$

To move from $j0.43$ to $j0.21$ requires a *negative* susceptance of $-j0.22$ or 4.5 milliSiemens. This is equivalent to 223 ohms of inductive reactance of 82 nH at 435 MHz.

The series inductor required to transform $1.23-j0.35$ at point **C** to $1.23+j0.80$ at Γ_L has an inductive reactance of 1.15×50 or 57.5 ohms (21 nH at 435 MHz). A preliminary schematic of the amplifier is shown in **fig. 5**.

Note that it is necessary only to determine approximate component values for the matching networks because, in this case, a computer program will be

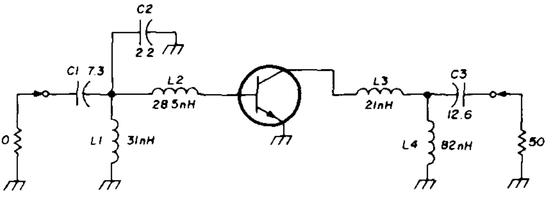


fig. 5. Basic 435-MHz low-noise preamplifier circuit with component values determined with the aid of a Smith chart (figs. 3 and 4).

used to adjust the values for optimum performance. However, values which are close to optimum will result in the usage of less computer time and, hence, lower cost.

Rather than winding inductors which could be lossy and cause stray coupling from unwanted radiation, it is better to use lengths of etched transmission lines for the inductive elements. This can be done providing the line lengths are less than λ/8 and preferably less than λ/16. This is more easily seen if you examine the input impedance of a lossless short-circuited transmission line:

$$Z_{in} = +jZ_0 \, tan \, \frac{2\pi l}{\lambda}$$

$$= +jZ_0 \, tan \, \Theta$$

Where:

Z_{in} = input impedance to the transmission line
Z_0 = characteristic impedance of the line
l = length of the transmission line
λ = wavelength
Θ = electrical length of the line in degrees

Note that this expression represents a pure reactance which varies almost linearly with the electrical length Θ, provided that Θ is small. Therefore, by varying the characteristic impedance Z_0 and the electrical length Θ it's possible to synthesize inductive elements which are very accurate and highly repeatable when printed-circuit techniques are employed.

computer optimization

The next step in the design of the low-noise preamplifier is to select an appropriate computer program to execute the calculations and optimize the component values. The COMPACT* Computer Program is used extensively for this purpose because it has broad capability in terms of network elements and interconnections and is modest in cost when used within certain guidelines.

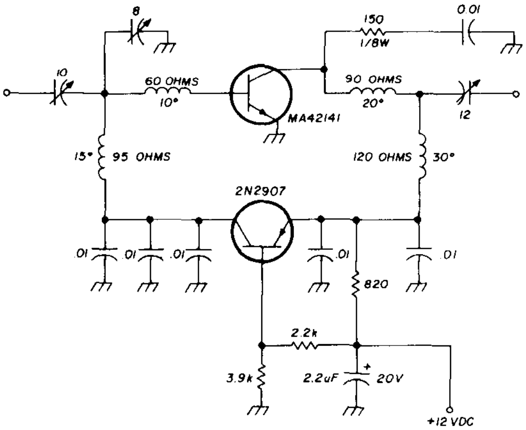


fig. 6. Low-noise 435-MHz preamplifier circuit with computer optimized circuit values. All inductive elements use etched transmission lines of the specified characteristic impedance and electrical length. Fixed values of capacitance are chip capacitors. The 2N2907 is part of the active bias circuit (see fig. 7).

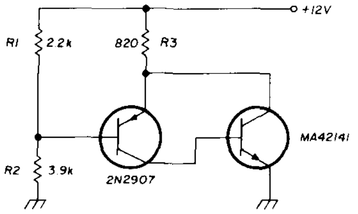


fig. 7. Active bias circuit is used in the low-noise preamplifier to allow direct grounding of the emitter lead. The collector-to-emitter voltage of the MA42141 is determined by voltage divider resistors R1 and R2 (see text).

The information for the computer is written in the form of a data file. Once the data file is written, the computer will vary the network elements and attempt to minimize the error between the desired circuit performance and the actual circuit performance. Specific performance parameters may be weighted so that their attainment carries more importance than other performance parameters. For example, if noise figure is the most important design goal, input impedance match or gain may be sacrificed so that the lowest noise figure may be achieved; the computer will adjust the variable elements in a direction which minimizes noise figure but not necessarily maximizing gain or lowering the input impedance mismatch.

In this case the computer analyzed the circuit and optimized it for operation at one frequency, 435 MHz. Additional or broader optimization could be performed by altering the data file, but this would increase computer time (and cost) because of the larger number of variables. After optimizing the component values, the computer predicted the following preamplifier performance at 435 MHz:

Noise figure	1.81 dB
Power gain	16 dB
Output vswr	1.22:1

The noise figure might be somewhat optimistic since no allowance has been made for circuit losses associated with the variable capacitors and high input vswr.

A complete schematic of the optimized preamplifier circuit is shown in **fig. 6**. The synthesized induc-

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*COMPACT *is an acronym for Computer Optimization of Microwave Passive and ACTive circuits. Additional information is available by writing to Compact Engineering, Inc., 1651 Jolly Court, Los Altos, California, 94022.*[5,6]

table 1. Comparison of computer predicted performance with measured performance.

	computer predicted	measured performance unit 1	unit 2
Noise figure	1.8 dB	1.9 dB	1.9 dB
Gain	16.1 dB	16.0 dB	16.5 dB
Output vswr	1.22:1	1.15:1	1.12:1

tors are specified in terms of their characteristic impedance and electrical length. **Table 1** shows a comparison between computer predicted performance and the measured performance of two preamplifiers which were built in the lab.

stability considerations

A broadband computer stability analysis reveals that the preamplifier is unconditionally stable over a frequency band from 400 MHz to 2800 MHz. The importance of the stability analysis cannot be over emphasized because, in many applications, the source and load impedances may take on any value outside the particular frequency band of interest. When a high-gain microwave transistor is used, it is most important to assure that the amplifier does not oscillate as a result of various out-of-band source and load impedances.

dc bias circuit

To realize the predicted performance when using the manufacturer's transistor data, the designer must mount the transistor in a manner which closely approximates the electrical and mechanical environment under which the manufacturer obtained the data. The introduction of parasitic elements in mounting the transistor can lead to large discrepancies between the predicted and measured performance.

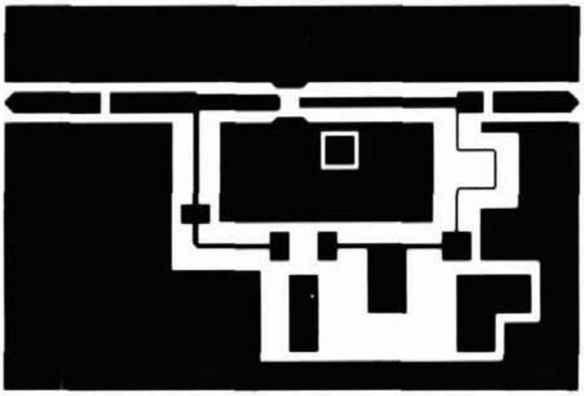

fig. 8. Full-size printed-circuit layout for the low-noise 435-MHz preamplifier. Circuit is etched on 1/16" (1.5 mm) double-clad G-10 fiberglass-epoxy circuit board. Component layout is shown in fig. 9.

The parasitic element which is most sensitive to performance degradation is the emitter lead inductance, which, if not kept to a minimum, will both reduce gain and alter the source impedance required for minimum noise figure. It may also introduce instabilities within the circuit which, under certain conditions, could result in oscillations. For these reasons an active bias circuit has been utilized in this amplifier. The active bias circuit will provide the proper collector-to-emitter voltage and collector current, while allowing direct grounding of the emitter lead to minimize the introduction of any parasitic impedance into the circuit. A schematic of the active bias circuit is shown in **fig. 7**.

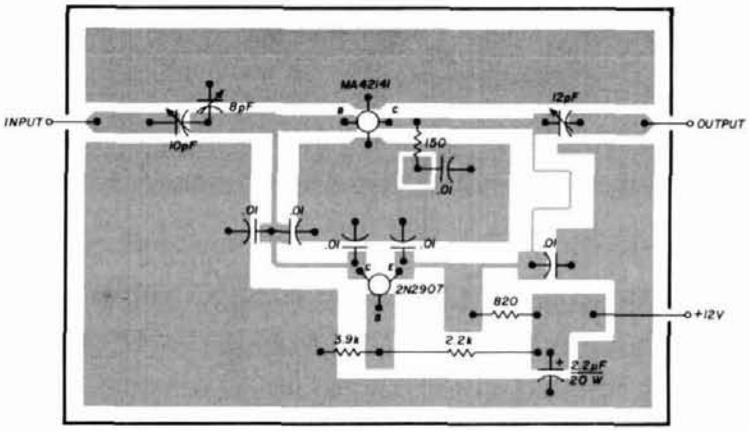

fig. 9. Component layout for the 435-MHz low-noise pre-amp. For best performance all fixed values of capacitance should be chip capacitors.

The active bias circuit is actually a feedback loop which senses the collector current of the rf transistor and adjusts the base current to hold that collector current fixed. The collector-to-emitter voltage of the rf transistor is held at a fixed potential determined by the voltage divider R1 and R2. The current through resistor R3 becomes the collector current of the rf transistor under the assumption (a good one) that both the 2N2907 and the MA42141 have moderate dc current gain.

references

1. *S-Parameters — Circuit Analysis and Design*, Application Note 95, Hewlett-Packard, Palo Alto, California, 1968.

2. *S-Parameter Design*, Application Note 154, Hewlett-Packard, Palo Alto, California, 1972.

3. Philip H. Smith, *Electronic Applications of the Smith Chart in Waveguide, Circuit, and Component Analysis*, McGraw-Hill, New York, 1969.

4. James R. Fisk, W1HR, "How to Use the Smith Chart," *ham radio*, March, 1978, page 92.

5. *COMPACT Version 4.5*, Compact Engineering, Los Altos, California.

6. *Computer Aided Microwave Circuit Design with COMPACT*, Application Note 1, Compact Engineering, Los Altos, California.

7. *Transistor Designer's Guide*, Microwave Associates, Burlington, Massachusetts, 1978.

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single IC
Touch-Tone decoder

A new integrated circuit
and high performance
active filter
are combined into
an extremely reliable
Touch-Tone decoder

A majority of repeater stations today are using *Touch-Tone** circuitry for such functions as autopatch, control, and signaling; individual home and mobile stations make use of encoders and decoders for selective calling and radio control. Dozens of designs have been published for *Touch-Tone* decoders during the last several years. Unfortunately, virtually none of these circuits is reliable.

The use of the 567 phase-lock loop IC, upon which nearly all designs are based, is not recommended unless limited performance is acceptable. Elaborate support circuitry is required, and even then you may not achieve the desired noise immunity or stability. The tradeoffs are many: response time *vs* bandwidth, noise immunity *vs* bandwidth, and economy *vs* reliability.

The 567 PLL chip has several important limitations which must be dealt with regardless of whether you are using the 567, or are a circuit designer developing a totally new decoder IC.

signal consideration

Amplitude Variations. Twisted-pair telephone wires are transmission lines, just as coaxial cables are. Shunt capacitance and series inductance serve to increase attenuation as frequency goes up. This disparity means that high group *Touch-Tone* signals are usually attenuated more than the low group. This variation in amplitude is referred to as "twist." Tone pads attempt to compensate for this by having a stronger output from the high group than the low

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**Touch-Tone* is the registered trademark of the American Telephone and Telegraph Company.

By Larry Nickel, W3QG, 216 Highmeadow
Road, Reisterstown, Maryland 21136

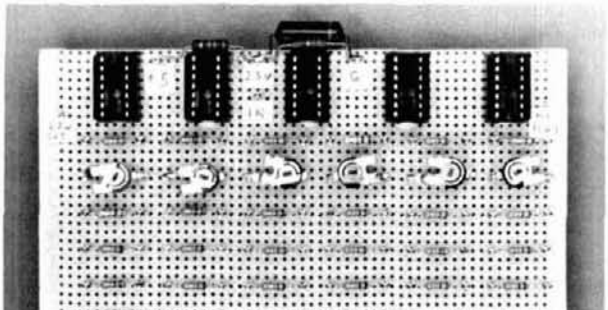
group. In addition, when decoding tones from an fm receiver, signal strength and deviation are two more variables. An effective decoding scheme must incorporate an audio ALC system. If the decoder circuitry is sensitive to twist, then separate ALC control could be necessary for the high and low groups.

Bounce And Noise. A *Touch-Tone* source may not present a clean, stable leading edge. Secondly, noise, music, or speech may momentarily produce coincident tones at the proper frequencies, which could be recognized as a legitimate *Touch-Tone* pair. What is required is a delay, of perhaps 40 milliseconds, before a valid tone pair is acknowledged. Then the decoder output must turn on and stay on until the signal disappears, with no bounce. It has been my experience that achieving good noise rejection, fast response without false tripping, and freedom from bounce is not practical with PLL techniques.

Frequency Stability. Tone generation schemes which depend on RC time constants for frequency stability are not reliable, especially at temperature extremes. This is why the Motorola MC14410 and Mostek MK5087 crystal-controlled encoder chips were developed. The same is true of decoding circuitry. Crystal control is a must!

new generation integrated circuits

Within the last two years, several manufacturers have introduced some very sophisticated tone-decoder ICs. The first entry was Rockwell International's Collins CRC8030 dual tone multi-frequency (DTMF — another name for tone control) receiver. It is an MOS decoder chip in a 28-pin dual-in-line package which uses a standard 3.579545 MHz TV color-burst crystal for its reference. This ceramic IC was originally priced at $49 in unit quantities, but a plastic case (CRC8030-3-3) now sells for $42. An ALC system, a filter (which separates high and low group tones), and two voltage comparators are required to complete the decoder. General Instrument also produces a decoder selection designated the AY59800 series. One or more of these chips use a 1 MHz crystal and require dual power supplies.



Layout of the tone separation filter.

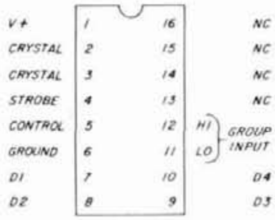


fig. 1. Pinout diagram for the Mostek 5102 *Touch-Tone* decoder.

table 1. Data output from the MK5102 decoder.

	4-bit binary				dual 2-bit row column			
digit	D1	D2	D3	D4	D1	D2	D3	D4
1	0	0	0	1	0	1	0	1
2	0	0	1	0	0	1	1	0
3	0	0	1	1	0	1	1	1
4	0	1	0	0	1	0	0	1
5	0	1	0	1	1	0	1	0
6	0	1	1	0	1	0	1	1
7	0	1	1	1	1	1	0	1
8	1	0	0	0	1	1	1	0
9	1	0	0	1	1	1	1	1
0	1	0	1	0	0	0	1	0
*	1	0	1	1	0	0	0	1
#	1	1	0	0	0	0	1	1
A	1	1	0	1	0	1	0	0
B	1	1	1	0	1	0	0	0
C	1	1	1	1	1	1	0	0
D	0	0	0	0	0	0	0	0

The newest entry into the tone-decoder field is the Mostek MK5102. It's a CMOS chip in a 16-pin package, with a typical power dissipation of only 25 mW, at 5 V dc. Available in either a ceramic (MK5102P-5) or plastic case (MK5102N-5), unit quantity prices start at $34.50.* Even though this is a large sum of money to pay for an IC, at this time it is the *only* way to build a complete, top-quality decoder without spending more than $60.

A pinout diagram for the MK5102 is shown in **fig. 1**. Compared to the 28-pin CR8030, this is sheer simplicity. The 5 V dc and ground connections, pins 1 and 6 respectively, are self-explanatory. An inexpensive 3.579545-MHz TV-color burst crystal is connected between pins 2 and 3. Pin 5 is used to control the output format of pins 7 through 10 (D1 through D4). This tri-state input line selects a four-bit binary code

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*Quality Components, 13628 Neutron Road, Dallas, Texas 75240.

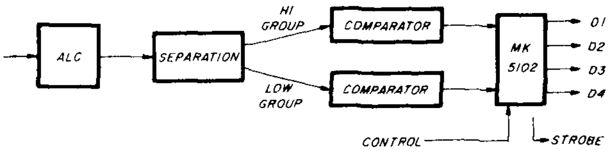


fig. 2. Block diagram of a complete tone decoding system using the new single IC tone decoder.

(input high), a dual two-bit row/column code (input floating), or high-impedance output (input low) for use with bus-structured circuitry.

Pins 7 through 10 are the data out lines. The outputs are CMOS loads when enabled, and open circuited (high impedance) when disabled by the control pin. The output data formats are shown in **table 1**. The two output codes allow the user to obtain either 1-of-16 or 2-of-8 output data by only using a single additional package.

Pin 4, the strobe output, goes high after 40 mS of a valid tone pair, and remains high for a minimum of 10 mS after the input ceases. The output information is valid when the strobe signal goes high and will remain unchanged until the next DTMF digit is detected.

The low- and high-group tones are filtered, separated, and applied to pins 11 and 12, respectively. The MK5102 can detect capacitively-coupled, square-wave signals as small as 1.2 volts pk-pk. The tones are detected, after band splitting, using the digital-counter method. The zero crossings of the incoming tones are counted over a longer period. When a minimum of 40 milliseconds of a valid signal is detected, the proper data is latched into the outputs and the output strobe goes high. When a valid digit is no longer detected, the strobe will return low and the data will remain latched into the outputs. The minimum interdigit time is 35 milliseconds.

A block diagram of a complete *Touch-Tone* decoding system using the MK5102 is shown in **fig. 2**. The ALC reduces any amplitude variations from the signal source.

The low-group tones, the rows on your *Touch-Tone* pad, and the high group tones, the columns, are separated in the tone-separation filter. Its outputs are two sine waves which are squared up in comparators and applied to the MK5102.

active filter

Design Considerations. An active filter for a 1-kHz frequency range is generally of low cost, small, has gain, high-input impedance, low-output impedance, and is easy to design. My intention here is not to make the reader a filter expert but to give a little of the philosophy behind the design of this one. My criteria were:

1. It must be inexpensive.
2. It must use readily available components.
3. It must be easily constructed.
4. It must provide adequate out-of-band rejection.

For the bandwidth and Q required, a stagger-tuned circuit is necessary. After examining sample response curves for 2-section filters, I felt that at least 3-sections would be required to achieve adequate out-of-band rejection. One section is tuned to the center frequency, another is tuned to s (the "staggering value") times the center frequency, and

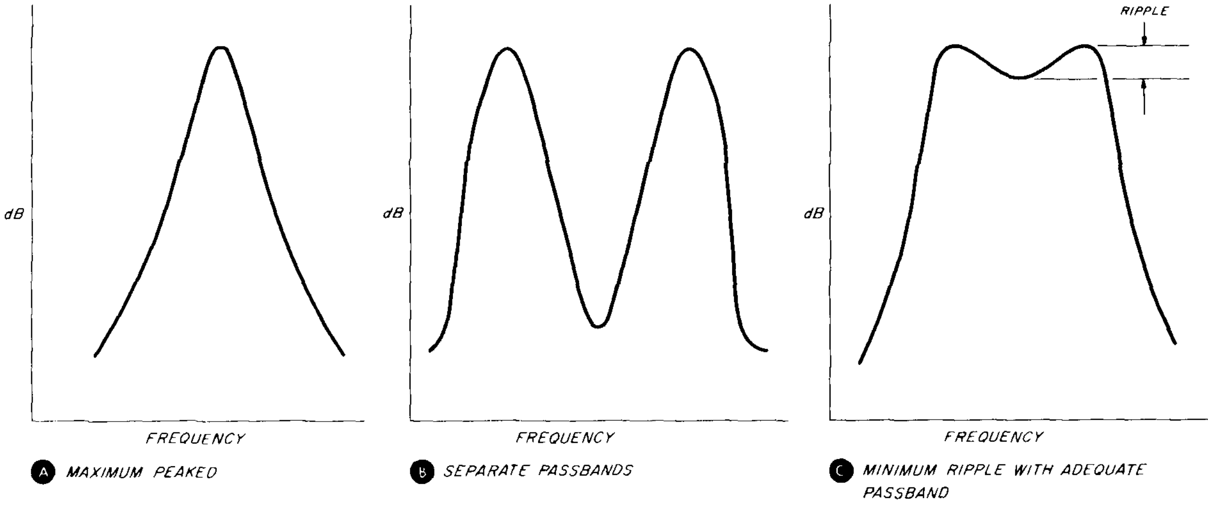


fig. 3. Passband response as a result of varying s in equation 1. A shows a single-peaked response when $s = 1$. For large values of s, B shows the dual-peaked response. In C, a response is obtained that has a minimum passband ripple, yet adequate bandwidth ($s = 1.16$).

the third $1/s$ times the center frequency. For $s=1$, the response has one peak and a very-narrow bandwidth (**fig. 3A**). For a large value of s, 1.5 for instance, there are two separate distinct passbands (**fig. 3B**). By selecting the best value of s for two- or three-section filters, a suitable bandwidth with minimum ripple can be achieved, as shown in **fig. 3C**. Each of the three sections is designed for a particular Q. Usually, it is best for the center section to have a lower Q than the outside sections which have identical higher Qs. This makes for a flatter passband and a steeper slope beyond the passband (if the Q is too high the ripple in the passband will be excessive).

The transfer function for a three-section filter is:

$$\frac{E_{out}}{E_{in}} = 20 \log_{10} (A \bullet B \bullet C) \qquad \textbf{eq. 1}$$

where

$$A = \sqrt{1 + Q^2 \left(\frac{f^2 s^2 - 1}{fs} \right)^2}$$

$$B = \sqrt{1 + Q^2 \left(\frac{f^2 / s^2 - 1}{f/s} \right)^2}$$

$$C = \sqrt{1 + \left(\frac{Q}{2} \right)^2 \left(\frac{f^2 - 1}{f} \right)^2}$$

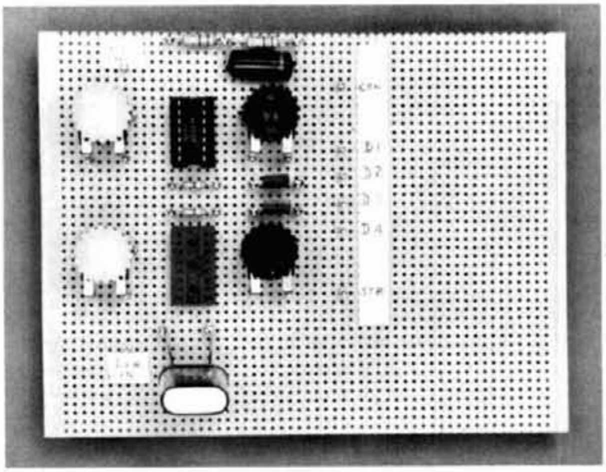
s = *staggering value*

f = *normalized center frequency, with two outside sections of Q selectivity and one center section of Q/2 selectivity.*

Various values of s and Q were calculated and plotted. Using $s=1.16$ and $Q=10$ and 20 for the center and outside sections, produced a passband ripple of 3 dB and 32 dB of rejection for the other tone group. With the s and Q values determined, it only remained to select a suitable circuit.

Many designs, using 1, 2, 3, and 4 amplifiers per section, have been published, but the disadvantage of the 1- and 2-op amp versions is that they are not generally suitable for high Q applications, especially with inexpensive ICs which have low gain-bandwidth products. Since low-cost quad op amps are available, and in many pin compatible packages, a 3- or 4-op amp design is preferable; any circuit configuration would be acceptable, especially if one per cent tolerance resistor and capacitors are used, but I did not wish to use precision components, and therefore, expended the additional labor to ensure that standard parts can be used.

Filter Selection. The BIQUAD filter section (see **fig. 4**) was chosen because the center frequency and Q can easily be adjusted by trimming just one resistor for each function. The principle of operation of the BIQUAD is as follows. Since the integral of a sine wave is a cosine wave, or a 90-degree phase shift, U1 is an integrator, giving a 90-degree shift. U2 is an inverter yielding 180-degree shift, for a subtotal of 270 degrees. U3 is another integrator giving an additional 90 degrees, for a grand total of 360 degrees. Positive feedback may then be provided from input to output.



The partially completed decoder board.

Without the Q setting resistor, the gain and Q of the BIQUAD would be excessively high, causing the circuit to oscillate at the frequency where the phase shift is 360 degrees (the integrator and inverter do not have exactly 90 degrees and 180 degrees shift respectively at more than one frequency). This resistor introduces enough loss so that the Q is controlled and the BIQUAD does not oscillate. The actual frequency response curve for the complete filter is shown in fig. 5 and its schematic is presented in **fig. 6**.

Filter Operation. The tonal input is simultaneously applied to both sides of the filter, passing through the 686 Hz, 809 Hz, and 955 Hz sections of the low-group filter as well as the 1191 Hz, 1404 Hz, and 1657 Hz sections of the high-group filter. Resistive dividers R19/R20 and R41/R42 reduce the outputs of the 686 Hz and 1191 Hz sections so that these sections may be driven farther toward cutoff and saturation without overloading the following stages. Since a single 12-volt supply is used, R39 and R40 divide 12 volts down to 6 volts, establishing the dc bias so that the output may swing equally about 6 V dc. C13 ensures that the 6 V dc bias line is at ac ground.

filter construction

My filter was built using wire-wrap techniques. I used standard, wire-wrap IC sockets with a phenolic

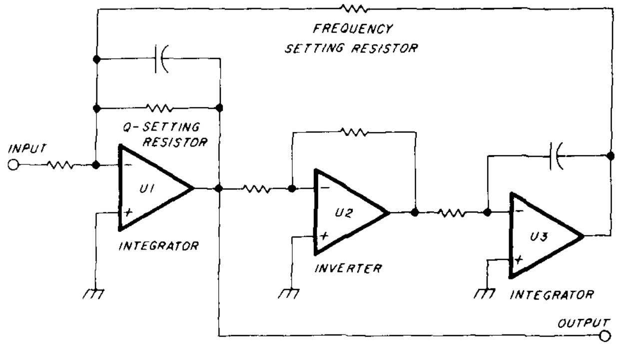


fig. 4. Diagram of the basic BIQUAD active filter. The two integrators produce a 90-degree phase shift and the inverter provides 180 degrees of shift. With proper feedback, this filter will pass a single frequency.

board and Vector wire-wrap terminals to mount the resistors and capacitors. This method has one very attractive advantage (though it is slightly more expensive), it's very fast, especially compared to point-to-point soldered connections.

Drop the Vector pins into place, seating them by pulling from the bottom of the board. Epoxy the sockets into position. The board can be wired using an inexpensive, hand wire-wrap tool. The use of precut and stripped no. AWG 30 (0.25mm) wire further speeds assembly. Use an ohmmeter to check *all* wiring for errors. This is extremely important since it will prevent damaging components and could save considerable time later.

Temporarily install the final 12 resistors using the nominal values shown in the schematic. Miniature potentiometers set to these values are highly recommended. Only six are needed since the low and high group filters can be tuned separately. These pots can be removed later and precision resistors installed.

Make your own precision resistors by wiring two or more resistors in series, or by using the W3QG trimming technique. For instance, to make a precision 11.5k-ohm resistor, file a V notch in a 1/2-watt, carbon, 10k-ohm resistor until the exact value is attained. A small grinding wheel on a Dremel tool is even better; use a light-stroking motion. And finally, seal the exposed carbon with a dab of epoxy.

tuning and alignment

For checkout, you will need a sine-wave audio source and an oscilloscope. It would be helpful if the sine-wave source does not change in amplitude as it is tuned from one frequency to another, but if necessary its output can be readjusted with the scope.

You should now install the ICs and apply power. Set the generator for approximately 50 mV peak-to-peak. Beware, a larger value may reduce the Q and/or drive the op amps into nonlinearity. Be sure the generator does not cause a dc-bias problem with the filter; you may want to include a 0.01 μF capacitor in series with the filter input.

Tune the generator from approximately 600 Hz to 1200 Hz with the scope connected to the low group output. Notice where the three filter sections are peaking. Don't expect the peaks to be the same amplitude since the Q has not been tuned yet. If you have chosen to use pots, tune the center frequency of each section to the correct value, using R6, R12, and R18.

If you are using individual resistors, divide the actual center frequency of each section by the desired frequency for that section. Square this fraction and multiply it times the existing resistor value. This will give you the approximate value for a resistor which will put you very close to the desired frequency. Set the center frequency for the three high group sections in a similar manner by tuning the generator from approximately 1000 Hz to 2000 Hz.

To tune the Q, each BIQUAD could be driven and monitored separately and adjusted to the desired Q. An easier method is as follows. The Q of the first low group section is 20; the frequency is 686 Hz; the bandwidth is 686/20 or 34 Hz. Hook the oscilloscope to U3 pin 7. Adjust the generator to the center frequency and note the amplitude. Find the two frequencies where the output is 3 dB (0.707 times) less than at the center. Is the bandwidth more or less than 34 Hz? Adjust R2 upward to increase Q or down to decrease Q. Once this value equals 20, connect the scope to the output of the low group filter.

Set the generator for the center frequency of the 686 Hz section. If, for instance, the output is 500 mV peak-to-peak, tune the generator to the center of the 809-Hz section and adjust R8 for 500 mV, then tune the generator to the center of the 955-Hz section and adjust R14 for 500 mV.

The high-group filter may now be tuned in a similar manner at its respective frequencies, first adjusting the 1191-Hz section, via R22 for a Q of 20 and a 60-Hz bandwidth with your scope on U3 pin 8. Then,

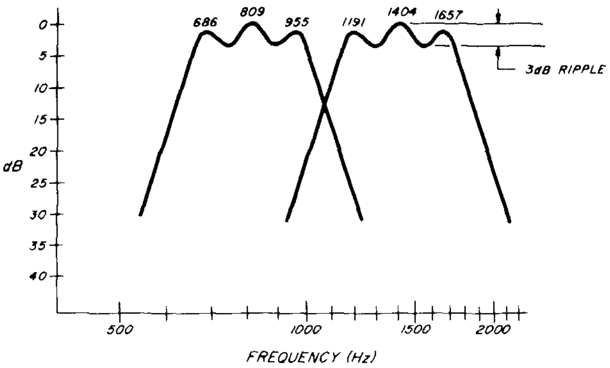


fig. 5. Filter response for the high and low tone separation filter.

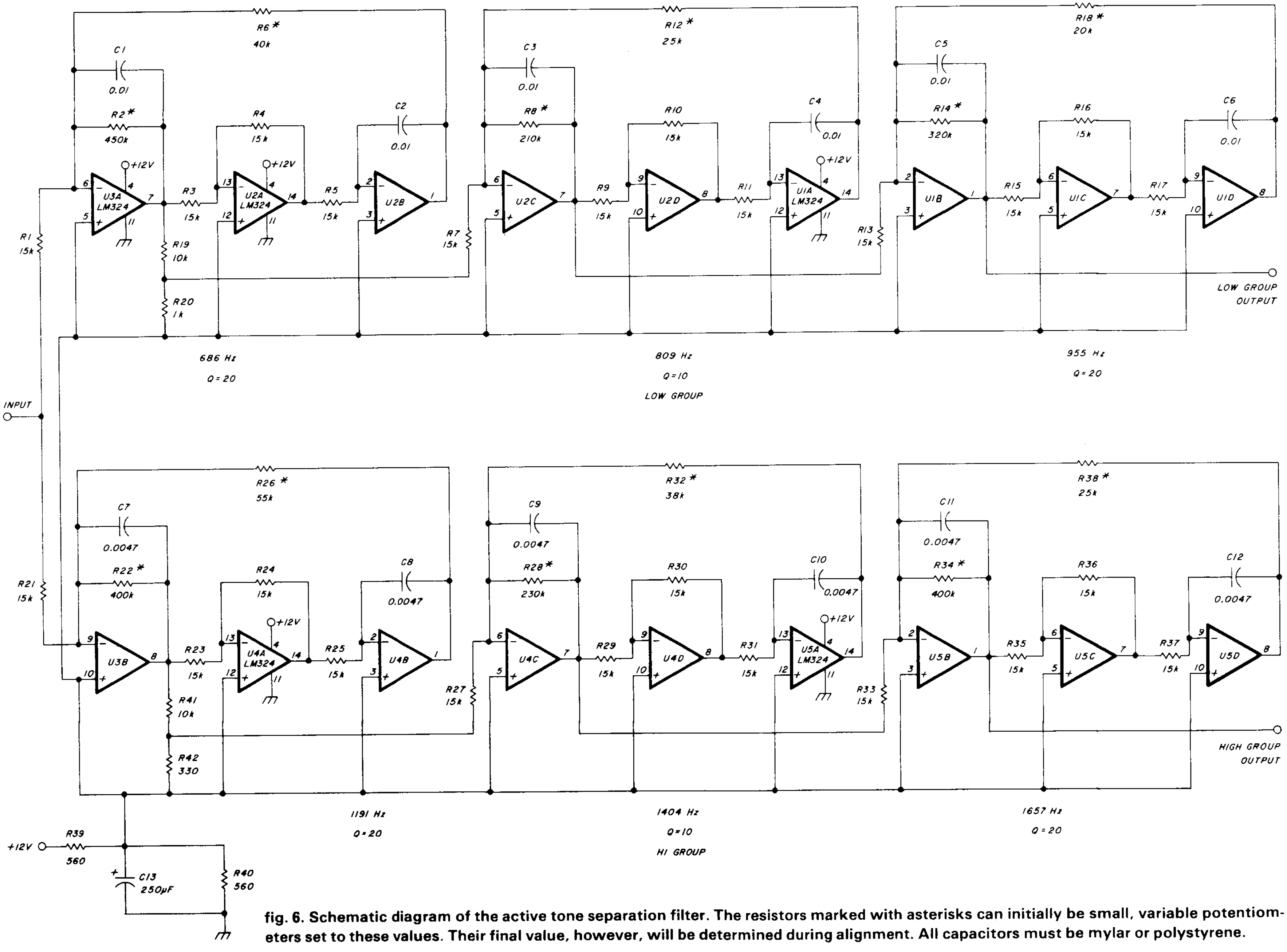


fig. 6. Schematic diagram of the active tone separation filter. The resistors marked with asterisks can initially be small, variable potentiometers set to these values. Their final value, however, will be determined during alignment. All capacitors must be mylar or polystyrene.

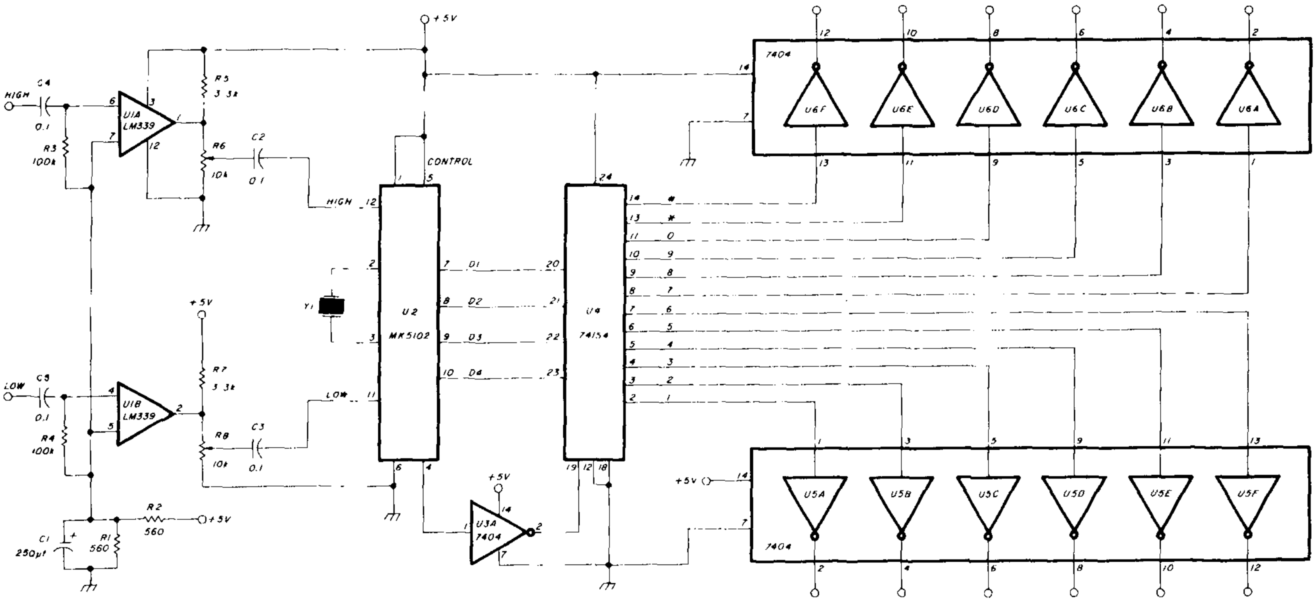


fig. 7. Schematic diagram of the decoder section. The data from the 74154 is active low, and can be inverted (by U5 and U6), depending upon the needs of your system.

with your scope on pin 1 of U5, adjust R28 and R34 at 1404 Hz and 1657 Hz respectively as you did for the low-group sections. Finally, check to ensure that 1209 Hz is really 30 dB down from 941 Hz in the low-group filter, and vice versa.

A voltmeter may be substituted for an oscilloscope for every filter test, but it will not allow you to see nonlinearities, oscillations, and hum. Also, a *Touch-Tone* pad can be used as a frequency standard to calibrate the generator by setting up a Lissajous pattern. On most pads, pressing two row or column buttons will produce only the sine wave for that row or column.

If your filter oscillates, the problem may be:

1. The Q of one or more stages is too high.
2. The power supply is not adequately bypassed.
3. The ground circuit is not adequate.
4. Circuit layout causes unwanted feedback.

The filters I have constructed have not had these problems. Should you decide to use a substitute op amp be aware that if it has poor power supply rejection or insufficient phase margin, it could cause oscillation.

comparator and decoder circuitry

Fig. 7 is the schematic for the comparator and decoder. The two sections of the comparator U1 are used to square up the filter outputs. The resistive dividers on the output of the comparators allow adjustment of the drive to the MK5102, although this does not seem critical; you may choose to replace the pots with fixed dividers.

In this circuit, the decoder's data control pin is tied to 5 V dc to constantly enable the proper format. A 74154 separates the twelve subsequent commands. The 74154 outputs are active low, so if you require active high signals include hex inverters U5 and U6. If the digit 1 is received, then pin 2 of the 74154 will stay low just as long as the 1 is being received.

The filter, decoder, and ALC circuitry has been in operation for many hours. It's presently connected to the output of a 2-meter fm receiver tuned to a noisy, busy, repeater channel, and is used every day for selective call and remote control. The circuit does not trigger on false signals. In fact, it has proven to be stable and reliable, sufficiently so that it has permanently replaced an earlier sophisticated 567 PLL decoder system which was in use here for over a year and a half.

Incidentally, there is a minor limitation of which you should be aware. Because of the ALC used with this system, a signal with somewhat low deviation will not be a problem. However, a signal with excessive deviation will be wider than your receiver's passband and will not be decoded. This is not a fault of the decoder, but must be corrected at the transmitter.

Soon the MK5102, with its tri-state outputs, will be connected to a MOS-Technology 6502 microprocessor system so that more complex functions may be performed. I welcome and solicit any and all comments and improvements to this *Touch-Tone* decoder.

ham radio

antenna guys and structural solutions

Advice on choosing guying materials and installing them for safety and long life

Amateurs with free-standing antenna towers are fortunate indeed: no need to worry about guy wires, anchors, and supports. But if your antenna tower must be guyed, how do you ensure that your guying system will withstand the forces of high winds? What about your soil conditions? Can your soil hold guy anchors?

This article gives some guidelines on how to handle the problem of guying antenna towers erected on various types of soil (from hard rock through loose sand and gravel). Also included are some tips on guying materials and how to use them. The author has had some 30 years of experience in the engineering and construction of antenna systems in locations where wind velocity often exceeDS 185 km/hr (100 knots).

guy-anchor placement

Starting at ground level and going up, the location of each guy anchor is our first consideration. Ideally, guy anchors should be placed the same distance from the tower or mast base as the guy attachment to the structure, a 1:1 ratio. A minimum of three guys, spaced 120 degrees apart are considered while four guys spaced 90 degrees apart is most desirable. When real estate is not available to maintain the desired 1:1 ratio, consideration should be given to an acceptable ratio of 6:4.

anchors

Table 1 shows how we may expect our anchors to accept the strain when installed in various soils. Considering the load that an average guy will put on the anchor and rod, the stamped 152-mm (6-inch) anchor with a 13 mm (1/2 inch) by 1.5-meter (5 foot) rod will perform satisfactorily in most locations (**fig. 1**).

table 1. Classification of soils. The soil classification is used for determining the type of holding anchor guy wires (Courtesy Graybar Electric).

soil class	soil description
1	hard rock, solid
2	shale or sandstone, solid or layered
3	hard, dry, hardpan
4	crumbly, damp
5	firm, moist
6	plastic, wet
7	loose dry sand, gravel

In my case anchor holes were drilled with a power-driven post-hole digger leased from a local equipment rental agency. Angle the anchor hole so that guy tension is in a straight line with the anchor rod. The holding ability of this type of construction is shown in **table 2**. Before placing the anchor and rod, dress the rod threads to prevent the nut from backing off.

table 2. Holding power of a 152 mm (6 inch) cone anchor in several soil types (courtesy Graybar Electric).

soil classification (table 1)	3	4	5
pounds (kg) ultimate	10,000(4540)	8,000(3632)	6,000(2724)

These units will survive for many years if the soil composition is not corrosive. A test with litmus

By Marchal H. Caldwell, Sr., W6RTK, 4620 Greenholme Drive, No. 4, Sacramento, California 95842

paper will reveal the presence of any contaminants. Coat the rod and anchor with thinned roofing mastic before back filling.

guy wire material

Consider the actual guy wire. There are probably more different guy wire types than vacuum tubes, and most will survive for a long time. Since an antenna and its supporting structure represent a considerable investment, the proper selection and use of guying materials is a must. **Table 3** lists some of the available solid and stranded guy wire.

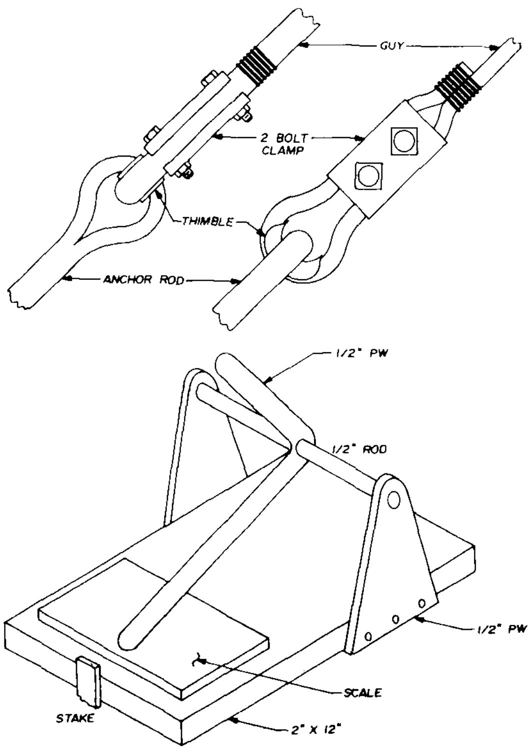


fig. 1. Mechanical details for securing anchor hardware on guy wires. Lower sketch shows a method for adjusting guy-wire tension. An ideal ratio of 1:1 is assumed for the distance of guy-wire attachment to structure (that is, guy locations should be the same distance from tower base as the guy attachment to the structure). A compromise ratio of 6:4 is acceptable.

attaching the guys

Guy-wire attachment to the anchor rod eye is usually by a clevis-and-eye turnbuckle, with the clevis end attached to the rod and the guy strand attached to the eye by wire rope clamps. At least *two* clamps must be used spaced six times the diameter of the wire. The wire dead-end should be served around the wire adjacent to the outer clamp. Turnbuckles should be safety-wired. A thimble should be used under the wire and inside the eye (**fig. 2**).

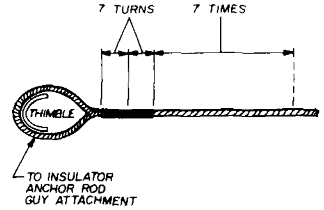


fig. 2. Method for securing terminal hardware to a guy. Note how guy wire should be served (7 turns, 7 times).

Towers and masts are sometimes provided with a guy attachment bracket. Terminate the guy wire in the same manner as used at the turnbuckle (**fig. 3**). When no guy bracket is provided, wrap the guy around the tower leg above a cross brace.

Proper guy tension has always presented a problem. The only sure and safe method is to use a strand dynamometer, which is expensive and normally not available. However, most amateurs use the eyeballing method — keeping too much tension out and not too much sag.

strain insulators

Some antenna structures will require the guy wires to be broken with strain insulators while others won't need this treatment. **Fig. 4** shows how to connect strain insulators in the guy wires. Note the recommended method of serving the loose ends of the wires, which is extremely important. At amateur frequencies, the most desirable maximum distance between guy-wire insulators is 3 meters (10 feet). Your

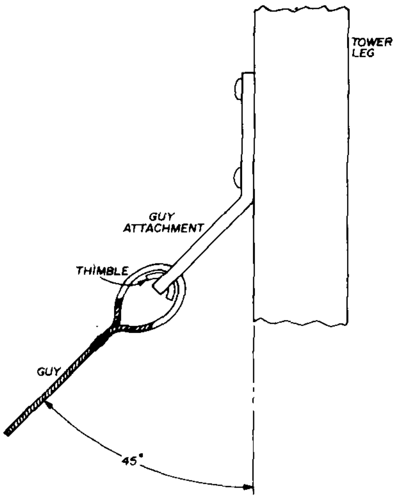


fig. 3. Connecting terminal hardware to a mast or tower, showing recommended geometry for guy placement. An angle of 45 degrees is ideal, but compromises are acceptable depending on your local wind conditions and available real estate.

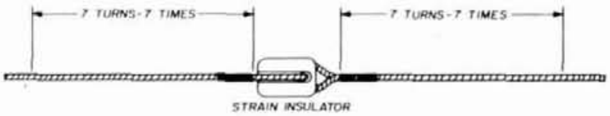


fig. 4. How to connect strain insulators to your guys. Serving the loose ends of the guys follows the rule: 7 turns, 7 times.

pocketbook will be the deciding factor since the insulators and guy wire clamps could cost about $5 at each point.

Reasonably corrosion-proof materials should be used in your antenna construction. Hot-galvanized materials are among the best. An excellent source of supplies is your local electrical contractor. Exploration of surplus and salvage agencies often produces items at a considerable saving — but again, don't compromise on quality!

Personal safety during construction is a most important consideration, which must be practiced and observed. Have an adequate supply of strong hands and backs available when erecting any type of supporting structure. Ground-crew members should be equipped with hard hats, safety shoes, work gloves, and a knowledge of your construction plans. Climbers should be similarily equipped and have a good safety-belt.

If you're considering constant experimental work at the top of your structure, fall-safe units are available, which will prevent a disastrous fall. (This stuff is expensive, but so is a hospital bed!)

table 3. Guy-wire strength in terms of size, breaking strength, and maximum load (courtesy Graybar Electric).

	size, mm(AWG)	breaking strength, kg (lb)	maximum load, kg (lb)
galvanized telephone & telegraph	2.6 (10)	293 (645)	136 (300)
	2.1 (12)	193 (425)	91 (200)
	1.6 (14)	112 (247)	52 (115)
	diameter, mm (in)	**breaking strength, kg (lb)**	**maximum load, kg (lb)**
seven wires twisted into 1 strand (common grade)	5.0 (3/16)	522 (1150)	250 (550)
	6.5 (1/4)	863 (1900)	409 (900)
	8.0 (5/16)	660 (3200)	681 (1500)
seven wires twisted into 1 strand (utility grade) — Western Union, AT&T	5.0 (3/16)	999 (2200)	477 (1050)
	6.5 (1/4)	1816 (4000)	908 (2000)
	8.0 (5/16)	2724 (6000)	1362 (3000)

Finally, but by no means of less importance, remember that erecting a supporting structure near high-voltage power lines could cause you to miss out on the Quarter Century Wireless Club.

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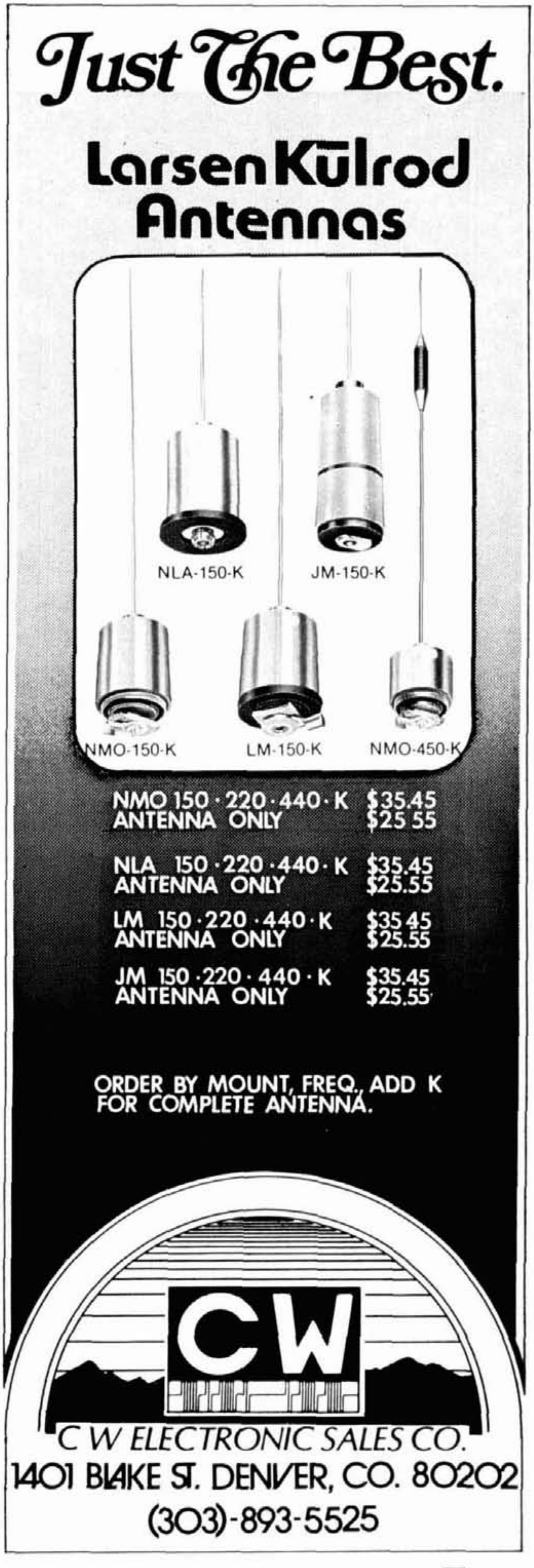

vfo design using characteristic curves

Graphical aid to help you choose vfo component values on the basis of working-frequency range and scale linearization

***This article will help you** design a vfo using what I* call the "universal characteristics" of the Colpitts oscillator. The hard work has already been done with the aid of a computer. The result is a family of parametric curves that allow you to choose frequency determining values of critical components precisely and without guesswork.

background

Several months ago I started the project with an ssb transceiver using ICs, following the new and well-known concept of concentrating all common circuits that don't depend on reception-transmission frequency in a single printed circuit. An external vfo and a tuned amplifier in the input-output circuit defined the transceiver operating frequency. Several IC manufacturers have developed exclusive ICs for the common parts of the transceiver mentioned *above by standardization and by reducing the* number of discrete components.

the external vfo

The first problem I met was designing the external vfo. I needed a vfo in the 5 to 5.5-MHz frequency range with good stability and linearity. Because of the chosen frequency and the oscillator characteristics, I chose the Colpitts oscillator. I first tried to find articles that already described vfos working in my desired frequency range. I found a couple of circuits, and despite the different component values shown, I started construction following the scheme in **fig. 1**. First of all I used a capacitor, $C_v = 80\ pF$ with an inductance of approximately $L = 5\ \mu H$, using different values for C1 and C2. I immediately realized the dif-

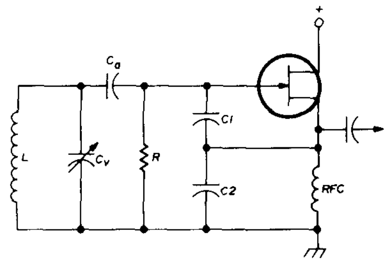

fig. 1. Typical vfo Colpitts oscillator circuit used in the text example. Components L, C_v, C_a define the oscillation frequency, for which parametric curves have been derived and are shown in fig. 3.

