one dollar

ham radio magazine

JUNE 1976

vfo design techniques for improved stability

henry radio

a name that says it all

For over 40 years...dedicated to amateur radio...to offering the finest products...to dependable service.

YAESU FT-101E

More radio from the radio company! The new FT-101E includes a potent R.F. speech processor and easy-to-use lever switches. A more refined clarifier control for pushbutton, independent clarifier operation. A 160 meter crystal is included. And all the other features that have made the FT-101 series of transceivers among the world's most popular are still here: 260 watts SSB PEP and globe circling power on CW and AM. 160 to 10 meters range.
The FT-101E $749.00

KENWOOD

TS-520

"The trend setter..the hottest little rig on the air." You have heard it on every band..Kenwood's go-every-place/do-everything transceiver. SSB & CW on 80 thru 10 meters, built-in AC & 12VDC power supply, VOX, RIT, noise blanker and all the other features you want. The 520's low price... $629. Write for full description on the 520 as well as Kenwood's new TS-700A 2-meter transceiver and the R-599D/T-599D "twins."

Henry Radio's

2K-4

The 2K-4 linear amplifier embodies all of the famous features of the 2K-3...rugged construction, reliable performance and heavy duty components, plus unique modern styling. The tilted RF deck faces up for easy visibility and convenient operation. If you are one of the more than 3000 happy 2K owners, trade up to the new 2K-4. If you are not one of the group, now is the time to join.
The 2K-4 (console or desk model). $995.00

Henry Radio's

TEMPO "ONE"

. . . a proven name, a proven value. Look at the specifications, look at the price tag, ask any of the thousands of Tempo ONE owners about its reliability . . . and the reason for its unparalleled popularity will be obvious.
Frequency range: All amateur bands 80 through 10 meters • Operates SSB upper and lower sideband, CW and AM
The Tempo "ONE" $399.00
AC/one, 110-220 volt 50/60 cycle power supply $99.00
DC/1A, 12 volt DC power supply $120.00

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W6ZN
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Ted Henry
W6UOU
LOS ANGELES

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BUTLER

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We stock the Bird Model 43 Wattmeter and accessories.

Prices subject to change without notice.

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NORTH SHORE
RF TECHNOLOGY

The Originators of DUPLEXER "KITS"

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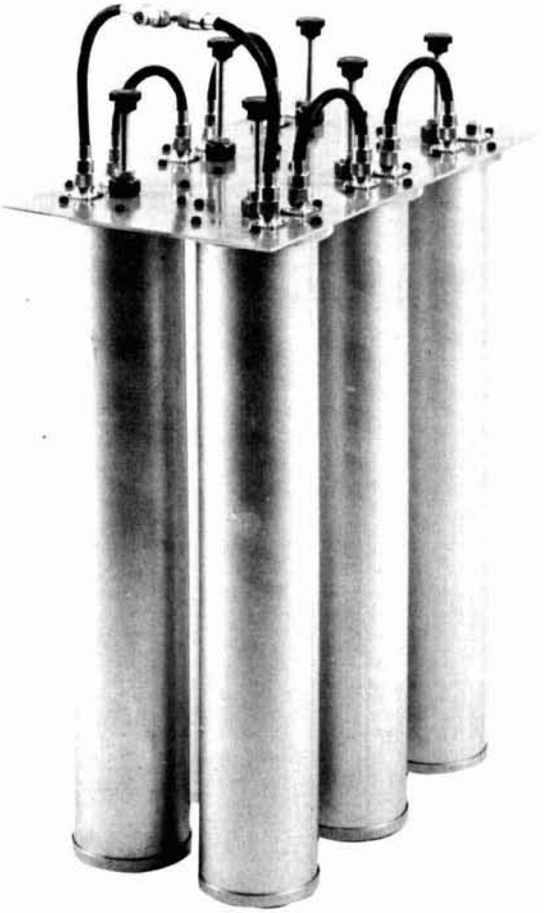

NOW...INTRODUCES ALL NEW IMPROVED MODELS

MODEL: 42-3...4 cavity, freq. range, 140 to 170 MHz, isolation 80db max., insertion loss 0.8db min., freq. spacing 450 KHz min., impedance 50 ohms, power rating 350 watts continuous temp. stable over wide range. Shipping weight 30 lbs. Size 26" x 8-3/4" x 19". Rack mount. **Price $249.**

MODEL: 4220-3...4 cavity, freq. range 220 to 240 MHz, isolation 80db max., insertion loss 0.8db min., freq. spacing 1.3 MHz min., impedance 50 ohms, power rating 350 watts continuous, temp. stable over wide range. Shipping weight 30 lbs. Size 17" x 8-3/4" x 19". Rack mount. **Price $249.**

MODEL: 4440-3...4 cavity, freq. range 430 to 500 MHz, freq. spacing 3 MHz min., isolation 80db max., insertion loss 0.8db min., impedance 50 ohms, power rating 350 watts continuous, temp. stable over wide range. Shipping weight 30 lbs. Size 10" x 8-3/4" x 19". Rack mount. **Price $249.**

Individual cavities...**$65 each.**

NEW INTERDIGITAL BAND PASS FILTER KITS:

All models power rating 250 watts with insertion loss 1db.

MODEL: ID-2... Freq. range 144 to 148 MHz adjustable, 1db band with 2 MHz, 60db band with 10 MHz. Size 1" x 22" x 10". **Price $39.**

MODEL: ID-220... Freq. range 220-225 MHz adjustable, 1db band with 2.5 MHz, 60db band with 12.5 MHz. Size 1" x 13" x 10". **Price $39.**

MODEL ID-440... Freq. range 430 to 450 MHz adjustable, 1db band with 5 MHz, 60db band with 25 MHz. Size 1" x 7" x 10". **Price $39.**

• Easier than ever to assemble and tune • Rugged construction • Easy maintenance • Low cost

NOW..You can get first hand knowledge on how a DUPLEXER works by assembling it yourself and save money, too!

MODEL: 62-3...6 cavity, freq. range, 140 to 170 MHz, isolation 100db max., insertion loss 0.6db min., freq. spacing 450 KHz min., impedance 50 ohms, power rating 350 watts continuous, temp. stable over wide range. Shipping weight 40 lbs. Size: 26" x 10-1/2" x 19". Rack mount. **Price $349.**

ALL..these kits can be assembled and tuned in one evening by following easy to read manual.

THE PERFORMANCE of all units are equal to or better than most commercially manufactured units.

ALL PARTS are professionally made to insure you of first quality performance.

NORTH SHORE
RF TECHNOLOGY

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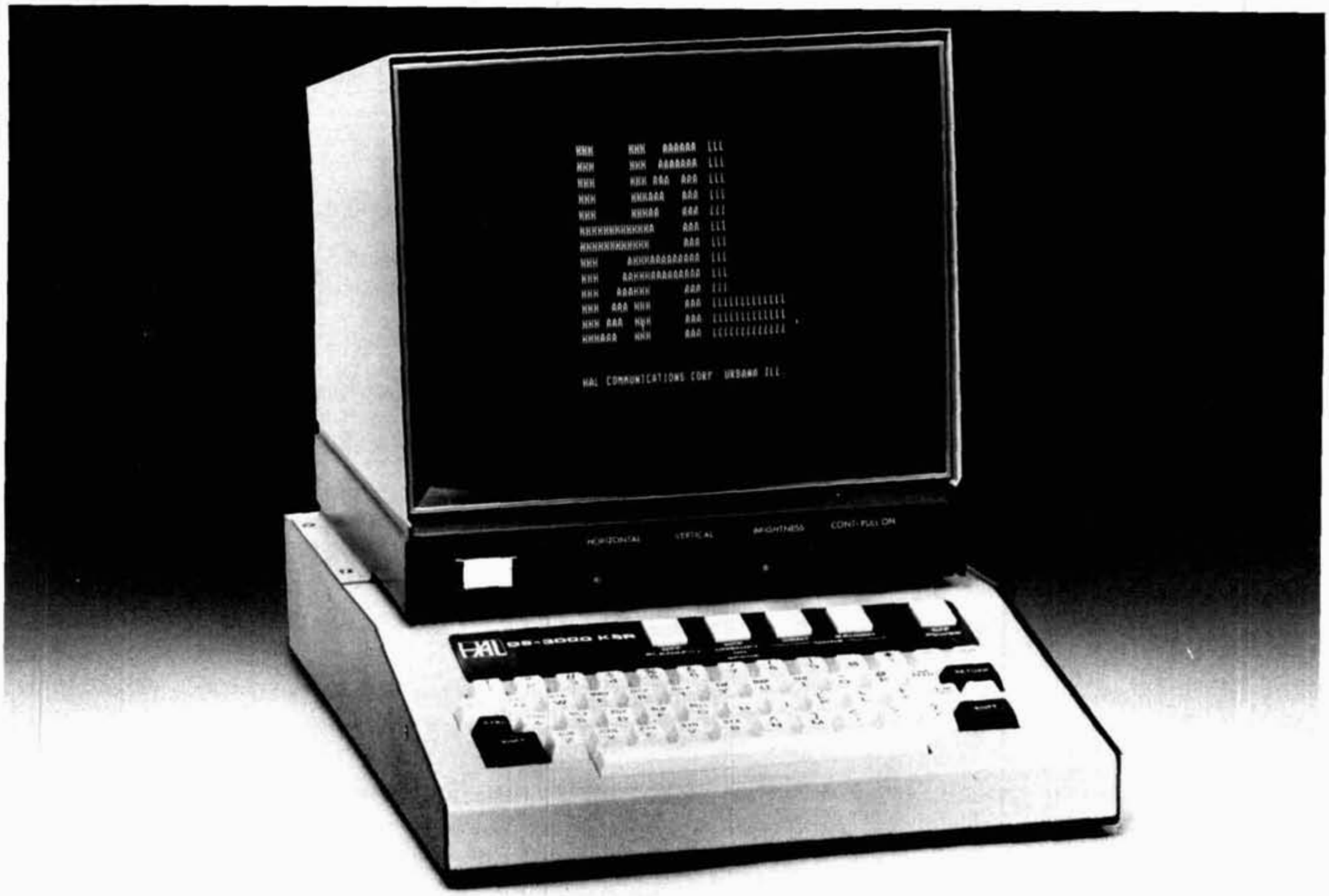
(Prices F.O.B. Medford, Mass. All units can be shipped U.P.S.
C.O.D. orders require $50 deposit. Mass. residents add 5% sales tax.)

Stay tuned for future programs.



The HAL ST-6000 demodulator /keyer and the DS-3000 and DS-4000 KSR/RO series of communications terminals are designed to give you superlative TTY performance today —and in the future. DS series terminals, for example, are re-programmable, assuring you freedom from obsolescence. Sophisticated systems all, these HAL products are attractively priced—for industry, government and serious amateur radio operators.

The HAL ST-6000 operates at standard shifts of 850, 425, and 170 Hz. The tone keyer is crystal-controlled. Loop supply is internal. Active filters allow flexibility in establishing different tone pairs. You can select AM or hard-limiting FM modes of operation to accommodate different operating conditions. An internal monitor scope (shown on model above) allows fast, accurate tuning. The ST-6000 has an outstandingly high dynamic range of operation. Data I/O can be RS-232C, MIL-188C or current loop.

The DS-3000 and DS-4000 series of KSR and RO terminals provide silent, reliable, all-electronic TTY transmission and reception, or read-only (RO) operation of different combinations of codes, including Baudot, ASCII and Morse. The powerful, programmable 8080A microprocessor is included in the circuitry to assure maximum flexibility for your present needs —and for the future. The KSR models offer you full editing capability. The video display is a convenient 16-line format, of 72 characters per line.

These are some of the highlights. The full range of features and specifications for the ST-6000 and the DS series of KSR and RO terminals is covered in comprehensive data sheets available on request. Write for them now—and tune in to the most sophisticated TTY operation you can have today... or in the future.

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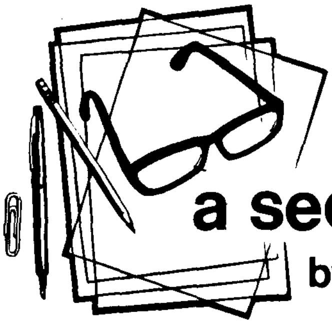


a second look

by Jim Fisk

For the past ten years or so many of the advances in communications circuits and components have been made in the digital area. Although great progress has also occurred in solid-state devices for communications circuits, digital techniques have taken over in many areas previously dominated by more traditional analog circuits – pulse-counting fm detectors, phase-locked loops, frequency synthesizers, high-speed T/R switches, and digital filters are only a few of the more common digital circuits found in modern amateur radio equipment. In the future I expect to see a good deal more innovative digital circuit design as engineers work to improve the operating efficiency and convenience of commercial amateur gear.

When the first low-cost digital circuits became available to amateurs and experimenters in the mid 1960s, the only obvious amateur application was in the electronic keyer. Amateurs soon discovered that frequency calibrators and VOX circuits lended themselves to digital techniques, and digital frequency counters started to replace the venerable BC-221 as the standard for amateur frequency measurement, but other than these somewhat limited applications, digital circuitry seemed to hold little promise for the future of receiver and transmitter design.

However, as the speed of digital circuits increased into the MHz range, and phase-locked loops became commercially available, amateurs were quick to recognize the potential of using these circuits in their own equipment. The equipment manufacturers responded quickly, too, with the result that today's radio gear offers operating accessories and convenience not previously available to the amateur operator. Complex commercial communications circuits that were once considered far too expensive for the amateur market are now commonplace, and recently introduced equipment offers more performance per dollar than most amateurs ever thought possible.

The new Kenwood TS-820 is a prime example of innovative design in amateur radio gear. In addition to such niceties as i-f passband tuning, rf speech processing, rf monitor, rf attenuator, and digital readout (optional plug-in accessory), the TS-820 features the use of a phase-lock filter in the local-oscillator circuit, a first in commercial amateur radio equipment. Although most amateurs have been exposed to the use of the phase-locked loop in frequency synthesizers, this is not its only function. Its original use, in fact, was to filter very noisy signals, and that's how it's used in the new Kenwood transceiver.

In most receivers and transceivers the vfo is mixed with a crystal oscillator signal to provide the required transmit-receive frequency – the vfo always tunes the same low-frequency range to maintain overall stability. The problem with this approach is that, instead of a single injection signal, there are at least four signals present (the vfo, the crystal oscillator, and the sum and difference of both). Since these additional signals cause spurious responses in both the receiver and transmitter, overall operation can be greatly improved if a clean injection signal is available. The phase-locked source is able to suppress all harmonics of the reference frequency by as much as 120 dB – this is inherent in the basic phase-lock circuit and doesn't require any additional filtering.

In the TS-820 the signals from the vfo, crystal oscillator, and carrier oscillator are combined in a phase detector to produce a control signal which sets the frequency and phase of a voltage-controlled oscillator that provides the actual injection signal. The result is a clean sinusoidal injection signal with all control signals attenuated by more than 100 dB. This is the key to the TS-820's very high spurious rejection specification of more than 80 dB.

Although Kenwood is the first to apply this important technique to an amateur transceiver, it is indicative of the innovative thinking of many amateur equipment manufacturers. In the future I expect that amateur equipment designers, inspired by low-cost, high-performance digital circuits, will be able to offer equipment performance and convenience not now available at any price.

Jim Fisk, W1DTY
editor-in-chief

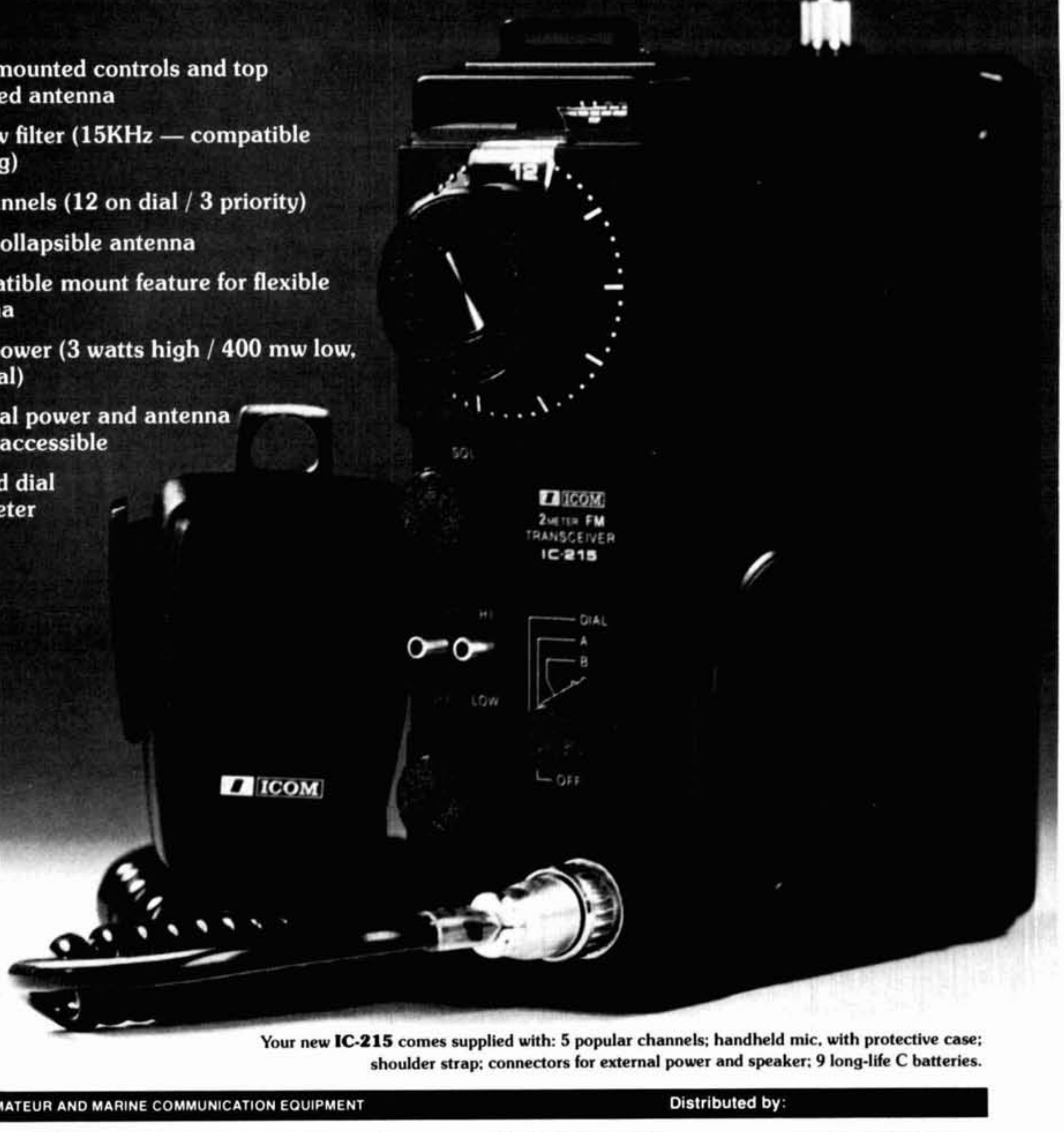
Now ICOM Introduces 15 Channels of FM to Go!

The New IC-215: the FM Grabber

This is ICOM's first FM portable, and it puts good times on the go. Change vehicles, walk through the park, climb a hill, and ICOM quality FM communications go right along with you. Long lasting internal batteries make portable FM really portable, while accessible features make conversion to external power and antenna fast and easy.

Grab for flexibility with the new **IC-215** FM portable.

- Front mounted controls and top mounted antenna
- Narrow filter (15KHz — compatible spacing)
- 15 channels (12 on dial / 3 priority)
- Fully collapsible antenna
- Compatible mount feature for flexible antenna
- Dual power (3 watts high / 400 mw low, nominal)
- External power and antenna easily accessible
- Lighted dial and meter



Your new **IC-215** comes supplied with: 5 popular channels; handheld mic, with protective case; shoulder strap; connectors for external power and speaker; 9 long-life C batteries.

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presstop

EXTRA CLASS LICENSEES who've been on the air at least 25 years will be the first to have their choice of open callsigns as a result of FCC's Report and Order on Docket 20092 released in late April. The Report and Order, which becomes effective July 1, gives first priority to Extra Class licensees already eligible for a one-by-two (e.g., K1AA) callsign for a three-month period starting July 1. Then, after all those eligible during the first period have exercised their options (if they wished to) a second group, which includes all additional Extra Class licensees who were licensed as Extra Class by November 22, 1967, will be eligible to apply for the remaining callsigns of their choice.

Two Additional three-month periods, the first for all who received their Extras on or before July 2, 1974 and the final for those who were Extras by July 1, 1976, follow. After that, presumedly, any Extra Class licensee, no matter how short a time he's been licensed, will be able to apply for the available callsign of his choice.

LONG AWAITED "BANDWIDTH" Notice of Proposed Rule Making has also been approved by the Commissioners and proposes changing the present sub-band divisions by emission type to divisions predicated on maximum permissible bandwidth. Under the terms of the NPRM any type of emission would be permitted on a given frequency as long as it did not exceed the bandwidth limits for that frequency.

The Three Bandwidths proposed in this new and revolutionary approach to dividing up the Amateur sub-bands are 350 Hz, 3.5 kHz and 35 kHz, presumedly equivalent to the present CW, SSB and FM divisions. It's definitely a "deregulatory" proposal, permitting as it does experimentation with new techniques while encouraging spectrum conservation. It also has some serious potential problem areas such as already exist between slow-scan TV users and SSB DXers on the low end of the 20-meter phone band.

RADIO DEALERS MODIFYING Amateur Radio transmitting equipment to operate on CB frequencies are treading on very thin ice, according to a recent conversation with the FCC. Making such a conversion appears to be a violation of Section 302 of the Communications Act since the conversion makes the equipment a piece of non-Type Accepted CB equipment. It probably also puts the dealer in a "Catch 22" type situation — if he has a commercial license he has a good chance of losing it, and if he doesn't he is subject to penalty for working on "commercial" equipment without one.

FCC STUDY GUIDES for both Novice Class and General/Conditional/Technician Class Amateur exams were released by the FCC in April. Though they are very general in scope the guides would be a useful tool for anyone planning to take an FCC Amateur exam.

Copies Of The Study Guides are available from Ham Radio. Send an SASE with 24¢ postage for each guide and be sure to specify which you want.

FCC FORM 610, the application for an Amateur license, is not currently available from the FCC in Washington. Their supply is exhausted and won't be replenished until a revised Form 610 that is currently being developed receives final OK and can be printed — and that's probably a month from now!

Both Ham Radio And ARRL do have some stocks of Form 610 and Ham Radio plans another printing "just in case." A photocopy or other reproduction of Form 610 may also be used — the only stipulation is that reproductions must be the same size as the FCC original.

WRITTEN CW TESTS are likely to be with us for some time to come despite the recent relaxation of the rules to permit code "comprehension" exams. The new procedures still haven't been firmed up, and even after they are it will take a while before new tapes and matching examinations can be produced and distributed. The change should take place some time this year, though — late fall seems likely.

PC-76, THIS YEAR'S "PERSONAL COMMUNICATIONS" TRADE SHOW in Las Vegas, while primarily CB, did have some interesting new items for the many Amateurs who attended. Most exciting was probably Hy-Gain's new all-band (10-160) 200-watt transceiver, which boasts a number of neat features like an LED digital readout with memory for storing and recalling an interesting frequency for later reference. A new entry to two meters is Fieldmaster, which is importing the Multi-2000 and Multi-11 from Japan, and CEPCO had touchtone pads and decoders for Amateur autopatch use. Breaker was showing a VHF mobile antenna line they'll be bringing out this summer under the Hallicrafters name, and Silitronix had the Swan SS-747 in its booth. Henry introduced three new VHF/UHF pocket receivers to complement its popular MR-2, and both Midland and TPL had their Amateur equipment on display. ARRL's booth had a steady stream of visitors, both individual Amateurs and distributers interested in getting in on the forthcoming Amateur Radio boom.

Dentron Amplifies America

We took the most desirable and important features and engineered them into the all new Dentron **Continuous Duty** 160-10 meter amplifier.

160-10L Specifications

Size: 7¼"Hx14½"Wx14"D
Weight: 43 lbs.
Frequency Range: 1.8 MHz (1.8-2.5) 3.5 MHz (3.4-4.6)
7 MHz (6.0-9.0) 14 MHz (11.0-16.0)
21 MHz (16.0-22.0) 28 MHz (28.0-30.0)
Power Input: SSB 1200 P.E.P. Continuous
CW 1000 watt DC Continuous
SSTV 1000 watt DC input 25 minute continuous
RTTY 1000 watt DC input 25 minute continuous
TUNE 1000 watt DC input 15 minute continuous
Output impedance: 50-75 ohms Pi network wide range
VSWR not to exceed 2 to 1
Third-order Distortion: Down at least 30 db

Meter Selector Switch-plate, voltage, Plate Current
Built-in Antenna change over relay
Dual-speed Cooling System
AC Input Source 110V or 220V AC, 50-60 Hz
Automatic Circuit Breaker Protection

160-10L Features

- **160 thru 10 meters**
- **1200 watts P.E.P. on SSB continuous**
- **1000 watts DC on CW, RTTY or SSTV**
- **"On demand" Variable forced air cooling system**
- **Self contained continuous duty power supply**
- **4-811A Triodes in Grounded Grid mounted in cooling chamber**
- **Compact, low profile, solid, one-piece cabinet, tube cooling chamber eliminates need for perforated cabinet.**
- **Covers MARS Frequencies without modifications**
- **Broadbanded input and output circuit**
- **70 watt drive for maximum legal input**

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Another surprise from Dentron, but the biggest surprise of all is the price.
Just $499.50 Post paid USA from Dentron Radio Co., Inc.
Also available from your favorite dealer.

All Dentron products are made in U.S.A.

KENWOOD'S
TS-520

...worth waiting for!

Why wait any longer for a rig that offers top performance, dependability and versatility . . . the TS-520 has proven itself in the shacks of thousands of discriminating amateurs, in field day sites, in DX and contest stations, and in countless mobile installations.

Superb craftsmanship is evident throughout . . . in its engineering concepts as well as its construction and styling . . . craftsmanship that is a Kenwood hallmark.

Maybe the Kenwood TS-520 is the one you have been waiting for.

Kenwood offers accessories guaranteed to add to the pleasure of owning the TS-520. The TV-502 transverter puts you on 2-meters the easy way. (It's completely compatibile with the TS-520.) Simply plug it in and you're on the air. Two more units designed to match the TS-520 are the VFO-520 external VFO and the model SP-520 external speaker. All with Kenwood quality built in.

TS-520 Specifications

MODES: USB, LSB, CW
POWER: 200 watts PEP input on SSB, 160 watts DC input on CW
ANTENNA IMPEDANCE: 50-75 Ohms, unbalanced
CARRIER SUPPRESSION: Better than –45 dB
UNWANTED SIDEBAND SUPPRESSION: Better than –40 dB
HARMONIC RADIATION: Better than –40 dB
AF RESPONSE: 400 to 2600 Hz (–6 dB)
AUDIO INPUT SENSITIVITY: 0.25μV for 10 dB (S+N)/N
SELECTIVITY: SSB 2.4 kHz (–6 dB), 4.4 kHz (–60 dB), CW 0.5 kHz (–6 dB), 1.5 kHz (–60 dB) (with accessory filter)
FREQUENCY STABILITY: 100 Hz per 30 minutes after warmup
IMAGE RATIO: Better than 50 dB
IF REJECTION: Better than 50 dB
TUBE & SEMICONDUCTOR COMPLEMENT: 3 tubes (2 x 6146B, 12BY7A), 1 IC, 18 FET, 44 transistors, 84 diodes
DIMENSIONS: 13.1" W x 5.9" H x 13.2" D
WEIGHT: 35.2 lbs.
SUGGESTED PRICE: $629.00

VFO-520

Provides high stability with precision gearing. Function switch provides any combination with the TS-520. Both are equipped with VFO indicators showing at a glance which VFO is being used. Connects with a single cable and obtains its power from the TS-520. Suggested price: $115.00.

SP-520

Although the TS-520 has a built-in speaker, the addition of the SP-520 provides improved tonal quality. A perfect match in both design and performance. Suggested price: $22.95.

TV-502

TRANSMITTING/RECEIVING FREQUENCY: 144-145.7 MHz, 145.0-146.0 MHz (option).
INPUT/OUTPUT IF FREQUENCY: 28.0-29.7 MHz
TYPE OF EMISSION: SSB (A3J), CW (A1)
RATED OUTPUT: 8W (AC operation)
ANTENNA INPUT/OUTPUT IMPEDANCE: 50Ω
UNWANTED RADIATION: Less than –60 dB
RECEIVING SENSITIVITY: More than 1μV at S/N 10 dB
IMAGE RATIO: More than 60 dB
IF REJECTION: More than 60 dB
FREQUENCY STABILITY: Less than ±2.5 kHz during 1-60 min after power switch is ON and within 150 Hz (per 30 min) thereafter.
POWER CONSUMPTION: AC 220/120V, Transmission 50W max., Reception 12W max. DC 13.8V, Transmission 2A max., Reception 0.4A max.
POWER REQUIREMENT: AC 220/120V, DC 12-16V (standard voltage 13.8V)
SEMI-CONDUCTOR: FET 5, Transistor 15, Diode 10.
DIMENSIONS: 6⅜" W x 6" H x 13¼" D
WEIGHT: 11.5 lbs.
SUGGESTED PRICE: $249.00

CW-520
500 Hz CW Crystal Filter: $45.00.

Prices subject to change without notice

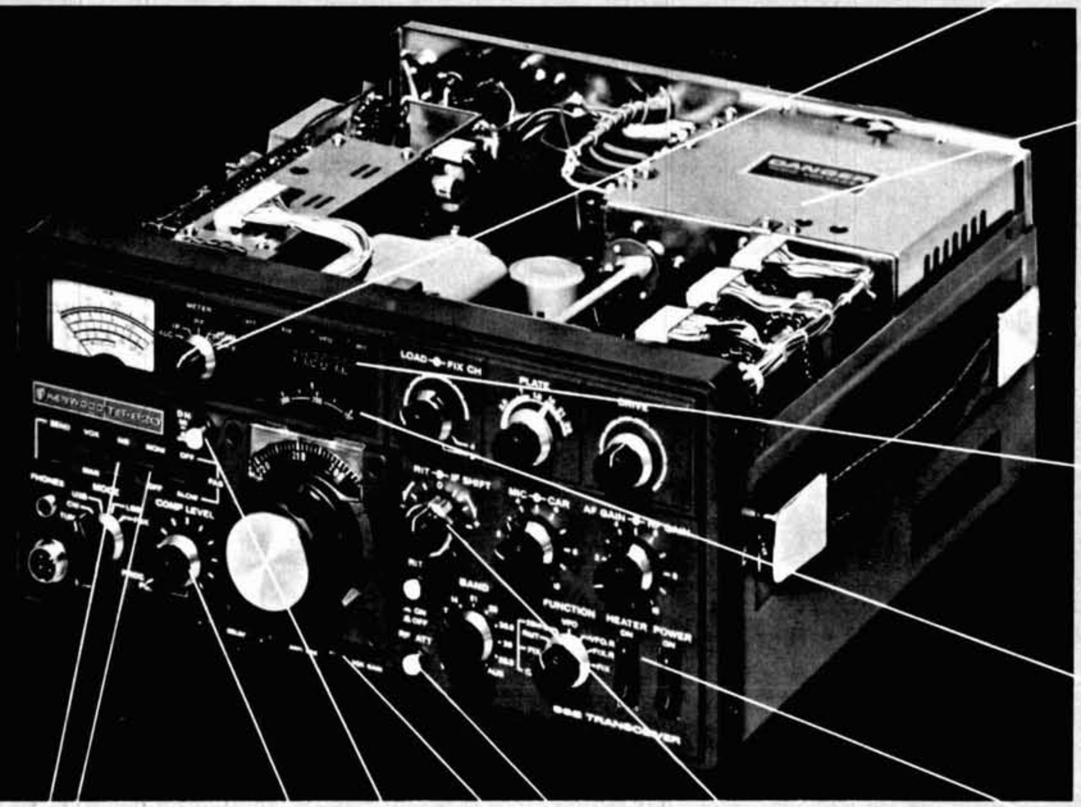
TRIO-KENWOOD COMMUNICATIONS INC.

KENWOOD'S
the TS-820
Pacesetter

LIMITED QUANTITIES AVAILABLE IN JULY

Kenwood's well deserved reputation for fine craftsmanship and superb performance has never been more evident than in the TS-820. As a result of a host of innovative features being brought together, the 820 offers a degree of versatility, performance and pleasure second to none.

The Kenwood TS-820 is destined to be the world's new standard of excellence in amateur radio for years to come . . . a true "Pacesetter".



Features

PLL • The TS-820 employs the latest phase lock loop circuitry. The single conversion receiver section performance offers superb protection against unwanted cross-modulation. And now, PLL allows the frequency to remain the same when switching sidebands (USB, LSB, CW) and eliminates having to recalibrate each time.

FULL METERING • During receive, an easy to read meter functions as an S-meter. The same meter displays ALC level, plate current, RF output, and plate voltage during transmit. Includes COMP setting for adjusting the compression level of the built-in speech processor.

FINAL AMPLIFIER • The TS-820 is completely solid state except for the driver (12BY7A) and the final tubes. Rather than substitute TV sweep tubes as final amplifier tubes in a state of the art amateur transceiver, Kenwood has employed two husky S-2001A (equivalent to 6146B) tubes. These rugged, time-proven tubes are known for their long life and superb linearity. The input power of the TS-820 is conservatively rated at 160 W DC, 200 W PEP. Tubes run cool with the aid of a noiseless fan (standard) mounted on the rear panel. The above tube and power combination minimizes the possibilities of TVI and helps to maintain the Kenwood reputation for excellent audio quality.

DIGITAL READOUT DG-1 • (optional) A digital counter display can be employed as an integral part of the VFO readout system. Counter mixes the carrier, VFO, and first heterodyne frequencies to give *exact* frequency. Figures the frequency down to 10 Hz and digital display reads out to 100 Hz. Both receive and transmit frequencies are displayed in easy to read, Kenwood Blue digits.

DRS DIAL • Includes the same satin-smooth planetary drive found on other fine Kenwood models plus special, high-precision gears to add a new "monoscale" feature for easier frequency readout. LSB, USB, and CW operating frequencies can be accurately read from the same pointer.

HEATER SWITCH • The filaments of the three vacuum tubes may be turned off during periods of "receive only".

CW AUDIO CHARACTERISTICS • During CW reception, a special filter is used to alter the audio frequency response to provide a more comfortable, easy to copy tone.

Other features include:
- Built-in 25 kHz calibrator*
- Built-in speaker*
- CW Sidetone and semi-break in*
- Rear panel terminals for linear amplifier, IF OUT, RTTY, and XVTR.
- Handy phone patch IN and OUT terminals*

*Also available, the VFO-820 . . . the perfect companion to the TS-820.

NOISE BLANKER • The TS-820 uses an efficient noise blanker circuit, another Kenwood exclusive. A special crystal filter assures unsurpassed efficiency in eliminating unwanted pulse noises.

RF MONITOR • Built-in monitor circuit allows you to hear your own voice by sampling the RF signal. Especially useful for adjusting the RF Processor.

HIGH STABILITY VFO • The VFO, heart of any SSB transceiver, is an exclusive Kenwood design using FET technology.

DIGITAL HOLD • A single pushbutton switch offers the operator unprecedented versatility. The digital hold circuit will lock the counter and display at any frequency, but will allow the VFO to tune normally. Ever wanted to return to a certain spot on the band and forgotten the frequency? That won't happen again with the new digital hold feature on the Kenwood TS-820.

SPEECH PROCESSOR • An HF circuit provides quick time constant compression using a true RF compressor as opposed to an IF clipper. Amount of compression is adjustable to the desired level by a convenient front panel control.

IF SHIFT • The IF SHIFT control varies the IF passband without changing the receive frequency. This "IF shift" control is located on the front panel and provides excellent unwanted signal reject control or "pass band tuning." The 820 moves the signal across the IF pass band not the pass band across the signal.

RF ATTENUATOR • Easy, one touch activation of the attenuator supplies 20 dB of padding on receive.

VOX • A voice-activated microphone circuit is built into the TS-820 with VOX GAIN, ANTIVOX, and VOX DELAY controls placed on the front panel for convenient adjustment any time.

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vfo design techniques for improved stability

Complete description of a new and improved solid-state variable-frequency oscillator with exceptional frequency stability

Baffled by the pros and cons of solid-state vfo design? A great many points of view are given in published material concerning vfos, so it's a small wonder that a newcomer to solid-state design finds himself in a state of perplexity when he attempts his first variable-frequency oscillator design. Some amateur writers laud the Franklin vfo circuit, while others express a definite preference for the Seiler or Vackar designs. Each type of oscillator has keynote qualities – even the common Colpitts variety. It can be said without reservation that each in the foregoing list can be made adequately stable for most amateur work by following a few simple design rules. Some guidelines are offered here. They are based on considerable laboratory work, and represent the cream of data which I gathered during the course of three years of investigation.

circuit choice

Having been exposed for many years to tube-type vfos with their confounding tendencies to drift and produce hum-modulated output voltage, the appearance of transistors was a welcome event, indeed. However, It was learned that a significant reduction in heat through the application of semiconductor active devices did not always result in acceptable vfo stability. Furthermore, experience proved that a considerable amount of frequency drift resulted from rf-current heating within the capacitors, transistors, and inductors used in a vfo. Such heating causes changes in component values, and drift prevails. Elimination of ac voltage practically resolved the hum-modulation syndrome in most transistor vfos, as there were no filaments to heat. This advantage also reduced the long-term drift problems related to tube-type variable-frequency oscillators.

Many experimenters, and I was among them, chose the parallel-tuned Colpitts as a practical oscillator. In fact, most commercial designers of amateur equipment still use that breed of oscillator with fets and bipolar transistors. Various stability profiles have resulted from the use of Colpitts vfos, but I have yet to see one – commercial or home designed – that exhibits a long-term drift characteristic better than 60 or 70 Hz from a cold start to some period a few hours later. Worst-case frequency runs have unmasked solid-state oscillators which drifted as much as 2 kHz before stabilizing. After "stability" was attained, it was not unusual to find the oscillator rambling up and down constantly over a 100-Hz range. This characteristic can be distressing,

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especially when the operator finds it necessary to keep readjusting the operating frequency during a QSO. Matters are complicated further when narrow-band i-f filters are employed, say, a 300-Hz passband for *CW* work.

I needed a better vfo than could be provided easily by a simple parallel-tuned Colpitts. At some time during the course of numerous experiments there came an important recollection from vacuum-tube days: best stability always seemed to result when the then-popular series-tuned Clapp vfo was used. It was reasonable to conclude that the principle was applicable in solid-state design work as well. An incredible improvement in long- and short-term drift was noted when tests were performed on the first model built. A succession of circuit improvements followed, each providing greater insight into the causes of drift. Those matters are treated here.

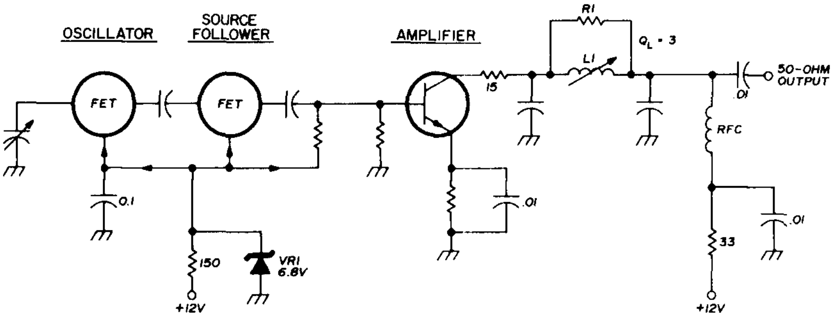

fig. 1. Diagram showing regulated voltage applied to various parts of a vfo circuit. A 50-ohm output pi-network tuned circuit is used at the amplifier output.

observations

A major cause of drift in a bipolar oscillator which contains a parallel-tuned LC circuit is inductance change. Typically, an inductor is used which relies on powdered iron or ferrite as a core material. Slug-tuned coils are common choices because they enable the designer to take advantage of the small size – a product of our present trend toward miniaturization. However, most bipolar oscillators require a high C to L ratio, resulting from the typically low impedance levels of bipolar-device input ports. Because of the foregoing, a 40-meter vfo, for example, might have a total tuning capacitance of 500 pF at its lowest operating frequency, and an inductance of only 1 μH. In this situation we have an inductor which is subject to a high percentage of change when the total inductance varies by only a fraction of a microhenry. Such a change, however slight, will cause a major shift in operating frequency. The change will probably result from slight variations in the core properties of the inductor.

Additionally, mechanical stability of such a circuit is borderline because the leads going to and from the inductor, plus the PC-board elements which are common to that part of the circuit, comprise a significant portion of the inductance. Flexing of the vfo circuit board or chassis can shift the operating frequency markedly. Another disadvantage of a low-L circuit is that the connecting leads related to the coil degrade the tuned-circuit Q by virtue of being parasitic inductances in series with the desired inductance. The foregoing illustrates the undesirable aspects of a high-C, low-L oscillator tank.

In a typical series-tuned vfo tank, an inductance of 4 μH might be required with the same amount of tuned-circuit capacitance, thereby greatly reducing the bad effects just outlined. In an ideal vfo one would not use a coil with a magnetic core. Rather, an air-dielectric inductor of large wire diameter and superb rigidity would be employed. This approach would impose certain physical restrictions which would not be acceptable to many amateur builders – notably those who specialize in assembling compact equipment.

A good practice is to use a slug-tuned coil which has a low-permeability core, and that core should just enter the coil winding at resonance rather than occupy most of the area within the coil. This will minimize thermal drift caused by changes in core properties. Powdered-iron cores are more stable than ferrite ones, and are highly recommended when a core must be used. The slug mechanism should be physically stable when in the coil-form collar. This will help prevent frequency changes caused by slight movement of the mechanical components of the coil assembly.

Perhaps one of the worst cores you can use when striving for optimum stability is a toroid. Changes in core characteristics are quite pronounced as the ambient temperature varies. For casual design work it is possible to get satisfactory results with powdered-iron toroids, but they are best suited to environments where the room temperature is relatively constant. A heavy coating of Q-dope on a toroid coil will enhance stability because the cement will keep the coil winding from shifting position. In fact, doping the windings of slug-tuned coils is similarly beneficial. Ceramic or steatite slug-tuned coil forms are best for vfo work, and phenolic material should be used only when nothing else is available.

It has been more or less standard procedure for amateurs to use silver-mica capacitors in the frequency-determining part of a vfo. The stability characteristics of these units are pretty good, but seldom good enough. That is, the drift characteristics from a given production run of these capacitors may vary considerably when they are placed in an oscillator circuit and checked one by one. I am referring here to temperature tolerance versus rf heating and changes in ambient temperature. Ceramic compensating capacitors can often be added to a vfo which contains silver micas, and eventually a combination can be found which provides acceptable stability. However, this exercise can become one of frustration which most amateurs would like to avoid.

Some experiments with polystyrene capacitors showed a remarkable reduction in nonuniformity with respect to changes from heat. Whenever these low-cost capacitors were used, drift was so minor that compensating capacitors could be eliminated if ideal stability was not a prime criterion. Suddenly, the path to stability was becoming shorter, and I adopted polystyrene capacitors for all succeeding vfos.* The results were always superior to those obtained with plain or dipped silver micas.

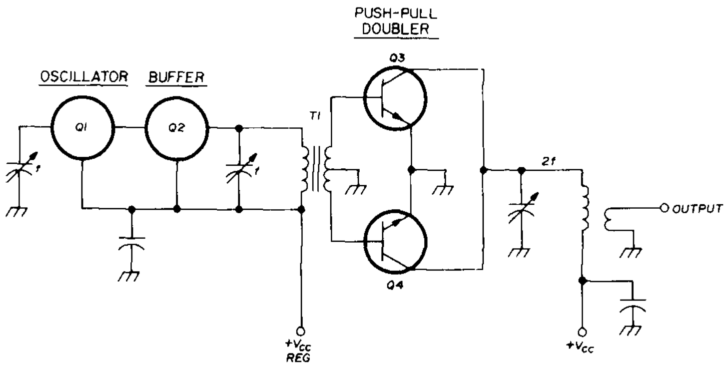

fig. 2. Illustration of a basic push-push class-C doubler.

Another trial-and-error performance standard developed while comparing the drift traits of various trimmer capacitors. It was found that the worst of the lot for vfo applications was the ceramic trimmer. Not only did changes occur in the preset capacitance when ambient temperature excursions took place, but also changes in heat caused additional drift as a result of mechanical shifts in the movable parts of the trimmers. Among the best trimmers I have used are the E. F. Johnson silver-plated, PC-board, air trimmers. The plates are milled rather than manufactured separately. This results in a unit with superb mechanical stability. The Q of these trimmers is also very high.

A further contribution to oscillator stability can be realized through application of moderate operating voltages. That is, if a 12-volt dc supply is available it's better to lower the drain or collector voltage to 6.8 or some other low potential in that general area. Of course, the addition of a zener diode to regulate the reduced voltage is recommended. The reduced operating voltage lowers the oscillator power, which as a result reduces heating and changes in junction capacitance. It is best to develop the required oscillator-chain power *after* the vfo stage by means of class-A buffer/amplifier stages.

Finally, in the long search for improved stability traits, a technique introduced in *QST* by George Hanchett, W2YM, was tested and adopted in all vfos which employed jfets and mosfets[1]. This calls for the addition of a high-speed silicon switching diode from the oscillator gate to ground. The anode is connected to the gate terminal of the device. The principle is one of regulating the transistor bias, which of course enhances stability. Furthermore, the diode clamps on the positive-going sine wave to limit the transconductance, which in turn minimizes changes in junction capacitance. This feature greatly reduces the harmonic currents in the oscillator output – another good design goal. A 1N914A or equivalent diode is satisfactory for the purpose. The beneficial effects are most pronounced when a source-bias resistor is used in the oscillator. If the source return has no appreciable dc resistance, the gate-source junction of the fet tends to perform the same function as the diode, but not as completely. Therefore, some improvement is always obtained by adding the diode.

isolating the load

Stability is not totally dependent upon the oscillator parameters. Changes in the load to which the vfo is connected will cause phase shifts which change the oscillator frequency. The condition is seen when studying a chirpy CW signal. Of course, unwanted rf which is allowed to get into the vfo circuits can cause a similar condition, but we shall ignore that matter here.

Because of the effect load changes bring about, the lightest amount of coupling practicable should be used between the oscillator output and the stage to which it is connected. It is not recommended that series resistance be placed in the signal line (in series with the output voltage), even though this is done by some designers to reduce the coupling. The addition of series resistance contributes to vfo noise output, which is a very undesirable characteristic: a well-designed vfo should have a noise plateau 90 dB or more below the desired energy output level. This is especially true when the vfo is used in a receiver. For this reason it is best to use capacitive coupling from the oscillator, making the capacitor as small in value as can be tolerated. Additionally, the succeeding buffer stage should represent a fairly high input impedance to lessen oscillator loading. An fet

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*Based on ARRL laboratory findings, polystyrene capacitors are suitable for applications from dc to at least 30 MHz source follower makes a fine buffer stage in this case. Polystyrene coupling capacitors are recommended between the vfo and buffer stages, as changes in capacitance due to heating will cause minor changes in the operating frequency of an oscillator.