By Maurizio Gramigni, I2BVZ, 1621 16th Avenue NW, Rochester, Minnesota 55901

ficulties ahead; in fact, when turning C_V 180 degrees, the frequency range was around 1.6 MHz, which was not the desired range. After this failure I decided to face the problem from a technical point of view, starting from these assumptions:

1. Determine frequency stability *vs* temperature variation.

2. Calculate circuit-component values on the basis of the chosen working frequency range and scale linearization.*

Regarding point **1**, the use of an fet is highly recommended compared with bipolar transistors or vacuum tubes. The advantages are listed below:

1. An fet, with its high input impedance, can amplify signals with very low current level. As a result the power dissipation will be less than with bipolar transistors and vacuum tubes.

2. As a consequence of point **1** above, the heat dissipated and transferred to the oscillator components is lower, resulting in better thermal stability.

3. Since the power used is very low and the fet mass is very small and compact, the thermal equilibrium will be reached in a very short time — 30-40 seconds.

Using components such as silver mica capacitors helped to provide an oscillator with a very good frequency stability.

Calculating component values as a function of frequency range and scale linearization is the subject of this article. **Fig. 1** shows our vfo circuit. Let's say, first of all, that L, C_v, C_a define oscillation frequency, while $C1$ and $C2$ are the positive feedback network, which provides self starting and maintains oscillation. Distortion due to the nonlinear elements is limited by the proper choice of resistor *R*.

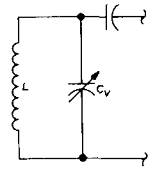

fig. 2. *At the resonant frequency the oscillator impedance will equal zero. The network L, C_v, C_a formed the basis of the FORTRAN program, which resulted in the universal characteristic curves for determining vfo values as shown in fig. 3.*

Generally it's easy to design an oscillator working at one predetermined frequency. In fact, this occurs when the capacitive reactance of the oscillator circuit equals its inductive reactance. If a variable frequency oscillator is needed, however, a different approach to the problem is required. In this case, once the frequency range is chosen we need to know L, C_v, and C_a values.

universal characteristics

To reach our goal we start by calculating the transfer function of the complete oscillatory circuit. Then if we indicate

$$\omega = 2\pi f$$

$$C = \frac{C_1 \bullet C_2}{C_1 + C_2}$$

$$X_L = j\omega l$$

$$X_v = -j\frac{1}{\omega C_v}$$

$$X_a = -j\frac{1}{\omega C_a}$$

$$X_C = -j\frac{1}{\omega C}$$

the final equation is

$$\vec{Z} = \frac{\left(\frac{X_L \bullet X_v}{X_L + X_v} + X_a\right) \bullet \left(\frac{R \bullet X_C}{R + X_C}\right)}{\left(\frac{X_L \bullet X_v}{X_L + X_v} + X_a\right) + \frac{R \bullet X_C}{R + X_C}}$$

Because of the quantity of calculations I used a computer to solve for $\vec{Z}$.

As mentioned previously the real oscillator circuit consists of L, C_v, C_a components (see **fig. 2**). At the resonant frequency, its impedance will equal zero, therefore our complex impedance, $\vec{Z}$, must also equal zero. The program, in FORTRAN language, was based on the observation above. In fact, the computer printout directly supplied C_v values for that particular frequency value where $\vec{Z}$ equals zero.

parametric curves

Starting from frequency values of 2.5 MHz, and for fixed values of L, C, C_a, and R, we obtained from the computer the C_v values for $\vec{Z} = 0$. The results are summarized in the curves of **fig. 3**.

Fig. 3A shows the universal characteristics family for $L = 7.5\mu H$. C_a values vary from 150 to 400 pF in 50-pF

---

*Scale linearization means that any variation of C_v capacitance, ΔC_v, always corresponds to the same frequency variation, Δf, in the entire oscillator range; that is, the linearity ratio, $\Delta f / \Delta C$, remains constant in the chosen range.

steps. **Fig. 3B** shows the universal characteristics for $L = 4.5\ \mu H$. Seven curves for C_a values between 250 and 550 pF have been calculated.

Fig. 3C refers to the universal characteristics for $L = 2\ \mu H$. These curves show that the effect of decreasing L causes an extension of the frequency range of interest by universal characteristics. For the characteristics of **figs. 3A** and **3B** it was not possible to calculate other C_a values because of the unstable conditions I found. Therefore, only 12 curves for C_a, from 250 to 800 pF, have been calculated.

how to use the universal characteristics

I call these characteristics "universal" because they are valid for all vfos (Colpitts) as shown in **fig. 1**. With these characteristic features you can determine directly the values of all vfo components, as shown in the following example.

Assume you want a variable oscillator covering 3.5-3.9 MHz. Choose two curves, the first from **fig. 3B** with $C_a = 300\ pF$ and the second one from **fig. 3C** with $C_a = 800\ pF$. In the first case, the linearity ratio value is $\Delta f/\Delta C = 4.4\ \frac{kHz}{pF}$; while in the second case it is $\Delta f/\Delta C_v = 2.1\ \frac{kHz}{pF}$. To obtain C_v, (which in this case is 90 pF instead of 190 pF as in the second case) the curve of **fig. 3B** could be used. From this figure it's possible to get all the other values, which are:

$$C_a = 300\ pF \qquad C_v = 90\ pF$$

$$L = 4.5\ pF \qquad R = 22\ K$$

$$C1 = C2 = 600\ pF$$

Usually $C1$ and $C2$ have the same values to guarantee self-starting oscillations.

in conclusion

Once the working frequency range is chosen, it's possible to satisfy, through the universal characteristics of **fig. 3**, the following points:

1. Dial linearization; that is, keeping the $\Delta f/\Delta C_v$ ratio constant within the chosen range.
2. Definition of minimum and maximum C_v values.

In any case, for about 200 kHz of frequency range, the linearity error is very low for each curve of the families. On the contrary, for a wider frequency range, the choice of the curve is much more limited and depends on the desired $\Delta f/\Delta C_v$ ratio; that is the derivative value of the curve. Generally, for the $\Delta f/\Delta C_v$ ratio, it's advisable not to select very high values, around $4\ kHz/pF$.

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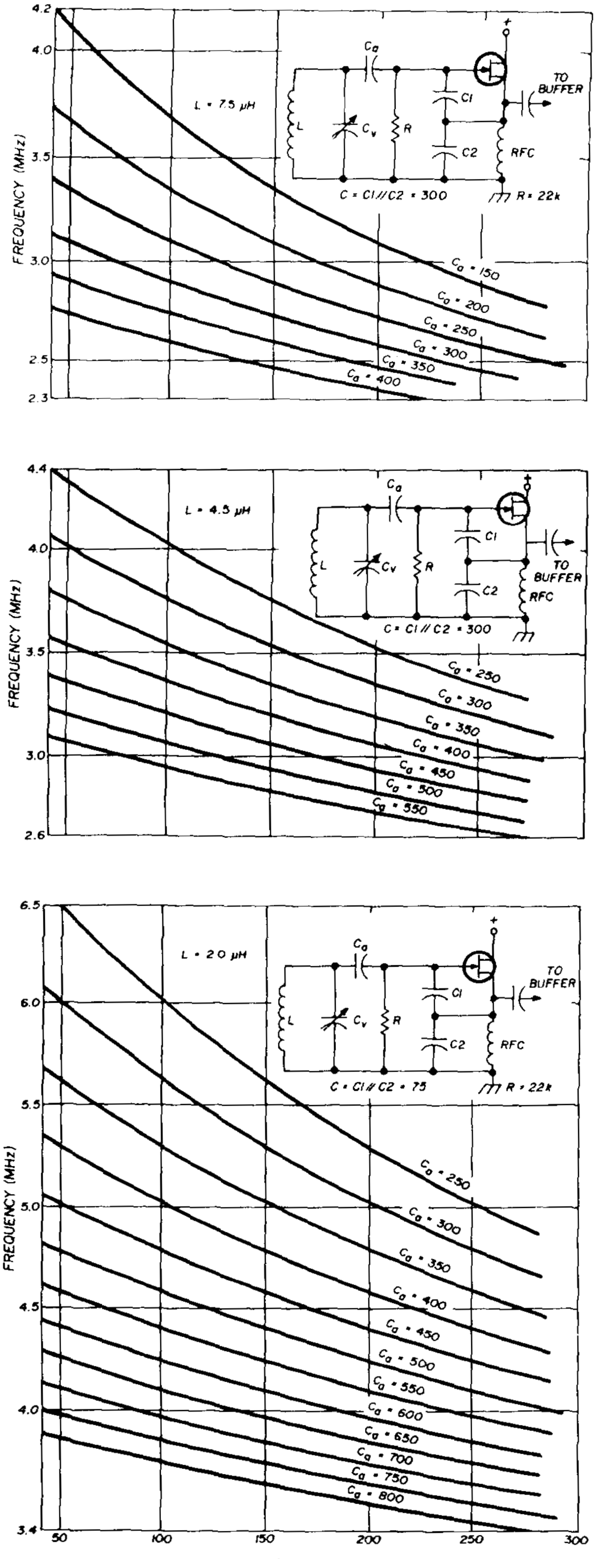

fig. 3. A family of parametric curves for determining component values for the Colpitts vfo in fig. 1. Operating frequency as a function of variable capacitance, C_v, is shown as a function of oscillator frequency with values of C_a as a parameter. The three sets of curves are for various values of inductance, L.

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rf chokes

their performance above and below resonance

An investigation into the properties of rf chokes over wide frequency ranges

For years I've heard various electronics engineers quote a simple rule-of-thumb about rf chokes: "Never use an rf choke above its self-resonant frequency because it's capacitive!" The inference is, I think, that above its self-resonant frequency, the rf choke will have a very low reactance, which is the opposite effect usually desired from an rf choke. After all, capacitors are used for bypass and coupling functions, and an rf choke *does* show capacitive reactance above its self-resonant frequency.

This rule-of-thumb is a very safe and conservative way to apply rf chokes in circuit design, I suppose, but sometimes it makes it difficult to get the impedance you want over a desired frequency range; in general, the larger the inductance of an rf choke, the lower will be its self-resonant frequency.

A frequent application of rf chokes by amateurs is the use of a 2.5 millihenry choke in a circuit which operates up to 30 MHz. Such use is in direct conflict with the stated rule-of-thumb, because the self-resonant frequency of these chokes is usually on the order of 3 MHz! In the paragraphs which follow, I have attempted to resolve this conflict by mathematical analysis.

mathematical analysis of the rf choke

To evaluate the performance of rf chokes at different frequencies, I felt it necessary to develop a general mathematical expression for impedance as a function of self-resonant frequency. Starting with the mythical ideal rf choke, we have a pure inductor as shown in **fig. 1**. The equation for its impedance in ohms is

$$Z = j2\pi fL \qquad (1)$$

where Z is the impedance, f is frequency in Hertz, and L is inductance in henries. The j is simply a notation which indicates that the phase angle of the impedance is +90° with respect to a pure resistance. To simplify the following equations a little, I will substitute ω for $2\pi f$

$$\omega = 2\pi f \qquad (2)$$

where ω is frequency in radians-per-second. You can always get back to frequency in Hertz by a rearrangement of **eq. 2**.

$$f = \frac{\omega}{2\pi} \qquad (3)$$

The solid line on the graph of **fig. 2** shows how the impedance of a pure inductor, having an inductance of 1 henry, rises linearly with increasing frequency, according to **eq. 1**. The linear relationship will continue to any frequency.

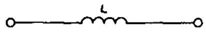

fig. 1. The ideal rf choke is a pure inductance.

Practical rf chokes, however, are not pure inductors; stray capacitance between turns of the coil is effectively in parallel with the ideal inductor. For the purpose of this discussion all of the stray capacitance may be lumped into one equivalent parallel capacitor, as shown in **fig. 3**. The rf choke now has a self-resonant frequency whose value is determined by the values of L and C. The equation for the impedance of this parallel circuit is

$$Z = \frac{(j\omega L)\frac{1}{-j\omega C}}{j\omega L + \frac{1}{-j\omega C}} = \frac{j\omega L}{1 - \omega^2 LC} \qquad (4)$$

The self-resonant frequency of the circuit will be

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designated ω_o, and its value is

$$\omega_o = \frac{1}{\sqrt{LC}} \qquad (5)$$

If ω_o is substituted for ω in **eq. 4**, we obtain the value of the choke's impedance at the self-resonant frequency.

$$Z_o = \frac{j\omega_o L}{1 - \omega_o^2 LC} = \frac{j\omega_o L}{1 - \left(\frac{1}{LC}\right) LC} = \frac{j\omega_o L}{1 - 1}$$

The denominator in **eq. 6** is equal to zero, so the impedance, Z_o, must be infinitely large (remember, we don't have any losses in our mathematical model, yet).

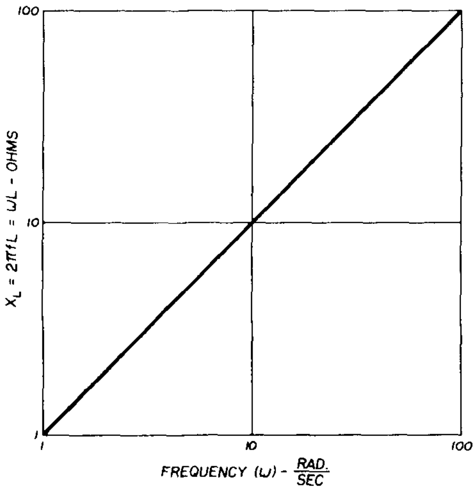

fig. 2. Reactance of a pure 1 henry inductor vs frequency (no stray capacitance or loss resistance).

To solve for the choke's impedance at one octave below and above the self-resonant frequency, substitute $\frac{\omega_o}{2}$ and $2\omega_o$, respectively, for ω in **eq. 4**

$$Z_{\frac{\omega_o}{2}} = \frac{j\left(\frac{\omega_o}{2}\right) L}{1 - \frac{\omega_o^2}{4} LC} = \frac{j\left(\frac{\omega_o}{2}\right) L}{1 - \frac{LC}{4LC}}$$

$$= \frac{2}{3}\,(j\omega_o L) \qquad (7)$$

$$Z_{2\omega_o} = \frac{j(2\omega_o)\,L}{1 - 4\omega_o^2\,LC}$$

$$= \frac{j(2\omega_o)\,L}{1 - \frac{4LC}{LC}} = -\frac{2}{3}\,(j\omega_o L)$$

Let's closely examine these two results. Notice that the quantity $(j\omega_o L)$ in each answer is the reactance a pure inductor would have at ω_o, the frequency at which the practical choke is self-resonant. Notice too that the magnitudes of the two answers are equal; the choke has as much impedance one octave above the self-resonant frequency as it does one octave below. The minus sign of the impedance one octave above self-resonance indicates the impedance has a phase angle of −90° with respect to a pure resistance, and this means it is a capacitive reactance.

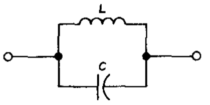

fig. 3. Practical rf choke has stray capacitance, creating a resonant circuit.

To explore this a little further, let's find the choke's impedance one decade below and above self-resonance

$$Z_{\frac{\omega_o}{10}} = \frac{j\frac{\omega_o}{10}\,L}{1 - \frac{\omega_o^2}{100}\,LC} = \frac{j\frac{\omega_o}{10}\,L}{1 - \frac{LC}{100LC}} = \frac{10}{99}\,(j\omega_o L) \qquad (9)$$

$$Z_{10\omega_o} = \frac{j\,(10\omega_o)L}{1 - 100\omega_o{}^2 LC}$$

$$= \frac{j(10\omega_o)L}{1 - \frac{100LC}{LC}} = -\frac{10}{99}\,(j\omega_o L)$$

Again, both answers have the same magnitude, and the impedance is inductive below self-resonance and capacitive above self-resonance. I have solved for the choke's impedance at several more frequencies and plotted the curve shown in **fig. 4**. Although the choke's impedance is capacitive above self-resonance, it doesn't fall off any faster than it does below self-resonance.

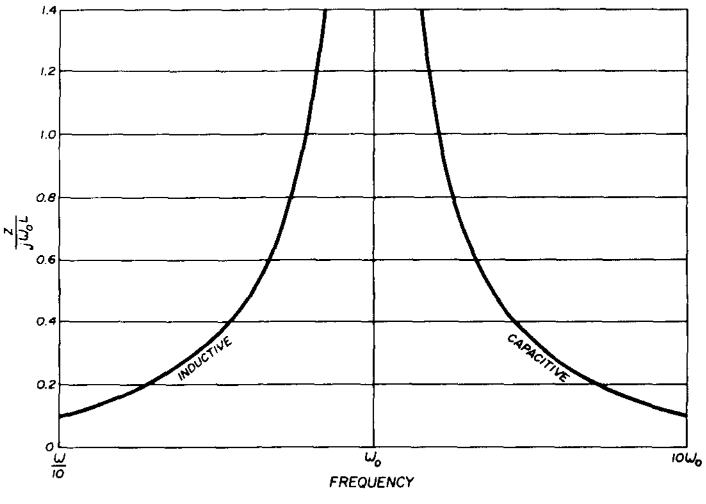

fig. 4. Relative frequency response of a lossless, but self-resonant rf choke. The frequency of resonance is at ω_o.

We must add an equivalent parallel resistance, R_p, as shown in **fig. 5**, to make the mathematical choke completely realistic. Another way to show this is pictured in **fig. 6**, where R_p is connected in parallel with the impedance, Z, solved for above. R_p accounts for losses in the choke; at the self-resonant frequency, the impedance of the choke will be equal to R_p.

The value of R_p does not stay constant as frequency changes because losses tend to increase at higher frequencies. A major contributor to this characteristic is the skin effect in the wire of the coil, which causes R_p to decrease as a function of the square-root of frequency. Solving for the exact impedance of the rf choke with R_p present is a little tedious and will not be dealt with here. It is assumed, however, that R_p will be large enough so that the calculations above may be taken as rough approximations at frequencies at least one octave away from self-resonance. Thus the curve of **fig. 4** is assumed to be roughly correct outside the frequency range from $0.5\omega_o$ to $2\omega_o$. An example may help to verify this.

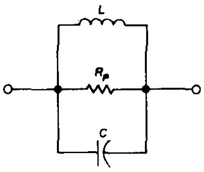

fig. 5. Equivalent parallel resistance, R_p, accounts for losses in rf chokes.

example

Using manufacturer's specifications for a typical 2.5 mH rf choke, let's examine its performance using the relationships developed above. Inductance is specified as 2.5 mH at 250 kHz with a Q of 55. The choke's reactance and R_p at 250 kHz are

$$X = 2\pi(.25x10^6)\,(2.5x10^{-3}) = 3927 \text{ ohms} \qquad (11)$$

$$R_p = QX = 55 \times 3927 = 215{,}985 \text{ ohms} \qquad (12)$$

Self-resonant frequency is given as 2.5 MHz. Therefore,

$$j\omega_o L = j\,(2\pi f_o)\,L = j(2\pi \times 2.5 \times 10^6)\,(2.5 \times 10^{-3}) = j39{,}270 \text{ ohms} \qquad (13)$$

Assuming R_p has decreased by the square-root of frequency change, we can estimate its value at 2.5 MHz as

$$R_p = \frac{215{,}985}{\sqrt{\dfrac{2.5\ MHz}{.25\ MHz}}} = \frac{215{,}985}{\sqrt{10}} = 68{,}300 \text{ ohms} \qquad (14)$$

Dividing R_p by $j\omega_o L$, we find the choke's Q at 2.5 MHz is about 1.74, a very low value. To satisfy our curiosity, let's see what the value of the equivalent parallel capacitor is. The capacitor's reactance must equal the inductor's reactance at resonance, so

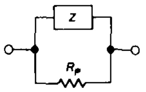

fig. 6. Another way of schematically representing an rf choke. Z is the lossless impedance calculated in the text.

$$C = \frac{1}{2\pi(2.5 \times 10^6)\,(39{,}270)} = 1.6\,pF \qquad (15)$$

Now let's see what sort of impedance the choke has at 25 MHz, one decade above its self-resonant frequency. Substituting the results of **eq. 13** into **eq. 10**

$$Z_{10\omega_o} = -\frac{10}{99}\,(j\omega_o L) = -j\,\frac{10}{99}(39{,}270) = -j3967 \text{ ohms}$$

The value of R_p at 25 MHz is estimated to be

$$\frac{215{,}985}{\sqrt{\dfrac{25\ MHz}{.25\ MHz}}} = \frac{215{,}985}{\sqrt{100}} = 21{,}598.5 \text{ ohms} \qquad (17)$$

so it won't cause too large an error in the result of **eq. 16**. Notice that the impedance at 25 MHz, one decade above self-resonance, is very nearly the same as the impedance at 250 kHz, one decade below self-resonance (see **eq. 11**).

One final calculation of interest is the value of capacitance the choke represents at 25 MHz

$$C = \frac{1}{2\pi(25 \times 10^6)\,(3967)} = 1.6\,pF \qquad (18)$$

Well, how about that? The same value as at self-resonance. Obviously, the equivalent parallel capacitance of the choke is totally dominating the value of reactance at 25 MHz. But then, it should.

conclusion

After going through the exercise above, it is evident that an rf choke behaves like any parallel tuned circuit. But since an rf choke has a self-resonant frequency, we knew it was just a parallel tuned circuit all along, didn't we? If we can use an rf choke below its self-resonant frequency, I see no reason not to use it above its self-resonant frequency, so long as it will provide the required impedance. An rf choke does look like a capacitor above self-resonance, but as we saw with the 2.5 mH choke, it can be a very small capacitor.

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INTER-OFFICE MEMO

TO: TOM BALL, Sales Manager
FROM: ROBERT BROWN, Chief Engineer

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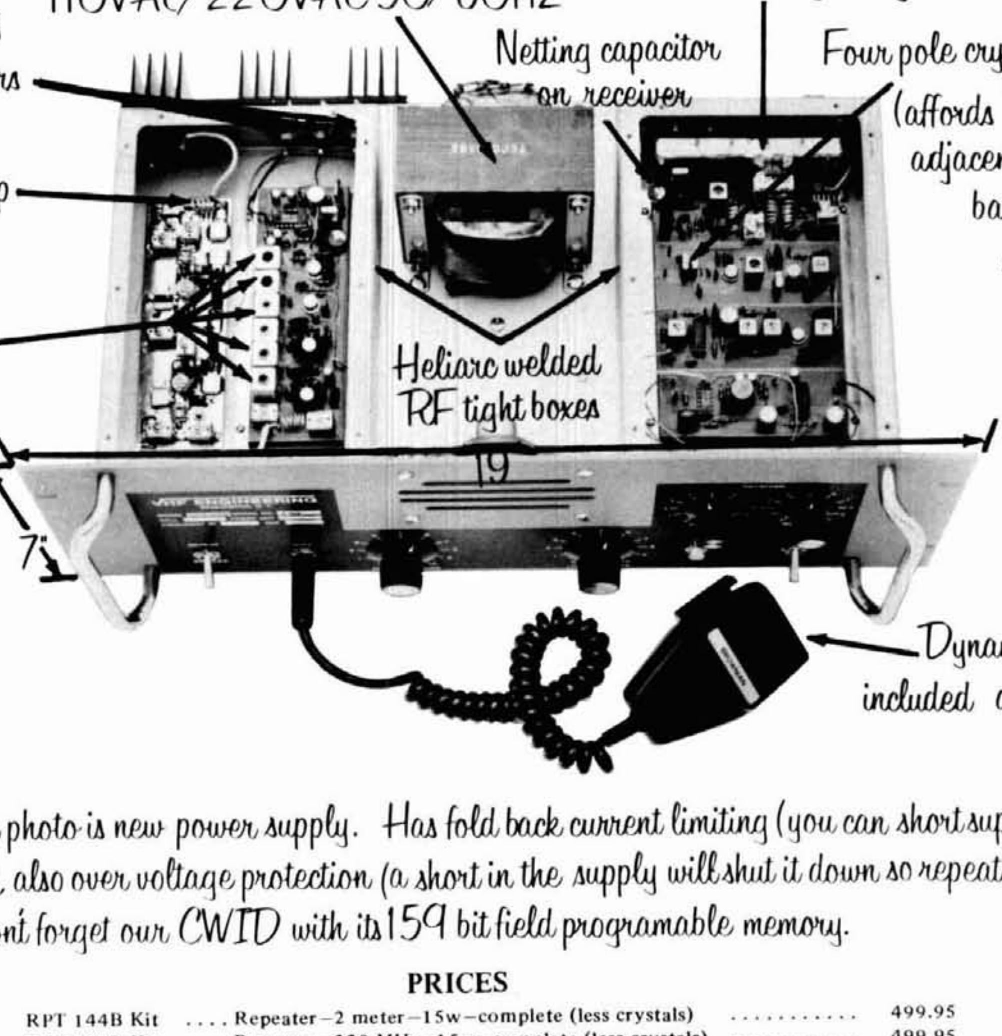

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More Details? CHECK—OFF Page 142

techniques for preventing rf leakage from your transmitter

Lowering unwanted rf leakage from your transmitter reduces radio-frequency interference

We are all aware of the increasing incidence of RFI problems caused by solid-state home entertainment products which are not designed to function normally in the presence of a strong RF field. These kinds of problems can be cured only by adding filtering and/or shielding to the affected device.

At the same time it behooves us all not to forget to be sure that our own transmitters are clean. This means using a good lowpass filter and making sure that the only path out of the transmitter for rf energy is through that lowpass filter. If you have any RFI problems, this is the first thing that should be checked.

Run your transmitter into a shielded dummy load. If the RFI is still present, you have rf leakage which should be eliminated. If it is harmonic interference, no lowpass filter will do any good if the harmonics are leaking out ahead of it. If it is overload interference, it may be possible to eliminate it by curing the leakage, depending on the amount of leakage to begin with and the relative distances from the equipment and the antenna to the device suffering the interference.

Three areas need to be addressed to solve rf leakage problems: filtering of power, audio, and control leads; shielding effectiveness of coaxial cable; and leakage at joints in shielded enclosures. Techniques

By John E. Becker, K9MM, 201 East Marion Street, Prospect Heights, Illinois 60070

for filtering of power, audio, and control leads has been thoroughly discussed in many amateur publications so that topic will not be addressed here. Instead, I will concentrate on the other two areas.

There is considerable difference in the shielding efficiencies of different types of coaxial cable. The numbers to be quoted are from manufacturers' literature, and while different manufacturers do not necessarily agree on the shielding efficiency of a particular type of cable, there is no doubt about the significant difference in the shielding efficiency afforded by the different types of cable construction to be discussed, and the numbers should be considered with that in mind. The most commonly used type of coax, that having a single shield braid of stranded copper wire, has a shielding efficiency of −48 dB at 100 MHz for a 30 cm (1 foot) length of cable. That is, the total power radiated by that 30 cm of cable is 48 dB down from the signal level in the cable. This assumes 95 per cent shield coverage. This shielding efficiency increases only slightly with decreasing frequency, to −52 dB at 10 MHz according to data published by the Times Wire and Cable Company.

The shielding efficiency is significantly reduced by lower shield coverage, and 85-90 per cent is more typical. This means that if you have 30 cm of coax between your transmitter and lowpass filter, harmonics radiating from that piece of coax are 48 dB down from their level at the transmitter output. Under these conditions, a lowpass filter with 100 dB harmonic attenuation is no better than one with 48 dB attenuation as far as nearby interference problems are concerned. The filter will keep the harmonics from getting to the antenna to be radiated for long distances, but the TVI problem next door is just as likely to be due to the radiation from the cable.

While we're still on the subject of single shielded coax, be especially wary of bargain priced coax that is not made to military specifications. Some manufacturers have drastically reduced shield coverage in the last few years to keep costs down.

There are more sophisticated types of coaxial cable with much better shielding efficiencies. The most often encountered construction is double shielded coax. This type of cable uses two shield layers with no dielectric between them. Shielding efficiency is typically −87 dB at 100 MHz for a 30 cm (1 foot) length, and since this is a premium cable designed for excellent shielding you can be sure that the shield coverage is as great as possible.

A still better type of construction for shielding efficiency is triaxial cable. This cable has two shield layers with a dielectric layer between them. Shielding efficiency is further improved to −97 dB at 100 MHz for a 30 cm length.

The ultimate in shielding efficiency is the solid jacketed type of cable. Radiation from this type of cable is below measurable limits, and system shielding efficiency is limited only by leakage at a connector interface.

The use of one of these improved types of cable for all station interconnections up to the lowpass filter will ensure that you are getting all the harmonic protection the filter is capable of. Double-shielded substitutes for RG-8A/U or RG-213/U are RG-9B/U or RG-214/U. The double-shielded substitute for RG-58C/U is RG-55A/U or RG-223/U. A triaxial substitute for RG-8A/U or RG-213/U is Times TRF-8. A triaxial substitute for RG-58C/U is Times TRF-58 or Essex 21-204.

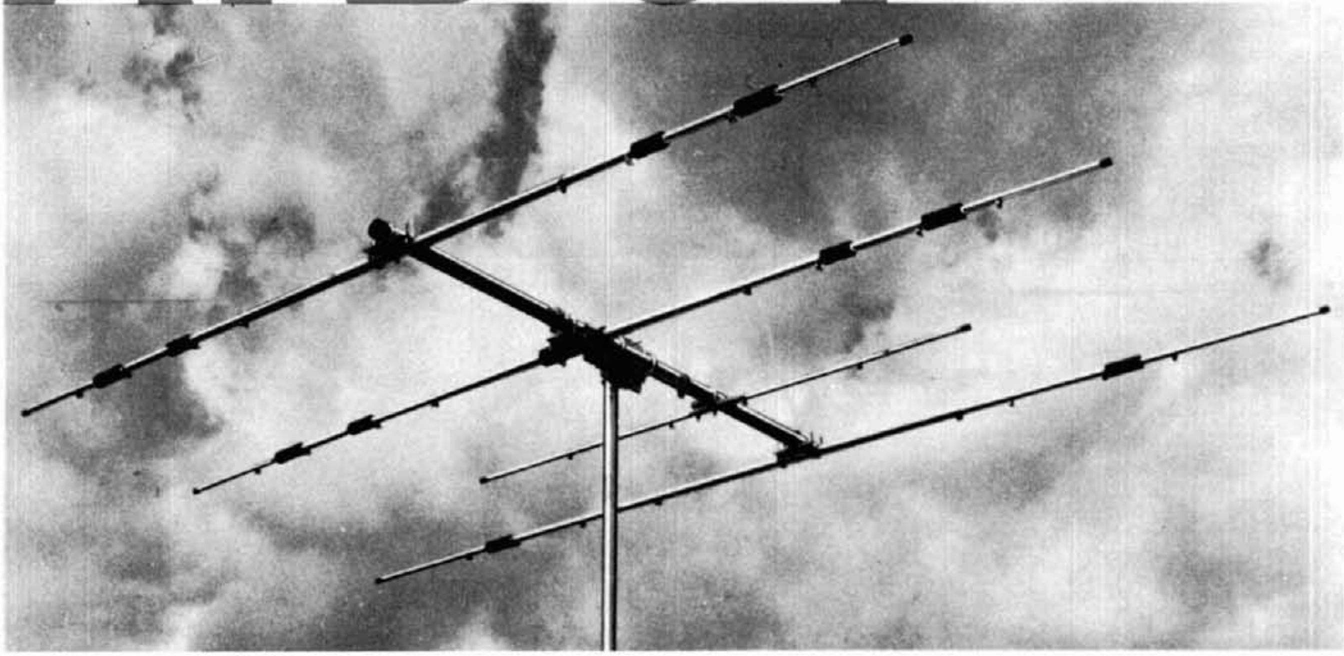
Whatever kind of cable is used, be sure the connectors are properly installed. An improperly attached shield will seriously degrade shielding effectiveness. With double-shielded and triaxial cables, both shields should be attached to the connector shell at both ends of each cable run. Assembly instructions for UHF, N, and BNC connectors can be found in both the ARRL *Handbook* and *Antenna Book*.

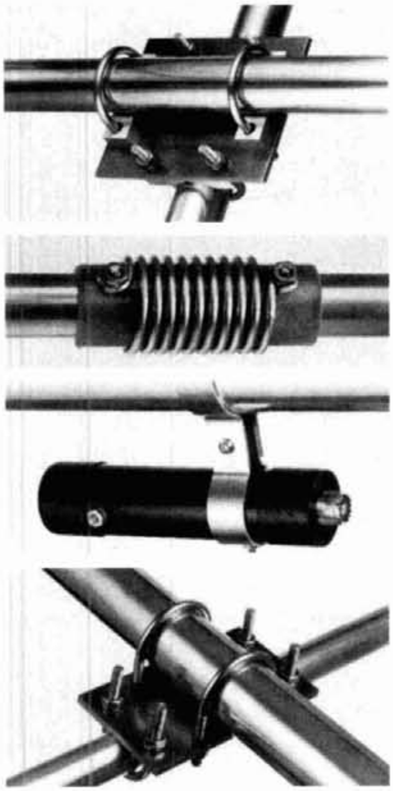
For sealing joints of shielded enclosures, the 3M company has two products that are hard to beat for effectiveness and ease of application. They are copper foil tapes with conductive adhesives, especially designed for RFI shielding. Type X-1181 is a smooth tape, and type X-1245 is embossed with a grid pattern for more reliable electrical contact with the surface on which it is applied. Both are available in widths from 6 to 25 mm (1/4 to 1 inch). Shielding efficiency of up to −65 dB is claimed by 3M, depending on the type of metal the tape is applied to. If desired, it is possible to solder to the tape without damaging it.

I have applied this tape to the edges of all shield enclosures in my equipment, to the seams of lowpass filter boxes, and over the edges of coax connectors. The same piece has been removed and re-applied on my linear amplifier cover shield several times with no apparent loss of adhesion. If the metal surface is clean to begin with, the adhesion is excellent. This type of tape may also be spirally wound over a length of conventional single shielded coax to obtain improved shielding effieciency. Each turn should overlap the previous turn by half the width of the tape, and the tape should extend over the shell of the connector at each end.

ham radio

ATB-34





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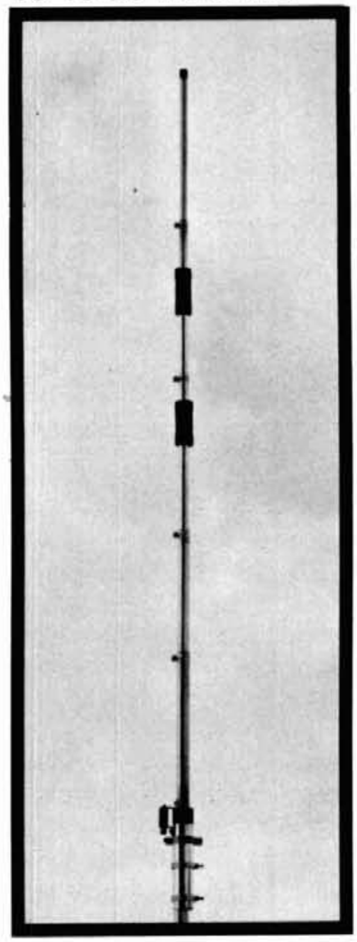
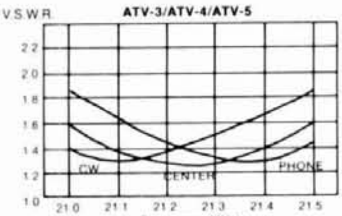
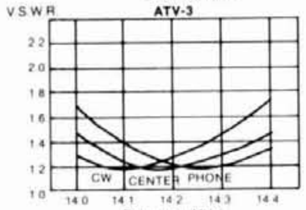
10-15-20 METERS



ATV-3 Cushcraft's ATV-3 multiband vertical provides low VSWR operation for both SSB and CW on 10, 15, and 20 meters. Matched to 50 ohms; built-in connector mates with standard PL-259. Stainless-steel hardware is used for all electrical connections. The ATV-3 is a compact 166 inches (4.2 meters) tall. Rated at 2000 watts PEP.



15 METERS



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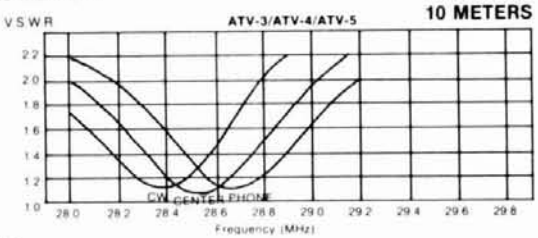
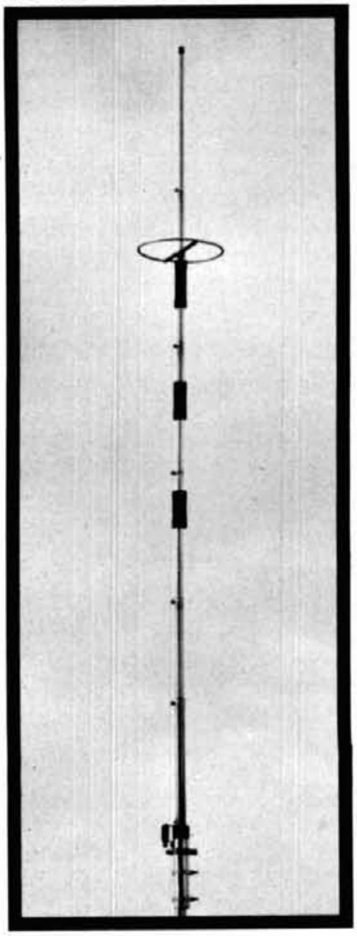


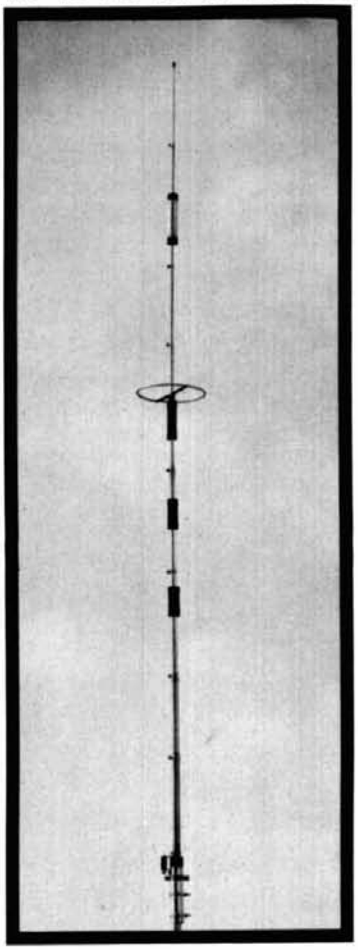
10 METERS

10-15-20-40 METERS



ATV-4 The Cushcraft ATV-4 four-band vertical antenna has been optimized for wide operating bandwidth on 10, 15, 20, and 40 meters. SWR is less than 2:1 over the CW and SSB segments of 10, 15, and 20. The 2:1 SWR bandwidth on 40 meters is approximately 240 kHz, may be quickly and easily adjusted to favor any part of the band. Coaxial fitting takes 50-ohm transmission line with PL-259 connector. Overall height, 233 inches (5.9 meters). Rated at 2000 watts PEP.

10-15-20-40-80 METERS



ATV-5 The ATV-5 trapped vertical antenna system has been engineered for five-band operation on 80 through 10 meters. The high Q traps are carefully optimized for wide operating bandwidth. 2:1 SWR bandwidth with 50-ohm feedline is 1 MHz on 10 meters, more than 500 kHz on 15 and 20 meters, 160 kHz on 40 meters, and 75 kHz on 80 meters. Instructions are provided for adjusting resonance to your preferred part of the band, CW or SSB. Built-in coaxial connector takes PL-259. Nominal height, 293 inches (7.4 meters). Rated at 2000 watts PEP on **all** bands.

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More Details? CHECK—OFF Page 142

simple and effective vertical antenna for portable communications

How to build
a simple
vertical antenna mount
that can be
set up quickly
for emergency
radio communications

One of the important aspects of amateur radio is the provision for efficient and timely communications in emergency or disaster situations. Having been a ham for several years I have found it interesting that, in the various ham-oriented magazines, there is substantial coverage given for proper procedures to follow during disaster or emergency communications but little mention or suggestion for effective and simple antenna systems. The following presents an idea which fulfills both the "simple" as well as "effective" aspects of an emergency antenna set-up and is easy and inexpensive to make. The secret to success is in the use of a vertical antenna (for the bands you intend to operate) with ground radials, and a homebrew base section which mounts in the spare tire from your vehicle (see **fig. 1**).

construction

The materials required to build the base section are a short length of mast or pipe and a front wheel hub that will bolt into your vehicle's spare tire (the wheel hub can be obtained from a local junk yard for a few dollars). You will also need a set of lug nuts that will fit the bolts on the hub.

The outside diameter of the mast should be as close to the inside diameter of the outside grease-seal surface of the hub as possible to make it easier to position the mast perpendicular to the hub. The mast must be welded to the hub.

Clean the hub of all oil or grease. Place it on a hard surface (that will not burn) with the lug-bolts facing up, stand the mast in the hub, and weld the mast and hub together as pictured in **fig. 2**. Be sure to position the mast perpendicular to the hub so the antenna will be straight and not tilted to one side or the other.

field use

To use the antenna set-up for emergency or portable operation (such as Field Day or a camping trip) all you need to do is remove the spare tire from your automobile, bolt in the base-section, lay the spare on the ground so the mast points up, and mount the antenna on the mast. If the vertical leans to one side, remove some dirt from under the high side of the tire or place some dirt, rocks, or a board under the low side to correct it. If you wish, you can place several

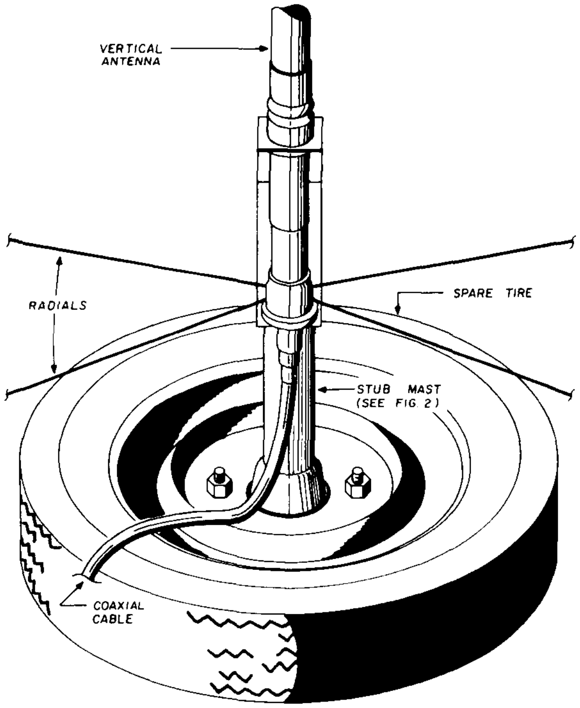

fig. 1. Portable vertical antenna mount consists of a junk-yard hub bolted to the spare tire from your car. In high wind conditions you may want to weight the tire down with rocks, but in most cases this isn't necessary. Construction of the hub section is shown in fig. 2.

By **John S. Jolly, WA7NWL,** 1840 North 64th Lane, Phoenix, Arizona 85035

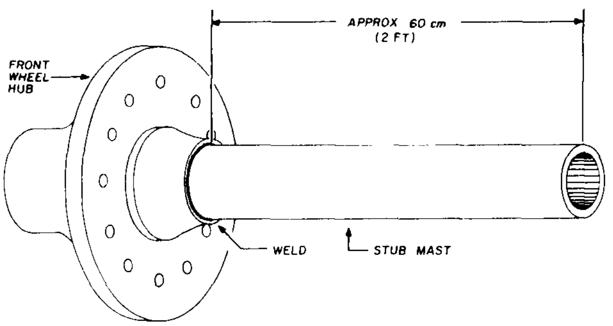

fig. 2. Stub mast for the portable antenna base consists of a front hub from the junk yard which fits your car, and a short steel mast which is welded to the hub. The outside diameter of the short mast should be very close to the inside diameter of the hub's grease-seal surface so the mast is perpendicular to the stub.

rocks on top of the spare for additional weight and stability (under normal conditions this should not be necessary). Attach the ground radials and coax, and you are ready to go on the air.

conclusion

It is the intent of this article to describe a relatively simple and inexpensive method for an average amateur to have an antenna set-up which is portable and effective for use when conditions necessitate it. In addition to emergency and portable use, this set-up could be used by those hams living in apartments or townhouses which forbid permanent fixture on their roofs.

ham radio

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cleanup tips for amateur equipment

Being in a position that would be considered enviable among some amateur radio operators (this was written during my fifth year in the R.L. Drake Company Customer Service Department; I now work for ETO), I've been able to pick up on some tips and hints on routine maintenance for amateur equipment. Even though I work for one of the manufacturers, don't wrinkle your nose and flip the page in favor of the ads on the latest offerings from your local dealer. What I'm going to talk about is directly applicable to any amateur equipment.

The item I want to deal with is cleaning the exterior of your gear. The benefits here are numerous; you can operate without having an air-sick bag handy, most technicians would rather spend an hour giving the gear a little extra tweaking instead of cleaning it, and it keeps the wife from nagging you about operating a home for wayward cockroaches.

For those of you who smoke, the gear really gets coated with tobacco stains in a hurry. The primary reason for this fact is that most of us get so wrapped up in a hot contest that we wind up with two cigarettes between the lips and three burning in the ashtray without realizing it. In time, the panel markings get dim and blurred and you find yourself shading the vfo with one hand while squinting your eyes trying to read the numbers and keying with the other.

There are only two cures for this condition that I know of. One is to stop smoking (if you have the willpower — I don't), the other is a couple of products called *Sani-Wax* and *Fantastik* along with about two hours work. Even if you decide to quit smoking, you still have the gear to clean up or trade in, and clean equipment almost always brings a few extra bucks when you trade.

Sani-Wax is a white liquid that comes in a handy-dandy plastic quart container and retails for a dollar ninety-nine in my neck of the woods. The things it does for metal panels and cabinet borders is magnificent. It's the only product I've used that will cut through smoke, grease, oil, and coffee stains while leaving a nice shine behind. The best part is that it goes on easy and wipes off easier.

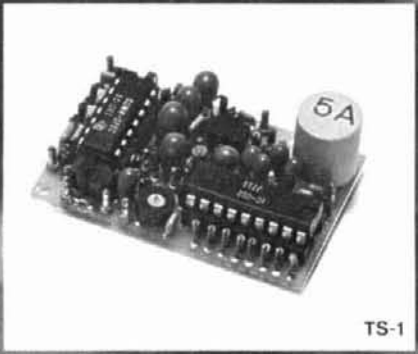
Fantastik is a spray cleaner from Texize Chemicals Company that will totally fascinate you with what it does for meters, vfo dials and windows, and especially knobs. It knocks the skin oils and accumulated dirt out of the little grooves in those plastic knobs like crazy and it doesn't scratch or discolor them. An old toothbrush makes the job easier and a lot faster. Just make sure you get it back in the rack before your mother-in-law shows up for her weekly overnight visit.

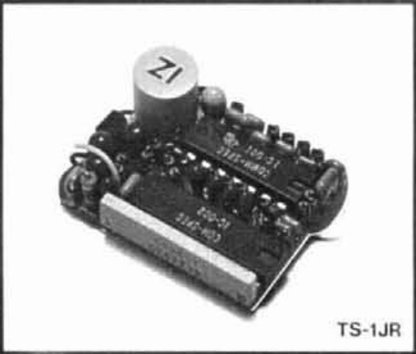
A word of caution before you start. It's a good idea to remove all knobs before beginning and to mark down what position your knobs are in BEFORE removing them. A lot of the controls, particularly bfo, audio/rf gain, passband tuning, and veniers, don't have flatted or keyed shafts to realign the pointers.

If you can't find *Fantastik* at your local supermarket or electronics surplus store, try writing to the Consumer Relations Department, Texize Chemicals Company — Division of Morton-Norwich Products, Inc., Greenville, South Carolina 29602. They can put you hot on the heels of a local distributor. The people at *Sani-Wax* can be contacted by writing to Roger Solem, Market Mechanics, 1900 East Randoll Mill Road, Suite 106, Arlington, Texas 76011.

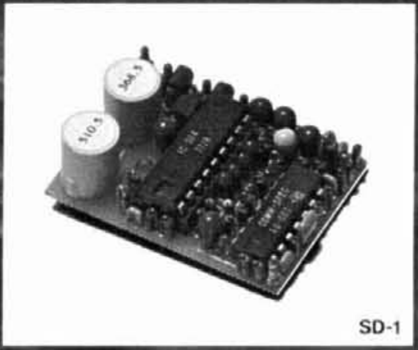
By using *Sani-Wax* on all the metal parts, and *Fantastik* on all the plastic parts, your amateur equipment will shine like new with a minimum of work.

William D. Fisher


TS-1


TS-1JR


PE-2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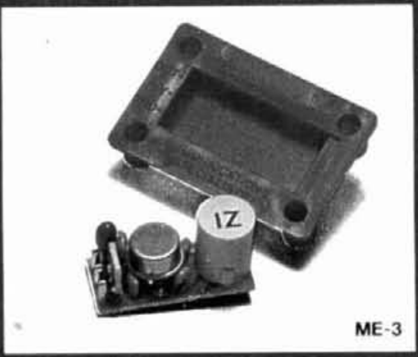
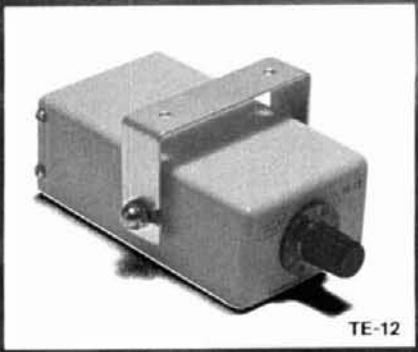


ME-3

TE-8



TE-12

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ST-1 Burst-Tone Encoder • Measures .95" x .5" x .5" plus K-1 measurements • Frequency range is 1650 - 4200 Hz • **$29.95** with K-1 element.

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pi network design

for high-frequency power amplifiers

A complete discussion of pi and pi-L networks with computer derived component values for a wide range of operating conditions

The design of rf power amplifiers has always fascinated the typical radio amateur, and it remains one of the few fields in which a person of modest technical capability can still actively participate. Although the number of home-built transmitters has steadily diminished as more commercial companies have entered the market, many amateurs still like to design and build their own final amplifier. The information contained in this article should greatly assist those so inclined. Many interesting comparisons will be presented between amplifiers running at different power levels as well as pertinent computer-derived data for the proper selection of component values.

With single sideband and its legal 2-kW PEP maximum input power, certain problems crop up which many amtateurs overlook or are unable to handle. This is because the operator wants to run the amplifier at one power level for ssb and another for CW. The problems are compounded when the operator also wants to run RTTY, which is 100 per cent key-down continuous-carrier operation.

There is also a growing tendency to build power amplifiers with higher plate voltages than were common a few years ago. Part of this trend is due to the fact that the newer power tubes provide maximum performance at high plate voltages. Many of the pi-network design charts previously published have not been extended to include these higher operating voltages.

pi networks

The pi network is so named because of its resemblance to the Greek letter pi as shown in **fig. 1**. The same network in its electrical form with input and output impedances is shown in **fig. 2**. Since most amateurs use 50-ohm coaxial transmission line, the output load impedance of the pi network is usually 50 ohms.

When the pi network is used in a power amplifier, the circuit looks like that shown in **fig. 3**. The antenna provides the output load impedance, Z_L, and the power tube provides the input load impedance, Z_p. Since the plate load impedance usually falls into the range from 1200 to 5000 ohms, the pi network transforms the high impedance of the vacuum tube into the 50-ohm antenna load. It performs this job quite efficiently, and with predictable results.

Actually, the pi network is a basic form of a three-pole lowpass filter. With proper care in design it will attenuate the second harmonic by 35 dB or more.[1] This would be for a loaded Q of 12; if the Q is doubled, attenuation is increased by approximately 6 dB.

The pi-L network shown in **fig. 4** consists of a standard pi network with an additional inductor. Since the pi-L network is a four-pole lowpass filter, second harmonic attenuation is increased to approximately 50 dB. This is particularly important if you want maximum suppression of TVI.

In addition to increased harmonic suppression, the pi-L network offers greater bandwidth for a given variation in operating Q, requires less output capacitance, and is able to operate efficiently with lower Q at very high plate load impedances. These advantages will become more apparent later.

By Irvin M. Hoff, W6FFC (reprinted from the September, 1972, issue of *ham radio*)

The dc plate resistance of a vacuum tube, at a given input power level, can be calculated with Ohm's law: $R = E/I$, where E is the dc plate voltage and I is the dc plate current. However, since we are dealing with an ac circuit, this is of little value. What we need to know is the plate load *impedance.* This is given approximately by the following equation which has been derived from the complex functions of a vacuum tube operating in class B.

fig. 1. The pi network is so named because of its basic resemblance to the Greek letter π.

$$Z_p \approx \frac{E}{1.57I} \qquad (1)$$

where Z_p is the plate load impedance, I is the indicated plate current, and E is the dc plate voltage.

When the vacuum tube is operated in class C, as for CW, the plate load impedance is approximated by

$$Z_p \approx \frac{E}{2I} \qquad (2)$$

If you are using a linear amplifier that runs with very high idling current, and approaches class A, the following approximation for plate load impedance would be more appropriate.

$$Z_p \approx \frac{E}{1.3I} \qquad (3)$$

Zero-bias grounded-grid linears are usually thought of as being class B, but there is no hard and fast rule in this regard. A number of articles has been written on this subject, and you are likely to have already formed some opinions of your own.

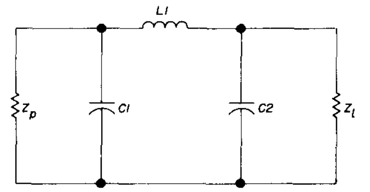


fig. 2. Basic pi network showing the input and output load impedance. The input load impedance in transmitters is the plate load impedance; output load impedance is usually 50 ohms in amateur stations.

Consider the case of a class-B rf power amplifier with a 2100-volt plate power supply and indicated plate current of 476 mA (1kW input). As calculated from **eq. 2**, the plate load impedance is 2800 ohms:

$$Z_p = \frac{2100}{1.57 \bullet 0.476} = 2800\ ohms$$

Typical plate load impedances for various power levels and different operating voltages and currents are shown in **table 1**. It can be seen from this data that the plate load impedance rises to very high levels when the plate voltage is increased above 4000 volts. More amateurs than might be expected use 4000 to 6000 volt power supplies, and many of the associated problems have not been adequately discussed in the past.

circuit Q

The letter Q stands for quality factor, and is used to describe, in simple numerical terms, the efficiency and performance of capacitors and inductors. Actually, there are two types of Q — *loaded* Q and *unloaded* Q. The unloaded Q is the inherent quality factor of the component itself; loaded Q is the quality factor of the component when it is used (and loaded down) by the circuit.

The unloaded Q of a component is given by

$$Q_u = Q\ (unloaded) = \frac{X}{r} \qquad (4)$$

where X is reactance and r is ac resistance. The unloaded Q of a high-quality capacitor might be 1000 or more, and a silver-plated inductor might have an unloaded Q of more than 500.

The loaded Q of a pi network is usually on the order of 10 to 20 for maximum harmonic attenuation, and is given by:

$$Q_o = Q\ (loaded) = \sqrt{\frac{Z_p - Z_L}{Z_L}} \qquad (5)$$

where Z_p is the input impedance to the network, and Z_L is the output impedance.

When designing pi networks a value of loaded Q is chosen on the basis of harmonic attenuation, and is used in the design equations to determine the inductance and capacitance values for a given operating frequency.

L-networks

A typical step-down L-network is shown in **fig. 5**. This network is used to transform its input impedance to a lower output impedance. The Q of this circuit is entirely dependent upon the ratio of the input and output impedances as given in **eq. 5**.

For example, if the input impedance to an L-network is 2500 ohms, and the output impedance is 50 ohms, the loaded Q of the network is 7:

$$Q_o = Q\ (loaded) = \sqrt{\frac{2500 - 50}{50}} = \sqrt{49} = 7$$

However, a loaded Q of 7 is much too low for good harmonic suppression. To determine the L-network input impedance required to provide a desired value of loaded Q, **eq. 5** is rearranged as shown below:

$$Z_p = Z_L(Q_o^2 + 1) \qquad (6)$$

For example, with an output load impedance of 50 ohms, and a desired loaded Q of 12 (for good harmonic suppression), the required input impedance is 7250 ohms. This is very restrictive and does not allow the designer sufficient latitude. So, although the L network is extremely efficient (98 per cent, typical), a pi network is usually used in transmitter output circuits.

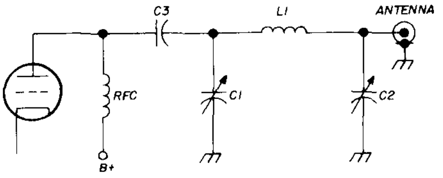


fig. 3. Pi network used in the output of an rf power amplifier is coupled to the power tube through a dc blocking capacitor (C3). C1 is the tuning capacitor, C2 is the loading capacitor, and L1 is the tank inductor.

pi network analysis

You can think of the pi network as being two L networks in tandem as shown in **fig. 6**. The first L network is a step-down type while the second L network is reversed for impedance step up. As an example, consider the case where the input impedance to the dissected pi network in **fig. 6** is 2900 ohms. With a Q of 12, the first L network would step the input impedance down to 20 ohms. This is often called the *virtual* impedance.

$$Z_L = \frac{Z_p}{Q_o^2 + 1} = \frac{2900}{12^2 + 1} = \frac{2900}{145} = ohms \quad \textbf{(7)}$$

The second L network would then be designed to raise this virtual impedance of 20 ohms to 50 ohms to match the antenna. The Q of the second section would be quite low, on the order of 1.5.

As the input impedance is increased with Q held constant, the virtual impedance increases, and when the virtual impedance is equal to the desired output impedance, the pi network reverts to an L network. For example, with a plate load impedance of 7250 ohms and a Q of 12, the virtual impedance is 50 ohms. This is the maximum possible impedance transformation for a Q of 12 and an output impedance of 50 ohms.

Normally, about 70 per cent of the maximum possible impedance transformation is used in a practical circuit. For a Q of 12 and an antenna load of 50 ohms, this would represent a plate load resistance of 5075 ohms. If the plate load resistance in an rf power amplifier is higher than 5075 ohms, a Q of more than 12 is required to retain the same level of harmonic suppression. This problem is circumvented by the use of the pi-L network, as discussed below.

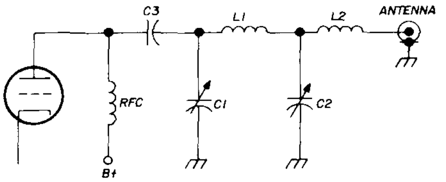


fig. 4. The pi-L network requires an additional inductor and provides increased second harmonic attenuation.

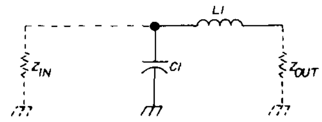
pi-L network design

Another L network may be added to the pi network as shown in **fig. 7** for additional harmonic attenuation. In actual practice C2 and C3 are combined into one capacitor so the circuit used in the transmitter is like that shown in **fig. 4**.

In the pi-L network, the input pi section transforms the plate load impedance to some lower figure, such as 300 ohms; this is often called the *image* impedance. The final L network transforms the image impedance down to 50 ohms to match the antenna.

From **eq. 6** it can be seen that with an image impedance of 300 ohms and a Q of 12, the pi network has a maximum transformation of 43500 ohms.

fig. 5. Typical step-down L network is highly efficient but very restrictive as far as acceptable Q is concerned.



Using 70 per cent of the maximum possible transformation as a practical maximum, as noted before, results in a maximum practical input impedance of 30500 ohms with a Q of 12. This is far in excess of what you will ever need in a power amplifier designed for amateur service.

The image impedance usually falls in the range between 200 and 400 ohms. It is selected for good harmonic attenuation, as well as balance in the T section of the pi-L network, and reasonable component values for the capacitors and inductors. If the image impedance is too high, the tuning capacitor (C1) will be too small on 10 and 15 meters, and the two inductors will be very large. Large inductors, of course, increase circulating currents which result in higher losses due to heat.

Q vs frequency

The loaded Q of a pi network (or any tank circuit, for that matter) is equal to its parallel-resonant impedance divided by either the inductive or capacitive reactance of the network.

$$Q_o = \frac{Z_p}{X} \quad \textbf{(8)}$$

The reactance of any inductor is directly proportional to frequency, increasing as the frequency increases. Therefore, from **eq. 8** it can be seen that if a particular inductor is used, loaded *Q* will vary inversely with frequency. As the frequency is lowered, for example, *Q* is raised a proportionate amount. With this in mind, it is easy to determine the *Q* for a given network on a different frequency from the following formula:

$$\frac{f1}{f2} \cong \frac{Q2}{Q1} \qquad \textbf{(9)}$$

Where *f1* and *Q1* are the frequency and *Q* at one frequency, and *f2* and *Q2* are at the second, different frequency.

For example, if an 80-meter pi network has a *Q* of 12 at 4.0 MHz, what is the *Q* at 3.5 MHz?

$$\frac{4.0}{3.5} = \frac{Q2}{12} \quad Q2 = 13.7$$

Although the actual loaded *Q* is somewhat dependent upon the value of plate load impedance used in the circuit, this approximation is accurate within 1 per cent. In the above example, with a plate load impedance of 3000 ohms, *Q2* would actually be 13.84.

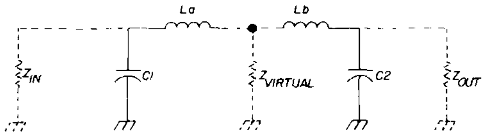


fig. 6. Pi network is basically two L networks in tandem.

Since the *Q* of the network goes up as the frequency goes down, it's a good idea to design the pi network for the highest frequency that is to be used.[2] With this approach, when the same inductor is used at lower frequencies within an amateur band, *Q* increases somewhat, improving harmonic attenuation.

Table 2 shows how *Q* varies as a pi network is retuned to a different frequency (same inductor). **Table 2A** shows a pi network designed for 4.0 MHz which is retuned to 3.5 MHz; *Q* increases from 12 at 4.0 MHz to 13.8 at 3.5 MHz. The values of the tuning and loading capacitors are shown for comparison.

Table 2B shows the case where a pi network is designed for 3.5 MHz with a *Q* of 12 and retuned to 4.0 MHz (same inductor). The *Q* drops to 10.4, well below the selected minimum of 12.

network efficiency

As the loaded *Q* of a network is increased, efficiency goes down because of higher circulating currents and higher losses in the components. Approximate efficiency is given by

$$efficiency = 100\left(1 - \frac{Q_o}{Q_u}\right) \qquad \textbf{(10)}$$

where Q_o is the loaded circuit *Q* and Q_u is the unloaded component *Q*. The graph in **fig. 8** shows that efficiency is a linear function of loaded *Q*. For minimum loss, the loaded *Q* should be as low as convenient, while still providing adequate harmonic attenuation. This figure has arbitrarily been chosen as 12.

When the pi network is designed, the minimum *Q* of 12 can only be obtained at the upper frequency of each amateur band, and then only at the maximum input power level. For other frequencies or lower input powers, the loaded *Q* is higher than 12.

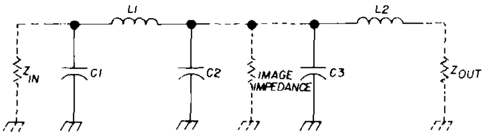


fig. 7. In the pi-L network a second L network is added to the basic pi network. Capacitors C2 and C3 are combined into one capacitor in a practical circuit, as shown in fig. 4.

pi network design

Usually, when you are trying to design a pi network for your transmitter or linear amplifier, you must refer to graphs shown in reference books such as the ARRL "Radio Amateur's Handbook."[3] These graphs are often somewhat confusing because you must first determine the plate load impedance, select a value of *Q* and then find the reactance of each of the components. Then you must locate yet another graph to convert these reactance values into actual values of inductance and capacitance.

Few of these charts and graphs are extended above plate load impedances of 5000 ohms, and most give vague reference to the fact that if the plate load impedance is greater than about 5000 ohms, the *Q* should be increased.

The charts in **table 3** and **table 4** are computer derived and offer all the required information to build

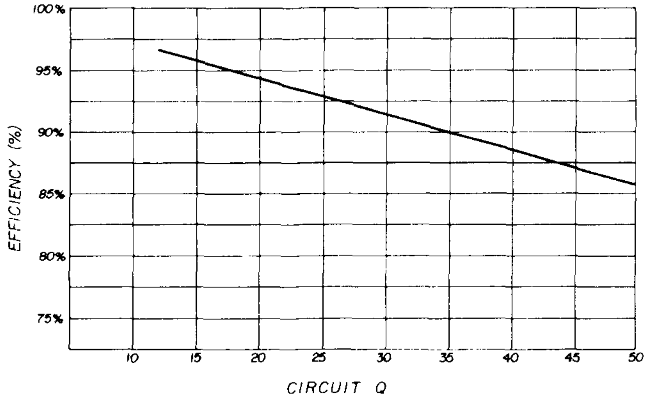


fig. 8. Efficiency of a network is inversely proportional to the loaded *Q* of the network.

table 1. Plate load impedances for different input power levels and different operating voltages and currents.

input power (W)	volts	mA	plate impedance (ohms)
1000	2000	500	2546
2000	2000	1000	1273
2500	2000	1250	1019
1000	2500	400	3979
2000	2500	800	1989
2500	2500	1000	1592
1000	2800	357	4991
2000	2800	714	2496
2500	2800	893	1996
1000	3300	303	6933
2000	3300	606	3466
2500	3300	758	2773
1000	4000	250	10186
2000	4000	500	5093
2500	4000	625	4074
1000	5000	200	15915
2000	5000	400	7958
2500	5000	500	6366
1000	6000	167	22918
2000	6000	333	11459
2500	6000	417	9167

a practical pi network. The pi networks in **table 3** for plate load impedances above 5000 ohms have increasing *Q* so that the transformation ratio never exceeds the 70 per cent maximum. In addition, the inductors chosen for each of the designs are calculated for the highest frequency in the band.

The *Q* of the network at the highest frequency is 12 except when the plate load impedance is greater than 5075 ohms. The chart shows the capacitance values required to resonate the network to the lowest frequency in the band (maximum capacitance), as well as the operating *Q* at that frequency. In **table 4**, the image impedance (R3) at the lower frequency is also given.

You will notice that the *Q* of the pi-L network does not go up as fast when frequency is lowered as it does with the pi network. Also, the *Q* remains the same for the pi-L for higher plate loads.

In both **table 3** and **table 4** the values for ten meters are for 29.7 MHz, the highest frequency in the band. This is because you need to know minimum capacitance values to reach this frequency in a five-band transmitter.

effect of swr

A standing-wave ratio of 4:1 will affect the capacitance required at C1 by ± 10 per cent and at C2 by ± 25 per cent. If the swr is caused by capacitive reactance, the tuning and loading capacitors are on the smaller side, and if the swr is the result of inductive reactance, the loading and tuning capacitors must be larger. Keep this in mind when selecting component values for a transmitter so you will be able to compensate for an antenna that is not exactly matched to your transmission line.

ssb and CW operation

Table 1 shows that for a given plate supply voltage, the plate load impedance is inversely proportional to the input power level. That is, 1000 watts at 2800 volts represents 5000 ohms, while 2 kW at the same supply voltage is 2500 ohms. Pi network values for a *Q* of 12 for each of these impedances are shown below (capacitace in pF, inductance in μH):

f	R1	C1	L1	C2	Q
4.0 MHz	2500	191	9.18	1097	12.0
4.0 MHz	5000	95	17.38	534	12.0

Note that the required inductance values are quite different.

As an example of what you may expect under actual operating conditions, consider the 2-kW design above (9.18 μH inductor). At 3.5 MHz with 2 kW input, C1 is 252 pF, C2 is 1536 pF, and *Q* is 13.8; not too bad. However, if the input power is reduced to 1000 watts at 3.5 MHz, C1 is 246 pF, C2 is 2287 pF, and *Q* reaches 27.0, increasing the circulating currents and heat losses in the network.

These figures point out the problems you can run into when you use the same operating voltage and same inductor at different power levels. Fortunately, there are several things which the designer can do to minimize these problems.

variable inductors

There are various variable rotary inductors available on the market which allow the operator to select the proper inductance for 1000 watts CW at the bottom of a band as well as 2000 watts PEP ssb at the top. When compared to fixed inductors, these variable units are fairly expensive, and require a turns counter, further increasing cost. However, they are available in various inductance and current-carrying abilities, so they encompass practically any design requirement. Also, using a variable inductor eliminates the need for a bandswitch.

bandswitch

The primary purpose of the bandswitch is to change the tap on the tank-circuit inductor to one better suited for the band in use. However, there are several other important functions for the bandswitch:

1. Used to switch input networks to match the 50-ohm output of the exciter.

2. Changes taps on the second inductor in a pi-L network.

3. Sometimes used to switch in additional tuning/loading capacitance on the 80-meter band so smaller variable capacitors may be used in the circuit.

Since you may wish to use a bandswitch in your power amplifier because of these additional uses, the variable inductor may lose some of its appeal.

In a novel approach to this problem a ten-position bandswitch has been used in one design to select different amounts of inductance for the CW and ssb ends of the band.[4] However, the additional switch leads and the large number of inductor taps make this approach seem impractical for the typical home builder.

table 2. Variations in *Q* as the resonant frequency of the pi network is changed (same inductor).

	frequency	plate impedance (ohms)	load impedance (ohms)	C1 (pF)	L1 (μH)	C2 (pF)	*Q*
A. Decreasing	4.0 MHz	2500	50	191	9.18	1097	12.0
frequency	3.5 MHz	2500	50	252	9.18	1536	13.8
B. Increasing	3.5 MHz	2500	50	218	10.49	1254	12.0
frequency	4.0 MHz	2500	50	165	10.49	863	10.4

Table 5 compares the performance of 1000- and 2000-watt transmitters, as well as a 2000-watt transmitter run at 1000 watts input. In the latter case some additional losses are evident, but they're hardly large enough to cause much excitement. The same comparison shows that the 2-kW transmitter with a *Q* of 12 at 4 MHz, has a *Q* of 16.2 at 3.0 MHz. However, considerably more capacitance is required at C1 and C2. The pi-L network will alleviate this problem to some extent, as the *Q* of the pi-L does not increase as rapidly as frequency is lowered as it does with the straight pi network.

Since the 80-meter band is proportionally wider than any other high-frequency amateur band, there is some merit in using an extra bandswitch position for 80 meters.[5] While I have shown previously that this is not required, it would be beneficial because you could select the 75-meter inductor for 4 MHz and 2-kW input, with the 80-meter inductor chosen for 3.7 MHz and 1-kW input.

The primary advantage in such an arrangement would be the ability to add a second input network to match the exciter. Since the input networks have low *Q* (typically 2 to 3), they are quite broadband and are usually set to a frequency in the middle of the band. However, it would be literally impossible for the same input network to work equally well on both 3.5 and 4.0 MHz, so it would be desirable to have one for each end of the band. From a practical standpoint, this might not be necessary because most operators have ample drive on CW if they are able to push the final to 2000 watts PEP on ssb.

power supply voltage

Since, as I just mentioned, most exciters have more than ample drive for 1000-watts input on CW if they are capable of driving the final to 2000-watts PEP on ssb, it's desirable to include some sort of automatic swamping so the exciter can be run in a normal manner for both ssb and CW. Lowering the plate supply voltage on the final-amplifier tubes decreases the plate load impedance required for a given input power level, therefore requiring more drive to reach this input power level.

For example, if it takes 70 watts drive with 3000 volts on the plate to reach 2000-watts input, then, depending upon the tubes used, it would take 70 to 80 watts drive to reach 1000-watts input with a substantially lower plate supply voltage. At the same time, the voltage-current relationship has changed, lowering the plate load impedance to something much closer to that which would give a *Q* of 12 with the same inductor.

Also, the plate voltage must be lowered to retain the same *Q* with the same inductor at the same operating frequency. This voltage reduction can be determined from

$$E2 = 0.71\,(E1) \qquad \textbf{(11)}$$

where $E1$ is the original plate voltage for 2000-watts input and $E2$ is the lowered plate voltage for 1000-watts input. For example, a plate supply of 2800 volts for 2000-watts input must be changed to 2000 volts for 1000-watts input at the same operating frequency and circuit *Q*. Actually, on 3.5 MHz, this would be perhaps 1800 to 1900 volts to provide a *Q* of 12 at 3.5 MHz (1000 watts input) using a 2-kW transmitter designed for a *Q* of 12 at 4.0 MHz. However, it is unlikely that you could get 1000-watts input at this plate voltage, even with 100 watts drive on a cathode-driven grounded-grid amplifier.

tuning capacitance

Table 3 and **table 4** show that the C1 tuning capacitance becomes quite small on 10 and 15 meters as the plate load impedance is raised. A typical 2000-watt transmitter might use 2800 volts on the plate,

table 3A. Pi network component values for matching a 50-ohm antenna load. Values have been chosen for a *Q* of 12 at the top edge of each amateur band. For plate load impedances greater than 5000 ohms, the *Q* of the network has been adjusted upward to compensate for the maximum transformation ratio, as discussed in the text. R1 is the plate load impedance.

R1 OHMS	F MHZ	C1 PF	L1 UH	C2 PF	R2 OHMS	'Q' QUAL.
200	3.5	3147	0.98	6244	50	13.8
200	7.0	1427	0.54	2827	50	12.6
200	14.0	701	0.27	1387	50	12.3
200	21.0	465	0.18	921	50	12.3
200	29.7	322	0.13	636	50	12.0
300	3.5	2098	1.38	5071	50	13.8
300	7.0	952	0.76	2294	50	12.6
300	14.0	467	0.39	1125	50	12.3
300	21.0	310	0.26	747	50	12.3
300	29.7	214	0.19	516	50	12.0
400	3.5	1573	1.76	4368	50	13.8
400	7.0	714	0.97	1973	50	12.6
400	14.0	350	0.49	968	50	12.3
400	21.0	233	0.33	643	50	12.3
400	29.7	161	0.24	444	50	12.0
500	3.5	1259	2.14	3886	50	13.8
500	7.0	571	1.18	1753	50	12.6
500	14.0	280	0.60	859	50	12.3
500	21.0	186	0.40	571	50	12.3
500	29.7	129	0.29	394	50	12.0
600	3.5	1049	2.51	3528	50	13.8
600	7.0	476	1.38	1590	50	12.6
600	14.0	234	0.70	779	50	12.3
600	21.0	155	0.47	517	50	12.3
600	29.7	107	0.34	357	50	12.0
700	3.5	899	2.88	3248	50	13.8
700	7.0	408	1.58	1462	50	12.6
700	14.0	200	0.81	716	50	12.3
700	21.0	133	0.54	475	50	12.3
700	29.7	92	0.39	328	50	12.0
800	3.5	787	3.24	3021	50	13.8
800	7.0	357	1.78	1358	50	12.6
800	14.0	175	0.91	665	50	12.3
800	21.0	116	0.61	442	50	12.3
800	29.7	80	0.44	304	50	12.0
900	3.5	699	3.60	2832	50	13.8
900	7.0	317	1.98	1271	50	12.6
900	14.0	156	1.01	622	50	12.3
900	21.0	103	0.67	413	50	12.3
900	29.7	71	0.49	285	50	12.0
1000	3.5	629	3.96	2671	50	13.8
1000	7.0	285	2.18	1197	50	12.6
1000	14.0	140	1.11	586	50	12.3
1000	21.0	93	0.74	389	50	12.3
1000	29.7	64	0.54	268	50	12.0
1100	3.5	572	4.32	2532	50	13.8
1100	7.0	260	2.37	1133	50	12.6
1100	14.0	127	1.21	555	50	12.3
1100	21.0	85	0.81	368	50	12.3
1100	29.7	58	0.58	253	50	12.0
1200	3.5	524	4.67	2410	50	13.8
1200	7.0	238	2.57	1077	50	12.6
1200	14.0	117	1.31	527	50	12.3
1200	21.0	78	0.87	350	50	12.3
1200	29.7	54	0.63	241	50	12.0
1300	3.5	484	5.03	2302	50	13.8
1300	7.0	220	2.76	1027	50	12.6
1300	14.0	108	1.40	502	50	12.3
1300	21.0	72	0.94	333	50	12.3
1300	29.7	49	0.68	229	50	12.0
1400	3.5	457	5.38	2205	50	13.8
1400	7.0	204	2.95	982	50	12.6
1400	14.0	100	1.50	480	50	12.3
1400	21.0	66	1.01	319	50	12.3
1400	29.7	46	0.73	219	50	12.0
1500	3.5	420	5.73	2117	50	13.8
1500	7.0	190	3.14	942	50	12.6
1500	14.0	93	1.60	460	50	12.3
1500	21.0	62	1.07	305	50	12.3
1500	29.7	43	0.77	210	50	12.0
2000	3.5	315	7.46	1776	50	13.8
2000	7.0	143	4.09	783	50	12.6
2000	14.0	70	2.08	382	50	12.3
2000	21.0	47	1.39	253	50	12.3
2000	29.7	32	1.01	174	50	12.0
2500	3.5	252	9.17	1536	50	13.8
2500	7.0	114	5.03	670	50	12.6
2500	14.0	56	2.56	326	50	12.3
2500	21.0	37	1.71	216	50	12.3
2500	29.7	26	1.24	148	50	12.0
3000	3.5	210	10.86	1352	50	13.8
3000	7.0	95	5.95	583	50	12.6
3000	14.0	47	3.03	283	50	12.3
3000	21.0	31	2.02	187	50	12.3
3000	29.7	21	1.46	128	50	12.0
3500	3.5	180	12.53	1203	50	13.8
3500	7.0	82	6.86	512	50	12.6
3500	14.0	40	3.49	247	50	12.3
3500	21.0	27	2.34	164	50	12.3
3500	29.7	18	1.69	111	50	12.0
4000	3.5	157	14.19	1079	50	13.8
4000	7.0	71	7.77	451	50	12.6
4000	14.0	35	3.95	217	50	12.3
4000	21.0	23	2.64	144	50	12.3
4000	29.7	16	1.91	97	50	12.0
4500	3.5	140	15.84	971	50	13.8
4500	7.0	63	8.66	397	50	12.6
4500	14.0	31	4.40	190	50	12.3
4500	21.0	21	2.95	126	50	12.3
4500	29.7	14	2.13	84	50	12.0
5000	3.5	126	17.48	875	50	13.8
5000	7.0	57	9.55	348	50	12.6
5000	14.0	28	4.85	165	50	12.3
5000	21.0	19	3.25	109	50	12.3
5000	29.7	13	2.34	72	50	12.0
5500	3.5	119	18.41	861	50	14.4
5500	7.0	54	10.05	341	50	13.1
5500	14.0	27	5.11	162	50	12.8
5500	21.0	18	3.42	107	50	12.8
5500	29.7	12	2.47	70	50	12.5
6000	3.5	114	19.18	862	50	15.1
6000	7.0	52	10.48	341	50	13.7
6000	14.0	25	5.33	162	50	13.4
6000	21.0	17	3.56	107	50	13.4
6000	29.7	12	2.57	70	50	13.1
6500	3.5	110	19.92	862	50	15.7
6500	7.0	50	10.89	341	50	14.2
6500	14.0	24	5.54	162	50	14.0
6500	21.0	16	3.70	107	50	13.9
6500	29.7	11	2.67	70	50	13.6
7000	3.5	106	20.63	862	50	16.3
7000	7.0	48	11.28	341	50	14.8
7000	14.0	24	5.74	162	50	14.5
7000	21.0	16	3.84	107	50	14.4
7000	29.7	11	2.77	70	50	14.1
7500	3.5	102	21.31	862	50	16.8
7500	7.0	46	11.66	341	50	15.3
7500	14.0	23	5.93	162	50	15.0
7500	21.0	15	3.97	107	50	14.9
7500	29.7	10	2.86	70	50	14.6
8000	3.5	99	21.98	862	50	17.4
8000	7.0	45	12.02	341	50	15.8
8000	14.0	22	6.11	162	50	15.5
8000	21.0	15	4.09	107	50	15.4
8000	29.7	10	2.95	70	50	15.1
8500	3.5	96	22.62	862	50	17.9
8500	7.0	44	12.38	341	50	16.3
8500	14.0	21	6.29	162	50	16.0
8500	21.0	14	4.21	107	50	15.9
8500	29.7	10	3.04	70	50	15.6
9000	3.5	93	23.24	862	50	18.5
9000	7.0	42	12.72	341	50	16.7
9000	14.0	21	6.47	162	50	16.4
9000	21.0	14	4.33	107	50	16.4
9000	29.7	10	3.12	70	50	16.0
9500	3.5	91	23.85	862	50	19.0
9500	7.0	41	13.06	341	50	17.2
9500	14.0	20	6.64	162	50	16.9
9500	21.0	13	4.44	107	50	16.8
9500	29.7	9	3.21	70	50	16.4
10000	3.5	88	24.44	862	50	19.5
10000	7.0	40	13.38	341	50	17.7
10000	14.0	20	6.81	162	50	17.3
10000	21.0	13	4.55	107	50	17.3
10000	29.7	9	3.29	70	50	16.9
10500	3.5	86	25.02	862	50	19.9
10500	7.0	39	13.70	341	50	18.1
10500	14.0	19	6.97	162	50	17.8
10500	21.0	13	4.66	107	50	17.7
10500	29.7	9	3.37	70	50	17.3
11000	3.5	84	25.58	862	50	20.4
11000	7.0	38	14.01	341	50	18.5
11000	14.0	19	7.13	162	50	18.2
11000	21.0	12	4.77	107	50	18.1
11000	29.7	9	3.44	70	50	17.7
11500	3.5	83	26.13	862	50	20.9
11500	7.0	37	14.32	341	50	18.9
11500	14.0	18	7.28	162	50	18.6
11500	21.0	12	4.87	107	50	18.5
11500	29.7	8	3.52	70	50	18.1
12000	3.5	81	26.67	862	50	21.3
12000	7.0	37	14.61	341	50	19.3
12000	14.0	18	7.43	162	50	19.0
12000	21.0	12	4.97	107	50	18.9
12000	29.7	8	3.59	70	50	18.5

providing a plate load impedance of approximately 2500 ohms. This transmitter would require only 26 pF tuning capacitance to reach the top end of the 10-meter band.

Unfortunately, most modern rf power tubes designed for the 2000-watt level have output capacitances on the order of 10 pF — this leaves about 16 pF for tuning, including stray circuit capacitance.

If you study the various air-variable capacitors available you will find that it is virtually impossible to find a variable capacitor that will provide the necessary spacing for this operating voltage as well as tune the capacitance range needed for both 10 and 80 meters. Also, you must keep in mind that ± 10 per cent leeway should be provided to compensate for any swr on the transmission line.

As the plate load impedance increases, the situation becomes even more acute. A 1000-watt transmitter with a plate supply of 2800 volts has a plate load impedance of 5000 ohms — on ten meters this means the tuning capacitor C1 is a total of 13 pF. In this case you would probably have to delete C1 entirely from the circuit and let the capacitance of the power tube supply the necessary tuning capacitance. However, this is not practical.

Fortunately, there are several things you can do to help alleviate this situation. You can use a smaller capacitor and add fixed capacitance on 40 and 80 meters, or use two variable capacitors, switching in the larger one on the lower bands. The vacuum capacitor is another possibility because of its low minimum capacitance, often as low as 3 pF. You can also blunder ahead and use a too-large capacitor, allowing the *Q* to be higher than normal.

table 3B. Pi-network component values for use within the 160-meter amateur band. Values were determined as in table 3A.

R1 OHMS	F MHZ	C1 PF	L1 UH	C2 PF	R2 OHMS	'Q' QUAL.
1000	1.8	1187	7.94	5019	50	13.4
1000	1.9	1062	7.95	4459	50	12.7
1000	2.0	955	7.96	3979	50	12.0
1250	1.8	949	9.71	4419	50	13.4
1250	1.9	849	9.72	3917	50	12.7
1250	2.0	764	9.74	3487	50	12.0
1500	1.8	791	11.47	3969	50	13.4
1500	1.9	708	11.48	3510	50	12.7
1500	2.0	637	11.49	3116	50	12.0
1750	1.8	678	13.21	3613	50	13.4
1750	1.9	607	13.22	3177	50	12.7
1750	2.0	546	13.23	2822	50	12.0
2000	1.8	593	14.94	3322	50	13.4
2000	1.9	531	14.94	2922	50	12.7
2000	2.0	477	14.95	2579	50	12.0
2250	1.8	527	16.65	3076	50	13.4
2250	1.9	472	16.65	2697	50	12.7
2250	2.0	424	16.66	2373	50	12.0
2500	1.8	475	18.36	2864	50	13.4
2500	1.9	425	18.36	2504	50	12.7
2500	2.0	382	18.36	2194	50	12.0
2750	1.8	432	20.05	2678	50	13.4
2750	1.9	386	20.05	2333	50	12.7
2750	2.0	347	20.04	2036	50	12.0
3000	1.8	396	21.74	2513	50	13.4
3000	1.9	354	21.73	2181	50	12.7
3000	2.0	318	21.72	1894	50	12.0
3250	1.8	365	23.41	2364	50	13.4
3250	1.9	327	23.40	2043	50	12.7
3250	2.0	294	23.38	1766	50	12.0
3500	1.8	339	25.08	2228	50	13.4
3500	1.9	303	25.06	1917	50	12.7
3500	2.0	273	25.04	1647	50	12.0
3750	1.8	316	26.75	2104	50	13.4
3750	1.9	283	26.72	1801	50	12.7
3750	2.0	255	26.68	1538	50	12.0
4000	1.8	297	28.40	1938	50	13.4
4000	1.9	265	28.37	1693	50	12.7
4000	2.0	239	28.32	1435	50	12.0
4250	1.8	279	30.05	1881	50	13.4
4250	1.9	250	30.00	1591	50	12.7
4250	2.0	225	29.95	1337	50	12.0
4500	1.8	264	31.69	1779	50	13.4
4500	1.9	236	31.64	1495	50	12.7
4500	2.0	212	31.57	1244	50	12.0
4750	1.8	250	33.33	1684	50	13.4
4750	1.9	224	33.26	1403	50	12.7
4750	2.0	201	33.17	1155	50	12.0
5000	1.8	237	34.96	1593	50	13.4
5000	1.9	212	34.87	1315	50	12.7
5000	2.0	191	34.77	1058	50	12.0
5250	1.8	230	36.01	1566	50	13.7
5250	1.9	206	35.93	1290	50	12.9
5250	2.0	185	35.82	1042	50	12.2
5500	1.8	225	36.81	1566	50	14.0
5500	1.9	201	36.73	1290	50	13.2
5500	2.0	181	36.63	1042	50	12.5
5750	1.8	220	37.59	1567	50	14.3
5750	1.9	197	37.52	1290	50	13.5
5750	2.0	177	37.41	1042	50	12.8
6000	1.8	215	38.36	1567	50	14.6
6000	1.9	193	38.28	1290	50	13.8
6000	2.0	173	38.18	1042	50	13.1
6250	1.8	211	39.11	1567	50	14.9
6250	1.9	189	39.03	1290	50	14.1
6250	2.0	170	39.94	1042	50	13.3
6500	1.8	207	39.84	1567	50	15.2
6500	1.9	185	39.77	1290	50	14.4
6500	2.0	166	39.68	1042	50	13.6
6750	1.8	203	40.56	1567	50	15.5
6750	1.9	182	40.49	1290	50	14.6
6750	2.0	163	40.40	1042	50	13.9
7000	1.8	199	41.27	1567	50	15.8
7000	1.9	178	41.20	1290	50	14.9
7000	2.0	160	41.11	1042	50	14.1
7250	1.8	196	41.96	1567	50	16.1
7250	1.9	175	41.90	1290	50	15.2
7250	2.0	158	41.81	1042	50	14.4
7500	1.8	193	42.64	1567	50	16.3
7500	1.9	172	42.58	1290	50	15.4
7500	2.0	155	42.50	1042	50	14.6
7750	1.8	189	43.31	1567	50	16.6
7750	1.9	169	43.25	1290	50	15.7
7750	2.0	152	43.17	1042	50	14.8
8000	1.8	186	43.97	1567	50	16.9
8000	1.9	167	43.92	1290	50	15.9
8000	2.0	150	43.84	1042	50	15.1
8250	1.8	184	44.62	1567	50	17.1
8250	1.9	154	44.57	1290	50	16.2
8250	2.0	148	44.49	1042	50	15.3
8500	1.8	181	45.26	1567	50	17.4
8500	1.9	162	45.21	1290	50	16.4
8500	2.0	146	45.14	1042	50	15.6
8750	1.8	178	45.89	1567	50	17.6
8750	1.9	160	45.84	1290	50	15.7
8750	2.0	144	45.77	1042	50	15.8
9000	1.8	176	46.51	1567	50	17.9
9000	1.9	157	46.47	1290	50	16.9
9000	2.0	142	46.40	1042	50	16.0
9250	1.8	173	47.13	1567	50	18.1
9250	1.9	155	47.08	1290	50	17.1
9250	2.0	140	47.02	1042	50	16.2
9500	1.8	171	47.73	1567	50	18.4
9500	1.9	153	47.69	1290	50	17.4
9500	2.0	138	47.63	1042	50	16.4
9750	1.8	169	48.33	1567	50	18.6
9750	1.9	151	48.29	1290	50	17.6
9750	2.0	136	48.23	1042	50	16.7
10000	1.8	167	48.92	1568	50	18.9
10000	1.9	149	48.88	1290	50	17.8
10000	2.0	134	48.82	1042	50	16.9
10250	1.8	165	49.50	1568	50	19.1
10250	1.9	147	49.46	1290	50	18.0
10250	2.0	133	49.41	1042	50	17.1
10500	1.8	163	50.07	1568	50	19.3
10500	1.9	146	50.04	1290	50	18.3
10500	2.0	131	49.98	1042	50	17.3
10750	1.8	161	50.64	1568	50	19.6
10750	1.9	144	50.61	1290	50	18.5
10750	2.0	130	50.56	1042	50	17.5
11000	1.8	159	51.20	1568	50	19.8
11000	1.9	142	51.17	1290	50	18.7
11000	2.0	128	51.12	1042	50	17.7
11250	1.8	157	51.76	1568	50	20.0
11250	1.9	141	51.73	1290	50	18.9
11250	2.0	127	51.68	1042	50	17.9
11500	1.8	156	52.30	1568	50	20.2
11500	1.9	139	52.28	1290	50	19.1
11500	2.0	125	52.23	1042	50	18.1
11750	1.8	154	52.85	1568	50	20.5
11750	1.9	138	52.82	1290	50	19.3
11750	2.0	124	52.78	1042	50	18.3
12000	1.8	152	53.38	1568	50	20.7
12000	1.9	136	53.36	1290	50	19.5
12000	2.0	123	53.32	1042	50	18.5

Oddly enough, each of these different techniques is currently being used in commercial amateur-band power amplifiers. The vacuum variable provides the best answer to this problem, but it is also the most expensive (by a wide margin). However, the vacuum variable has many advantages worth considering if you are more interested in performance than in total cost.

From **table 6** you can see that the *Q* on ten meters goes up quite rapidly if too much capacitance is used at C1. One currently available commercial amplifier uses 2800 volts at 2-kW input (plate impedance, 2500 ohms). For ten meters this calls for an input capacitor of about 15 pF, after the output capacitance of the tubes has been subtracted. However, this amplifier uses two 20-150 pF capacitors in parallel which are tuned in tandem with a geared arrangement. Thus, their minimum capacitance is about 40 pF, plus 10 pF added by the power tubes, providing a minimum input capacitance of more than 50 pF without any allowance for strays.

Table 6 shows that this gives a minimun *Q* of 24.0 at the top end of the ten-meter band (around 25.5 at the bottom end). If the amplifier were used at 1000-watts input, the *Q* would be nearly 48 at the top band edge and over 50 at the bottom!

This amplifier would obviously lose substantial power output in the form of heat in the tank inductor, and proper tuning would be very critical. It would also have to be retuned more often as frequency was changed.

This design is what I call the *blunder-ahead* method. In my mind, it would have been relatively simple for the manufacturer to use only one of the two tuning capacitors on 10, 15, and 20 meters, switching in the second tuning capacitor on 40 and 80.

Another manufacturer does precisely this. He uses a dual-section capacitor — half is used for the three upper bands and the other half is added in parallel on 40 and 80 meters. This provides normal *Q* for 2000-watts input on 10 meters. It still gives *Q* in excess of 20 with 1000-watts input, but that's really not too bad. This tuning system gives more than twice the *vernier* of the other system since the maximum capacitance on 20 meters, for example, is 120 pF. On the previous amplifier there is 300 pF available, even on 20 meters. The unit with the lower capacitance is far easier to tune on the upper three bands.

table 4A. Pi-L network component values for matching a 50-ohm antenna load. Values have been chosen for a *Q* of 12 at the top edge of each amateur band. The image impedance (R3) has been chosen to provide a balanced transformation in the T section of the pi-L network. R1 is the plate load impedance.

R1 OHMS	F MHZ	C1 PF	L1 UH	C2 PF	L2 UH	R2 OHMS	R3 OHMS	'Q' QUAL
500	3.5	1219	2.86	2118	4.45	241	50	13.4
500	7.0	565	1.59	927	2.44	280	50	12.4
500	14.0	277	0.81	451	1.24	288	50	12.2
500	21.0	185	0.54	300	0.83	288	50	12.2
500	29.7	129	0.39	206	0.60	300	50	12.0
600	3.5	1015	3.30	1963	4.45	241	50	13.4
600	7.0	471	1.83	861	2.44	280	50	12.4
600	14.0	231	0.94	419	1.24	288	50	12.2
600	21.0	154	0.63	279	0.83	288	50	12.2
600	29.7	107	0.45	191	0.60	300	50	12.0
700	3.5	870	3.74	1843	4.45	241	50	13.4
700	7.0	403	2.07	809	2.44	280	50	12.4
700	14.0	198	1.06	394	1.24	288	50	12.2
700	21.0	132	0.71	262	0.83	288	50	12.2
700	29.7	92	0.51	180	0.60	300	50	12.0
800	3.5	762	4.17	1746	4.45	241	50	13.4
800	7.0	353	2.31	767	2.44	280	50	12.4
800	14.0	173	1.18	373	1.24	288	50	12.2
800	21.0	116	0.79	249	0.83	288	50	12.2
800	29.7	80	0.57	170	0.60	300	50	12.0
900	3.5	677	4.60	1666	4.45	241	50	13.4
900	7.0	314	2.54	733	2.44	280	50	12.4
900	14.0	154	1.30	357	1.24	288	50	12.2
900	21.0	103	0.87	238	0.83	288	50	12.2
900	29.7	71	0.63	163	0.60	300	50	12.0
1000	3.5	609	5.02	1598	4.45	241	50	13.4
1000	7.0	282	2.77	703	2.44	280	50	12.4
1000	14.0	139	1.42	342	1.24	288	50	12.2
1000	21.0	92	0.95	228	0.83	288	50	12.2
1000	29.7	64	0.68	156	0.60	300	50	12.0
1100	3.5	554	5.43	1539	4.45	241	50	13.4
1100	7.0	257	3.00	678	2.44	280	50	12.4
1100	14.0	125	1.53	330	1.24	288	50	12.2
1100	21.0	84	1.02	220	0.83	288	50	12.2
1100	29.7	58	0.74	151	0.60	300	50	12.0
1200	3.5	508	5.85	1488	4.45	241	50	13.4
1200	7.0	235	3.23	656	2.44	280	50	12.4
1200	14.0	116	1.65	320	1.24	288	50	12.2
1200	21.0	77	1.10	213	0.83	288	50	12.2
1200	29.7	54	0.80	146	0.60	300	50	12.0
1300	3.5	469	6.25	1443	4.45	241	50	13.4
1300	7.0	217	3.45	637	2.44	280	50	12.4
1300	14.0	107	1.76	310	1.24	288	50	12.2
1300	21.0	71	1.18	207	0.83	288	50	12.2
1300	29.7	49	0.85	142	0.60	300	50	12.0
1400	3.5	435	6.66	1403	4.45	241	50	13.4
1400	7.0	202	3.67	619	2.44	280	50	12.4
1400	14.0	99	1.88	302	1.24	288	50	12.2
1400	21.0	66	1.25	201	0.83	288	50	12.2
1400	29.7	46	0.90	138	0.60	300	50	12.0
1500	3.5	406	7.06	1367	4.45	241	50	13.4
1500	7.0	188	3.89	604	2.44	280	50	12.4
1500	14.0	92	1.99	294	1.24	288	50	12.2
1500	21.0	62	1.33	196	0.83	288	50	12.2
1500	29.7	43	0.96	134	0.60	300	50	12.0
2000	3.5	305	9.05	1228	4.45	241	50	13.4
2000	7.0	141	4.97	544	2.44	280	50	12.4
2000	14.0	69	2.54	265	1.24	288	50	12.2
2000	21.0	46	1.69	177	0.83	288	50	12.2
2000	29.7	32	1.22	121	0.60	300	50	12.0
2500	3.5	244	10.99	1132	4.45	241	50	13.4
2500	7.0	113	6.03	503	2.44	280	50	12.4
2500	14.0	55	3.08	245	1.24	288	50	12.2
2500	21.0	37	2.05	164	0.83	288	50	12.2
2500	29.7	26	1.48	112	0.60	300	50	12.0
3000	3.5	203	12.90	1062	4.45	241	50	13.4
3000	7.0	94	7.07	472	2.44	280	50	12.4
3000	14.0	46	3.61	231	1.24	288	50	12.2
3000	21.0	31	2.41	154	0.83	288	50	12.2
3000	29.7	21	1.74	106	0.60	300	50	12.0
3500	3.5	174	14.79	1006	4.45	241	50	13.4
3500	7.0	81	8.10	449	2.44	280	50	12.4
3500	14.0	40	4.13	219	1.24	288	50	12.2
3500	21.0	26	2.76	146	0.83	288	50	12.2
3500	29.7	18	1.99	100	0.60	300	50	12.0
4000	3.5	152	16.67	961	4.45	241	50	13.4
4000	7.0	71	9.12	429	2.44	280	50	12.4
4000	14.0	35	4.65	210	1.24	288	50	12.2
4000	21.0	23	3.10	140	0.83	288	50	12.2
4000	29.7	16	2.24	96	0.60	300	50	12.0
4500	3.5	135	18.53	924	4.45	241	50	13.4
4500	7.0	63	10.12	413	2.44	280	50	12.4
4500	14.0	31	5.17	202	1.24	288	50	12.2
4500	21.0	21	3.44	135	0.83	288	50	12.2
4500	29.7	14	2.49	93	0.60	300	50	12.0
5000	3.5	122	20.37	892	4.45	241	50	13.4
5000	7.0	56	11.13	399	2.44	280	50	12.4
5000	14.0	28	5.68	195	1.24	288	50	12.2
5000	21.0	18	3.78	130	0.83	288	50	12.2
5000	29.7	13	2.73	90	0.60	300	50	12.0
5500	3.5	111	22.21	864	4.45	241	50	13.4
5500	7.0	51	12.12	388	2.44	280	50	12.4
5500	14.0	25	6.18	189	1.24	288	50	12.2
5500	21.0	17	4.12	126	0.83	288	50	12.2
5500	29.7	12	2.97	87	0.60	300	50	12.0
6000	3.5	102	24.03	840	4.45	241	50	13.4
6000	7.0	47	13.11	377	2.44	280	50	12.4
6000	14.0	23	6.69	184	1.24	288	50	12.2
6000	21.0	15	4.46	123	0.83	288	50	12.2
6000	29.7	11	3.22	85	0.60	300	50	12.0
6500	3.5	94	25.85	819	4.45	241	50	13.4
6500	7.0	43	14.09	368	2.44	280	50	12.4
6500	14.0	21	7.19	180	1.24	288	50	12.2
6500	21.0	14	4.79	120	0.83	288	50	12.2
6500	19.7	10	3.46	83	0.60	300	50	12.0
7000	3.5	87	27.65	799	4.45	241	50	13.4
7000	7.0	40	15.07	360	2.44	280	50	12.4
7000	14.0	20	7.69	176	1.24	288	50	12.2
7000	21.0	13	5.12	117	0.83	288	50	12.2
7000	29.7	9	3.70	81	0.60	300	50	12.0
7500	3.5	81	29.45	782	4.45	241	50	13.4
7500	7.0	38	16.05	352	2.44	280	50	12.4
7500	14.0	18	8.18	172	1.24	288	50	12.2
7500	21.0	12	5.45	115	0.83	288	50	12.2
7500	29.7	9	3.93	79	0.60	300	50	12.0
8000	3.5	76	31.25	766	4.45	241	50	13.4
8000	7.0	35	17.02	345	2.44	280	50	12.4
8000	14.0	17	8.68	169	1.24	288	50	12.2
8000	21.0	12	5.78	113	0.83	288	50	12.2
8000	29.7	8	4.17	78	0.60	300	50	12.0
8500	3.5	72	33.03	751	4.45	241	50	13.4
8500	7.0	33	17.99	339	2.44	280	50	12.4
8500	14.0	16	9.17	166	1.24	288	50	12.2
8500	21.0	11	6.11	111	0.83	288	50	12.2
8500	29.7	8	4.41	76	0.60	300	50	12.0
9000	3.5	68	34.82	738	4.45	241	50	13.4
9000	7.0	31	18.95	333	2.44	280	50	12.4
9000	14.0	15	9.66	163	1.24	288	50	12.2
9000	21.0	10	6.44	109	0.83	288	50	12.2
9000	29.7	7	4.64	74	0.60	300	50	12.0
9500	3.5	64	36.59	725	4.45	241	50	13.4
9500	7.0	30	19.91	328	2.44	280	50	12.4
9500	14.0	15	10.15	160	1.24	288	50	12.2
9500	21.0	10	6.77	107	0.83	288	50	12.2
9500	29.7	7	4.88	74	0.60	300	50	12.0
10000	3.5	61	38.36	714	4.45	241	50	13.4
10000	7.0	28	20.87	323	2.44	280	50	12.4
10000	14.0	14	10.64	158	1.24	288	50	12.2
10000	21.0	9	7.09	105	0.83	288	50	12.2
10000	29.7	6	5.11	73	0.60	300	50	12.0
10500	3.5	58	40.13	703	4.45	241	50	13.4
10500	7.0	27	21.82	318	2.44	280	50	12.4
10500	14.0	13	11.12	156	1.24	288	50	12.2
10500	21.0	9	7.42	104	0.83	288	50	12.2
10500	29.7	6	5.34	72	0.60	300	50	12.0
11000	3.5	55	41.89	693	4.45	241	50	13.4
11000	7.0	26	22.78	314	2.44	280	50	12.4
11000	14.0	13	11.61	154	1.24	288	50	12.2
11000	21.0	8	7.74	102	0.83	288	50	12.2
11000	29.7	6	5.58	71	0.60	300	50	12.0
11500	3.5	53	43.65	683	4.45	241	50	13.4
11500	7.0	25	23.73	310	2.44	280	50	12.4
11500	14.0	12	12.09	152	1.24	288	50	12.2
11500	21.0	8	8.06	101	0.83	288	50	12.2
11500	29.7	6	5.81	70	0.60	300	50	12.0
12000	3.5	51	45.40	674	4.45	241	50	13.4
12000	7.0	24	24.67	306	2.44	280	50	12.4
12000	14.0	12	12.57	150	1.24	288	50	12.2
12000	21.0	8	8.38	100	0.83	288	50	12.2
12000	29.7	5	6.04	69	0.60	300	50	12.0

table 4B. Pi-L network component values for the 160-meter amateur band. Values were determined as in table 4A.