I have always obtained the best results by having two isolating stages after the oscillator. An fet source follower with a broadly resonant source circuit will increase the signal level to the second buffer, and this is desirable when very light oscillator coupling is used. The second buffer can be a bipolar transistor operating in class A. This will amplify the signal to a practical level for most amateur work, and will add to the isolating properties of the overall circuit. When sufficient power is available from the source follower, the last stage (buffer/amplifier) may be operated in class C, but this will increase the harmonic currents in the collector circuit. Forward bias for the bipolar amplifier should be obtained by means of the usual resistive divider, but the voltage source for the divider should be a regulated one – typically the same one used to power the oscillator. This practice will also help reduce load changes. An example of the principle is shown in **fig. 1**.

Shown also in **fig. 1** are the details of a recommended output network for minimizing oscillator pulling from load changes. The rationale calls for a low-impedance output port . . . in the region of 50 ohms. The goal is not one of impedance matching. Rather, it is to develop a low characteristic output impedance which will be relatively immune to external load changes. In most practical circuits the transmitter stage which follows the oscillator chain is operated in class A, and uses a bipolar transistor. This puts the input resistance of the outboard stage in the region of 500 to 1000 ohms for low-level amplification. Since the characteristic impedance is somewhat higher than that of the last vfo buffer, changes in level have a minor effect on the oscillator chain.

L1, C1 and C2 comprise a pi network in **fig. 1**. This increases the output voltage and discriminates against harmonics. To ensure ample bandwidth for the vfo tuning range a low-Q network is employed. Furthermore, it is helpful to shunt L1 with a swamping resistor – usually 3300 to 5600 ohms. If the output transistor has a high beta, some instability can occur when the oscillator chain is connected to a high-impedance load. It's the usual open-loop gain syndrome versus unconditional stability. Therefore, R1 assures stable operation even when no load is connected to the overall vfo circuit. R1 also increases the bandwidth of the buffer/amplifier.

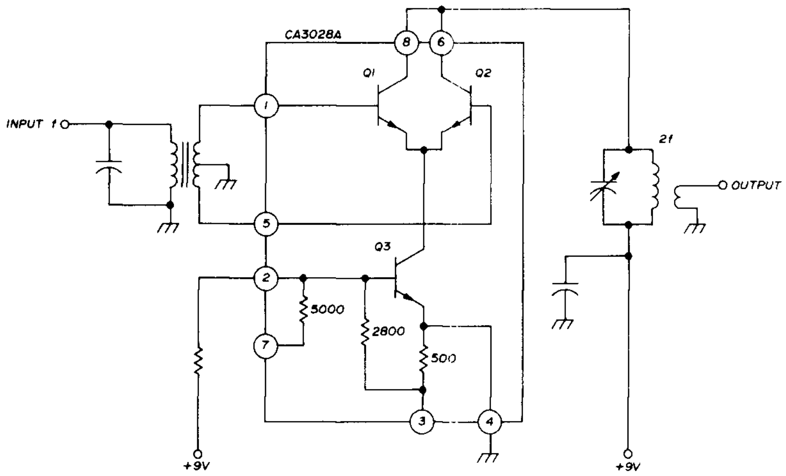


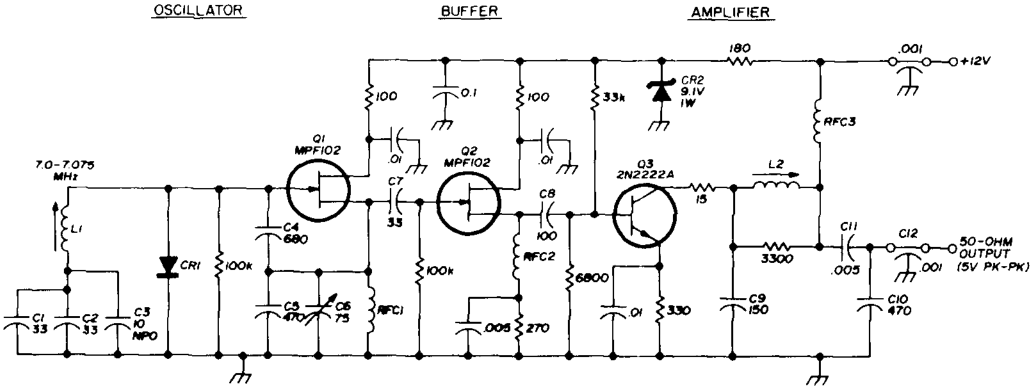
fig. 3. A method for using the matched characteristics of a CA3028A IC in a push-push doubler, as suggested by W7ZOI.

mechanical considerations

A generally accepted practice these days is to use double-sided PC board in solid-state work. The back side of such boards is used as a ground plane to minimize rf current loops and to discourage vhf and uhf parasitic oscillations. The technique is a good one indeed, but it can greatly complicate a vfo design if double-sided board is used in the immediate vicinity of the oscillator. The etched circuit-board elements function in combination with the ground plane to form numerous low-value capacitors, and the epoxy or phenolic insulating material of the PC board becomes the dielectric element of the capacitors. Capacitors of this kind are low in Q and can degrade the oscillator tuned circuit. Worse yet, capacitors formed in that manner are extremely subject to changes in value as variations in ambient temperature occur. As a general rule, therefore, no part of the oscillator chain should be built on double-clad board, just to stay on the safe side of things.

The entire vfo assembly (buffers included) should be housed in a shielded enclosure. This will help to reduce long-term drift and will offer isolation against stray oscillator radiation. The technique will also prevent rf from circuits external to the vfo from entering the oscillator chain. The shield-box walls should be quite rigid to prevent them from moving toward or away from the tuned-circuit elements of the oscillator as this would cause changes in frequency.

The vfo main-tuning capacitor should be of the double-bearing variety. It should have a shaft which turns with minimum torque, and should be driven by a smooth-running reduction mechanism. There should be no significant stress required when changing the operating frequency from the front panel of the equipment. Also, the rotor of the tuning capacitor should be grounded at both ends of the frame. Variable capacitors with aluminum plates have a greater drift characteristic than those with plated brass vanes. I personally prefer the latter.



X_{L1}	265 ohms	X_{C3}	2275 ohms	X_{C7}	690 ohms	X_{C11}	4.5 ohms
X_{L2}	140 ohms	X_{C4}	33 ohms	X_{C8}	227 ohms	X_{C12}	23 ohms
X_{C1}	690 ohms	X_{C5}	48 ohms	X_{C9}	152 ohms	X_{RFC1}	4400 ohms
X_{C2}	690 ohms	X_{C6}	303 ohms (minimum)	X_{C10}	48 ohms	X_{RFC2}	4400 ohms

C1,C2,C4,	polystyrene capacitor (Mallory type SX or equivalent)
C5, C6, C7, C8	75 pF miniature air variable, double-bearing type (one section of a Miller 2109 suitable)
C9,C10	dipped silver-mica capacitor
CR1	high-speed silicon switching diode (1N914A or equivalent)
L1	variable inductor, 6 μH nominal (Miller 42A686CBI)
L2	variable inductor, 3.2 μH nominal (Miller 23A47RPC)
RFC1,RFC2	100 μH miniature rf choke (Millen J301 type)
RFC3	500 μH miniature rf choke (Millen J301 type)
Z1	9.1-volt, 1-watt zener diode

fig. 4. Schematic diagram of a practical 7-MHz vfo. Fixed-value capacitors are disk ceramic unless otherwise indicated. Resistors are 1/2 watt composition.

another isolation technique

It was learned many years ago by tube-oriented amateurs that oscillator pulling from load changes could be reduced significantly by operating the oscillator one octave lower than the desired output frequency. The principle has merit, and is completely germane to solid-state design work. It was not uncommon to find amateurs using a 40-meter vfo which employed a 3.5-MHz oscillator. Of course, a frequency doubler had to be included in the oscillator chain, but most designs used a single-ended multiplier.

Better multiplier efficiency can be obtained by using a push-push doubler, as it has an efficiency profile nearly equivalent to that of a straight class-C amplifier. **Fig. 2** shows a circuit example of a push-push doubler. It can be seen that the drive to Q3 and Q4 is supplied in push pull by means of T1. However, the collectors of the class-C transistor pair are in parallel. The collector tuned circuit is resonant at twice the drive frequency. If good dynamic balance is effected at Q3 and Q4, the output waveform will be nearly a pure sine wave at the desired frequency. The example does not show the necessary balancing controls for discrete devices. A practical vfo circuit which includes the required components is presented later in this paper.

Dynamic balance is important in a push-push doubler to ensure that a minimum amount of the driving frequency appears at the doubler output port. In laboratory experiments it was learned that a well balanced push-push doubler yielded a clean output waveform when a 1000-ohm resistor was used in place of the tuned circuit. However, because of the *IR* drop imposed by the resistance there was a marked reduction in doubler output power.

An interesting approach to effecting dynamic balance was suggested to me during an exchange of correspondence with W7ZOI. He offered that the use of a CA3028A IC would practically eliminate the need for balancing controls in a push-push doubler. This is because the bipolar transistors on the IC substrate have nearly identical characteristics, because they are manufactured from the same silicon slice in a given production run. **Fig. 3** shows how a CA3028A or similar IC might be configured to function as a doubler. The resistances shown inside the rectangle are those which are part of the IC. Terminal 4 has been grounded in this example, and a 2200-ohm resistor has been placed in the base lead of the current source, Q3. In this arrangement Q3 is saturated, bringing the emitters of differential pair

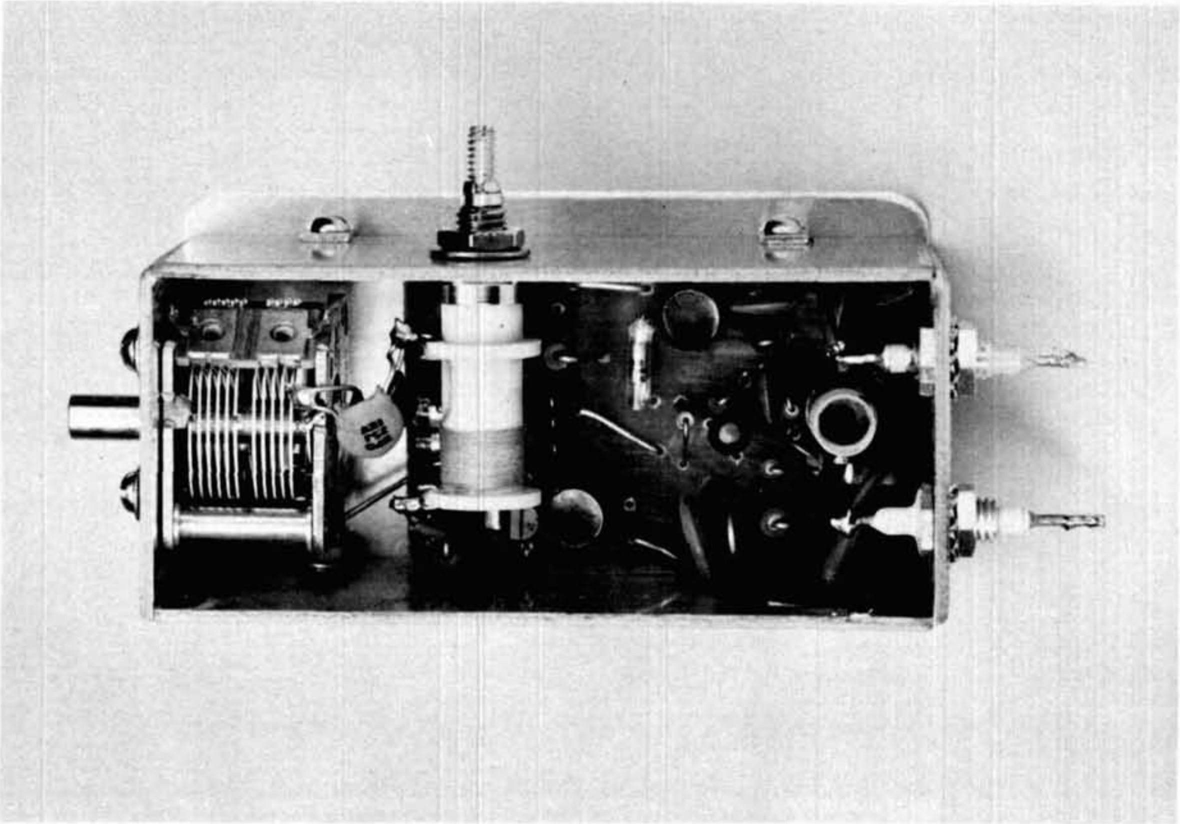


fig. 5. View of the assembled 40-meter vfo. The silver-mica capacitor at the right of the large coil was replaced by a polystyrene unit, as was the one between the coil and tuning capacitor. The vfo shield box is made from sections of double-sided PC board. When in use, an aluminum top cover is pressed in place (friction fit) to completely enclose the circuit.

Q1 and Q2 to dc and rf ground. The differential pair of transistors now operates in class C. A test of this circuit indicated excellent dynamic balance without any need for external tweaking controls.

some practical vfos

Fig. 4 illustrates the circuit for a practical 40-meter vfo chain. The circuit can be scaled to other operating frequencies in the medium- and high-frequency spectrum by using the X_L and X_C values listed to compute the coil and capacitor values. The results will bring the circuit into a workable area. Final adjustments for frequency and bandspread can be done experimentally.

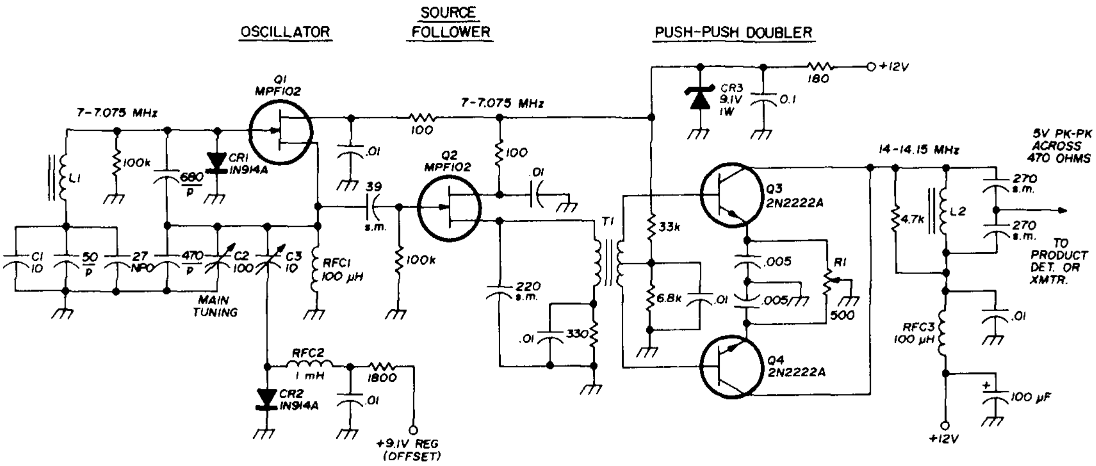
Maximum drift with this circuit (cold start to a period three hours later, at 25°C) was 25 Hz. Only 30 seconds were required to reach the point of maximum frequency change (25 Hz), and the major part of that change resulted from junction heating at Q1, plus the slight heating within the coil and capacitors of the gate tank, caused by the flow of rf current. After stabilization occurred, a "hunting" of no more than 5 Hz was noted. RFC1 and RFC2 are broadly self-resonant at 7 MHz with the existing stray circuit capacitance.

Three series capacitors are used at the lower end of L1. It was learned during lab experiments that drift could be reduced considerably by paralleling two or more capacitors in that part of the circuit. The improvement comes from a division of rf-current flow among several capacitors rather than one. Therefore, the heating effects on any one capacitor are greatly reduced. In general terms, the same technique applies to the feedback capacitors, C4 and C5.

The output energy from this circuit is quite clean. The noise is at a low enough level (-90 dB or greater) to be beyond meaningful measurement with a basic spectrum analyzer setup. The second harmonic was down in excess of 36 dB, and the third harmonic was 45 dB below the fundamental output. Greater spectral purity can be had by inserting a 50-ohm half-wave filter in the output line. However, for most amateur applications it is unnecessary to sanitize the output waveform to that extent.

It should be noted that C12 of **fig. 4** is a 0.001-μF feedthrough type capacitor. The combined value of C10, C11, and C12 serve as the output capacitance of the pi-section tank. In this arrangement the feedthrough capacitor is used also as a feedthrough terminal on the shield enclosure. The details can be seen in the photograph (**fig. 5**).

Immunity to load changes was checked by placing a dead short across the circuit output at C12. The frequency change was noted by means of a counter. The shift from an open circuit to a dead short was only 40 Hz. The pi network was modified to have a characteristic output impedance of 1000 ohms. From an open to a shorted condition the frequency changes almost 400 Hz. This indicates the value of having a low output impedance in an oscillator chain.



C1,C3	subminiature PC-board-mount air trimmers (Johnson 189-507-5 or T-9-5)
C2	100 pF miniature air variable (large gang of Miller 2109 suitable)
L1	7.6 µH toroidal inductor. 37 turns no. 24 (0.5mm) enamelled wire on Amidon T-68-2 toroidal core (see text)
L2	1 µH toroidal inductor. 14 turns no. 22 (0.6mm) enamelled wire on Amidon T-50-6 toroidal core
R1	500-ohm PC-board-mount control
T1	toroidal transformer. Primary, 2 µH. Use 23 turns no. 24 (0.5mm) enamelled wire on Amidon T-50-6 toroidal core. Secondary is 20 turns no. 24 (0.5mm) enamelled wire (center tapped) over primary winding. Observe same rotation sense when winding
Z1	9.1 volt, 1 watt, zener-diode regulator

fig. 6. Schematic diagram of the vfo and doubler for 20-meter use. Fixed value capacitors are disk ceramic unless noted otherwise. P = polystyrene. SM = silver mica. Fixed-value resistors are 1/2-watt composition.

practical push-push doubler

An oscillator chain was needed for use with a QRP transceiver which contained a direct-conversion receiver and a straight-through transmitter strip. The operating frequency of the transceiver was 14 MHz. Rather than tackle the problem of instability at 14 MHz, it was decided that a 7-MHz vfo would be used with a push-push doubler. Also, such an arrangement would minimize the occasion for chirp during CW transmit periods. The circuit under discussion is illustrated in **fig. 6**.

The oscillator is similar to that of **fig. 4**. However, a tuned toroidal tank is used in the source of the intermediate stage, Q2, rather than an rf choke, as was done in **fig. 4**. T1 is necessary in order to furnish drive to the doubler in push-pull. A center-tapped secondary winding accomplishes that. Forward bias is applied to Q3 and Q4 to make the doubler easier to drive. In operation, the transistors are driven into the class-C region and the efficiency is good.

Since discrete devices are used at Q3 and Q4, some means for establishing dynamic balance is required. For that purpose R1 has been included in the circuit. It is adjusted while the circuit is operating, and is set at a point which provides best output-waveform purity. Examination of the output energy was done while using a Tektronix 453 scope (50-MHz bandwidth). There was no visual evidence of 7-MHz or harmonic energy on the waveform after R1 was properly set.

The characteristic impedance of the output port of this oscillator chain is approximately 500 ohms. The lower 50-ohm output condition recommended earlier is not necessary in this design because of the excellent isolation afforded by the doubler. The 4700-ohm swamping resistor across L2 is used to broaden the response of the tuned circuit to permit uniform voltage output from 14 to 14.15 MHz.

Fig. 7 shows a breadboard version of the circuit on a test fixture with a direct-conversion receiver. A toroidal inductor was tried at L1, and once doped with cement provided acceptable stability in a near-constant temperature environment. The circuit would be entirely suitable for most home-station applications, but is not recommended for portable use where temperature excursions are the rule rather than the exception. The inductor specified in **fig. 4** is better suited for general use of the variable-frequency oscillator.

Stability tests were run with a slug-tuned coil at L1, but without a shield box around the vfo assembly. The drift characteristics were similar to those of the vfo in **fig. 4**, but the change was multiplied by a factor of two because of the frequency doubler, Q3 and Q4. Total drift over a three-hour period was roughly 70 Hz. Slightly greater "hunting" took place after stabilization because of slight air currents in the room. The hunting never exceeded 15 Hz, however.

When a dead short was placed across the doubler output port, a maximum frequency change of 15 Hz was observed. This illustrates the good isolation properties of a frequency multiplier when used in a vfo chain. No sign of chirp could be detected on the transmitter signal while monitoring the CW with a receiver set for a 300-Hz i-f bandwidth.

An offset circuit is shown in the oscillator of **fig. 6.** CR2 is used as a diode switch to offset the vfo frequency by approximately 700 Hz during receive (necessary with direct-conversion transceivers). C3 is set to provide the required offset amount while CR2 is saturated by application of 9.1 volts regulated (available at Z1). C1 is used to calibrate the vfo if a toroidal inductor is used at L1. It need not be included if a slug-tuned coil is employed.

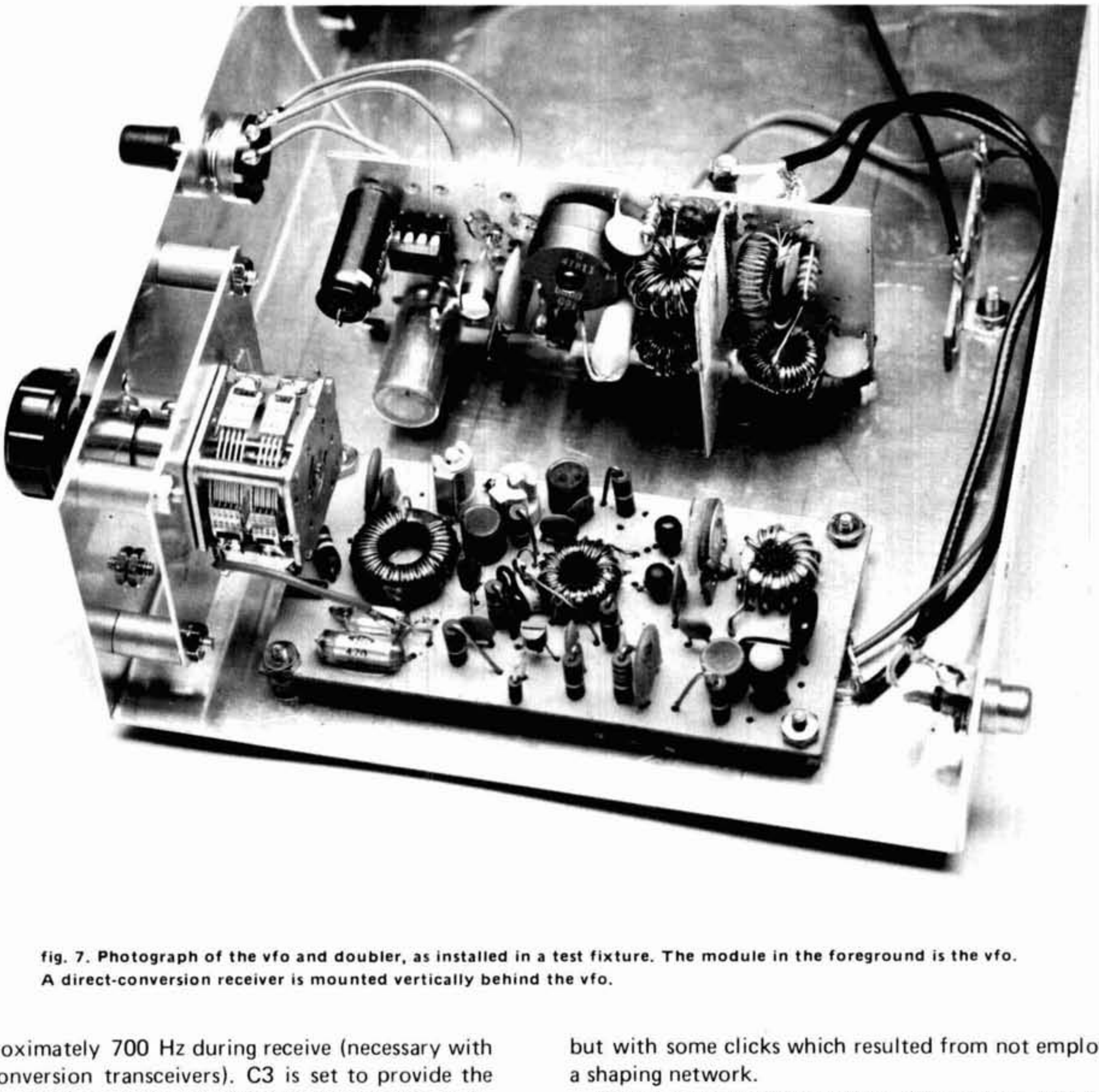


fig. 7. Photograph of the vfo and doubler, as installed in a test fixture. The module in the foreground is the vfo. A direct-conversion receiver is mounted vertically behind the vfo.

summary comments

A 160-meter version of the vfo shown in **fig. 4** was built for use in a 10-watt CW transmitter.[2] No drift could be measured with a frequency counter. The last digit of the counter rambled up and down 1 Hz, but that was the maximum amount of change noted during 15 individual attempts to measure the drift over a period of several days. It is entirely possible that through chance luck an exceptional group of capacitors was installed in the oscillator the first time around. But, when the circuit was duplicated later the same results were noted.

All of the vfos discussed here were subjected to direct keying by breaking the supply voltage line to the oscillator. In each instance a chirpless CW note was obtained, but with some clicks which resulted from not employing a shaping network.

Perhaps the basic guidelines offered here will be of value to amateurs who enjoy building their own solid-state equipment. The information should supply the basis for innovation, and who knows? Someone may develop a 7-MHz vfo that is as stable as the one for 160-meters discussed in the foregoing text.

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ham radio

time/date printout for RTTY

Multiplexer ICs and a PROM are combined in a circuit that transmits ID information in a 32-character format

The time printout is becoming popular with RTTY operators as a 10-minute ID check and as a useful addition for auto-control stations. This article shows one way to make your own programmable stunt box with enough variations to allow customization to fit your own preferences. The unit prints out time, date, and 16 characters. My unit prints out UNIVERSAL TIME 2146-02/12/75, as an example.

The heart of the unit is a 256-bit programmable read-only memory (Monolithic Memories 6330 or Signetics 8223). This PROM is the equivalent of a 256-diode matrix (32 x 8) in a 16-pin dual in-line package. Not included in the article is the digital clock proper as many such circuits are available; however, only those clocks with TTL levels and BCD format can be used. For simplification, the logic is designed to transmit two full stop pulses (8.0).

circuit description

The schematic is in two parts, timing and control (**fig. 1**) and information transfer (**fig. 3**). The output message is thirty-two 8-bit words. A word is one RTTY character, consisting of 1 space, 5 information, and 2 stop bits. Sixteen characters are directly read out of the PROM. They may be any message/operation and may occur before or after the time readout. The other 16 characters are read from a 4-pole 16-position multiplexer and may be programmed for the desired time format.

timing and control

Integrated circuits U1-U4, the oscillator and countdown chain, provide the timing pulses for the baudot divider, ICs U5-U8. When S1 is in the 60 position (**fig. 1**) U5, a 4-pole, 2-position multiplexer, switches to divide 1 kHz by 22 to obtain the 45.45 Hz baud rate (22 ms pulse width) for 60 wpm. When S1 is in the 100 position, the multiplexer switches and sets up to divide 10 kHz by 132 to obtain the 75.75 Hz baud rate (13.2 ms pulse width) for 100 wpm. U9, U10 provide the binary timing sequencing of the serial output and are held in reset when the circuit is nonoperating. U11A U11B are a flip-flop that starts the circuit functioning when S2 is depressed.

Relay driver Q1 turns on during operation and energizes relay K. Relay K contacts, placed across your loop transistor emitter-base terminals, turn off the loop transistor during the time-sending operation. U11C gates the serial time pulses, which are inverted by U11D, and

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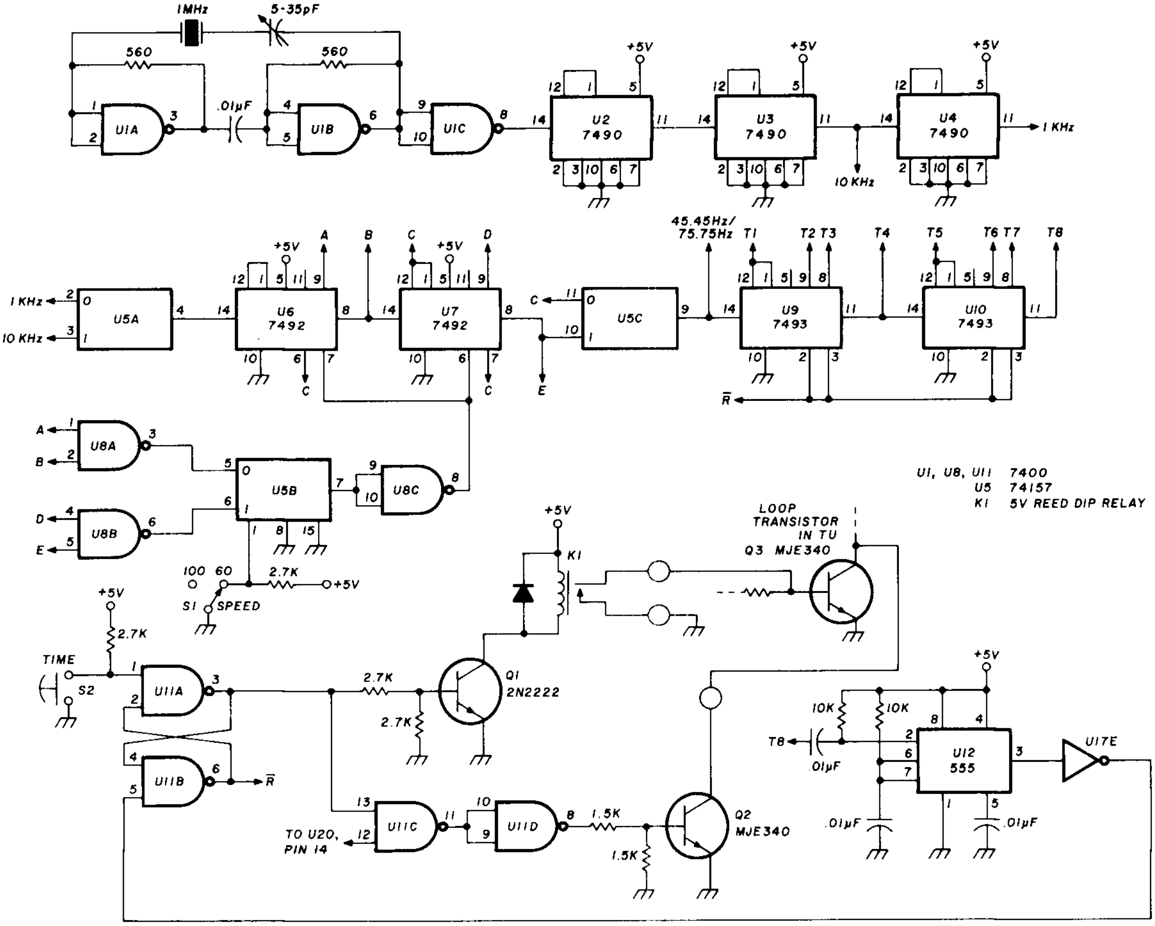

fig. 1. Timing and control schematic showing oscillator-divider chain, baudot divider, binary timing sequencer, and loop control circuits.

enables Q2, the loop transistor used during the time transmission. At the end of the time transmission T8 goes to zero, triggering one-shot U12. U12 resets flip-flop U11A, U11B, which ends the time transmission.

information transfer

U13-U16 (**fig 3**) are 16-position multiplexers that act as a 4-pole, 16-position switch whose position is controlled by timing pulses T4-T7. **Table 1** shows how I connected the inputs from the clock and the hard-wired control characters. The multiplexers sequentially look at the BCD time from the clock, and the date from the thumbwheels and wired operations, then send this information through U18 to the PROM, U19, for baudot coding. **Table 2** shows the relationship between the input address and the stored character conversions.

When T8 is low on the S input of U18, a 4-pole, 2-position multiplexer, the outputs look at the zero inputs, and timing pulses T4-T7 operate the PROM directly. T8 is also sent to the PROM (A4) and addresses the first half of the PROM. The first half of the PROM is sequentially addressed by T4-T7, reading out the programmed message from **table 2**. When T8 is high, U18 S input is high, and U18 switches to read the 4-bit information from multiplexers U13-U16. When high, T8 also switches the PROM to read the second half of the memory (**table 2**). The PROM is addressed randomly according to the input information.

The PROM has 8 output bits, but I used only 5 (the needed information bits). The other 3 bits could be used for the start and stop bits but are hard-wired in the output multiplexer, U20. U20, a 1-pole 8-position multiplexer controlled by T1-T3, is sequenced through at every address selected by the PROM and adds the start and 2 stop bits to the 5 information bits.

circuit operation

Set S1 to the machine speed. Depress S2. U11 goes high and turns on Q1, which energizes relay K, turning

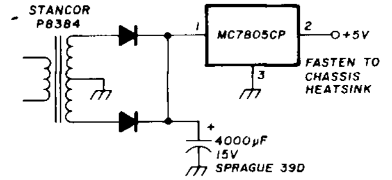

fig. 2. Regulated power supply schematic.

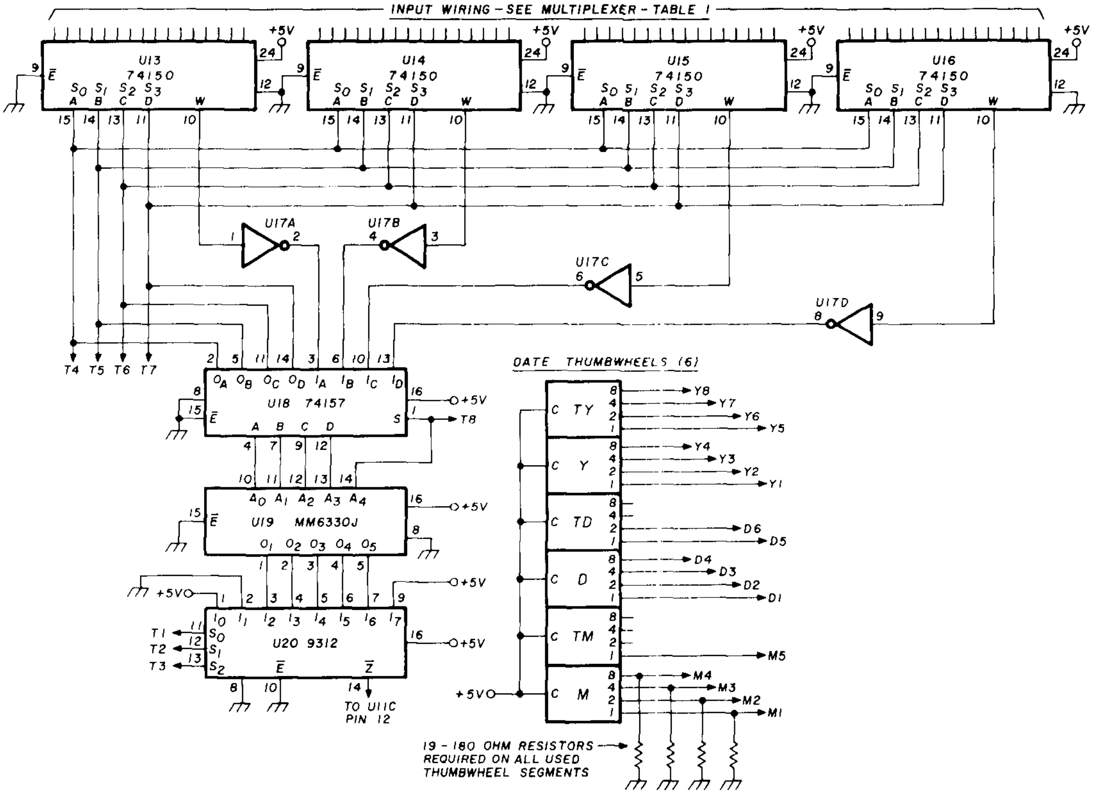

fig. 3. Information transfer schematic. Output is 32 8-bit words. The PROM outputs 16 words directly; the other 16 words may be programmed for the desired time format.

off loop transistor Q3. U11C is also enabled which turns on loop transistor Q2. U11B goes low, enabling U9, U10, which starts the timing sequence.

With T1-T8 at 00000000, the first character is ready. U18 reads T4-T7 and U19 reads the first half of the memory. T1-T3 sequence through U20, reading the first memory location (00000). The SPACE character (table 2) is serially output on U20 pin 14. When T3 returns to

table 1. Input connections from clock, and hardwired control characters.

9312 pin no.	74150 pin no.	address S3 T7	S2 T6	S1 T5	S0 T4	multiplexers U16	U15	U14	U13	comments
9A	1	0	1	1	1	GND	GND	GND	M5	tens, months
7A	2	0	1	1	0	+5V	+5V	GND	+5V	dash (-)
6A	3	0	1	0	1	t3	t2	t1	t0	unit, minutes
5A	4	0	1	0	0	GND	GND	t5	t4	tens, minutes
4A	5	0	0	1	1	t9	t8	t7	t6	unit, hours
3A	6	0	0	1	0	GND	GND	t11	t10	tens, hours
2A	7	0	0	0	1	+5V	GND	+5V	+5V	FIGURES
1A	8	0	0	0	0	+5V	GND	+5V	GND	SPACE
*	9	—	—	—	—	GND	GND	GND	GND	ENABLE
15A,B	10	—	—	—	—	U17A	U17B	U17C	U17D	output pin
------	11	—	—	—	—	T7	T7	T7	T7	S3 input (D)
8A,B	12	—	—	—	—	GND	GND	GND	GND	ground pin
13A,B	13	—	—	—	—	T6	T6	T6	T6	S2 input (C)
12A,B	14	—	—	—	—	T5	T5	T5	T5	S1 input (B)
11A,B	15	—	—	—	—	T4	T4	T4	T4	S0 input (A)
9B	16	1	1	1	1	+5V	+5V	+5V	+5V	LETTERS
7B	17	1	1	1	0	Y4	Y3	Y2	Y1	unit, years
6B	18	1	1	0	1	Y8	Y7	Y6	Y5	tens, years
5B	19	1	1	0	0	+5V	+5V	+5V	GND	slash (/)
4B	20	1	0	1	1	D4	D3	D2	D1	unit, days
3B	21	1	0	1	0	GND	GND	D6	D5	tens, days
2B	22	1	0	0	1	+5V	+5V	+5V	GND	slash (/)
1B	23	1	0	0	0	M4	M3	M2	M1	unit, months
16A,B	24	—	—	—	—	+5V	+5V	+5V	+5V	+5V pin

*not grounded on 9312s

0, T4 becomes a 1, addressing the second memory location (00001) that has the U character stored. This action continues for the words UNIVERSAL (SP) TIME until T8 becomes a 1, when U18 switches to read the time/date multiplexers, U13-U16, and U19 switches to its second half. U20, with T1-T3, reads the PROM memory locations addressed by U13-U16 as wired from **table 1**. T4-T7 now sequence the multiplexers through positions 0-15, reading the inputs as wired. At the end of the timing sequence (T1-T8 are a 1), T8 goes low starting one-shot U12, which resets flip-flop U11A, U11B, shutting off the time unit.

The date storage (**fig 3**) is on six thumbwheels. For those who would like to have the day changed automatically when the clock goes to 0000, the circuit of **fig. 4A** may be used. With this circuit S3 is changed monthly along with the month thumbwheel. ICs U13-U16 are 24-pin devices; and if 16-pin devices are desired, the circuit in **fig 4B** may be substituted, which uses eight 8-position multiplexers in pairs with an OR gate. A regulated power supply is shown in **fig. 2**.

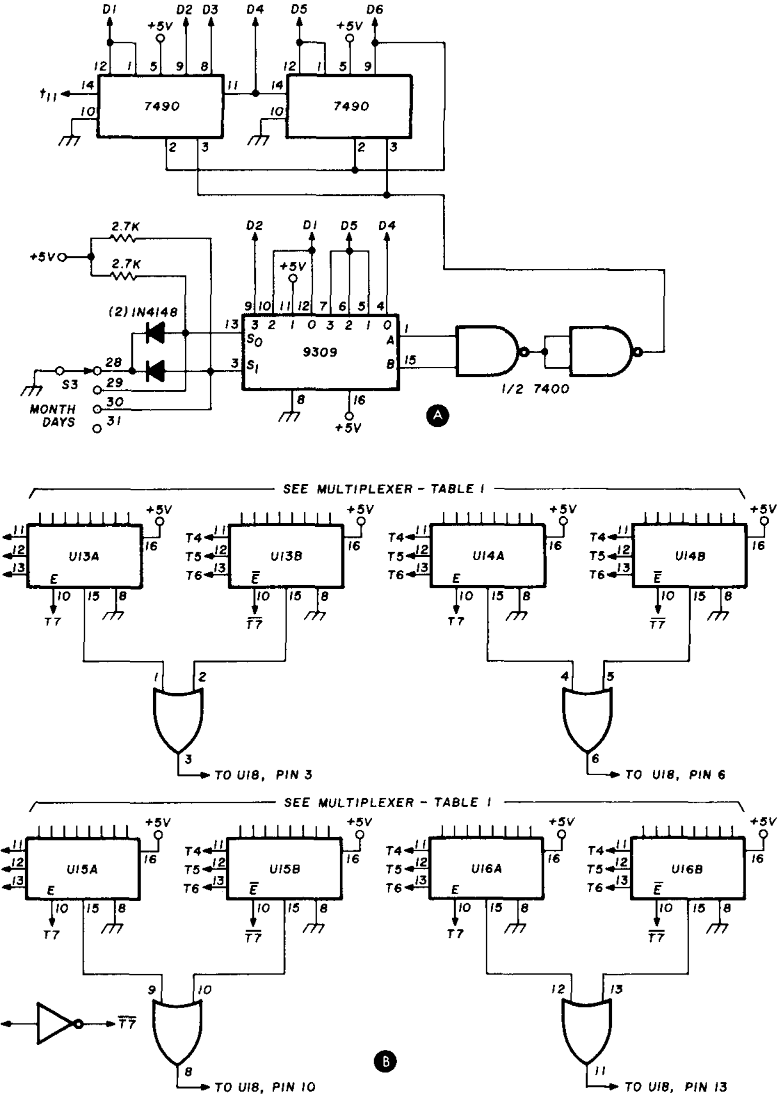

fig. 4. Optional circuits. Arrangement at A may be used for changing the day automatically when clock goes to zero; B shows how to use 16- instead of 24-pin multiplexers.

table 2. Conversions from input address to stored characters.

PROM address					stored	output bit coding					decimal	
A4	A3	A2	A1	A0	character	0_5	0_4	0_3	0_2	0_1	address	
0	0	0	0	0	SP	X	X		X	X	0	character input
0	0	0	0	1	LT						1	
0	0	0	1	0	U	X	X				2	
0	0	0	1	1	N	X			X	X	3	
0	0	1	0	0	I	X	X			X	4	
0	0	1	0	1	V					X	5	
0	0	1	1	0	E	X	X	X	X		6	
0	0	1	1	1	R	X		X		X	7	
0	1	0	0	0	S	X	X		X		8	
0	1	0	0	1	A	X	X	X			9	
0	1	0	1	0	L		X	X		X	10	
0	1	0	1	1	SP	X	X		X	X	11	
0	1	1	0	0	T		X	X	X	X	12	
0	1	1	0	1	I	X	X			X	13	
0	1	1	1	0	M				X	X	14	
0	1	1	1	1	E	X	X	X	X		15	
1	0	0	0	0	0		X			X	16	time/date printout
1	0	0	0	1	1		X				17	
1	0	0	1	0	2		X	X			18	
1	0	0	1	1	3	X	X	X	X		19	
1	0	1	0	0	4	X		X		X	20	
1	0	1	0	1	5		X	X	X	X	21	
1	0	1	1	0	6		X		X		22	
1	0	1	1	1	7	X	X				23	
1	1	0	0	0	8	X	X			X	24	
1	1	0	0	1	9			X	X	X	25	
1	1	0	1	0	SP*	X	X		X	X	26	
1	1	0	1	1	FG			X			27	
1	1	1	0	0	:*	X				X	28	
1	1	1	0	1	—	X	X	X			29	
1	1	1	1	0	/				X		30	
1	1	1	1	1	LT						31	
T8	T7	T6	T5	T4								

input timing

*not used

X=burn a "0"

construction

A breadboard PC card is available that holds 36 chips for either 14/16- or 24-pin devices.* Both cards have IC foil patterns and the +5 volt and ground buses; also, each has a 44-pin connector (22 pins each side). The connector number is 44C.

Use number-26 AWG (0.3mm) solid wire and bypass each chip with a 0.05 μF disc capacitor and each row of 5-6 chips with a 47 μF tantalum capacitor. The finished card and power supply should be housed in an rf-tight enclosure. Bypass each side of the line where it enters the box with a 0.01 μF disc capacitor to chassis, and use shielded cable into and out of the box, or else rf can sneak in and foul up the logic — TTL makes a good detector!

ham radio

*Douglas Electronics, 718 Marina Boulevard, San Leandro, California 94577. Specify part number 11-DE-5 for 14/16-pin or 12-DE-5 for 24-pin devices.

fm detectors

The development of fm demodulators is traced from past to present — also included is a rundown on IC availability

The fm transceiver-repeater scene on the amateur vhf bands is an unusual part of amateur radio history. The technology was commercially developed and used by amateurs. This is in contrast with most other communications techniques in which the amateur contributed to development, and techniques were later applied to commercial use. The growth of amateur fm transceiver-repeater activity resulted from ingenious adaptation of cast-off 30-50, 150-170, and 450-470 MHz commercial equipment. The result is that today you'll find just about every kind of equipment in use from the oldest transceiver with loctal-based tubes to sophisticated designs using ICs, fets, and silicon power transistors. All have one thing in common: a circuit to convert fm signals to audio frequencies. In this article I've attempted to cover most of the practical fm detectors that have been developed. Some have been omitted but these have seen only limited use and remain as curiosities in the literature.

slope detection

Anyone who's tuned the two-meter band with an a-m receiver is aware that fm may be demodulated by an a-m detector. As you tune to an fm signal the demodulation is fairly effective until the receiver S-meter is at or near maximum; that is, the audio is clearest and loudest when you're tuned off to the side of the fm signal. This is called slope detection.