R1 OHMS	F MHZ	C1 PF	L1 UH	C2 PF	L2 UH	R2 OHMS	R3 OHMS	'Q' QUAL
1000	1.8	1155	10.08	2985	8.90	252	50	13.1
1000	1.9	1047	10.12	2626	8.90	275	50	12.5
1000	2.0	955	10.16	2322	8.90	300	50	12.0
1250	1.8	924	12.14	2739	8.90	252	50	13.1
1250	1.9	838	12.18	2412	8.90	275	50	12.5
1250	2.0	764	12.22	2135	8.90	300	50	12.0
1500	1.8	770	14.17	2556	8.90	252	50	13.1
1500	1.9	698	14.20	2253	8.90	275	50	12.5
1500	2.0	637	14.23	1997	8.90	300	50	12.0
1750	1.8	660	16.17	2413	8.90	252	50	13.1
1750	1.9	590	16.19	2129	8.90	275	50	12.5
1750	2.0	546	16.22	1889	8.90	300	50	12.0
2000	1.8	578	18.14	2298	8.90	252	50	13.1
2000	1.9	524	18.15	2029	8.90	275	50	12.5
2000	2.0	477	18.17	1801	8.90	300	50	12.0
2250	1.8	514	20.09	2203	8.90	252	50	13.1
2250	1.9	466	20.10	1946	8.90	275	50	12.5
2250	2.0	424	20.11	1729	8.90	300	50	12.0
2500	1.8	462	22.02	2121	8.90	252	50	13.1
2500	1.9	419	22.02	1876	8.90	275	50	12.5
2500	2.0	382	22.02	1667	8.90	300	50	12.0
2750	1.8	420	23.94	2051	8.90	252	50	13.1
2750	1.9	381	23.93	1815	8.90	275	50	12.5
2750	2.0	347	23.92	1614	8.90	300	50	12.0
3000	1.8	385	25.85	1990	8.90	252	50	13.1
3000	1.9	349	25.83	1762	8.90	275	50	12.5
3000	2.0	318	25.81	1568	8.90	300	50	12.0
3250	1.8	356	27.74	1936	8.90	252	50	13.1
3250	1.9	322	27.71	1715	8.90	275	50	12.5
3250	2.0	294	27.68	1527	8.90	300	50	12.0
3500	1.8	330	29.62	1887	8.90	252	50	13.1
3500	1.9	299	29.58	1673	8.90	275	50	12.5
3500	2.0	273	29.54	1490	8.90	300	50	12.0
3750	1.8	308	31.50	1844	8.90	252	50	13.1
3750	1.9	279	31.45	1635	8.90	275	50	12.5
3750	2.0	255	31.40	1457	8.90	300	50	12.0
4000	1.8	289	33.37	1804	8.90	252	50	13.1
4000	1.9	262	33.30	1600	8.90	275	50	12.5
4000	2.0	239	33.24	1427	8.90	300	50	12.0
4250	1.8	272	35.23	1768	8.90	252	50	13.1
4250	1.9	246	35.15	1569	8.90	275	50	12.5
4250	2.0	225	35.08	1399	8.90	300	50	12.0
4500	1.8	257	37.08	1735	8.90	252	50	13.1
4500	1.9	233	36.99	1540	8.90	275	50	12.5
4500	2.0	212	36.91	1374	8.90	300	50	12.0
4750	1.8	243	38.92	1704	8.90	252	50	13.1
4750	1.9	221	38.83	1513	8.90	275	50	12.5
4750	2.0	201	38.73	1351	8.90	300	50	12.0
5000	1.8	231	40.76	1675	8.90	252	50	13.1
5000	1.9	209	40.65	1489	8.90	275	50	12.5
5000	2.0	191	40.54	1329	8.90	300	50	12.0
5250	1.8	220	42.60	1649	8.90	252	50	13.1
5250	1.9	200	42.47	1466	8.90	275	50	12.5
5250	2.0	182	42.35	1309	8.90	300	50	12.0
5500	1.8	210	44.43	1624	8.90	252	50	13.1
5500	1.9	190	44.29	1444	8.90	275	50	12.5
5500	2.0	174	44.16	1290	8.90	300	50	12.0
5750	1.8	201	46.25	1601	8.90	252	50	13.1
5750	1.9	182	46.10	1424	8.90	275	50	12.5
5750	2.0	166	45.95	1273	8.90	300	50	12.0
6000	1.8	193	48.07	1579	8.90	252	50	13.1
6000	1.9	175	47.91	1405	8.90	275	50	12.5
6000	2.0	159	47.75	1256	8.90	300	50	12.0
6250	1.8	185	49.88	1559	8.90	252	50	13.1
6250	1.9	168	49.71	1387	8.90	275	50	12.5
6250	2.0	153	49.53	1241	8.90	300	50	12.0
6500	1.8	178	51.69	1539	8.90	252	50	13.1
6500	1.9	161	51.50	1370	8.90	275	50	12.5
6500	2.0	147	51.32	1226	8.90	300	50	12.0
6750	1.8	171	53.50	1521	8.90	252	50	13.1
6750	1.9	155	53.30	1354	8.90	275	50	12.5
6750	2.0	141	53.10	1212	8.90	300	50	12.0
7000	1.8	165	55.30	1503	8.90	252	50	13.1
7000	1.9	150	55.09	1339	8.90	275	50	12.5
7000	2.0	136	54.87	1199	8.90	300	50	12.0
7250	1.8	159	57.10	1487	8.90	252	50	13.1
7250	1.9	144	56.87	1325	8.90	275	50	12.5
7250	2.0	132	56.64	1186	8.90	300	50	12.0
7500	1.8	154	58.89	1471	8.90	252	50	13.1
7500	1.9	140	58.65	1311	8.90	275	50	12.5
7500	2.0	127	58.41	1174	8.90	300	50	12.0
7750	1.8	149	60.69	1456	8.90	252	50	13.1
7750	1.9	135	60.43	1298	8.90	275	50	12.5
7750	2.0	123	60.17	1163	8.90	300	50	12.0
8000	1.8	144	62.47	1442	8.90	252	50	13.1
8000	1.9	131	62.20	1285	8.90	275	50	12.5
8000	2.0	119	61.93	1152	8.90	300	50	12.0
8250	1.8	140	64.26	1428	8.90	252	50	13.1
8250	1.9	127	63.97	1273	8.90	275	50	12.5
8250	2.0	116	63.69	1141	8.90	300	50	12.0
8500	1.8	136	66.04	1414	8.90	252	50	13.1
8500	1.9	123	65.74	1262	8.90	275	50	12.5
8500	2.0	112	65.44	1131	8.90	300	50	12.0
8750	1.8	132	67.82	1402	8.90	252	50	13.1
8750	1.9	120	67.50	1251	8.90	275	50	12.5
8750	2.0	109	67.19	1122	8.90	300	50	12.0
9000	1.8	128	69.59	1390	8.90	252	50	13.1
9000	1.9	116	69.27	1240	8.90	275	50	12.5
9000	2.0	106	68.94	1112	8.90	300	50	12.0
9250	1.8	125	71.37	1378	8.90	252	50	13.1
9250	1.9	113	71.02	1230	8.90	275	50	12.5
9250	2.0	103	70.69	1104	8.90	300	50	12.0
9500	1.8	122	73.14	1366	8.90	252	50	13.1
9500	1.9	110	72.78	1220	8.90	275	50	12.5
9500	2.0	101	72.43	1095	8.90	300	50	12.0
9750	1.8	119	74.91	1355	8.90	252	50	13.1
9750	1.9	107	74.53	1211	8.90	275	50	12.5
9750	2.0	98	74.17	1087	8.90	300	50	12.0
10000	1.8	116	76.67	1345	8.90	252	50	13.1
10000	1.9	105	76.28	1202	8.90	275	50	12.5
10000	2.0	95	75.90	1079	8.90	300	50	12.0
10250	1.8	113	78.43	1335	8.90	252	50	13.1
10250	1.9	102	78.03	1193	8.90	275	50	12.5
10250	2.0	93	77.64	1071	8.90	300	50	12.0
10500	1.8	110	80.19	1325	8.90	252	50	13.1
10500	1.9	100	79.78	1184	8.90	275	50	12.5
10500	2.0	91	79.37	1063	8.90	300	50	12.0
10750	1.8	107	81.95	1315	8.90	252	50	13.1
10750	1.9	97	81.52	1176	8.90	275	50	12.5
10750	2.0	89	81.09	1056	8.90	300	50	12.0
11000	1.8	105	83.71	1306	8.90	252	50	13.1
11000	1.9	95	83.26	1168	8.90	275	50	12.5
11000	2.0	87	82.82	1049	8.90	300	50	12.0
11250	1.8	103	85.46	1297	8.90	252	50	13.1
11250	1.9	93	85.00	1160	8.90	275	50	12.5
11250	2.0	85	84.54	1042	8.90	300	50	12.0
11500	1.8	100	87.21	1288	8.90	252	50	13.1
11500	1.9	91	86.73	1152	8.90	275	50	12.5
11500	2.0	83	86.26	1036	8.90	300	50	12.0
11750	1.8	98	88.96	1280	8.90	252	50	13.1
11750	1.9	89	88.47	1145	8.90	275	50	12.5
11750	2.0	81	87.98	1029	8.90	300	50	12.0
12000	1.8	96	90.71	1271	8.90	252	50	13.1
12000	1.9	87	90.20	1138	8.90	275	50	12.5
12000	2.0	80	89.70	1023	8.90	300	50	12.0

band	turns	approximate inductance
80	11.000	4.43 μH
40	7.125	2.43 μH
20	4.5000	1.23 μH
15	3.500	0.83 μH
10	2.875	0.60 μH

A suitable coil for the L-network inductor consists of two inches (5cm) of Air-Dux 1606T [6 turns-per-inch, (2.5cm), no. 14 wire, 2″ (2.5cm) diameter]. This inductor should be placed at right angles to the main pi inductor to avoid mutual inductance. In the following chart, 7.125 would be slightly over 7 full turns, 2.875 is slightly less than 3 full turns.

table 5. Comparisons between a 1-kW transmitter, a 2-kW transmitter, and a 2-kW transmitter operated at 1-kW input. A frequency of 4 MHz was used, but other frequencies from 3 to 30 MHz should produce comparable results. (These calculations are computer derived for comparative purposes and only approximate actual operating conditions.)

	1 kW	2 kW	1 kW on 2-kW transmitter	
Plate voltage	2800	2800	2800	volts
Plate current	357	714	357	mA
Plate load impedance	5000	2500	5000	ohms
Power input	1000	2000	1000	watts
Tube output (typical)	700	1400	700	watts
Power at antenna	672	1343	647	watts
Transmitter efficiency	67.2	67.1	64.7	per cent
Network efficiency	96.0	95.9	92.5	per cent
Lost in L1 (heat)	27.9	56.9	52.6	watts
Circuit Q	12	12	23.6	
Inductor Q (typical)	350	350	350	
Frequency	4.0	4.0	4.0	MHz
Antenna load	50	50	50	ohms
C1 tuning capacitor	95.5	191.0	187.8	pF
L1 inductor	17.38	9.18	9.18	μH
C2 loading capacitor	533.8	1096.9	1703.0	pF
C1 reactance	416.7	208.3	211.9	ohms
L1 reactance	436.9	230.7	230.7	ohms
C2 reactance	74.5	36.3	23.4	ohms
Current in C1	4.49	8.98	8.83	amps
Current in L1	4.73	9.29	8.93	amps
Current in C2	2.46	7.14	7.70	amps
Voltage across C1	2645.8	2645.8	2645.8	peak volts
Voltage across C2	259.2	366.5	254.4	peak volts
Voltage on antenna	183.3	259.1	179.9	*rms volts*
Current in antenna	3.67	5.18	3.60	amps

One other circuit trick which can be used quite successfully is to use a dual-section variable, placing the two sections in series rather than parallel. This reduces the minimum capacitance to 10 pF or less.

broadband power amplifier

Many operators need special frequencies outside the five amateur bands for MARS or other purposes, and need a power amplifier which can be tuned up at any frequency in the range from 3.0 to 30 MHz. **Table 7** shows a pi-network design that gives continuous frequency coverage in five switch positions. A pi-L network for similar use is shown in **table 8**. The pi-L is more broadband for a given Q variation, and requires substantially less output capacitance. Both designs are for 2000-watts input with a 2800-volt plate supply, or 1000-watts input at 2000 volts.

component ratings

To determine the peak voltage across C1 you can use the maximum dc plate voltage. This is not precisely correct, but it's close enough. Normally you would increase the voltage by at least 30 per cent when selecting a capacitor to prevent arcing if the tank circuit is not prefectly resonated, and to allow for some oxidation if you use an air variable.

There are several ways to determine peak voltage. If the power output is known at this point you can use **eq. 12** to determine peak voltage:

$$E_{pk} = \sqrt{2PZ} \qquad \textbf{(12)}$$

where E_{pk} is the peak rf voltage, P, is output power, and Z is plate load impedance. For example, in a 1-kW transmitter with 2800 volts on the plate, the peak voltage across C1 and L1 is 2646 volts. (The power output of class-B stages may be estimated at 70 per cent of the input power as this gives some margin of protection and is suitable for this purpose).

The peak voltage across C2 can also be figured in a similar manner, except that Z in **eq. 12** is the antenna load impedance. Power output may be estimated at 65 per cent of the input. For example, if the output power is 650 watts (for a 1-kW amplifier), and the antenna load is 50 ohms, this represents approximately 254 peak volts across C2. Thus, for a 1000-watt transmitter, a 350-volt, 365-pF broadcast receiver type capacitor could be used successfully. For 2000 watts input at 2800 volts, the peak voltage across C2 would be 367 volts, and the broadcast-tuning capacitor would be too marginal.

In the pi-L network the image impedance must be used when calculating the peak voltage across capacitor C2, and the voltage rating must be substantially higher than for the same capacitor in the pi network. For example, in a 1-kW transmitter, the peak voltage across C2 is about 635 volts; for a 2000-watt amplifier the peak voltage is about 895 volts.

The peak voltage across C1 has already been determined, but to find the current through C1, rms voltage is more useful. This can be found from **eq. 13**:

$$E_{rms} = \sqrt{PZ} \qquad \textbf{(13)}$$

where E_{rms} is the rms voltage, P is the output power, and Z is the plate load impedance. In the previous example of the 1000-watt transmitter with a 2800-volt plate supply, the rms voltage across C1 is nearly 1870 volts.

To calculate the current through C1 you must first determine the reactance of C1 (**eq. 14**) and calculate its impedance (**eq. 15**). The current is found from **eq. 16**:

$$X_c = \frac{Z_p}{Q} \qquad \textbf{(14)}$$

$$Z_{C1} = \sqrt{R^2 + X_C^2} \qquad \textbf{(15)}$$

$$I = \frac{E_{rms}}{Z_{C1}} \qquad \textbf{(16)}$$

However, since the resistance of a high-quality air-variable capacitor is very small, less than 1 ohm, for all practical purposes the impedance of the capacitor is equal to its reactance. Therefore, the current can be found from

$$I = \frac{E_{rms}}{X_{C1}} \qquad \textbf{(17)}$$

As you can see in **table 5**, the current through C1 is much higher than you might think, with nearly 4.5 amperes flowing through C1 in the 1000-watt transmitter with 2800 volts on the plate. Most air variables and vacuum capacitors can handle this current easily, but you must be careful when selecting fixed capacitors to pad the variables. Transmitting-type capacitors with high *Q* and good current-carrying capability are required (such as the Centralab 850 series).

The current through C2 can also be determined with **eq. 17**. However, when calculating the rms voltage across C2 the antenna load impedance must be used in **eq. 13**. Again, there is substantial current flowing through C2 — nearly 2.5 amperes in the 1000-watt transmitter.

For all practical purposes, the current through inductor L1 is equal to that through C1. It is actually a little higher, and the following formula is reasonably correct for class B:

$$I_{cc} = 1.05\, Q_o I_p \qquad \textbf{(18)}$$

where I_{cc} is the circulating current, Q_o is loaded circuit *Q*, and I_p is the indicated plate current. **Eq. 18** is a close approximation that compares favorably with answers derived from using complex vector analysis of reactive components used in rf circuits at resonance.

inductor power loss

To determine heat losses in the inductor, it is necessary to know the rf resistance of the inductor. Then you can use **eq. 19** to find power loss.

$$P = I^2 r \qquad \textbf{(19)}$$

where I is the circulating current and r is the rf resistance.

table 6. Large value at C1 and smaller inductor cause the *Q* on ten meters to rise very rapidly, especially when running the transmitter at a lower power input which requires 5000 ohms plate load impedance.

f (MHz)	R1	C1 (pF)	L1 (μH)	C2 (pF)	Q
29.7	2500	26	1.24	148	12.0
29.7	2500	32	1.00	210	15.0
29.7	2500	39	0.84	251	18.0
29.7	2500	45	0.72	300	21.0
29.7	2500	51	0.63	348	24.0
29.7	5000	26	1.24	234	24.0
29.7	5000	32	0.98	303	30.0
29.7	5000	45	0.70	437	42.0
29.7	5000	51	0.61	503	48.0

table 7. Pi-network component values for a broadband 3-30 MHz rf power amplifier matching a 50-ohm antenna load. This is accomplished in five bands: 3.0-5.0 MHz, 5.0-8.5 MHz, 8.5-14.4 MHz, 13.5-22.0 MHz and 20.0-30.0 MHz. The *Q* is set for a minimum of 12 at the top of each band. The 2500-ohm plate load impedance corresponds to a grounded-grid amplifier running 2000 watts at 2800 volts, or a 1000-watt amplifier with 2000 volts on the plate.

R1 OHMS	F MHZ	C1 PF	L1 UH	C2 PF	R2 OHMS	'Q' QUAL.
2500	3.0	433	7.34	2878	50	20.4
2500	3.5	317	7.34	2053	50	17.4
2500	4.0	242	7.34	1517	50	15.2
2500	5.0	153	7.34	878	50	12.0
2500	5.0	265	4.32	1764	50	20.8
2500	7.0	134	4.32	834	50	14.7
2500	7.3	123	4.32	755	50	14.1
2500	8.5	90	4.32	516	50	12.0
2500	8.5	155	2.55	1034	50	20.8
2500	14.0	56	2.55	327	50	12.4
2500	14.35	54	2.55	308	50	12.1
2500	14.4	53	2.55	305	50	12.0
2500	13.5	94	1.67	621	50	19.9
2500	21.0	38	1.67	225	50	12.6
2500	21.45	37	1.67	212	50	12.3
2500	22.0	35	1.67	199	50	12.0
2500	20.0	59	1.22	383	50	18.4
2500	28.0	30	1.22	176	50	13.0
2500	29.7	26	1.22	151	50	12.2
2500	30.0	25	1.22	146	50	12.0

To minimize these losses, the inductor should be silver plated, as should all leads to the bandswitch. Power losses on the order of 30 to 100 watts are not unusual, even with low standing-wave ratios. The use of tubing is encouraged, particularly on the higher frequencies to provide better unloaded *Q*.

It may come as a surprise to find that the conductivity of silver is only slightly superior to that of copper. In fact, a silver-plated coil is little more efficient than a new tank coil made of copper. Copper, however, oxidizes, and the outer rf-current-carrying layer becomes less effective. On the other hand, silver develops a form of silver sulfide on its outer surface which barely affects its conductivity. Over a period of years the silver-plated coil will retain most of its original conductivity.

safety

An rf choke should be used at the antenna output of any pi or pi-L network. This choke should be large enough to blow the overload relay (or fuse) in the high-voltage power supply if the dc blocking capacitor should short out. This is the only backup protection you have to keep high dc voltage off the pi-network components if the blocking capacitor

table 8. Pi-L network component values for a broadband 3-30 MHz rf power amplifier matching a 50-ohm antenna load. This is accomplished in five bands: 3.0-5.0 MHz, 5.0-8.5 MHz, 8.5-14.4 MHz, 13.5-22.0 MHz and 20.0-30.0 MHz. The *Q is set for a minimum of 12 at the top of each band.* The 2500-ohm plate load impedance corresponds to a grounded-grid amplifier running 2000 watts at 2800 volts, or a 1000-watt amplifier with 2000 volts on the plate.

R1 OHMS	F MHZ	C1 PF	L1 UH	C2 PF	L2 UH	R2 OHMS	R3 OHMS	'Q' QUAL
2500	3.0	388	9.00	2004	3.90	158	50	18.3
2500	3.5	292	9.00	1409	3.90	197	50	16.0
2500	4.0	228	9.00	1042	3.90	242	50	14.4
2500	5.0	153	9.00	622	3.90	350	50	12.0
2500	5.0	237	5.29	1231	2.29	154	50	18.6
2500	7.0	127	5.29	572	2.29	253	40	14.0
2500	7.3	118	5.29	519	2.29	270	50	13.5
2500	8.5	90	5.29	366	2.29	350	50	12.0
2500	8.5	139	3.12	724	1.35	154	50	18.6
2500	14.0	56	3.12	232	1.35	330	50	12.3
2500	14.35	54	3.12	219	1.35	345	50	12.1
2500	14.4	52	3.12	216	1.35	350	50	12.0
2500	13.5	85	2.04	431	0.89	165	50	18.0
2500	21.0	38	2.04	158	0.89	325	50	12.5
2500	21.45	36	2.04	150	0.89	335	50	12.3
2500	22.0	35	2.04	141	0.89	350	50	12.0
2500	20.0	53	1.50	263	0.65	183	50	16.7
2500	28.0	29	1.50	121	0.65	315	50	12.7
2500	29.7	26	1.50	106	0.65	345	50	12.1
2500	30.0	25	1.50	104	0.65	350	50	12.0

A suitable inductor for the L-section of the pi-L network consists of 5 cm (2 inches) of Air-Dux 1606T [6 turns-per-inch (2.5cm), no. 14, 5 cm (2 inches) diameter]. It should be placed at right angles to the main pi inductor to avoid mutual inductance.

frequency	number turns	approximate inductance
3.0-5.0 MHz	10.00	3.90 μH
5.0-8.5 MHz	6.75	2.25 μH
8.5-14.4 MHz	4.75	1.33 μH
12.5-22.0 MHz	3.50	0.83 μH
20.0-30.0 MHz	3.00	0.65 μH

shorts out. This rf choke also keeps any dc component off the antenna.

RTTY and ssb

Many amateurs are interested in RTTY as well as CW and ssb. Since RTTY is essentially 100 per cent key-down, it's quite hard on the various components in the transmitter. On ssb, the typical duty factor is 30 to 50 per cent, depending on how much ALC and other compression you use. *Typically, however, the average* circulating current in the network is perhaps one-third of that for key-down operation.

Table 5 shows that 2000-watts key-down gives comparable circulating currents to that of the same transmitter run at 1000-watts key-down with the same plate voltage and same inductor. This is due to the higher *Q* that is being used. Because of the lower duty cycle of ssb, running a 2000-watt transmitter key-down at 1000 watts for RTTY is three times as hard on the transmitter as running 2000-watts PEP! This is rather startling, and indicates why some rf power amplifiers should not be used on RTTY, although they are perfectly suitable for ssb at higher input power levels.

Conversely, it follows that if a manufacturer guarantees his unit to run indefinitely at 1000-watts key-down RTTY, that same transmitter should last forever at 2000-watts PEP ssb. Some manufacturers hedge if this specific question is posed to them.

Using a 2000-watt rf power amplifier at the 1000-watt level for RTTY or CW poses certain inherent problems regarding heat and efficiency. High plate supply voltages raise the plate load impedance to the point where it may be difficult to get the minimum capacitance required for resonance on 10 and 15 meters.

When building a high-power final amplifier, consideration must be given to selecting components which will handle the voltage and currents encountered in the circuit. The formulas given in this article should make it relatively easy for the builder to predict what these voltages and circulating currents will be before he actually builds the amplifier.

Computer-derived tables provide much data for the builder, and clarify many design points only hinted at in previous articles. I hope that the information presented here will be of benefit to anyone who builds or buys a final rf power amplifier.

acknowledgements

Many people are interested in pi and pi-L networks, and have been of direct assistance. Providing particular assistance was Bob Sutherland, W6UOV, or EIMAC. I also spent a great deal of time reading articles written by George Grammer, W1DF, former Technical Editor of QST. His work in this field, and his series of three articles in QST[5] represent an outstanding contribution. Bill Craig, WB4FPK, was most helpful, as was Garey Barrell, K4OAH. Bill Carver, K6OLG, also provided stimulating comments.

The Computer Terminal Corporation of San Antonio, Texas, provided over 100 hours of computer terminal time which was invaluable in this project.

references

1. Collins Radio Company, "Fundamentals of Single Sideband," second edition, 1965, page 7-6.
2. George Grammer, W1DF, "Simplified Design of Impedance-Matching Networks, Part II," *QST*, April, 1957, page 32.
3. American Radio Relay League, "Radio Amateur's Handbook," 49th edition, 1971, page 158.
4. Douglas Blakeslee, W1KLK, and Carl Smith, W1ETU, "Some Notes on the Design and Construction of Grounded-Grid Linear Amplifiers," *QST*, December, 1970, page 22.
5. George Grammer, "Simplified Design of Impedance-Matching Networks," Parts I and III, *QST*, March, 1957, page 38, and May, 1957, page 29.

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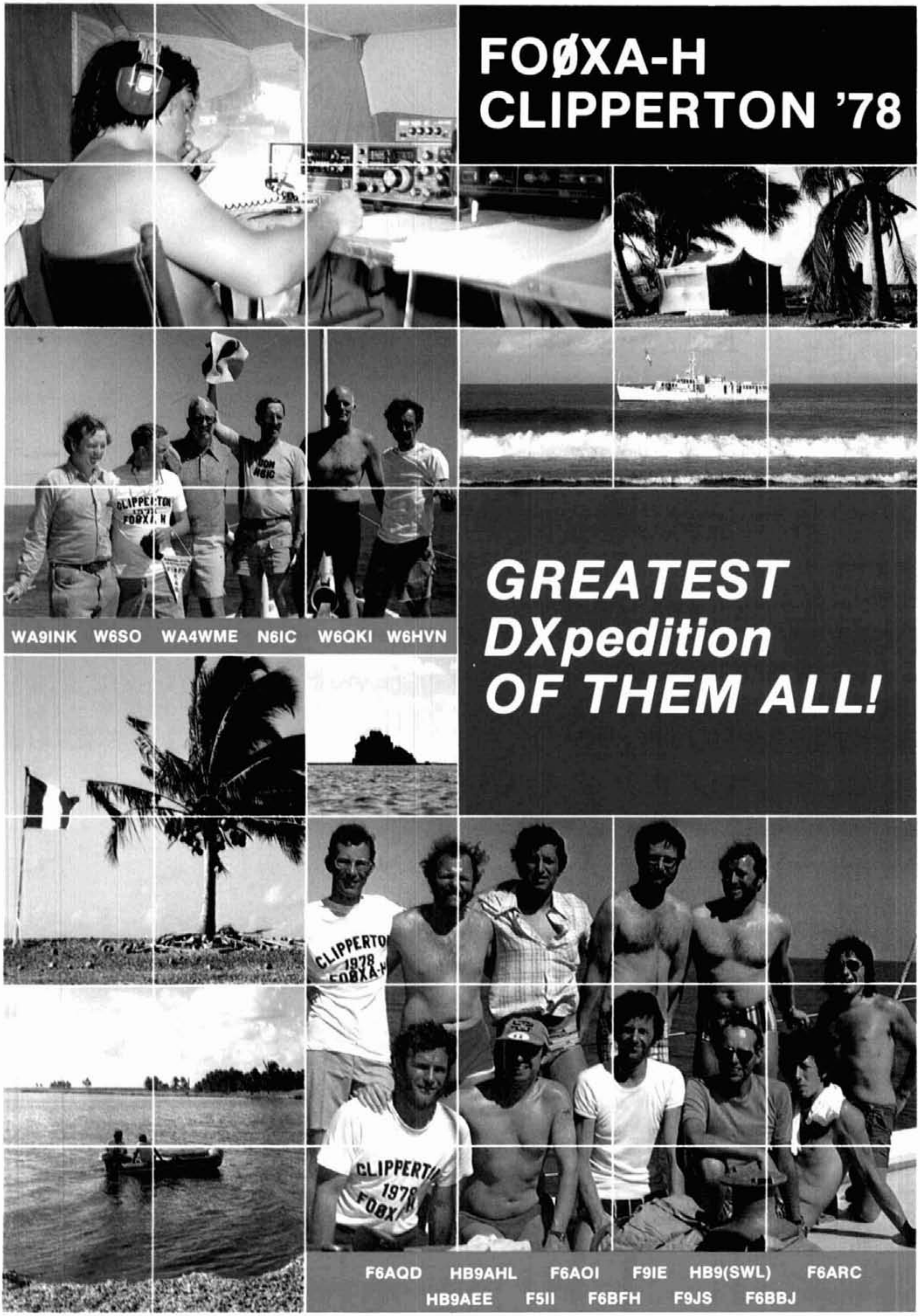

WA9INK W6SO WA4WME N6IC W6QKI W6HVN

F6AQD HB9AHL F6AOI F9IE HB9(SWL) F6ARC
HB9AEE F5II F6BFH F9JS F6BBJ

ATLAS 350-XL
Champion of Clipperton!

If you were one of the fortunate 29,069 hams who worked Clipperton Island in March of 1978, you've worked an Atlas 350-XL transceiver. The *350-XL was selected by the DXpedition logistics* team, headed by Don Bostrom, N6IC, because it had all of the necessary features required for the *operation contained in one compact package.* This included primary and auxiliary VFO's for split frequency operation, digital frequency display *with accuracy of ± 50 Hz, VOX for SSB and full* break-in for CW, sidetone, more than 200 watts output (twice that of most other transceivers), all *solid state design permitting efficient operation* from a storage battery if necessary. And above all, rugged design and construction that permits *hour after hour of continuous operation without* failure.

> ***"The 350-XL is a fine, rugged transceiver . . . even works after a salt water bath . . ." Willy, HB9AHL***

One very important point we want to make clear . . . the Clipperton DXpedition was *financed* by the 16 operators who went there, and by many generous donations from DX clubs, radio clubs, individual hams, and others. Atlas Radio was *not* a financial sponsor, except to the extent of loaning equipment. Other manufacturers provided similar support.

> ***"As equipment logistics manager, my selection of the Atlas 350-XL proved to be the perfect choice . . ." Don, N6IC***

Needless to say, we at Atlas Radio were very pleased when the team chose the 350-XL as the transceiver for all 3 stations. At that point, how *could I (W6QKI) turn down the invitation to join* the team, and to share in a tremendous adventure? Did I go along to keep our radios working? *Well, truthfully I brought along a box full of spare* parts and pieces. Happily I can report that the box could have stayed at home. And there are 15 witnesses *who will verify this. Their unanimous and* whole hearted endorsement of the 350-XL is most gratifying.

Many of you will be interested in how the 3 stations were organized. Number 1 station was set up in the metal Quonset-type building which the French put up in 1957 during the IGY scientific work conducted on the island. This station worked *strictly 20 meters 'round the clock for 7 days, SSB* and CW. It included a Dentron MLA-2500 Linear which was used much of the time to break *through to Europe and other distant points.* The antenna was a Wilson 4 element monobander about 30 feet high. Power was supplied by a 2500 watt Honda *gasoline generator.* This station ran continuously for 7 days, and made 11,158 contacts! Problems, zero!

> ***"Unbelievable performance and reliability under extremely adverse portable conditions and constant use by DXpedition multi-operators . . ." Hugh, WA4WME***

Incidentally, we took one box ashore which contained 3 fans. They were intended for blowing air on the transceiver heat sinks. The box is still on the island, unopened! Ambient temperature outside was 85 degrees F. Inside the metal building? Up to 95 degrees!

Station Number 2 was located about 200 feet *from Number 1, and was set up in a tent. It* worked 10 meters daytime, 80 and 160 meters at night. A Dentron MLA-2500 Linear was used, *mainly on 80 and 160, some of the time on 10* meters. A 3 element Wilson monobander was used on 10. A doublet was used on 80 meters, *later changed to a Delta loop by F6ARC,* a KLM vertical with ground radials worked very well on 160 meters. A Dentron MT-3000 antenna tuner was used on *80 and 160. Power was supplied by a* Sears 2200 watt generator. This station averaged 21 to 22 hours operation each of the 7 days. Problems? *The digital frequency display made signs of* acting up. One of the IC's was replaced. A 5 minute job. The rig had been liberally sprayed with salt water on the trip in through the surf, as also was the Dentron linear. Total contacts from station Number 2 were 6401 on 10 meters, 1644 on 80 meters, and *202* on 160 meters.

> ***"Clipperton: The best location for DXers. Atlas 350-XL: The best equipment for hardest DXpedition. Result: One of the best DXpeditions ever . . ." Jack, F5II/FO0XB***

Station Number 3 was located in a tent about 300 feet (and 5000 crabs) from Number 2. It operated on 15 and 40 meters. Foreign broadcast QRM was very rough on 40, so most operating time was on 15 using a Wilson 3 element monobander. No linear was used at this station because the generator would not provide enough power.

So, if you heard *Clipperton on 15 or 40 meters,* it was strictly barefoot. A Dentron MT-3000 tuner was used with a KLM vertical on 40 meters. Station Number 3 ran all week *on a generator that* delivered 155 volts AC when receiving . . . and only 75 to 90 volts during transmit! We were unable to adjust the problem, so *simply let it go.* Didn't bother the rig. Total contacts on 15 meters numbered 7194, second only to 20 meters! 40 meters netted *2450* contacts.

This report hardly is complete if we don't mention 6 meters and Oscar. N6IC and W6SO were the Oscar specialists. Unfortunately, some equipment difficulty (not Atlas) limited Oscar contacts to only 20. Rather disappointing, but the best we could do, and the guys really tried. 6 meters just never produced an opening. We monitored everyday without ever hearing a signal.

> ***"I cannot say enough about the excellent performance of the Atlas equipment. Under the most trying conditions of operation the gear came through with flying colors. With 16 operators pushing switches and twisting knobs 24 hours a day for 7 days, the equipment never faltered. Truly remarkable. The success of the DXpedition was due in large to the faultless operation of the 350-XL . . ." Hoppy, W6SO***

All in all, we feel the performance record on the HF bands is something to brag about, and hope you'll pardon us for indulging. One final thing to boast about was really unexpected. The ride through the surf back to the ship was quite a ride. Everyone, and everything thoroughly soaked. Much of the gear was full submerged. But all 3 of the 350-XL's worked normally after drying out! Being very low on fresh water we could not afford to wash the gear down. All we could do was dry them out in the sun. Obviously, as soon as we got back we had to wash out the salt and clean the sets up. But, they were used "maritime-mobile" on the trip back to San Diego.

The Clipperton '78 DXpedition was undoubtedly *the biggest expedition and adventure of its kind* ever put together, and turned out to be a smashing success in all respects. All the gang at Atlas is *mighty proud at how well the 350-XL proved itself,* truly a great performer; a real classic that will set the pace for years to come.

73 Herb Johnson W6QKI

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programming for automated satellite communication

Following the lead of Ball in February *ham radio*, author Milazzo has also derived the equations for tracking Oscar — emphasis in this case has been placed on developing a program suitable for use with the Texas Instruments calculators which use algebraic notation

Of primary importance in satellite communication is the required antenna orientation and the time during which the satellite is available from the ground station. Such information increases the dependability and efficiency of satellite use. Presently, the means of obtaining this data is widely available due to the increased popularity of low-cost programmable calculators and minicomputers.

Previous articles have dealt with the prediction of equatorial crossings.[1,2] These offer few advantages since such information is published monthly and interpolation of this data is easily accomplished. Other articles do offer more useful information but require the use of slide-rule type devices which are imprecise and incapable of being interfaced with station equipment.[3,4]

This article presents a series of equations for deter-

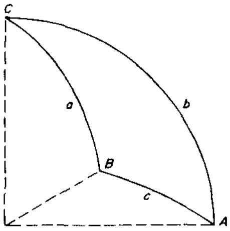

fig. 1. Basic figure used for the derivation of the main equations to track the satellite; the law of cosines for spherical trigonometry applies to this figure.

By Charles F. Milazzo, KP4MD, University of Puerto Rico School of Medicine, Apartado 2-2, GPO Box 5067, San Juan, Puerto Rico 00936.

mining the exact position of any earth satellite that approximates a circular orbit, at any given time. The calculations are useful for manually or automatically tracking a satellite, for preparing tables for future reference, or for alerting the operator when a satellite is approaching. This algorithm has been used to prepare programs for the Texas Instruments SR-52 calculator, but can be programmed for other calculators and computers as well.

theory

The theoretical model considers the earth as a stationary sphere with the satellite travelling in a circular orbit moving from east to west. Thus, the coordinates of the ground station remain constant while those of the satellite vary as a function of time. Solving this problem involves the application of spherical trigonometry which implies that the computer must be supplied subroutines for trigonometric functions. Algebraic methods for evaluating these functions are found in various references.[5,6]

The main equations are derived from the law of cosines of spherical trigonometry (see **fig. 1**).

$$\cos a = \cos b \cos c + \sin b \sin c \cos A$$

To calculate the latitude and longitude of the satellite, the angle labelled A is placed at the equator crossing point of a reference orbit, angle B is at the satellite's position at time T, and angle C is at the North Pole. Thus, A is equal to 360° minus the orbital azimuth during equator crossing ($A = 360° - \alpha_{eqx}$), and C is equal to longitudinal displacement of the satellite from the reference crossing ($C = \lambda_s - \lambda_{eqx}$). Side a is the complement of the satellite's latitude ($a = 90° - \psi_s$), side b is a function of the orbital period P_s and of the time elapsed from the reference crossing [$b = 360°(T - T_{eqx})/P_s$], and side c is 90°.

Substituting known values into the equation for the law of cosines results in:

$$\cos(90° - \psi_s) = \cos[360°(T - T_{eqx})/P_s] \cos 90° + \sin[360°(T - T_{eqx})/P_s] \sin 90° \cos(360° - \alpha_{eqx})$$

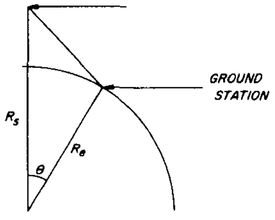

fig. 2. Calculation of the antenna elevation is based on this plane geometric figure. R_s **is the orbital radius, referenced to the center of the earth.**

which simplifies and rearranges to give the satellite latitude

$$\psi_s = \arcsin\{\sin[360°(T - T_{eqx})/P_s] \cos \alpha_{eqx}\}$$

The result is used again in the same equation to calculate angle C

$$\cos[360°(T - T_{eqx})/P_s] = \cos(90° - \psi_s) \cos 90° + \sin(90° - \psi_s) \sin 90° \cos C$$

which rearranges to give

$$C = \arccos\{\cos[360°(T - T_{eqx})/P_s] \cos\psi_s\}$$

The true longitude of the satellite is calculated by adding the longitude of the equator crossing reference point (λ_{eqx}), changing the sign of C when the satellite is in the Southern Hemisphere, adding the displacement due to the earth's rotation (0.25°/min), and compensating for a constant orbital drift factor (D) if necessary.

$$\lambda_s = (|\psi_s|/\psi_s) \arccos\left\{\frac{\cos[360°(T - T_{eqx})/P_s]}{\cos\psi_s}\right\} + \lambda_{eqx} + (T - T_{eqx})(0.25 + D)$$

Again referring to **fig. 1**, angle A is now placed at the location of the ground station and is equal to 360° minus the correct antenna azimuth ($A = 360° - \alpha_{gs}$). Angle C is the difference between the longitudes of the satellite and the ground station ($C = \lambda_s - \lambda_g$). If C is greater than zero, then the true azimuth is 360° minus α_{gs}. Side b is the complement of the ground station's latitude ($b = 90° - \psi_g$), and side c is the distance from the ground station to the satellite in great circle degrees ($c = \theta$). Side c is calculated using the law of cosines.

$$\cos\theta = \cos(90° - \psi_s) \cos(90° - \psi_g) + \sin(90° - \psi_s) \sin(90° - \psi_g) \cos(\lambda_s - \lambda_g)$$

which simplifies to give the degrees distance

$$\theta = \arccos[\sin\psi_s \sin\psi_g + \cos\psi_s \cos\psi_g \cos(\lambda_s - \lambda_g)]$$

This value is used to calculate the azimuth

$$\cos(90° - \psi_s) = \cos(90° - \psi_g) \cos\theta + \sin(90° - \psi_g) \sin\theta \cos\alpha_{gs}$$

which rearranges to give

$$\alpha_{gs} = \arccos[(\sin\psi_s - \sin\psi_g \cos\theta)/\cos\psi_g \sin\theta]$$

The antenna elevation is calculated using a plane geometric model as shown in **fig. 2**. R_e is the earth's radius (6371.315km) and R_s is the orbital radius. According to Newton's law of gravitation, the radius of a circular orbit is a function of the orbital period. For any satellite in such an orbit, the centrifugal force ($F = mv^2/R_s$) is equal to the gravitational force ($F = GM_em/R_s^2$). The velocity of the satellite is equal to the orbital circumference divided by the orbital period in seconds ($v = 2\pi R_s/60P_s$), when P_S is in minutes. GM_e is the earth's gravitational constant (398603km^3/s^2). Thus, we can calculate the orbital radius by equating the centrifugal and gravitational forces

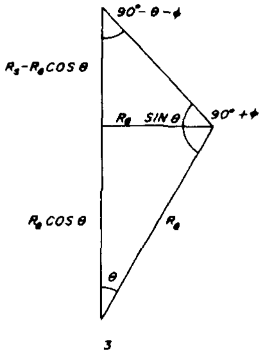

fig. 3. By drawing a perpendicular line from the ground station to the orbital radius line, all angles and distances can be analyzed using basic trigonometric functions. As shown in the text, the actual antenna elevation angle is derived by this method.

$$m(2\pi R_s/60P_s)^2/R_s = GM_em/R_s^2$$

or

$$R_s = \sqrt[3]{GM_e(30P_s/\pi)^2}$$

Fig. 3 shows the trigonometric relationships which result when a perpendicular is drawn from the ground station to the R_s line. Solving for the angle whose apex is at the satellite's position yields

$$90° - \theta - \phi = \arctan\,[R_e \sin\theta/(R_s - R_e \cos\theta)]$$

which rearranges to give the antenna elevation

$$\phi = \arctan\,[(R_s - R_e \cos\theta)/R_e \sin\theta] - \theta$$

If the satellite is below the horizon, the antenna elevation will be a negative number. This is useful as a conditional test to determine if the satellite is within range.

Ground distance is directly proportional to the arc distance and can be found by $D = k\theta$, where k is 111.14 for kilometers, or 69.06 for statute miles. Direct line-of-sight distance can also be determined by the law of cosines (**fig. 4**).

$$D = \sqrt{R_s^2 + R_e^2 - 2R_sR_e \cos\theta}$$

The constants for the Oscar 6 and 7 satellites are as follows:

	α_{eqx}	P_s	D
Oscar 8	351.0100°	103.23162 min	0
Oscar 7	348.2990°	114.94483 min	0

the SR-52 program

Due to the complexity of the calculations required, the program is divided into two modules.* The first module enters the appropriate reference and constant information into the data memory, while the second module computes the satellite's position and direction in terms of azimuth and elevation from a specified ground location. In the second module, the desired time is entered from which the calculator displays the elevation angle, indicating if the satellite is within range. The azimuth and arc distance can then be called from the calculator. To facilitate the tabulation of the results, one key has been programmed to advance or reverse the position of the satellite by a desired number of minutes. The following example demonstrates the use of the program.

The antenna aiming data for the first Oscar 7 pass of August 1, 1977 is desired. The first program card is read into the calculator, and the R/D switch is placed in the degrees mode. A reference orbit from January 1, 1977 is available. The satellite is found to cross the equator at 77.0° west longitude at 0148:49 on January 1. The station coordinates are 18°25′ north latitude and 65°58′ west longitude. Therefore, the following key sequence is executed:

enter	press	display	
7	A	7	(satellite #)
1	B′	2400	(enter date)
148.49	B	1548.82	
77.0	C	77.	
18.25	D	18.42	
65.58	E	65.97	

The second card is now read into the calculator. Since the exact time of acquisition is not known, a rough estimate can be made based on the fact that the satellite travels at about 3 degrees per minute and

---

*A copy of the program is available by sending a self-addressed, stamped-envelope to *ham radio*, Greenville, New Hampshire 03048.

it must be within 36 degrees of the station to be heard. First, determine if the satellite is within range at 0000 GMT on August 1 (213th day of 1977).

enter	press	display	
213	A′	511200	(enter date)
0	A	−9.23	(enter time/ disp. elev.)
	C	45.8	(disp. distance)

The negative value for elevation showed that the satellite is below the horizon at 0000 GMT, while pressing C showed that it is about 10 degrees beyond the 36 degree range limit. If the satellite is approaching, it will take about four minutes to come within range. Advancing the satellite four minutes produces:

enter	press	display	
4	E	2.25	(elevation)
	B	147.8	(azimuth)
	C	33.4	(distance)

The satellite can be advanced at one minute intervals to produce a listing for this pass.

time	elevation	azimuth	distance
0004	2.2	147.8	33.4
0005	5.7	146.2	30.3
0006	9.4	144.3	27.2
0007	13.5	142.0	24.2
0008	18.1	139.0	21.2
0009	23.4	135.1	18.3
0010	29.3	129.8	15.5
0011	35.9	122.4	12.9
0012	42.7	111.5	10.6
0013	48.7	95.5	8.8
0014	51.6	74.3	8.0
0015	50.1	52.1	8.5
0016	44.8	34.3	9.9
0017	38.1	22.0	12.1
0018	31.3	13.6	14.6
0019	25.2	7.8	17.4
0020	19.7	3.7	20.3
0021	14.9	0.6	23.3
0022	10.6	358.1	26.3
0023	6.7	356.2	29.4
0024	3.2	354.7	32.4
0025	0.0	353.5	35.6

Results from this program have been compared with published equatorial crossing data, with the predicted coordinates accurate to within one tenth of one degree for both Oscar 6 and Oscar 7. This, for one year from a single reference orbit.