The fact that the a-m (diode) detector works at all on the fm signal is because of the receiver i-f characteristic. If the fm signal carrier is at point **A** or **C** on the i-f selectivity curve (**fig. 1**) frequency deviations will be converted to changes in amplitude. If the carrier is at point B, frequency deviations will not be converted to amplitude changes, especially if the i-f response is flat and symmetrical in its passband (as it should be for an a-m receiver).

Travis detector

A modification of the slope detector is the Travis detector (**fig. 2**). By using two resonant circuits offset by a small frequency difference, $f2-f1$, each driving a diode detector of opposite polarity, the sum of the diode detectors can give a near-linear output. **Fig. 2B** shows how the nonlinearities of the two (identical) resonant circuits cancel, in much the same way as in other push-pull circuits. The composite amplitude versus frequency curve of the Travis detector, when carefully adjusted, is much like that of the more familiar curves of the Foster-Seely discriminator or ratio detector.

Foster-Seely discriminator

The Foster-Seely discriminator is one of the most

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common forms of fm detector, although in recent years the ratio detector has become more popular. The basic Foster-Seely discriminator is shown in **fig. 3**; variations are possible, as shown in **fig. 4.** The characteristic of the discriminator is the connection from the top of the tuned-transformer primary to a center tap of the tuned secondary circuit and the fact that the diodes are connected pointing in the same direction as in a full-wave rectifier. The explanation of discriminator operation is a bit tedious and usually involves phase vectors and "parallelogram of forces" diagrams.[1]

ratio detector

The ratio detector was developed later than the discriminator and is shown in **fig. 5.** The ratio detector is so called because it is sensitive to the ratio of the two voltages developed from the applied signal rather than to their difference. Since the ratio between the two voltages is the same at any level, an ideal ratio detector does not respond to a-m at any frequency deviation.

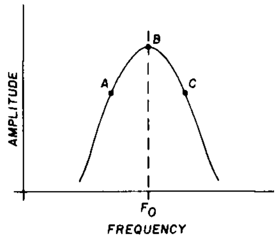


fig. 1. A-m receiver i-f response. An fm signal's audio may be recovered at point A or C on the selectivity curve.

The version shown in **fig. 5A** is the balanced circuit. Note that unlike the discriminator no direct rf connection is made between primary and secondary; rather a third or tertiary winding is used. Also note that the diodes point in opposite directions and that a large electrolytic capacitor is used in the diode load system to maintain a constant voltage during af variations. A variation of the ratio detector is shown in **fig. 5B.**

The ratio detector has one great advantage over the discriminator: it is relatively amplitude insensitive. Whereas discriminators are generally preceded by one or more stages of limiting amplifiers, the ratio detector is often used without any limiter stage ahead of it. The one awkard feature of the ratio detector is that the load capacitor must be disconnected during sweep frequency alignment. The detailed explanation of this detector's operation is similar (in approach) to that of the discriminator and is covered in the same chapter of reference 1.

injection-locked demodulator

The Bradley detector is one form of injection-locked oscillator fm demodulator.[2] A special tube (the Philco FM1000) was developed for this detector, and the circuit had a great deal to recommend it when these special pentagrid tubes were available. The Bradley detector is shown in **fig. 6.** Note that the cathode and first two grids of the FM1000 act as a Hartley oscillator in much the same fashion as many other electron-coupled oscillators. The Bradley detector requires no limiters ahead of it and has the additional advantage of very good output amplitude linearity versus frequency deviation. Note that the regions of amplitude beyond the linear portion (**fig. 6B**) are those where the oscillator is not being injection synchronized by the incoming signal (i.e., beyond lock-in range). The Bradley detector is one example of the injection-locked oscillator fm detectors described almost a decade earlier by Woodyard.[3] Woodyard did not have the special FM1000 tube available so he used a simple triode oscillator and diode detector as shown in **fig. 7.**

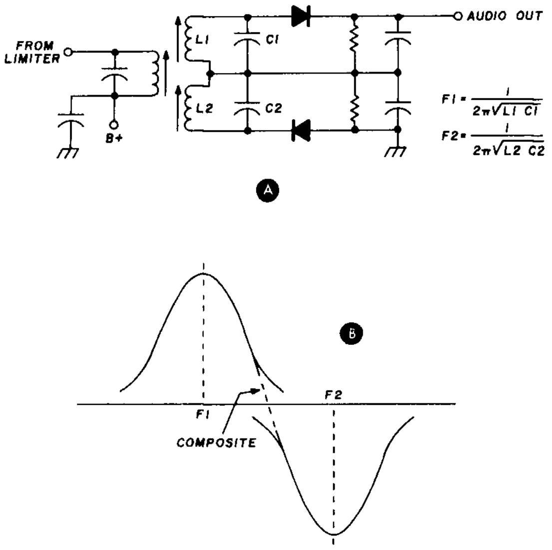


fig. 2. Circuit of the Travis detector (A) and its response (B) as a function of a frequency difference, F_2-F_1.

An injection-locked fm detector that achieved relatively large use in television sets as the sound detector was built around the 6DT6. This circuit is shown in **fig. 8** and is somewhat simpler than the Bradley detector, both in number of tube elements and number of resonant circuits. The oscillation mode is that of the tuned-plate tuned-grid, with the suppressor grid operating as a plate in the oscillator circuit.

gated-beam detector

This circuit was a popular fm detector, especially in television sets, before digital logic devices came into use. A gated-beam detector using the 6BN6 tube is shown in **fig. 9.** This tube was especially designed for this use and is a form of AND gate. Limiting is introduced because of symmetrical transconductance with respect to a fixed value of bias on the first grid. A tuned circuit develops a voltage whose phase is a function of the incoming signal

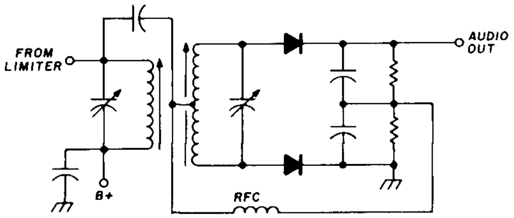


fig. 3. Basic Foster-Seely discriminator.

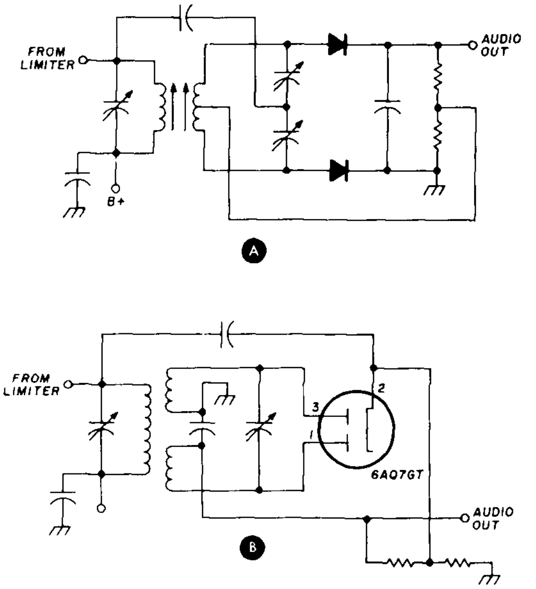


fig. 4. Variations of the Foster-Seely discriminator with capacitive secondary center tap (A) and dual-diode tube with common cathode (B).

frequency, producing discriminator action. An elaborate explanation of this circuit is given in reference 4.

pulse-counting detector

Another circuit that's seen some commercial use is the pulse-counting detector. **Fig. 10** shows a pulse train, its differentiated components, and the resultant waveform (positive spikes) that are used to trigger a one-shot. The integral of the pulses is proportional to frequency deviation, since each pulse contributes a constant positive charge to an integrating capacitor. The voltage on the integrating capacitor is then propartional to the number of pulses per second. The early versions used tubes and operated at an i-f of about 200 kHz.[5] A later version is described in reference 6. These low-frequency detectors are shown in **fig. 11.**

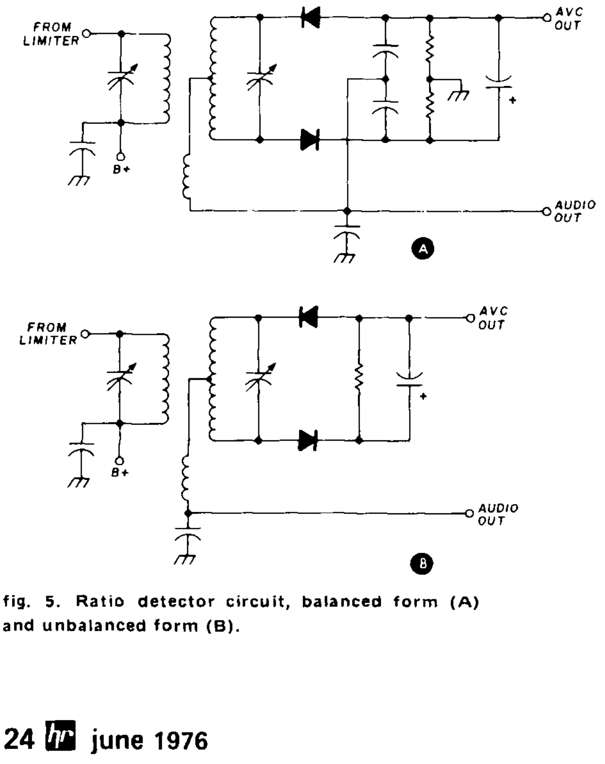


fig. 5. Ratio detector circuit, balanced form (A) and unbalanced form (B).

A pulse-counting detector operating at 10.7 MHz was developed in 1967.[7] The circuit used fast switching transistors and a delay line to generate a short (25 ns) pulse (**fig. 12**). The delay line is used in much the same manner as in radar modulators to create a short pulse. A positive (limited) half cycle of the i-f waveform drives the delay line. CR1, CR2 conduct for a period that represents twice the delay-line length. At this point the delay line appears as an open circuit, since it's completely charged, and stops conducting. Q2's output, which is averaged by the 18k, 120 pF RC time constant, is proportional to frequency deviation.

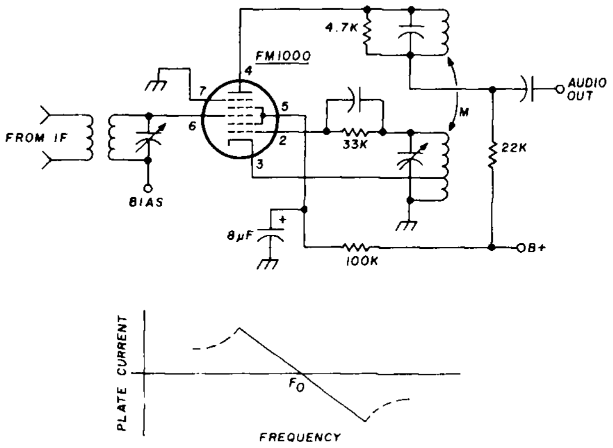


fig. 6. The Bradley detector and its frequency response.

IC fm demodulators

Digital IC one-shots have made their appearance as the pulse-generating portion of a pulse-counting fm detector. The IC one-shots perform well, but until recently the fastest devices have been the Fairchild 9601 and the Texas Instuments SN74121N and SN74122N. These one-shots have minimum pulse lengths of about 40 ns, barely fast enough for 10.7-MHz pulse-counting detectors. The technique of using TTL one-shots in fm detectors at lower frequencies is described in application

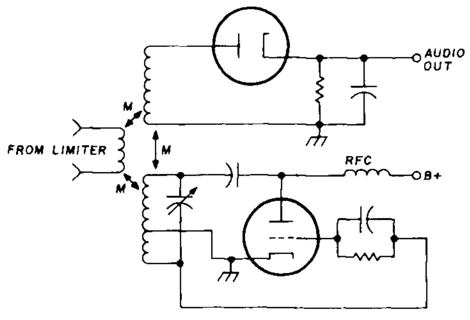


fig. 7. Injection-locked oscillator demonstrated by Woodyard in 1937.

notes.[8] Such a low-frequency pulse-counting fm detector is shown in **fig. 13.**

Note in this circuit how two other IC's (710 and 709 linear devices) are used as a limiter and averaging integrator respectively. Recently a second-generation Schottky clamped TTL dual one-shot, the 96S02, became available from Fairchild, which makes pulse-counting fm detectors much easier to design at 10.7 MHz. The minimum pulse length of the 96S02 is specified as 27 ns.

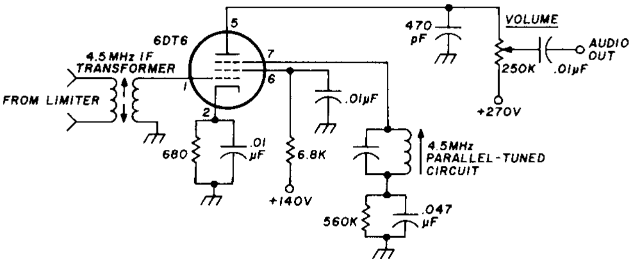


fig. 8. Injection-locked oscillator fm detector popular in early television sets.

With IC one-shots in a pulse-counting detector, the IC Pandora's Box was opened. As mentioned in the section on the 6BN6, an AND gate can function in a quadrature-frequency modulation detector. Since a positive logic AND gate is functionally identical to a negative logic OR gate, either AND or OR gates will work. The operation is shown in **fig. 14** using square waves. Note that when **C** lags in phase (using the **B** quadrature as the reference), then the average AND gate output is increased. In opposite fashion, when **D** leads in phase from the reference position, the average AND gate output is decreased.

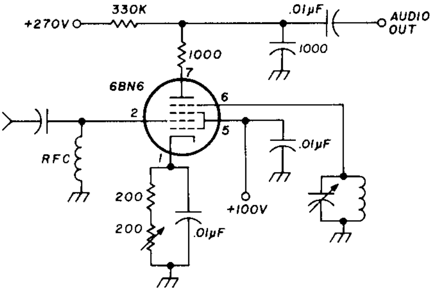


fig. 9. Another popular fm detector used in television sets, the gated-beam detector.

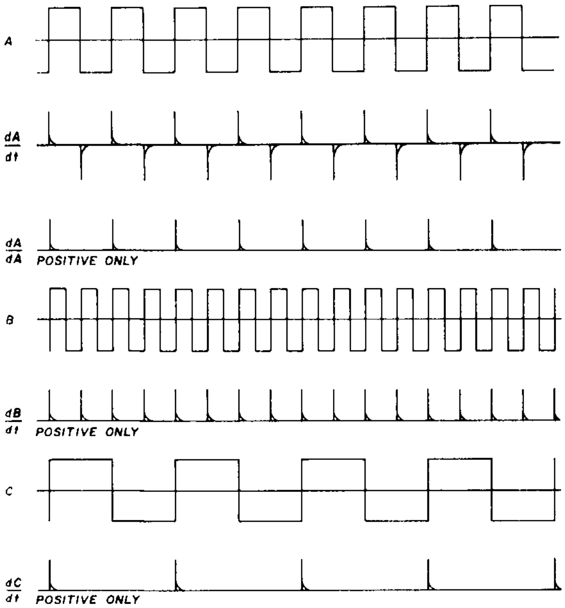


fig. 10. Waveforms in the pulse-counting detector. The positive-only diffferentiated spikes from three frequencies (A, B, C) give an output proportional to frequency.

The μA717, μA718, and μA719 linear IC's by Fairchild are quadrature detectors using an OR gate. The μA717 and μA718 were introduced in 1967 with the first monolithic IC op amps (the μA702 and μA709). and so are probably the fm detector ICs deserving "granddaddy" titles. The μA717, μA718, and μA719 are shown in fm detector circuits in **fig. 15.** Note that, like the 6BN6 tube-type detector, only a simple parallel-tuned resonant circuit is required to provide quadrature. These Fairchild ICs were made as OEM sales components, so they rarely became part of experimental or amateur equipment. They are found in commercially made equipment, however.[9,10] Fairchild no longer lists the μA717, 718, or 719 in its current price sheets; however,two newer quadrature fm detector ICs are available: the

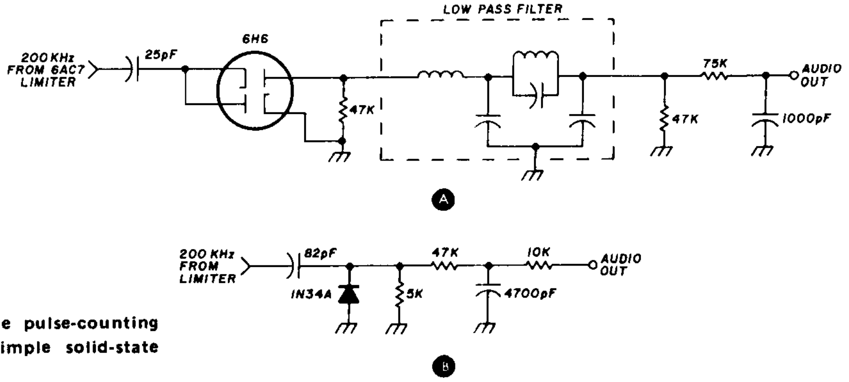
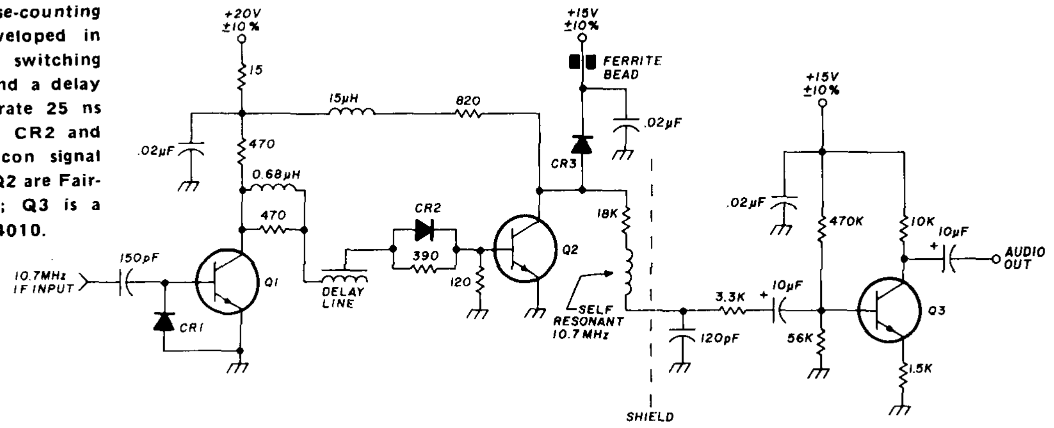


fig. 11. Early tube-type pulse-counting detector (A) and a simple solid-state version (B).

fig. 12. Pulse-counting detector developed in 1967 using switching transistors and a delay line to generate 25 ns pulses. CR1, CR2 and CR3 are silicon signal diodes; Q1, Q2 are Fairchild S1374; Q3 is a Fairchild SE4010.

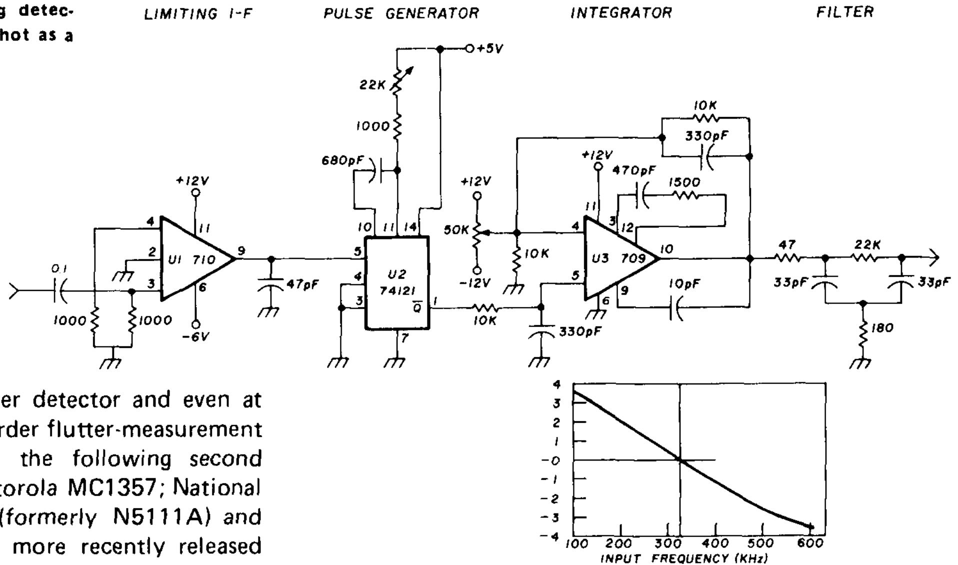


μA754 and μA784. The latter is a second source for a European IC, the TAA640.

At about the same time Fairchild introduced their μA717 and μA718, Sprague described their version of the quadrature detector IC.[11] The ULN2111A by Sprague is perhaps the most widely used fm detector IC of all and is second sourced by at least five other IC manufacturers. The circuit using a ULN2111A is shown in **fig. 16.**

The fact that only a parallel resonant circuit is needed to obtain quadrature means that quadrature detectors such as the ULN2111A may be used at almost any frequency with a relatively simple frequency-determining element. I have seen the ULN2111A used at 40 kHz in an ultrasonic Doppler detector and even at audio frequencies in a tape-recorder flutter-measurement system. The ULN2111A has the following second sources: Fairchild μA2136; Motorola MC1357; National LM2111; Signetics ULN2111 (formerly N5111A) and RCA CA2111AE. Sprague has more recently released another more advanced IC called the ULN2113A, which is also a quadrature detector. The ULN2113A is also second sourced (as the LM2113A) by National Semiconductor.

fig. 13. Pulse-counting detector using a TTL one-shot as a pulse generator.



Radio Corporation of America has had a line of linear ICs for fm detection for some years. The earlier ones were simply a combination of limiting i-f amplifier and diodes to implement a ratio detector or discriminator. These ICs (CA3013, CA3014, CA3041, CA3042, and CA3043) required the usual special transformers for these applications. The CA3043 is shown in **fig. 17** as a ratio detector. Later ICs used the quadrature detector method; these are the CA3065, CA3075, CA3089, and CA3134. The CA3065 and CA3075 are second sourced by National Semiconductor as the LM3065 and LM3075. Motorola makes replacements for these two RCA units: the MC1358 and MC1375. Fairchild also makes a second source for the RCA CA3075, the μA3075.

Motorola has the MC1351 (second sourced by National Semiconductor as the LM1351) detector in addition to the second source types listed above, and National Semiconductor has the LM1808. National Semiconductor also has the LM373 and LM374, which are communications type ICs that will not only serve as fm detectors but also as a-m detectors or as product detectors for CW and ssb. The LM373 is shown in **fig. 18** in its several configurations; note that in the fm detection mode it uses the quadrature detection method.

phase-locked loop

ICs have been described that use the discriminator, ratio detector, and quadrature detector methods of fm demodulation. It's natural to ask, "Didn't the locked oscillator ever get tucked into an IC?" The answer is yes and no. The injection-locked oscillator has all but disappeared in our technology and has been replaced by the phase-locked loop. Both types of synchronized oscillators may be used as fm detectors, but in IC technology only the phase-locked loop system has been used.

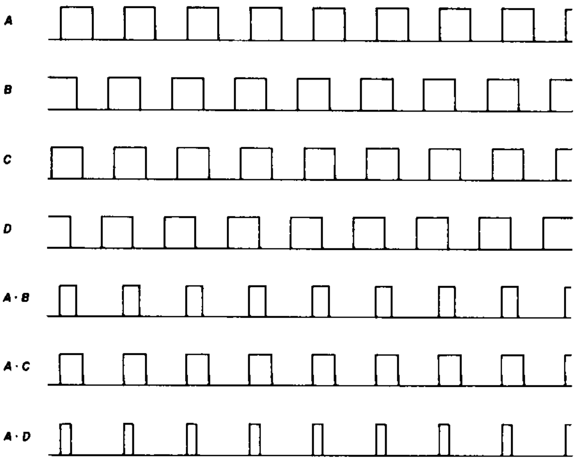


fig. 14. Representation of two square waves in quadrature in an AND gate. When pulse train C lags in phase with respect to B, average output is increased.

The phase-locked loop did not come into general use until the severe demands of space communications made it a necessity. The first reference to the phase-locked loop (in the U.S. open literature) was as a result of the Vanguard satellite program.[12] From its beginning in the mid-1950s, the phase-locked loop developed rapidly. Signetics introduced a one-chip version in the late 1960s.

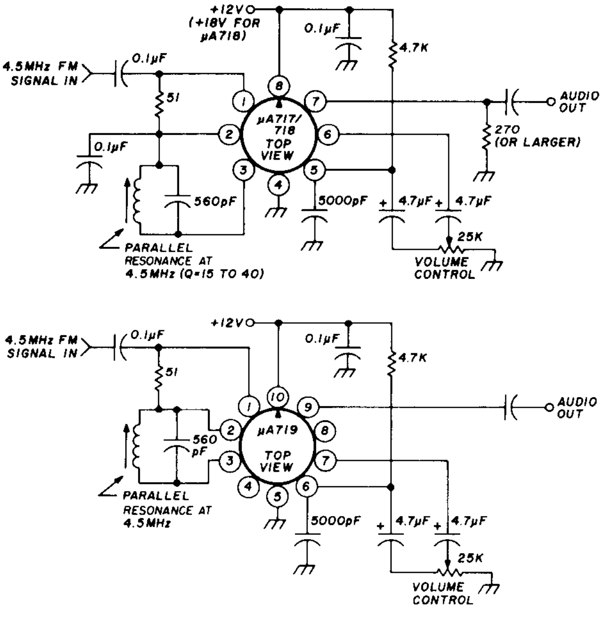


fig. 15. The Fairchild µA717/718 and µA719 as an fm detector and audio amplifier.

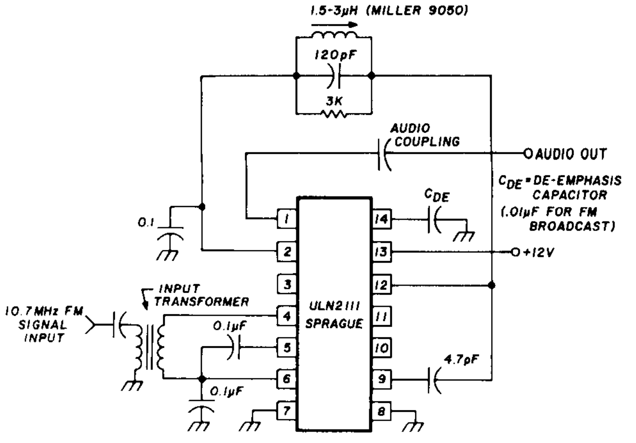


fig. 16. The Sprague ULN211 as a quadrature fm detector.

The Signetics NE560, NE561, NE562, and NE565 were monolithic IC phase-locked loops capable of a number of applications including fm detection.

The basic block diagram of the PLL is shown in **fig. 19.** Note that the loop locks to the carrier signal and deviations from this frequency are translated by the phase detector to deviations in dc average voltage. This phase detector output as applied to a low-pass filter whose output acts as a correction voltage to keep the voltage-controlled oscillator on frequency. The low-pass filter between the phase detector and vco is usually called the tracking filter and must be of special form if the phase-locked loop is to be stable.

The phase detector output is the audio recovered from the fm signal, assuming that the tracking-filter cutoff frequency will pass the audio frequencies of interest. An fm detector using the Signetics NE560 phase-locked loop IC is shown in **fig. 20.** Limiting ahead of the NE560 is provided in this case by another Signetics IC, the NE510. Note that the NE560 in **fig. 20** has no inductors associated with it; the vco in this IC is an RC oscillator so no resonant circuits are required. This is true for the NE561, NE562, and NE565. The NE560, NE561, and NE562 will operate to at least 15 MHz,

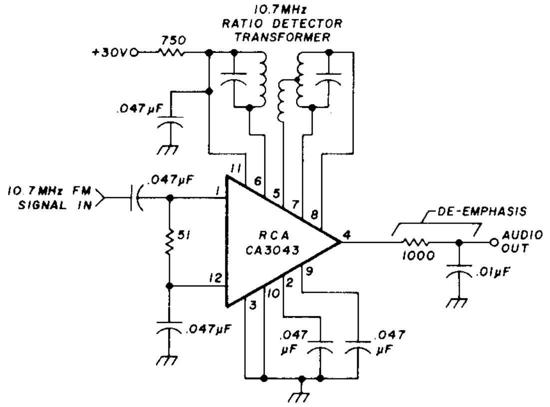


fig. 17. The RCA CA3043 IC as a ratio detector.

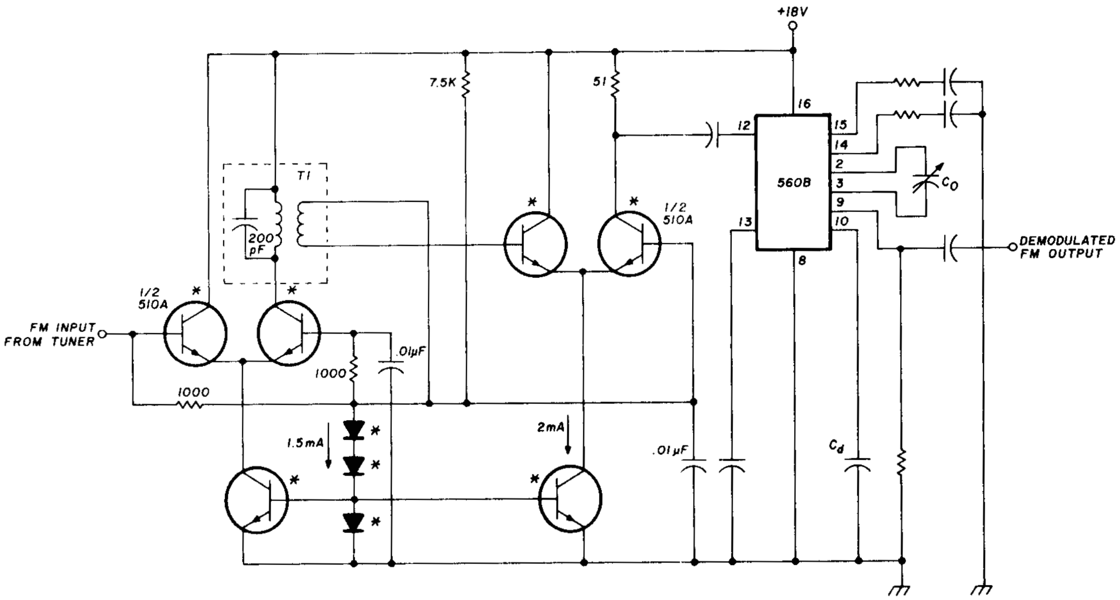


fig. 20. Fm detector using the Signetics NE560B phase-locked loop IC. Devices marked with an asterisk are part of a NE510A. T1 is bifilar wound on ½-watt, 100k resistor.

while the NE565 is only useful to 500 kHz. The NE565 is second sourced by National Semiconductor as the LM565.

Motorola also has a phase-locked loop IC family. The MC4024 and MC4044 comprise a dual vco and a phase detector respectively. Like the Signetics units, the vcos in the MC4024 are RC oscillators and only a capacitor is needed ot determine the oscillation frequency for a given value of vco control voltage. Since the MC4024-MC4044 pair is also used for frequency synthesizer circuits, it is TTL compatible and listed with Motorola's MC4000 series of TTL ICs. The MC4024 is

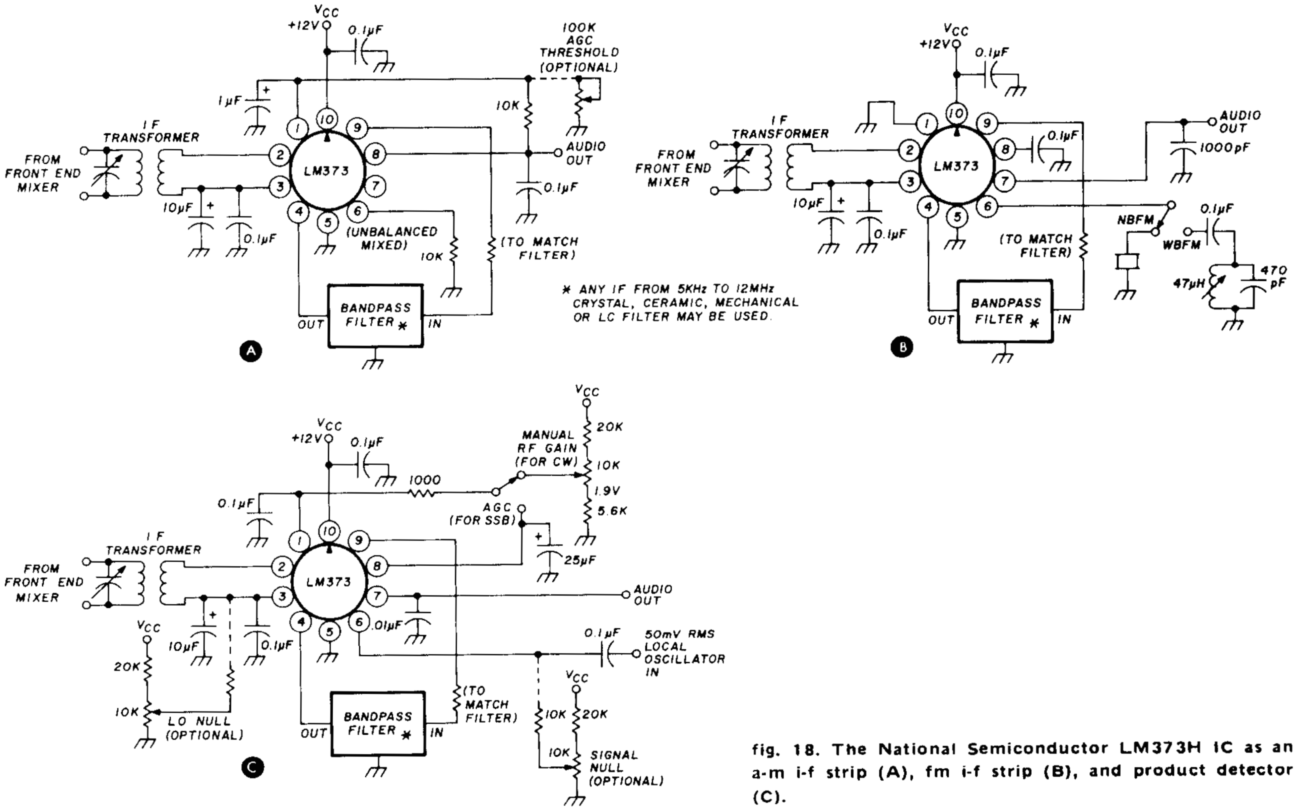


fig. 18. The National Semiconductor LM373H IC as an a-m i-f strip (A), fm i-f strip (B), and product detector (C).

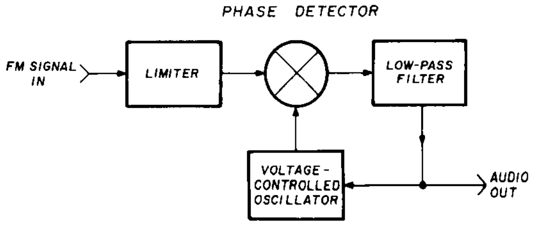


fig. 19. Phase-locked loop block diagram.

usable to 25 MHz. Fairchild has the μA780 phase-locked loop IC. This device is aimed principally at the color television market to be used to lock onto the 3.58-MHz color-burst frequency. The μA780 should work as an fm detector also, at least to 4.5 MHz.

The phase-locked loop ICs described above are designed for general PLL use or for some special purpose other than fm detection. Recently, Signetics has released the NE563, an IC PLL specifcally designed as an fm detector. In fact, the NE563 is designed as a complete i-f amplifier and demodulator for an fm receiver. The circuit is shown in **fig. 21**. Note that there is a down conversion from 10.7 MHz to 900 kHz, where the phase detector operates. I-f selectivity is provided at 10.7 MHz by a ceramic bandpass filter.

The phase-locked loop method of fm detection has some advantages over other methods in terms of signal-to-noise ratio. Even further increases in signal-to-noise ratio are possible using PLL techniques in more complex systems employing frequency compression. References 13 and 14 offer some light on signal-to-noise ratio advantages and frequency compression techniques.

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ham radio

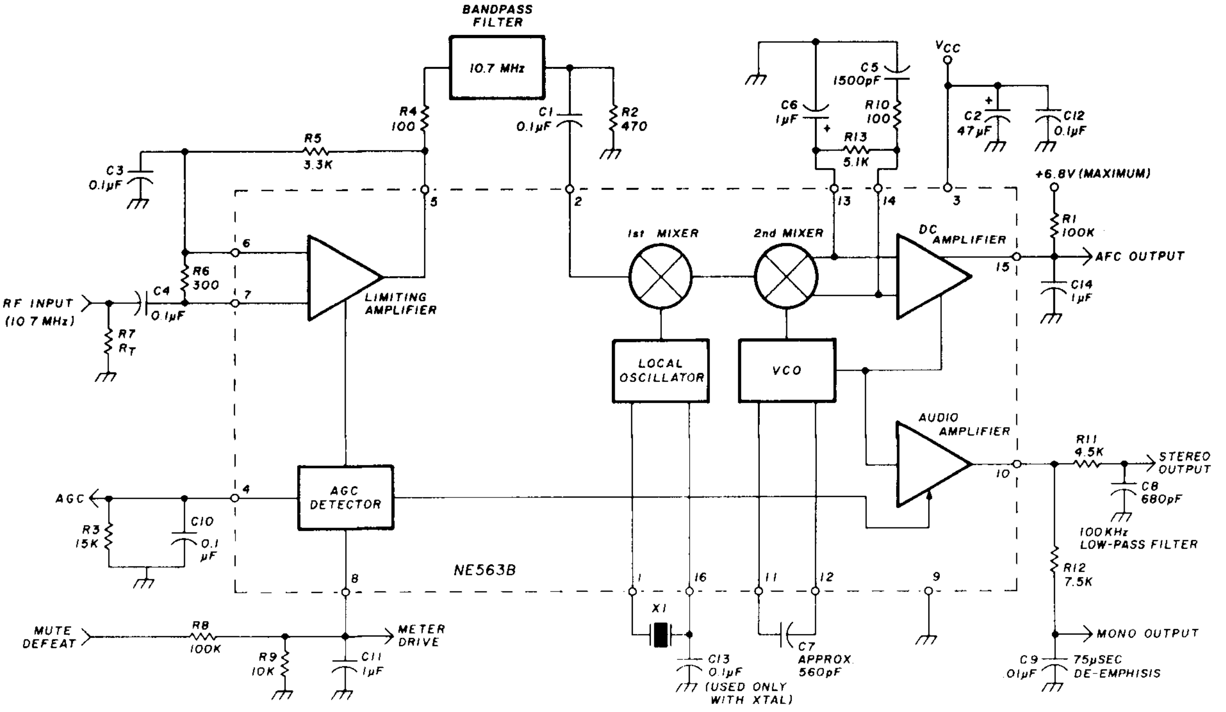

fig. 21. Signetics NE563 PLL IC as a complete i-f amplifier and demodulator for an fm broadcast receiver. X1 is a 9.8 MHz ceramic resonator, 9.8 MHz crystal, an LC network or a capacitor and is chosen for the required stability. For broadcast fm reception a ceramic resonator should provide adequate stability.

novel audio speech processing technique offers maximum talk power with negligible distortion

A review of ssb speech processing techniques and a look at a new approach

Recently I was given the opportunity to preview a new speech processing unit which, to me at least, uses a different and novel design principle. I was impressed by the performance claim for the new unit, as well as by the incorporation of human engineering features which would enhance the performance and usefulness of speech processors based on other, older techniques.

The purpose of speech processing in transmitting equipment is to increase the average power output without exceeding the peak rating of the equipment. More specifically, the idea is to increase the amplitude of the weaker consonants in the human voice in relation to the louder vowel sounds. If this is done without introducing too much distortion, the intelligibility of the transmission will be greatly enhanced at the distant end during periods when propagation conditions are poor. This enhancement or increase in "talk power" can be as much as 10 to 12 dB according to recent literature (as well as articles dating back to the 1940s).

In recent years there has been renewed interest in devices which are essentially audio peak limiters, often known as speech clippers, logarithmic (quasi or otherwise) limiters, etc. This is not surprising when you consider the easy availability of inexpensive, miniature components. However, regardless of what these gadgets are called by their designers, they are essentially distorting devices, and this poses a problem in ssb systems. Several years ago, K1YZW took issue with such devices when they are used with ssb exciters;[1] I will try to summarize the points he presented.

In properly designed a-m and fm systems, speech or audio clipping (instantaneous limiting, logarithmic compression, or whatever) is useful as there is nothing to alter the critical phase relationship between the funda-

By Jim Fisk, W1DTY, Editor-in-Chief

mental signal and the harmonics generated in the process (see **fig. 1**). In ssb generators, however, this coherence, as it is generally called, is completely lost as can be seen in **fig. 2.** The fundamental signal will combine with the harmonics to produce peaks and valleys in the amplitude level. Using the numbers from Walter's article, these peaks can be as high as 1.7 times the original (limited) amplitude. To accommodate these peaks within the linear region of the transmitter, the exciter gain has to be reduced 5 dB, manually or automatically (alc), as compared to a sinusoidal input of the same peak amplitude! Although we want to increase our talk power, this means that we have to start with a 5 dB deficit – lowering our increased talk power by that amount to 6 dB or so.

Take a look at **fig. 3** which is a computer plot (submitted recently by K1YZW) of the rf envelope produced by a single clipped and filtered 400-Hz tone. This clearly shows the loww of power as compared to a pure sine-wave input. The latter, of course produces a CW signal with no envelope variations.

This amount of gain is still useful despite the very noticeable distortion in the modulation of the outgoing signal, although only little more than is obtainable with a well designed and virtually distortionless alc system. Unfortunately, in most cases a further reduction in exciter gain is necessary to accommodate the transients produced in the exciter ssb filter. K1YZW reports seeing an additional 4 dB overshoot from his Collins mechanical filter exciter with a square-wave audio input. Other exciters, especially those featuring filters with very steep skirts, may well be worse. With some exciters, most likely older ones, the problem may be less severe – it is obviously absent in phasing-type ssb generators.

I believe that the unknown and unpredictable transient behavior of ssb filters is the reason for the inconsistent results obtained with audio limiting; many amateurs find the process quite useless, while others using similar or even identical devices report a useful improvement in performance. If, on the average, we allow for total gain reduction of 7 or 8 dB, the few extra dB gain in talk power which remain hardly seem worth the effort since they are accompanied by the usual clipping distortion. As K1YZW and others have shown, a well designed alc system with properly chosen time constants will give a modest 2 to 3 dB of apparent talk power gain, free of distortion, and also provide a desirable safeguard against overmodulation or flat-topping.

It is worth noting that advocates of audio processors favor extremely severe cutting of the lower speech frequencies. Rolloffs of 12 dB or even 18 dB per octave, starting at 1.5 kHz, have been suggested.[2,3] K1YZW reported in a letter that in his experience with an essentially distortionless rf clipping system such drastic bass cutting has not proved desirable. In fact, he commented rather sarcastically that taking this approach to its ultimate limit will result in clipping only at the highest audio frequencies where it is not needed (and where it will produce virtually no power gain). It seems to me that severe bass cutting with its resultant lower talk power gain is used as a corrective measure against excessive low-frequency distortion, rather than to increase readability, though in final analysis these may amount to the same thing.

Clipping at rf rather than audio is free from these deficiencies. While harmonics are produced by the rf clipping process, they are far from the passband of interest so are easily removed by filtering, and maximum talk power is obtained without difficulty. Many articles have appeared on the subject of rf speech processing which should be referred to for more detailed information (see list of references at end of article). At least two manufacturers in the United States provide kits for modifying the more popular commercial exciters.

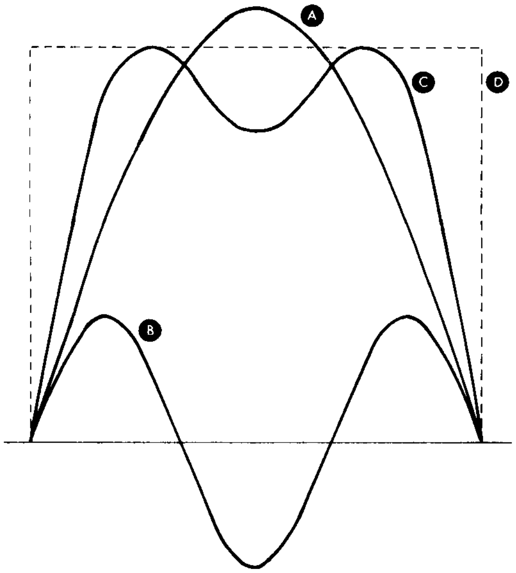

fig. 1. The derivation of a square wave. The fundamental component is shown in A. B is the third harmonic. The sum of A and B is shown in C. The square wave at D is the resultant with higher odd-order harmonics of proper amplitude and phase.

Clipping a double-sideband signal has been suggested occasionally,[2] but a little imagination will show that this is really no different from audio clipping. In a letter to me concerning ZL1BN's article, K1YZW mentions that, in his original work with rf clipping in 1961, he actually investigated this method using a high resolution spectrum analyzer to confirm this point. He also suggested that the good results which ZL1BN obtained with his circuit (**fig.** 7, page 33, reference 2) was due to the fact that it was not DSB clipping at all. His conjecture is based on the fact that most ssb filters show some selectivity at their input terminals where ZL1BN placed his clipping diodes. Unfortunately, you cannot rely on being able to duplicate ZL1BN's results because they seem to depend on a characteristic of the ssb filter which is not controlled by the manufacturer.

An interesting variation of rf clipping is the approach first used by Comdel, Inc., and described by me in 1968.[4] This is essentially a closed-loop ssb system with rf clipping so the output is at the original audio frequency. The advantage of this system is that it forms a self-contained unit and avoids the need to modify existing ssb exciters. The same principle is now being used by manufacturers in England and Japan.

Until recently I was firmly convinced that rf clipping was the only way to achieve a significant, distortionless increase in the talk power of an ssb transmitter. However, this conviction was severely shaken by the presentation of a radically different approach to the problem in a unit produced by Maximilian Associates, a small consulting company here in New England.* After reading the specifications of the claimed performance, I found it hard to accept that I was looking at an audio processor. Following are the important operating features of the Maximilian Associates model SBP-3, as it is tentatively called:

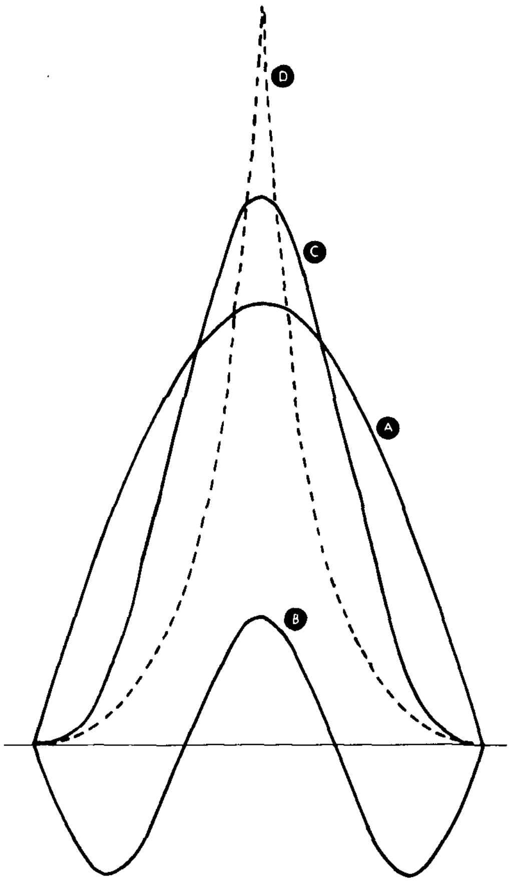

fig. 2. The effect of loss of phase coherence. A is the fundamental; B is the third harmonic; C is the sum of A and B; D is the resultant of all harmonics in the passband.