The user instructions for the program are straightforward, but the following hints are useful. A date need not be entered if the reference and unknown orbits occur within the same day. When entering a date, it must always be entered before the time. The dates of the reference and unknown orbits must be either within the same month, or else each day of the year must be assigned a consecutive number. The "+ Time" key may be used to reverse the satellite's position by merely entering the negative value of the desired number of minutes. Finally, if you desire to enter a new time without using the "+ Time" key, it is necessary to re-enter the date (if used) before entering the new time. I can supply the program on magnetic cards with any station coordinates and reference orbit recorded for the cost of $5. This includes program documentation.

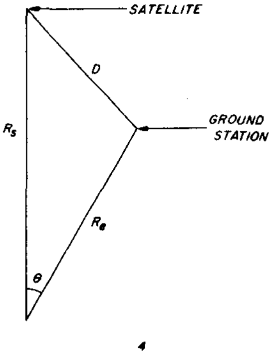

fig. 4. The direct line-of-sight distance to the satellite is calculated using the law of cosines and this figure.

conclusion

By using the preceding equations, any person can build his own computerized satellite tracking station by interfacing a digital clock and station controls to a microcomputer. Even without a computer, this program offers valuable, accurate information for any satellite operator.

references

1. Joe Kasser, G2ZCZ, "Oscar Orbits on your Altair," *73*, November, 1976, page 146.
2. Loring C. White, W1ODI, "Satellite Orbit Predicting," *73*, August, 1976, page 113.
3. Kazimierz Deskur, K2ZRO, "Shoot Oscar with a Satellabe," *73*, July, 1975, page 33.
4. Charles J. Harris, WB2CHO and Joel P. Kleinman, "The Oscarlocator," *QST*, November, 1976, page 51.
5. R. S. Burlington, *Handbook of Mathematical Tables and Formulas*, McGraw-Hill, New York, 1965, page 56.
6. R. C. Weast, editor, *CRC Handbook of Tables for Mathematics*, Chemical Rubber Company, Cleveland, 1967, page 581.

ham radio

KENWOOD

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The fully-synthesized TR-7400A 2-meter FM transceiver operates on 800 channels and features repeater offset over the entire 144-148-MHz range, dual frequency readout, six-digit display, and subaudible tone encoder and decoder. RF output is at least 25 watts!

The TR-7400A 2-meter FM transceiver provides fully synthesized operation, including 600-kHz repeater offsets, over the entire 144-148-MHz range. It can operate on any of 800 channels, spaced 5 kHz apart. RF output is at least 25 W, and typically 30 W. A low power position produces 5-15 W (adjustable). Included is a dual frequency readout with large six-digit LED display plus a dial readout. The subaudible CTCSS signaling feature may be used on transmit and receive, or transmit only. Optional tone-burst modules are available. Receiver sensitivity is better than 0.4 μV for 20 dB quieting. Large, high-Q, helical resonators minimize interference from outside the band. A two-pole 10.7-MHz monolithic crystal filter provides excellent selectivity. Optional active filters are available for 15-kHz "split" operation. Intermodulation distortion is down more than 66 dB, spurious rejection is better than −60 dB, and image rejection is better than −70 dB.

See your local Authorized Kenwood Dealer today, for a demonstration of the fantastic TR-7400A.

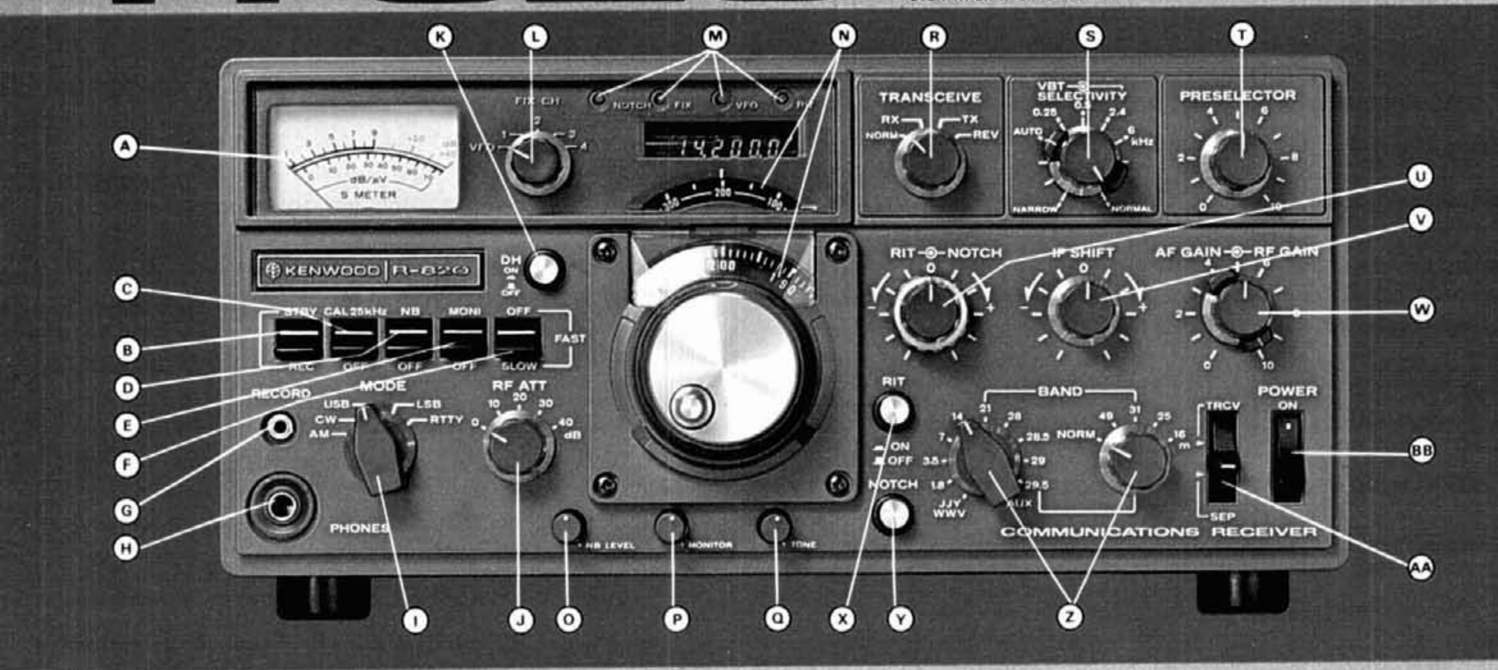
TR-7400A

PS-8

The PS-8 AC power supply matches the TR-7400A 2-meter FM transceiver, and produces 13.8 VDC at 8 A intermittent (50% duty cycle) and 5 A continuous. It can also be used with other Kenwood VHF and UHF mobile transceivers. It is well-regulated (less than ±4% fluctuation), has low ripple (less than 10 mV rms), and features current limiting (less than 3 A short circuit).

MC-30S & 35S

The MC-30S and MC-35S dynamic mobile microphones provide 150-5000 Hz frequency response (150-4000 Hz when operated as noise-cancelling microphones). The MC-30S impedance is 500 Ω and the MC-35S is 50 kΩ.



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protecting solid-state devices from voltage transients

There has been a great deal of discussion lately about solid-state equipment failing "for no apparent reason." If you have experienced such an occurrence and you can't explain it, chances are your solid-state gear has been zapped by a voltage transient. These are the little "gremlins" that can appear at any time, unannounced, and proceed to do their dirty work on your favorite electronic device (even when it is turned off).

While this problem may appear at first to be a recent phenomenon, it may surprise many of you to learn that voltage transients have been around for a long, long time. Why, then, have we begun to experience solid-state equipment failures (traceable to transients) only in the last few years?

The key to answering this question begins with an examination of the way equipment is built today as compared to 10 or 15 years ago. The one major and obvious difference is the use of solid-state devices in place of vacuum tubes. While transients have been around for a long time, they never bothered vacuum tubes, which can withstand momentary abuses without damage. Consequently, we have never paid much attention to the elusive voltage transient. To summarize our present situation, we know that:

1. High energy voltage transients can destroy solid-state devices.
2. We must design circuits more conservatively or add protective devices to suppress the transients.
3. We must try to eliminate some of the man-made causes of voltage transients.

In this article, I hope to provide you with some information on what voltage transients are, what causes them, why protection is necessary, and how to detect and suppress transients.

what are voltage transients?

To begin with, voltage transients are generally considered to be abnormally high voltages, occurring in a place where they don't belong, for an extremely short period of time (usually in the nanosecond range). These transients can be generated by a device within the electronic gear (relays or SCRs) or they may come from a number of external sources such as lightning or power line switching.

For example, if an electric current is made to increase or decrease rapidly in an inductive circuit, an extremely high voltage will be generated (directly proportional to the amount of inductance and the rate at which the current is attempting to change). While this all happens very fast, there is a possibility that enough energy will be generated to exceed the breakdown characteristics of the solid-state components in the conduit.

Another problem area exists with transients caused by outside sources that find their way into solid-state equipment through power connections, antenna lead-ins, and other signal inputs to the equipment. This type of transient is much harder to control than the internal transient, and yet can produce just as much damage.

sources of voltage transients

As discussed earlier, transients may be generated under all types of conditions, and may occur on an ac line as well as dc bus. An example of the generation of an internal transient is one that occurs in the windings of the transformer in a power supply. If the line switch on the primary side of the transformer is opened at the exact instant that the transformer core is beginning a downward swing of magnetization current (**fig. 1A**), a voltage spike is developed on the secondary winding of the transformer. The same thing can happen when the power supply is first turned on (**fig. 1B**). In this example, we are causing a rapid increase of current in an inductive circuit (the transformer winding) and the result is a momentary spike on the secondary circuit.

While the previous two examples involve ac circuits, the same phenomenon can occur with the interruption of dc circuits that supply inductive loads. A diode connected across the coil of a dc relay is a good example (**fig. 1C**). When power is interrupted, this circuit is designed to conduct and thereby clip any high-voltage transients that may be developed.

By W. J. Prudhomme, WB5DEP, 6419 Rosalie Court, Metairie, Louisiana 70003

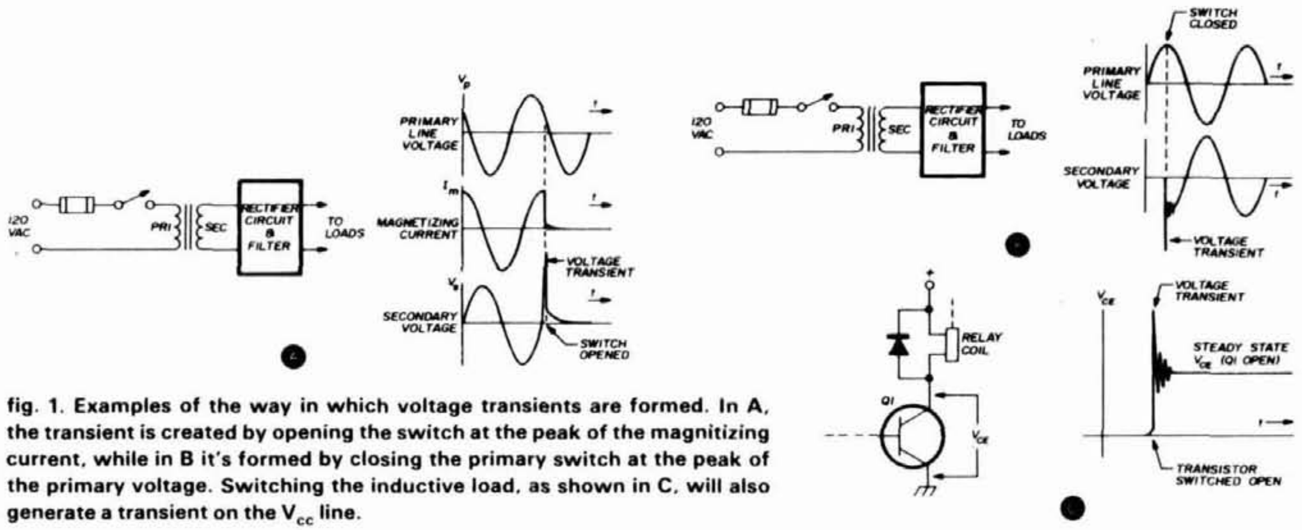
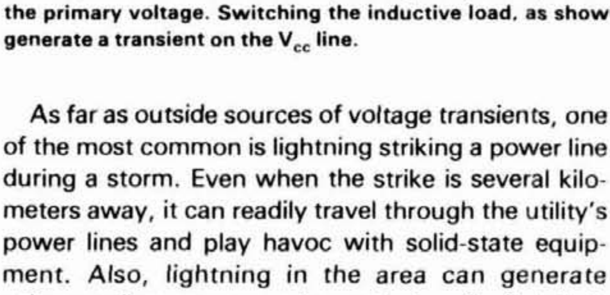


fig. 1. Examples of the way in which voltage transients are formed. In A, the transient is created by opening the switch at the peak of the magnitizing current, while in B it's formed by closing the primary switch at the peak of the primary voltage. Switching the inductive load, as shown in C, will also generate a transient on the V_{cc} line.

As far as outside sources of voltage transients, one of the most common is lightning striking a power line during a storm. Even when the strike is several kilometers away, it can readily travel through the utility's power lines and play havoc with solid-state equipment. Also, lightning in the area can generate voltage spikes on your antenna that easily find their way into the sensitive rf stages of receivers and transceivers. Here again, the actual lightning may be kilometers away and still generate enough transient energy to damage unprotected equipment.

When I was younger and didn't know better, I used to connect an NE-2 neon lamp across the lead-in of an unused antenna to detect these occurences. Even when an electrical storm was far away (and although the NE-2 requires about 90 volts to ignite), it would flash with almost every lightning strike. Naturally, for safety reasons, I don't recommend that anyone try this experiment. However, it should give you some idea of the amount of energy an antenna system can absorb and what can happen if you don't protect sensitive rf circuits.



Transients are capable of destroying solid-state components such as IC's, rectifiers, and transistors (even power transistors usually assumed to be protected by heatsinks). To protect these sensitive components from voltage transients, it's necessary to use some type of energy absorbing device such as the metal oxide varistors shown in the photo. These are the four round shaped components on the right that look like disc capacitors. Commercial solid-state equipment such as the well designed power supply in the background may be protected by installing a varistor on the line side of the power transformer. See text.

Other forms of ac voltage transients may come from arcing contactors, incandescent lighting dimmers, electric drills, appliance motors with brushes, power-line switching, and many more. Also, air conditioning motor-starting contactors can produce damaging transients, as well as relays in the control circuits.

why is protection required?

To further illustrate the fact that sensitive solid-state equipment should be properly protected, refer to a study conducted by the General Electric Company in 1969.[1] In this study, which took two years to complete, surge voltages in both residential and industrial circuits were measured at 400 different locations in twenty cities.

Surprisingly, higher surge levels were recorded in the residential circuits than in the industrial areas. In addition, the results showed a peak as high as 2500 volts generated by a motor contactor within a residence, and nearby lightning generated a 5600-volt peak on a 120-volt residential service. There were also a significant number of surges in excess of 2000 volts occurring in homes on a repetitive basis.

The GE study proved conclusively that residential lighting circuits are subjected to severe transients, as well as any electronic equipment connected to those circuits. As a result, the solid-state equipment in your home is subject to damage from voltage spikes if not properly protected.

suppression of transients

There are several ways to suppress voltage transients, and depending on the circuit application, some devices are better than others. Some of the devices available for you to choose from include metal-oxide varistors, power zeners, and short-circuiting devices such as spark gaps and electronic *crowbar* circuits.

Metal-Oxide Varistors. These dynamic resistance devices feature both low cost and small size, and are capable of dissipating a considerable amount of energy for a short period of time. One source for metal-oxide varistors is the General Electric Company; their registered trade name for these devices is GE-MOV. These varistors are available from most electronics supply houses.

If you are going to use these devices, I would recommend that you obtain a copy of GE's "Transient Voltage Suppression Manual," ($2.50 from GE, Semiconductor Products Department, Electronics Park, Syracuse, New York 13201). This manual is a complete guide to the proper application of varistors.

Since varistors are bi-lateral devices, they may be used in both ac and dc applications. In low-voltage dc applications, however, they may not provide adequate protection due to their soft clamping characteristics. They are generally more suitable for ac line voltages, and consequently are excellent in suppressing transients on the line side of equipment power supplies. An example is shown in **fig. 2**.

Power Zener. While varistors may exhibit soft characteristics at low dc voltages, power zeners can clamp very hard and fast at those voltages. Also, high transient currents do little to raise the clipping level of most zeners, provided ratings are not exceeded. The most effective way to apply zeners is with some amount of series resistance to safely limit the current. Two schemes for protecting both ac and dc circuits are shown in **fig. 3**.

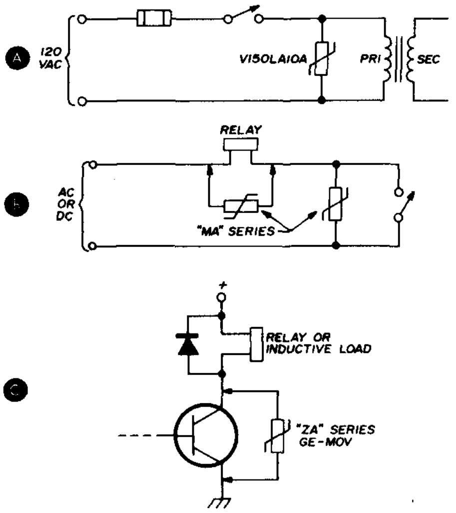
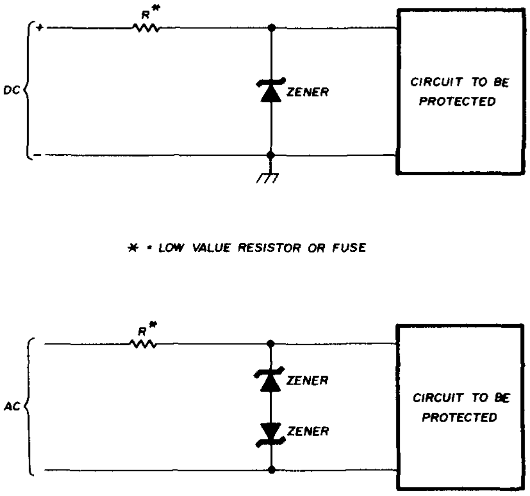


fig. 2. Application of commercial varistors will help eliminate line transients. The L series of GE-MOV varistors can handle up to 2750 amps (transient) and peak voltages from 95 to 1000 volts RMS (A). The MA series varistors are used primarily in low power applications, either ac or dc. In B, they're used to prevent contact arcing and line noise. To prevent transients while switching inductive loads, the ZA series of varistors are connected across the switching transistor as shown in C.



* = LOW VALUE RESISTOR OR FUSE

fig. 3. Instead of using commercial varistors, zener diodes can also be used to provide protection against voltage transients. The two examples show ways in which zeners can protect both ac and dc circuits. For the dc circuit, the zener is rated at a voltage greater than the dc bus, but less than the maximum voltage of the circuit to be protected. In an ac application, they should be rated at slightly greater than the peak ac value.

Short Circuit Methods. At first, this approach may seem contrary to normal applications. After all, a short circuit in most cases is a very undesirable situation. However, if it is properly controlled and occurs for very short periods of time (microseconds), the end result can be very beneficial in suppressing transients.

The two most commonly used devices in this category are spark gaps (both open and sealed units) and electronic crowbar circuits. The first is often used by amateurs for antenna applications, while the second is usually too complex for most hobby applications. The spark gap is adjusted to arc at a voltage above a certain level, effectively grounding the transient energy. Which method or combination of methods you choose, will depend on the application and what you are attempting to protect.

The best approach is to buy transient suppressors only in component form and apply them yourself using the guidelines in this article. Only then can you be assured of applying these useful devices for their intended purpose — protecting solid-state devices from voltage transients.

reference

1. IEEE Transactions on Power Apparatus and Systems, Vol. PAS-89, 1970.

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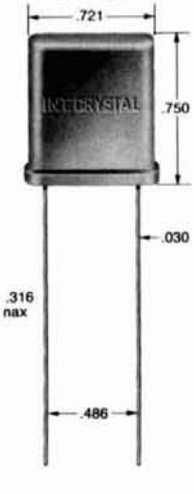

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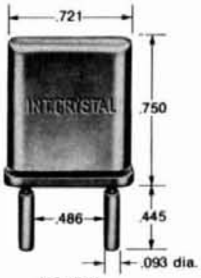

HC-17/U

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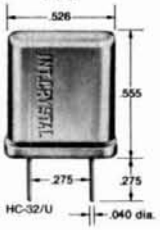

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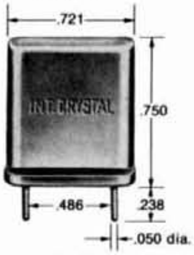

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F605-SL

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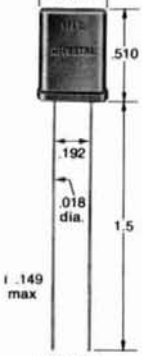

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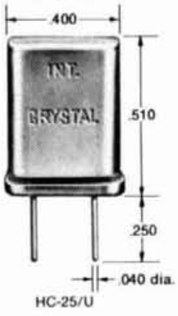

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Amateur Band transmission, including capability for MARS, Embassy, Government, and future band expansions*

The Drake TR-7 System significantly advances the technology of worldwide radio communications and unfolds an entirely new state of the art.

solid state synthesized hf system

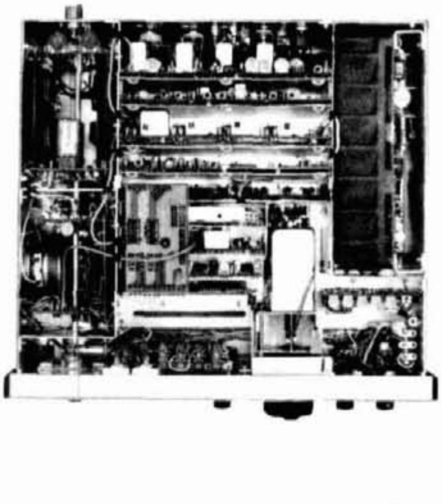
In 1963 Drake led the way by producing the first commercially available transceiver that employed the now widely copied 9 MHz i-f frequency. Even today, 15 years later, many major competitive transceivers are still being introduced using i-f's in this range.

In 1978 Drake leads the way again by developing the first commercially available amateur transceiver that uses a 48 MHz i-f, through the technique of "Up-Conversion." This system greatly improves image and general coverage performance, and will be copied in the years to come. With Drake, you can join the new state of the art today!

The design philosophy behind the new Drake "7 system" has created a most sophisticated system concept, extending from engineering to the visual appearance of the system and each of its parts.

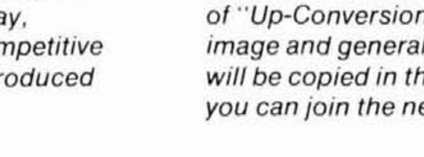
The TR-7 System is the result of one of the most extensive engineering and development programs in the history of the R. L. Drake Company, and provides the user with many innovative design features.

With the excellent design of its front panel and controls, the system is simple and straightforward to operate–makes state of the art performance a pleasure.

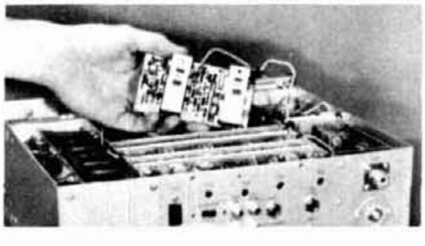


Broadband, Solid State Design—100% solid state throughout. All circuits are broadbanded so there is no need for preselection tuning or transmitter adjustments of any kind.

Synthesized/PTO Frequency Control—A Drake exclusive: Special high performance synthesizer, combined with the famous Drake PTO, provides smooth, linear tuning with 1 kHz dial and 100 Hz digital readout. 500 kHz up/down range switching is pushbutton controlled.

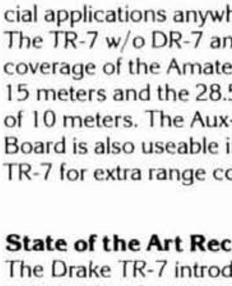


Continuous, Wide Range Frequency Coverage—The TR-7/DR-7 provides reception from 1.5 thru 30 MHz—continuously, and **zero** thru **30 MHz** continuously with the optional Aux-7 Range Program Board. The highly advanced Drake Synthesizer makes this possible, and is an industry first. The TR-7/DR-7 provides transmit coverage for all Amateur Bands 160 thru 10 meters. With the optional Aux-7 Range Program Board, diode-programmable out-of-band transmit coverage is available for MARS, Embassy, Government, and future band expansions in the range 1.5 thru 30 MHz.* The Aux-7 Board provides 0 thru 1.5 MHz receive coverage and crystal-controlled fixed channel operation for Government, Amateur, or semi-commercial applications anywhere in the hf range. The TR-7 w/o DR-7 and Aux-7 provides coverage of the Amateur Bands 160 thru 15 meters and the 28.5-29.0 MHz range of 10 meters. The Aux-7 Range Program Board is also useable in the standard TR-7 for extra range coverage as noted.



State of the Art Receiver Design—The Drake TR-7 introduces another industry first for amateur transceivers: "Up-Conversion," in combination with a special uhf high level double balanced mixer for superior strong signal handling, spurious and image response performance. The first i-f of 48.05 MHz places images well outside the receiver passband, and provides for true general coverage operation without i-f gaps.

True Passband Tuning—The TR-7 employs the famous Drake Full Passband Tuning instead of the limited range "i-f shift" found in some other units. The Drake System tunes from the top edge of one sideband, through center, to the bottom edge of the other sideband. In fact, the range is even wider to accommodate RTTY. Full passband tuning greatly improves receiving performance in heavy QRM.



(TR-7 features continued on next page)

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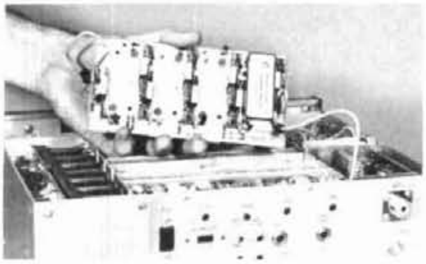
*Note: Out-of-band transmitter coverage for MARS, Government, etc. is available only in ranges authorized by the FCC, Military, or other government agency for a specific service. Proof of license for that service must be submitted to the R. L. Drake Company, including the 500 kHz range to be covered. Upon approval, and at the discretion of the R. L. Drake Company, a special range IC will be supplied for use with the Aux-7 Range Program Board. Prices quoted from the factory. See operator's manual for details.

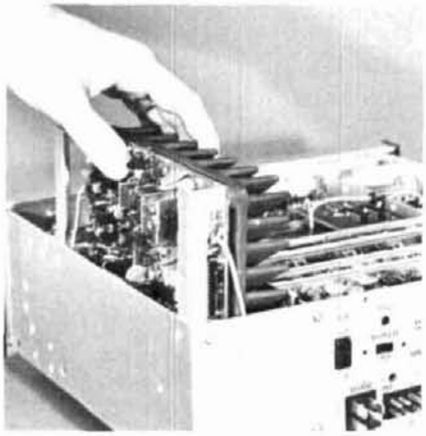
DRAKE TR-7 solid state continuous coverage synthesized hf system

Unique Independent Receive Selectivity—Optional receiving selectivity filters can be installed **internally** and pushbutton-selected from the front panel. These may be selected independently of transmit mode and provide optimum response for various conditions of ssb, cw, RTTY, and a-m. You may also transmit cw while receiving ssb, or vice versa, or even transmit one sideband while receiving the other. The standard filter is 2.3 kHz for ssb. You may choose from optional 300 Hz, 500 Hz, a special 1.8 kHz for crowded ssb, or 6 kHz filter for a-m.

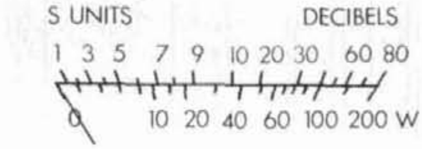


Effective Noise Blanker—This accessory is custom engineered to provide true blanking performance.

Special High Power Solid State PA—A Drake custom-designed diagonal heat sink provides for an internally mounted power amplifier with nothing mounted outboard subject to physical damage. The unique air ducting effect of this amplifier allows an optional rear-mounted fan to provide continuous duty on SSTV/RTTY. Continuous ssb/cw operation is available without the fan, due to the excellent heat sink design. The optional Drake PS-7 Ac Supply is rugged, rated for continuous duty, and will easily handle power requirements. The System is rated 250 watts input—in any of its modes. Fully VSWR protected.



TR-7 Internal Test Facilities—As well as the standard "S" meter function, the TR-7 metering includes a built-in rf Wattmeter/VSWR Bridge. Also, the DR-7 digital counter reads frequencies to **150 MHz** for test purposes. Access to the counter is from the rear panel.



Receiver Incremental Tuning (RIT)—Complete RIT flexibility is provided for **both** the TR-7 and RV-7 remote VFO for maximum convenience. The RV-7 also includes a special "spot" function for easy zero beating.

Model 1337	Drake TR-7 Transceiver	$ 886.00
Model 1530	Drake DR-7 General Coverage/ Digital Readout Board	186.00
Model 1336	Drake TR-7/DR-7 General Coverage Digital R/O Transceiver	1072.00
Model 1338	Drake RV-7 Remote VFO	156.00

Model 1502	Drake PS-7 120/240V Ac Supply includes special wide range voltage and frequency capability. Operates from any nominal line voltage (90-132 V/ 180-264 V; 50-60 Hz) ideal for overseas	$166.00
Model 1536	Drake Aux-7 Range Program Board	38.00
Model 1531	Drake MS-7 Matching Speaker	33.00
Model 1537	Drake NB-7 Noise Blanker	74.00
Model 1529	Drake FA-7 Fan	24.00
Model 7021	Drake SL-300 Cw Filter, 300 Hz	49.00
Model 7022	Drake SL-500 Cw Filter, 500 Hz	49.00
Model 7023	Drake SL-1800 Ssb/RTTY Filter, 1.8 kHz	49.00
Model 7024	Drake SL-6000 A-m Filter, 6.0 kHz	49.00
Model 1335	Drake MMK-7 Mobile Mounting Kit	to be *announced*
Model 1538	Drake MN-7 250 Watt 160-10 Meter Antenna Tuner with Rf Wattmeter and complete switching functions	165.00
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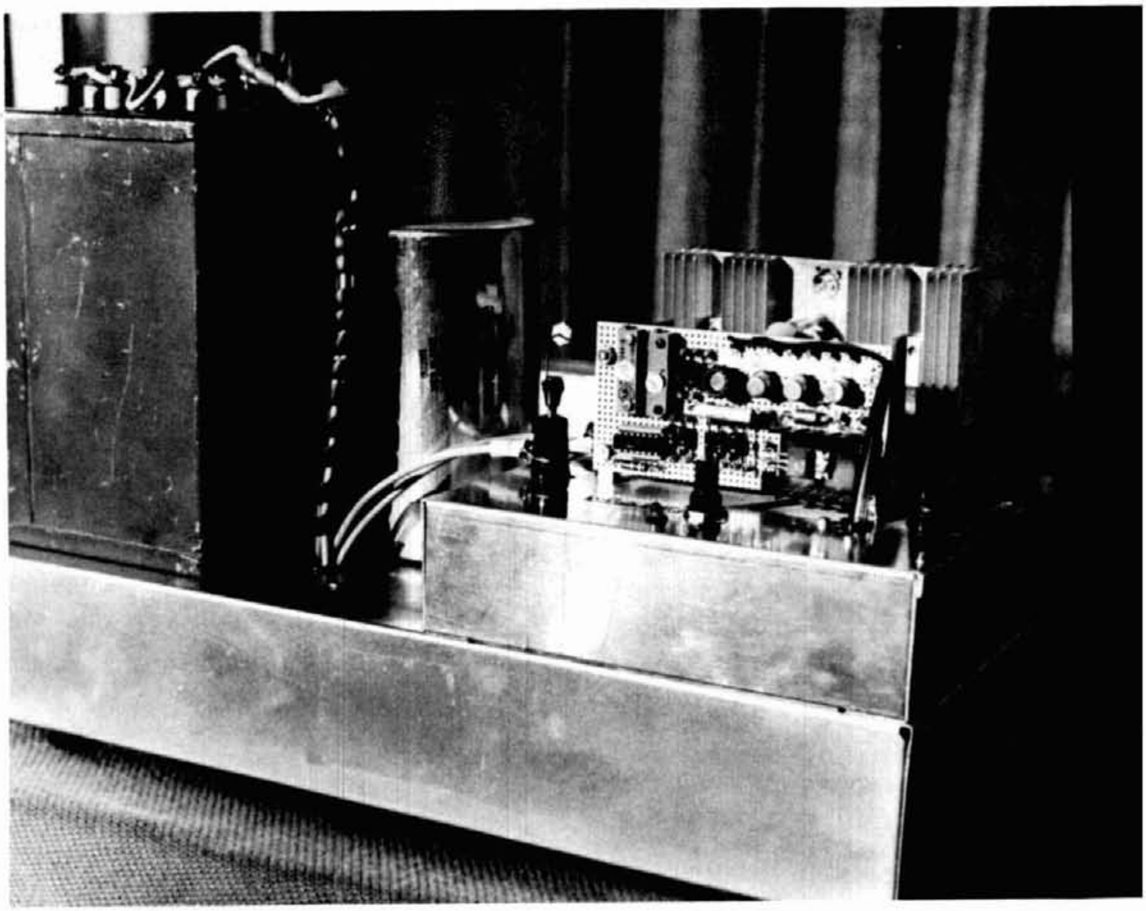

instantaneous-shutdown high-current regulated power supply

Protect both the new circuit and power supply by using this high-current instantaneously shutdown power supply

Anybody who builds a semiconductor circuit is faced with a potentially disastrous problem — what will happen when power is applied to the circuit? A short circuit could be catastrophic, for both the power supply and the newly-built circuit.

A high-current regulated power supply will continue to supply power, even with a short circuit, until one of the following events takes place.

1. The short circuit clears itself.
2. A semiconductor failure occurs (either the silicon or metal leads melts).
3. The power supply is damaged.

By Alan Nusbaum, W6GB, Dalmo Victor Operations, Bell Aerospace Textron, Division of Textron, Inc., 1515 Industrial Way, Belmont, California 94002

4. A fuse is blown, but usually too late to protect the circuit.

5. The power supply contains an extremely fast over-current sensing circuit that will cut off the current in less than 200 nanoseconds.

This article will describe just such an over-current shut-down circuit.

Over the past few years, there have been some new and novel voltage-regulator devices which will tolerate shorts or over-current loads by application of current fold-back circuits or thermal shutdown. Other versions which use a crow-bar device rely on blowing a fuse in the power supply primary. This method, however, is rather brutal treatment, and is often fatal to the pass transistor. I feel that a "grace-ful" but high-speed shutdown circuit is necessary to protect both the newly developed circuit and the power supply. Essentially, it must shutdown and not be allowed to restart after some pre-determined current level has been exceeded.

This power supply contains a high-gain error voltage control circuit and a voltage comparator that functions as a high-speed switch.

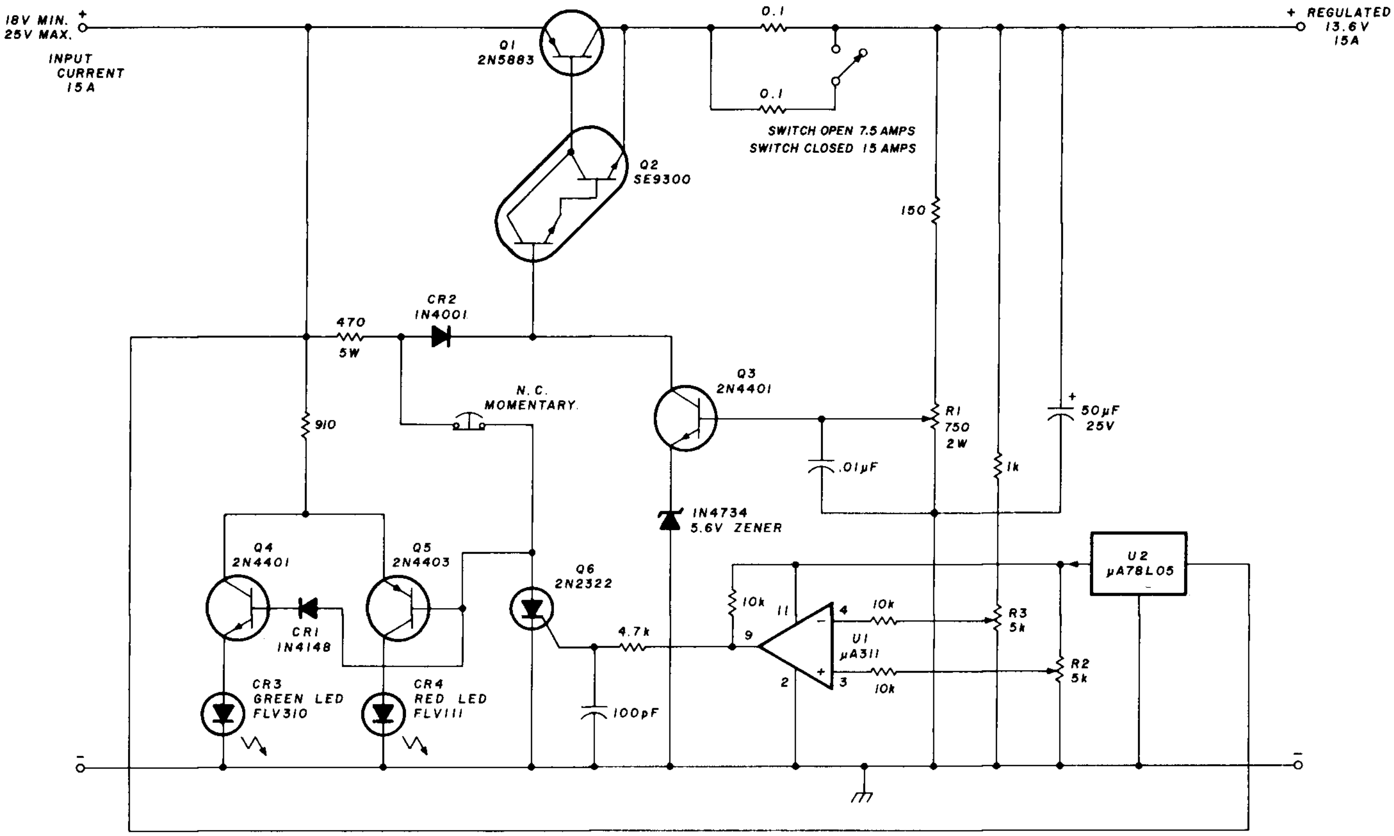

fig. 1. Schematic diagram of the high-current power supply. The separate 5-volt regulator is used to bias one input of the voltage comparator. The SCR is fired when the second leg of the voltage comparator detects a drop across the 0.1 ohm resistors. S1 is a normally-closed momentary type switch. Q1 must have an adequate heatsink (see text).

As seen in **fig. 1**, a PNP pass transistor is driven by a complimentary NPN monolithic Darlington. The Darlington in turn is current driven by a medium-gain transistor which acts as a voltage error detector. This form of regulator has proven to be very sensitive and reliable in that it will hold to within 30 mV from no load to a 15 ampere load, with less than 10 mV ripple at full load.

The shutdown portion of the circuit uses an SCR to rob the base current from the Darlington pair. When the SCR is triggered from the voltage comparator, the point between the 470-ohm resistor and CR2 is effectively grounded, reducing the output voltage to zero. U1, a µA311 voltage comparator, is used to sense the voltage drop caused by over-current across the two 0.1-ohm resistors. The noninverting input of the comparator is fed from a separately regulated source (U2). The inverting input is the actual output voltage, after it has been appropriately divided. When an under-voltage condition is created by over current, the output of the comparator will go high, turning on the SCR. To restart the regulator, it is necessary to momentarily disconnect the anode of the SCR, after clearing the over current condition. The green and red LEDs are used to indicate the status of the regulator, with red indicating that the SCR has been fired.

construction

The actual construction of the power supply is straightforward. However, the pass transistor must have an adequate heatsink. The power dissipated is

$$W_{diss} = (V_{in} - V_{out}) + V_{CEsat} \times I_{CE}.$$

To setup and adjust the supply, all components are connected with the exception of the SCR, Q6. A 100-ohm, 100-watt adjustable resistor can be used as a load. With the load resistor set for maximum resistance, the power supply is energized and R1 is adjusted for the desired output voltage (13.6 volts). An oscilloscope can also be connected to determine if there are any oscillations on the output waveform. If so, a 27-pF capacitor connected from collector to emitter of Q3 should eliminate the problem.

With a high-impedance voltmeter connected to the wiper arm, R2 should be adjusted to provide 2 volts to the comparator. This is the reference set point and should not be disturbed once set. After moving the voltmeter to the wiper of R3, this potentiometer should be set for a reading of 2.5 volts. With the meter still connected to R3, change the tap on the load resistor to the 50-ohm point. The 2.5 volt reading should not change.

The final step consists of checking the action of Q6. With the power supply switched off, connect the SCR. Also disconnect the load resistor and set the slider for a resistance of 1 ohm, but do not reconnect the resistor at this time. After re-energizing the supply, the red LED should be on; pressing the arming switch will turn on the green LED while extinguishing the red. If the LEDs do not function as indicated, remove the SCR and check the voltage on R3 to ensure that it's no lower than 2.5 volts. Also, check the voltage on the output of the comparator; it should be less than 100 millivolts. With the SCR installed and the circuit armed, the gate of Q6 should also measure less than 100 millivolts.

To test the circuit, momentarily connect the 1-ohm load resistor the to supply output. The shutdown circuit should operate instantaneously, and the red LED should come on. You should test this action several times to verify consistent shutdown.

At one ohm, the load current is 13.6 amps, but you can adjust R3 to actuate the shutdown at any current you desire. However, the voltage from R3 must not be lower than R2's voltage or the circuit will lock up in the fired mode. This system has been in use for over a year and has operated flawlessly during the entire time, even when powering tube-type mobile transmitters.

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command function debugging circuit

This device takes command information from standard PLL function decoders and applies a short time delay to provide debugged control commands

Our club had just finished installing an autopatch, exhausting all available funds, when the need for a better command decoder became evident. Each of the users had noted voice falsing of the decoder, and it was enough of an annoyance to be serious. More than once a telephone conversation had been terminated by a voice peak.

The investigation of causes and cures ran the gamut, until we finally decided that a fraction of a second delay on the command-function decoders would probably solve the problem. A number of designs were passed around and considered, and a few almost built, but the one described here was finally implemented — for three reasons: one, it works; two, it costs nothing to build; and three, it was built before any of the others. The design was based on the available components, and on the assumption that it might be necessary to drive a number of different types of loads. These considerations led to the use of transistor switches and reed relays to provide the outputs.

circuit description

The output circuitry from the tone decoder is shown in **fig. 1**. In our repeater, the debugging circuit was added without making any modifications to the autopatch. As shown in **fig. 2**, the debugging circuit consists of two portions, the transistor switches are wired to provide V_{CC} to their respective reed relays and the delay circuit which provides the ground return for the relay coils. Since only one relay

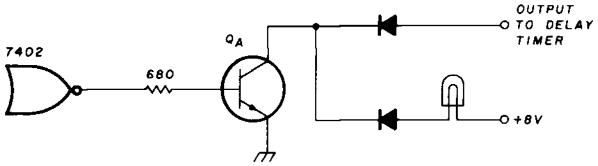

fig. 1. Output switching from the autopatch, prior to the installation of the debugger.

By J. Thomas Norman, WA7HFY, 1002 South
8th Street, Laramie, Wyoming 82070

is actuated at a time, only a single delay circuit is required. The diodes at the input of the delay timer form a multiple-input OR gate to actuate the delay after any digit has been decoded.

The timer itself is not very critical, especially since four different transistor types were used (even an unidentified NPN transistor). In its quiescent state, Q1 is biased on, charging C1 to approximately 8 volts. This level maintains Q2 and Q3 on, and Q4 off. When a function is decoded, Q1's base is effectively grounded back through the two diodes and Q_A. With the transistor now cut off, C1 will discharge through R3.

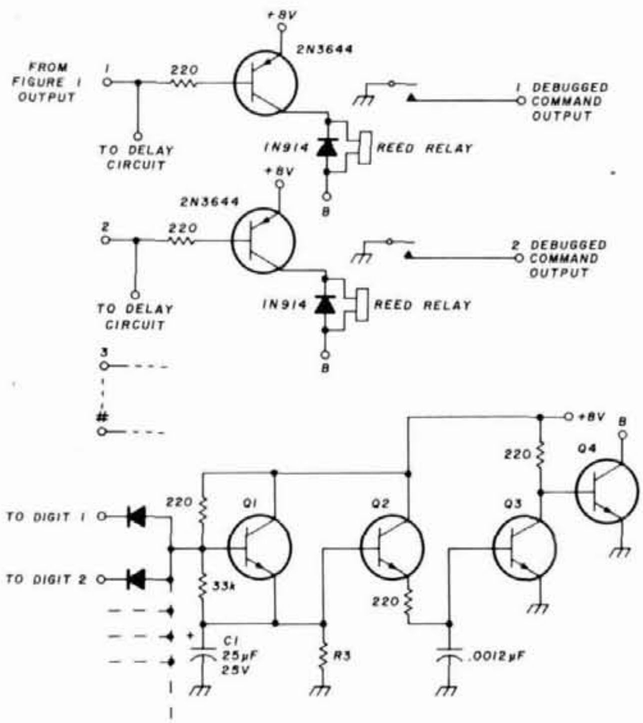

fig. 2. Schematic diagram of the add-on debugging circuit. Instead of the commands being controlled by transistor switches, they are controlled by reed relays. The delay portion of the circuit prevents the relays from picking up on noise spikes. The transistors can be almost any NPN type. R3 should be adjusted for the desired delay.

The value of this resistor can be adjusted for the desired amount of time delay, in our case approximately 0.1 second. When the voltage on the base of Q2 drops below about 1.2 volt, Q2 and Q3 are cut off and Q4 is turned on. With Q4 on, the reed relay is actuated, but when a noise spike is decoded as a pulse, the 2N3644 is turned on; since most noise pulses are very short in duration, they do not allow the timer to complete the circuit to actuate the relay.

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no-cost grid-dip meter

How to use no-cost parts salvaged from an old broadcast radio to build a grid dipper that tunes from 1 to 90 MHz

In these days of shortages and skyrocketing prices it seems improbable that anything could be free. However, except for a little spray paint, the instrument described here can, in truth, be free. Originally it was built for novice use to enable them to prune antenna systems, and to serve as an absorption wavemeter to insure output was on the correct band. It has proven so stable and reliable, however, that it can also serve a more experienced ham as a rugged instrument for general purpose work, and where considerably more output is needed than is available from solid-state dippers.

The frequency range is limited to approximately 1-90 MHz due to the variable capacitor I used for tuning. If a fairly clean capacitor is used — one which is not corroded and has good wipers — tuning will be unusually smooth and free from spurious dips. From the photographs it is obvious that it is more bulky than most commercial dippers. The vacuum tube protruding from the end may not be pretty, but this arrangement contributes substantially to frequency stability.

The schematic, **fig. 1**, shows the basic circuit. The tuning capacitor is the type commonly used in older five-tube ac-dc broadcast sets. If you have no 150-volt supply easily available, you can add a series resistor in the B+ line. This resistor should be about 50k for each 100 volts higher than the desired 150-volt supply. For instance, if the dipper is to be run from a 350-volt supply, the supply voltage is 200 volts too high, so a 100k dropping resistor would be chosen. It can be any value from 82k to 120k, and should be rated at 2 watts. The heater voltage can probably be picked off the same supply.

If you don't have a milliammeter available, you can use a 1000 ohms-per-volt multimeter on the 1.0- or 1.5-volt scale, or you can install a 2.2k resistor in place of the meter and read across this resistor with a 20,000 ohms-per-volt multimeter or vtvm on a 1.0- to 1.5-volt scale. This hookup is shown in **fig. 2**.

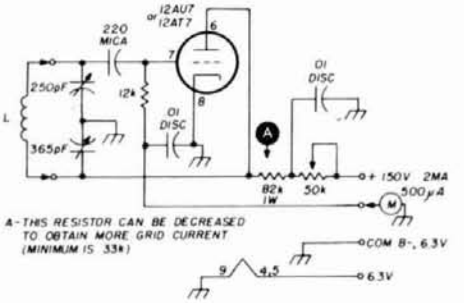
If you want to modulate the dipper, you can add the simple circuit shown in **fig. 3**. This transistor oscillator is powered by the dipper grid current and grid modulates the dipper. This makes it easier to locate the dipper signal during calibration, and allows the dipper to be used as a temporary signal generator for alignment work.

By Bill Wildenhein, W8YFB, 41230 Butternut Ridge, Elyria, Ohio 44035.

The dipper can also be used to check that your rig is tuned to the correct band. Switch off the B+ voltage to the dipper, but leave the heater voltage on. Poke the dipper into the rig near the output tank coil after you have tuned the rig, and tune the dipper for a *peak* instead of a dip. The peak will indicate which band you are actually on. Be careful of the high voltage!

plug-in coils

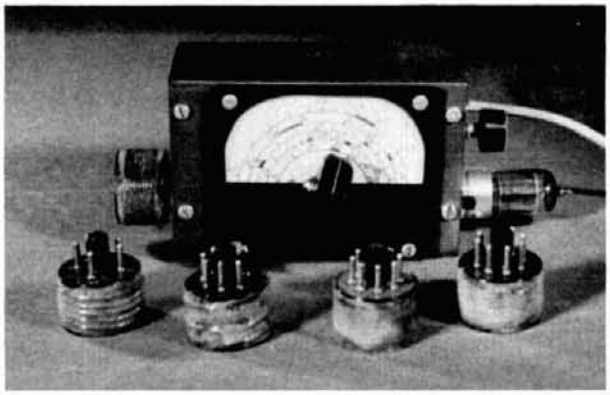
All the coils are wound on bases of defunct octal tubes. For those of you who have never smashed tubes, it can be done safely by holding the tube by the base with the glass envelope against the inside of a wastebasket. Give the glass a sharp rap with a hammer and the tube breaks without showering glass around as you would expect. Normally, the glass part cemented into the base remains relatively intact. This part of the glass can be broken up by punching it with a screwdriver. The remaining cement can easily be scratched out with a jackknife. Remove the leads from the pins by applying a soldering iron to the tips of the base pins while you pull on the leads with a pair of pliers.



coil number	frequency range	wire size	number of turns
1	0.97 - 2.9 MHz	34 AWG (0.16 mm)	83
2	2.8 - 8.7 MHz	24 AWG (0.51 mm)	27
3	6.7 - 20 MHz	24 AWG (0.51 mm)	12
4	15 - 45 MHz	20 AWG (0.81 mm)	5
5	30 - 90 MHz	20 AWG (0.81 mm)	2

fig. 1. All the parts for this "no-cost" grid dipper were salvaged from old radios and TV sets. All coils are wound on 32 mm (1-1/4 inches) diameter octal tube bases; winding length is 14 mm (9/16 inch).