1. Provides 16 dB of instantaneous limiting.

2. Harmonic distortion does not exceed 9%, and is typically around 5%.

3. Frequency response is within 1 dB between 460 and 2300 Hz (-6 dB points at 400 and 2600 Hz).

4. Shows sensitivity at limiting threshold of 2 mV rms with a signal-to-noise ratio of more than 30 dB.

5. Cannot be overloaded with inputs up to 1 volt rms.

6. Incorporates audio agc so that 16 dB of compression cannot be exceeded.

7. Features two front panel lamp indicators, one (green) signifying adequate input, the other (red) denoting an excessive gain setting.

The design philosophy behind this new speech processing device was described to me as follows: In K1YZW's paper[1] the conclusion was reached that any process which causes appreciable distortion of the audio signal is not suitable for application to ssb systems. The obvious question at this point is how large is "appreciable" or how much distortion can, in fact, be tolerated. If we accept an initial gain reduction of 1 dB to accommodate the amplitude peaks caused by the non-coherent addition of the distortion products, then the distortion of the process must be held below 10 per cent (note that straight audio clipping produces more than 40 per cent distortion). Such low distortion can hardly be perceived by the human ear in a speech communications set-up and is unlikely to cause any appreciable transients in the ssb filter.

In order to achieve such low distortion, the speech frequency spectrum is split up into four bands and each band is independently processed, i.e., peak limited and filtered. **Fig. 4** shows a block diagram of the scheme and the center frequencies of each band. Since each band is quite narrow, the distortion products fall (theoretically) outside its limits and can be removed by filtering. The

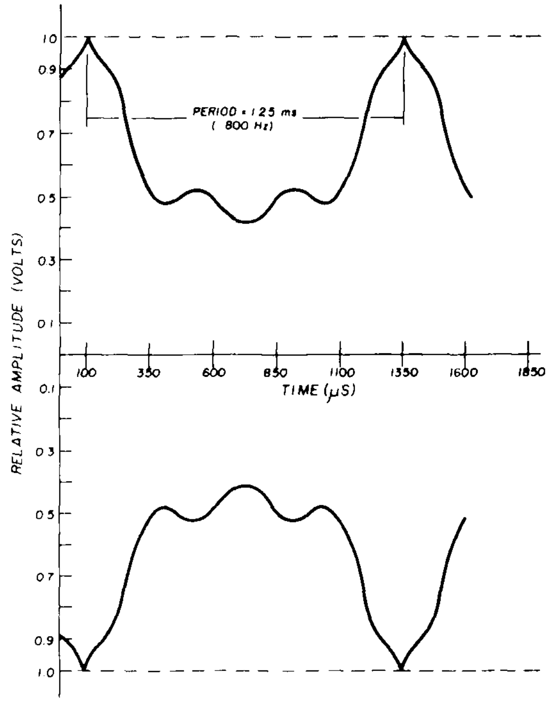

fig. 3. Envelope of rf signal with 400-Hz clipped and filtered input. Average power is -5.3 dB. Dotted line denotes envelope with sine-wave input; average power is 0 dB.

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*Maximilian Associates, Box 223, Swampscott, Massachusetts 01907.

concept is straightforward and has been around for quite some time. As a footnote, it is probably fortunate that the designers did not discover some earlier references until after the first model of the SBP-3 had been successfully tested – H. Schneider[7] discussed this method in *considerable detail 20 years ago and concluded that a* working system was not economically feasible. This view seems to be shared by ZL1BN (though he does not even consider the major problem of the combiner stage which will be mentioned later).

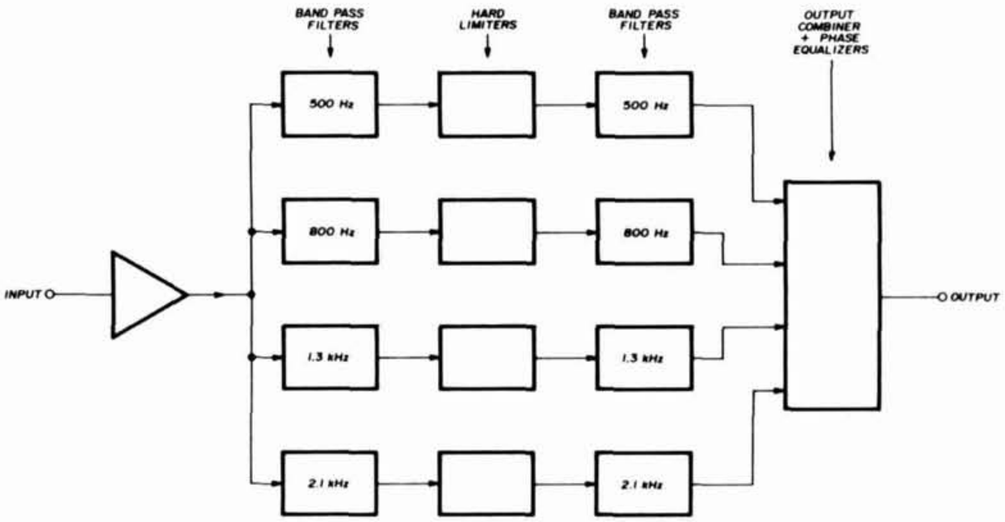
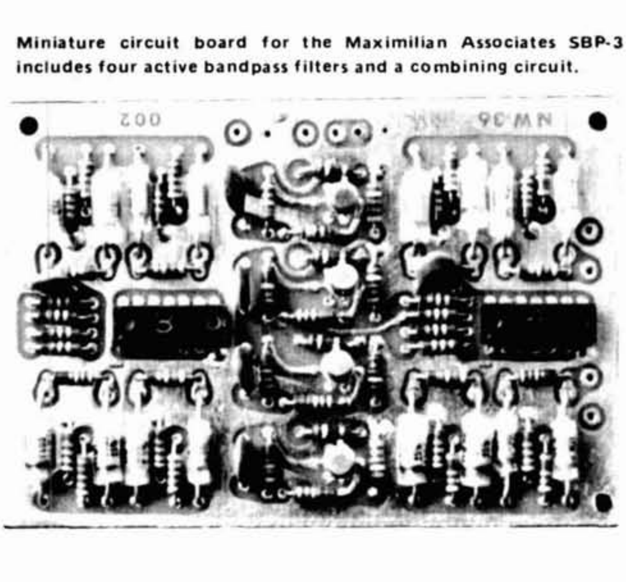


fig. 4. Simplified block diagram of the band-splitting speech processor. This processing scheme, as embodied in the Maximilian Associates SBP-3, provides 16 dB of instantaneous limiting with harmonic distortion not exceeding 9% (typically 5%). Frequencies are the center frequencies of the bandpass filters.

At first thought, it would seem desirable that the bandpass filters should have steep skirts so that there would be practically no overlap between adjacent bands. This approach is extremely costly and, as it turns out, technically unsatisfactory. The post clipper filters would show the typical "ringing" effect when subjected to a near square wave input, and undo most of the clipping action as well as introduce considerable distortion. To avoid this a filter is needed with a Gaussian characteristic which, unfortunately, exhibits a rather gradual cut-off response. This type of response is approximated fairly closely by a low-Q tuned circuit (this is what was used in the new speech processor). The Q values and center frequencies of the individual bandpass filters were chosen to give a reasonably flat response between 400 and 2400 Hz. Of course, a considerable overlap exists between adjacent bands with this approach.

Miniature circuit board for the Maximilian Associates SBP-3 includes four active bandpass filters and a combining circuit.



Contrary to initial expectations, the overlapping filter bands have proven quite satisfactory. A signal falling near the center of a band will have its clipping harmonics attenuated by more than 20 dB which is more than adequate. Signals which fall near the middle of the overlap region (i.e., half way between adjacent filters) will be clipped less severely and therefore less filtering is needed. The mathematics showing this are quite tedious, but clearly indicate that the distortion can be held under 10 per cent for any signal between 400 and 2400 Hz, relative to the limited output level. Great care was taken in the design of the limiters to obtain *near perfect symmetry*. This assures that only odd order harmonics are produced; the simple bandpass filters are not adequate to deal with any appreciable second harmonic content.

A final difficulty arises in the design of the combiner unit. A particular tone may easily produce near-equal outputs from adjacent bands. If these outputs were simply added together, partial amplitude cancellation may result due to the phase difference between them. To avoid this and to maintain a flat frequency response, the output combiner contains phase shifting networks.

Almost as impressive as the design of the processing circuitry are the ancillary features and attention to detail which makes the SBP-3 a truly deluxe instrument. The audio agc circuit at the input is virtually free of distortion up to one volt input and is so effective that 16 or 17 dB of compression cannot be exceeded. This makes the device essentially overload proof. Front panel indicators, in the form of LEDs, show that full compression has been reached (green) or that excessive gain is being used (red). The latter condition, if allowed to exist, is simply a warning that there may be considerable background noise during long speech pauses.

The threshold levels for the green and red indicators are 10 and 100 mV respectively; the output signal level of the SBP-3 is approximately 80 mV. Remarkably, there are no critical components employed in the circuits, the closest tolerance being 5 per cent, and there are no internal adjustments. This makes the device suitable for marketing in kit form and I believe that this is being considered by the manufacturer.

A not uncommon difficulty with solid-state transmitting accessories is rf feedback or local RFI. Curing this is often laborious and time consuming. In the SBP-3 this possibility has been virtually eliminated through the use of rf layout, construction and bypassing techniques. As an extra precaution, the unit is housed in a metal enclosure arranged for good additional shielding. The power requirements are modest, nominally +12 volts dc at 35 mA (voltages between 10 and 18 volts are acceptable and don't affect performance in any way).

How does the SBP-3 stack up against a well designed rf clipping system? Tests have been going on for over six months and results seem to favor the new device by a small margin. This is believed to be due to the agc circuitry in the SBP-3 rather than the difference in the processing techniques. It is worth noting that there is a subtle difference in performance which, depending on circumstances, may make either method slightly preferable. The band splitting approach in the SBP-3 is likely to produce less intermodulation distortion (beats between two co-existing, non-harmonically related tones) than rf processing methods; on the other hand, rf processing (in theory) is completely free from harmonic distortion which is present, though small, in the new approach. The SBP-3, as presented to me is a high quality, technically superior — though not inexpensive — accessory for the transmitting radio amateur.

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ham radio

SB-102 modifications

Too many CW signals sounded less than T9 on my Heath SB-102. Hum modulation in the receiver section was suspected but the audio section was clean and the CW monitor oscillator tone was pure. The trouble was traced to the wiring of the switched ac for the power supply. Heath uses unshielded wire laced into the cable to run from the power supply plug to the on/off section of the *function* switch on the front panel. This induced hum into the other wires in the harness. Also, it was noted the proximity of the wires at the rear of the switch to the envelope of V3 had a bearing on the amount of induced hum.

Two methods may be used to solve this problem. The first is to use shielded wire for the run between the plug and the switch section. Small diameter coaxial-type wire was used here. The second method is to disconnect the wires from the power plug pins and insert a jumper. The center-off switch on the HP-23B power supply is then used for turning the SB-102 on and off.

The Heath SB-102 provides one extra relay point for use with linear amplifier switching If more relay-switched functions are desired, an extra relay must be employed. A Potter & Brumfield KHP17D12VDC 12-volt dc relay was used in the circuit of **fig. 1.** These are similar in construction to the ones originally used in the SB-102. The 12 volt ac line is tapped at board 85-130, rectified and filtered by D1 and C1. Relay points 10, 6, and 2 of RL1 are used to switch the ground end of RL3. RL1-6 is removed from pin 11 of the power plug and similar points of relay RL3 are used to provide that switching function.

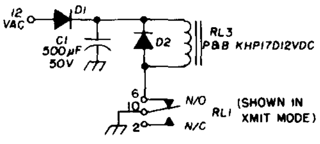

fig. 1. Circuit for adding a control relay to the Heath SB-102 for additional relay-switched functions (one auxiliary set of contacts is available in the original circuit).

The relay is socket-mounted on a small L-shaped bracket of aluminum fastened to the wall of the final amplifier rf cage. There is adequate room here for mounting the relay and routing the wires to and from the relay points.

When cleaning relays of the type used in the SB-102, it is best to remove the armature by unhooking the spring and gently prying back on the flat spring at the armature center point. Burned relay points not noticeable with the armature intact are now readily seen and cleaning is simplified. Use a burnishing blade designed specifically for cleaning relay points. Do not use excessive pressure on the bodies of these relays because the frame is made of soft metal and is easily bent. Alignment of the normally-open, normally-closed and armature points of the relay should be checked. See that the centers of the points contact each other. Gentle bending of the relay frame will align points that are off-center. Also, check to see if there is a small amount of "rise" to the armature points on the make to insure a slight wiping action. These relays should be checked periodically, especially if receive/transmit intermittents are encountered.

Paul K. Pagel, K1KXA

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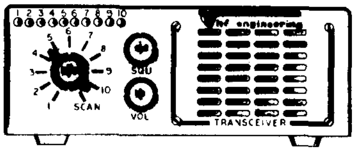
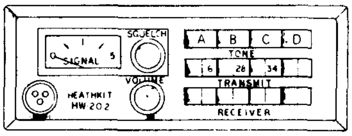
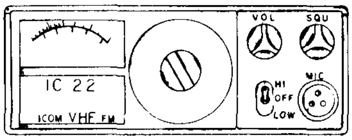
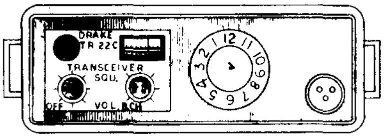
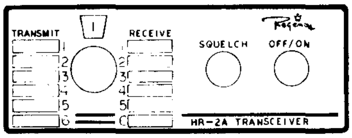
If you have one of these fine rigs . . .
. . . or any transceiver whose transmit crystals are 6-8-12 MHz and receiver crystals are in 15 or 45 MHz range, and are tired of buying crystals, but you can't afford $400-$700 for a new synthesized rig . . .

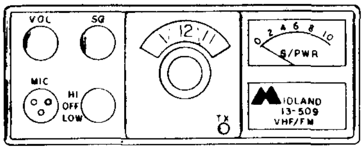












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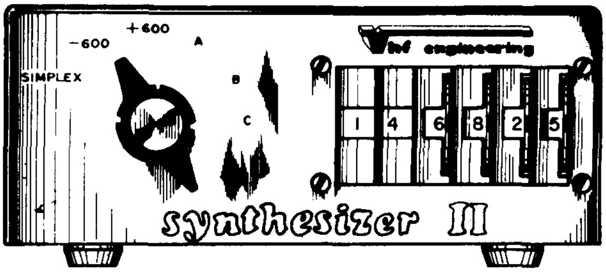

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improved selectivity for Collins S-line receivers

A simple no-holes modification provides the equivalent of a 14-pole filter with a measured 1.54 shape factor

With the inevitably increased crowding of the high-frequency amateur bands combined with stronger signals from better equipment, receiver manufacturers have been acting to satisfy the need for increased selectivity through the use of better filters. Presented here is a simple means of increasing the voice-range selectivity of the S-line receiver to exceed that of most receivers on the amateur market.

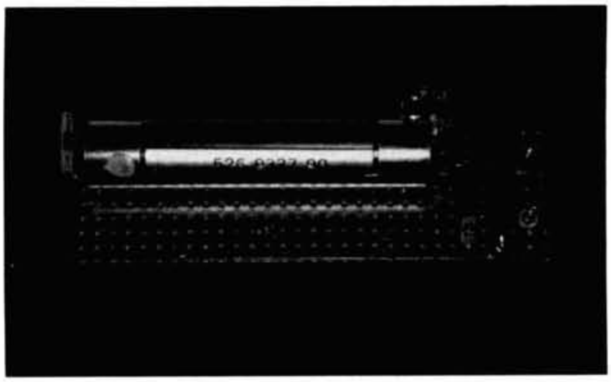
The cascade configuration of filters is a well-known method of increasing selectivity, which should theoretically improve skirt selectivity by doubling the attenuation. For proper results, it's necessary to employ a stage of isolation between the filters. In my case, this also serves to make up for the insertion loss of an additional filter.

approach

In my receiver, the S-line 75S3B, this concept becomes a relatively simple procedure. A second filter was added in the i-f strip as shown in **fig. 1**. The i-f gain *control*, R57, is used to touch up the calibration for the S-meter after the modification. Point A is where the signal was inserted for my measurements, and B is the output point. **Fig. 2** provides the circuit details regarding the additional filter, FL1, and its associated amplifier. The new filter is always operational, which precludes some problems and simplifies the modification.

Fig. 3A is the stock 2.1-kHz i-f passband of the S-line as a result of the Collins 455FA21 mechanical filter. This filter is a seven-disc unit, which is the equivalent of a seven-pole filter. **Fig. 3B** is the resulting improvement through the addition of a second filter, which was a 455Y21, the hermetically sealed version of the 455FA21. **Fig. 3C** is a double exposure of the two, superimposed for ease of comparison, which dramatizes

By Marv Gonsior, W6FR, 418 El Adobe Place, Fullerton, California 92635



Added filter and amplifier mounted on Vector board clad on one side. Isolation between input and output leads and existing filter below is important.

the improvement. The results of cascading the 1.5-kHz filter through the 2.1-kHz filter are depicted in **fig. 3D.** It may be seen, as expected, that a modest improvement is obtained. **Fig. 3E** is the passband of the 0.5-kHz CW filter before matching by proper adjustment of the resonating capacitors, and **fig. 3F** is the very worthwhile result of proper termination. Peaking by use of the S meter is not adequate for proper resonating/terminating of the filter. Collins advises that it is quite important to resonate their filters at the *lowest* signal level possible to preclude saturation. **Table 1** summarizes the measured relative performance of the two systems.

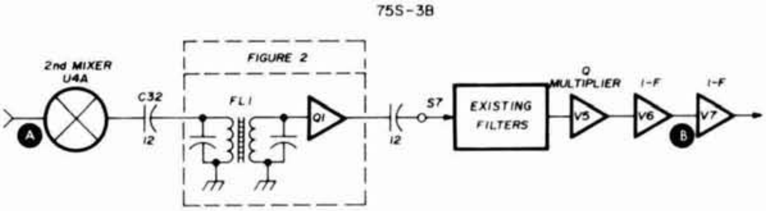


fig. 1. Collins 75S-3B i-f strip showing addition of the 455Y21 filter. Test signal for measurements was inserted at point A; output was taken at point B.

measurements

My instrumentation included Hewlett-Packard equipment consisting of an 8443A tracking generator in conjunction with their spectrum analyzer made up of the 141 display and the 8553B rf and 8552B i-f units. An H-P 1121 fet probe was used to sample the signals. For ease of photography, the signal voltages from the spectrum analyzer were transferred to a Tektronix 7704 oscilloscope. All instruments were laboratory grade and have accuracies traceable to the National Bureau of Standards. The calibration scales on all scope pictures are 1 kHz and 10 dB per division. Measurements down to the noise at -75 dB were easily accomplished.

If you wish to duplicate my measurements, it's necessary to remove V8, the bfo tube, otherwise it will produce a broad signal on one or the other skirt; i.e., the upper or lower sideband. A very interesting and applicable article by Arthur Lux[1] describes a relatively simple system for observing filter bandpass characteristics, which could be used instead of the more sophisticated equipment I used.

supply voltage

Regarding a source of V_{DD} for the fet, I used a 9-volt, 1-watt zener from the 72-volt screen supply for the i-f strip. This voltage was dropped through two 15k, 1-watt resistors in parallel. The current requirement of only 4 mA is nominal. This may be met in numerous ways, such as dropping down from the 140-volt zener, CR6. The power consumption is the same. Just be sure that the V_{DD} supply is well-filtered dc and is adequately decoupled. One change I incorporated, as a result of seeing the 72-volt i-f screen supply move sharply upward as much as 20 volts coincident with agc voltage, was to regulate it with a 75-volt zener that is barely regulating but limits the upward excursion of this supply voltage. A 0.1 μF bypass capacitor across the zener eliminated the small noise it generated. The importance of this change is to correct the regulation, which tends to drive up the G_m of the tube while the agc is simultaneously trying to lower it! The same problem existed in the 32S1 exciter with its alc voltage.[2]

table 1. Performance comparison of the two filter systems.

mode	6 dB	60 dB	shape factor
one filter	2.12 kHz	4.70 kHz	2.22:1
two filters	1.97 kHz	3.03 kHz	1.54:1

construction

The modification is easily accomplished without any drilling and results in the equivalent of a 14-pole filter

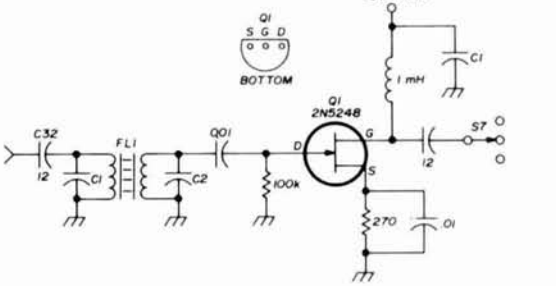
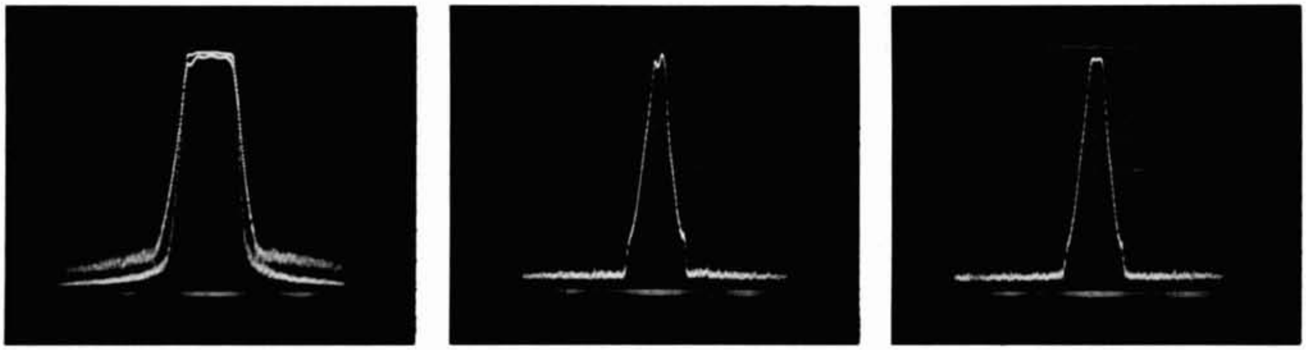


fig. 2. Circuit of added filter and its amplifier. V_{DD} for the fet was obtained through a 1-watt zener diode from the i-f strip 72-volt screen supply, which was decreased through two 15k, 1-watt resistors in parallel. C1, C2 are 130 pF, 1%, or trimmers.

A. 2.1-kHz i-f passband of the stock 455A21 mechanical filter.

B. Passband improvement by adding the 455Y21 filter.

C. Traces A and B superimposed for comparison.



D. Results obtained from cascading the 1.5-kHz filter through the 2.1-kHz filter.

E. 500-Hz CW filter response before proper termination.

F. Passband response with filters correctly resonated and terminated.

fig. 3. Oscilloscope traces obtained during measurements, which show improvements obtained by adding a second filter. Vertical and horizontal scale calibrations are respectively 10 dB and 1 kHz per division.

with a 1.54:1 shape factor. The basic cost of the change is that of the additional Collins mechanical filter. The 455FA21 (part no. 5269427-000) currently retails for $59.88. The equivalent filter in a hermetically sealed case is the 455Y21 (part no. 5269337-000), which retails for $96.13. Both units may be found in surplus and other markets at relatively favorable prices.

I constructed my unit using a pad cutter on a piece of Vector board clad on one side. It measures 7/8 x 3-1/8 inches (22x80mm). Layout isn't critical as long as certain basic rules are followed. These are: keep the input and output leads apart, remembering that you're working with −75 dB signal levels; use a ground plane to shield the new filter from the ones below it; and keep the drive levels low to avoid overdriving the second filter. The total job should take about two hours. The board mounts easily on its own leads and with a lug to a ground terminal, which conveniently protrudes inside the shield around the bottom of T4 and the existing mechanical filters (**fig. 4**).

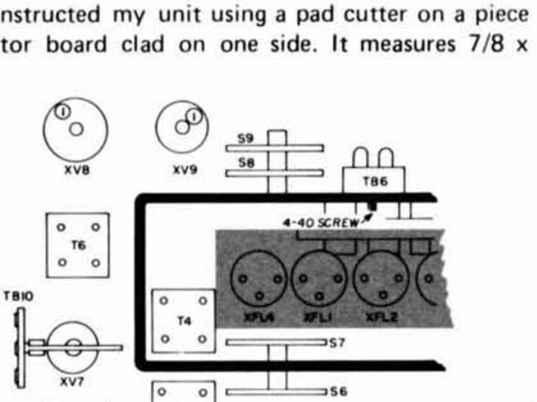


fig. 4. Shaded area shows location of filter circuit board on the S-line receiver. Board is secured to a solder lug attached to TB6 ground terminal.

results

The benefits of using the two filters in cascade, properly terminated, are quite impressive as the scope pictures show. For example, the frequency excursion required for my S9 +40 dB crystal calibrator signal to become inaudible was reduced by 750 Hz with two filters installed versus one. In digging out weak signals in interference, this filter system is quite effective, as the theory predicted.

references

1. Arthur E. Lux, W7UC, "Filter Alignment," Ham Notebook, *ham radio*, August, 1975, page 61.

2. P. Kreager, W6UYW, and M. Gonsior, W6VFR, "32S1 Operating Improvements," *CQ*, August, 1962, page 47.

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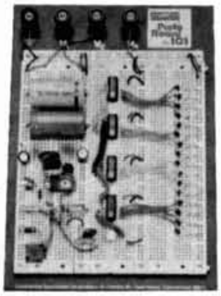

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the weekender

linearity meter for rf power amplifiers

In a previous article I remarked that speech splatter is *almost* impossible to detect from the usual transmitter meter indications.[1] This is certainly true for meter indications of plate and grid current and power output. However, *a method used in commercial equipment* is available for obtaining a meter indication of splatter, which can be added to any linear amplifier as an external "black box." This article describes the design and construction of such a meter and gives hints on its use.

linearity constant

Recall that a linear amplifier, by definition, obeys the relationship $P_{out} = k\ (P_{in})$, where P_{out}, P_{in} are output and input power and k is a constant, which is determined by amplifier design and which does not change during amplifier operation. In practical linear amplifiers k is most often about 20. But it may be as low as 5 to 7 or as high as 50 to 100. The lower values are usual in grounded-grid designs; the higher values prevail in class AB_1 designs using tetrode tubes.

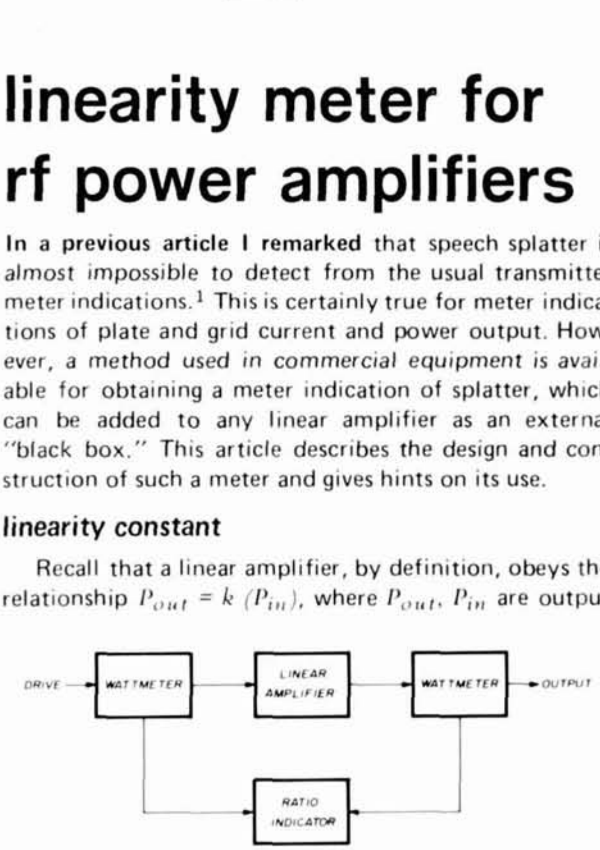


fig. 1. Principle of the linearity/splatter meter. The ratio P_{out}/P_{in} is determined. As long as it remains constant operation is linear and no splatter is generated.

Reference 1, in discussing sources of splatter, noted that k could increase or decrease, with splatter generation occurring for either case. An increase in k is associated with instability: for example, with a parasitic that is keyed on, at, or near modulation peaks. A decrease in k is almost always the result of flat-topping (driving the amplifier to the point of saturation).

meter design

These factors point the way to the design of a splatter meter. Simply put, this means a circuit that measures k. As long as k remains constant the amplifier operates linearly and will not generate splatter. However, if k changes by an appreciable amount, the amplifier is not linear and is probably generating splatter.

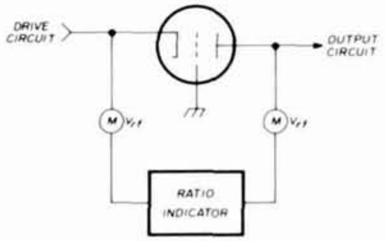
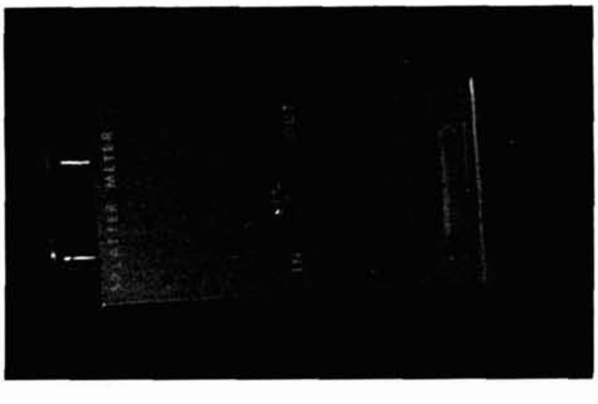


fig. 2. Linearity meter using voltage measurement applied to a *grounded-grid amplifier*. See ARRL handbook. Circuit must be built into amplifier.

One method of designing such a meter is evident from the equation above. As shown in **fig. 1**, two wattmeters are used; one measures the drive power to the amplifier and the second measures its output. The ratio of these meter readings is the desired indication. Those amateurs who have two wattmeters can connect them in in this fashion, using the simple ratio circuit described later to obtain splatter-detection capability.

In most situations it's not necessary to measure the powers. Instead only the circuit voltages or currents

Completed linearity meter for measuring the splatter of single-sideband signals.



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*A complete parts kit for this ssb linearity meter is being made available in conjunction with this article. For ordering information and prices, write to G.R. Whitehouse & Company, 10 Newbury Drive, Amherst, New Hampshire 03031.

By R.P. Haviland, W4MB, 2100 South Nova Road, Box 45, Daytona Beach, Florida 32019

need be measured; usually the voltages, since this is easier. Such a splatter meter is sketched in **fig. 2** for a typical grounded-grid stage. Design values for this circuit are in the ARRL *Radio Amateurs Handbook*, Chapter 6 of the 1972 edition. (The circuit is not in the 1975 edition, but may be in some earlier ones.)

Owners of the Collins 30L1 amplifier will recognize this circuit as the heart of the *load* position of the meter indicator. In this amplifier, k was determined during design and operating instructions call for the loading to be adjusted to give this value. The circuit can also serve as a nonlinearity or splatter detector, but the presence of automatic load control makes this a secondary use.

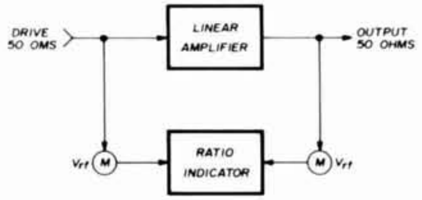


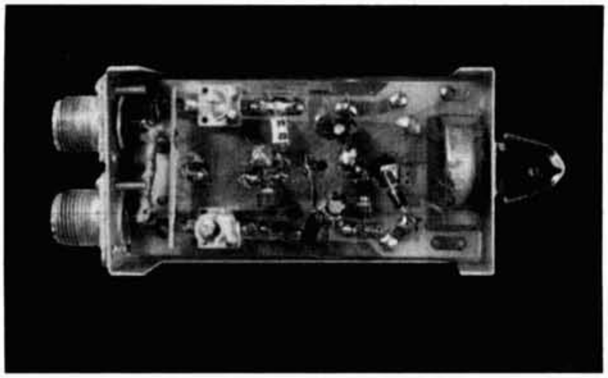
fig. 3. External linearity meter, which measures voltages at 50 ohms. The circuit can be applied to any linear amplifier.

The circuit of **fig. 2** can be added to any amplifier. Most users of commercial amplifiers don't want to make changes to the equipment lest they reduce the resale value. Also, many amateurs seem to prefer separate black-box add-ons for such functions.

practical circuit

The splatter meter is easily made into a separate add-on circuit by changing the design voltage levels of the input and output voltmeters to agree with those of the amplifier in use. For most designs, this means measuring the voltage across the 50-ohm input and the 50 ohm output, as in **fig. 3**.

Suppose that the amplifier is a typical one-kilowatt linear, with about 50 watts of drive requirement and about 500 watts output. The input voltage is about 50 volts rms (70 volts peak), and the output voltage is $\sqrt{10}$ times the input, or 158 volts rms and 221 volts peak. The voltmeters should have some adjustment range, since a) the impedances may not be exactly 50 ohms, and b) amplifier output tends to fall off on the higher-frequency bands. An adjustment range of 3:1 or so allows for this.



Prototype 50-ohm splatter meter using circuit of fig. 4. The zero-center meter is a surplus item, originally intended for fm, a-m tuner use.

One such circuit is shown in **fig. 4**. Two capacitive dividers reduce the voltage on the input and output lines to a common working level, in the range of 2 to 5 volts peak: this is the main factor in setting the ratio value. Germanium diodes give the corresponding dc levels. The meter has a zero center, with switching arranged to give E_{drive}, E_{output}, and $E_{output} - E_{drive}$. The first two are for convenience in setting up the instrument, and the last is the desired linearity measurement, or splatter detection.

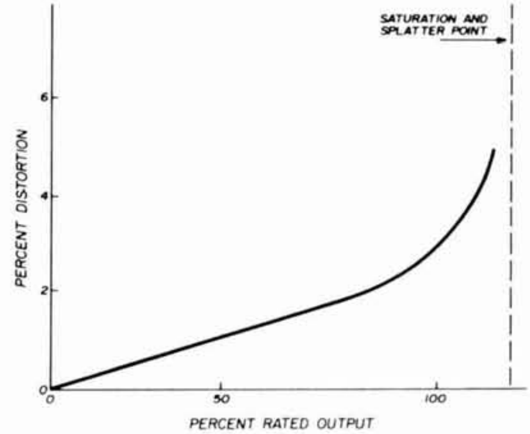


fig. 5. Normal performance of a linear amplifier. Distortion is approximately 30 dB down at the rated output. An actual curve may show more variation from a straight line.

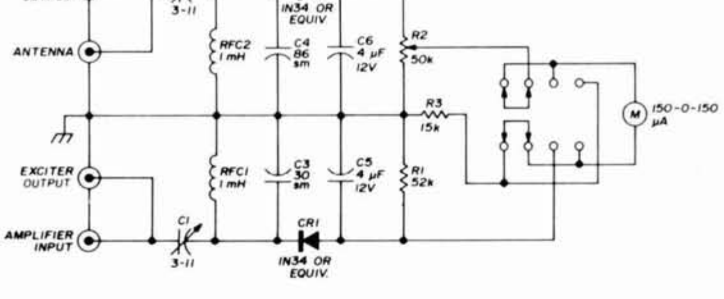


fig. 4. Circuit for an external (50 ohm) linearity/splatter meter. C1, C2 are set for power levels involved. R2 compensates for changes in antenna load and amplifier efficiency as band is changed.

construction

Except for good shielding between the drive- and amplifier-output terminals, circuit construction isn't critical. The PC board layout is shown in **fig. 6**. Note that the PC board is used as a part of the shielding. The drive side connectors, choke, and variable capacitor are on one side of the board and the output side elements are on the other.

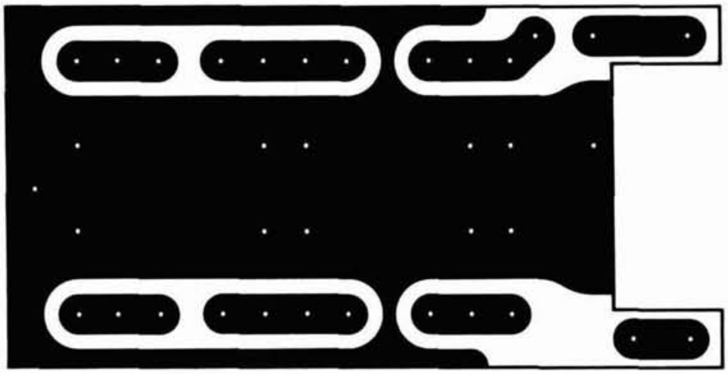


fig. 6. Full-size circuit-board layout for the splatter meter. Component placement is shown in fig. 7.

operation

Set the potentiometer to half scale and C1, C2 to minimum capacitance. Set the transmitter for half maximum output voltage (¼ power) using a dummy load. Place the meter switch on drive voltage and adjust C1 for half-scale meter reading. Adjust C2 with the meter on output voltage. Switching to the differential position gives the departure from linearity. The circuit sensitivity increases because the voltage-dropping resistor, R3, is out of the circuit in the differential position. When the band is changed, it may be necessary to reset the potentiometer for reasons discussed above.

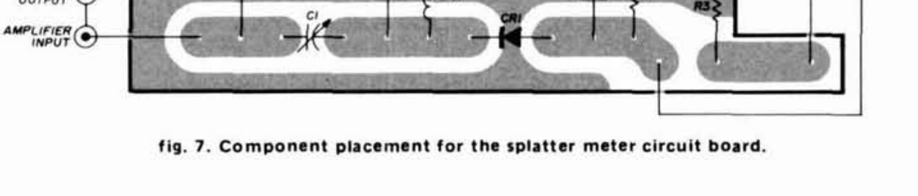


fig. 7. Component placement for the splatter meter circuit board.

Full-scale meter deflection should correspond approximately to a 10% departure from linear operation, or to distortion products 20 dB down. This sensitivity makes it easy to keep operation well below the point of objectionable splatter. Negligible loss of amplifier output occurs. The distortion-output curve of most amplifiers behaves as shown in **fig. 5**. The difference between a reading just discernible on the meter and bad splatter amounts to a few tenths of a dB.

A few tricks make the splatter meter easier to use. One is to use a matchbox between the antenna and the amplifier, which eliminates a variable because the amplifier output will be presented to a constant impedance. Another trick is to bias the readings slightly. I find it easiest to set up for a small, just-perceptible deflection to the right under tune-up conditions. Drive is then increased until the meter just barely flicks to the left; overdrive is indicated by a larger deflection to the left. Amplifier instability shows up as a large swing to the right.

I've made no real effort to optimize the design. The relative sensitivity on the linearity position and the time constant of the meter filters can probably be improved, as can the internal layout.

reference

1. R.P. Haviland, W4MB, "Single Sideband Speech Splatter," *ham radio*, September, 1975, page 28.

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improving transmitter keying

Methods for shaping code characters to eliminate key clicks

During a decade of activity in the ARRL intruder watch program I have observed that insufficient attention has been given by amateurs to the keying quality of CW and RTTY transmitters. This article addresses the problem of keying transients in terms of keying-circuit time constants and presents several methods for optimizing these time constants to eliminate this form of interference to other stations.

A properly designed and operated radiotelegraph transmitter produces radiation in the form of clean-cut dots and dashes having rounded edges. If the energy contained in these dots and dashes rises and falls too rapidly, the abrupt changes in amplitude cause high-order sidebands, which produce energy at a frequency greatly different from the transmitter-carrier frequency. Although weaker than signals at the carrier frequency, the sidebands introduce disturbances in the form of clicks or thumps in nearby (or even distant) receivers, even though these receivers are tuned to other frequencies. Such transients may be eliminated or greatly reduced by proper design of keying-circuit time constants.*

rise time

Observation of signals indicates that the rise and fall time of dots and dashes should be at least five milliseconds long – after passing through all the following linear stages. This rise and fall time is satisfactory at code speeds through at least 60 words per minute. **Fig. 1A** shows a dot with rise and fall times of about one millisecond, which causes key clicks in a distant receiver. **Fig. 1B** shows the dot with the rise and fall times extended to five milliseconds, which provides a clean signal that will not cause interference in a distant

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*One equipment manufacturer points out that propagation conditions are the cause of some key clicks. However, this leads to a misconception because a wave shape that is abrupt may generate clicks which may not be noticed on weaker signals or under other conditions. One phenomenon that brings out key clicks probably is selective fading which may permit independent fading of frequencies as close as 500 Hz. This is noted when a carrier fades down in a-m reception, leaving the overmodulated sidebands. Similarily, a CW signal can fade, leaving the adjacent key clicks which stand out as spikes on an oscilloscope display of the received signal.

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receiver tuned to an adjacent signal while using a 200-Hz CW filter.

The dot shapes shown in **fig. 1** are those displayed on an oscilloscope connected to the audio output of a distant receiver, with agc off, and rf gain turned down appropriately.

contact bounce

Contact-bounce clicks are generated in almost all types of keys and relays. An electronic keyer may be completely free of them provided no relay is used. An example is transistor keying in the grid circuit. For some years I have used a 2N398B pnp transistor driven by a 2N404 pnp transistor at the end of a discrete-component keyer.[1] The 2N398B operates on the negative 25 volts from the grid-keying lead of a Collins 32S3 exciter. The self-completion feature of the keyer leaves nothing to create a contact bounce in the keying circuit.

The Curtis keyer kit[2] uses a 2N4124 npn transistor driver and a MJE350 pnp transistor switch for negative keying voltage (or a 2N5656 npn transistor for positive keying voltage).† The Curtis 8043 keyer IC has built-in debouncers for each keying line. These are proprietary circuits with gates that provide feedback in conjunction with RC timing networks, apparently so arranged that the addition of the two paths tend to fill in any "holes" caused by bounce.

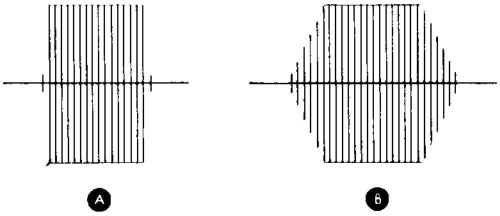

fig. 1. Dot waveforms at 1 kHz beatnote showing effect of keying-circuit time constants. Abrupt dot (A) has less than 1 ms rise and fall time, generating key clicks. Dot at (B) has a minimum 5 ms rise and fall time.*

A dot with contact bounce on make looks like **fig. 2** in a distant receiver. Most bounce occurs in the first three milliseconds, although a few keyers that use keying relays have actually split a dot into two halves. Also, bounce can occur at the break end of a dot.

RTTY bounce

In manual keying most bounce is near the front end of the character, although some bounce on break is possible. In RTTY keying, bounce is more frequently encountered with keyboard operation and less so on tape with the transmitter-distributor that has a commutator. The mark pulses as seen on the oscilloscope usually start with the bounce, while the space pulses end with it. The bounce causes a fast reversal between mark and space and back again, which causes fast, broader clicks. Such conditions may create variable distortion at the receiving printer. Cleaning the contacts and varying the voltage across the contacts may change the pattern but may not entirely eliminate the problem.

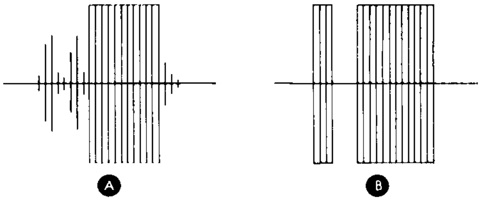

fig. 2. The irregular bounce at (A) looks like noise and is associated with "mushy" key clicks. The square-shaped bounce in (B) may not be noted by ear, except that the abrupt rise and fall times generate sharp key clicks.

vox clicks

The adverse effects of vox-type clicks and possible contact bounce can be reduced materially. It helps to have a long rise time provided by some form of RC filter in the vox circuit. If the rise time is extended to ten milliseconds, the signal amplitude at the time of the vox-type click or at the end of the bounce will be considerably less than that of the full exciter output.

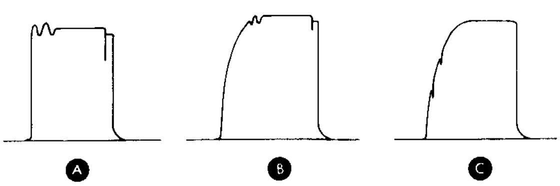

fig. 3. Key output dc waveforms showing bounce at both ends of a dot (A); with 5k resistor in keying line (B); and after adding a 0.1 µF capacitor across key (C). Bounce on make is barely perceptible (well down the curve); on break it has disappeared.

key capacitor

Fig. 3A shows a dot keyed by a reed relay in a Palomar electronic keyer. Note the bounce at both ends of the dot. Any part that exhausts itself in the fully on or the fully off condition in the exciter may be expected to cause no trouble. However, it's possible to add further external treatment.

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*Rise and fall time can be measured by displaying on an oscilloscope the output of a receiver tuned for a 1-kHz beatnote, then counting the "cycles" (which are one millisecond each). When using this simplified measurement technique disregard any low-level cycles adjacent to the baseline.

†The labels for negative and positive keying were inadvertently reversed in the keyer schematic in reference 2. However, author Olsen clearly states that an npn device must be used for positive key-up voltages and vice versa.

Although my Collins 32S3 vox circuit won't operate with much more than 5k ohms added in the grid-keying lead, it will take a 0.1 μF capacitor from key to ground. Without this capacitor, a 5k resistor between the key and exciter produces the RC time-constant curve of **fig. 3B**, but the bounce is not affected. When the 0.1 μF capacitor is added the bounce moves down on the slope of the curve and the bounce on break disappears, as shown in **fig. 3C**. Just which method is better depends upon where on the curve the transmitter output is interrupted by the bounce. After experimenting with debouncing circuits, it appears that the capacitor always should be across the key contacts.

Kenwood example

Problems with click elimination in a T-599 Kenwood transmitter may be of interest. All attempts to insert adequate resistance in the keying circuit unacceptably reduced rf output. At a distance of about one-half mile (1km) from the transmitter, I watched the keying patterns with an oscilloscope on my receiver while changes were made. The clicks were from contact bounce, and were not caused by the T-599 at all!

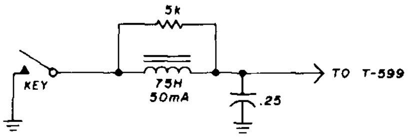

fig. 4. Inductive filter used on Kenwood T-599 to eliminate contact bounce and provide rise and fall time.

A 75 henry, 50 mA audio choke with a resistance of 2300 ohms was installed in the key lead instead of a resistor. To reduce contact bounce, a 0.25 μF capacitor was placed from the key line at the transmitter end to ground. This circuit resulted in excellent rise and fall time with no bounce, but the dots were shaped like dumbbells! A potentiometer was tried across the choke and was finally replaced with a fixed 5k resistor. The final circuit is shown in **fig. 4**. It wasn't necessary to put another capacitor across the key and no separate debouncing circuit was necessary.

The result was a keying waveform with a rise time of 6 milliseconds, a fall time of about 3 milliseconds, and a flat top similar to **fig. 1B**.

debouncing

Debouncers can be applied to keys and relays and can be used in RTTY terminal equipment.[3,4] They generally use a one-shot IC, such as the 74122 and the dual 74123. Several debouncers provide gates to use the switch or key circuit and a one-shot output (74122 or 74123 with the feedback connection to prevent retriggering).[3] The keyed output is delayed for at least five milliseconds while the bounce has a chance to settle down, with or without a later re-extension of the key-down pulse to restore its original length.

This approach appears to be good for calculator keyboards, flip-flop testers, and many other applications in which the final clean pulse length is not highly important. Note, however, that loss of a few milliseconds at the start of a dot is not noticeable to the ear, although it may change the best setting of the range selector in a teletype machine. A dual one-shot (74123) circuit is shown in **fig. 5**.

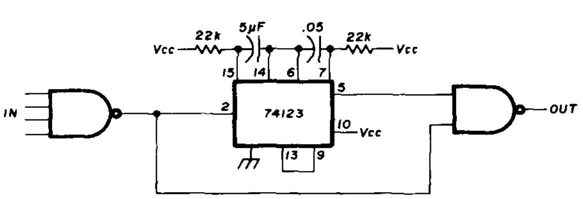

fig. 5. A type of delayed start circuit to sliminate bounce on make when contacts are closed.

Another debouncer method is to use a gate to add the key pulse and a one-shot output during the first five milliseconds of the key-down position, thus swamping out the contact bounce on make with the one-shot output (**fig. 6**). Note that the break end is not corrected.

NE555 timer circuit

The NE555 and the dual NE556 timers simplify the circuit by eliminating the need for gates. A resistor can be brought from the 5- to 15-volt V_{cc} to the trigger input; the input to the IC simply can be keyed to ground. On the NE555 timer output end it's not necessary to add the V_{cc} side of the key to the timer output. The NE555 not only can provide a pulse of at least 5 milliseconds long (and much longer if desired), but it also can remain on as long as the trigger input (key) pulse is low (grounded).

The timer triggers on the negative-going edge of a low-going pulse, such as key down to ground. Normally the trigger pulse length must be shorter than the RC time interval of the timer. If the trigger is held low, the timer output will stay high until the trigger is driven high again (key-up condition). A simple debouncing circuit for keying purposes or, for that matter, for many other purposes as well, is shown in **fig. 7**, using a common

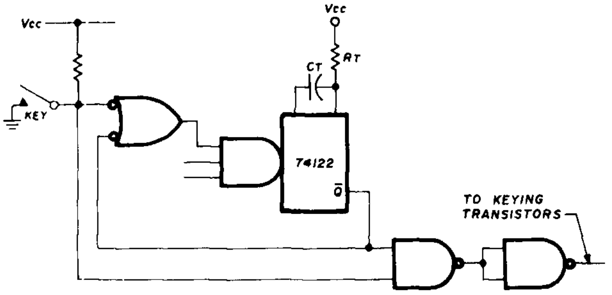

fig. 6. Circuit for swamping bounce on make by adding key output to that of a one-shot.

negative isolated from ground. The V_{cc} can be 5-15 Vdc and need not be highly filtered or regulated. The output is a perfect copy of the keying but without bounce on make. It has no special provision to eliminate possible retriggering on break; but the key voltage, after rising and releasing the timer, must pass through two widely spaced voltages to retrigger the timer. Retriggering has not been observed as yet, so there has been no need to inhibit the timer for a short time at the end of a dot.

The timer output may be connected to the exciter keying input without introducing any relay contacts as shown in **fig. 7** for negative grid keying, or as in the reference 2 drawing (with output polarity corrected) for positive keying. Note that internal common is *not* grounded to external ground.

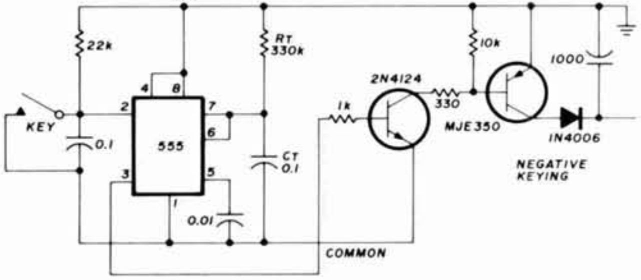

fig. 7. NE555 timer IC used to produce bounceless square output to a transistor keyer.

The keying transistor collector output can be protected against incorrect voltage polarity with a 1N4006 diode. If a ferrite bead is added for rf protection, the *large* Amidon bead, with at least 8 turns of small wire wound through it, makes a better choke than a single small bead slipped over the output lead. Whether the bypass capacitor should be on the output or on the transistor end of the bead for best rf isolation might be considered. Shielding and ground-strapping the NE555 timer and keying transistor enclosure should ensure isolation from a nearby high-power rf amplifier.

While the NE555 circuit removes the contact-bounce problem, it does have a squarewave on make and break (100 ns each). Therefore, it's still necessary to have circuitry in the exciter or, alternatively, between the keying transistors if needed, to provide a keying rise and fall time of at least 5 milliseconds for Morse keying. A suitable transition time must also be provided in RTTY keyers.

references

1. E. L. Klein, W4UHN/WB2PKE, "Der Kleiner Keyer," *73*, September, 1965, page 7.
2. Hank Olson, W6GXN, "Integrated-Circuit Electronic Keyer," *ham radio*, April, 1975, page 8.
3. John Gearhart, WA0AQO, "Scanning With a Synthesizer," *73*, April, 1975, page 23.
4. Hank Olsen, W6GXN, "Further Adventures of the Bounceless Switch," *73*, February, 1975, page 111.

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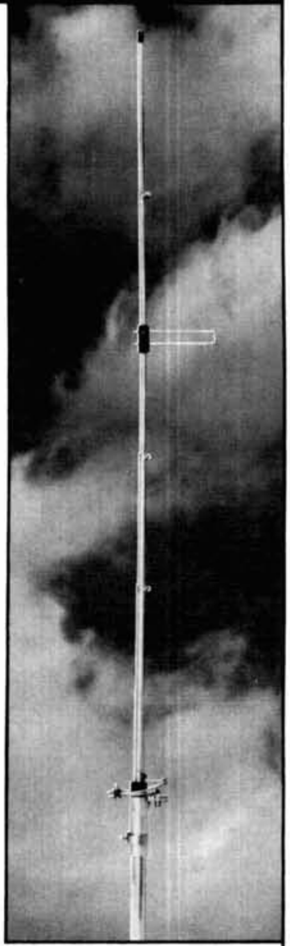

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CIRCUITS & TECHNIQUES

Jim Fisk, W1DTY

coaxial connectors can generate rfi

According to a recent report from the Naval Research Labs, weak-signal communications systems can be seriously degraded by Intermodulation Generation (IMG) introduced by coaxial cable connectors which contain *small* amounts of ferromagnetic materials. Many vhf, satellite, and EME operators who use receivers with sensitivities in the -120 to -140 dBm require minimal IMG for maximum sensitivity.

NRL investigators have found that even small quantities of ferromagnetic materials in coaxial connectors can degrade IMG on the order of 50 dB. Among the connectors that can cause rf nonlinearity problems are low permeability (<2) stainless-steel connectors and connectors which have been merely plated with nickel. Hermetically sealed connectors with *Kovar** conductors are especially bad in this respect, but few amateurs use this type of connector. Since nickel plating is widely used as a substitute for silver- or gold-plated finishes, and many newer-type, low-permeability, stainless-steel connectors qualify under MIL-C-39012B, it is becoming increasingly difficult to obtain rf connectors which are completely free of ferromagnetic materials.

In the measurements made at NRL, it was found that standard, silver-plated type-N or BNC connectors and adapters are quite linear (providing the devices are clean and the contact surfaces are well aligned), allowing IMG measurements to -140 dBm (60 watts drive). Even when sixteen UG-29B/U (double female) and UG-578/U (double male) type-N connectors were connected in series, IMG performance was degraded less than 4 dB. Multiple BNC connectors were only slightly worse.

In comparison tests with hermetically-sealed connectors which use *Kovar* conductors, the IMG level typically measured -85 dBm, an interference increase of 55 dB over the -140 dBm linear device reference. To verify that the high IMG level was a function of the ferromagnetic material, a solenoid dc field was applied coaxially to the connector. The initial IMG level of -85 dBm decreased to -105 dBm — upon removal of the external magnetic field the IMG level returned to -85 dBm.

Stainless-steel coaxial connectors fared only slightly better in the IMG tests. Six double-female adapters with stainless-steel outer conductors and gold-plated, beryllium-copper center contacts measured from -85 to -90 dBm IMG. To confirm that the non-linearity was in fact due to the stainless-steel outer conductors, identical structural elements were machined from brass and assembled with the gold-plated, beryllium-copper inner contact element. With this change the IMG levels measured from -137 to -140 dBm. When the connectors were reassembled with the stainless-steel body elements, the IMG levels once again increased to -85 to -90 dBm.

To cut cost, many rf coaxial connectors now on the market are nickel plated. Unfortunately, nickel-plated rf hardware shows large non-linear rf effects. Sample nickel-plated brass devices tested by NRL have shown IMG degradation in excess of 10 dB and often higher than 30 dB relative to silver-plated brass connectors. Furthermore, the IMG performance of some heavily nickel-plated connectors was as poor as that measured with stainless-steel connectors.

In conclusion the NRL investigators recommended that immediate steps be taken to eliminate the use of nickel plating as well as other ferromagnetic materials in rf connectors, and to eliminate ferromagnetic materials from rf components where the material is subjected to the effects of current flow. They also recommended that the pertinent military specifications be revised accordingly.

Although the communications receivers used by amateurs who operate primarily on the high-frequency bands are not sensitive enough to be seriously affected by IMG produced by ferromagnetic coaxial connectors, these connectors can cause interference to other radio services, especially television, OSCAR communications, and other long-distance vhf communications systems. In addition, the NRL measurements were made at an rf power input of 60 watts — with kilowatt inputs IMG interference can be expected to be much worse.

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*The thermal expansion characteristics of *Kovar* are similar to those of glass and ceramic, so it is widely used for glass-to-metal seals in vacuum tubes, semiconductors, and hermetically-sealed connectors. However, *Kovar* has high resistivity and permeability so rf losses at the seals are high, and at hf and vhf cracking can result. One amateur who used this type of connector in a 1000-watt two-meter linear lost an expensive 8877 when the ceramic seal cracked and allowed rf energy to arc to ground. As further proof of the unsuitability of these connectors for rf work, tests aboard the *USS Bunker Hill* indicated that third harmonic distortion from high-frequency Navy transmitters increased about 20 dB when hermetically sealed adapters were used.

This NRL report has widespread implications for the entire electronics industry. Television sets in fringe areas which are located near amateur or broadcast transmitters, and use ferromagnetic coaxial connectors, are likely to be subjected to undesired interference. Vhf-fm systems with close-spaced, diplexed antennas using ferromagnetic connectors may have increased intermodulation problems, and high-quality, commercial-grade antennas which feature stainless-steel hardware may have undesirable IMG characteristics.

improving speech intelligibility

During the Apollo moon shots the NASA flight controllers sometimes had difficulty separating an astronaut's voice from the background noise. Since the voice spectrum between 40 and 900 Hz and 1900 and 3000 Hz seems to contribute little to intelligibility, and only three portions of the speech spectrum are apparently required for clear speech (300-400 Hz, 900-1700 Hz [1100-1900 Hz for females], and 2500-3000 Hz), NASA engineers developed the circuit of **fig. 1** for more reliable voice communications. In this circuit the potentiometer adjusts the null to about 600 Hz, and the switch provides for either male or female voices. Although the audio bandwidth of most amateur transmitters is limited to 300-2400 Hz, this circuit has been used to good advantage for pulling weak DX signals out of the noise and correctly identifying their callsigns.

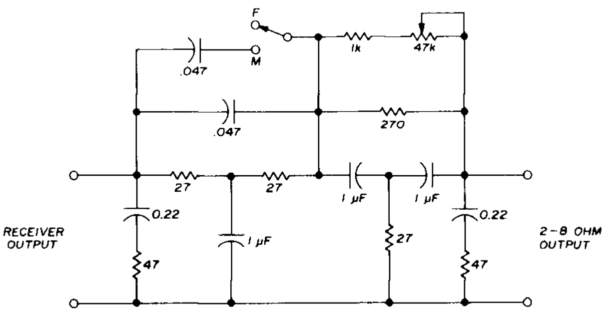


fig. 1. Circuit developed by NASA engineers to improve the intelligibility of voice communications. Potentiometer adjusts null to 600 Hz, and switch provides for either male or female voices.

low-level, high impedance preamplifier

A low-cost, transistorized preamplifier for oscilloscopes and meters can be a real time saver in the lab. The unit in **fig. 2** uses a Darlington circuit to obtain extremely high input impedance. The ac input impedance of this circuit is approximately $(h_{fe})^2$ times the emitter resistance of transistor Q2, and in practice has been measured in excess of 2.2 megohms. With the input shorted, the noise level is −78 dB down as read at the output with a vtvm. By using low value resistors in the base of Q1 to establish the operating point, the circuit exhibits good dc stability over wide temperature excursions. In addition, linearity is within 1.5 percent from 100 microvolts to 1 millivolt input, and frequency response is ±2 dB from 100 Hz to 350 kHz. Although originally designed to boost the input to an oscilloscope, this circuit may be adapted to other applications where high gain, low noise and high input impedance are required.

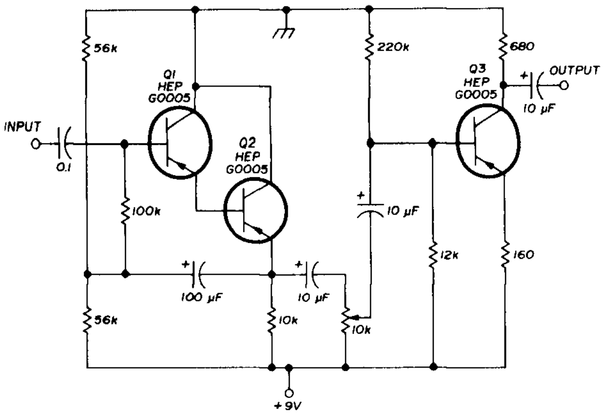


fig. 2. Low level, high impedance preamplifier has input impedance greater than 2.2 megohms. Frequency response is from approximately 100 Hz to 350 kHz. All transistors are Motorola HEP G0005.

dynamic microphones

Not too well known among amateurs is the fact that dynamic microphones exhibit a *proximity* effect which increases the bass output as the distance between the source of sound and the microphone is decreased. Although stage performers often use this effect to increase the bass registers or to add "warmth" to their voice, amateur operators should refrain from getting closer than about 4 inches (10cm) from a dynamic microphone.

The result of a signal source 3 inches (7.5cm) from a typical dynamic microphone is graphed in **fig. 3.** At 200 Hz the output is approximately 4 dB higher than at 1 kHz, an increase of about 58 per cent. What **fig. 3** doesn't show is that the power output per unit bandwidth is considerably higher at frequencies below 500 Hz than it is at the higher audio frequencies which are more effective for radio communications. In addition, the increased bass output caused by speaking too close to a dynamic microphone can introduce distortion be-

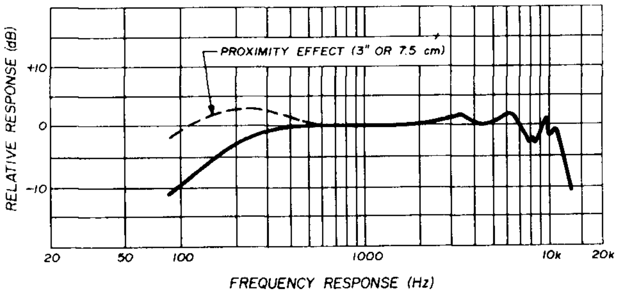


fig. 3. Proximity effect of dynamic microphones provides increased low-frequency output when the sound source is too close to the microphone. For best results in radio communications, keep the microphone at least 4 inches (10cm) away from your mouth.

cause of overloading and, in fm systems, overdeviation.

Speaking across the microphone may help, but different brands of microphones have different off-axis response and they are not very directional at the lower audio frequencies. For best results, speak directly into the front of the microphone, but keep it at least 4 inches (10cm) away from your mouth.

lightning protection

Most amateurs make sure their antennas and towers are well grounded for lightning protection, but sometimes forget that lightning can enter the service entrance to their homes, causing a good deal of damage. Since the high-voltage surges enter the service entrance and seek the least resistance path to ground, all to often that path is through your carefully grounded amateur equipment. Television sets, electric stoves, hot water heaters, and house wiring also fall prey to service entrance lightning and many bad fires have been caused by it. In most cases the damage isn't caused by a nearby lightning strike, but one to the power line a good distance from the house.

Fortunately, there is a very inexpensive solution to this problem in the form of a small, low-cost lightning arrestor which is similar to the large units used at electrical substations. Both General Electric and Westinghouse manufacture these devices. The General Electric 9L15CCB007 home lightning protector, for example, costs about $12.00, can be installed at the service entrance or inside the main breaker panel, and is guaranteed for minimum life of ten years. Some insurance companies will give a rate reduction with a properly installed service entrance lightning arrestor. With an arrestor of this type and a properly grounded antenna, the only worry is a direct hit on the house (which can be protected with lightning rods).

oscar antenna

The antenna shown in **fig. 4** was suggested by WA4DDH for use with Oscar 7, both Mode A and Mode B. The antenna consists of delta-loop beams for ten and two meters, a multi-element Yagi for 432 MHz, and is tilted about 35 degrees above the horizon. Separate gamma matches are used on the two delta loops, with all three feedlines taped along the boom. Although WA4DDH suggested the use of a 7-element Yagi, a number of suitable 432-MHz antennas have been described in the amateur magazines.

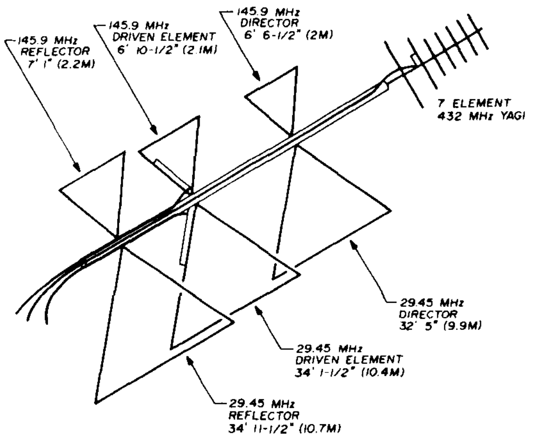


fig. 4. Antenna for Oscar 7, mode A and B, suggested by WA4DDH uses delta loops for 29.45 and 145.9 MHz, and a 7-element Yagi for 432. Each antenna has its own gamma match and transmission line.

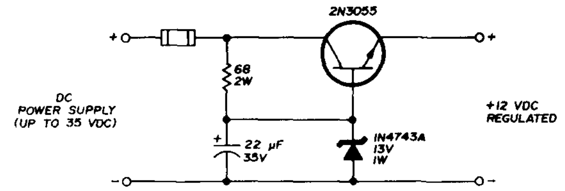


fig. 5. Simple 12-volt regulated power supply for up to 2 amperes. The 2N3055 is mounted on small U-shaped heatsink made from 2 inch (5cm) strip of aluminum.

coaxial cable

A number of readers have written to complain that coaxial cable they've purchased recently doesn't have the braid coverage it used to have. In some cases the braid coverage is so poor that you can see the inner insulation through gaping holes in the braid. This sad state of affairs is due to the fact that RG-8/U is no longer a Mil Spec cable (having been replaced by RG-213/U). Copper is expensive, so the manufacturers have cheapened the construction of non Mil Spec coaxial cable rather than cutting the price. Therefore, it's a good idea to stay away from commercial quality coax, insisting instead on those cables which are covered by military specifications (RG-58C/U, RG-59B/U and RG-213/U for example).

An additional benefit of Mil Spec coax is that the outer jacket is of the noncontaminating type. The outer jacket comes in two types and is very important in determining the life span of the cable. The older class 1 contaminating jacket (used on RG-8/U, RG-58/U and RG-59/U) incorporates a plasticizer during the manufacturing process to keep it flexible. As soon as the cable is jacketed, however, the plasticizer starts to leach through the shield braid into the polyethylene insulation around the center conductor. This changes the electrical characteristics of the insulation and results in increased cable losses. This process is relatively quick, and increased losses can be readily measured after only one or two years.

Later coaxial cables use a non-contaminating class 2A jacket which is long-lived, abrasion resistant, and not damaged by sunlight. Furthermore, this type of jacket is no more expensive than the contaminating type and can be directly buried for underground runs. Since it doesn't contaminate the center insulator, coax with a class 2A jacket has a useful life of ten to twenty years.

Although foam-filled cables are becoming more and more popular, the shield braid does not conform to Mil Specs, most foamed cables have contaminating type jackets, and unless the foam is gas filled to keep moisture from migrating into the foam, this type of coax is not very desirable.

For best results select only late types of coaxial cable which use class 2A jackets and leave the foamed coaxial cables to the Citizen Banders and CATV companies. The jacket type can be checked in the manufacturer's catalog (which your dealer should have). Coaxial cable with a class 2A jacket is usually no more expensive than the older non Mil Spec cables.

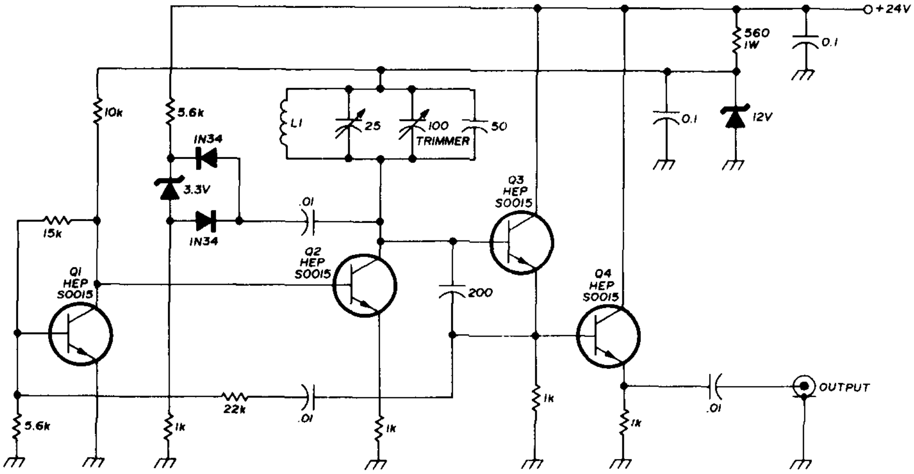


fig. 6. High-stability vfo tunes from 3.5 to 3.8 MHz. Output is 5 volts p-p minimum into a 200-ohm load. L1 is 25 turns no. 18 (1mm) closewound on a 1½-inch (38mm) diameter form. All transistors are HEP S001S or similar.

regulated dc supply

Since many of the inexpensive 12-Vdc power supplies which amateurs use to power low-power vhf fm gear are unregulated, the no-load voltage may be 18 volts or more. During transmit the voltage drops to about 12 volts, but when receiving the supply voltage may be high enough to exceed the maximum voltage ratings of the small-signal transistors in the set. The simple voltage regulation circuit in **fig. 5** will easily handle up to 2 amps or so, but a short to ground (negative lead) on the transistor or heatsink will probably burn out the transistor. One solution to this problem is to use a small plastic utility box to house the circuit. Be sure to include the 2 amp fuse -- many published circuits leave out this one small but important detail. The heatsink for low-power applications (2 amps or less) need be nothing more than a 2 inch (5cm) strip of aluminum bent into a U-shape.

stable vfo

The extremely stable vfo circuit shown in **fig. 6** has a total drift of less than 10 Hz from turn on, and a total frequency drift of less than 30 Hz as the supply voltage is varied from 15 to 30 volts. The frequency range is 3.5 to 3.8 MHz and output is a minimum of 5 volts peak to peak; amplitude stability over the entire tuning range is within 1 dB. Current drain with a 24-volt power supply is 50 mA.

This circuit, designed by G3ISP, is basically a Butler oscillator circuit with an emitter-follower output. The oscillator circuit consists of Q1 and Q2. Transistor Q3 is the emitter follower; Q4, also an emitter follower, insures good isolation between the oscillator and load, and provides a low-impedance output (200 ohms). Emitter-follower Q3 also provides isolation between the oscillator and the feedback amplifier.

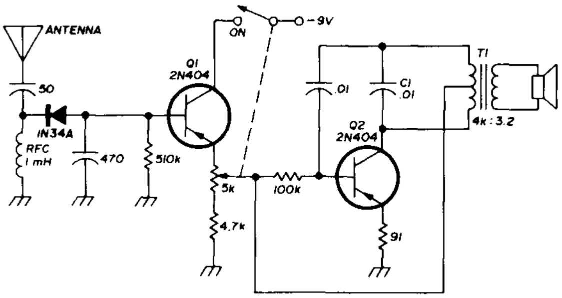
The output amplitude is stabilized by the two 1N34 diodes and 3.3-volt zener. Oscillator output is coupled to the diodes through a 0.01-μF capacitor. The voltage across the zener is maintained by a resistance voltage divider, and the rectified oscillator output is compared to the fixed zener voltage.

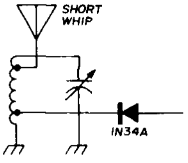
The original model of this vfo was built on perforated circuit board, 4 inches long by 3 inches wide (10x7.6cm). This was mounted in a 8x6x6-inch (20x15x15mm) enclosure along with the coil, 25 pF air variable and 100 pF trimmer. A communications receiver with a 100 kHz crystal calibrator was used for calibration.

cw sidetone

Every CW operator should have an audio sidetone oscillator to monitor his fist. Whether you use a sideswiper, an automatic bug or an electronic key, a monitor is necessary to insure proper sending. The sidetone oscillator circuit in **fig. 7** is simple and reliable and changes in transmitter operating frequency do not require any adjustments in the sidetone circuit.

The circuit is essentially a Hartley audio oscillator which is turned on by the diode rectifier and dc amplifier. For operation from 160 through 10 meters, the rf choke and coupling capacitor are more than adequate for coupling to the final tank coil; couple the lead just close enough to the final tank to get a four- or five-volt swing at the emitter of Q1 when the transmitter is keyed. For vhf use on 6 and 2 meters, a small tuned circuit and pickup antenna are usually required to obtain sufficient rf to turn the monitor on. To adjust the audio tone of the oscillator output, different values of capacitance may be substituted at C1.





INPUT CIRCUIT FOR VHF USE

fig. 7. Rf-activated CW sidetone circuit can be used on 160 through 2 meters (the tuned input circuit is recommended for vhf). Audio pitch is adjusted by changing the values of C1.

transient eliminator

When the circuit of **fig. 8** is placed between a dc power supply and a load, it will eliminate many transient overloads that might damage semiconductors and other components. The zener diode is chosen so that its value is slightly higher than the supply voltage so transistor Q1 is normally turned off. Transistor Q2 is normally conducting and transmitting power from its emitter to collector. When a voltage spike or transient is present on the input line, the zener diode conducts and turns Q1 on. With Q1 conducting, the flow of current into the emitter places a positive bias across the 10k pot. This bias turns off Q2 during the transient and protects the load circuitry connected across the output of the protection circuit.

staircase generator

A square wave may be converted into a staircase voltage output by the simple two-stage feedback transistor network in **fig. 9**. The amplitude of the staircase voltage is linearly proportional to the number of applied pulses, and each step approximates the amplitude of the input pulse. The circuit functions in the following manner: When the first pulse is applied to the input, capacitor C2 charges through C1 and Q2 to a voltage approximating the amplitude of the input pulse. When the input pulse terminates, the voltage across C2 acts as a signal for Q1, forcing C1 to charge to the same voltage that is across C2. When the second pulse is applied, it is added to the voltage across C2, thereby causing C2 to double its charge. Each subsequent pulse increases the height of the staircase until it reaches the level of the supply voltage.

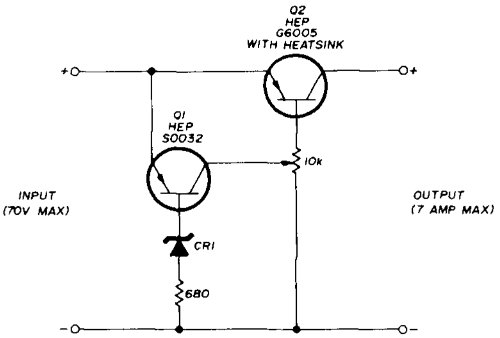


fig. 8. Protection circuit eliminates transients and voltage spikes from the supply line. Voltage rating of CR1 is chosen about 10% higher than supply voltage. The 10k pot sets input voltage at which Q2 is cut off. Although maximum current limit of a properly heatsinked G6005 is 7 amps, a similar scheme could be used with higher power transistors.

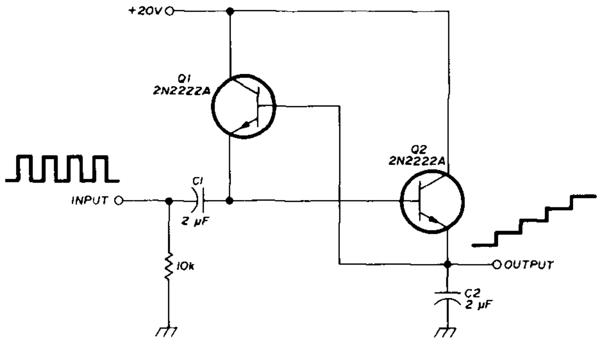


fig. 9. Simple staircase generator circuit converts a square wave into a staircase voltage output. Staircase is linearly proportional to the number of applied pulses, and each step approximates the level of the input pulse.

closing comments

In a recent *ham notebook* item on muting microphones* author W6IL noted that microphone disturbance (such as late at night) can be eliminated by taping a heavy-walled cardboard tube to your microphone and speaking through it. The tube compresses the sound, resulting in increased talk power, although it may sound as though you're in a barrel. To avoid the "bottom-of-the-barrel" effect, WB2CHO suggests placing a small amount of loose cotton in the tube. This damps out the echoes, and reduces the reverberation effect (which, judging from some 75-meter signals, some operators like).

WB2CHO also has some suggestions regarding speech processing and RFI as discussed in the *comments* section of the November, 1975, issue: infinite speech processing has the same effect on tube dissipation as running your rig in key down, full output most of the time. Most amateur ssb transceivers and linear amplifiers are designed for a 50 per cent duty cycle, which normal voice does not exceed. With heavy speech clipping or quasi-logarithmic processing, this duty cycle can be exceeded, however, reducing tube life or blowing out a power supply. To be safe, reduce drive when using speech clipping.

*R. Cabanillas, Jr., W6IL, "Muting Microphones," *ham radio* November, 1975, page 71.

ham radio

improved frequency readout for the Collins S-line

Two paper dials added to your S-line or KWM-2 allow frequency to be read within ten Hz

A casual glance at the accompanying photos shows what looks like an ordinary KWM-2 transceiver. Closer inspection, however, reveals that something has been done to the main tuning dial. The graduated scales shown mounted to the main tuning control allow frequency to be read to 10 Hz on a unit designed to read out in kHz. All this was done with just two pieces of paper.

You might say, "I've a good eye and can estimate frequency to 100 Hz on my Collins." Perhaps. But you'd be estimating to one-tenth of a 0.1-inch (2.5mm) space. The reliability of such an estimate is certainly questionable.

preliminary checks

Before adding the frequency dials to your Collins equipment, the first step is to determine the amount of frequency readout error that exists. After you've accurately set the vfo dial to eliminate end spread in accordance with Collins instructions, check the 100-kHz point on the dial. You'll probably notice an error of between 100 and 400 Hz. A recheck then should be made.

Put a reference mark on the desk. To avoid parallax, align the reference mark, using a magnifying glass, with the 100-kHz point. Offset the hairline 1 kHz so you're using the thinner and more precise dial marks. You'll probably find the frequency is still off at the 100-kHz check point.

If you have an accurate marker generator that goes to 5 or 10 kHz, you can check across the entire 200-kHz range. If you plot the data you'll most likely find an error curve that's somewhat sinusoidal. However, you'll seldom see more than 50-Hz error between any adjacent 5-kHz marks, even though the total error across the 200-kHz range may be as much as 400 to 600 Hz. If you had accurate 5-kHz markers and some way to read the dial to 10 Hz or so, you could plot an error curve, and by using it, be fairly sure of the frequency of any signal to within 25 Hz or better.

applying some leverage

What's needed is a bigger dial with marks, say, every 100 Hz instead of only every kHz. If you could set the dial accurately, you could also use a vernier to read to 10 Hz (and even estimate to 5 Hz).

The Collins knob turns nearly 9 revolutions to cover the 200-kHz range. The knob has a skirt circumference of about 8 inches (203mm), so if the knob skirt is appropriately marked, you would have nearly a 6-foot (1.8m) dial. If a second dial, also appropriately marked, were added to provide a vernier measurement then you would have the equivalent of a 60-foot (18.3m) dial.

And that's exactly what was done. The dials, shown in **fig. 1**, were made as described below and installed on my KWM-2. The dials will also work, with slight error, on the Heath SB-301, 303, and 401. The large dial is graduated in kilohertz from −10 through zero to +10. It is mounted to the Collins transceiver main tuning shaft

By Bob Gilson, W1GFC, Muhlthaler Str. 5, 8131 Starnberg-Hanfeld, West Germany

so that it doesn't move (press fit). The center hole of this dial must be cut as accurately as possible so that no play exists between it and the tuning shaft.* The small dial is graduated with 10 marks for each 0.9 kilohertz and is, therefore, a 10:1 vernier. The small dial is marked from 1 to 26 for reference. This dial is cemented to the back of the Collins tuning knob.

resetability checks

Before you decide to install the dials, here are a few words of advice – learned the hard way: make a check for resetability and backlash in your unit.

Mark a reference line on the knob skirt and on the front of the transceiver (white adhesive tape works well). Carefully align the hairline at 200 on the dial and count the number of revolutions of the knob to near zero. You'll find nearly 9 revolutions will be required. Now tune from zero to 200 and see if you get the same reading. In my case I read 8 turns from 200 to 12 and 8 turns from zero to 188.5. That's an accumulative error of 0.5 kHz across the tuning range, and if linear, would be 12 Hz between any two 5-kHz marks, or 6 Hz from the nearest mark.

If you find that one full knob revolution covers about 23.5 kHz, the dials are for you. If you find the knob covers less than 22 or more than 25 kHz, the dials are not recommended.

making the dials

I used heavy printer's stock and mounted it on a Bridgeport milling machine table. Then I learned that graduating 3-inch (76mm) diameter dials with marks every 1 degree, 22.5 minutes was a chore. Finally I used a 15-inch (381mm) diameter dial. The circular table of the milling machine is readable to one degree of arc, and the crank reads to one minute and can be interpolated to 30 seconds. On a 15-inch (381mm) diameter dial, the lines are 0.01 inch (0.25mm) thick. So even though the Bridgeport machine provides about 0.6 Hz resolution (in terms of frequency), the lines are 7 to 8 Hz thick. This inaccuracy, combined with occasional drafting errors, means that the average accuracy is 10 Hz or so.

The large dials were photo reduced and printed on stiff paper to 3 inches (76mm) diameter for the KWM-2. The printer did a good job – I measured 3.0010 inches (76.225mm) diameter on dial A and 3.0012 inches

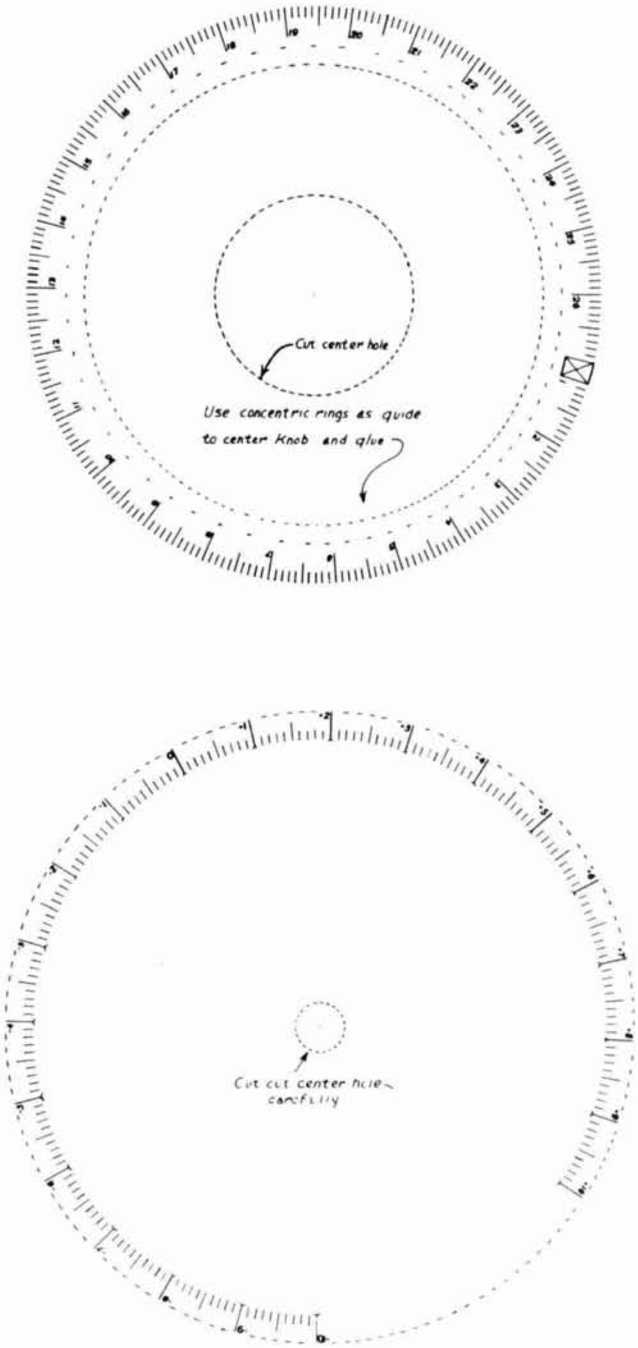


fig. 1. Frequency dials for use with Collins S-line equipment. These dials have been photo reduced from the original upsize masters, which were made on a milling machine table.

Closeup of Collins KWM-2 with frequency dials mounted. The equipment indicates a frequency of 14,211,220 Hz.

---

*The dials may be cut using a pair of dividers. Easy does it: rotate the dividers, using moderate pressure, until the dials start to separate from the paper. Then gently separate by bending back and forth. Clean the edges with fine-grit sandpaper. **Editor**

(76.230mm) on dial B, using the shadowgraph method. The main thing, however, is uniformity rather than exact dimensions of the dials.

installation and use

The dials should be cut out as indicated in **fig. 1.** Use care with the small center hole on the large dial because it should make a snug fit on the Collins tuning shaft. Also use care in cutting the circumference of the small dial, as it will become the vermier. After cutting out the dials, but before mounting, check to determine correct alignment of the two scales. If, for example, you align 15 on dial B with 0 on dial A, then 10 and 20 on dial B should line up with −4.5 and +4.5, respectively, on dial A; otherwise the dials haven't been cut and centered correctly.

Remove the tuning knob (two set screws) from the shaft and slide the large dial onto the shaft. Unless you've had experience, do not remove the nut on the shaft, even though the dial isn't flush. Center the knob skirt over the small dial, using the concentric circles as a guide, then cement the dial to the back of the knob with the numbers facing out. Re-install the knob onto the shaft.

Use any accurate marker generator (10 kHz or 5 kHz if you have it) and tune to the nearest marker in the part of the band where you want to measure frequency. Tune for zero beat (or offset if you have an audio oscillator), and set the large dial to line up with one of the numbered marks (1 to 26) on the small dial. You can use 0 kHz, for example, on the large dial. In this case, the large dial would be used much like the hairline on the regular Collins dial.

Hold the large dial and rotate the knob to the signal of interest (either zero-beat or audio offset), and read kilohertz and tenths of kilohertz on the large dial. You can read hundredths of kHz on the smaller dial where the lines line up. The correct vernier lineup is the first one beyond (in the direction you moved from reference) the tenth of a kHz.

The KWM-2 in the closeup photo is indicating 14,211,220 Hz. The first number (2) of the last three digits is read from the position of reference 12 on the small dial to the right of zero on the large dial. The last two numbers (20) are shown where the vernier lines up with the large dial (two lines to the right of the 12 on the small dial).

After you've used the dials for awhile, it's suggested that you cement a tab to the back of the large dial to use as a holding tab when you turn the knob (and the other dial). If you're right-handed you may find that mounting the tab near −3 kHz will be most comfortable.

final remarks

With the dials installed I can read frequency to 10 Hz and estimate to 5 Hz. With an accurate 5-kHz marker, I feel confident that I know the frequency to 20 Hz. My objective was to read frequency accurately without a counter. I succeeded, but I had to use a counter to verify my success.

ham radio

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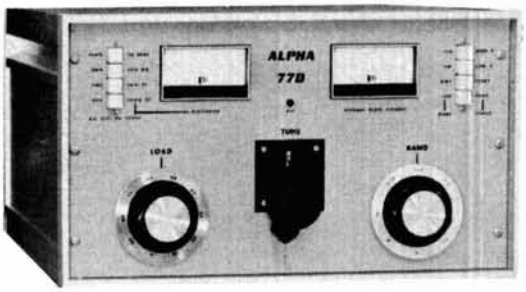

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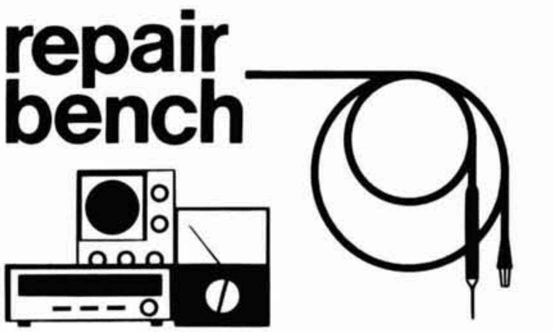


Joe Carr, K4IPV

basic troubleshooting: the dead receiver

Many amateurs seem to view troubleshooting as some kind of arcane, unfathomable process performable only by professional electronics personnel. It is my contention, shared by many others, that most troubleshooting of amateur radio equipment is a relatively simple skill which is easily acquired by anyone with a technical background good enough to pass the General or Technician class FCC examinations. To be sure, a person with twenty years experience in a communications service shop might run rings around the neophyte timewise, but your rig will work just as well after you correct the defect as when he does that neat trick for you.

The first step in any troubleshooting procedure is to observe performance of the defective unit. The test equipment requirements for this phase are almost zero. It is at this point, by the way, that the real pro exemplifies himself. There is a great deal of information to be gleaned from this process and it can significantly reduce the time required to diagnose and repair an equipment fault. Since the pro is in the business of making money he will use this information to full extent. You, too, should make use of your observations.

In order to simplify the discussion of "troubleshooting" I have limited the range of interest to the single-conversion, superheterodyne communications receiver and, by implication, the receiver portion of the typical ssb transceiver. Of course, it takes only the slightest effort to extend the procedures given here to dual- and triple-conversion models.

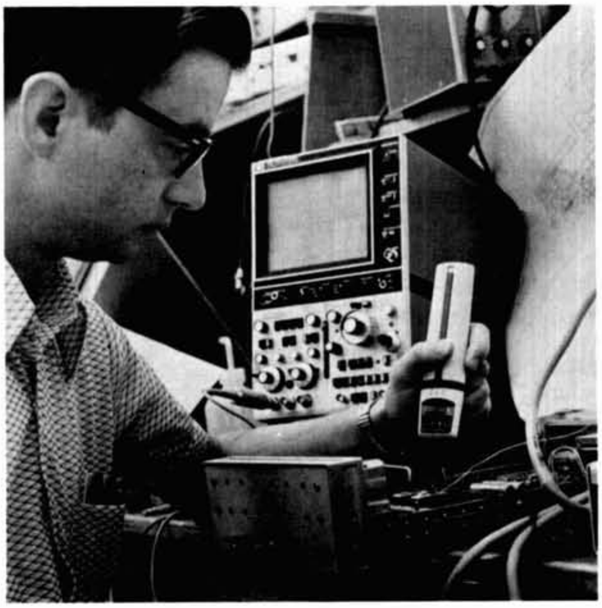
When you initially examine the receiver, determine just what is or is not working. The fact that the receiver is dead, while significant and interesting, is not the whole story. For example, does "dead" mean that no power seems to be applied, that neither the pilot lamps nor the tube filaments are glowing or is it simply a matter of no output even though the lamps and filaments seem normal?

In cases where the lamps come on and the tube filaments glow, you can look for some other, more subtle clues, which can be immensely valuable. Look first to the audio gain control. If you hear a scratching sound as you rotate the control through its range then it is a moderately safe bet that the defect is prior to the volume control. What you are hearing is the amplified noise voltages generated by the control wiper.

Next, switch on the bfo or turn to the *ssb/CW* position of the function switch. If the noise level increases or there is static as you turn the switch then one can generally assume the trouble to be prior to the detector. The next step might be to switch the bandswitch through its ranges. Look for either signals or static crashes as the switch changes bands. If the receiver is not dead on all bands look to components which are only common to the dead band or bands. Such components might be coils, converter crystals in double-conversion sets, loose connections or even the switch contacts themselves. This last is often overlooked by the inexperienced. On the other hand, if static crashes are heard as you switch bands then you can temporarily exonerate the i-f amplifier chain.