Line up the tube bases after they are cleaned and select a pair of pins roughly opposite from each other (different tubes may have different base arrangements with some pins missing). Adjacent to one pin drill about a 1.5 mm (1/16 inch) hole as close to the bottom of the base as possible. Adjacent to the other pin, drill a 1.5 mm (1/16 inch) hole 14 mm (9/16 inch) higher up on the socket from the first hole. Be sure the desired pins are cleaned of solder. It sometimes helps to run a piece of enameled wire down through the pin hole while heating the pin with a soldering iron. The wire sizes listed on the schematic need not be exactly as shown. Those are the wire sizes I used, but coils 2, 3 and 4 could use the wire commonly used in the yoke windings of TV sets. The first coil could use either number-34 or -36. This size range is often found in audio interstage transformers. If you are unwinding a transformer, it is easy to find out whether a particular wire size will fit. From the loose end of the transformer winding, measure 14 mm (9/16 inch) and place a bit of masking tape there as a marker. As you unwind to this point, count the turns. If there are at least 80 turns to that point, the wire is small enough for the job.



This view shows the GDO with the top of the enclosure and the dial face removed. The capacitor shaft fits through the notch in the top.

As a last resort, if you can't find wire that small, you can find a size that allows perhaps, 60 turns in the total length. Wind the 60 turns, then continue winding over the first layer to get a smooth layer of about 15 turns. Then wind up over that second layer with a third layer totaling, perhaps, 10 turns. If you have never hand wound coils, here are some of the basics: First, carefully scrape the enamel insulation from one end of the wire. Poke the end through the hole in the base nearest the pin end. Now poke the wire down through the proper pin and solder it into the pin. Carefully pull the excess wire back through

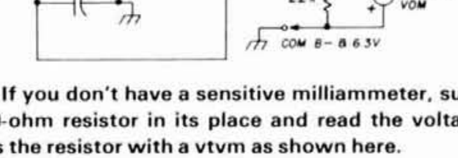
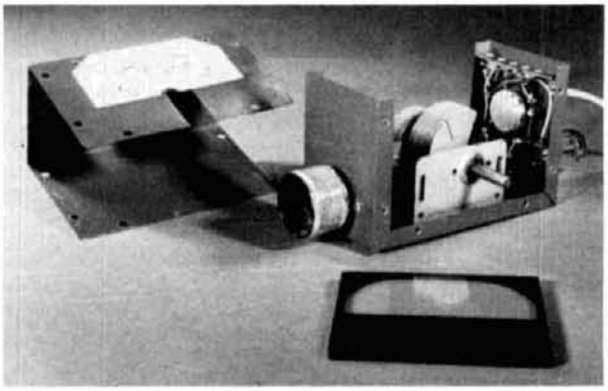


fig. 2. If you don't have a sensitive milliammeter, substitute a 2200-ohm resistor in its place and read the voltage drop across the resistor with a vtvm as shown here.



The finished grid-dip oscillator with the coils for different tuning ranges.

the 1.5 mm (1/16 inch) hole. Avoid kinks as they seriously weaken the wire. If one of these kinks forms, straighten the wire as you pull it through the hole so the kink isn't pulled tight.

Now reel off a length of wire and fasten the spool in a vise. Pull the wire taut. Make sure there are no kinks, though. Holding the coil form with both hands, wind your way toward the vise, keeping tension on the wire. When the correct number of turns are on the form, hold the winding from slipping with one hand and cut off the wire to leave 15 to 20 cm (6 to 8 inches) of excess. With your free hand, scrape the enamel off enough of this end to get through the other pin. Poke this end of the wire through the top 1.5 mm (1/16 inch) hole, pull it up tight, and put your thumb over it to keep it from slipping. Poke the end down through the correct pin and pull it taut. Pull it over to the side to make a sharp bend at the end of the tube pin. This will prevent the wire from slipping back through while you solder it to the pin. Now you can trim up the pin ends with a file.

Coat the entire winding and winding surface of the coil form with plastic model cement for Styrene models. Put on a heavy coat. For perhaps 15 minutes you will have to alternately stand the coil on the plastic locator between pins, then tip it over and stand it on the open end of the form as the cement slowly tries to run off the form. When it sets sufficiently that it stops running, leave it overnight. The next day add a second heavy coat. This will form a protective coating that will securely hold the turns in place when inserting or removing the coil, assuring that your calibration remains accurate.

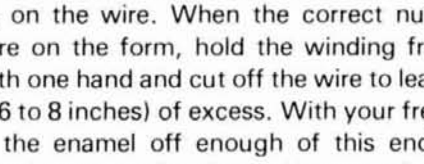


fig. 3. Simple modulator for the grid-dipper for fig. 1 uses a simple two-transistor oscillator which is powered by the grid current of the dipper.

Several of the coils are space-wound. After the winding of these coils is completed, the turns can be adjusted slightly until they are uniformly spaced.

enclosure construction

The photograph of the disassembled dipper shows the method of forming the sheet metal case. It was made of galvanized iron of the type used for furnace ducts. To form the sheetmetal box you need a couple lengths of angle iron about one foot long, and one piece about 5.7 cm (2-1/4 inch) long. Cold-rolled steel barstock is even better. Stock about 13x19 mm (1/2 by 3/4 inch) is good. In case you have neither, pick up some scraps of oak flooring and have a friend cut off the tongue and groove to give you a nice sharp corner. You also need a vise and a fairly husky C-clamp. Be sure to lay out and bend up the main chassis first. **Fig. 4** shows the layout I used. If your tuning capacitor is larger, make your box slightly larger. Take pains to make the layout very accurate. It saves headaches later when you bend up the lid.

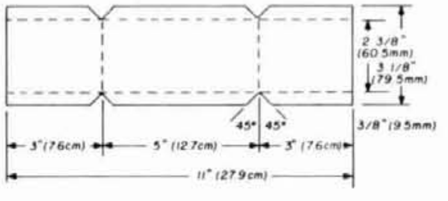


fig. 4. Sheet-metal layout used for the grid-dipper chassis.

Fig. 5A shows a cross-section if the bends are made correctly. Notice that the overall width is 6 cm (2-3/8 inch) plus two metal thicknesses. The reason for this is quite obvious if you look at **fig. 5B**. If the bending bar is placed exactly on the line, the outside edge of the metal extends one metal thickness beyond the line. Now look at **fig. 6A**: the metal is clamped differently than in **fig. 5B**. If you make one bend as in **fig. 5B** and the other bend as in **fig. 6A**, you will end up with the lopsided, inaccurate cross section shown in **fig. 6B**. Compare the dimensions with those in **fig. 5A**; to get these dimensions, you must clamp the bending bars as shown in **fig. 7**.

This leads to a simple sheet-metal rule: if you want the *inside* dimension of a U-shaped bend held to a size marked on a layout, the bending bars must also be on the inside, as shown in **fig. 7**.

For this first piece, the outside dimension is relatively unimportant. The lid is the really important piece because it must fit around this first box, and the inside measurement of the lid must be accurate. After this first piece is bent up, carefully measure the width at all points, then lay out and bend the lid. Next, lay out the holes in the lid and drill them with about a 5 mm (3/16 inch) drill. After removing the burrs, place the two sections together and carefully mark the hole locations on the inner box. These can be drilled with a number 36 (2.5 mm) drill. Then the box can be assembled with number 6 (about 3.5-mm diameter) sheet-metal screws salvaged from scrap TV sets.

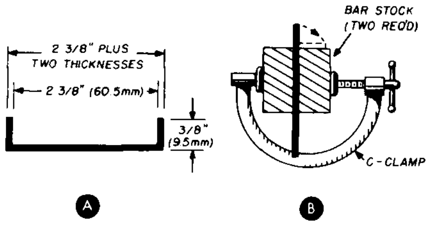
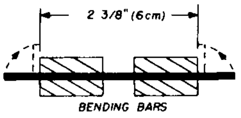


fig. 5. Proper method of bending the sheet metal used for the chassis (see text).

Locate and drill all socket holes, mounting holes and check the fit, then thoroughly clean both pieces with household cleanser. After they are dry they can be sprayed inside and out with gray primer paint before assembly and wiring is begun. The dial is made from a piece of card stock glued to the outer box. This is covered with a piece of clear plastic (small pieces are often available as scrap from hardware stores or glass shops). The "unbreakable" window panes are usually Plexiglass or Lexan, and they have very good rf insulating properties. For using a dial bezel, it is masked, then the layout drawn on the masking tape. With a sharp knife, cut away the part to be painted and spray with acrylic lacquer.

Your first homemade enclosure may take time and may be less than a professional job, but if you practice, using scraps of metal that can be picked up free, you will soon find it possible to do a fast, accurate job the first time. I usually spend less than a half-hour to make this sort of enclosure. The result is that you are no longer limited to standard box sizes or costs. Your dollar savings will pay for any investment in tools many times over. For example, you can get a combination square at a discount store for as little as a dollar, but in most cases they are anything but square! The aluminum or pot metal die-cast head may warp still more. For about $5.00 you can get one with a steel or cast-iron head that will be acceptably accurate for sheet metal work. With just a little care it will last you the rest of your life, and will guarantee a lifetime of accurate boxes.

fig. 7. Proper setup for bending the flanges on a chassis to maintain an internal dimension (see text).



If you have a very limited budget and can't afford anything but that discount store square, here is a way to check the square in the store, and pick the one that is square (see **fig. 8**). Take along a piece of sheet metal that has one edge sheared true and straight. If the square isn't a true 90 degrees, it will show up immediately as shown in the drawing. Just place it on the metal as shown in position A and scribe a line on the metal. Swing it around to position B and see if it falls exactly on the previously scribed line. Watch out for a head with a crooked edge, as in **fig. 9**. Strive for an accuracy of about 0.5 mm in 25 mm (1/64 inch in 10 inches), or better. It will make your work far easier.

calibration

Finally, let's cover calibration of the grid dipper. Up to about 30 MHz it can be checked against a general-coverage receiver. Above that frequency you may have to find a friend with a calibrated vhf dipper. Begin calibration at the lowest frequency and work toward the high end because general-coverage receivers commonly use a 455-kHz i-f which leads to poor image response at the higher frequencies. Starting at the low end, your calibration points will be accurate. If you are in doubt about one point, you can return to the last point to be sure you are correct, then carefully proceed higher in frequency. Another check is to watch the receiver's S-meter. The image signal is usually noticeably lower on the S-meter.

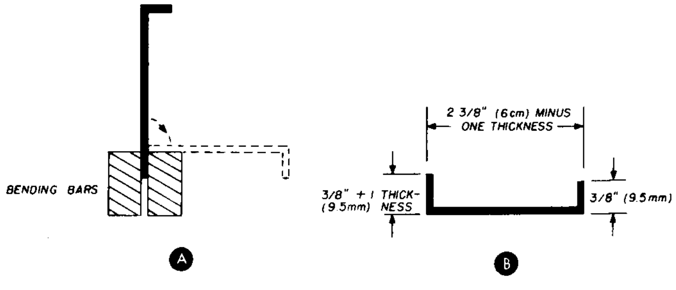


fig. 6. If bend bars are not used properly, one side of the chassis will have a different dimension than the other due to metal thickness (see text). Proper setup is shown in fig. 7.

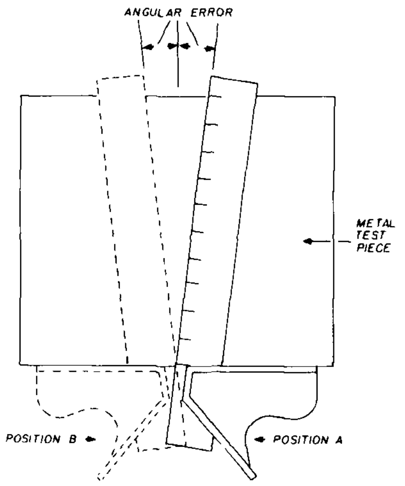


fig. 8. Simple method for checking the accuracy of a low-cost square.

Since the power output of this dipper will probably be as high as 200 milliwatts, it is inadvisable to attempt to use it to dip circuits connected to solid-state devices. You can easily blow a transistor. Remove the transistor before checking a circuit, but realize that the transistor itself adds capacitance to the circuit. I usually dip tank circuits before installing them, and include a small fixed capacitor to represent the capacitance of the transistor.

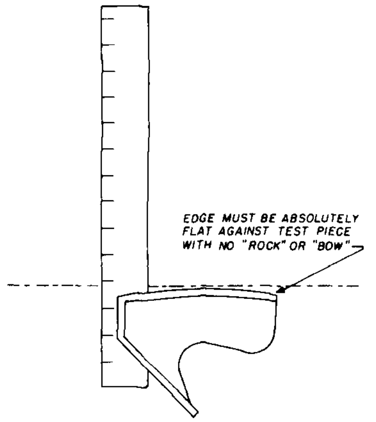


fig. 9. Beware of low-cost squares that are not perfectly flat — they should not rock against the test piece as shown here.

In conclusion, although this device is a homely looking gadget built from junk, it is still worth the effort to do the job right. I find it so stable and reliable that it has become one of the hardest working tools on my bench. I hope you enjoy the same benefits.

ham radio

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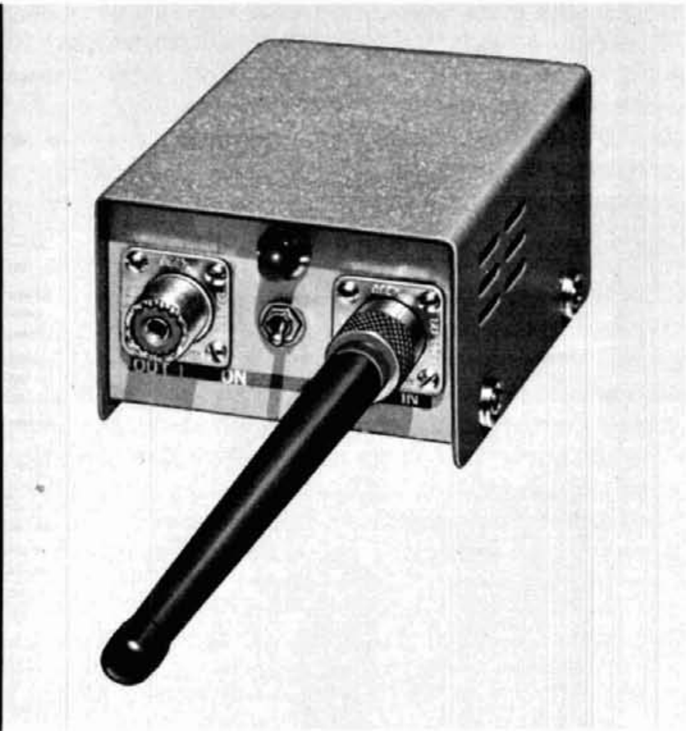


neat packaging for vhf prescalers

Novel packaging for K4GOK's prescaler uses readily available parts

At least one thing is quite apparent from the popularity of technical literature in amateur radio circles. A large part of the hamming community is putting certain minimums of time into electronic gear construction. To a big segment of talented do-it-yourselfers in hamdom, this kind of involvement is necessary to get maximum enjoyment from the hobby. It's not easy. Even those who live for the smell of hot rosin and solder soon learn that workbench time is a scarce luxury. One result of the paucity of time is that we get only the highest priority stuff to the bench and quite simply, lean on the stories others tell (or write) to learn about out-of-reach or lower priority items.

It is pretty well known that not being in a position to build a super hot new receiver doesn't spoil the fun of reading about how the author did it. The buzz word for this, of course, is *vicarious* and we'd be in rough shape without being able to enjoy things vicariously.

Even with the best intentions, many construction projects find their way into a file cabinet to await future action. Occasionally one may be pulled from the file and placed on the workbench for further thought, but every now and then lightning strikes and a construction article comes along to absolutely ruin your peace of mind until you can translate that writer's words into reality.

K4GOK's prescaler, as detailed in *ham radio* for February, 1976,* was just such a bolt for me. It turned out so well and so easy to assemble that I thought it deserved a little extra mention in all the shacks where it is filed under *projects — future*.

There is probably a great number of frequency counters in use which conk out at 50 MHz — or less. The need, however, for accurate frequency measurement in today's hamshack is in the order of 300 MHz, and if not a requirement for 2-meter fm, it is certainly a great convenience.

---

*M. D. Kitchens, K4GOK, "VHF Prescaler for Digital Frequency Counters," *ham radio*, February, 1976, page 32.

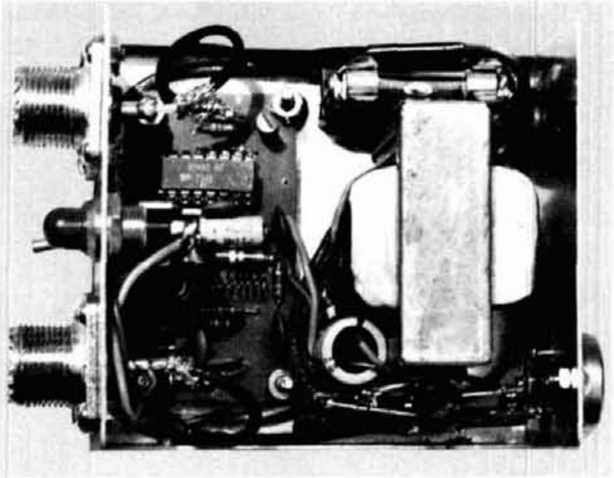
By Alan Smith, W8CHK, 3213 Barth Street,
Flint, Michigan 48504

There is no problem if you are in a position to select your needs from a supplier's shelf, but if you are in the more common position and want to soup up a flea market special or your old reliable Heath 1101, this prescaler is for you.

The construction approach recommended here is to build the prescaler as a separate unit. It will be easy on time and gentle on your pocketbook. You can even get several parts at your local Radio Shack store.

The unit in the photograph was built by my son, WB8YOB, and is a self-contained copy of the circuit described by K4GOK. As shown in the photo, it is set up to prescale two-meter signals with a rubber duck antenna as the coupling element.

The case is an Archer 270-250 ($2.98 from Radio Shack). You can get the transistors at Radio Shack by substituting 2N706 for 2N5179 and MPS-6533 for 2N5771. Otherwise the circuit can be assembled exactly as described in the original article.



Construction of the vhf prescaler showing the layout of the perfboard with the preamplifier and 95H90 decade scaler, left, and power supply components, right. Input and output coaxial connectors, left, give a good idea of the small size of the package.

The power supply is conventional. It requires a circuit-board transformer with an output voltage of 5.5 volts or more up to a maximum of 12 volts at 300 mA, a standard 500 mA bridge rectifier, one 1000 μF electrolytic capacitor, and an LM309K IC voltage regulator. The LM309K will keep the supply voltage at the required 5 volts.

These parts can be neatly fastened to a square of perf board and secured to the case, or the transformer can be fastened to the base and the remaining components simply hard wired. Add an on-off switch and a miniature red indicator light and you'll be ready to start prescaling.

ham radio

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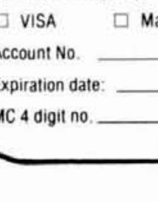

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precision voltmeter calibrator

It's always nice to have a high-accuracy, digital voltmeter around, but unfortunately they're very expensive. To solve this problem, I decided to build a variable voltage source to accurately calibrate the dc voltmeters I had on hand. There have been many precision ten-volt sources described in current literature;[1, 2, 3] I have used the circuit shown in reference 1 as the basis for my design.

circuit details

The circuit shown in **fig. 1** will produce from 0 to 10 volts with an error of less than 20 millivolts. In addition, it's also accurate with meter movements that have an internal resistance as low as a few thousand ohms. The 10 volts developed by the LM308 appears across R4. In my case, I used a ten-turn potentiometer and a suitably accurate ten-turn dial. The output from this potentiometer is fed into a 741 op amp connected for unity gain. In this way the op amp's high-input impedance will have negligible loading on the voltage source and its low output impedance will allow the calibration of meters with low internal resistance.

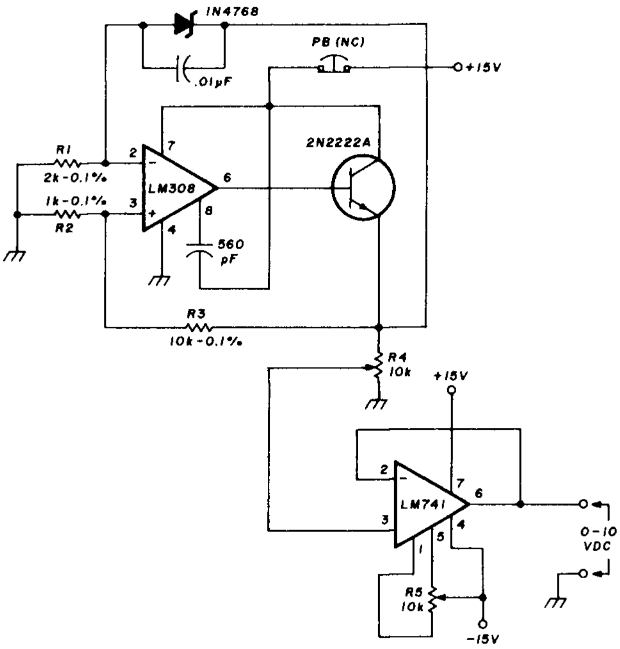

fig. 1. Schematic diagram of the 0 to 10 volt voltage standard. The pin numbers for the op amps are for the 8-pin mini-DIP package. R4 is a 10-turn potentiometer with a linearity of 0.1 per cent. The resistor tolerances should be closely observed to obtain a precise 10-volt output from the LM308.

By Hubert Woods, Calle Las Nubes, 1760,
Guadalajara 5, Jalisco, Mexico

It will be necessary to null out the small dc offset error which appears at the output of the 741 op amp. This is accomplished by the 10k potentiometer, R5; ground the input of the 741 and adjust R5 for zero volt output. The nulling procedure must be completed before final calibration is attempted. **Table 1** shows the results of calibration against a known voltage source.

For operation, this calibrator requires plus and minus 15 volts, at less than 50 mA. The normally closed switch shown in **fig. 1** is used to start the calibrator by creating a transient through the 560 pF capacitor. If the power supply for the calibrator is already running, this switch can be eliminated. Finally, you should realize that this calibrator can not be used as a substitute for a variable voltage power supply.

table 1. Calibration results for the 0 to 10 volt standard.

nominal voltage as read on R4	laboratory potentiometer reading
10.00	10.00
9.00	9.00
8.00	7.99
7.00	7.00
6.00	6.00
5.00	5.01
4.00	4.00
3.00	3.00
2.00	2.00
1.00	1.00
0.00	0.00

references

1. William Goldfarb, Electronics Circuit Designers Casebook, *Electronics*, June 7, 1975, page 107.
2. David W. Ishmael, WA6VVL, "Precision 10.000 V dc Reference Voltage Standard," *73*, September, 1975, page 124.
3. *Linear Data Book*, National Semiconductor Corporation, Santa Clara, California 95051, page 2-1.

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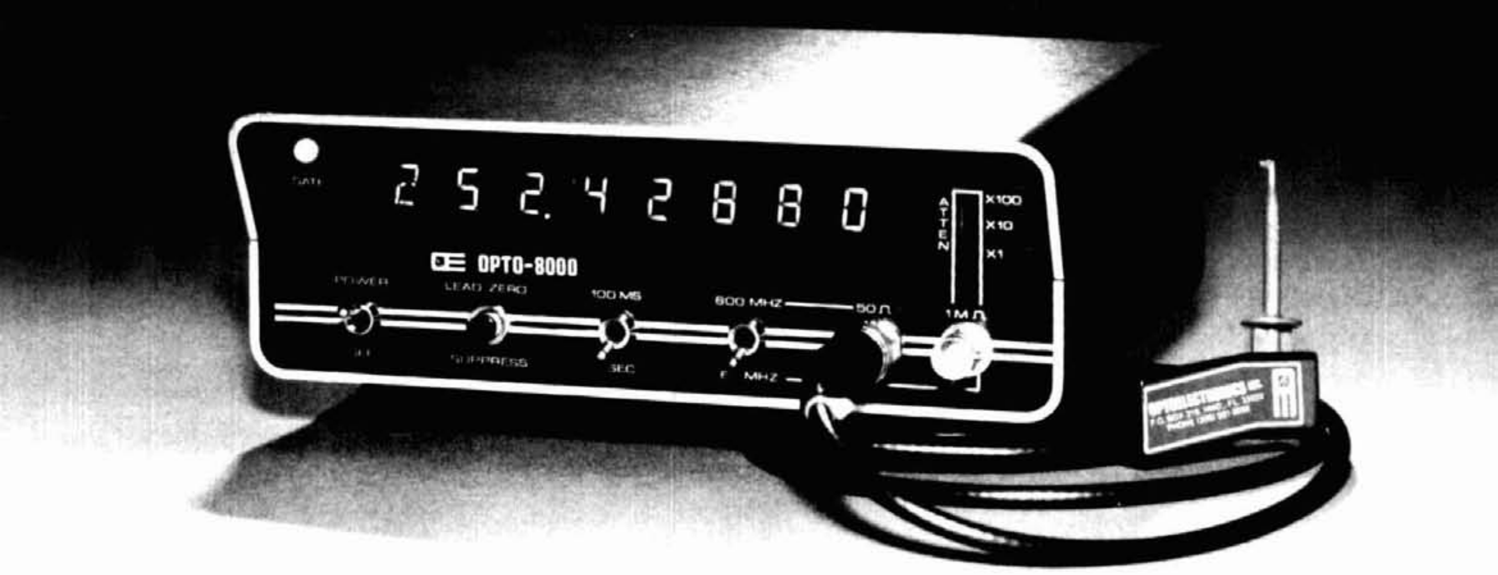

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the gyrator: a synthetic inductor

Using operational amplifiers you can simulate inductors in LC filter design

The Gyrator is an electronic device that inverts the impedance of a capacitor and therefore makes it take on the characteristics of an inductor. Through the use of such a device, some of the shortcomings of inductors can be eliminated. These shortcomings are large physical size, low Q, nonlinearity, and interwinding capacitance.

A properly designed Gyrator will provide a synthetic inductor with high Q, wide bandwidth, inductance value independent of frequency, and good stability. Filters for frequencies up to 50 kHz can be designed using Gyrators.

LC filters

Since a Gyrator can be inserted directly into an LC filter in place of an inductor, let's first review how an LC filter works. An LC filter is a reactive, two-port, doubly-terminated device that reflects power back to the source in frequencies that fall outside its bandpass. As the number of individual elements making up the filter is increased, the ability of any one component to greatly change the resonant frequency decreases. It can be said, therefore, that a coupled LC filter is basically rather insensitive to changes in values of either capacitors or inductors. What will happen (when changing a component) is that the amount of power reflected to the source will be decreased. As other component values are changed, the reflected power becomes less and less, and the stop bands become more and more poorly defined.

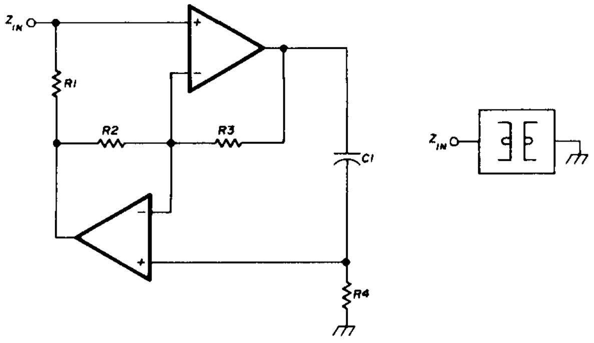

fig. 1. Basic Gyrator circuit and standard Gyrator symbol. Circuit is the basis for designing filters without inductors.

By John Loughmiller, WB9ATW, Route 1,
Box 480C, Borden, Indiana 47106

designing a Gyrator filter

To implement an LC filter without an inductor, first calculate the required inductive and capacitive impedance for the filter you have in mind. If desired, the filter can be built using standard inductances to check your calculations before actually building the Gyrator.

Next, using the circuit in **fig. 1**, construct a Gyrator replacement for the inductor. This circuit will simulate an inductor with the value of KC, where K is a constant derived from the resistors: $K=(R1 \bullet R3 \bullet R4)/R2$, and C is the capacitor whose impedance is being inverted (C1 in the circuit).

The resultant number so derived can be treated as if it were the value of impedance of an inductor, and the actual inductor can be removed and replaced with the synthesized inductor just created.

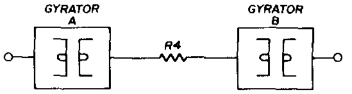

fig. 2. Method for simulating an ungrounded inductor using two Gyrators. Resistor R4 is the resistor that determines the simulated inductance.

A simpler approach is to make all four resistors the same value and use the formula R^2C. (The impedance presented to the input of the Gyrator is very nearly $j\omega R^2C$, hence the formula R^2C). Use a value of R large enough that the op amps won't be loaded, yet slightly lower than the differential input impedance.

The Gyrator circuit appears to be just another active filter circuit; however, there's a significant difference: in other active filter circuits amplifier phase shift degrades circuit Q. In Gyrators, the Q is enhanced. When the phase shift is greater than 90 degrees, the Q is actually *higher* than that of the capacitor itself.

table 1. Typical Q of various types of capacitors at 1 kHz.

capacitor type	Q at 1 kHz
Mica	600
NPO ceramic	1500
Glass	1500
Polystyrene	2000
Polypropylene	3000

Speaking of capacitors, **table 1** indicates the Q to be expected (at 1 kHz reference) for various types of capacitors. You can see that a high-Q inductor can be synthesized by using one of the high-Q capacitors, since the Gyrator inverts its capacitive impedance into an inductive-type impedance.

With regard to temperature, the NPO ceramic is least affected by changes of this variable. Higher stability could therefore be expected if NPO-type capacitors were used; however, there would be a tradeoff in Q. For high Q the choice is polystyrene or polypropylene, with the latter perhaps a better choice as it has a better temperature coefficient.

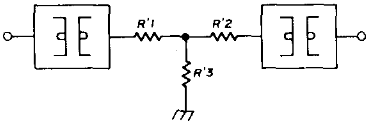

fig. 3. Synthesized T filter using Gyrators, which performs as if it were constructed as a standard T filter using inductors.

floating inductors

Perhaps the principal drawback to Gyrators is the fact that a floating (ungrounded) inductor can't be simulated by a single Gyrator. It's possible, however, to use two Gyrators as in **fig. 2** and successfully simulate such an inductor.

The formula is $L=[(R1 \bullet R3 \bullet C)/R2]R4$, and $R4$ is a shared resistor between Gyrator A and B, as in **fig. 2.** $R4$ is the resistor that determines the simulated inductance. So if $R4$ becomes a loaded port, the simulated inductance will be dependent on the value of resistance connected to the port. This being the case, resistor $R4$ could (if desired) be divided into sections and T or pi filters simulated, such as shown in **fig. 3**. Here, a T filter is created synthetically, which would perform as if it were constructed in the manner shown in **fig. 4**.

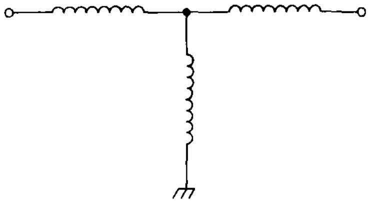

fig. 4. T filter using inductors in the usual manner, which can be simulated by Gyrator techniques.

When building multisection filters, a quad op-amp is recommended. A 4136 is the choice of Mr. Thomas Lynch, from whom much of the information in this article was obtained.

bibliography

1. Thomas H. Lynch, "The Right Gyrator Trims the Fat Off Active Filters," *Electronics*, July 21, 1977, page 115.
2. William C. Sutherland, "Op-Amp Gyrator Simulates High-Q Inductor," National Aeronautics and Space Administration Tech Briefs, Vol. 2, No. 3, Fall, 1977, page 318.

ham radio

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pi-network rf choke

The great majority of pi-network rf amplifiers use shunt feed for the high voltage dc to the plate. Therefore, great dependence is placed on the isolation properties of the rf choke. Most chokes are not suitable for this purpose due to resonances, especially when the amplifier is a multiband unit.

The most successful shunt feed rf chokes are single layer solenoid wound, preferably using resistance wire to lower the *Q* and damp out potential resonant frequencies. One of the best chokes was the one made by Collins for the ART-13 transmitter. They are difficult to obtain, however.

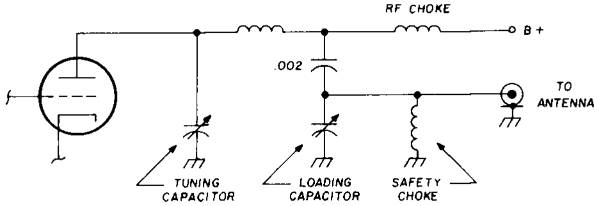

fig. 1. Suggested placement for rf choke in multiband rf power amplifiers. Since this is a low-impedance point in the output circuit, it reduces the performance requirements of the rf choke.

To avoid the problem, series feed at a low rf potential point as shown in **fig. 1** is suggested. In this circuit any of garden variety rf chokes are suitable. The plate blocking capacitor is now at the low rf potential part of the circuit; it must, however, be able to withstand the high voltage dc and be able to carry the tank circuit rf current without overheating. Transmitting ceramic capacitors are recommended.

Gary Legel, W6KNE

calculating feedline loss with a single measurement at the transmitter

Much has been written about the amount of insertion loss of various types of feedline and connectors, and about how the loss in some types of coax increases sharply with age and exposure to the elements. What is not widely known in amateur circles is that the loss in any run of cable can be determined with only an swr bridge or wattmeter, a transmitter or other drive source, and a shorted connector.

If a piece of cable is terminated with a short or an open circuit, the vswr measured at the transmitter will be infinite if the cable has zero insertion loss. In the real world, any cable has some loss, and this loss will cause the vswr measured at the transmitter to be less than infinity. The greater the cable loss, the lower the vswr.

To determine the cable loss, disconnect the antenna from the feedline and replace it with a shorted connector. This produces the infinite vswr at the transmitter end of the cable more reliably than simply leaving the cable unterminated. Connect the swr bridge or wattmeter at the transmitter and measure the vswr of both forward and reflected power, using the lowest possible transmitter power to avoid possible damage to the final amplifier. The reflection coefficient, ρ, is found by using one of the following formulas:

$$\rho = \sqrt{\frac{P_{reflected}}{P_{forward}}} \text{ or } \rho = \frac{SWR-1}{SWR+1}$$

This reflection coefficient is a numerical ratio which must then be converted to decibels:

$$\rho(\text{dB}) = 20 \log_{10} \left| \frac{1}{\rho} \right|$$

Note that a vswr of ∞ corresponds to $\rho = 1$ or $\rho(dB) = 0\ dB$, and a vswr of 1.0 corresponds to $\rho = 0$ or $\rho(dB) = \infty\ dB$. The cable loss is determined by using the general equation:

$$\rho(dB)_G = \rho(dB)_L + 2A_o$$

where $\rho(dB)_G$ is the reflection coefficient at the transmitter, $\rho(dB)_L$ is the reflection coefficient at the load, and A_o is the cable loss in decibels. Since $\rho(dB)_L = 0$ in this case,

$$A_o = \frac{\rho(dB)_G}{2}$$

This same general formula can also be applied if vswr or wattmeter readings are taken at both ends of the cable with the antenna connected instead of the shorted termination. The advantage of using the shorted termination is that it eliminates the need to take readings at the antenna, which is usually a two-man job.

Once the feedline loss is known, the antenna is reconnected, and it is now possible to accurately determine the vswr at the antenna based on the reading taken at the transmitter:

$$\rho(dB)_L = \rho(dB)_G - 2A_o$$

$$\rho_L = \frac{1}{antilog_{10} \frac{\rho(dB)_L}{20}}$$

$$SWR = \frac{1+\rho}{1-\rho}$$

For most accurate results with multiband antennas, a feedline loss calculation should be made for each band.

John E. Becker, K9MM

RM terminal modification

After using the Mini Micro Mart RM Terminal Unit for a number of months, some deficiencies were noted which made it a little unwieldy to use, and sometimes downright difficult! I decided to pull all the guts out of it, because I didn't know how it worked, and if it broke, about all I could do is use it for weight in the back of my car in the winter. This modification is used to convert the parallel output of the original keyboard into special data for insertion into the loop of a RTTY system. In addition to this, it gives you end of line (EOL), letters, and figures indications through the use of an LED. The EOL feature is especially nice if you are using a video display which has less than the 66 characters necessary for a complete line of hard copy. In addition to this, it provides parallel data out, still in Baudot code, just in case you need it to feed an ASCII converter.

Looking at the schematic of the converter itself, the data from the RM terminal is fed into the UART and strobed into it through a 74121. The strobe from the keyboard is only a high, and it is necessary to have a pulse, so I used the 74121 to make it. The UART is clocked with a NE555, which can be set at any speed. The required frequency for various speeds is:

speed	baud	clock frequency
60	45.45	728 Hz
66	50.00	800 Hz
75	57.00	912 Hz
100	73.70	1179 Hz

It can be seen that the clock speed necessary for the UART is the Baud rate times 16.

Coming out of the UART is the serial data, which is fed into a transistor driver, which keys an optical isolator. These devices are good for more than 20 mA, so if used in an application where the loop is less than this, no problems should be noted. Please note the polarity.

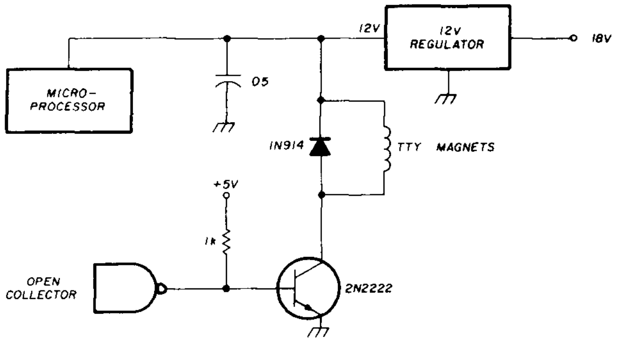

fig. 1. Initial circuit used by WA6ROC to interface an 8080A microprocessor with a teleprinter. This arrangement destroyed both the expensive 8080A and the 2N2222.

Also coming out of the UART from pin 24 is a terminal which says in effect, "one character is finished;" this is normally high, and when the character is complete, it goes low for a moment. This pulse is fed into a CD4020 binary counter, which can be set up for any count up to 2^{14}. In this instance we are counting up to 64, which is close to the 66 count maximum. Fortunately, the CD4020 is also equipped with a reset, and when the carriage return key on the keyboard is struck, a positive pulse resets the chip, and the process starts all over again. The output from the 4020 is used to drive a flip-flop made from a 7400, but in the configuration shown, another section is used to drive a LED or audible alarm to show that the end of line has arrived. The other flip-flop shown is used for indication of which shift you are in.

This modification can be made quite easily, and the additional circuitry can be put on perf board or a separate printed-circuit board. I built the unit on a wire-wrap card because it was incorporated into another system.

Tim Ahrens, WA5VQK

switching inductive loads with solid-state devices

Recently, while attempting to interface my 8080A microprocessor to a model 26 *Teletype* machine, I destroyed the 8080A and a 2N2222 transistor. The following suggestions may help others from encountering problems when trying to switch inductive loads with solid-state devices. My first attempt at a switching circuit is shown in **fig. 1**. What happens is this:

1. Assume that the 2N2222 is conducting, the collector of the transistor is at 0.2 volt (it is saturated).

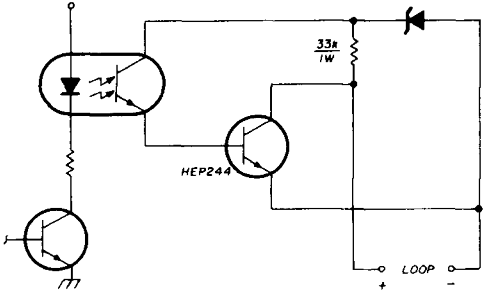

fig. 2. Basic opto-isolator circuit used by WA6ROC to provide protection to the delicate microprocessor.

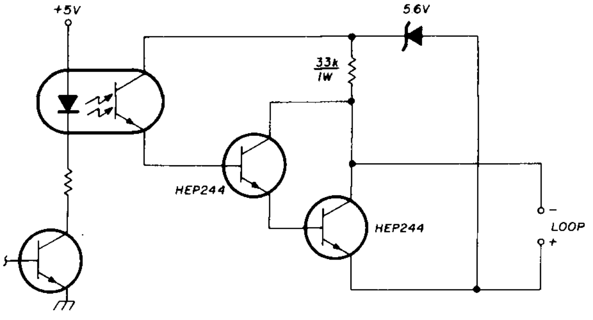

fig. 3. Since circuit of fig. 2 would not key low voltages, a Darlington pair was used, as shown here. Design of the circuit is discussed in the text.

2. The gate tries to turn off the 2N2222.

3. The inductor tries to maintain its current of 60 mA, thus the collector voltage of the 2N2222 rises, as it turns off.

4. When the collector reaches 12.7 volts the 1N914 starts to conduct. The + 12 volt regulator, however, will *not* clamp its output at + 12 volts (indeed most series-regulated power supplies will allow the output voltage to climb if you try to force current into the output).

5. Thus, the collector voltage of the 2N2222 climbs very high, and it experiences secondary voltage breakdown (fatal). Also, the + 12 volt line follows the collector voltage (but it is one diode drop less). Thus the large spike on the + 12 volt line destroys the microprocessor (and maybe other devices).

It was at this point that I decided to use an opto insulator — to provide a means of protection of the delicate microprocessor (or other solid-state parts). I tried the circuit which appeared in the November, 1976, issue of *ham radio** (see **fig. 2**).

This circuit is optically isolated, but it has one problem: it will not key low voltages. Since all I had at the time was a low-voltage power supply, a simple modification was made to allow this circuit to key a considerable amount of current, over a wide range of voltages.

The reason that this circuit will not key low voltage loops is that an appreciable voltage will exist from the collector to the emitter of the HEP244 when it is turned on. Suppose the HEP244 is supposed to key a 60 mA loop, let us further suppose it has a current gain of 60. Therefore, to key the loop, the collector current will be 60 mA and the base current must be

$$\frac{I_c}{B} = \frac{60}{60} = 1\,mA$$

(actually $I_c = 59\ mA$, $I_B = 1\ mA$, $\beta = 59$)

To sustain conduction, the collector to emitter voltage must be V_{be}(HEP244) + V_{CESAT} (opto-isolator transistor) + 1 mA x 33 kilohms = 0.7 + 0.2 + 33 = 33.9 volts.

The obvious way to reduce the collector-to-emitter voltage is to reduce the voltage drop across the 33k resistor. If the current gain of the HEP244 were higher, then it would draw less base current, and the voltage across the 33k resistor would be less. The best way to do this is to add another HEP244 and make the two transistors into a Darlington configuration as shown in **fig. 2**.

The effective current gain of the Darlington pair is β^2 so the current through the 33k resistor is about

$$\frac{60\text{ mA}}{60\text{x}60} = 167\,\mu\text{A}.$$

The collector-to-emitter voltage of the keying transistor(s) is

$$V_{BE2} + V_{CESAT} + 167\mu A \text{ x } 33k = 0.7 + 0.7 + 0.3 + 0.55 = 2.25 \text{ volts}$$

(versus 33.0 volts before). This circuit will satisfactorily key both low and high voltage loops, and will handle quite a bit more current than 60 milliamps.

Now, as to the matter of protecting the keying transistor from secondary voltage breakdown. The common trick is to clamp the collector of the keying transistor to the magnet supply. If you do this, be sure to follow these two precautions:

1. Use a diode capable of carrying several amps, as the current through the suppressing diode can be several orders of magnitude greater than the magnet current, and small signal diodes (such as the 1N914) will often be destroyed by the large surge.

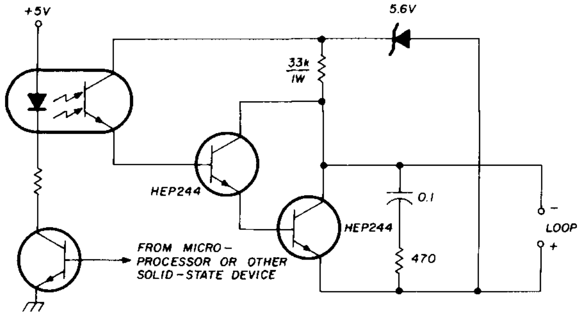

fig. 4. Final circuit configuration used by WA6ROC to interface a teleprinter with an 8080A microprocessor. The RC filter across the Darlington pair speeds up the release time of the print magnets.

2. Make sure the magnet supply has sufficient capacitance to adequately absorb the energy of the spike without allowing the voltage to climb.

Sometimes, however, the clamping diode will slow down the release time of the magnets (because the diode allows the current flow to continue for some time). In a case where this is important, an RC filter across the keying transistor will usually solve the problem. Thus the final configuration (**fig. 4**) is the circuit I now use to key my teleprinter magnets.

Thomas C. McDermott,
WA6ROC

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*K. Ebneter, K9GSC, and J. Romelfanger, K9PKQ, "RTTY Test Message Generator," *ham radio*, November, 1976, page 30.

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comments

satellite tracking

Dear HR:

The article in your September issue, "Tracking Oscar Satellites," was especially interesting, and I might make some comments regarding the nautical mile. Most Maritime nations, including the United States, have adopted the International Nautical Mile, which is exactly 1852 meters, or 6076.10333 . . . U.S. feet.

For most navigational purposes, the nautical mile is one minute of latitude or any other great circle. On the Clarke spheroid of 1866, used for mapping North America, the nautical mile varies from 6046 feet at the equator to 6108 feet at the poles. The length of one minute of a great circle of a sphere having an area equal to that of the earth is 6080.2 U.S. feet. This was the U.S. standard nautical mile prior to the adoption of the International Mile of 1852 meters.

One of the first attempts to establish a standard of length was made by the Greeks, who used the length of their Olympic stadium as a unit and called it, naturally, the stadium. It was 600 Greek feet (607.9 U.S. feet), or almost exactly one-tenth of the International Nautical mile. The Romans got into the act with a 625-foot stadium (606.3 U.S. feet). This is quite close to the British Cable of 608 feet. The Roman Mediterranean mile of 4859.59 feet was gradually replaced by the Greek unit and was probably the mile referred to in the Bible (Matthew 5:41). The word mile comes from the Latin *mille* (thousand) — the one-thousand paces of the Roman mile.

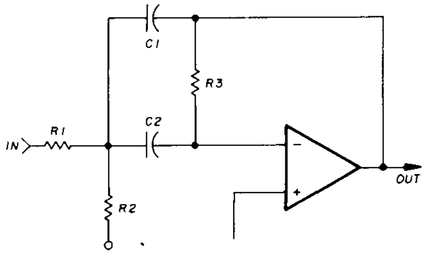
For convenience in short-range plotting in the Navy and Maritime Service, the Radar Plotting Sheet and Maneuvering Board use a 6000-foot (2000-yard) mile, which differs from the Nautical Mile by slightly over 1 per cent. It greatly simplifies range instruments, gear ratios, and computations, and is within the range accuracy of most electronic navigation systems.

I have written several navigational programs for my HP-97 calculator, and, in great-circle distances and bearing calculations, I use the 1852-meter International Nautical Mile.

I. L. McNally, K6WX
Sun City, California

active filters

Dear HR:



I would like to compliment W4IYB on the fine article concerning active RC filters in the October 1976, *ham radio*. He has presented three basic filter configurations, each with different adaptations. Personally I prefer the second configuration; I have used it in thousands of modems sold to users of the telephone network. I ran off a computer tracing of the bandpass characteristics of the filters, both single and 4-unit combinations, based on a Q of 6. My curves come quite close to what is shown in W4IYB's **fig. 2**. I should mention however, that the equations you presented are difficult for the average ham radio reader. I use the following simpler equations:

$$R_1 = \frac{Q}{C \cdot f \cdot g \cdot 2\pi}$$

$$R_2 = \frac{1}{2 \cdot (Q - 9/Q) \cdot C \cdot f \cdot 2\pi}$$

$$R_3 = \frac{2 \cdot Q}{C \cdot 2\pi \cdot f}$$

where

$$C = C_1 = C_2$$

$g =$ gain from input to output (usually set to 1 or 0.5)

$Q =$ not more than 10 or 20 for 741s *in* the audio *range*

$f =$ frequency in the audio range

Robert H. Weitbrecht, W6NRM
Redwood City, California

noise interference

Dear HR:

I ran across an unexpected source of interference not long ago. A noise sounding like a machine gun was creating tremendous interference. It covered up to 900 kHz, and with multiples of 900 kHz, up to 30 MHz. The source of the noise was finally found to be originating from the telephone lines, with faulty battery chargers at the substations being the cause. The intensity of the interference was great enough to cover local broadcast stations, even though I live more than 6 miles (9km) from the substation. Even after locating the source, it is very difficult to solve the problem because the telephone company is very reluctant to admit blame.

Keith Olson, W7FS
Belfair, Washington

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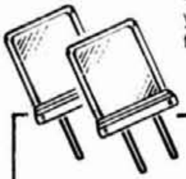

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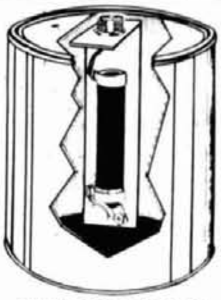

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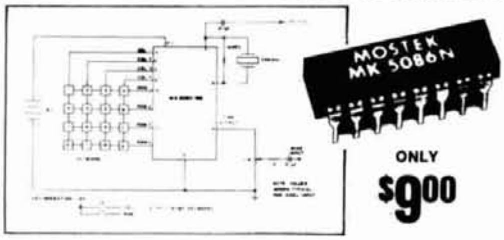

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Economical DTMF generating system combines CMOS logic, D-to-A converters, an operational amplifier and bipolar transistors on a single IC chip. Uses inexpensive 3.58 MHz crystal. Dual tones mix internally. Tones are 14-step synthesized sine waves for low distortion. Compatible with Digitran* keyboard. Common key function outputs. For 5-10 V.
Model MK 5086. Interfaces to either a 2-of-8 keyboard or other electronic systems **$9.00**

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12 Key
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16 Key
$10.00

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A star value at the Dayton Hamvention. Incorporates the ideal "tactile feel" leaving no doubt that contact has been made. These new keyboards are manufactured by the Digitran Company and are furnished with instructions for combining with a Mostek or Motorola chip and a crystal (plus several small components) to become a Tone Encoder.