In cases where the set is completely dead, as if the power switch was turned off, look to the primary side of the power supply. Actually, defects such as this, although they initially look bad, are actually pretty easy to solve. It seems that there is nothing quite so easy to find as the cause of a completely dead set. First and foremost, check to see if the ac receptacle has power and that the set is plugged into the receptacle. You would probably be surprised at how many service calls in the TV industry are due to something like a wall switch in the *off* position! Use an ohmmeter or continuity tester to check the fuse, power cord, power switch, and trans-

Technician using a modern hand-held digital voltmeter to troubleshoot electronic equipment. (Photo courtesy Hewlett-Packard)



former primary. Don't rely on sight to test the fuse – actually measure its resistance (should be zero ohms). Be aware, though, that a blown fuse may indicate some other defect which can be quite serious. An old maxim regarding fuses goes something like this, "A fuse doesn't cause trouble – it protects against and *indicates* trouble!"

Include in your preliminary inspection any unusual odors (might indicate that something is burning), any unusual sounds from the loudspeaker, any sounds from inside the cabinet which might tend to indicate arcing, and so forth. Although it has taken quite a bit of time to describe this inspection the actual implementation takes only a few moments. If you use these observations, coupled with a logical step-by-step procedure, there are few defects which will elude you in a typical superheterodyne receiver.

divide and conquer

One of the best methods for isolating defects in most types of electronic equipment is to divide the set into bite-size chunks then conquer each in its turn. There are two basic philosophies to troubleshooting, signal injection and signal tracing, but they both lead to the same thing. Once you have gained experience you will find that one will work better than the other in some cases, while in others the reverse is true. Most times, though, which to use is really only a matter of preferance so take your pick.

The signal injection procedure is shown in **fig. 1**. First connect some sort of output monitor. This can be an ac voltmeter, an oscilloscope or just a loudspeaker. Then inject a signal from a generator into the input of each stage in succession beginning with the output. Of course, if your preliminary investigation has shown the audio stages to be working then you can just skip them and go on to the detector. Check first one stage, then the stage preceding, until the stage is located which either passes no signal or a highly attenuated signal. You can then be reasonably sure that the defect is located between that point and the last point where signals passed normally.

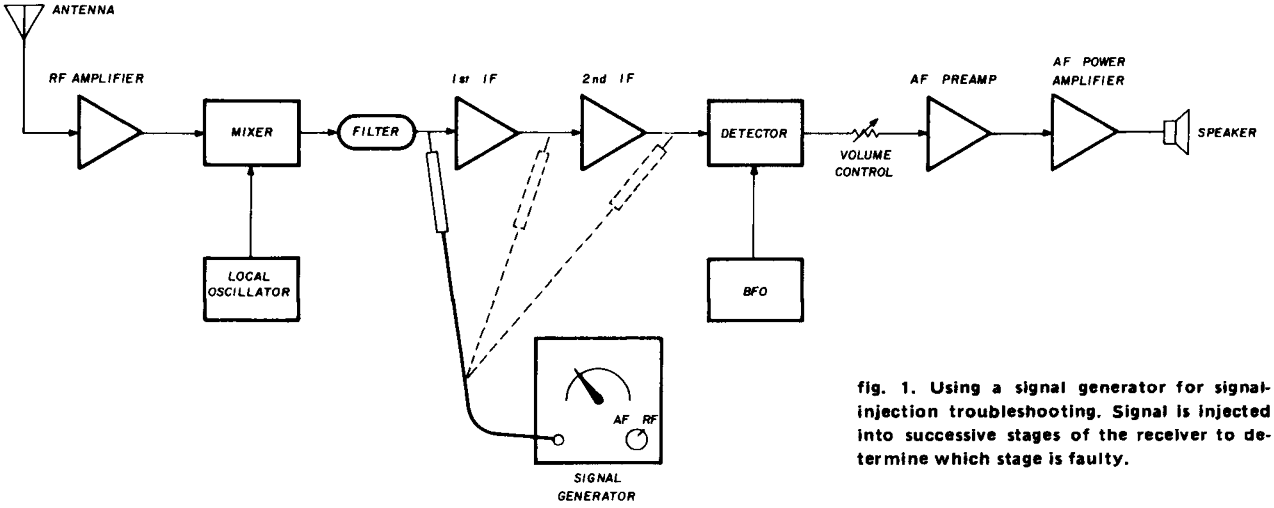


fig. 1. Using a signal generator for signal-injection troubleshooting. Signal is injected into successive stages of the receiver to determine which stage is faulty.

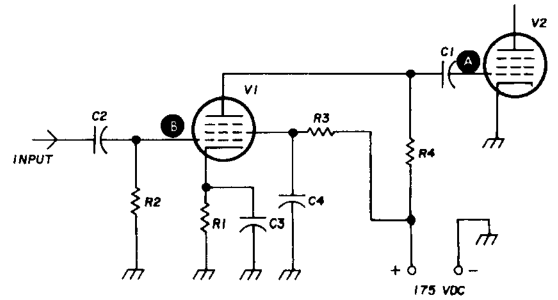


fig. 2. Typical audio amplifier stage which might be found in a vacuum-tube amateur receiver. Various faults which can be caused by component failure are discussed in the text.

Consider as an example the audio amplifier shown in **fig. 2**. Assume that output was heard when the signal was injected into the grid of V2 (at point A) but no output was produced when the signal was applied to point B, the grid of V1. The next step, of course, would be to check the vacuum tube either by substitution or on a tube checker. If you or a friend owns a tube tester then by all means use it but don't feel demeaned by going down to the local drug store tube tester (they work).

Since some defects will not show up on a tube tester I feel that substitution is the best method. The number of different tubes which the typical amateur is likely to have in his primary station equipment is low enough to warrant keeping one each (new, not hamfest specials of unknown history) in stock at all times. In most cases replacing the tube will cure the defect; although probably not the 95% claimed by tube tester ads.

You all know Murphy's law (one corollary of which states that Murphy was an optimist), so in your case, alone, the trouble will not be a tube and you will have to look further. When you remove the tube from its socket, leave the set turned on unless this exposes you to dangerous voltages while attempting to extract that tube from its socket. If you hear a "click" or static crash as the tube clears the socket pins then you know it was drawing current and can probably forget about the plate load resistor, or in rf/i-f circuits, plate tank coil.

When you cannot cure the problem by replacing a tube it will be necessary to make some voltage measurements on each pin of the tube socket. Unless you have all the tube pinouts memorized it's advisable to obtain a copy of the receiver schematic. If one is not available try getting one from a different version of the same model. Failing that, you can always consult the RCA *Receiving Tube Manual,* GE's *Essential Characteristics,* or the rear of any edition of the ARRL *Radio Amateur's Handbook*. Compare the voltages actually measured in the receiver with those given in the schematic. A variation of 10 to 20 per cent is normal.

If there is no schematic available then try comparing the voltages against what common sense tells you is approximately correct. I kept records in a shop and from them noted that nearly half of the jobs which were not tube replacements involved either the dc power to a stage or produced changes in the normal dc potentials on the tube elements. A shorted screen-bypass capacitor, for example, will drop the screen B+ to almost zero and may well overheat the screen-dropping resistor. An open cathode-bias resistor, on the other hand, will cause the plate and screen voltages to rise and the cathode-to-ground voltage will be almost equal to the plate voltage.

Note that there are actually two paths for current to flow in almost every receiver or audio amplifier circuit: the dc path just discussed and an ac signal path. When dc conditions look normal then look to that ac path for the defect. In the audio amplifier of **fig. 2** the ac path includes capacitors C1, C2, and C3. Should they open the set will be dead but the dc potentials will be close to normal. Capacitor C4, also in the ac path, will generally cause the stage to oscillate if it opens up. Simple substitution using either alligator chip leads or "solder tacks" is the best troubleshooting method.

An alternate troubleshooting technique, illustrated in **fig. 3** is called signal tracing. It is actually just signal injection viewed from the opposite end of the cascade chain of stages! Here, you inject a signal into the input, antenna terminals if a receiver, and look for it in successive stages using a simple signal tracer or oscilloscope. The most basic form of tracer is a high gain audio amplifier preceded by either a demodulation or low-capacitance probe depending upon which stage is being tested. Both of these probes (see **figs. 4** and **5**) are also needed when using an oscilloscope. Almost any audio amplifier can be pressed into service: junk public-address amplifiers, hi-fi amplifiers, a homebrew amplifier, or the audio stages of an old radio. Alternatively, you can use any of a number of small kits offered by most electronic supply houses. The only real requirement is for moderate to high gain and enough audio power to drive a small speaker.

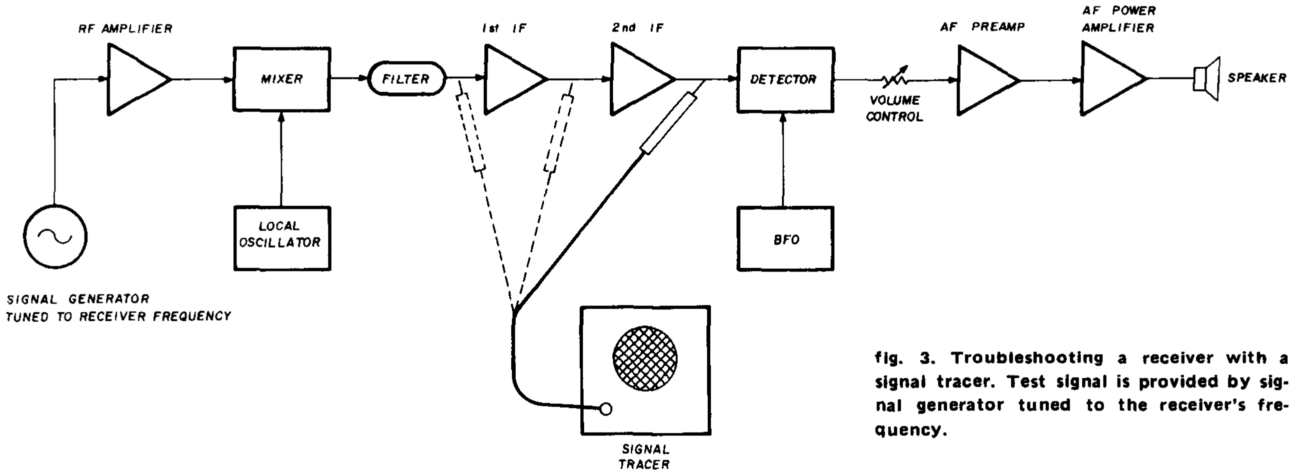


fig. 3. Troubleshooting a receiver with a signal tracer. Test signal is provided by signal generator tuned to the receiver's frequency.

In a superheterodyne receiver you sometimes find the converter or oscillator-mixer stages to be at fault. If either the mixer or the mixer portion of the converter is the culprit then the trouble can usually be located using the techniques already discussed. In other cases, though, the oscillator may not be running or may be running way off frequency. If the local oscillator (LO) is a vfo you can generally detect operation using a voltmeter. Measure the small negative voltage on the grid of the oscillator while tuning the dial from one end of the band to the other. If the LO is operating, then the voltage will vary. In crystal oscillators you will also observe a small negative voltage on the grid. If the crystal is in a socket try removing it while monitoring that voltage. It should drop as the crystal is removed. In either type of LO you can use an oscilloscope to actually view the oscillator signal provided that the scope has an adequate vertical bandwidth.

On some occasions you will find the LO is operating but at the wrong frequency. If the error is great enough, the result will be a dead receiver. If you have a frequency counter or other means of measuring frequency then that should tell the story. In other instances, though, you can use a substitute signal from either a signal generator or vfo. In either event the signal must be at the receiver dial plus or minus the intermediate frequency. Even a lowly grid-dipper can be used in some receivers. If the LO is running on the correct frequency you will note birdies (heterodynes) in the output. If the LO is *not* on frequency expect to hear radio stations!

That elaborate test equipment is *not* needed for most amateur radio troubleshooting jobs may come as a surprise to many. Adding to that belief is the fact that most commercial communications shops have a mighty large investment in multi-kilobuck instrumentation. Even the professional, though, needs only very simple stuff in *most* situations. It is to satisfy FCC regulations and to handle the really difficult service that he needs his equipment. You have one advantage over the pro in that your livelihood doesn't depend on your service work and you can always take your set to him if you fail.

The absolutely most basic piece of test equipment is the multimeter. For most jobs either a simple vom or electronic voltmeter is needed. If a vom is selected make sure it is a model with sensitivity over 20,000 ohms per volt. Between hamfests, auctions, low-cost kits, and the Japanese imports there is no reason why every amateur shouldn't own one. Don't be too awestruck by those modern digital jobs. Your little vom will do your job just as well! Besides, have you ever seen what happens to some of those new digital multimeters when a transmitter is turned on a few yards away? They go bananas!

As described earlier you can obtain a signal tracer by either construction or through a conversion job. Do *not* use any ac/dc dquipment for the conversion, however. The resultant "instrument" may well be lethal. Use only equipment with a power transformer!

Oscilloscopes are often described, quite rightfully, as the most useful piece of electronic test equipment. If, for example, the scope is dc coupled, you can use it in lieu of a voltmeter. If the scope is calibrated, the smallest full-scale range and the overall accuracy is better than most vom/vtvm instruments. Oscilloscopes tend to excite the newcomer and many an auction has seen a frenzy when an old clunker came up for a bid. Frequently you see old, junked, scopes fetch prices all out of proportion to their worth. Because of this a word of caution is in order. Before you pay $75 to $100 for some elderly 500-kHz, recurrent-sweep model which is old enough to vote, look to the kit manufacturers and some of the imports. For not too much more money you can get a lot more value.

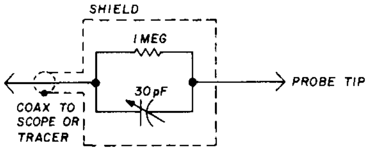


fig. 4. Low-capacitance probe for use with a signal tracer or an oscilloscope. The 30 pF trimmer is adjusted for best squareness of a 1 kHz square wave.

some advice

1. Troubleshooting a dead receiver or other piece of equipment is made easier by one simple fact: it once worked normally! In de-bugging new equipment, on the other hand, you have to give due consideration to that nagging fear that all your troubles may be due to either a false premise in design or a misplaced decimal point. Not-so with repair troubleshooting. Don't wax philosophical and look for deep, subtle troubles. The occult or difficult forms only the tiniest percentage of all amateur rapairs. In other words, think like a repairman, not like an engineer!

2. Don't *ever* use "alignment" as a troubleshooting technique. One of the quickest ways to spot the newcomer or the incompetent old timer is by the speed with which he grabs an alignment tool. Defects which cause a receiver suddenly to quit seldom, if ever, arise from "alignment." Lock that darn diddle stick up until you know for sure that alignment is indicated. You may find that you never need that tool again! Contrary to some "official" advice to amateurs, receiver alignment does not change enough to justify realignment every year. Although some minor improvement may be affected, alignment just loosens coil slugs and creates other damage that will either keep you off the air now or more often in the future.

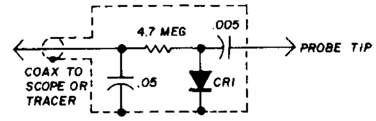


fig. 5. Demodulator probe for use with a signal tracer, an oscilloscope or a voltmeter. Diode CR1 is a germanium type such as the 1N34A, 1N60, etc.

3. Avoid bizarre repairs. One such fix which is heard of from time to time is the bending of tuning capacitor plates to make the oscillator track properly. Since it is a fair bet that the alignment of that oscillator was once correct this is a fool's method. I prefer to believe that the engineers who originally designed that receiver and the capacitor in it had a whole lot more sense than I do, at least concerning that receiver. In a situation involving a friend of mine I learned that the best procedure is to find out why the local oscillator shifted frequency. There are a lot of reasons for LO mistracking including use of the wrong brand of replacement oscillator tube! In this case the friend called and asked whether he should allow a buddy to bend the main tuning capacitor plates. I told him to retrieve that set, preferably without damage, and come on down to the shop after hours. There we could properly diagnose the defect and, if indicated, realign the oscillator with proper equipment. It turned out that the trouble was a small mica padder capacitor in series with the local oscillator tank coil. A replacement, in this case obtained locally, solved the 50-kHz shift! Incredibly enough, that other fellow didn't even notice that the error in tracking existed only on one band.

Troubleshooting is not such a gruesome procedure as some amateurs want to believe. Reduced to its simplest philosophical form, all defects in equipment which was once working are due either to the existence of an unwanted path for current or the loss of a desired current path. It is the job of the repairer to determine which is the case, and to either open or close the current path as indicated by the symptoms and his logcial deductions.

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time-out warning indicator for fm repeater users

An inexpensive transceiver-actuated circuit that inhibits repeater-timer override

Many fm operators have, on occasion, timed out a repeater and since this practice is frowned upon, the habitual offender is branded as a "leadfinger." This article describes an inexpensive timer that, when connected to an fm transceiver, prevents the user from timing out repeater stations. Other timer circuits have been described,[1,2,3] but all require manual triggering and reset by a negative pulse.

circuit

The timer consists of a 556 (U1) and two 555 (U2, U3) IC timers (**fig. 1**). The first half of U1 is connected to trigger on a positive step-input voltage.[4] The trigger voltage is sequenced with the push-to-talk microphone switch. (The methods of deriving the trigger voltage are described later.) The output of U1A is differentiated to trigger and reset U1B simultaneously, which is connected as a one-shot. The time delay is determined by R1, C1 to provide a delay equal to 10 seconds less than the repeater timer. Therefore, using a 60-second repeater, the time delay should be 50 seconds and is approximately found from $t(sec) = 1.1\ R1C1$. When U1B is on, its output triggers U2, which is connected as a flip-flop. U2 drives a green LED, which flashes approximately 80 times a minute during this time delay.

When the 50-second time delay is reached U1B goes low and U2 is disabled, simultaneously triggering and resetting U3, which functions as a one-shot for 10 seconds (set by R2 and C2). A red LED is on for this 10-second interval. At the end of 10 seconds, the red LED goes out and the cycle is completed. For other

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choices of delay times, the RC combinations can be determined from the equation. The status of the LEDs is shown in **fig. 2**.

power sources

For mobile installations the power supply voltage is taken from the car battery. For fixed station use, any regulated 12-volt supply can be used. I used the circuit described by WB2EAX[5] because of its simplicity and used an spdt switch to permit the use of the car battery voltage when operating mobile.

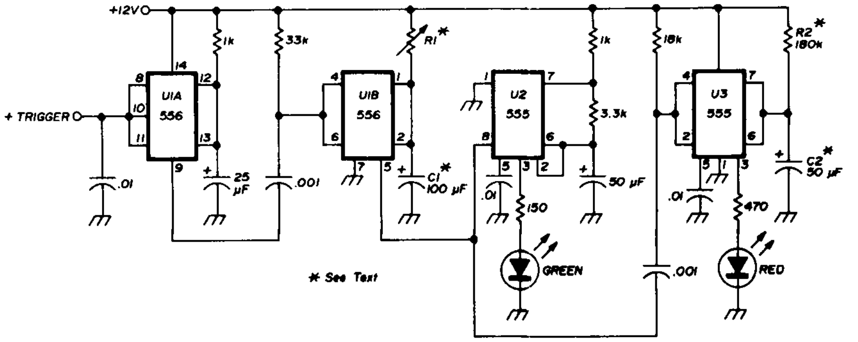

fig. 1. Schematic of time-out indicator.

triggering

Triggering the timer from a transceiver can be done in a number of ways. Using my TR-22C, I noticed that the microphone switch keys a transistor whose collector voltage is zero on receive and +12 volts on transmit (Q11). In this way, the push-to-talk action controls both the transceiver and the timer. Connection between the timer and the transceiver was by RG-174 coax cable.

If you're hesitant about going into your transceiver, the timer can be actuated by the transmitter rf output signal, since its voltage amplitude is constant. **Fig. 3** is a simple circuit for rectifying the rf signal. A suitable resistor may have to be placed in series with the input for transmitters with outputs greater than 10 watts. A quick estimation of the received rf voltage from your transceiver can be made by using Ohm's law for the power absorbed by a 50-ohm load: $V = \sqrt{50P}$ where P is the transmitter output power in watts.

operation

When the push-to-talk switch is pressed, the green LED will flash repeatedly and the red LED will be off. If a single transmission exceeds the first time delay (50 seconds), the green LED will stop flashing and the red LED will light. At this point you have 10 seconds to stop transmitting or else you will time out the repeater, and *all* the LEDs will be off. If the transmission time is less than that of the repeater timer, the timer indicator can be recycled when the PTT switch is again pressed.

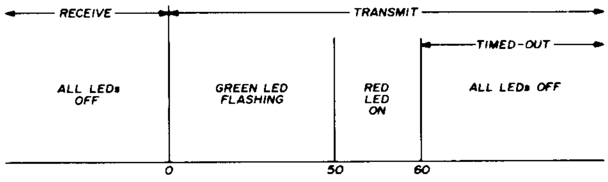

fig. 2. Status of LEDs for a transmission with a 60-second repeater.

other comments

Some of the more astute readers may wonder, "Why go through the trouble of triggering the IC timer by a positive voltage when the 555 and 556 ICs are normally triggered by negative pulses?" Well, I had a few of these chips around and wanted to experiment by wiring them in different configurations. Otherwise, a simple transistor inverter switch with a differentiated output will work as well in place of U1A, and a 555 could be used for U1B with appropriate pin connections. A 741 op-amp could also be used but requires a positive and negative supply. If negative triggering is preferred using the voltage from the transceiver circuitry, U1A can be eliminated.

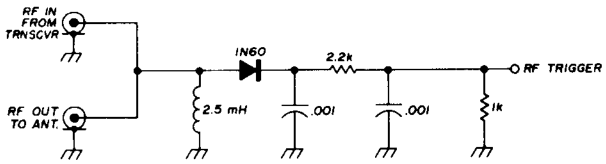

fig. 3. Circuit to trigger the timer from an rf source.

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3. H. Vordenbaum, W5ZHV, "Automatic Reset Timer," *ham radio*, October, 1974, page 50.
4. H. M. Berlin, K3NEZ, "IC Timer Triggered by Positive or Negative Pulses," accepted for future publication in *Electronics* (McGraw-Hill).
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ham radio

MICROPROCESSORS

microcomputer interfacing: accumulator I/O versus memory I/O

When data is transmitted between a microcomputer and an input/output device, three actions must occur simultaneously:

1. The microcomputer must select the specific input/output device that will either receive or transmit eight bits of data.

2. The microcomputer must indicate to the specific input/output device when the bidirectional data bus is available for data transmission.

3. The data must be transmitted between the microcomputer and the input/output device in a very short period of time, typically of the order of microseconds.

In a preceding column,[1] we discussed *accumulator I/O,* in which data is exchanged between the accumulator and an external I/O device. A significant disadvantage is associated with such an interfacing technique: only a single origin or destination for data exists. A typical microprocessor chip, such as the Intel 8080, has in addition to the accumulator a variety of internal general-purpose registers that can exchange information with memory. These registers include the B, C, D, E, H, and L registers, each of which is an 8-bit register. From a programming standpoint, it would be very useful to be able to exchange data between any of these registers and any external I/O device. This is the subject of this month's column.

If you desire to exchange data between a general-purpose register and an external I/O device, you would employ an exciting interfacing technique called *memory I/O* or *memory mapped I/O.* The basic gimmick behind this technique is quite simple: *you treat the input/output device as if it were one or more memory locations.* By doing so, you have the opportunity of employing microcomputer instructions such as MOV, STAX, LDAX, SHLD, LHLD, STA and LDA in the 8080 microprocessor instruction set. These instructions transfer data between registers and memory locations.

The differences between accumulator I/O and memory I/O is best understood with the aid of a specific examply of an interface between an 8080-based microcomputer and an external I/O "device." In this case, the "device" is the Intel 8255 programmable peripheral interface (PPI) IC. This chip has 24 I/O pins, shown as PA, PB and PC in **fig. 1** and **fig. 2,** that can be wired directly to any digital device having TTL-compatible logic.

An 8255 chip appears to an 8-bit microcomputer as either four different external I/O devices or four different memory locations. Four 8-bit registers in the chip can be addressed by the microcomputer:

By David G. Larsen, WB4HYJ, Peter R. Rony, and Jonathan Titus

Mr. Larsen, Department of Chemistry, and Dr. Rony, Department of Chemical Engineering, are with the Virginia Polytechnic Institute and State University, Blacksburg, Virginia. Mr. Jonathan Titus is President of Tychon Inc., Blacksburg, Virginia.

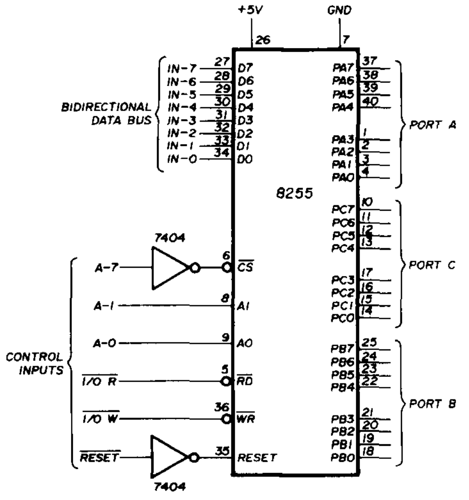

fig. 1. An example of accumulator I/O interfacing between an 8080 microcomputer and the Intel 8255 programmable peripheral interface (PPI) IC. The chip is treated as four different I/O devices.

1. Port A, an 8-bit port that can be configured as either an input port, output port, or a bidirectional I/O port.

2. Port B, an 8-bit port that can be configured as either an input or output port.

3. Port C, an 8-bit port that can be configured as an input or output port or as a pair of control ports, one for port A and the other for port B.

4. An internal 8-bit control register, which determines the specific I/O configuration of the 8255 chip and which can be altered at any time by the microcomputer.

The 8255 chip contains, in addition to the three I/O ports, an 8-bit bidirectional data bit, D0 through D7, that communicates directly with the 8080 chip; six control inputs, $\overline{\text{CS}}$, A1, A0, $\overline{\text{RD}}$, $\overline{\text{WR}}$, and RESET; and two power inputs.

accumulator I/O

In accumulator I/O, the $\overline{\text{I/O R}}$ and $\overline{\text{I/O W}}$ function pulses are used to read from and write into the 8255 chip.* The chip is addressed with the aid of bits A-0 through A-7 (or A-8 through A-15 on the 16-bit memory address bus of the 8080 A1 line to select one of the four different registers within the chip. For example, the following program

323_8	Enable the register for port A and allow it to accept data from the accumulator register
200_8	Device code for port A

writes information from the 8080 chip into port A. The port is treated as an I/O device, and an accumulator I/O instruction, 323_8, is employed. A simple change in the control register will turn port A into an input port and permit the use of the program

333_8	Enable the register for port A and allow it to send data to the accumulator register
200_8	Device code for port A

to read information into the 8080 chip from port A.

memory I/O

In memory I/O, the $\overline{\text{MEMR}}$ and $\overline{\text{MEMW}}$ memory read/write function pulses are used to exchange data between the internal registers within the 8080 chip and the 8255 registers. The entire 16-bit memory address bus can be used to address the chip. As shown in **fig. 2**, we have employed bit A-15 as the chip select input and bits A0 and A1 as the register select inputs. To output data from register B to port A, the following program is used:

041_8	Set the 16-bit memory address pointer register within the 8080 microprocessor chip to the memory address of port A
000_8	
200_8	
160_8	Move the contents of register B to port A

Once you have selected port A, you can successively output data from other registers in the 8080 microprocessor chip,

161_8	Move the contents of register C to port A
162_8	Move the contents of register D to port A
163_8	Move the contents of register E to port A
167_8	Move the contents of the accumulator to port A

---

*The accumulator I/O pulse abbreviations $\overline{\text{I/O R}}$, $\overline{\text{I/O W}}$, $\overline{\text{MEMR}}$, and $\overline{\text{MEMW}}$ are those employed by the Intel Corporation, Santa Clara, California. $\overline{\text{I/O R}}$ and $\overline{\text{I/O W}}$ respectively correspond to $\overline{\text{IN}}$ and $\overline{\text{OUT}}$, which we have employed in previous columns. See "Generating Input/Output Device-Select Pulses," *ham radio*, April, 1976, page 44.

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Each additional transfer of data requires only 2 microseconds of execution time, which is quite a bit faster than the 5 microseconds required for successive accumulator I/O data.

conclusion

We have demonstrated that both the accumulator I/O and the memory I/O techniques are applicable to the 8255 chip. The specific application will determine the best I/O technique. In some cases, accumulator I/O is best; in others, memory I/O simplifies programming and speeds the transfer of large quantities of data to or from memory. Some microprocessor chips permit only memory I/O interfacing techniques. Such chips frequently have special memory addressing instructions that speed execution time for memory I/O addressing.

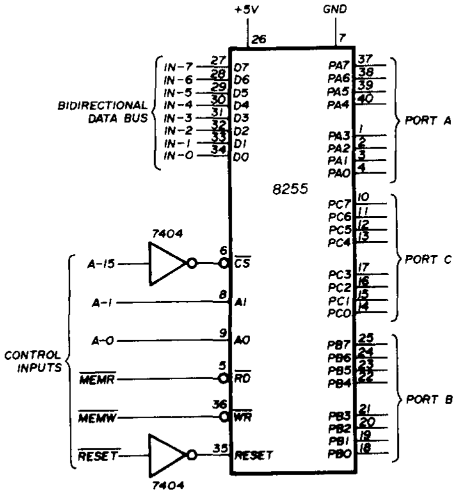


fig. 2. An example of memory I/O interfacing between an 8080 microcomputer and the 8255 chip. In this case the chip is treated as four different memory locations.

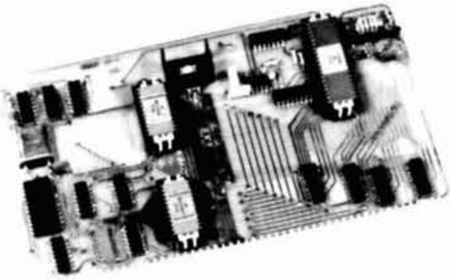
The main advantage of the 8255 chip is not in programming or execution time but rather in the ease of wiring of an interface to an external digital I/O device such as an analog-to-digital converter, digital-to-analog converter, digital panel meter, or a digital multimeter. No flip-flops, decoders, or gates are required for the interface; these are all contained within the 8255 chip. In most cases, only SN7404 inverters may be needed to match logic levels between port C, which is usually employed as a control port, and the control pins on the external digital I/O device. Possibly in the future manufacturers will provide I/O interfaces that will permit a digital instrument to be tied directly to a programmable peripheral interface chip.

reference

1. D.G. Larsen, WB4HYJ, P.R. Rony, and J.A. Titus, "Microprocessors," *ham radio,* January, 1976, page 36.

ham radio

IT ADDS UP–



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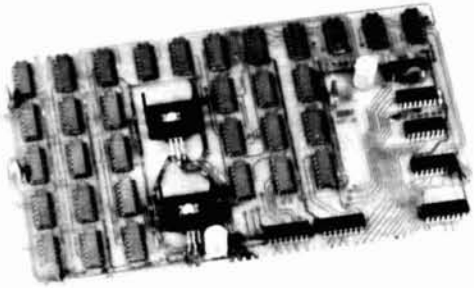

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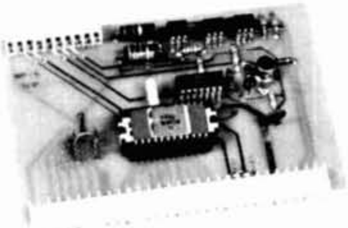

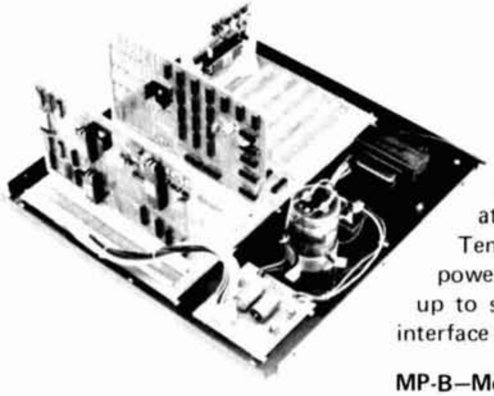

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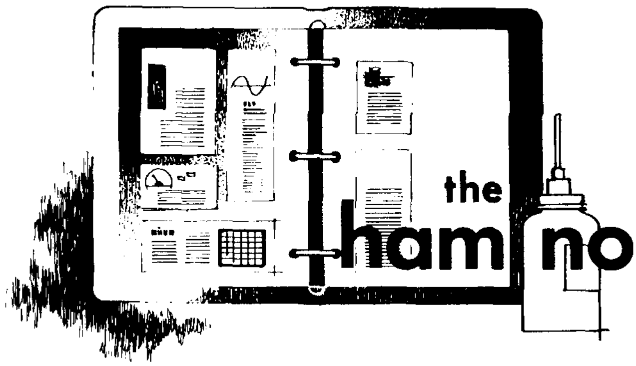

the ham notebook

signal-peaking indicator and generator for Regency HR transceivers

The purpose of the peaking indicator is to give a positive indication for maximum received signal strength while pointing a beam antenna or while aligning your receiver. The circuits are simple and are applicable to the Regency HR series transceivers. Since many fm monitor-type receivers use the N5111A or the ULN2111 fm detector IC, the peaking indicator may also be installed in them.

The peaking indicator simply monitors and amplifies the current drawn by the fm detector IC. Under no-signal conditions the current is very small. When a signal is present the current increases proportional to signal strength and can reach several hundred microamperes. The indicator can be a 50 or 100 microampere dc meter. A gain control is necessary to keep the meter from pegging on a strong signal. A multimeter can be used on the low current scale as a workbench aid for aligning receivers.

The actual construction of the peaking indicator is left up to the individual. The circuit is shown in **fig. 1** and can be easily installed on the receiver i-f-audio printed circuit. The meter can be mounted in an external case with the gain control. A 0.01 μF bypass capacitor should be connected from the collector of Q1 to ground to prevent negative indication on the peaking meter during transmit due to stray rf rectification. There is an unused pad island adjacent to the 8.2 Vdc track near U102 which can be used.

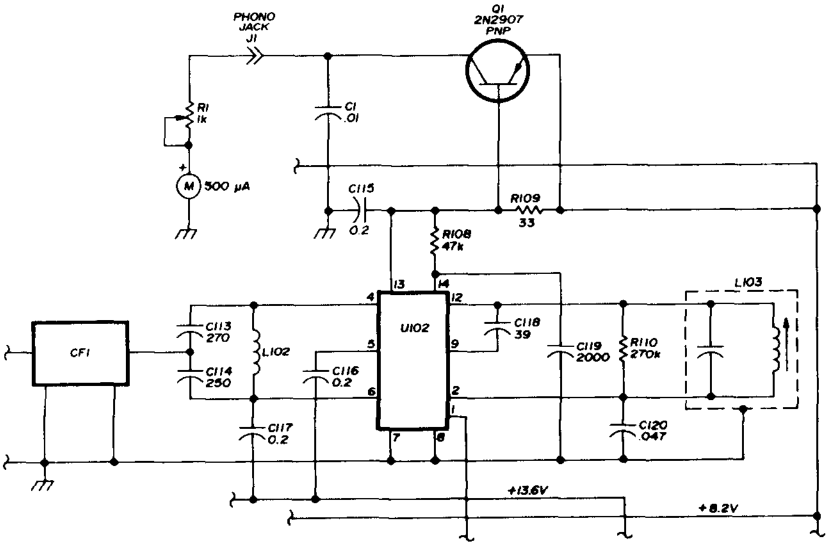

fig. 1. Peaking indicator hookup to Regency fm detector.

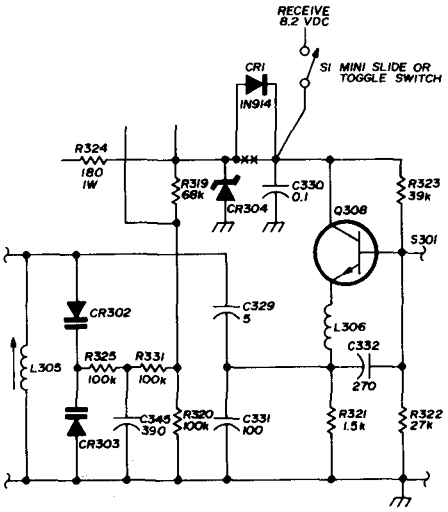

fig. 2. Permanent peaking generator for the Regency HR fm transceiver.

The amplifier transistor and bypass capacitor can be permanently installed on the i-f-audio board with the meter wire connected to a phono jack on the rear of the chassis. The meter may be plugged in as desired when the radio is used as a base station and disconnected when you go mobile.

peaking generator

The purpose of the peaking generator is to provide a stable signal on frequency to peak up a receiver. A simple way to accomplish this is to use the transmitter crystal oscillator right in the radio. This allows selecting and checking each and every transmit crystal in your own receiver.

There are several ways to energize

the transmitter crystal oscillator. The actual implementation is left to the individual.

For a temporary generator the 13.6 Vdc transmit end of R324 can be lifted and connected to a variable 13.6 Vdc source to power the oscillator during the alignment. Varying the voltage changes the signal strength to a certain extent. After the alignment the resistor can be reconnected (see **fig. 3**).

For a permanent installation the 8.2 Vdc transmit track near the ground end of zener CR304 may be cut and bridged with a diode. Then an externally added switched power source (receive 8.2 Vdc) can be connected to the cathode side of the diode which is the same as the collector of Q308, the transmitter crystal oscillator.

Be sure not to cut the trace feeding R323 which powers the base of Q308. The switch can be mounted on the rear of the chassis with a wire running to the 8.2 Vdc receiver power source. This can be any point common with the circuit trace connected to the orange jumper wire connecting the receiver rf and i-f-audio boards (see **fig. 2**). This allows switching the transmitter crystal oscillator on without the rest of the transmitter being powered and provides a signal source from the transmit crystal harmonics.

Ray Abraczinskas, W8HVG

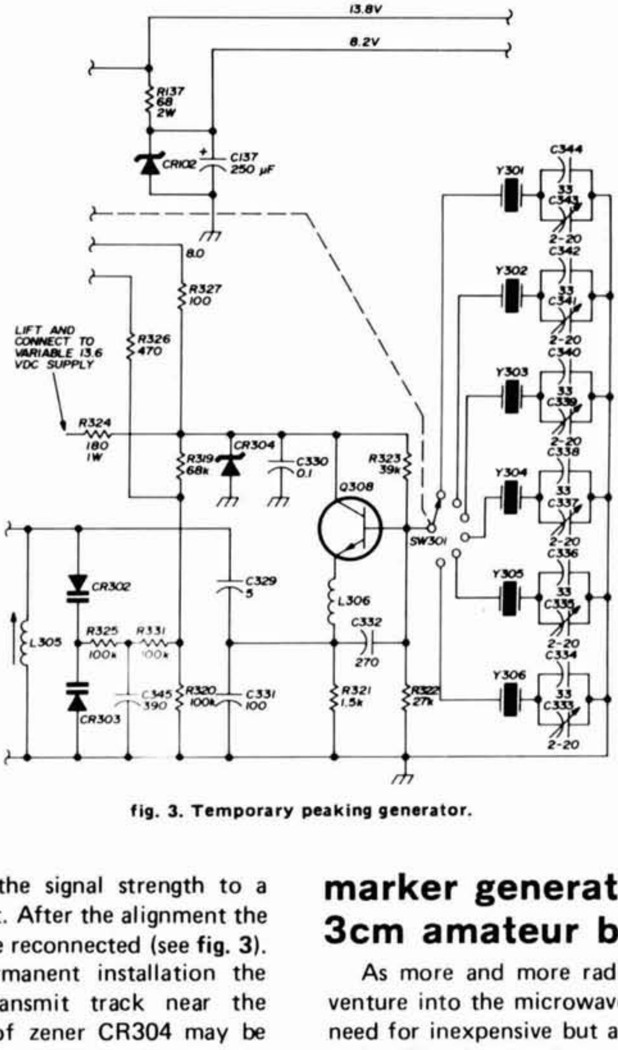

fig. 3. Temporary peaking generator.

marker generator for 3cm amateur band

As more and more radio amateurs venture into the microwave bands, the need for inexpensive but accurate test and calibration equipment increases. One of the most valuable pieces of test equipment is the marker generator. Described below is a simple unit supplying markers every 250 MHz from 8 GHz to above 12 GHz.

The generator consists of a 1N82 diode mounted in a waveguide fixture that is driven with a 300 mW 250-MHz source. The source is a modified transmitter strip from a surplus URT-33 beacon transmitter. Originally the beacon had a positive-ground power supply which is opposite to the rest of my equipment. The oscillator and driver stages were supplied from a pulsed six volts whereas the final was supplied a constant eight volts. The only modifications were to strap all the supply leads to a common 6 Vdc supply and isolate the printed-circuit board from the chassis with ceramic insulators and 100-pF capacitors.

Marker generator provides 250-MHz markers over the frequency range from 8 to 12 GHz.

The beacon originally operated on 234 MHz. Replacing the crystal with a 125 MHz crystal moved the output up to 250 MHz. The slight retuning was

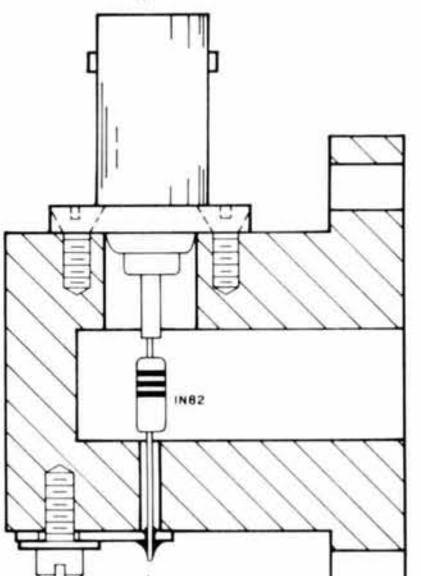

fig. 4. Marking generator for the amateur 3-cm band uses 1N82 diode and modified X-band coax to waveguide adapter.

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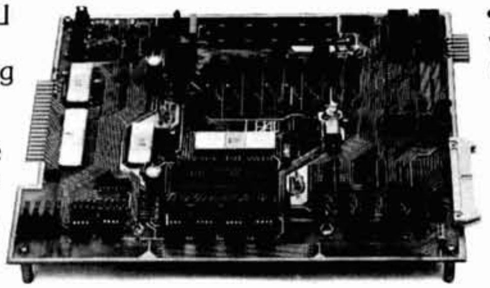

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accomplished by spreading the air-wound tank circuits while monitoring the output power. Incidentally, with +12 volts on the final, I obtained slightly more than 1 watt out which would make a good low power 220-MHz transmitter.

The harmonic generator diode is mounted in a modified X-band coax to waveguide adapter as shown in **fig. 4.** No bypass capacitors were used because they were found to be unnecessary. The only critical dimension is the spacing between the diode and the end of the waveguide. For best operation this distance should be 0.25 inch ±0.080 inch (6.25mm ±2mm).

The output was examined on a homebrew spectrum analyzer covering 8 Ghz to 12.4 GHz. 20 dB of attenuation was required to prevent the marker generator from overloading the analyzer. The spectrum was rich in harmonics from below 8 GHz to above 12 GHz. The unit provides convenient band-edge markers for the 3-cm amateur band (10.0 to 10.5 GHz) and a marker at the band center.

John M. Franke, WA4WDL

88-mH toroid coils

The surplus 88-mH toroid coils which are available from several advertisers in *ham radio* are often used in audio-frequency filters and other construction projects. Since these coils find widespread use, it's useful to know other values of inductance which are available by simply removing turns from

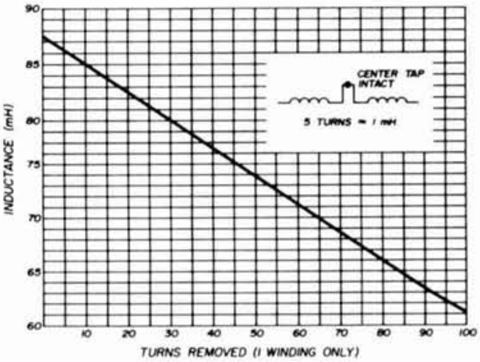

fig. 5. Effect of removing turns from one winding of 88-mH toroidal inductor with center tap intact. Each 5 turns represents approximately 1 mH.

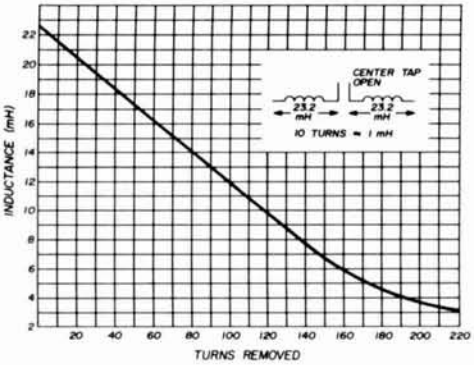

fig. 6. Effect of removing turns from one winding of 88-mH inductor with center tap open. Each 10 turns represents approximately 1 mH.

the core. The coil is manufactured with two separate windings so there are three basic methods for obtaining intermediate inductance values. These are plotted in **figs. 5** to **7**.

For values between 70 and 88 mH, it is probably easiest to remove turns from only one side. Leave the center tap connected. Use **fig. 5**, where a reduction of 1 mH is achieved for each 5 turns removed. **Fig. 6** gives lower values beginning approximately at 23 mH by opening the center tap and using only one winding. Here 10 turns yield 1 mH.

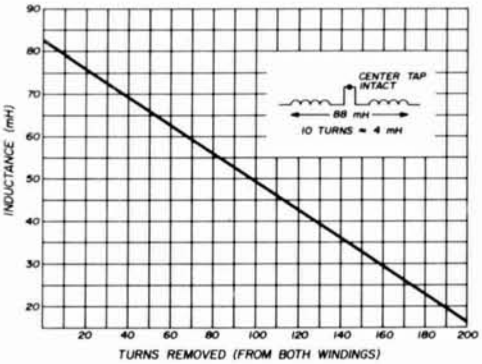

fig. 7. Effect of removing equal number of turns from both windings of 88-mH toroidal inductor with center tap intact. Each 10 turns represents approximately 4 mH.

When an equal number of turns are removed from both windings and the center tap remains intact, inductance values shown in **fig. 7** are realized.

Measurements were taken with a General Radio Impedance Bridge model 1650A.