12 Key (2 of 7 Matrix) 2" x 2.7" x 5/16" **$8.00**
16 Key (2 of 8 Matrix) 2.5" x 2.7" x 5/16" **$10.00**

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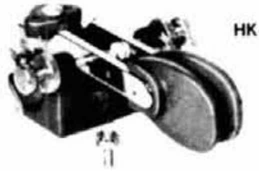
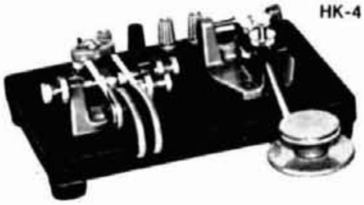


HK-1

HK-3

HK-2



HK-4

Model HK-1 Dual-lever squeeze paddle. Can be used with any electronic keyer. Heavy base has non-slip rubber feet. Paddles are reversible for wide-finger or close-finger spacing **$29.95**

Model HK-2. Same as HK-1 less base. For incorporation in own keyer **$19.95**

Model HK-3. Deluxe straight key. Heavy base so there's no need to attach to desk. Velvet smooth action **$16.95**

Model HK-3A. Same as HK-3, less base **$9.95**

Navy type knob only **$2.75**

Model HK-4. Combines models HK-1 and HK-3. On heavy base with non-slip rubber feet **$44.95**

Base only, with rubber feet. Heavy **$12.00**

Terminals. Red or black .... **Each $ .75**

More Details? CHECK—OFF Page 142

NEW products

For literature on any of the new products, use our *Check-Off* service on page 142.

new Drake transceiver

The new TR-7 transceiver from the R.L. Drake Company is the first commercially available amateur transceiver that uses a 48-MHz i-f. This concept allows great flexilility in frequency coverage as well as providing greatly improved image rejection.

Reception through the entire range of 1.5 through 30 MHz is provided by the TR-7, and, with the use of an Aux-7 Range-Program board, the range can be expanded to cover *from 0 to 30 MHz. The up-conversion* technique, along with the synthesized/PTO frequency control, makes this extended frequency coverage possible.

Full passband tuning is another feature of the receiver portion of the unit. It is possible to tune from the top edge of one sideband, through zero, to the bottom edge of the other sideband. The range is also wide enough to allow tuning through RTTY signals. This ability to place a *wanted signal at the proper spot in* the filter passband is a great aid when working on the crowded amateur bands.

Further improved reception can be obtained by installing optional receiving-selectivity filters in the rig; you can select the desired filter by pushbutton switches on the front panel. Also, a unique system permits you to select the receiving filter independently of the transmitter mode or function. Thus you can transmit on CW but receive with an ssb filter, or even transmit on one sideband while receiving the other. Optional *filter widths include* 300 Hz, 500 Hz, 1.8 kHz, or 6 kHz.

On the transmit side of the unit, optional programmable coverage for nonamateur-band parts of the spectrum are available. Proof of license for operation out of the amateur bands must be submitted to the R.L. Drake Company before obtaining these options, however. This feature also takes care of any possible later expansion of the amateur frequencies.

The all-solid-state design and broadband tuned circuits means that there are no preselector or peaking circuits to contend with in the TR-7. The power amplifier is designed for continuous-duty ssb and CW operation. The efficient, internal heatsink provides enough dissipation in free air for full power on all modes except SSTV or RTTY; these high-duty-cycle transmissions are provided for by an optional fan for extra cooling. The transmitter is rated at 250 *watts input on all modes, and the PS-*7 ac power supply is designed to provide continuous-duty power for any mode. This supply also accepts input voltages of 90-132 Vac, 180-264-Vac, at 50 to 60 Hz, which makes it ideal for overseas locations. The TR-7 transceiver may also be operated from any nominal 13.6 Vdc supply capable of providing 3 Amps on receive and 25 Amps on transmit.

Additional features of the TR-7 include a digital frequency readout, *which will provide accuracy of* ±100 Hz, or an analog readout with ±1 kHz accuracy when properly calibrated. The digital frequency display can be used as a test instrument with frequency capability of up to 150 MHz, with access to the counter input through a rear panel connector. Power-output metering is obtained by making the standard S-meter double as a built-in wattmeter/swr indicator.

Here are some of the specifications from the TR-7 brochure:

Dimensions (height, width, depth): 11.6 x 34.6 x 31.7 cm (4.6 x 13.6 x 12.5 in.).

Receiver sensitivity: less than 0.5 μV for 10 dB S + N/N ratio.

Image and i-f rejection: greater than 80 dB

Power input: 250 watts PEP 1 ssb; 250 watts CW.

Spurious output: greater than 50 dB down.

Harmonic output: greater than 45 dB down.

Intermodulation distortion: 30 dB below PEP.

Undesired sideband suppression: greater than 60 dB at 1 kHz.

A *wide range of optional features* are available, including a noise blanker, mobile mounting kit, and crystal filters. A speaker in a matching cab*inet, and a similarly matching remote* vfo, will combine with the TR-7 transceiver to make a complete, attractive, and state-of-the-art amateur station that will set the pattern for years to come.

For more information, see your authorized Drake dealer, or write R.L. Drake Company, 540 Richard Street, Miamisburg, Ohio 45342.

prime components purchasing guide

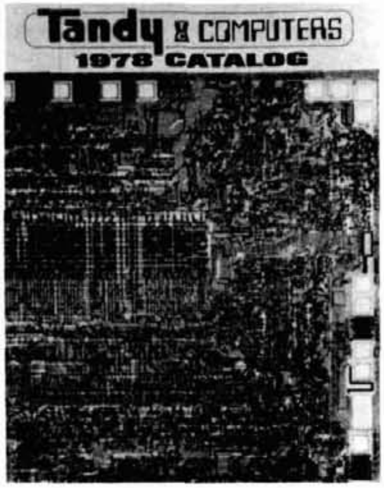
A new components catalog has just been released by Prime *Components Corporation of Hauppauge,* New York.

The 36-page illustrated booklet lists many of the small parts often needed by hobbiests, experimenters, and small development laboratories.

A partial list of items that can be purchased from Prime Components Corporation includes cleaning and servicing chemicals, test equipment, tools, integrated circuits, diodes, transistors, capacitors, resistors, LEDs and LED displays, lamps, and fuses. All of the parts are brand-name manufactured, and are available from stock. The catalog is free, and there is a minimum order requirement of $25.

To receive your free catalog, write to Prime Components Corporation, 65 Engineers Road, Hauppauge, New York 11787.

tandy computers catalog



A microcomputer mail-order catalog has just been issued by Tandy Computers, the newly created retail division of Tandy Corporation, parent company of the nationwide Radio Shack electronics store chain. The 52-page, four-color catalog details a full line of popular brand microcomputers and accessories, software packages, parts, and literature currently in stock. Both kits and fully assembled microcomputer systems are listed in the catalog, at prices that range from several hundred dollars to more than $20,000.

Among the nationally known

VLF Converter

All Palomar Engineers products are made in U.S.A. Since 1965, manufacturers of Amateur Radio equipment only.

- **New device opens up the world of Very Low Frequency radio.**
- **Gives reception of the 1750 meter band at 160-190 KHz where transmitters of one watt power can be operated without FCC license.**
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The converter moves all these signals to the 80 meter amateur band where they can be tuned in on an ordinary shortwave receiver.

The converter is simple to use and has no tuning adjustments. Tuning of VLF singles is done entirely by the receiver which picks up 10 KHz signals at 3510 KHz, 100 KHz signals at 3600 KHz, 500 KHz signals at 4000 KHz.

The VLF converter has crystal control for accurate frequency conversion, a low noise rf amplifier for high sensitivity, and a multipole filter to cut broadcast and 80 meter interference.

All this performance is packed into a small 3'' x 1½'' x 6'' die cast aluminim case with UHF (SO-239) connectors.

The unique Palomar Engineers circuit eliminates the complex bandswitching and tuning adjustments usually found in VLF converters. Free descriptive brochure sent on request.

Order direct. VLF Converter $55.00 postpaid in U.S. and Canada. California residents add sales tax.

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FOR BASE STATION & REPEATER USE

MODEL	INPUT	OUTPUT	PRICE
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V71	1-5W	60-70W	$329
V130	25-40W	110-130W	$389
V131	1-5W	110-130W	$419
V135	5-10W	110-130W	$419
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Universal 19" Rack Mount			$25

* All units: Harmonics exceed – 60 dB specification of FCC R&O 20777

- ☆ 143-149 MHz No Tuning
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- ☆ Size 8-1/2 x 13 x 7" H

Only two things are needed to put this power house on the air with your handy-talky or mobile transceiver: a two foot piece of coaxial cable and a 115 or 230 volt AC outlet. That's all. You do not need anything else. The mobile transceiver can be powered directly from the accessory socket located in the rear panel of the RFPL amplifier. It puts out + 13.5 volts at 3 amperes. This is sufficient for powering most 15 watt transceivers.

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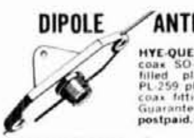
DIPOLE ANTENNA CONNECTOR



HYE-QUE (HQ-1) dipole connector has coax SO-239 socket molded into glass filled plastic body to accept coax PL-259 plug on feedline. Drip-cap keeps coax fittings dry. Instructions included. Guaranteed. At your dealers or **$4.95 postpaid**. Companion insulators **2/$.99.**

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COMPLETE Ready to put up with 30 ft. Dacron end support cords! Wt. 3 lbs., 1"X5" MOLDED RESONANT TRAPS - just switch your transmitter to desired band for EXCELLENT PERFORMANCE!

NO TUNERS OR BALUNS NEEDED! CAN BE USED IN ATTICS, TOPS OF BUILDINGS, INVERTED Vs IN MINIMUM SPACE. NO CENTER SUPPORT NEEDED, NO HAYWIRE HOUSE APPEARANCE COMPLETELY ASSEMBLED. No tuning - cutting - soldering - measuring - JUST HANG IT, AND USE IT! SWR IS 1.2 AT RESONANCE THOUSANDS IN USE - EASIEST INSTALLATION!

80-40-20-15-10 meter bands---102 ft. with 90 ft. RG58U coax - connector - Model 998BU. . . $49.95
40-20-15-10 meter bands---54 ft. with 90 ft. RG58U coax - connector - Model 1001BU $48.95
20-15-10 meter bands--- 26 ft. with 90 ft. RG58U coax - connector - Model 1007BU $47.95

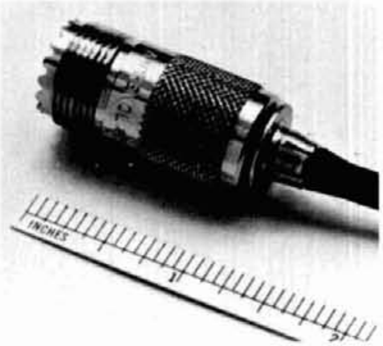
Send only $5.00 (cash, ck., mo.) and pay postman balance plus COD postage OR SEND FULL PRICE FOR POST PAID DEL. IN USA (Canada is $5.00 extra) or order by MAIL OR PHONE with BankAmericard VISA - MASTER CHARGE - OR AM EXP. Give number and ex. date. Ph 1-308-236-5333 week days. We ship in 2-3 days. INFLATION? PRICES MAY INCREASE - SAVE - ORDER NOW! INFO. AVAILABLE FROM. WESTERN ELECTRONICS Dept. AH-6 Kearney, Nebraska, 68847

brands carried by Tandy Computers are Radio Shack's TRS-80, the IMSAI 8080, Vector 1 and 1+, Xitan, Equinox 100, Polymorphic System 8813, and many others offering beginners, hobbyists, educators, and business users a wide selection from which to choose.

In addition, the store carries a complete selection of microprocessor mainframes, peripherals, software, printed-circuit accessories, discrete parts, and literature. The new store also offers programming assistance and on-premises computer service by skilled technicians.

Copies of the new Tandy Computers 1978 Catalog are available by telephoning toll-free 800-433-1679, by writing to Tandy Computers, Dept. R7, P.O. Box 2932, Fort Worth, Texas 76101.

amphenol solderless coax jack assembly



A new Amphenol in-line UHF coax cable jack that can be installed in seconds without special tools or solder has been announced by the RF Operations of Amphenol North America Division, Bunker Ramo Corporation. Developed as a follow-up to last year's introduction of the Amphenol no-solder PL-259 connector for RG-58/U, the new companion in-line splice jack also uses the innovative FCP termination approach, resulting in an extremely fast cable termination — less than 20 seconds.

Whenever an in-line antenna or hookup coax cable splice is needed, the user has only to strip the cable, insert the center conductor into the back of the connector, and slide the ferrule into place. Once accomplished, termination is complete. The result is a handy, in-line SO-239 receptacle that will directly accept any PL-259 plug. All need for a second PL-259 connector plus PL-259 to PL-259 adapter has been eliminated.

Called the Amphenol UHF Cable Jack 83-58FCJ, the new device easily handles all power levels up to maximum ratings of the RG-58/U coax cable itself. The 83-58FCJ connector adapters have a frequency range of 0-300 MHz, and a voltage rating of 500 volts peak. And, unlike conventional solder connection techniques, the 83-58FCJ can be easily disassembled and reused. It also has standard 5/8-24 threads for simple, screw-on mating with conventional UHF plugs.

Manufactured by Amphenol exclusively in the United States, the new jacks are machined from brass rod stock and plated with *Astroplate*®, lustrous, non-tarnish finish. For more information, contact Bunker Ramo Corporation, 33 East Franklin Street, Danbury, Connecticut 06810.

turner personal communications catalog

The Turner Division of Conrac Corporation now has available a newly revised personal communications catalog. The catalog is all inclusive, containing Turner's entire personal communications product line. Twenty-eight pages in size, the new catalog has sections on microphones, stainless steel antennas, fiberglass antennas and accessories. Previously, Turner had separate catalogs for each product line.

The four-color catalog features a section on Turner's new no-solder microphone connector program, "The Turner Connection." The catalog contains general information and engineering specs to aid the distri-

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news Update from DRAKE

Glad you asked...

TR-7 SYSTEM:

The new TR-7 System is an addition to the Drake line. The Drake C-Line with its accessories is continuing to be produced.

The TR-7/DR-7 features continuous reception from 1.5 thru 30 MHz and transceive 160 thru 10 meter Amateur Bands. For reception from 0 thru 1.5 MHz use the optional AUX-7 Range Program Board and an RRM-7 Receive Module for each 500 kHz segment to be covered. Each RRM-7 plugs directly into the AUX-7 board and is selected from the front panel.

Out-of-band transmit for MARS, etc., is accomplished by plugging an RTM-7 Transceive Module into the AUX-7 for each 500 kHz segment to be covered. Proof of license is necessary to purchase transceive modules.

The MN-7 Antenna Matching Network covers the Amateur Bands from 160 thru 10 meters; matches balanced lines, long wires, and coax-fed antennas; features a built-in RF Wattmeter/VSWR Bridge; and has complete switching functions.

The MN-4C Antenna Matching Network offers the same features, but is styled to match the 4-Line/C-Line.

UV-3 SYSTEM:

The UV-3 System is fully synthesized to 5 kHz on each of the bands it covers. Among other firsts, it is presently the only rig in the world synthesized on 440 MHz fm.

There is a separate SO-239 Coax Connector for each band, so a choice of antennas may be used.

Extra fixed channels and special offsets are diode-programmable, so crystals are not necessary at all.

These thoughts of interest are provided by Drake,
"The Newsmakers"

To receive a FREE Drake Full Line Catalog, please send name and date of this publication to:

R. L. DRAKE COMPANY DRAKE®

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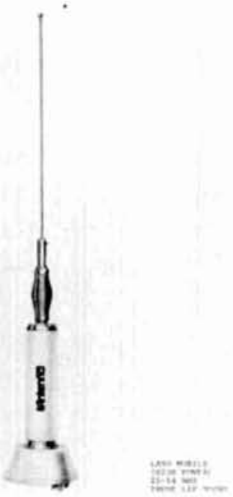
butor/dealer in promoting Turner products.

This new catalog encompasses all the changes and additions that Turner has made to its personal communications product line so that it is an up-to-date promotional tool as well. For more information, write to Turner, 716 Oakland Road, North East, Cedar Rapids, Iowa 52402.

high-power VHF mobile antennas



A line of mobile antennas with high power ratings, covering the six and two-meter frequency ranges, has been introduced by Antenna Incorporated. The six-meter antennas feature 200-watt loading coils; the two-meter antennas are available with either 150 or 200-watt loading coils. They are available with 3/4-inch toggle mounts, cowl mounts, and no-hole trunk-lip mounts. Also available are 100-watt models with either the same mounts, or with 3/8-inch snap-in, spring-clip gutter, and magnet mounts. Loading coils are tuned at the factory to achieve a standing wave ratio of 1.5:1 or less, and each antenna includes a cutting chart so the whips can be field trimmed to exact frequencies.

Each antenna features a plated stainless steel whip for low resistivity to combat skin effect, stainless steel impact spring, shock-resistant and weatherproofed PVC-wrapped loading coil, and 17 feet of coaxial cable with a soldered PL-259-type connector.

The 200 watt two-meter antennas also feature Antenna Incorporated's new high-power coaxial cable. While the 150 watt high-band and 200 watt low-band antennas include RG/58-U cable, this cable cannot safely handle 200 watts of power on two meters. Antenna Incorporated's high-power cable has performance characteristics similar to RG-8/U, but in a smaller size, thus eliminating the problems of using the larger cable in mobile applications.

"These antennas also are part of Antenna Incorporated's professional land mobile line and have been designed to meet the needs of high power communications users," sales manager Randall Friedberg said. "They offer the amateur the best in antenna quality and dependability."

For further information on the company's complete line of communications antennas and accessories, contact Randall J. Friedberg, Antenna Incorporated, 23850 Commerce Park Road, Cleveland, Ohio 44122. Phone (216) 464-7075.

hallicrafters H2M-1000 two-meter transceiver

Hallicrafters Company, a long-time manufacturer of amateur radio equipment and systems, has announced the introduction of its new two-meter PLL frequency synthesized multimode transceiver. Hallicrafters' new H2M-1000 is designed to operate in fm, usb, lsb, and CW modes. In the fm mode, the H2M-1000 provides 800-channel coverage (5 kHz steps) and a vxo variation of ±7 kHz in the ssb/CW modes. The H2M-1000 also features simplex and repeater offsets of ±600 kHz and ±1 MHz for fm.

The H2M-1000 provides easy readout with a six-digit, seven-segment, light-emitting diode (LED) frequency display in the fm mode and five-digit display in single sideband (ssb) mode.

PUNCH UP

Your
Most Called Numbers
with a
Single Key Punch!

Now you can dial up to 18 complete 7 or 8-digit phone numbers by punching only one (or two) keys on your pad. The AD-1 Auto Dialer's 10 number capacity RAM can be completely programmed from its own pad in less than a minute. The optional field - installable factory-programmed PROM adds 8 more numbers for $4.95. The AD-1 is ideal for mobile autopatches, home or business use. It features a *unique MOS microprocessor which* permits both tone duration and spacing to be programmed along with the numbers, adding versatility for repeater or similar control functions. Its crystal controlled tone generator assures high stability over a wide temperature range. The AD-1 is fully *automatic and foolproof in operation.* Coil cord provides convenient connection to your rig. See it at your Amateur Radio distributor or use the coupon below today.

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24 HOUR DIGITAL CLOCK

with HUGE 1-5/8 inch digits that you can keep set to GMT. Alarm and snooze functions let you use it as an ID Timer. Assembled, too!

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MFJ Enterprises brings you a new 24 hour digital alarm clock with HUGE 1-5/8 inch orange 7 segment digits that you can see clear across the room.

This one is strictly for your ham shack, one that you can leave set to GMT. No more mental calculations to get GMT.

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250-watt input with full VSWR protection

Synthesized PTO
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Up-conversion receiver for superior dynamic range
True passband tuning

Independent receive selectivity
Built-in VSWR/watt/S-meter

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Digital read-out board
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AM filter
RTTY filter
2 CW filters, 300 Hz, 500 Hz
Fan (for RTTY)
Noise blanker
Mobile mount
Antenna tuner/wattmeter
Wattmeter/VSWR bridge
Aux-7 Expanded receive Capability

*includes capability for MARS, Embassy, and Government frequencies, and possible future Amateur-Band expansion. Receiver coverage continuous from 1.5 - 30 MHz, and 0 - 1.5 MHz with Aux-7.

Call Now to find out how easy it is to put a new DRAKE TR-7 in your shack.

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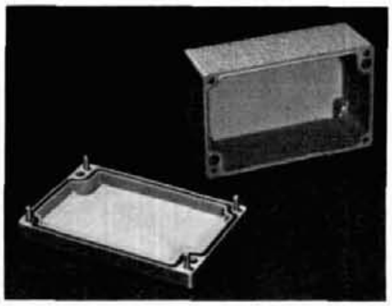
The H2M-1000 can be operated on either ac or dc and has two panel meters; a combination S and rf power output plus a discriminator meter. The rf power output is in excess of 10 watts in the high-power mode and one watt in low-power mode. Other features include a noise blanker switch, an agc recovery switch (standard and slow agc), mike gain control, a built-in vox, and receiver incremental tuning (RIT). For *additional information, contact the* Hallicrafters Company, 2501 Arkansas Lane, Grand Prairie, Texas 75051.

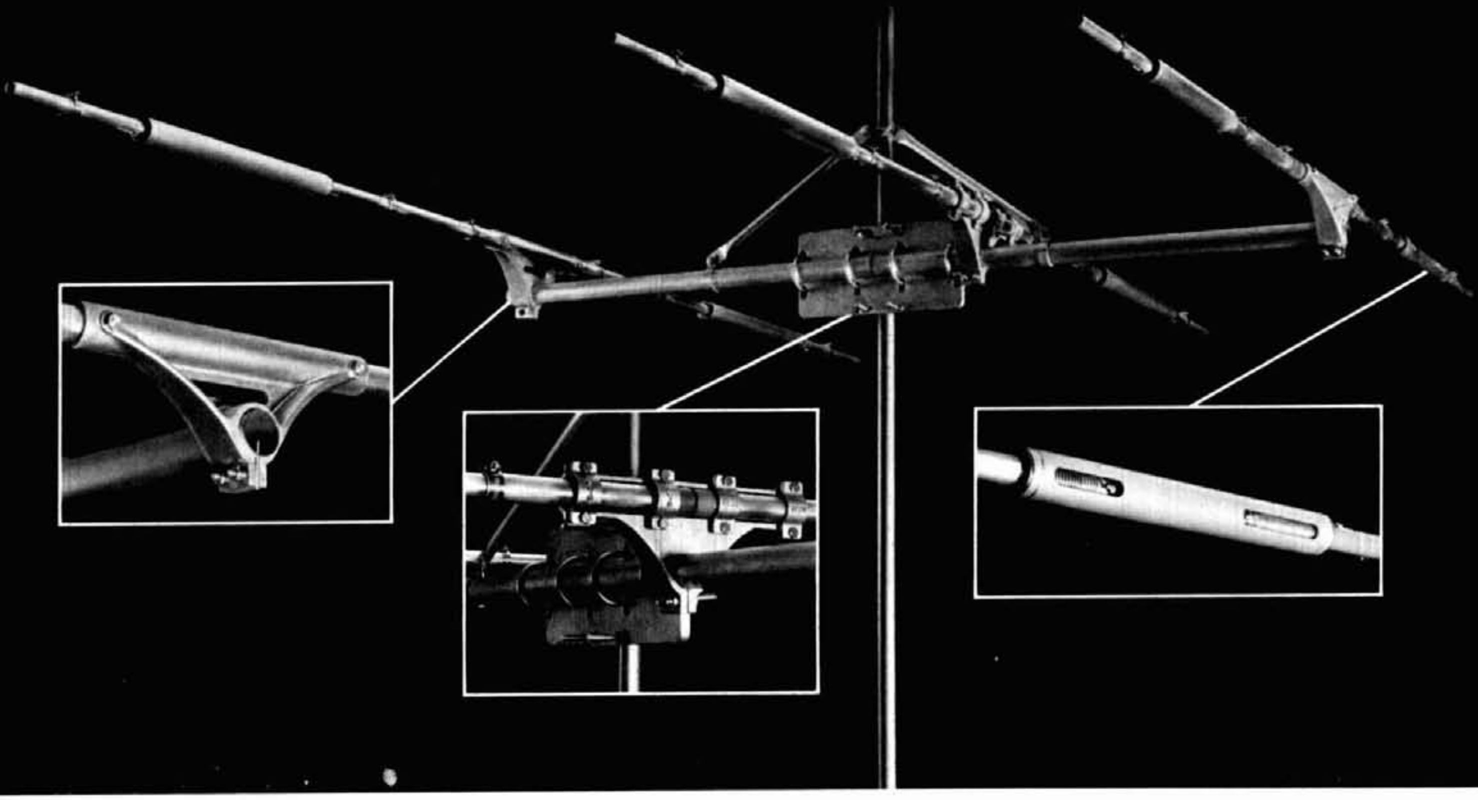
hammond diecast utility boxes



Hammond Manufacturing has introduced two new water and corrosion-resistant utility boxes, 12.5 x 7.9 x 5.6 cm (4.9 x 3.1 x 2.2 inches) and 22 x 12 x 7.9 cm (8.7 x 4.7 x 3.1 inches). Diecast in an aluminum alloy, they have an exceptionally good finish, unmarred by closure screws which have been recessed into the lid. The color is baked on Hammertone Grey enamel.

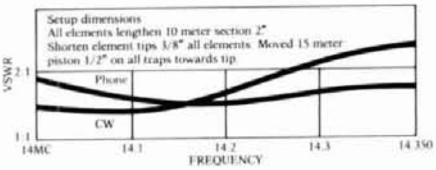
Sealing is facilitated by an interlocking flange and neoprene rubber ring inset in the lid. Both models come with two bolt holes outside of the sealing ring and concealed beneath the lid for attractive and secure mounting of the box. Electrical, rf shielding, and environment protection are some of the many applications for these products. For more in*formation, contact Larry Humphries,* Hammond Manufacturing Company, Inc., 385 Nagel Drive, Buffalo, New York 14225.

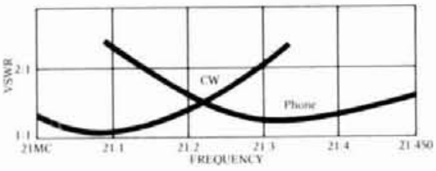
TOO STRONG TO GIVE THE WIND A BREAK!

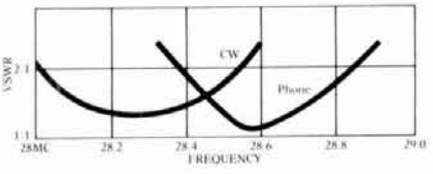


Braced against the elements as only Swan can do it! Even hurricane winds to 100 MPH can't lower the boom on your operations.

The Swan TB3HA Tri-Bander: a really heavy-duty 20-15-10 meter beam. 3 solid elements, all working on all bands. With a VSWR of 1.5:1 or better at resonance, plus a full 2000-watt PEP rating, our TB3HA is built to work up a storm!







Strongest fittings available: this you've got to see. Exclusive cast-aluminum braces grasp tubes at every joint, spreading stress over an 11¾" span. Compared to slipshod U-bolt plates—no contest!

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☐ 8dBd average forward gain.
☐ 20-22 dB front to back ratio.
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☐ longest element: 28′2″.
☐ 16′ boom, optimum spacing.
☐ direct 52 Ohm coaxial feed.
☐ wind load @ 80 mph: 110 lbs.
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For $199.95 at your local Swan dealer you can start operating tri-band from a position of real strength—because TB3HA is Swan-engineered to work under pressure!

Please rush full information on Swan's Heavy Duty Tri-Band Beam Antennas:
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☐ 4-element TB4HA

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Finally! Superior 8-Pole CW Selectivity for Drake TR-4, TR-4C, TR-4 Cw

350 Hz at – 6db, 850 Hz at – 60db. Cuts QRM. More selective than 6-pole CW filter in new TR-4Cw which is 500 Hz at – 6db, and 2000 Hz at – 60db. CF-350/8 $100.00. Switch and mounting kit $10.00

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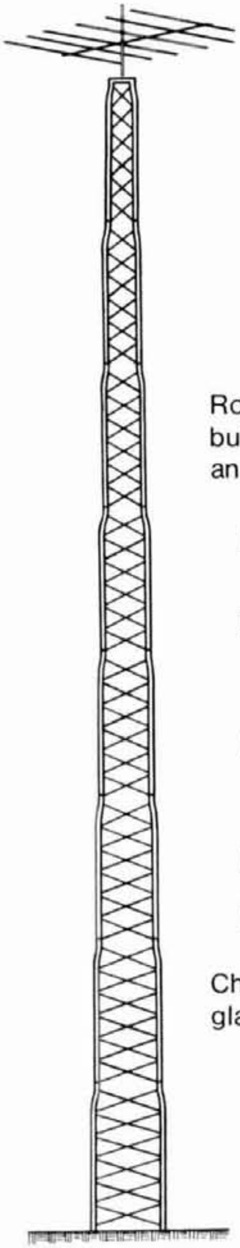

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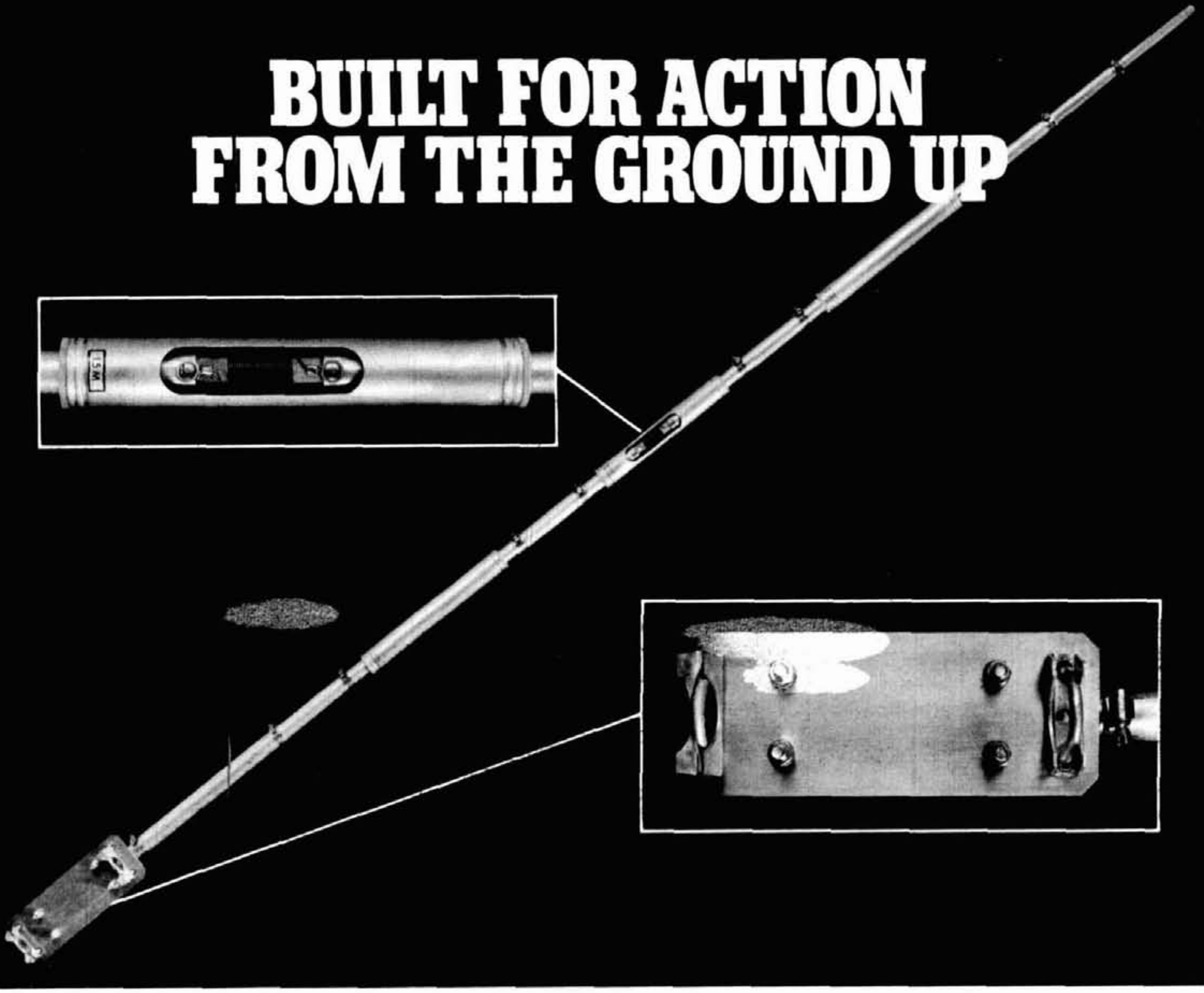
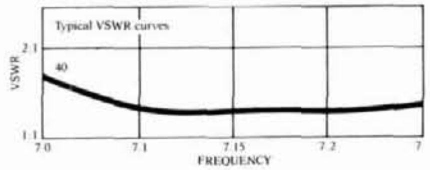
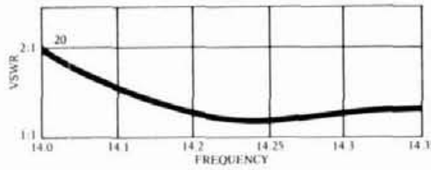
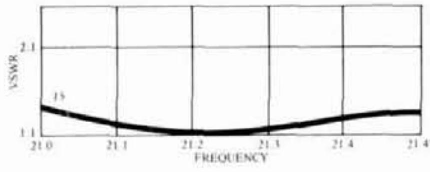


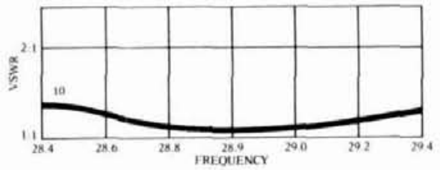
If you've got a calling for far-reaching action, have we got a number for you!

Swan's 4010V: precision engineered for 40-20-15-10 meters.









With slim-line traps, this 4-band vertical offers advanced lightweight construction *with* heavy weight performance.

4010V's fine-tuned to handle 2000 PEP. With a typical VSWR of 1.5:1 at resonance.

Powerfully designed—yet powerfully simple to set up.

No-hassle installation. The 21′ vertical comes in short, easy to assemble lengths. Complete with mounting hardware. You're up and running in record time.

Expandable too. No trick at all to stretch your reach into 75 meters, with the optional Swan 75 AK Kit.

Just $74.95 for an *outstanding* 4-band trap vertical, the 4010V (and $39.95 for the 75-meter add-on kit), at your Swan dealer. And by all means, use your Swan Credit Card.

Please rush full specs for Swan's

☐ 4010V 4-band trap vertical antenna

☐ 75 AK 75-meter Kit

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XF903	8999.0 kHz	BFO	$4.15
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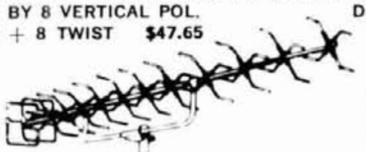

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A remote control plug allows you to operate with the amplifier ON or OFF, or in SSB/AM, FM or CW from the dashboard.

The 2002 utilizes the latest state of the art engineering including microstrip circuitry and modular construction. The three final transistors combine to produce 250W when driven by 15W or more at 13.8VDC.

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5-20W Carrier FM or CW
20W PEP maximum SSB or AM

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200-250W carrier FM or CW
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144 to 148 MHz*
* will operate with slight degradation at 142-150 MHz.

HARMONIC ATTENTUATION:
All Harmonics Attenuated
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CURRENT DRAIN:
FM-40 Amps @ 250W
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DUTY CYCLE:
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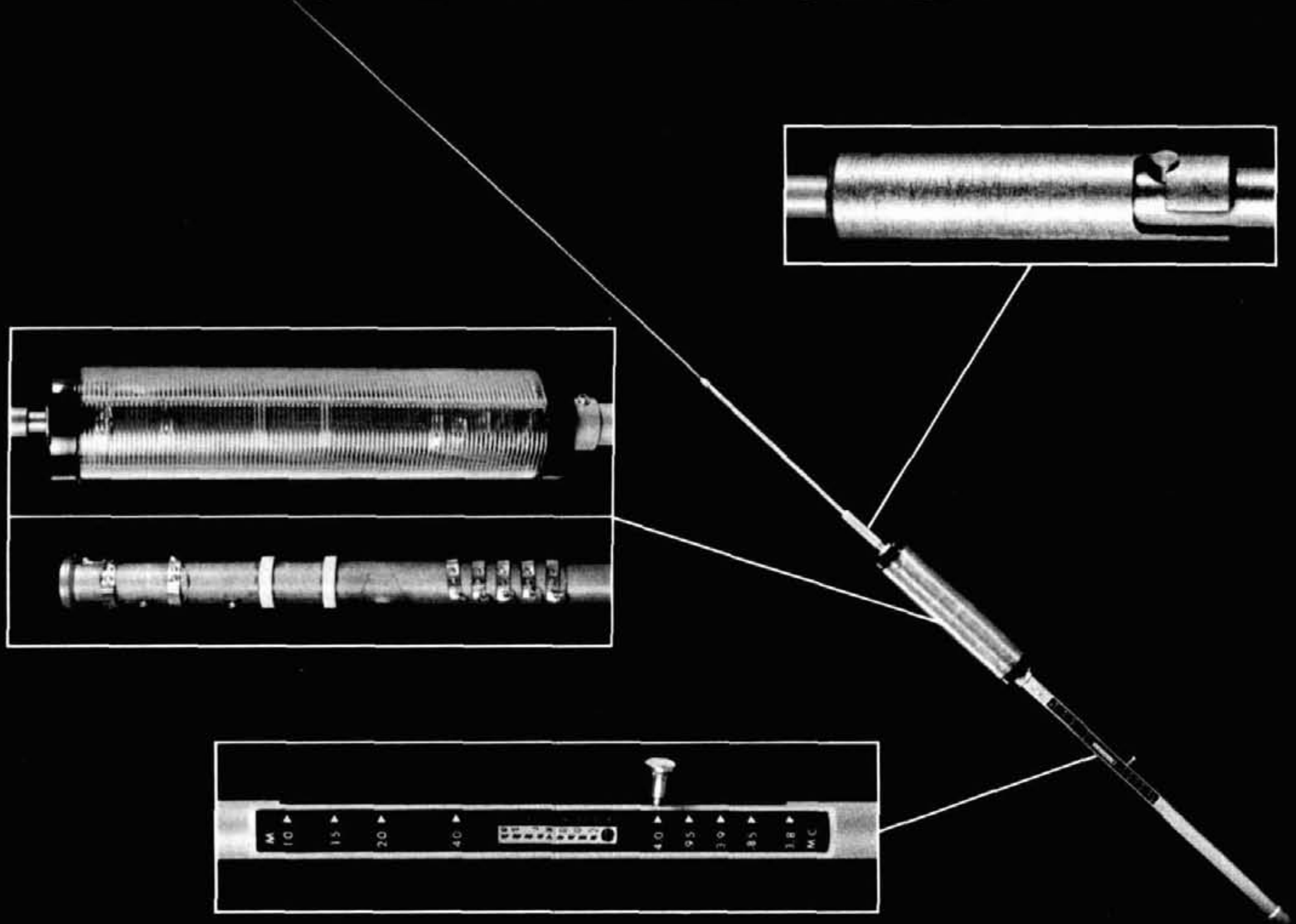

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Swan's 5-band Mobile 45, loaded with high-engineering specs unavailable from any other antenna source today.

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No more coil changing. At the flick of the positive-stop switch, skip across all 5 bands freely using our High-Q tapped coil. Nine positions to shift to:

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ITS WHAT YOU CAN'T HEAR THAT MAKES YOUR QSO Q5

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During your SSB/SSTV operations, the Frequency-Agile FL-1 AUTOMATICALLY scans, locks, and tracks interference within the 280-3000 Hz. spectrum, and in a second or two reduces QRM up to 40 db! For CW/RTTY usage, fully INDEPENDENT control of bandwidth and center frequency provide rejection of interfering signals up to, or greater than 40 db.

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including Pre-Paid shipping & full insurance

- Made in England
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BUY-SELL-TRADE. Send $1.00 for catalog. Give name, address and call letters. Complete stock of major brands. New and reconditioned equipment. Call for best deals. We buy Collins, Drake, Swan, etc. SSB & FM. Associated Radio, 8012 Conser, Overland Park, KS 66204. 913-381-5901.

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TELETYPEWRITER PARTS, gears, manuals, supplies, tools, toroids. SASE list. Typetronics, Box 8873, Ft. Lauderdale, FL. 33310. N4TT Buy parts, late machines.

VHF-UHF TRANSVERTERS: Extend frequency range of your HF, VHF gear. Send for info. UHF-VHF COMMUNICATIONS, 53 St. Andrew, Rapid City, SD 57701.

FOR SALE: Pair of 1977 call books; $6.00: Late issues of QST and Ham Radio $2.50 per year: plus shipping all items: Hy-Gain 204Ba, with BN86 balun, BMC clamp, $115.00. Prefer pick up: Clark W3HZ.

CERTIFICATE for proven two-way radio contacts with Amateurs in all ten USA call areas. Award suitable to frame and proven achievements added on request. SASE brings TAD data sheet from W6LS, 2814 Empire, Burbank, CA 91504.

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WANTED: Davco DR230 receiver. Please state price and condition in first letter. Jim Fisk, W1HR, Ham Radio, Greenville, NH 03048.

SEE OUR AD in this issue, Pyramid Data, Page 000.

B&K TEST EQUIPMENT. Free catalog. Free shipping. Dinosaur discounts. Spacetron-CE, 948 Prospect, Elmhurst, IL 60126.

MOTOROLA HT220, HT200, and Pageboy service and modifications performed at reasonable rates. WA4FRV (804) 320-4439, evenings.

AUTHORIZED DEALER for DenTron, KLM, Larsen, Bearcat, etc., Big Catalog 201-962-4695 Narwid Electronics, 61 Bellot Road, Ringwood, N.J. 07456.

RECONDITIONED TEST EQUIPMENT for sale. Catalog $.50. Walter, 2697 Nickel, San Pablo, Ca. 94806.

TELETYPEWRITER PARTS WANTED: for all machines manufactured by: Klienschmidt Corp., Teletype Corp. and Mite. Any quantity, top prices paid send list for my quote. Phil Rickson, W4LNW, Rt. 6, Box 1103G2, Brooksville, Fl. 33512.

VERY In-ter-est-ing! Next 4 issues $1. "The Ham Trader", 2435 Fruitville, Sycamore, IL 60178.

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CHANNEL ELEMENTS NEEDED KXN1024A, Motorola for Micor Radio. Need several. WA6COA, 4 Ajax, Berkeley, CA. 94708. (415) 843-5253.

ATLAS 210X $580, 220 CS $95, 10X $30, DMK $25. All new, unused, in original cartons. Package deal $700. Have two of each. Reid W6MTF, 2701 Durant #9, Berkeley, CA 94704. 415-549-0518.

QRP ACCU-KEYER PC board, G-10 drilled. See QST Jan. 76; $5.00. I/O Engineering, 9503 Gambels Quail, Austin, Texas. 78758. K5PA.

TELETYPES, Models 15-35 $75-up. SASE for list. Goodman, 5454 South Shore, Chicago, IL 60615.

RTTY — NS-1A PLL demodulator. Board $3.50; Parts $15.00; W/T $24.95, all postpaid. SASE for info. Nat Stinnette Electronics, Tavares, Fl. 32778.

NEED — IC-22S or better 2M Synthesized Transceiver, Atlas 180/210/215, R.F. Signal Generator. TRADE (or sell) TV camera with zoom lens — $179 for VTR. SSTV/ATV, Security uses. Data Precision #245 DMM (4★ digits) with nicads, manuals. W6DOM, 6017 Majorca Ct., San Jose, California 95120. (408) 997-0132.

flea market

WANTED: AN/PRC-70, 74 and/or parts and accessories. Send details and price. T. Stroh 6301 Glade Ave., K220 Woodland Hills, CA 91367.

SELL or trade for VHF rig: novice rigs, surplus gear, teletype parts, tubes, components. SASE for my list. **K0UP** Mike Reed, Rt. 1, Box 200, Wolbach, Nebraska 68882.

WANTED HAM RADIO back issues: May, July, Oct., Dec. of 1968; Jan., Oct. of 1969; March of 1970. Have many to sell, $.25 each, plus postage. SASE for list. K1MJT/4, Rt. 2, Box 50A-1, Scottsville, VA 24590.

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ICOM IC-245 Sell like new with ssb adapter. A super deal at $450. WB9LSW Angelo, 1875 W. Sheridan, Milwaukee, WI 53209 (414) 228-8719 evenings.

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THE "CADILLAC" of QSL's! Samples: $1.00 (Refundable) — W5YI, Box #1171-D; Garland, Texas 75040.

EXCLUSIVELY HAM TELETYPE 24th year, RTTY Journal, articles, news, DX, VHF, classified ads. Sample 35¢. $3.50 per year. 1155 Arden Drive, Encinitas, Calif. 92024.

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THE MEASUREMENT SHOP has used/reconditioned test equipment at sensible prices; catalog. 2 West 22nd St., Baltimore, MD 21218.

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AUDIO SPEECH PROCESSOR — details "Ham Radio", Aug. '77, page 48. Board only $5.60 ppd. Board and components, you add case and switch, $17.95 ppd. Getz Engineering, 685 Farnum Rd., Media, PA 19063.

NEW NORTH ELECTRIC COMPUTER POWER supplies, adjustable positive 12, negative 12 volts, 10 amps each, Positive 5 volts 15 amps, ripple .0015 typical, 105-132 volts common buss, punched metal cover. 78 lbs. FOB $114.75. Browns Electronics, RFD 2, Platte City, MO 64079.

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HAM RADIO HORIZONS, a super new magazine for the Beginner, the Novice and anyone interested in Amateur Radio . . . What it's all about, How to get started, The fun of ham radio. It's all here and just $10.00 per year. HURRY! HURRY! Ham Radio HORIZONS, Greenville, NH 03048.

Coming Events

MARYLAND: Frederick ARC 1st annual Hamfest Sunday, June 18, Frederick Fair Grounds, East Patrick St., Frederick. Grounds open 6 AM for commercial displays, general admission 8 AM. Talk-in 146.52, 13/73. Prizes, exhibits. Write: Mike Staley, 2 W. Main St., New Market, MD 21774.

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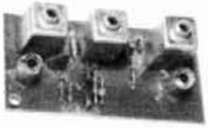

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P8-220	220-230 MHz
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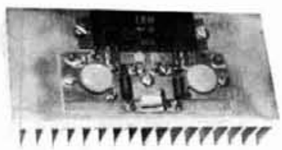

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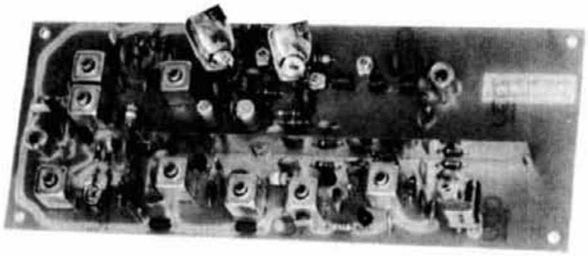

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Special	Other i-f & rf ranges available	

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flea market

NEW YORK: Long Island Mobile ARC Hamfest, Sunday, June 4, Islip Speedway. 9:30 AM to 4:00 PM. Admission $1.50. Ladies and children 12 and under free. Sellers and exhibitors spaces $3.00. Talk-in 146.25/85 and 146.52. Route 111, one block south of exit 43 of Southern State Parkway. Write: Hank Wener, WB2ALW, 53 Sherrard St., East Hills, NY 11577. Call 212-355-0606.

AMATEUR COMPUTING 78, WASHINGTON, DC, July 22-23. Sheraton National Hotel, Arlington, VA. To preregister send check for $4 payable to AMRAD, PO Box 682, McLean, VA 22101.

MICHIGAN: Fourth annual Midland Hamfest sponsored by Central Michigan Amateur Repeater Assoc. June 3, Midland County Fairgrounds. Admission: $1.50 advance, $2.00 door, under 12 free. Talk-in 07-67 Midland, 13-73 Pleasant Valley. Portables on 52. Demonstrations, Door Prizes, Auction. Tables available $2.00. Take I-75 N to US 10 West to Eastman Rd. exit. Send SASE with check to D. Zahm, WB8SDJ, 3871 Monroe, Rt. 8, Midland, MI 48640. Commercial exhibits advance reservation. Write: J. Gunsher, W8JDW, 4307 Bluebird Dr., Midland, MI 48640.

SANDUSKY COUNTY HAMFEST — Fleamarket June 11, 1978 — Held at Sandusky County Fairgrounds Freemont, Ohio. Free tables, good food, talk-in 31/91 — 52/52 simplex. Donation $1.00 at the gate. Further info contact Ken KuKay WD8NVF.

KANSAS: Ham Butchers Net Picnic, June 18, Kelley Park, Burlington. On Highway 75. Covered dish lunch. Prize drawing, flea market. Talk-in 146.52 or 3.963 MHz.

NEW YORK CITY — 2 fleamarkets bigger and better than ever. Indoor-Outdoor, Rain-Shine Sunday, June 18, and Sept. 10; 9 AM to 4 PM. The Municipal Parking Lot 80-25 126th St., Queens, N.Y. One block off Queens Blvd. Free Parking for 1000 cars. Raffle, Refreshments, Fun. Sellers $2.00; Buyers $1.00. Talk-in: .52/.52; .40/.00; Info: (212) 699-9400 days. Sponsored by Hall of Science Amateur Radio Club WB2TBC.

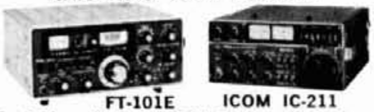
KENTUCKY: JEFFERSON DAVIS MONUMENT AWARD sponsored by the Pennyroyal A.R.S., Hopkinsville, Kentucky, in memory of Jefferson Davis, President of the Confederacy, who was born in Fairview Kentucky. The Pennyroyal A.R.S. will be operating from Jefferson Davis Memorial Park June 3rd, and this certified sequential award will be presented to any amateur who presents written confirmation of contact with any PARS member during the QSO period; or any ten Kentucky amateurs during the year. QSO Party begins 1400 UTC June 3rd and ends 0500 UTC June 4th. Frequencies are: 3.740, 21.140, 28.140 for Novice; and 3.970, 7.270, 14.310, 21.370, and 28.610 for General and higher licensees.

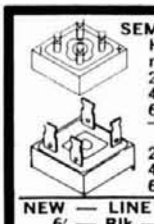
THE SIXTH DISTRICT DX-QSL Bureau is for receiving INCOMING DX-QSLs for Sixth District Amateur Radio Operators. Send a minimum of 5, (12 Maximum) self-addressed stamped 5-1/2" x 7" envelopes. Place stamp upper right corner and write call **only** in upper left corner. If more than 5-6 QSLs per month, clip extra 11¢ stamps to one of the envelopes. If reply desired, enclose a regular size SASE. The Bureau can supply envelopes and postage for a donation of $1.00. Amateurs should send 5 labels with CALL, name and address to Bureau.

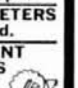
SOUTH DAKOTA: ANNUAL HAMFEST, sponsored by Black Hills A.R.C. July 1-2, Surbeck Center, South Dakota School of Mines and Technology, Rapid City. Technical Forums, ARRL Forum, Flea Market, Industrial Tours. Grand Prize, Preregistration Prize and many more. Admission: $4.50 advance (before June 1), $5.00 at door. For information write: Black Hills ARC, Box 1014, Rapid City, SD 57709.

MINNESOTA: AMATEUR FAIR '78, Swapfest & Exposition, Saturday, June 3, 9:00 AM to 6:00 PM, Minnesota State Fairgrounds. Admission: $2.00 Under 12 free. General admission ticket required to sell. Non-commercial car selling and inside tables no extra charge. Indoor commercial space $10.00/table. ADVANCE RESERVATIONS REQUIRED. Call (612) 933-2823. Major prizes. FM forum, Microprocessor Forum, ARRL Forum, FCC Q&A Session. Talk-in on 16/76, 52/52.

PENNSYLVANIA: MARC HAMFEST, White Deer Township, Firemen Grounds, Allenwood, PA. 8:00 AM to 5:00 PM, Sunday, June 4. $2.50 advance registration for sellers and tailgaters. $3.00 gate. XYL and children free. Auction swapping, surplus and commercial electronic equipment. Cash door prizes. Dozens of prizes. Parking for Flea Market. Bring your own table. Snack Bar. QSL and Frequency Guessing Contests. Indoor and outdoors. Talk-in Frequencies 3940 kHz, 2 meter FM, 146.34/.94, .37/.97, .52/.52. For information: Jerry Williamson, WA3SXQ, 10 Old Farm Ln., Milton, PA 17847. 717-742-3027.







DIODES/ZENERS

1N914	100v	10mA	.05
1N4005	600v	1A	.08
1N4007	1000v	1A	.15
1N4148	75v	10mA	.05
1N753A	6.2v	z	.25
1N758A	10v	z	.25
1N759A	12v	z	.25
1N4733	5.1v	z	.25
1N5243	13v	z	.25
1N5244B	14v	z	.25
1N5245B	15v	z	.25

SOCKETS/BRIDGES

8-pin	pcb	.25	ww	.45
14-pin	pcb	.25	ww	.40
16-pin	pcb	.25	ww	.40
18-pin	pcb	.25	ww	.75
22-pin	pcb	.45	ww	1.25
24-pin	pcb	.35	ww	1.10
28-pin	pcb	.35	ww	1.45
40-pin	pcb	.50	ww	1.25

Molex pins	.01	To-3 Sockets	.45
2 Amp Bridge		100-prv	1.20
25 Amp Bridge		200-prv	1.95

TRANSISTORS, LEDS, etc.

2N2222A	NPN (2N2222 Plastic .10)	.15
2N2907A	PNP	.15
2N3906	PNP (Plastic)	.10
2N3904	NPN (Plastic)	.10
2N3054	NPN	.35
2N3055	NPN 15A 60v	.50
T1P125	PNP Darlington	.35
LED Green, Red, Clear, Yellow		.15
D.L.747	7 seg 5/8" High com-anode	1.95
XAN72	7 seg com-anode (Red)	1.25
MAN71	7 seg com-anode (Red)	1.25
MAN3610	7 seg com-anode (Orange)	1.25
MAN82A	7 seg com-anode (Yellow)	1.25
MAN74A	7 seg com-cathode (Red)	1.50
FND359	7 seg com-cathode (Red)	1.25

C MOS

4000	.15
4001	.15
4002	.20
4004	3.95
4006	.95
4007	.35
4008	.95
4009	.45
4010	.45
4011	.20
4012	.20
4013	.40
4014	.95
4015	.90
4016	.35
4017	1.10
4018	1.10
4019	.50
4020	.85
4021	1.00
4022	.85
4023	.25
4024	.75
4025	.30
4026	1.95
4027	.50
4028	.95
4030	.35
4033	1.50
4034	2.45
4035	1.25
4040	1.35
4041	.69
4042	.95
4043	.95
4044	.95
4046	1.75
4049	.45
4050	.45
4066	.95
4069	.40
4071	.35
4081	.70
4082	.45
MC14409	14.50
MC14419	4.85

– T T L –

7400	.15
7401	.15
7402	.20
7403	.20
7404	.15
7405	.25
7406	.35
7407	.55
7408	.25
7409	.15
7410	.10
7411	.25
7412	.30
7413	.35
7414	1.10
7416	.25
7417	.40
7420	.15
7426	.30
7427	.45
7430	.15
7432	.30
7437	.30
7438	.35
7440	.25
7441	1.15
7442	.45
7443	.65
7444	.45
7445	.65
7446	.95
7447	.95
7448	.65
7450	.25
7451	.25
7453	.20
7454	.25
7460	.40
7470	.45
7472	.40

7473	.25
7474	.30
7475	.35
7476	.40
7480	.55
7481	.75
7483	.95
7485	.75
7486	.25
7489	1.35
7490	.55
7491	.95
7492	.95
7493	.35
7494	.75
7495	.60
7496	.80
74100	1.15
74107	.35
74121	.35
74122	.55
74123	.55
74125	.45
74126	.35
74132	1.35
74141	.90
74150	.85
74151	.65
74153	.75
74154	.95
74156	.95
74157	.65
74161	.85
74163	.85
74164	.60
74165	1.50
74166	1.35
74175	.80

74176	1.25
74180	.75
74181	2.25
74182	.95
74190	1.75
74191	1.05
74192	.75
74193	.85
74194	1.25
74195	.95
74196	1.25
74197	1.25
74198	2.35
74221	1.00
74367	.85
75108A	.35
75110	.35
75491	.50
75492	.50
74H00	.15
74H01	.25
74H04	.20
74H05	.20
74H08	.35
74H10	.35
74H11	.35
74H15	.45
74H20	.30
74H21	.25
74H22	.40
74H30	.20
74H40	.25
74H50	.25
74H51	.25
74H52	.15
74H53J	.25
74H55	.20

74H72	.45
74H101	.75
74H103	.75
74H106	.95
74L00	.25
74L02	.25
74L03	.30
74L04	.30
74L10	.30
74L20	.35
74L30	.45
74L47	1.95
74L51	.45
74L55	.65
74L72	.45
74L73	.40
74L74	.45
74L75	.55
74L93	.55
74L123	.85
74S00	.35
74S02	.35
74S03	.30
74S04	.30
74S05	.35
74S08	.35
74S10	.35
74S11	.35
74S20	.35
74S40	.20
74S50	.20
74S51	.25
74S64	.20
74S74	.35
74S112	.60
74S114	.65

74S133	.40
74S140	.55
74S151	.30
74S153	.35
74S157	.75
74S158	.30
74S194	1.05
74S257 (8123)	1.05
74LS00	.25
74LS01	.35
74LS02	.35
74LS04	.30
74LS05	.45
74LS08	.25
74LS09	.35
74LS10	.35
74LS11	.35
74LS20	.25
74LS21	.25
74LS22	.25
74LS32	.40
74LS37	.35
74LS40	.45
74LS42	1.10
74LS51	.50
74LS74	.65
74LS86	.65
74LS90	.95
74LS93	.95
74LS107	.85
74LS123	1.00
74LS151	.95
74LS153	1.20
74LS157	.85
74LS164	1.90
74LS367	.75
74LS368	.75
74C04	.25
74C151	2.25

9000 SERIES

9301	.85	95H03	1.10
9309	.35	9601	.45
9322	.75	9602	.45

LINEARS, REGULATORS, etc.

MCT2	.95
8038	3.95
LM201	.75
LM301	.45
LM308 (Mini)	.95
LM309H	.65
LM309K (340K-5)	.85
LM310	1.15
LM311D (Mini)	.75
LM318 (Mini)	.95
LM320K5(7905)	1.65
LM320K12	1.65

LM320T5	1.65
LM320T12	1.65
LM320T15	1.65
LM324N	.95
LM339	.95
7805 (340T5)	.95
LM340T12	1.00
LM340T15	1.00
LM340T18	1.00
LM340T24	.95
LM340K12	1.65

LM340K15	1.25
LM340K18	1.25
LM340K24	.95
78L05	.75
78L12	.75
78L15	.75
78M05	.75
LM373	2.95
LM380 (8-14 PIN)	.95
LM709 (8, 14 PIN)	.25
LM711	.45

LM723	.50
LM725N	2.50
LM739	1.50
LM741 (8-14)	.25
LM747	1.10
LM1307	1.25
LM1458	.95
LM3900	.50
LM75451	.65
NE555	.50
NE556	.95
NE565	.95
NE566	1.75
NE567	1.35

MICRO'S, RAMS, CPU'S, ETC.

74S188	3.00
1702A	4.50
MM5314	3.00
MM5316	3.50
2102-1	1.45
2102L-1	1.75
TR1602B	4.50
TMS 4044-45NL	14.50
8080AD	12.00
8T13	1.50
8T23	1.50
8T24	2.00
8T97	1.00
2107B-4, A	4.00
2708	11.50

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Total Order	Deduct
\$35 - \$99	5%
\$100 - \$300	10%
\$301 - \$1000	15%
\$1000 - Up	20%

flea market

THE TRI-STATE AMATEUR RADIO ASSN. (TARA) 16th annual hamfest, Sunday, June 4, 1978. 11:30 AM Camden Park, Rte. 60 West Huntington. Talk-in; W8VA/8, 04/64, 16/76, 34/94. For information and tickets write: TARA, P.O. Box 1295, Huntington, W.VA 25715.

ROME HAM FAMILY DAY will be held on June 4, 1978. For information write Rome Radio Club, PO Box 721, Rome NY 13440. (Dealer inquiries invited).

ILLINOIS: Egyptian Radio Club Annual Hamfest, Sunday, June 11, at club grounds, Granite City.

ILLINOIS — Six Meter Club of Chicago 21st annual ABC Hamfest, June 11, Santa Fe Park, 91st and Wolf Rd., Willow Springs. Tickets: Advance $1.50; Gate $2.00. Talk-in 146.94 FM or WR9ABC 37-97 (PL2A). Swap Row, Refreshments, AFMARS Meeting. Write: Val Hellwig, K9ZWV, 3420 South 60th Court, Cicero, IL 60650.

MICHIGAN S.P.A.R.K. Activities/Weekend, June 10th and 11th Newberry, Michigan. Saturday: fish fry, Toonerville Trolley and River Trip; Sunday: Annual SWAP and SHOP. Fun and enjoyment for all — hams, CBers, YLs, XYLs, children. Donations $2 for registration and drawings; Tables $1.50 and $2.50. Talk-in on 01/61, 31/91, and 52 simplex. Contact W8GBR, Box 67, Newberry, MI 49868. Tel. 906-293-8651 for details.

"TIN LIZZY" INTERNATIONAL QSO PARTY — Saturday and Sunday, June 17 and 18 — commemorating the 75th anniversary of the Ford "Tin Lizzy" and sponsored by the Ford Amateur Radio League, an employee organization of the Ford Motor Company. Open to all amateurs throughout the world, on all bands 160 through 10 meters, the contest will run from 2400 UTC Friday, June 16th through 2400 UTC Sunday, June 18th. Work stations once per band, per mode — CW or ssb **only**. Call "CQ Tin Lizzy" on SSB, and "CQ TLC" on CW. For details of logs, exchanges, etc. contact The Tin Lizzy Contest, P.O. Box 932, Dearborn, Michigan 48121. Be sure to include a #10 SASE with 26¢ postage (U.S.) or an I.R.C. For other questions, contact K8BTH, 14468 Bassett Ave., Livonia, MI 48154; tel. (313) 464-9149 at home; or (313) 594-1779 at work.

MICHIGAN — Monroe County A.R.C. Annual Swap & Shop 8:00 AM to 4:00 PM Sunday, June 4th at Monroe County Community College, Raisinville Road (off M-50) Monroe, Michigan. Talk-in 13/73. Donation $1 at gate. FREE tables and trunk sales. Details WB8ULF, 3473 Vermont Court, Monroe, MI 48161.

INDIANA — Fifth Annual "Dad's Day" Hamfest, sponsored by Lake County A.R.C., 8:00 AM to 5:00 PM Sunday, June 18th, at the Izaak Walton League Picnic Grounds, Portage, Indiana. Take I-94 to Indiana 249 — Portage exit — then North 1/2 mile. Overnite camping, no hookups. Talk-in 146.52 or 84/24. Tickets $2 donation at gate or $1.50 advance. Details from TICKETS, Box 348, Griffith, Indiana 46319.

PONY EXPRESS CERTIFICATE — Available from the Missouri Valley A.R.C. to any ham who works the HF bands. Work 5 MVARC members, send 5 QSLs confirming QSOs and include two 13¢ stamps (U.S hams); or 3 MVARC members and 3 confirming QSLs, plus one I.R.C. (DX hams) to WB0LVW, P.O. Box 141, Station E, St. Joseph, MO 64505. Also, list of MVARC stations from same address.

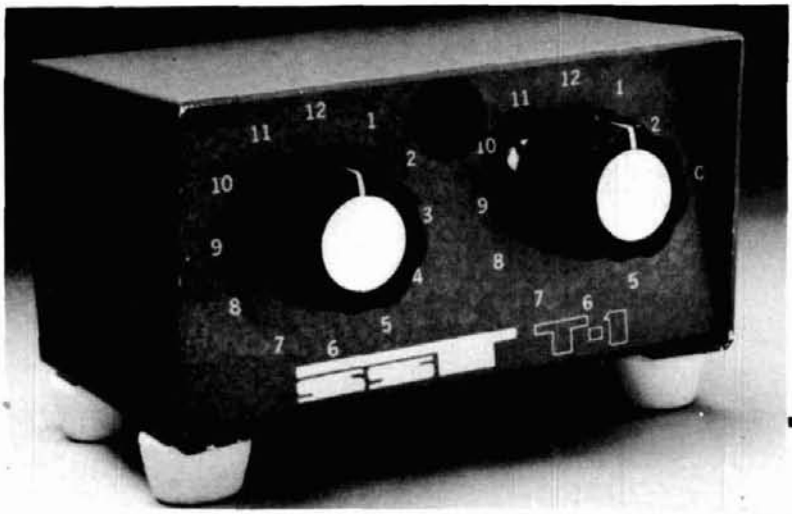
OHIO — The Goodyear A.R.C. 11th Annual Hamfest and Family Picnic, Sunday, June 11th, 10:00 AM to 6:00 PM at Wingfoot Lake Park, Akron, Ohio on county road 87 near Route 43. Many prizes, ample parking, shelters, picnic facilities, play areas for children, refreshments. Flea market and display space FREE to ticket holders. Family donation $2.50 advance, $3 gate. Details from WA8SXJ, 161 So. Hawkins Ave., Akron, OH 44313; tel. (216) 864-3665.

THE WEST WASHTENAW SWAP & SHOP, sponsored by the Dexter Amateur Radio Club — Chelsea Communications Club, at the Chelsea Fairgrounds, June 4th, 8:00 AM to 3:00 PM. Donations $1.50 advance, $2.00 gate. Table space $.50 a foot, trunk sales $1.00 per space.

EYEBALL FRIENDS July 16 Tri Club Hamfest, Allentown. Information SASE K3AI, RI Emmaus, Pennsylvania.

AMATEUR FAIR '78: SWAPFEST & EXPOSITION for Amateur Radio Operators and Computer Hobbyists. Saturday, June 3rd. Minnesota State Fairgrounds. Free overnight parking for self-contained campers, June 2 only. Talk-in on 16/76 and 52/52. Sell from your car in the GIANT FLEA MARKET. Inside space available. Great prizes, scheduled forums on FM and microprocessors. Admission: $2.00. For information or reservations for commercial exhibit space, call (612) 933-2823.

SST T-1 RANDOM WIRE ANTENNA TUNER



All band operation (160-10 meters) with any random length of wire. 200 watt **output** power capability—*will work with* virtually any transceiver. Ideal for portable or home operation. Great for apartments and hotel rooms—simply run a wire inside, out a window, or anyplace available. Efficient toroid inductor for small size: 4-1/4" x 2-3/8" x 3", and negligible loss. Built-in neon tune-up indicator. SO-239 connector. Attractive bronze finished enclosure.

only $29.95

THE ORIGINAL Random Wire Antenna Tuner. . . in use by amateurs for 6 years.

SST T-2 ULTRA TUNER

Tunes out SWR on any coax fed antenna as well as random wires. Works great on all bands (80-10 meters) with any transceiver running up to 200 watts power **output.**

Increases usable bandwidth of any antenna. Tunes out SWR on *mobile whips from inside your car.*

Uses efficient toroid inductor and specially made capacitors for small size: 5-1/4" x 2-1/4" x 2-1/2". Rugged, yet compact. Negligible line loss. Attractive bronze finished enclosure. SO-239 coax connectors are used for transmitter input and *coax fed antennas. Convenient binding posts are provided for* random wire and ground connections.

only $39.95

only $19.95

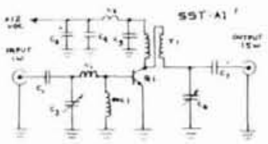
SST T-3

Mobile Impedance Transformer

Matches 52 ohm coax to the lower impedance of a mobile whip or vertical. 12-position switch with taps spread between 3 and 52 ohms. Broadband from 1-30 Mhz. Will work with virtually any transceiver—300 watt **output** power capability. SO-239 connectors. Toroid inductor for small size: 2-3/4" x 2" x 2-1/4". Attractive bronze finish.

GUARANTEE

All SST products are guaranteed for 1 year. In addition, they may be returned within 10 days for a full refund (less shipping) if you are not satisfied for any reason. Please add $2 for shipping and handling. Calif. residents, please add sales tax. COD orders OK by phone.



only $29.95

$49.95 wire and tested

SST A-1 VHF Amplifier Kit

1 watt input gives you 15 watts output across the entire 2 meter band without re-tuning. This easy-to-build kit (approx. 1/2 hr. assembly) includes everything you need for a complete amplifier. All top quality components. Compatible with all 1-3 watt 2-meter transceivers. Short and open protected—not damaged by high SWR.

Kit includes:
- Etched and drilled G-10 epoxy solder plated board.
- Heat sink and mounting hardware. All components—including pre-wound coils.
- Top quality TRW RF power transistor.
- Complete assembly instruction with details on a carrier operated T/R switch.

SST ELECTRONICS
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90260 · (213) 376-5887

More Details? CHECK—OFF Page 142

flea market

JUNE 4, 1978, STARVED ROCK RADIO CLUB HAMFEST, Bureau County Fairgrounds, Princeton, Illinois. Advance registrations $1.50 before May 25, after $2.00. Large SASE please for registrations, map, information, etc. W9MKS/WR9AFG/SRRC, RFD #1, Box 171, Oglesby, Illinois 61348. 815-667-4614.

ALASKA: ARRL Convention, Anchorage. August 26, 27. Write: ARRL Alaska Convention 78, Anchorage ARC, PO Box 1987, Anchorage, AK 99510.

WIMU (Wyoming, Idaho, Montana, Utah) The 46th Annual WIMU Hamfest is scheduled for August 4, 5, and 6, 1978 at Mack's Inn, Idaho; 25 miles South of West Yellowstone, Montana. Talk-in 146.34/94 and 3935. Advance registration: $6.00 for adults and $2.00 for children, before July 25th, 1978. Late/regular registration: $7.00 and $2.50. SPECIAL PRIZE DRAWING FOR PRE-REGISTRATION. Please send pre-registration to: WIMU Hamfest, 3645 Vaughn Street, Idaho Falls, Idaho 83401. Phone (208) 522-9568.

CENTRAL MICHIGAN Amateur Repeater Association Fourth Annual Swap & Shop in Midland, Michigan, June 3rd at the Midland County Fairgrounds. Camping & Program Friday evening. Computer Demonstrations, Door Prizes. Donation: $2.00 at door, $1.50 in advance. Talk-in: 146.07/146.67 WR8AKN, 146.13/146.73 WR8AHM and 146.52 Simplex. Info & Tickets, SASE to Don Zahm, WB8SDJ, 3871 Monroe R#8, Midland, MI 48640.

ANNUAL TEXAS VHF-FM SOCIETY SUMMER CONVENTION, hosted by the Houston Echo Society, August 4, 5, 6, 1978 at the Galleria Plaza Hotel off Interstate Loop 610 at Westheimer Road. Microprocessors/microcomputers, hidden transmitter hunt, OSCAR communications, VHF-FM activities. ARRL & FCC forums, open hospitality suite, ladies' activities, Astrodome-Astroworld tours for the kids, Exhibitors, and prizes. Saturday night banquet featuring Bill Tynan, W3XO, editor of *QST*'s "World Above 50 MHz", as guest speaker. For information and reservations write FM Society Summer Convention, P.O. Box 717, Tomball, Texas 77375.

MANASSAS HAMFEST SPONSORED BY The "Ole Virginia Hams" A.R.C. June 4, 1978 at the Prince William County Fairgrounds one-half mile south of Manassas, Virginia on Rt. 234. Gates open 7 AM for tailgating, 8 AM for general admission. Fantastic Prizes. Admission $3.00 adult, under 12 free. Tailgating $2.00 per vehicle, over 300 spaces available. Refreshments, YL Program, Children's entertainment. FM Clinic; QSL Bureaus: learn how they work. CW Proficiency awards: 5 wpm up. Indoor exhibit space available for Dealers: for info contact Sam Lebowich, 9512 Sudley Manor Dr., Manassas, VA 22110. Talk-in on 146.37/146.97, 147.84/147.24 and CB Ch. 1. Accommodations: Olde Towne Inn in Manassas, Holiday Inn at I-66 and Rt. 234 Interchange. Camping at Prince William County Forest (on Rt. 234 near the intersection of 234 and I-66).

HAMFESTERS 44TH ANNUAL PICNIC AND HAMFEST, Sunday, August 13, 1978 at Santa Fe Park, 91st and Wolf Road, Willow Springs, Illinois, Southwest suburb of Chicago. Exhibits for OM's and XYL's, FAMOUS SWAPPERS ROW. Tickets at gate $2.00, Advance $1.50. For Hamfest info or Advance Tickets (send check or money order — SASE appreciated) to Bob Hayes W9KXW, 18931 Cedar Ave., Country Club Hills, IL 60477.

SATELLITE AMATEUR RADIO CLUB Annual Swap/Fun fest and Santa Maria BBQ on Sunday, June 18. Best steak and biggest hamfest in the west. Fantastic prizes! Swap tables available. All you can eat dinner — $6.00 adults; $3.00 children under 12. Contact W2KVA/6 at (805) 925-0398, or write SWAPFEST, P.O. Box 2531, Orcutt, CA 93454.

Stolen Equipment

STOLEN FROM AIRLINE BAGGAGE, probably either in Minneapolis/St. Paul or San Francisco, Wilson WE-800 s/n 12521811 with 10 white "no brand" Ni-Cad batteries inside, flex antenna with UHF ell connector and UHF to BNC connector. Also homebuilt battery charger with 723 IC. Mitt Nodacker, WA7TFE, Box 2632, Pocatello, ID 83201.

STOLEN EQUIPMENT: 1. KLM 160 watt amplifier, no I.D. 2. Black Heath 2036 with Micoder and several obvious modifications: hi-low power selector on squelch knob, variable power on internal potentiometer, RCA plug replaced with SO-239, Social Security No. 350-30-1717 etched in foil on transmitter board. Darrel Dorsett, K9JKZ, Kankakee Area Career Center, Rt. 2, Road 100-W, Bourbonnais, IL 60914.

7400 TTL

SN7400N	16				
SN7401N	18	SN7472N	29	SN74160N	89
SN7402N	18	SN7473N	35	SN74161N	89
SN7403N	18	SN7474N	35	SN74162N	1.95
SN7404N	18	SN7475N	49	SN74163N	89
SN7405N	20	SN7476N	35	SN74164N	89
SN7406N	29	SN7479N	5.00	SN74165N	89
SN7407N	29	SN7480N	50	SN74166N	1.25
SN7408N	20	SN7482N	99	SN74167N	1.95
SN7409N	20	SN7483N	59	SN74170N	1.59
SN7410N	18	SN7485N	79	SN74172N	6.00
SN7411N	25	SN7486N	35	SN74173N	1.25
SN7412N	25	SN7489N	1.75	SN74174N	89
SN7413N	40	SN7490N	45	SN74175N	79
SN7414N	70	SN7491N	59	SN74176N	79
SN7416N	25	SN7492N	43	SN74177N	79
SN7417N	25	SN7493N	43	SN74179N	1.95
SN7420N	20	SN7494N	65	SN74180N	79
SN7421N	29	SN7495N	65	SN74181N	1.95
SN7422N	39	SN7496N	65	SN74182N	79
SN7423N	25	SN7497N	3.00	SN74184N	1.95
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SN7429N	39	SN74116N	1.95	SN74190N	1.25
SN7430N	20	SN74121N	35	SN74191N	1.25
SN7432N	25	SN74122N	39	SN74192N	79
SN7437N	25	SN74123N	49	SN74193N	79
SN7438N	25	SN74125N	49	SN74194N	89
SN7439N	25	SN74126N	49	SN74195N	69
SN7440N	20	SN74132N	75	SN74196N	89
SN7441N	89	SN74136N	75	SN74197N	89
SN7442N	49	SN74141N	79	SN74198N	1.49
SN7443N	75	SN74142N	2.95	SN74199N	1.49
SN7444N	75	SN74143N	2.95	SN74200N	5.59
SN7445N	75	SN74144N	2.95	SN74251N	1.79
SN7446N	69	SN74145N	79	SN74279N	79
SN7447N	59	SN74147N	1.95	SN74283N	2.25
SN7448N	79	SN74148N	1.29	SN74284N	3.95
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SN7451N	20	SN74151N	59	SN74365N	69
SN7453N	20	SN74153N	59	SN74366N	69
SN7454N	20	SN74154N	99	SN74367N	69
SN7459A	25	SN74155N	79	SN74368N	69
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CD4001	23			CD4071	23
CD4002	23	CD4028	89	CD4072	49
CD4006	1.19	CD4029	1.19	CD4076	1.39
CD4007	25	CD4030	49	CD4081	23
CD4009	49	CD4035	99	CD4082	23
CD4010	49	CD4040	1.19	CD4093	99
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CD4024	79	CD4060	1.49	CD4515	2.95
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CD4026	2.25	CD4068	39	CD4520	1.29
CD4027	69	CD4069	45	CD4566	2.25

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LM304H	1.00	LM340T-12	1.25	LM747H	79
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LM340K-8	1.35	LM703CN/H	45	75454CN	39
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LM340K-15	1.35	LM709N	29	75492CN	89
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74LS02	23			74LS157	69
74LS03	23	74LS74	35	74LS160	89
74LS04	29	74LS75	49	74LS161	89
74LS05	29	74LS76	35	74LS162	89
74LS08	23	74LS83	75	74LS163	89
74LS10	23	74LS85	99	74LS164	99
74LS13	49	74LS86	35	74LS175	79
74LS14	99	74LS90	49	74LS181	2.49
74LS20	23	74LS92	59	74LS190	89
74LS26	29	74LS93	59	74LS191	89
74LS27	29	74LS95	79	74LS192	89
74LS28	29	74LS96	89	74LS193	89
74LS30	23	74LS107	35	74LS194	89
74LS32	29	74LS109	35	74LS195	89
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MAN 84	Common Cathode-yellow	300	99	DL707	Common Anode-red	300	99
MAN 3620	Common Anode-orange	300	99	DL741	Common Anode-red	600	1.25
MAN 3630	Common Anode-orange ±1	300	99	DL746	Common Anode-red ±1	630	1.49
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MAN 6630	Common Anode-orange	560	99	5082-7300	4 x 7 Sgl. Digit-RHDP	600	19.95
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ASST. 3	5 ea	470 OHM 1.2K	560 OHM 1.5K	680 OHM 1.8K	820 OHM 2.2K	1K 2.7K	1/4 WATT 5%	50 PCS.
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ASST. 5	5 ea	22K 56K	27K 68K	33K 82K	39K 100K	47K 120K	1/4 WATT 5%	50 PCS.
ASST. 6	5 ea	150K 390K	180K 470K	220K 560K	270K 680K	330K 820K	1/4 WATT 5%	50 PCS.
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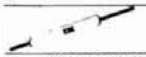

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XR1310P	1.30	XR2240	3.45	XR4558	.75
XR1468CN	3.85	XR2264	4.25	XR4739	1.15
XR1488	1.39			XR4741	1.4

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1N751A	5.1	400m	4/1.00	1N4006	800 PIV	1 AMP	10/1.00
1N752	5.6	400m	4/1.00	1N4007	1000 PIV	1 AMP	10/1.00
1N753	6.2	400m	4/1.00	1N3600	50	200m	6/1.00
1N754	6.8	400m	4/1.00	1N4148	75	10m	15/1.00
1N959	8.2	400m	4/1.00	1N4154	35	10m	12/1.00
1N965B	15	400m	4/1.00	1N4305	75	25m	20/1.00
1N5232	5.6	500m	.28	1N4734	5.6	1w	.28
1N5234	6.2	500m	.28	1N4735	6.2	1w	.28
1N5235	6.8	500m	.28	1N4736	6.8	1w	.28
1N5236	7.5	500m	.28	1N4738	8.2	1w	.28
1N456	25	40m	6/1.00	1N4742	12	1w	.28
1N458	150	7m	6/1.00	1N4744	15	1w	.28
1N485A	180	10m	5/1.00	1N1183	50 PIV	35 AMP	1.60
1N4001	50 PIV	1 AMP	12/1.00	1N1184	100 PIV	35 AMP	1.70
1N4002	100 PIV	1 AMP	12/1.00	1N1185	150 PIV	35 AMP	1.70
1N4003	200 PIV	1 AMP	12/1.00	1N1186	200 PIV	35 AMP	1.80
1N4004	400 PIV	1 AMP	12/1.00	1N1188	400 PIV	35 AMP	3.00

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TIS98	6/1.00	2N3398	5/1.00	2N4123	6/1.00
TIS133	5/1.00	PN3567	3/1.00	PN4249	4/1.00
TIS135	5/1.00	PN3568	4/1.00	PN4250	4/1.00
40409	1.75	PN3569	4/1.00	2N4400	4/1.00
40410	1.75	MPS3638A	5/1.00	2N4401	4/1.00
40673	1.75	MPS3702	5/1.00	2N4402	4/1.00
2N918	4/1.00	2N3704	5/1.00	2N4403	4/1.00
2N2219A	3/1.00	MPS3704	5/1.00	2N4409	5/1.00
2N2221A	4/1.00	2N3705	5/1.00	2N5086	4/1.00
2N2222A	5/1.00	MPS3705	5/1.00	2N5087	4/1.00
2N2369	5/1.00	2N3706	5/1.00	2N5088	4/1.00
2N2369A	4/1.00	MPS3706	5/1.00	2N5089	4/1.00
MPS2369	5/1.00	2N3707	5/1.00	2N5129	5/1.00
2N2484	4/1.00	2N3711	5/1.00	PN5134	5/1.00
2N2906	4/1.00	2N3724A	.65	PN5138	5/1.00
2N2907	5/1.00	2N3725A	1.00	2N5139	5/1.00
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MJE2955	1.25	2N3823	1.00	2N5449	3/1.00
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10 pf	.05	.04	.03	.001µF	.05	.04	.035
22 pf	.05	.04	.03	.0047µF	.05	.04	.035
47 pf	.05	.04	.03	.01µF	.05	.04	.035
100 pf	.05	.04	.03	.022µF	.06	.05	.04
220 pf	.05	.04	.03	.047µF	.06	.05	.04
470 pf	.05	.04	.035	.1µF	.12	.09	.075

100 VOLT MYLAR FILM CAPACITORS

.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22

+20% DIPPED TANTALUMS (SOLID) CAPACITORS

.1/35V	.28	.23	.17	1.5/35V	.30	.26	.21
.15/35V	.28	.23	.17	2.2/25V	.31	.27	.22
.22/35V	.28	.23	.17	3.3/25V	.31	.27	.22
.33/35V	.28	.23	.17	4.7/25V	.32	.28	.23
.47/35V	.28	.23	.17	6.8/25V	.36	.31	.25
.68/35V	.28	.23	.17	10/25V	.40	.35	.29
1.0/35V	.28	.23	.17	15/25V	.63	.50	.40

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Axial Lead				Radial Lead			
.47/50V	.15	.13	.10	.47/25V	.15	.13	.10
1.0/50V	.16	.14	.11	.47/50V	.16	.14	.11
3.3/50V	.14	.12	.09	1.0/16V	.15	.13	.10
4.7/25V	.15	.13	.10	1.0/25V	.16	.14	.11
10/25V	.15	.13	.10	1.0/50V	.16	.14	.11
10/50V	.16	.14	.12	4.7/16V	.15	.13	.10
22/25V	.17	.15	.12	4.7/25V	.15	.13	.10
22/50V	.24	.20	.18	4.7/50V	.16	.14	.11
47/25V	.19	.17	.15	10/16V	.14	.12	.09
47/50V	.25	.21	.19	10/25V	.15	.13	.10
100/25V	.24	.20	.18	10/50V	.16	.14	.12
100/50V	.35	.30	.28	47/50V	.24	.21	.19
220/25V	.32	.28	.25	100/16V	.19	.15	.14
220/50V	.45	.41	.38	100/25V	.24	.20	.18
470/25V	.33	.29	.27	100/50V	.35	.30	.28
1000/16V	.55	.50	.45	220/16V	.23	.17	.16
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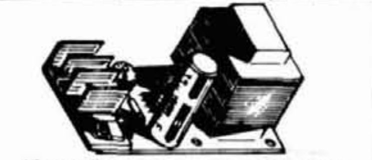

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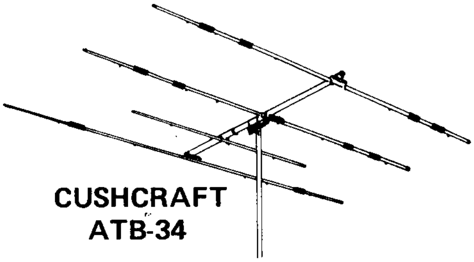

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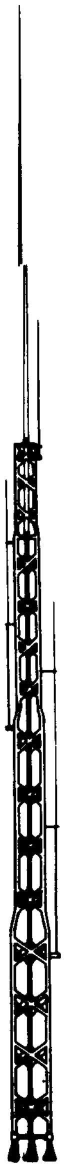

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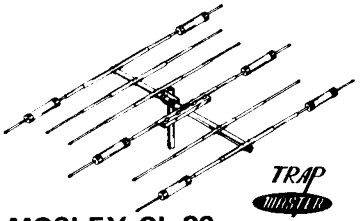

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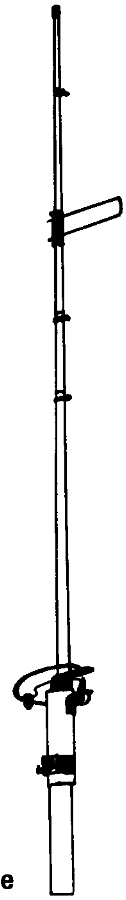

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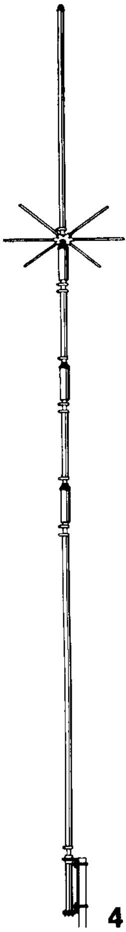

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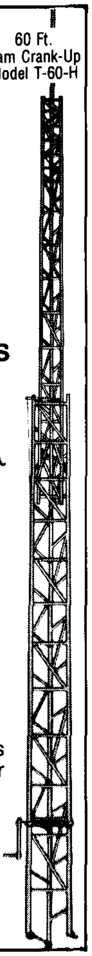

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While we are talking about **clocks** check out the MINI GRANDFATHER CLOCK Reviewed in April 1978 RADIO ELECTRONICS. We have the *only* kit in the world with all the below listed features. The biggest problem is to describe how unique and fascinating this timepiece really is! The LED **"Swinging " Pendulum and Matching Tick-Tock Sound** are available only on our clock. In addition the electronic "bell" notes each hour (ie 3 times for 3 o'clock). Housed in the optional Solid Hardwood Case, the unit makes a beautiful addition to any room.

- ½″4 DIGIT LED READOUT
- Adjustable tone & duration on chime
- Simulated swinging LED Pendulum
- All CMOS Construction
- Quality plated boards
- All electronics switches
- and XFMR included

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Optional Solid Hardwood Case for MG-01 Clock over 10 inches tall. Includes Ruby front. Unassembled.
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Parts

MC1469R	½A positive Voltage Reg.	House#	1.25
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CA3011	Wideband IF Amp IC	House#	.50
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555	Timer & Pulse Gen Chip		.49
741	Op amps 8 pin MINI DIP		.20
LM3900	QUAD OP AMP		.45
723	*Pos Voltage Reg DIP*		.65
725	Ultra low noise high gain Op amp	House#	.99
NE565A	PLL DIP		.50
TCA430	Quad Audio Oscillator Dip		.69
MJ900, MJ1000,	Matched Pair 8A Darlington		Pair/3.00
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2N2712	NPN Small Signal		8/1.00
2N4343	P Channel J Fet		4/1.00
2N6028	Programmable Unijunction		2/1.00
2N6111	PNP Med Power 30W T0220		3/1.00

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.47mfd	@	35V Tant Axial	6/1.00
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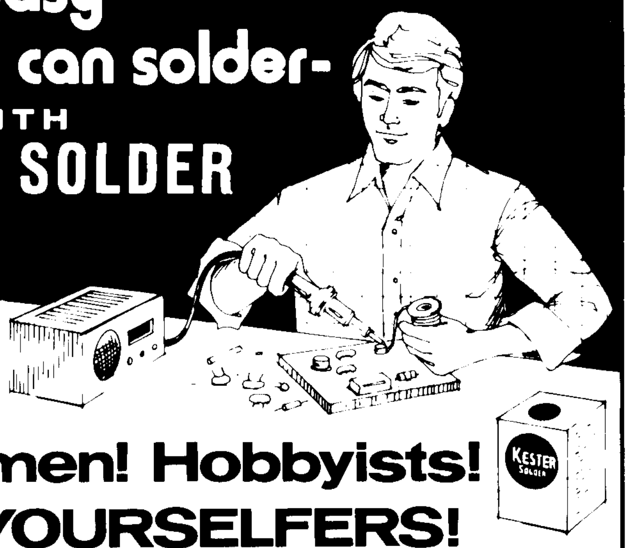

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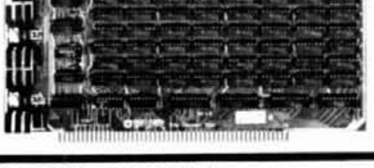

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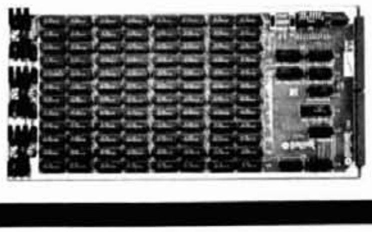

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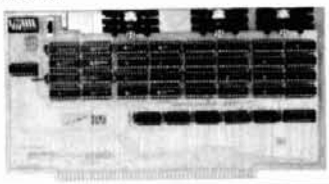

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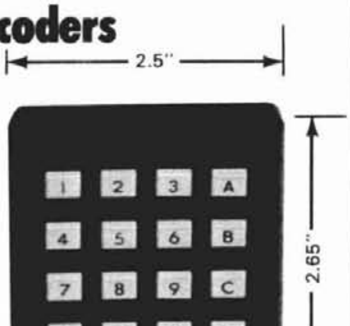

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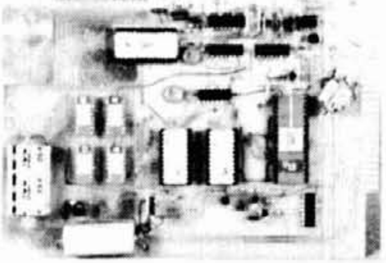

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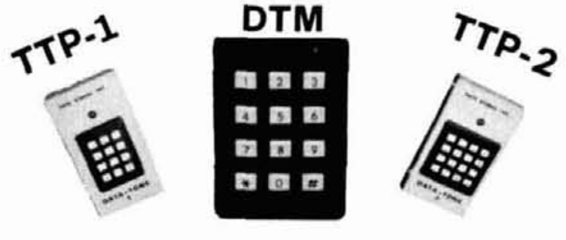

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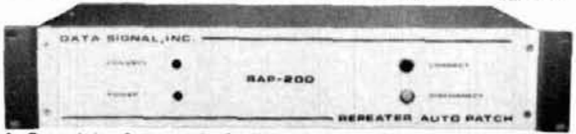

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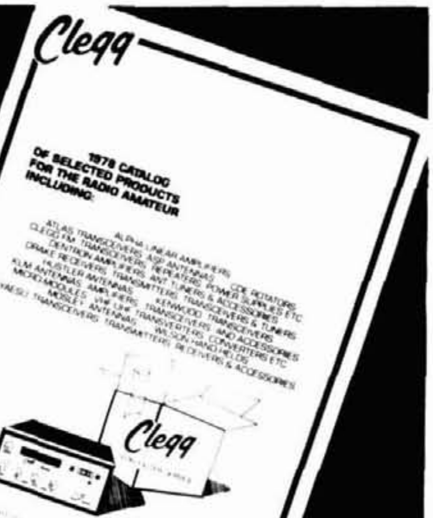

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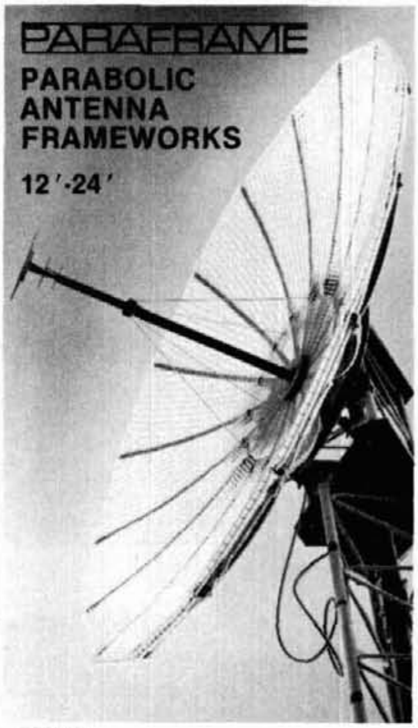

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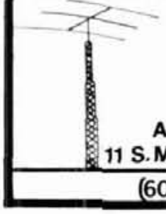

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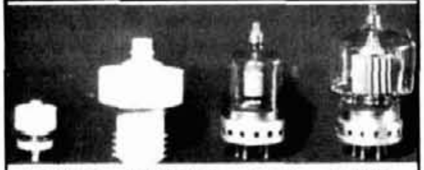

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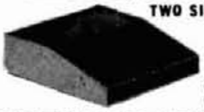

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June 1978

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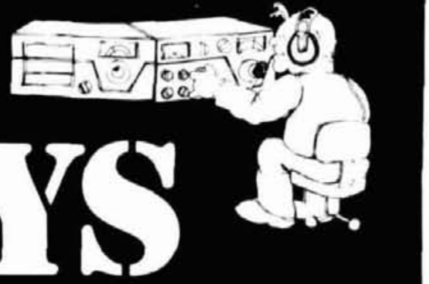

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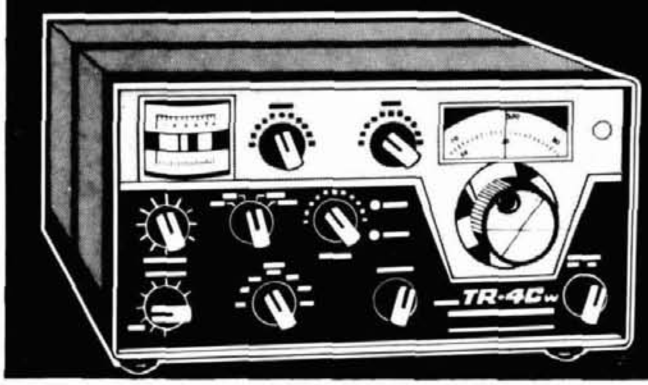

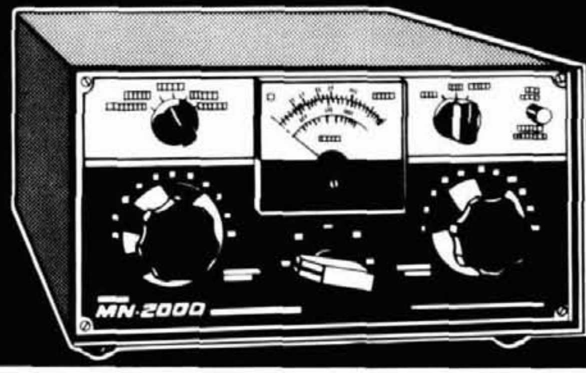

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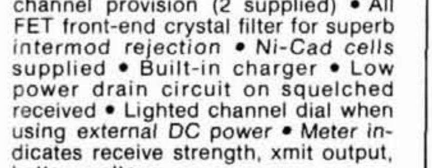

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TR-33C is a mobile 2m FM radio with 12 channel provision (2 supplied) • All FET front-end crystal filter for superb *intermod rejection* • *Ni-Cad cells* supplied • Built-in charger • Low power drain circuit on squelched received • Lighted channel dial when using external *DC power* • Meter indicates receive strength, xmit output, battery voltage.

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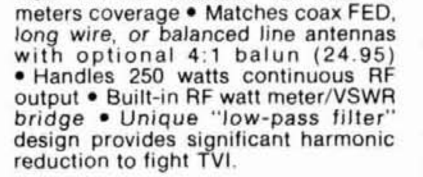

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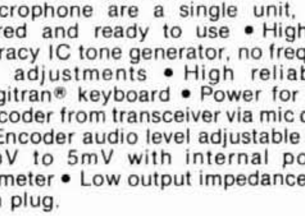

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More Details? CHECK—OFF Page 142

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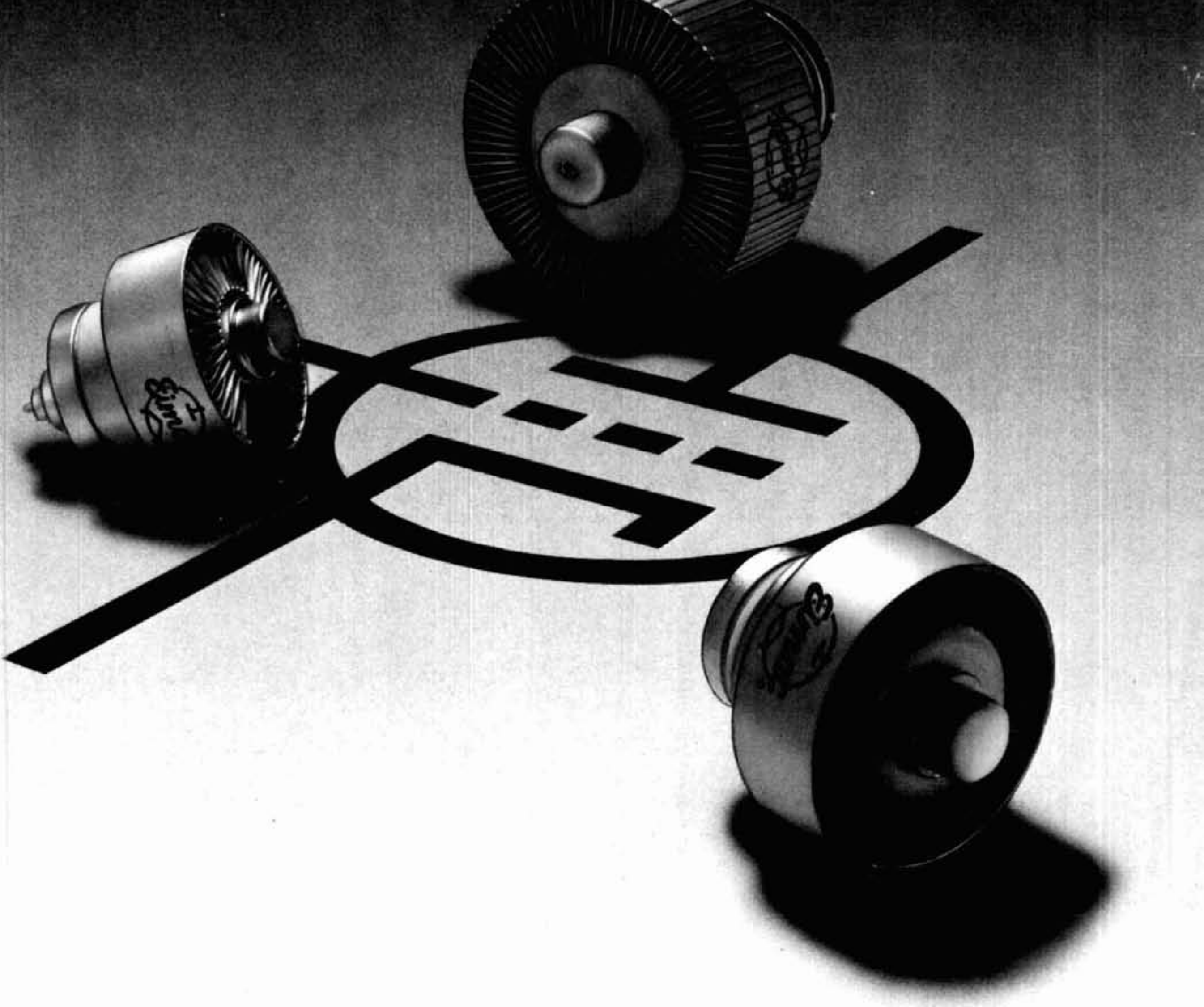

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