Max J. Fuchs, WA1NJG

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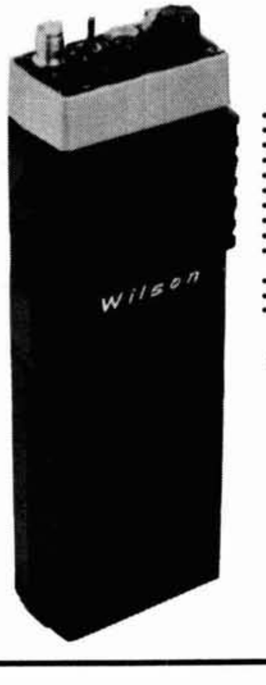

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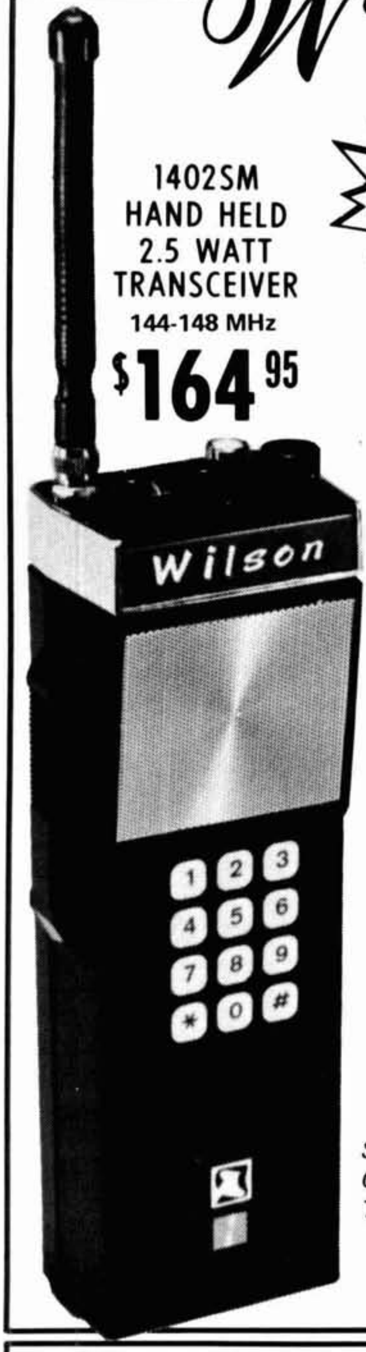

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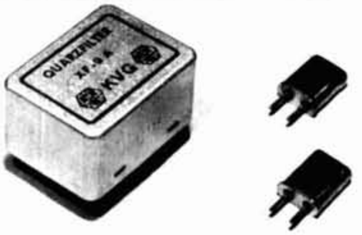

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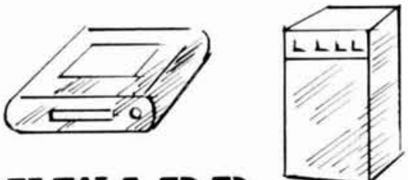

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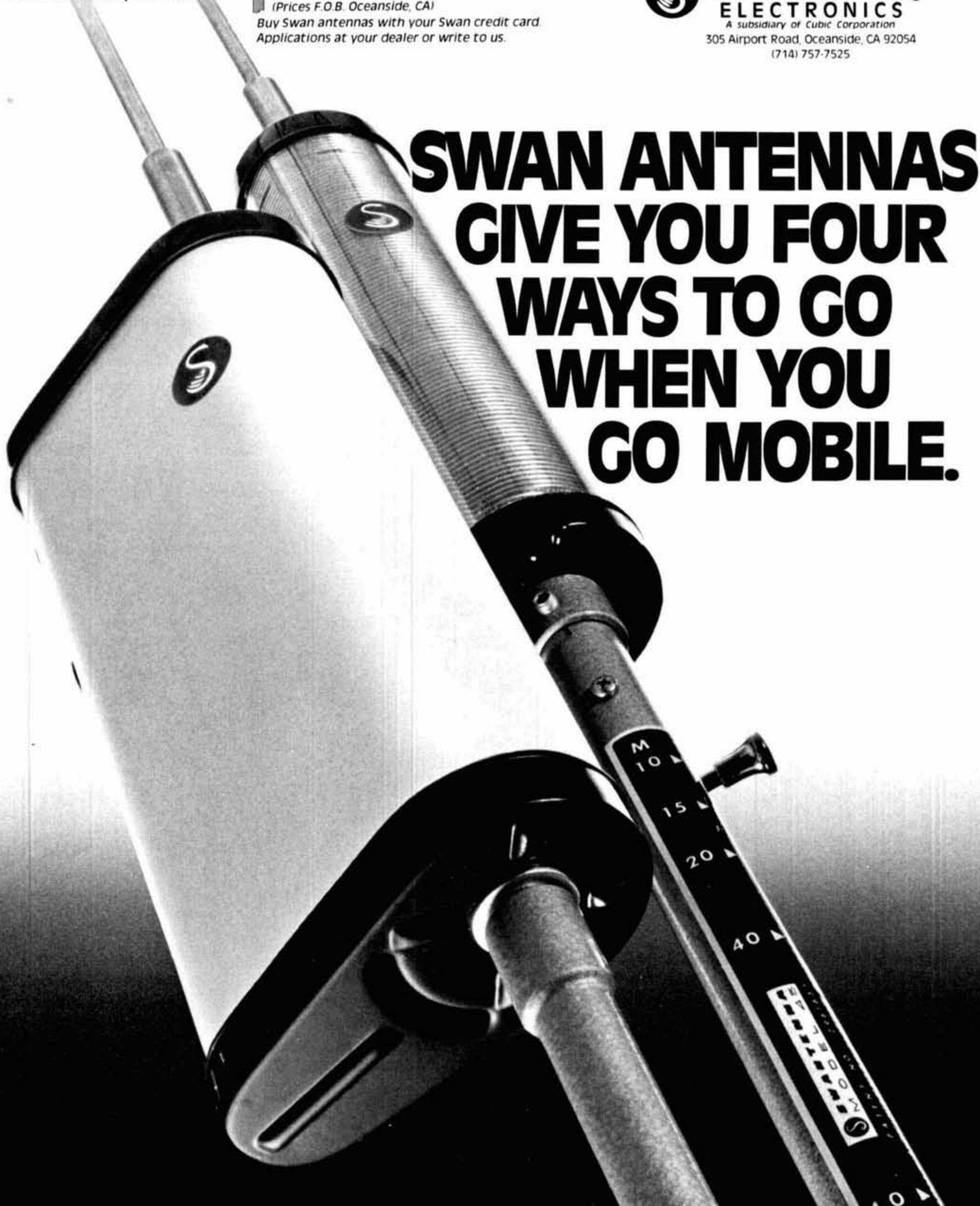

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Typical accuracy for dc voltage measurements is 0.5%. Dc current accuracy is 1.0%. On ac voltage ranges, frequency is specified to 10 kHz, while ac current measurement is to 5 kHz. Accuracy of resistance measurements on the three highest ranges is to 0.6% and to 0.4% on the two lower ranges. Open circuit voltage is less than 4 volts. Input resistance on all voltage ranges is 10 megohms with input capacitance of less than 30 picofarads. The 3476 is protected to 1100 volts peak on all ranges. The fuse that protects the ohms function is rated 250 volts rms. The current function is fuse protected to 1.5 amps. No special fuses are required and they can be quickly replaced without disassembling the instrument.

A range hold feature is included that allows the instrument to be locked to any desired range. This feature is necessary when measuring diode resistance. It also makes repetitive measurement faster. The LED readout gives all voltage readings in volts, all resistance readings in kilohms, and all current readings in amperes.

The model 3476A DMM is ac line powered only; model 3467B is ac line powered and also includes rechargeable nickel cadmium batteries. Typical operating time on fully charged batteries is 8 hours. Both units are 2.3 inches (6.5cm) high, 6.6 inches (16.8cm) wide and 8.1 inches (20.6cm) deep. Ruggedness is assured with the high impact resistance polycarbonate case.

U.S. price of the model 3476A is $225, and $275 for the 3476B. For more information, contact Inquiries Manager, Hewlett-Packard Company, 1501 Page Mill Road, Palo Alto, California 94304, or use *check-off* on page 118.

IC test clip

A new product by Continental Specialties Corporation, called Proto-Clip 24, is a welcome third hand for those working with 24-pin integrated circuits. The PC-24 design is patterned after the PC-14 and PC-16. It features a narrow throat, which aids in bringing IC leads up from high-density PC boards. Accidental shorts while testing live circuits are practically eliminated. The PC-24 can be used to inject signals and wire circuits to other boards.

Scope probes and test leads lock onto gripping contact teeth, freeing hands for other work. Contacts are noncorrosive nickel silver, which provides simultaneous wiping action and low-resistance connections to IC leads. Plastic construction eliminates springs and pivots, and a unique molded web ensures thousands of operations. The PC-24 is available off the shelf from local distributors or direct from Continental Specialties Corporation, 44 Kendall Street, P.O. Box 1942, New Haven, Connecticut 06509 or 351 California Street, P.O. Box 7809, San Francisco, California 94104. Write to either address or use *check-off* on page 118.

an introduction to microcomputers

Anyone who has a microcomputer or ever plans to own one should have a copy of this book. It is the nearest thing to a "Bible" for the microprocessor user that I have seen. With books and courses on microprocessors going for $25 to more than a hundred dollars, this book is also one of the biggest bargains available.

The first two chapters cover the basic vocabulary of microprocessing number systems, and Boolean algebra. Chapters 3 and 4 introduce the components of microprocessor architecture.

Chapter 5 describes logic external to the CPU: memories, I/O, Direct Memory Access (DMA), and system busses. Chapter 6 discusses programming concepts through the description of an imaginary processor instruction set. I prefer this approach to the more usual technique of taking an existing processor, usually the 8080 or 6800, and examining its instruction set. Since every microprocessor reflects the biases of its designers and intended market, a text tied to any existing set must continually digress to explain how other processors differ (or just pretend the others don't exist). Since programming is introduced through examining the instruction set, the reason for, as well as the operation, of each instruction is much clearer to the novice. All addressing modes are described with clear examples, again giving the reader an understanding of why they are provided as well as how they work.

Since the author is a consultant engaged in helping users choose the processor best suited for their application, he has an intimate knowledge of most processors presently available. Other authors usually have experience with only a single CPU chip, or are employed by a manufacturer and thus have a vested interest in the success of a particular chip.

For the user who is interested in a specific processor, the last third of the book applies the general concepts to seven commercial CPU chips: The Fairchild F8, the National Semiconductor PACE and SCAMP, the Intel 8080, the Motorola M6800, the Rockwell PPS-8, and the Signetics 2650. Each processor is discussed in terms of its architecture, instruction set (complete instruction sets are given for each processor), I/O and memory structure, and control signals. All support chips (four of them in the case of the 8080) are also described. The level of detail is excellent. For example, there are nineteen pages of information provided for the PACE microprocessor.

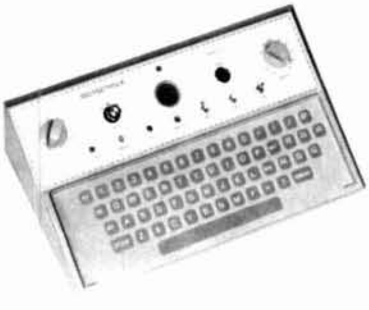
The final chapter is entitled "Selecting a Micrprocessor." The author's contention is that whatever processor requires the minimum external logic to perform a given task is the best processor for that task, regardless of its price, instruction set, or other features.

The beauty of the text is that it can start a chapter by defining what an accumulator is and end up with a discussion of microprogramming without losing the beginner along the way. The more knowledgable reader is assisted in finding the material he needs by a scheme which *outlines* the text in bold-face type, then provides explanatory material and examples in a lighter face. Major topics are further set off by boxed-in keywords in the right-hand margin. The entire design of the book optimizes it as an information retrieval device.

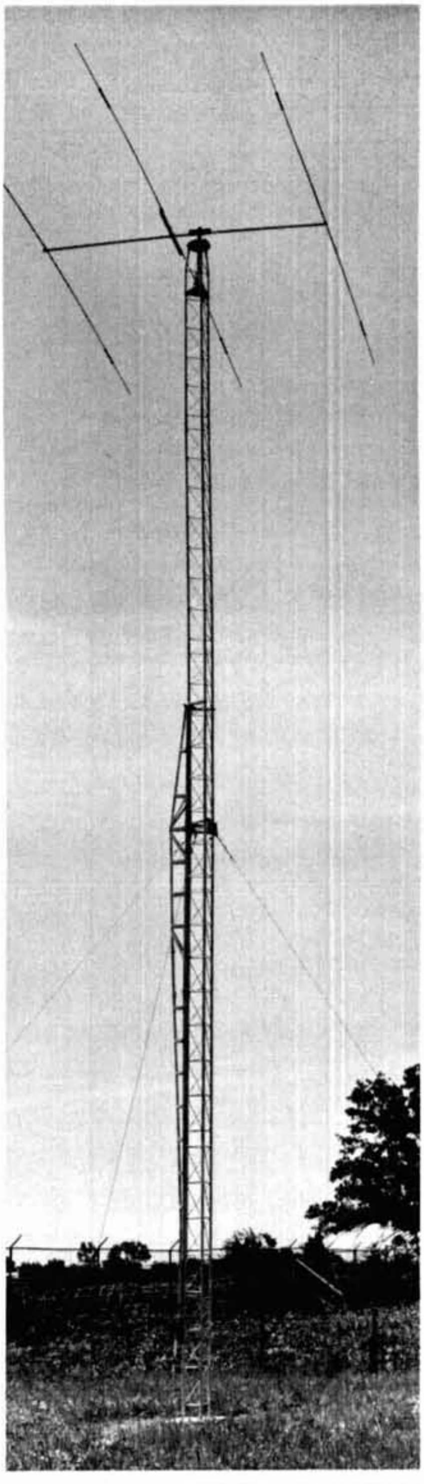
I don't know what more anyone could ask of a general book on microprocessors. Every microcomputer manufacturer should ship a copy of this with each machine he sells – it would stop the complaint that manufacturers never provide enough programming information with their products.

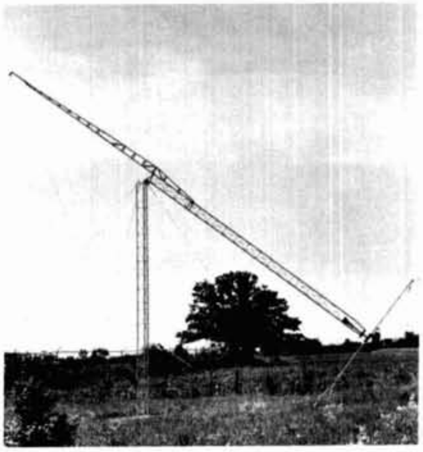
Hard cover, 250 pages, $7.50 from Ham Radio Books, Greenville, New Hampshire 03048.

morsetyper with memory



The Morsetyper model BDC computer terminal can store over six "Quick Fox" sentences or 256 "V" characters in its five registers. It uses this memory





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capacity in two modes, QSO or QST, at speeds from 5 to 200 wpm. Both modes allow random speed touch-in while the machine outputs uniformly at any set speed; touch-in slow, output fast, or touch-in fast, output slow. A 56-pad Touch-coder keyboard provides 36 alpha-numerics, 8 punctuation, 7 prosigns, 5 prowords, and error; there is automatic spacing between characters as well as between words. The monitor includes an internal sine wave oscillator with speaker, phones, and volume control.

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The Morsetyper weighs only 10 pounds (4.5 kg) and comes complete with lap mounting holders so you can send from your easy chair. The price is $495. Three other models of the Morsetyper are also available. For more information write Computronics Engineering, 7225 Hollywood Blvd., Hollywood, California 90046 or use *check-off* on page 118.

mobile radio headset

A mobile radio headset that is truly hands-free, operates with virtually no effect from engine and traffic noise, and has no obstruction in front of the face, *Mobil-Ear* has been introduced by JMR Systems Corporation. The heart of the *Mobile-Ear* system is a miniature electric microphone worn on the cheek which picks up the operator's voice through the skin. The technique was developed originally by JMR for use in Navy fighter and helicopter helmets, and for high-noise industrial intercom and mobile systems.

Safety is implicit in *Mobile-Ear's* single-earcup design, which enables the operator to don his headset with one hand, and to hear ambient sounds while still hearing his radio clearly. Comfort is ensured by adjustable eardome pressure and spring-band fit. A unique feature is the system's built-in sidetone, which enables the operator to monitor his own voice.

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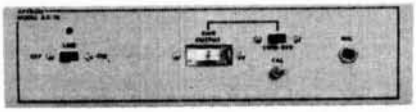

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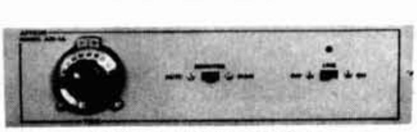

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new radio handbook

Since the first *Radio Handbook* was published in 1935, it has grown from a slim 256 pages to the more than 1000 pages of the latest edition, the 20th. A quick check of this new volume, edited by Bill Orr, W6SAI, indicates that about 60 per cent of the text has been revised and more than 115 pages have been added since the last edition was released in 1972.

New chapters in the 20th edition include one on propagation and another on specialized communications techniques. The new propagation chapter starts out with Maxwell's equations, then covers hf and vhf propagation, ionospheric activity cycles, and various vhf propagation modes. The "specialized communications techniques" chapter discusses space communications (Oscar), moonbounce, radioteletype and associated video displays, slow- and fast-scan television, and facsimile.

The chapter on transmission lines has been expanded to include a discussion of wave motion on a transmission line, the use of baluns and matching transformers, and an explanation of the use of the Smith chart. The antenna chapter includes more than twenty new antenna designs, including several high-gain moonbounce arrays for vhf and uhf.

The theory chapters of the new *Radio Handbook* include information on high-frequency broadband amplifiers, vhf solid-state power amplifiers, and the design of vhf circuitry, both for vacuum tubes and solid-state devices. The mathematics chapter has been ex-

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tensively revised and includes much new information not generally available to amateurs.

The 20th edition of the *Radio Handbook* also features a number of new projects including an interesting electronic keyer based on a cmos IC which reduces the keyer to a single integrated circuit. This is followed by a discussion of a buffered keyboard for the modern CW operator. For vhf enthusiasts there's a solid-state, ten-watt linear for 432 MHz which requires no intricate strip-line construction, and for the advanced builder there's a multi-band communications receiver which features excellent overload and cross-modulation characteristics combined with good sensitivity.

A deluxe 3-1000Z linear amplifier for the DXer or high-power buff is described, as is another linear based on the popular 8877 grounded-grid triode. For the vhf operator there's a new 500-watt amplifier for the 420-450 MHz which uses an 8874 triode. Hardbound, 1080 pages, $19.50 from Ham Radio Books, Greenville, New Hampshire 03048.

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The Channel Guard XL-1000, offered by Telco Products Corporation, has features not found in the usual manufactured lowpass TVI filter. It has five sections, each of which is tunable, for maximum rejection of harmonics from transmitters operating below 30 MHz. The XL-1000 handles full legal amateur power with negligible insertion loss.

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The Atlas transceiver fits anything that moves!

At 7 pounds, and 9½"x 9½"x 3½", the Atlas 210x or 215x is less than half the size and weight of other hf transceivers. Whether for an automobile, bicycle or sailboat, it's the perfect mobile or portable radio.

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Stacey Smith, WA2OIO, shown above, operates mobile from her bicycle with just her Atlas transceiver, a 12 volt portable power pack, and Mobile antenna. With this basic mobile set-up, Stacey has had many enjoyable QSO's on 20 and 75 meters while riding her bicycle. (Our congratulations to Stacey for her ingenuity in setting up this unusual mobile installation, and for getting her advanced class license five years ago at age 12.)

Bob Lengyel, WB6KDS, worked stations all over the world with an Atlas 210x transceiver installed in his sailboat while crossing the Atlantic single-handed. Bob's faith in the Atlas transceiver to maintain vital communications with the rest of the world is a real compliment to the dependability of Atlas equipment. During this month of June, Bob will be sailing from Portsmith, England, to Newport, RI, in the single-handed Transatlantic race, again depending on his Atlas transceiver for communications.

Dan Lepinski, WA7JUX, from Phoenix has just put 40,000 miles on his motorcycle, making hundreds of QSO's during his travels.

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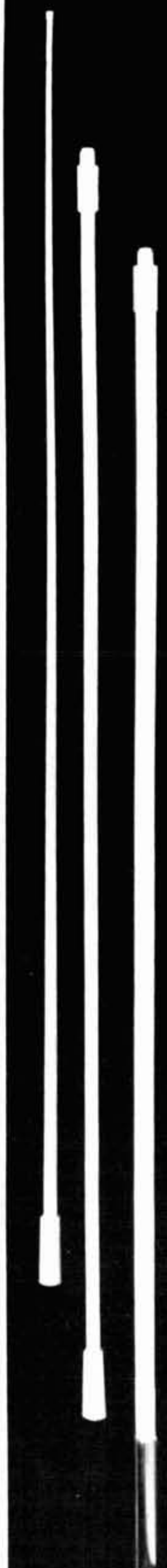

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More Details? CHECK—OFF Page 118

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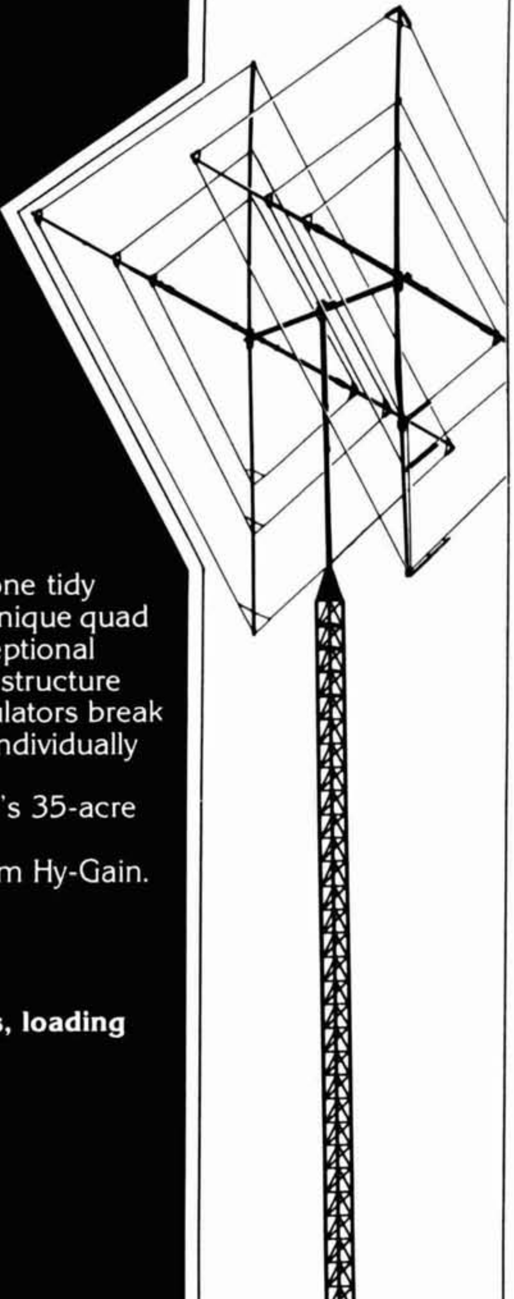

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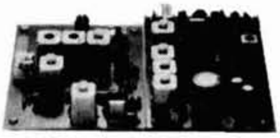

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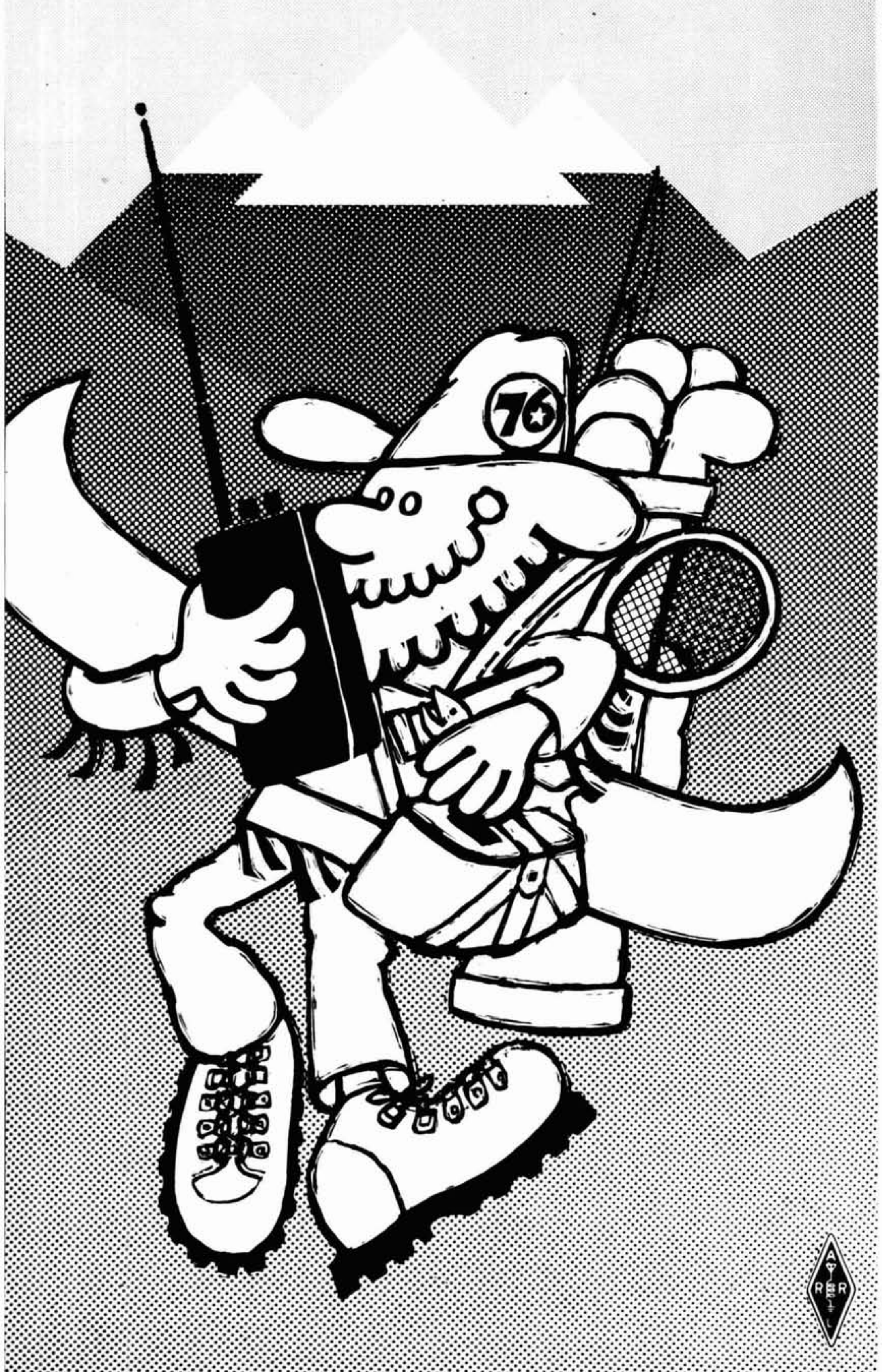
TUNE IN THE SPIRIT OF '76

ARRL NATIONAL CONVENTION

DENVER JULY 16, 17 & 18



There's a lot happening at the 1976 ARRL National Convention.

Friday

0800 Registration
0800 Bus Tour to Hewlett Packard
1200 Hams Hospitality Room
1200 Exhibits
1300 Bus Tour to Bureau of Standards
1400 Microprocessors for Beginners
1400 Microprocessors for Advanced
1800 General Hospitality Rooms with Entertainment
1900 Microprocessor Sharing Session

Saturday

0700 QCWA Open Breakfast
0800 Exhibits
0900 10X Forum
0900 Powerline Noise Forum
0900 Introduction to Amateur Radio ARRL Staff
1000 DX Forum Jack Reed, VE3GMT (Member, 1975 Sable Island DXpedition)
1000 Ionosphere Modification Project
1100 Search & Rescue Emergency Communications in N New Mexico
1100 Optical Communications in the Atmosphere Dr. Jack Baird (University of Colorado)
1100 Contesters Forum
1200 Lunch
1230 Antenna Forum/Basics
1230 Antenna Forum/Advanced
1230 Advances in Antenna Matching Jerry Sevick, W2NMI (Bell Labs)
1300 Amateur Radio for the Handicapped
1300 MARS/Combined Seminar
1400 Fiber Optics Communications Joe Mullins (Bell Labs, New Jersey)
1500 FM Forum
1600 Amateur Radio Talks to the Media
1600 Printed Circuit Board Construction & Demonstration
1700 Free Time
1800 Banquet with Two Featured Speakers
 *Father David L. Reddy, CE0AE, of Easter Island fame
 *Geoffrey Bryson (Director of Documentary Programming for BBC, London, England)
2100 ARRL Forum
2100 Ladies Variety Show
2400 Wouff Hong Ceremony

Sunday

0530 Sunrise Service at Civic Center (Multi-Denominational)
0700 Open Buffet Breakfast
0800 Registration
0900 Exhibits
0830 MARS/Army, Navy, Air Force
0930 National Bureau of Standards Time & Frequency Service (Time by Satellite)
0930 YLRL Forum
1030 FCC Forum
1200 Hotel Check-Out Time
1300 Lunch & The Great Prize Give-A-Way

Your family is going to love Colorado.

There's more for the family than just baby sitting services. We've planned things like family bus tours to nifty places and special entertainment for the ladies. And the State of Colorado would like to send you all the information you need to help make this summer's vacation the best you've ever had. Just write "Vacation", c/o State House, Denver, Colorado.

And there's more.

- Convention Stations: HF/VHF via NC0ARL
- FCC exams for all classes of licenses Friday afternoon and Saturday morning. (Contact Denver Field Office for reservations. First come, first served.)
- 2 Meter "Talk-In" via 146.34/94.
- Oscar demonstration by AMSAT.
- Propagation and tracking report on a balloon suspended repeater.
- And even more technical and operating sessions are being scheduled right now.

Come to Centennial Colorado. There's more happening for you and your family than at any other Amateur Radio convention.

Send for your application **now!**
Write to: ARRL National Convention,
c/o Slats Council, 2450 South Quitman,
Denver, Colorado 80219.

MAKE PROFESSIONAL LOOKING P.C. BOARDS FAST AND EASY

- •SENSATIONAL
- •REVOLUTIONARY
- •FANTASTIC

SEE MAY, 1975 QST (page 42) NEW PRODUCTS REVIEW

Reduces Printed Circuit Board Art Work From 2 Hours to 10 Min. . .

Simple as A.B.C.

A. Stamp Components on P.C. Board. **B.** Use Pen to Interconnect Lines. **C.** Etch Board.

SE-2 KIT CONTAINS

- CONNECTOR FINGERS
- 16 PIN DUEL IN LINE IC SOCKET
- 10 PIN ROUND IC SOCKET
- 8 PIN ROUND IC SOCKET
- TO-5 TRANSISTOR SOCKET
- TO-18 TRANSISTOR SOCKET
- LARGE & SMALL DONUT PAD

PLUS RESIST INK, INK PAD, RESIST PEN

ONLY **$9.95** PLUS 1 LB. POSTAGE

ADDITIONAL STAMPS

Bread board stamps for all integrated circuits "Great" for experimenters.

Only $2.95 each or all four $9.95

- #1 DUEL INLINE
- #2 FLAT PACK
- #3 8-PIN ROUND
- #4 10-PIN ROUND

- • **RESIST INK** . . . 95c per bottle
- • ***RESIST PEN*** **ea. 95c**
- • **INK PAD ea. $1.15**
- • **Etching Containers . . 10 for 95c**

Are you tired of the hours of small, detailed, eye-straining art work that goes into making printed circuit boards? "STAMP IT, ETCH IT" is introducing a NEW product called **"STAMP IT, ETCH IT"** Kit. This Kit will take the tedious art work and many tiresome hours out of printed circuit board preparation. In just *a few short minutes* you have a professional looking etched printed circuit board ready for drilling!

The "STAMP IT, ETCH IT" Kit is exactly as the *name implies*. Following the step by step simple instructions, you can have a printed circuit board and have saved hours of frustration. As easy as you use a rubber stamp to stamp messages on paper, you stamp your component connections on copper clad printed circuit boards.

In your "STAMP IT, ETCH IT" kit we supply all component stamps shown in SE-2 Kit. In the SE-2 kit we also have resist ink enough for months and months of experimenting, ink stamp pad, resist pen, and etching containers. The most revolutionary item in your "STAMP IT, ETCH IT" *Kit is . . . The Fool Proof* System of etching your printed circuit boards.

With our kits and our etching containers, you are able to etch a printed circuit board as fast as bubble etching machinery and the results are as **good** or **better.**

COAX CONNECTORS

PL 259	.55
SO 239	.50
PL 258 BARREL	1.15
DOUBLE MALE	1.75
M 358 'T' ADAPTER	2.95
M 359 Right ANGLE	1.49
UG 175/U REDUCER (RG58/U)	.25
UG 176/U REDUCER (RG59/U)	.25
PL 259 P.O. (PUSH ON TYPE)	1.25
UHF F to MOTOROLA M	1.50
UG 255 BNC.M to UHF.F	2.95
UG 273/U UHF.M to BNC.F	1.95
UG 260B/U BNC CABLE END	1.15
UG 274C/U BNC 'T' ADAPTER	2.45
UG 306B/U RIGHT ANGLE	1.75
UG 491B/U DOUBLE MALE	2.45

PRINTED CIRCUIT BOARDS G-10 FIBERGLASS

Size	1 Side	2 Sided
2"x 4"	.25	.35
2"x 6"	.35	.45
3"x 6"	.50	.65
4"x 6"	.65	.90
6"x 6"	.90	1.35
6"x12"	1.50	2.50
12"x12"	2.95	3.95

QUANTITY DISCOUNT (same size)

10 to 24	10%
25 to 99	15%
100 up	25%

$5.00 Minimum Order
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FAN (MUFFIN TYPE)

Rotron Mfg. Mod. MU2A2. 4 11/16" Square, no bezel. 80 CFM, Whisper Quiet, 115 VAC. 60 cy.

BRAND NEW. $9.95 ea.

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High Quality Module Type, wires easily into existing stereo where an equalizer pre-amp state is required, can be used in magnetic cartridges, tape decks, or heads, low impedance microphones, etc. 12 V power source. 20 to 20 KHZ Frequency response, very sensitive. 3"x4¼"x⅝" BRAND NEW WITH SCHEMATIC. **LIMITED QUANTITY— 3 for $2.00 — 10 for $5.00.**

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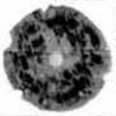

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MM 5312 CLOCK CHIP — 4 digit, seven segment multiplexed, BCD output, & 1 PPS output, 11-19 v.d.c. supply range. GET TO KNOW US SPECIAL — $1.95 ppd. with data.

MM 5320

MM 5320 TV CAMERA SYNC GENERATOR — this LSI chip supplies the basic sync functions for either color or monochrome 525 line/60 Hz. camera and video applications. The price is $4.95 ppd. and includes the data sheet.

OSC KIT.

CMOS CRYSTAL TIMEBASE KITS with .01 percent accuracy. 5-15 v.d.c. operation. Draws only 3 mA at 12 volts. Single I.C. — very small size — the P.C. board is 7/8" x 1-5/8". Choose a main output of 50 or 100 Hz., 60 Hz., 500 or 1000 Hz., or 1 Hz. Several related frequencies are also available on each board, in addition to the main ones listed above. Be sure to specify the Frequency you want. All kits are $10.95 ppd.

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THEN

Check these features:

Small: only 8"x2.6"x1.28" . . . **Appearance:** slim silhouette all black metal . . . **Serviceable:** easy access to separate receive and transmit circuit boards . . . **PLUS:** 6 pole xtal filter for superlative receiver operation . . . **and:** trimmers on receive and transmit xtals: standard 10.7 MHz 1st IF.

and specs:

Rec. Sens.: .2μv for 12 db SINAD . . . **Adjacent channel rejection:** ±30 kHz 55 db . . . **Spur. Resp.:** more than 65 db . . . **Audio Output:** 500 mw . . . **Power output:** Hi 3 w, Lo 1 w . . . **Audio Quality:** Distortion free, crisp, clear receive and transmit.

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Look at the Price:

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2 Meter 6 channel Hand-Held (without encoder)
$249.95
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with Built-In Tone Encoder
$299.95
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2-meter FM, 10 channels, 10 watts (Xtals not included)
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$189.95

☐ **GTX-1**
2-meter FM, 6-channel, 3.5 watts Hand-Held
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☐ **GTX-1T**
Same as GTX-1, plus Factory Installed Tone Encoder
Operate Auto Patch
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☐ **PSI-18** Optional Nicad battery pack $29.95 $______

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The heart of the system is our 4-digit Decade Counter (Kit 012) which features a full 4-digit LED readout (you choose the size best suited to your application). Combine this with a 5-volt regulated power supply (Kit 030) and you have the basis of a wide range of sophisticated electronic instruments, including:

A Digital Voltmeter (DVM) .. Kit 012 + Kit 030 + Kit 017
Frequency Counter................ *Kit 012 + Kit 030 + Kit 016 +Time Base*
RPM Counter......................... Kit 012 + Kit 030 + Kit 020 + Kit 018

KIT 016 FREQ. COUNTER

Features FET input front end with trigger circuit for measuring complex waveforms. Measures from 0.1Hz to 10MHz when used with Kit 015 or 019. Measures from .01Hz to 35MHz when used with Kit 013 and 014.
$24.50

KIT 017 DVM

1.999V as basic, with polarity indication. 1 M ohm input impedance and accuracy to 1% if properly adjusted
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KIT 020 RPM COUNTER

Counts from 1 to 100,000 RPM. RPM counter kit contains components and PC board.
$8.95

KIT 030 POWER SUPPLY

*Input voltage: 25V max. *Output current: 1 amp max. *Load regulation: 50mV. *Output voltage: 5V. *Line *regulation: .01%. (requires 8-20V transformer)*
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(Contains all parts except transformer)

TIME BASES

1 Mhz crystal chain time base divider. Outputs; 1Mhz-100Khz-10Khz-1Khz-100Hz-10Hz-1Hz-0.1Hz. Accuracy better than .005% with proper adjustment.

Kit 013 complete CMos with PC board **$15.75**
Buffer Circuit for TTL Interfacing

Kit 014 Same as Kit 013, but with TTL.......... **$13.75**

Kit 015 50Hz or 60Hz chain time base using line frequence as reference. Accuracy 0.1-0.05%. Outputs 10Hz-1Hz-0.1Hz. Complete with CMos shaping circuit and PC Board.. **$8.75**

Kit 019 Same as Kit 015, but with TTL and 60Hz only.. **$7.75**

Kit 018 60Hz chain time base using line frequence for Kit 020 RPM counter.

*Outputs: .6 sec. = 100th of RPM
6 sec.= 10th of RPM
60 sec. = full revolution

$9.75

4-DIGIT DECADE COUNTER KIT

$19.95

KIT 012

One chip 4 digit decade counter kit, with both 7 segment and BCD output.

1. Chip features internal oscillator for scanning speed.
2. Overflow and count extent outputs.
3. Transfer, reset, count, blanking *and true compliment control inputs.*
4. PC Boards can be cascaded to 8-12-16, etc. digits.
5. Kit includes counter chip, drive circuit for 4 cathode type displays and PC Board. (For readout board see (FND70-FND503)

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One of our best readouts .5 in. high, 20mA per segment. Common anode. **$3.75**

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Red, .30 in. high 15mA per segment. Common anode.... **$1.25**

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If you like an array of displays, we have it. Common cathode. **$1.45**

New .5 in. display by Fairchild. Common Cathode.

FND503

$1.00
5/$7.50

MAN 5 GREEN
MAN 7 RED
MAN 8 YELLOW

Why not make a clock in 3 diff. colors. .27 in. high Common anode. **$1.25**

HP7730

.33 in. high red very bright 25mA per seg. Common anode.

TI

Fully multiplexed common cathode. Goldplated. Ideal for mini 6 digit clock. **$1.30**

BURROUGHS 12 DIGIT

.25 in. high orange digit. 160v dc. Free socket. **$2.50**

LEDS

Mini red	.12
Jumbo red	.15
Jumbo green	.20
Jumbo yellow	.25

4 & 6 DIGIT PC BOARDS

PC Board for 4 digit display FND 800 or 807	$2.75
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PC Board for 4 digit display MAN series or DL707	$1.75
PC Board for 6 digit display MAN series or DL707	$2.25
PC Board for 4 digit display FND503	$2.00
PC Board for 6 digit display FND503	$3.00
PC Board for 4 digit display DL747	$2.50
PC Board for 6 digit display DL747	$3.00
PC Board for 4 digit display DL727	$2.25
PC Board for 6 digit display DL727	$3.00
PC Board for 4 digit display FND70	$1.75

All PC display boards are multiplexed for adding additional digits.

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2N3906 PNP Compl. 2N3904		0.15
2N4400 NPN Low level noise		0.20
2N5401 PNP Nixie-driver		0.25
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MEMOREX computer boards with TTL's Diodes and Transistors, etc.

5 Boards containing 150-250 IC's. **$3.95**

$$$ SAVE! 4-DIGIT ALARM CLOCK

KIT NO.1 **$13.95**
(with PC Board)

FEATURES:

Direct drive display outputs, *Current control regulation-on chip, *Low power brightness control-on chip, *RFI eliminating slowup circuitry, *Sleep radio feature, *24 hour snooze alarm, *Independent digit setting, *Non multiplexed output circuitry. 12VAC CT 1/2 amp transformer for Kit No. 1 **$2.00**

*KIT NO. 2

Complete kit with components, PC Board, Transformer, wood grain case, and filter for display window. Includes .25 in. readouts. **$21.50**

*KIT NO. 3

Complete kit with components, PC Board, Transformer, wood grain case, and filter for display window. Includes .5 inch readouts. **$22.50**

*Components for Kit No. 2 or Kit No. 3 sleep radio feature, add **$.95**

CSC
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Kit includes Components, PC board, Transf., Fuse, Pilot Light
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Ideal for Frequency counter case, function generator, etc. Overall height 4", length 12" width 7 1/2".

(Includes top, bottom, and hardware.)

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MUSIC LIGHTS

60 WATT COLOR ORGAN

Completely self contained unit with 120 volt power cord included.

$1.50

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(Example) Set your alarm for 7: a.m., set timer for 15 min. At exactly 7: a.m., the appliance will start; at 7:15, your clock alarm will wake you.

Kit includes all components, PC Board and instructions for interfacing with THE KING 6-digit alarm clock. **Addition Number 2**

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4-DIGIT TEMP. KIT

$19.95

Features 4-digit temperature display; farenheit or Centigrade; complete C-Mos application; uses 7002 4-digit counter.

Kit includes all components, PC Board and instructions for interfacing with THE KING 6-digit alarm clock. **Addition Number 1**

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6-DIGIT ALARM CLOCK

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THE KING FEATURES:

1) 6 digit, 12 hr. 60 cycle or 24 hr. 50 cycle alarm clock
2) Time sharing capability for display of additional information.
3) Single 12v. supply and a minimum of interface components
4) AM-PM and automatic power failure indications
5) 10 minute snooze
6) Intensity control of LEDs.

Kit No. 70250-1R (Red readout)
Kit No. 70250-1G (Green readout)
Kit No. 70250-1Y (Yellow readout)
Kit No. 70250-2R (DL727 readout)... **$28.50**
Kit No. 70250-3R (FND807 readout). **$29.50**

All kits include components, PC Boards, Transformer, case, and construction manual.

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7404	.16	7492	.75
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7442	.69	74164	1.89
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7448	.89	74174	1.29
7453	.16	74175	1.39
7473	.37	74181	2.75
7474	.37	74192	1.25
7475	.65	74193	1.25
7476	.39	74195	.79
		74197	.79

CMOS

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4002	.24	4028	.99
4006	1.49	4029	1.39
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4011	.24	4035	1.39
4012	.24	4037	4.50
4013	.59	4040	1.59
4014	1.49	4041	.89
4015	1.19	4042	.79
4016	.59	4043	.80
4017	1.29	4044	.59
4018	1.49	4047	.59
4019	.59	4049	.59
4020	1.59	4050	.59
4021	1.49	4066	.99
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4023	.24	74C92	.29
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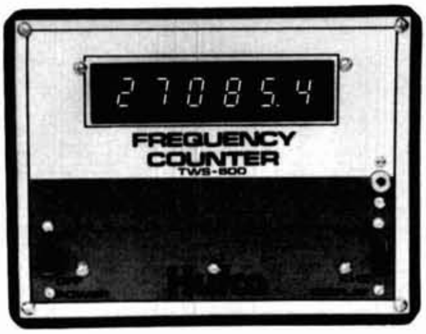

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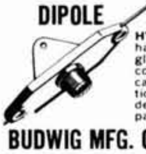

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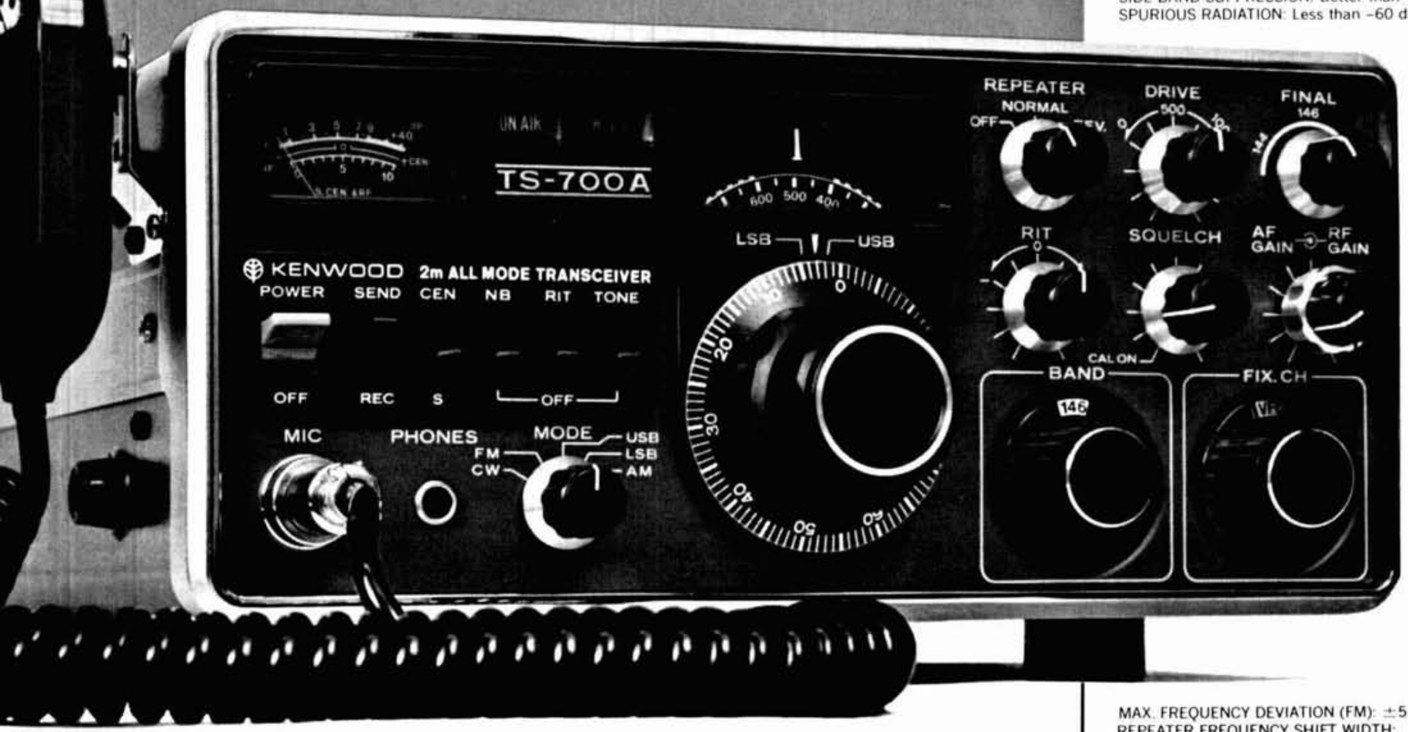

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TRANSMIT/RECEIVE FREQUENCY RANGE: 144-148 MHz
MODE: SSB, FM, CW, AM
RF OUTPUT: CW, FM: more than 10W output. AM: more than 3W output. SSB: more than 20W DC input.
ANTENNA IMPEDANCE: 50Ω (unbalanced)
CARRIER SUPPRESSION: Better than 40 dB
SIDE-BAND SUPPRESSION: Better than 40 dB
SPURIOUS RADIATION: Less than -60 db
MAX. FREQUENCY DEVIATION (FM): ±5 kHz
REPEATER FREQUENCY SHIFT WIDTH: 600 kHz
TONE BURST TIME: 0.5-1.0 sec.
MODULATION: Balanced modulation for SSB. Variable reactance frequency shift for FM. Low power modulation for AM.
MICROPHONE: Dynamic microphone, 500Ω
AUDIO FREQUENCY RESPONSE: 400-2600 Hz, within -9 db
RECEIVING SYSTEM: SSB, CW, AM: Single-superheterodyne. FM: Double-superheterodyne.
INTERMEDIATE FREQUENCY: SSB, CW, AM: 10.7 MHz. FM: 1st IF: . . . 10.7 MHz. 2nd IF: . . . 455 kHz.
RECEIVING SENSITIVITY: SSB, CW: S/N = 10 dB or better at 0.25μV. 20 dB noise quieting = Less than 0.4μV. AM: S/N = 10 dB or better at 1μV.
IMAGE RATIO: Better than 60 dB
IF REJECTION: Better than 60dB
PASS-BANDWIDTH: SSB, CW, AM: More than 2.4 kHz at -6 dB. FM: More than 12 kHz at -6 dB.
RECEIVER SELECTIVITY: SSB, CW, AM: Less than 4.8 kHz at -60 dB. FM: Less than 24 kHz at -60 dB.
SQUELCH SENSITIVITY: 0.25μV
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RECEIVER LOAD IMPEDANCE: 8Ω
FREQUENCY STABILITY: Within ±2 kHz during one hour after one minute of warm-up, and within 150 Hz during any 30 minute period thereafter.
POWER CONSUMPTION: Transmit mode: 95W (AC 120/220V), 4A (DC 13.8V), max. Receive mode (no signal): 45W (AC 120/220V), 0.8A (DC 13.8V).
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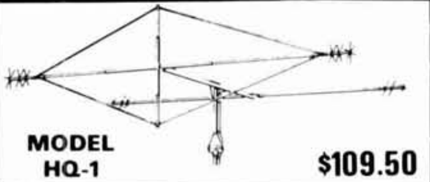

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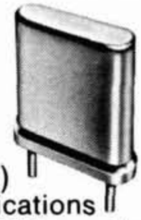

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Type TO-92 (TO-18), all manufacturers, variety of 2N #'s. **Cat.No. 6H 2604**

BARREL KIT #30
PREFORMED RESISTORS
250 for $1.98
We got barrels of ¼ and ½" watters for pc use. You'll get even amount. 100: ¼, 100 ½" watters. **Cat.No. 6H2608** 100 % good

BARREL KIT #31
METALLIC RESISTORS
100 for $1.98
100 % good.
Made mostly by Corning, the finest resistor made. Mostly ½ watters, 1 % to 5 % tol. & a barrel of values. **Cat.No. 6H 2609**

BARREL KIT #32
TRANSISTORS WITH A HOLE IN IT
50 for $1.98
Cat.No. 6H2610 Untested.
Can't name factory but we bought barrels of 25 watters with mtg. hole in middle. PNP'S and NPN'S.

BARREL KIT #35
NEON LAMPS
40 for $1.98 100 % good.
Famous NE-2's. All prime, but factory made millions and barrel'ed 'em. Your advantage **Cat.No 6H 2613**

BARREL KIT #36
GERMANIUM DIODES
200 for $1.98 Untested
Famous maker, popular item. Never grows old. But this is the way the RE-TESTERS buy 'em from the factories. **Cat.No. 6H 2614**

BARREL KIT #37
1 AMP "BULLETT" RECTIFIERS Untested.
100 for $1.98
Famous style, asstd. voltages, silicon, axial includes all types of voltages to 1KV. **Cat.No. 6H 2615**

BARREL KIT #39
2N3055 HOBBY TRANSISTORS
15 for $1.98 100 % good.
From factory to you, these fallouts of the famous 2N3055. We have 10 barrels. **Cat.No. 6H2617**

BARREL KIT #40
PNP HIGH-POWER TRANSISTORS
20 for $1.98
Popular germanium TO-3 case units, now available at "good ole barrel" prices. **Cat.No. 6H2618** 100 % good.

BARREL KIT #46
G.E. 3.5 WATT AMPLIFIERS
25 for $1.98 Untested.
Hobby type, factory fallouts, we purchased them in barrels. These are unknowns. **Cat.No. 6H 2624**

BARREL KIT #50
SIGNAL SILICON DIODES
200 for $1.98
Includes many, many types of switching, signal silicon types, all axial leads. Some may be zeners. **Cat.No. 6H2628** Untested.

BARREL KIT #51
HOBBY OPTO COUPLERS Untested.
40 for $1.98
We bot 1,000's unknown both the sensor or transmitter may be good, or both. WE DON'T KNOW! We don't know the types. 1500V isolation. **Cat.No. 6H 2629**

BARREL KIT #52
DISCS!
500 for $1.98
Cat.No. 6H2630 100 % good
The bargain of a lifetime! First time ever offered by Poly Paks for the economy-minded bargain hunters.

BARREL KIT #53
JUMBO RESISTOR PAK
100-pc. $1.98
Cat.No. 6H2721
Assortm metal films, precisions, carbons, metal oxide powers, from ⅛ watt to 7 watts. Color coded & 100 % good. Worth $10.

BARREL KIT #58
SLIDE SWITCHES
30 for $1.98
All shapes, sizes, spst, dpdt, momentaries, etc. Tremendous shop pak for 100's of switching projects. **Cat.No. 6H 2726** 100 % good.

BARREL KIT #59
POWER TRANSISTORS
40 for $1.98
15 watt Bendix B-5000 pellet transistors, npn, all good, purchased from a pretester, have millions of 100 % good **Cat.No. 6H 2727**

BARREL KIT #60
DTL'S IC'S
75 for $1.98 Untested.
This is prime barrel material. Who wants DTL's? 930, 936, 946's. Your gain is our loss. They're marked too. **Cat.No. 6H 2728**

BARREL KIT #61
POLYSTYRENE CAPS
100 % good
100 for $1.98
Finest caps made. As a gamble we bought 10 barrels from factory, mixed values; all good. **Cat.No. 6H 2729**

BARREL KIT #65
MIXED READOUTS
15 for $1.98
Factory returns — such numbers as MAN-4's, MAN-7's, MAN-3's, 11 barrels & no time to separate. **Cat.No. 6H 2733** Untested.

BARREL KIT #68
2 WATTERS
100 for $1.98 100 % good.
Nobody seems to want 'em! So many suppliers don't count, but throw 'em in the barrel. It's a li'l gold mine All marked. **Cat.No. 6H 2735**

BARREL KIT #71
CAPACITOR SPECIAL
100 pcs. $1.98
Emptied stockrooms into barrels of mylars, poly's, micas, moldeds, plastics, ceramics, discs, etc. Nifty 100 % good **Cat.No 6H2738**

BARREL KIT #73
TRANSISTOR ELECTROS
50 for $1.98
It "bugs" us why the factories dump 'em in barrels. We don't wish to separate wide asst voltages & values up to 300 mf. **Cat. 6H 2747**

BARREL KIT #75
400MW ZENERS
150 for $1.98
Factory out of biz! Amazing offer: 6, 8, 10, 12 to 15V. You test. Hermetically sealed glass pak. Double plug. **Cat.No. 6H 2740**

BARREL KIT #76
1-WATT ZENERS
100 for $1.98 Untested.
Factory same as 400-mw's. Never-to-see-again offer. 6, 8, 10, 12, 15V. under glass. Double plug. **Cat.No. 6H2741**

BARREL KIT #77
"BROWN" BODY TRANSISTORS
40 for $1.98
G-E D-40 series: has hi-voltage, Darlingtons, hi-current, npn's. Factory line discontinued. Power tabs. **Cat.No. 6H 2742** Untested.

BARREL KIT #78
"RED" BODY TRANSISTORS
40 for $1.98
D-42 series. You test—go into your own biz! High current, hi-V, NPN. **Cat.No. 6H 2743** Untested

BARREL KIT #81
SUBMINI RESISTORS
200 for $1.98 100 % good.
PC, upright type, color coded, ⅛ watt. Asst values. Came to us in a barrel. **Cat.No 6H 2746**

BARREL KIT #83
15 for $1.98
LM-340T VOLTAGE REGULATORS Untested
Factory rejected them for length of leads, May include 5, 6, 8, 12, 15, 18, 24 volts. Power tab **Cat.No. 6H 2635**

BARREL KIT #87
NATIONAL IC BONANZA
100 for $1.98
Factory dumps into barrels. Types 8000, 7400 series, DTLs, ROMs, registers, clock & calc. chips, linears, etc. **Cat.No. 6H2860** Untested.

BARREL #91
SILVER MICAS
100 for $1.98
Cat.No. 6H3018
For the first time silver micas so low in price! Axial, red case, variety of physical sizes & values. Big savings from distributor prices. Wt. 1 lb.

BARREL KIT #94
"BUBBLE" READOUTS
12 for $1.98
DL-33B bubble magnifiers. Segs missing. Truthfully so many of 'em we don't care. Untested, 3 oz. **No. 6H 3046**

BARREL KIT #99
PHOTO ELECTRIC CELLS
10 for $1.98
Asst. GE types, CDS types. Mixed by factory. Big job for us to separate. 100 % good. **Cat.No. 6H 3052**

BARREL KIT #102
CLOCK CHIPS
5 for $1.98 **No. 6H 3055**
National is dumping! MM-5316 — what's wrong with 'em, we don't know, but we got barrels. Hobby special. Wt. 2 oz.

BARREL KIT #104
SLIDE VOLUME CONTROLS
10 for $1.98
Cat.No. 6H 3057
Used in hi-fi, volume control maker unloads. Asst. values, what a buy. Worth $1 ea. We've got barrels of 100 % material.

BARREL KIT #107
SQUARE OHMS
60 for $1.98 **Cat.No. 6H3096**
Factory people are sometimes "squares" when they topple prime square ohms mix 'em up in barrels. Asst. values watts. Wt. 1 lb.

BARREL KIT #108
TO-5 PLASTIC TRANSISTORS
Cat.No. 6H3101
40 for $1.98
Includes PNP, NPN, 2N-3638, 2N3641, 2N5000 series, etc. Untested, but guaranteed to a 60 % yield.

BARREL KIT #109
TERMINAL STRIPS
150 for $1.98
Wide asst. of terminal strip connectors, from 1 contact up. Strip manufacturers barrel dump is your gain. Wt. 1 lb **Cat.No 6H3136**

BARREL KIT #110
SUPPRESSOR DIODES
50 for $1.98 **Cat.No. 6H3137**
Keeps ignition noises out axial. Untested, but the of your eqpt., car, industrial, etc. Double plug.

BARREL KIT #111
MULTI DIGIT READOUTS
8 for $1.98
barrels of blemished 3, 4 and/or 5 digit readouts to USA for "dump". Untested. **Cat.No. 6H3138**

BARREL KIT #112
MICRO MINI LEDS
40 for $1.98
All the tiny leds, axial, upright of Monsanto, Litronix, variety of colors. Yield 50 % or better. **Cat.No. 6H 3139**

BARREL KIT #113
STABISTORS
50 for $1.98 **Cat.No 6H3140**
Regulator, sensing and computer circuitry. Axial double plug type. Discontinued factory line. PIV 20 volts. 80 % yield. U test 'n save!

BARREL KIT #115
MOLEX SOCKETS
300 for $1.98
100 % good.
Calculator maker dump! We gut a zillion of 'em. Used for IC sockets, etc. **Cat.No. 6H 3144**

BARREL KIT #116
BUTTONS 'N FEEDTHRU'S
100 for $1.98
100 % good.
Truthfully worth a small fortune. Wide asst. of button-feedthru caps! HAMS TAKE NOTE! RF, UHF, etc. Wt. 1 lb. **Cat.No. 6H3141**

BARREL KIT #117
20-MIL OPTICAL FIBERS
200-FT. $1.98
Fiber optics factory bankruptcy purchase! High quality, most-commonly used size (20-mil), CLEAR. Lowest price. **6H 3206**

BARREL KIT #118
MINI SCRS
50 for $1.98
UNBELIEVABLE! TO-92 plastic SCRS in barrels . . . rite from factory. Includes all voltages up thru 200 prv. **6H3135**

BARREL KIT #119
MODULAR SWITCHES
25 for $1.98
Centralab "push-ON" switches. TV-makers excess. Dpdt, 6pdt, etc. Brand new. **Cat. No. 6H3150**

BARREL KIT #120
TRIGGER DIODES
25 for $1.98
Type ER-900, same type used to trigger scrs, triacs. Sometimes called "diacs". Untested. **No. 6H3160**

BARREL KIT #121
"MINI" MAGNETS
100 for $1.98
Magnet circular and rectangular cuttings from a major maker — For reed switches & micro-circuitry. **Cat. No. 6H 3168**

BARREL KIT #122
PLASTIC OPTICAL FIBERS
500-Ft. $1.98
Pop'lr 10-mil size. Excellent for making lite pipes, experiments, lamp sprays. **Cat. No. 6H 3159**

BARREL KIT #123
CD-4002 C-MOS IC
15 for $1.98
mostly good. But we have 250,000. Can never sell 'em out. YOUR GAIN! Their number is CD-5602. **Cat. No. 6H 3217**

BARREL KIT #126
UPRIGHT ELECTROS
40 for $1.98
Wide asst. of values from 1mf to 300mf in mixture of voltages. 100 % marked 'n good. Why barreled? U-got-a-buy! **Cat. No. 6H 3226**

BARREL KIT #127
AXIAL ELECTROS
40 for $1.98
Truthfully the factories (by mixing 'em in barrels) do all of us a favor. WUT A BUY! Asst. capacities and voltages. **Cat. No. 6H 3227**

BARREL KIT #128
MINI DIP ICS
75 for $1.98
Large mfgr dumped 100's of lbs into barrels. Includes 741s, LM-380-8, 703, 567, 555, 558—but who knows? Factory to you. All mixed, you test. Wt. 1 lb. **Cat. No. 6H 3245**

BARREL KIT #131
TANTALUM ELECTROS
30 for $1.98
Mixed, marked prime, top grade asst. values, voltages. GE, Centralab, etc. **Cat. No. 6H 3258**

BARREL KIT #133
C-MOS IC'S
60 for $1.98
Deliberately thrown in barrels, so we can't test 'em! The famous CD4000 series. How good? Who knows?. Who cares? It's only 3c ea. **Cat. No. 6H 3257**

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RECONDITIONED TEST EQUIPMENT for sale. Catalog $.50. Walter, 2697 Nickel, San Pablo, Ca. 94806.

GOVERNMENT SURPLUS Communication Equipment, FREE catalog. Colonel Russell, 9410 Walhampton, Louisville, KY 40222.

KLM PRODUCTS, Larsen ants., Icom, police and fire scanners. Send for prices. Not given over phone. Narwid Electronics, 61 Bellot Road, Ringwood, N. J. 07456.

ARRL HANDBOOK, 1st edition, needed to complete my collection. Any reasonable price paid. Have many early Handbooks and radio/electronics books for sale or trade. Send business-size SASE for list. Jim Fisk, W1DTY, Ham Radio, Greenville, NH 03048.

SAVE! Bomar FM, xtals $4.00 ppd. Dentron, Hustler, CushCraft, W. M. Nye, Ameco. Used gear. Complete catalog - write Ferris Radio, 308 E. Harry, Hazel Park, Mich. 48030.

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RTTY TERMINAL UNIT: PLL decoder, AFSK generator, loop supply, handsome cabinet, wired and tested, $169.95. Save, separate boards & kits available. Com Tech Electronics, P. O. Box 73, Rensselaer, N. Y. 12144.

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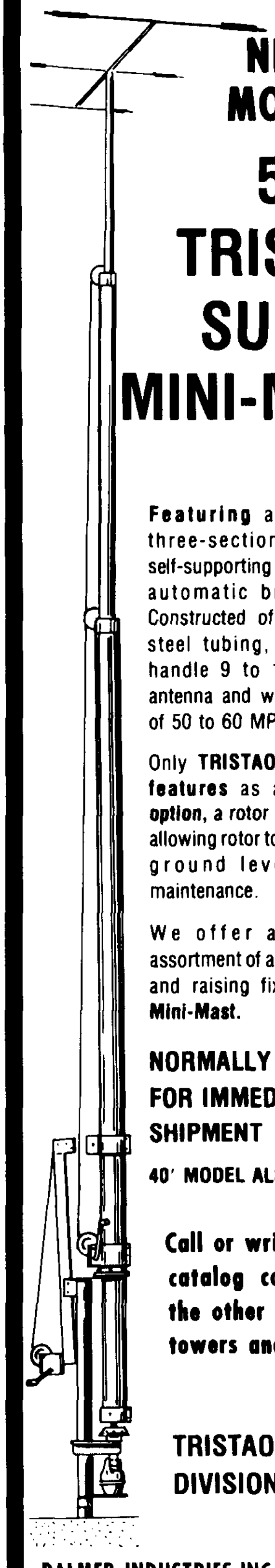

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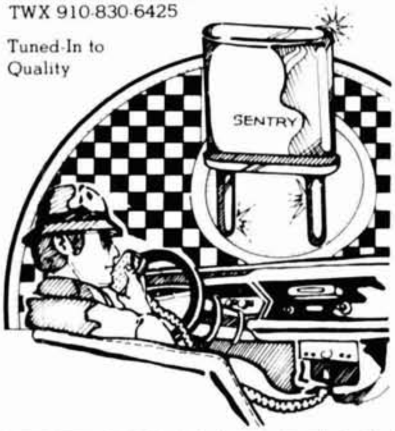

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Have a "Vacation with a Purpose" at this beautiful location in the Blue Ridge Mountains. A highly qualified staff and excellent facilities combine to make license study a pleasant memorable experience.

C. L. PETERS, K4DNJ, Director
P. O. Box 458, Glade Valley, N. C. 28627
Please send me the Booklet and Application Blank for the 1976 Glade Valley School Radio Session.

Name________________Call______
Address________________________
City/State/Zip__________________

More Details? CHECK—OFF Page 118

7400N TTL

SN7400N*	13	SN7453N	27	SN74150N	1.00
SN7401N	16	SN7454N	20	SN74151N	79
SN7402N	21	SN7459A	25	SN74153N	89
SN7403N	16	SN7460N	22	SN74154N*	1.25
SN7404N*	16	SN7470N	45	SN74155N	99
SN7405N	24	SN7471N*	69	SN74156N	99
SN7406N	20	SN7472N	39	SN74157N	99
SN7407N	29	SN7473N*	37	SN74160N	1.25
SN7408N	25	SN7474N*	32	SN74161N	99
SN7409N	25	SN7475N*	50	SN74163N*	99
SN7410N*	16	SN7476N*	32	SN74164N	1.10
SN7411N	30	SN7479N*	5.00	SN74165N	1.10
SN7412N	33	SN7480N	50	SN74166N	1.25
SN7413N	45	SN7482N	98	SN74167N	5.50
SN7414N	70	SN7483N	70	SN74170N	2.10
SN7416N	35	SN7485N	89	SN74172N	18.00
SN7417N	35	SN7486N	39	SN74173N	1.50
SN7420N	21	SN7488N	3.50	SN74174N	1.25
SN7421N	33	SN7489N	2.25	SN74175N	99
SN7422N*	49	SN7490N*	45	SN74176N	90
SN7423N	37	SN7491N	75	SN74177N	90
SN7425N	29	SN7492N	49	SN74180N	99
SN7426N	29	SN7493N*	49	SN74181N	2.49
SN7427N	37	SN7494N	79	SN74182N	95
SN7429N	42	SN7495N	79	SN74184N	1.95
SN7430N	26	SN7496N	89	SN74185N	2.20
SN7432N	31	SN7497N*	4.00	SN74186N*	5.00
SN7437N	27	SN74100N*	1.00	SN74187N	6.00
SN7438N	27	SN74107N	39	SN74190N	1.19
SN7439N	25	SN74121N*	39	SN74191N	1.25
SN7440N	15	SN74122N	39	SN74192N*	89
SN7441N	89	SN74123N*	70	SN74193N*	89
SN7442N	59	SN74125N	60	SN74194N	1.25
SN7443N	75	SN74126N	60	SN74195N	75
SN7444N	75	SN74132N	1.09	SN74196N	1.25
SN7445N	75	SN74136N	95	SN74197N	75
SN7446N	81	SN74141N	1.15	SN74198N	1.75
SN7447N*	69	SN74142N*	4.00	SN74199N	1.75
SN7448N	79	SN74143N*	4.50	SN74200N	5.59
SN7450N	26	SN74144N*	4.50	SN74279N*	90
SN7451N	27	SN74145N	1.15	SN74251N	1.79
SN7452N*	27	SN74147N	2.35	SN74284N	6.00
		SN74148N	2.00	SN74285N	6.00

MANY OTHERS AVAILABLE ON REQUEST
20% Discount for 100 Combined 7400's

CMOS

CD4000	25			74C04N	75
CD4001	25			74C10N	65
CD4002	25	CD4035	1.85	74C20N	65
CD4006	2.50	CD4040	2.45	74C30N	65
CD4007	25	CD4042	1.90	74C42N	2.15
CD4009	59	CD4044	1.50	74C73N	1.50
CD4010	59	CD4046	2.51	74C74	1.15
CD4011	25	CD4047	2.75	74C90N	3.00
CD4012	25	CD4049	79	74C95N	2.00
CD4013	47	CD4050	79	74C107N	1.25
CD4016	56	CD4051	2.95	74C151	2.90
CD4017	1.35	CD4053	2.95	74C154	3.00
CD4019	55	CD4060	3.25	74C157	2.15
CD4020	1.49	CD4066	1.75	74C160	3.25
CD4022	1.25	CD4069	45	74C161	3.25
CD4023	25	CD4071	45	74C163	3.00
CD4024	1.50	CD4072*	45	74C164	3.25
CD4025	25	CD4081	45	74C173	2.60
CD4027	69	CD4511	2.56	74C193	2.75
CD4028	1.65	CD4518	2.50	74C195	2.75
CD4029	2.90	74C00N	39	MC4044*	4.50
CD4030	65	74C02N	55	MC14016*	56

LINEAR

LM300H	80			LM1351N	1.65
LM301H	35			LM1414N	1.75
LM301CN	35	LM377N	4.00	LM1458C	65
LM302H	75	LM380N	1.39	LM1496N	95
LM304H	1.00	LM380CN	1.05	LM1556V	1.85
LM305H	95	LM381N	1.79	LM2111N	1.95
LM307CN	35	LM382N	1.79	LM2901N	2.95
LM308H	1.00	NE501K	8.00	LM3065N	69
LM308CN	1.00	NE510A	6.00	LM3900N	55
LM309H	1.10	NE531H	3.00	LM3905N	60
LM309K	1.25	NE536T	6.00	LM3909*	1.25
LM310CN	1.15	NE540L	6.00	LM5556N	1.85
LM311H	90	NE550N	79	MC5558V	1.00
LM311N	90	NE553	2.50	LM7525N	90
LM318CN	1.50	NE555V*	45	LM7535N	1.25
LM319N	1.30	NE560B*	5.00	80388*	4.95
LM319D	9.00	NE561B*	5.00	LM75450	49
LM320K-5	1.35	NE562B*	5.00	75451CN	39
LM320K-5.2	1.35	NE565H*	99	75452CN	39
LM320K-12	1.35	NE565N*	1.25	75453CN	39
LM320K-15	1.35	NE566CN*	1.95	75454CN	39
LM320T-5*	1.75	NE567H*	1.25	75491CN	79
LM320T-8*	1.75	NE567V*	1.50	75492CN	89
LM320T-12*	1.75	LM703CN	45	75494CN	89
LM320T-18*	1.75	LM709H	29	**RCA LINEAR**	
LM323K-5*	9.95	LM709N	29	CA3013	1.70
LM324N	1.80	LM710N	79	CA3023	2.15
LM339N	1.70	LM711N	39	CA3035	2.25
LM340K-5	1.95	LM723N	55	CA3039	1.35
LM340K-12	1.95	LM723H	55	CA3046	1.15
LM340K-15	1.95	LM733N	1.00	CA3059	2.46
LM340K-24	1.95	LM739N	1.29	CA3060	2.80
LM340T-5	1.75	LM741CH	35	CA3080	85
LM340T-6	1.75	LM741CN	35	CA3081	1.75
LM340T-8*	1.75	LM741-14N	39	CA3082	2.06
LM340T-18*	1.75	LM747H	79	CA3083	1.60
LM340T-12	1.75	LM747N	79	CA3086	59
LM340T-15	1.75	LM748H	39	CA3089	3.25
LM340T-24	1.75	LM748N	39	CA3091	8.25
LM350N	1.00	LM1303N	90	CA3123	1.85
LM351CN	65	LM1304N	1.19	CA3130*	1.49
LM370N	1.15	LM1305N	1.40	CA3600	1.75
LM370H	1.15	LM1307N	85	RC4194	5.95
LM373N	3.25	LM1310N	2.95	RC4195	3.25

KITS EXAR ICS

XR-2206KA SPECIAL $17.95
Includes monolithic function generator IC, PC board, and assembly instruction manual.

XR-2206KB SPECIAL $27.95
Same as XR 2206KA above and includes external components for PC board.

TIMERS		**STEREO DECODERS**	
XR-555CP	$.69	XR-1310P	$3.20
XR-320P	1.55	XR-1310EP	3.20
XR-556CP	1.85	XR1800P	3.20
XR-2556CP	3.20		
XR-2240CP	3.25	**WAVEFORM GENERATORS**	
		XR-205	8.40
PHASE LOCKED LOOPS		XR-2206CP	4.49
		XR-2207CP	3.85
XR-210	5.20	**MISCELLANEOUS**	
XR-215	6.60	XR-2211CP	6.70
XR-567CP	1.95	XR-2261	3.79
XR-2567CP	2.99	XR4136	2.00

DATA HANDBOOKS

7400	Pin-out & Description of 5400/7400 ICS	**$2.95**
CMOS	Pin-out & Description of 4000 Series ICS	**$2.95**
LINEAR	Pin-out & Functional Description	**$2.95**

ALL THREE HANDBOOKS $6.95

CONSUMER ELECTRONICS

exelar

DIGITAL WATCH
This watch is manufactured by National Semiconductor. It provides 5 functions: hours, minutes, seconds, date, A.M. indicator dot. Accuracy is assured to 5 seconds per month by precision quartz crystal. If something should go wrong with the watch, repair is assured within 48 hours after it is received. Complete with steel black leather band.

ES4-YS
3 MICRON GOLD PLATE BEZEL
$29.95
NOT A KIT

Novus

DIGITAL ALARM CLOCK
This 4 digit Novus Alarm Clock is a very reliable and smartly styled unit. It provides such features as an alarm settable to any minute of the day, a 7 minutes snooze alarm, a power failure indicator, and even an A.M., P.M. indicator.

NOT A KIT **$19.95**

OPTO ELECTRONICS

XCITON
LITRONIX
MONSANTO

DISCRETE LEDS

R - RED
G - GREEN
Y - YELLOW
O - ORANGE

125" dia.

XC209R	5/$1
XC209G	4/$1
XC209Y	4/$1
XC209O	4/$1

.185" dia.

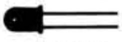
XC526R	5/$1
XC526G	4/$1
XC526Y	4/$1
XC526O	4/$1

.190" dia.

XC111R	5/$1
XC111G	4/$1
XC111Y	4/$1
XC111O	4/$1

.200" dia.

XC22R	5/$1
XC22G	4/$1
XC22Y	4/$1
XC22O	4/$1



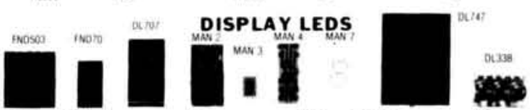
.200" dia.

XC556R	5/$1
XC556G	4/$1
XC556Y	4/$1
XC556O	4/$1

.085" dia.

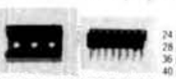
MV50
.085" dia. Micro red led
6/$1

DISPLAY LEDS



TYPE	POLARITY	HT		TYPE	POLARITY	HT	
MAN 1	COMMON ANODE	270	$3.25	MAN 74	COMMON CATHODE	300	$1.50
MAN 2	5 x 7 DOT MATRIX	300	4.95	DL707	COMMON ANODE	300	$1.50
MAN 3	COMMON CATHODE	125	39	DL747	COMMON ANODE *	600	2.25
MAN 4	COMMON CATHODE	187	1.95	DL750	COMMON CATHODE	600	2.49
MAN 7	COMMON ANODE	300	1.50	DL338	COMMON CATHODE	110	1.25
MAN 7G	COMMON ANODE-GREEN	300	2.50	FND70	COMMON CATHODE	250	50
MAN 7Y	COMMON ANODE-YELLOW	300	2.50	FND503	COMMON CATHODE	500	1.75
MAN 72	COMMON ANODE	300	1.50	FND507	COMMON ANODE	500	1.75

IC SOLDERTAIL — LOW PROFILE (TIN) SOCKETS



	1-24	25-49	50-100		1-24	25-49	50-100
8 pin	$.17	16	15	24 pin	$.38	37	36
14 pin	20	19	18	28 pin	45	44	43
16 pin	22	21	20	36 pin	60	59	58
18 pin	29	28	27	40 pin	63	62	61
22 pin	37	36	35				

SOLDERTAIL STANDARD (TIN)

14 pin	$.27	25	24	28 pin	$.99	90	81
16 pin	30	27	25	36 pin	1.39	1.26	1.15
18 pin	35	32	30	40 pin	1.59	1.45	1.30
24 pin	49	45	42				

SOLDERTAIL STANDARD (GOLD)

8 pin	$.30	27	24	24 pin	$.70	63	57
14 pin	35	32	29	28 pin	1.10	1.00	90
16 pin	38	35	32	36 pin	1.75	1.40	1.26
				40 pin	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

10 pin	$.45	41	37	24 pin	$1.05	95	85
14 pin	39	38	37	28 pin	1.40	1.25	1.10
16 pin	43	42	41	36 pin	1.59	1.45	1.30
18 pin	75	68	62	40 pin	1.75	1.55	1.40

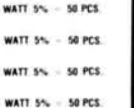
50 PCS. RESISTOR ASSORTMENTS $1.75 PER ASST.

ASST. 1	**5 ea.**	10 OHM 27 OHM	12 OHM 33 OHM	15 OHM 39 OHM	18 OHM 47 OHM	22 OHM 56 OHM	**1/4 WATT 5% - 50 PCS**
ASST. 2	**5 ea.**	68 OHM 180 OHM	82 OHM 220 OHM	100 OHM 270 OHM	120 OHM 330 OHM	150 OHM 390 OHM	**1/4 WATT 5% - 50 PCS**
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**
ASST. 4	**5 ea.**	3.3K 8.2K	3.9K 10K	4.7K 12K	5.6K 15K	6.8K 18K	**1/4 WATT 5% - 50 PCS**
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**
ASST. 7	**5 ea.**	1M 2.7M	1.2M 3.3M	1.5M 3.9M	1.8M 4.7M	2.2M 5.6M	**1/4 WATT 5% - 50 PCS**

ALL OTHER RESISTORS FROM 2.2 OHMS - 5.6M AVAILABLE IN MULTIPLES OF 5 ea.
5-25 PCS .05 ea. 30-95 PCS .04 ea. 100-495 PCS .03 ea. 500-995 .027 ea.

14 PCS. POTENTIOMETER ASSORTMENTS

ASST. A 2 ea. 10 OHM-20 OHM-50 OHM-100 OHM-200 OHM-250 OHM-500 OHM
ASST. B 2 ea. 1K, 2K, 2.5K, 10K, 20K, 25K, 50K
ASST. C 2 ea. 50K, 100K, 200K, 250K, 500K, 1M, 2M



$9.95 Per Asst.

Each assortment contains 14 pcs of 10 turn pots. All pots are available in single unit quantities. **$.99 ea.**

Astrisk Denotes Items On Special For This Month
Satisfaction Guaranteed. $5.00 Min. Order. U.S. Funds.
California Residents — Add 6% Sales Tax — Data Sheets 25c each
Send a 13c Stamp (postage) for a FREE 1976 Catalog

JAMES

1021 HOWARD ST., SAN CARLOS, CA. 94070
PHONE ORDERS — (415) 592-8097

74LS00 TTL

74LS00	39	74LS55	.39	74LS151	1.55
74LS02	39	74LS73	65	74LS153	1.89
74LS03	39	74LS74	65	74LS157	1.55
74LS04	45	74LS75	79	74LS162	2.25
74LS05	45	74LS76	65	74LS163	2.25
74LS08	39	74LS83	2.19	74LS164	2.25
74LS10	39	74LS86	65	74LS181	3.69
74LS13	79	74LS90	1.25	74LS190	2.85
74LS14	2.19	74LS92	1.25	74LS191	2.85
74LS20	39	74LS93	1.25	74LS192	2.85
74LS26	49	74LS95	2.19	74LS193	2.85
74LS27	45	74LS96	1.89	74LS194	2.25
74LS28	49	74LS107	65	74LS195	2.25
74LS30	39	74LS112	65	74LS257	1.89
74LS32	45	74LS132	1.55	74LS260	55
74LS40	49	74LS136	65	74LS279	79
74LS51	39	74LS138	1.89	74LS670	5.95

DL728

The DL728 is a dual 0.5" common cathode red display. It is ideal for use with clock chips, as segments are already multiplexed. **$2.95**

MINATURE TOGGLE

DPDT				JMT	1	2-9	10-29	30-99
	ON	OFF	ON	221	3.05	2.65	1.97	1.76
	ON	NONE	ON	223	2.85	2.25	1.68	1.51
	ON	OFF	ON	121	2.35	1.95	1.43	1.30
	ON	NONE	ON	123	2.05	1.65	1.21	1.10

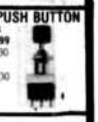
PUSH BUTTON

SPDT - SERIES PB, PB1

	Model Number	1 Each	2-9	10-29	30-99
Maintained Action Switch Push To Make Contact And Push Again To Reverse Action	PB-123	$2.35	$1.95	$1.47	$1.30
Momentary Action Switch Normally Open or Normally Closed (For N.C. circuit use terminals 2 & 1, for N.O. 2 & 3, for N.C. and N.O. 1 2 & 3)	PB-126	$2.35	$1.95	$1.47	$1.30

Quanity net prices

5 AMP RATINGS



THUMBWHEEL SWITCHES

THUMBWHEEL SWITCH ONLY
SF - Front Mount SR - Rear Mount

Part No.	Description	Price
SF-17	Single Pole 10 Position	$2.50
SR-17	Decimal	3.00
SF-21	10 Position BCD only	2.50
SR-21	" "	3.00

Ordering: Order desired switch or switches and add necessary accessories for your particular application.

SERIES SF Front Mount Assembly

ACCESSORIES

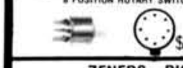
Part No.	Description	Price
SF-EP	End Plate (Pair)	$.50
SF-DP	Divider Plate (each)	.40
SF-BB	Blank Body (each)	.40
SF-HB	Half Body (each)	.40

SERIES SR Rear Mount Assembly

ACCESSORIES

Part No.	Description	Price
SR-EP	End Plates (pair)	$.50
SR-DP	Divider Plate (each)	.40
SR-BB	Blank Body (each)	.40
SR-HB	Half Body (each)	.40

8 POSITION ROTARY SWITCH



$.79

These switches are a 7 position, one position open, rotary switch enclosed in a TO-5 can. They have a standard 8 pin configuration and will mount perfectly on printed circuit board.

ZENERS—DIODES—RECTIFIERS

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
IN746	3.3	400m	4/1.00	1N4005*	600 PIV	1 AMP	10/1.00
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
1N965B	15	400m	4/1.00	1N4154	35	10m	12/1.00
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
IN485A	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	IN1186	200 PIV	35 AMP	1.80
1N4003	200 PIV	1 AMP	12/1.00	1N1188	400 PIV	35 AMP	3.00
1N4004	400 PIV	1 AMP	12/1.00				

TRANSISTORS

MPS-A05	5/$1.00			PN4249	4/$1.00
MPS-A06	5/$1.00	PN3567	3/$1.00	PN4250	4/$1.00
2N2219A	3/$1.00	PN3568	4/$1.00	2N4400	4/$1.00
2N2221	4/$1.00	PN3569	4/$1.00	2N4401	4/$1.00
2N2222A	5/$1.00	2N3704	5/$1.00	2N4402	4/$1.00
2N2369	5/$1.00	2N3705	5/$1.00	2N4403	4/$1.00
2N2369A	4/$1.00	2N3706	5/$1.00	2N4409	5/$1.00
PN2415	5/$1.00	2N3707	5/$1.00	2N5086	4/$1.00
2N2484	4/$1.00	2N3711	5/$1.00	2N5087	4/$1.00
2N2906A	4/$1.00	2N3724	$.65	2N5088	4/$1.00
2N2907A	5/$1.00	2N3725	$1.00	2N5089	4/$1.00
2N2925	5/$1.00	2N3903	5/$1.00	2N5129	5/$1.00
2N3053	2/$1.00	2N3904	4/$1.00	2N5138	5/$1.00
2N3055	$.88	2N3905	4/$1.00	2N5139	5/$1.00
MJE3055	$1.00	2N3906	4/$1.00	2N5209	5/$1.00
MJE2955	$1.25	2N4013	3/$1.00	2N5951	5/$1.00
2N3392	5/$1.00	2N4014	3/$1.00	C106B1SCR	2/$1.00
2N3398	5/$1.00			2N5432	$2.00

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-49	50-100		1-9	10-49	50-100
	05	04	03	001μF	04	035	
	05	04	03	0047μF	05	04	035
	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

MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS

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	15	13	10	1.0 16V	15	13	10
4.7 25V	16	14	12	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
2200 16V	70	62	55	470 25V	31	28	26

TRANSFORMER RIOT

American made, 115V Primarys:
6.3 V, 1 Amp, Shielded $1.75 Ea. ppd.
12V — 250 mils — for P.C. Board. Size: 1½" x 1⅛" x 1⅛", 3.5 OZ. $1.40 ea. ppd.
12 volt ½ amp. $1.68 ppd.
12V 1.2 Amp $2.57 ppd.
12V, 3 Amp $4.15 ppd.

NEW NEW NEW

Dual Secondarys; 18-0-18V @ 1.2 Amp and 7-0-7V @ 400 MA, 1 lb. 5 oz., Shielded. 2⅝" x 2" x 2¼" (3¼" MTG) — $3.85 ppd.
22-0-22V — 1 Amp, 6.3V. Tap ¼ Amp — 2" x 2¼" x 2⅜" (MTG 2⅜") Leads from top of shield, 1 lb. 4 oz. $3.20 ppd.
24-0-24 @ 1 amp with tap at 6.3 volt for pilot light. $3.15 ea. ppd.

TRANSISTOR OUTPUT TRANSFORMER — One watt rating 200 ohm Centertapped primary, 8 ohm secondary 85¢ Each ppd.

NEW Transistor and Relay Assembly — consists of (2) MJE3055 and (2) MJE2955 transistors (10 amp, 90w, 60v complementary pairs) mounted in "U" channel heat sink 2½" x 1⅛" x 1½". (2) XTAL CAN RELAYS, DPDT, 28v, 8000Ω, 5.8 ma DC, 1 amp contacts mounted on PC board with resistors. $2.85 ea. ppd.

NEW SIZES — VERTICAL MOUNT PC BOARD POTENTIOMETERS
American made (CRL) Cermet sizes: 25K, 100K ohms. 5/$1.30 ppd.
CTS Blue wheel. Values: 750, 1K, 1.5K, 50K, 300K ohms. 5/$1.20 ppd.

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Price: 5 for $1.20 ppd.

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3000 MFD @ 30 Volt Capacitors.
Size 1" Diameter x 3" Long. 90¢ Each or 3 For $2.25 ppd.

3000 MFD @ 20V Capacitors. Same size as above. 80¢ ea. or 3 for $2.00 ppd.

ALSO 3000 MFD @ 50V
95¢ ea. or 3/$2.65 ppd

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MOTOROLA RAILROAD MOTRACS. R43HHT-1139CA with manual. $100. VE2BFT, 460 Greenock Ave., Montreal, P. Q., H3P 2H2. 514-733-8841.

YAESU OWNERS — To learn the advantages and method of applying RF clipping to any rig, send a dollar (creditable towards dues) for May 1976 Newsletter of International Fox-Tango Club, 248 Lake Dora Dr., W. Palm Beach, FL 33411.

PC's, Send large S.A.S.E. for list. Semtronics, Rt. #3, Box 1, Bellaire, Ohio 43906.

DC-DC CONVERTER power supply, brand new manufacturers surplus, complete with cables. Input: 12 VDC @ 32 A; outputs: 800 VDC @ 0.253 A, 300 VDC @ 0.155 A, —100 VDC @ 0.060 A, 12 VDC @ 5 A. Ideal for 200 watt PEP SSB transceivers. $50 plus shipping. W2EKB, 348 Bortons Mill Road, Cherry Hill, N. J. 08034.

T.V. — SERIOUS EXPERIMENTERS — R.C.A. military image orthicon system, camera, sync unit, power supply, 7" monitor, 600 lines resolution. Info, Peter S. Gerry, 34 Newcomb Dr., New Providence, N. J. 07974.

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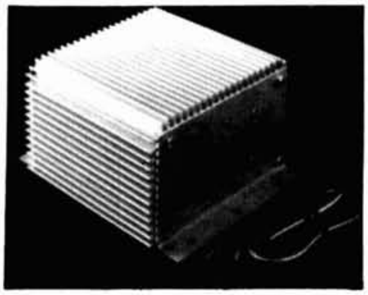

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DEI TDU-2 30mHz video display	55
GR546C Audio microvolter	65
GR821A Twin-T imp bridge to 40mHz	165
GR1302A Audio Osc .01-100kHz	75
HP160B(USM105) 15mHz scope with norm horiz, dual trace vert plugs	375
HP166B(Mil) Delay sweep for above	130
HP185A Scope-sampling-to 1 gHz 186B Xstr rise-time vert. plug-in	335
HP205AG Audio Gen. .02-20kHz, input and output meters	195
HP212A Pulse Gen .06-5kHz PRR	65
HP430CR Microwave Pwr Mtr	40
HP540B Transfer Osc. to 12.4gHz	115
HP571B-561B Digital clock/rcdr	245
HP608D(TS510) Std sig gen 10-420mHz calib. attn.	395
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HP1750A Vert. amp. for HP175 50mHz	125
PRD 907 Sweep Gen 40-900mHz	95
SINGER SSB4 Sideband spec anal 0-40mHz, res. to 10Hz	685
TEK 181 Time mark scope calib.	45
TEK 565 Dual beam 10mHz scope less plug-ins	525
TS 497B Mil vers Meas 80 Sig gen	215
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Coming Events

ELECTRONIC FLEA MARKET, Old Westbury, L. I., NY, Sunday, June 6, 1976 (Rain date June 20) 9 a.m. to 4 p.m. Admission: $1.00 per buyer, $2 per space seller at N. Y. Institute of Technology, Rte. 25A and Whitney Lane. Sponsored by Long Island Mobile Amateur Radio Club (LIMARC). No advance notice necessary . . . just come. Talk-in 25/85. Additional info from W2KPQ — (516) 938-5661.

SAN JOSE BICENTENNIAL AWARD. The Santa Clara County Amateur Radio Association (SCCARA) is issuing a San Jose Bicentennial Award to all amateurs who request it and qualify for it by working a number of San Jose, Santa Clara County and Pacific Division stations for a total of 200 points. For full details send SASE to Club Secretary, SCCARA, P. O. Box 6, San Jose, CA 95103.

FIRST ANNUAL ELMIRA HAMFEST, Sept. 25 For details write WA2SMM, 320 W. Ave., Elmira, N. Y. 14904. Dealer inquiries invited.

1976 INDIANAPOLIS HAMFEST, Sunday, July 11, Marion County Fairgrounds, Send SASE for full details to Indianapolis Hamfest, P. O. Box 1002, Indianapolis, IN 46206.

MIDWEST HAMFEST, June 20, 1976, at Lake Hills Senior Citizens Picnic Grove, 8100 Austin Rd., Schereville, IN. 8 a.m. to 5 p.m. Food, drinks, door prizes, talk-in WR9ADK, 146.31-.91, or .52 or .94. Tickets $2.00 at gate, or $1.50 in advance. Send SASE to I.D.A.R.C., P. O. Box 5, Dyer, IN. 46311.

HAM HOLLER'IN AWARD: for contacting NC4NHC. Date - 19 June 76, 9 a.m. to 9 p.m. E.S.T. Frequencies: 14280-7280-3980. NC4NHC will be operating from the National Holler'in Contest grounds located at Spivey's Corner, N. C. The theme is "Communication - The Old and The New." The award is sponsored by the Cape Fear Amateur Radio Society, Methodist College, Box M-618, Fayetteville, N. C. 28301. The certificate will be issued to stations who make contact with NC4NHC and send $1.00 (postage and handling fee) to the society prior to 1 Sept. 1976.

VISITING YELLOWSTONE THIS YEAR? Drop in to the Wyoming-Idaho-Montana-Utah Hamfest. WIMU will be held on August 6-7-8 at Mack's Inn, Idaho, 20 miles west of West Yellowstone. Facilities available, ranging from cabins to modern motels. Forest service campgrounds adjoining. Activities begin Friday afternoon, and continue until noon Sunday. Registration is $6.00 per person at the hamfest, or $5.00 per person for pre-registration before July 24. For more info or to register write: WIMU Hamfest, c/o Larry Jacobs, WA7ZBO, 5655 So. 4060 West, Salt Lake City, Utah 84118.

FOURTEENTH ANNUAL ILLINOIS QSO PARTY Sponsored by the Radio Amateur Megacycle Society (RAMS). 1800Z July 31, 1976 to 2300Z August 1, 1976 with a rest period from 0500 to 1200Z August 1. All bands, CW and phone. Same station may be worked with each mode on each band. No repeater contacts allowed. SASE for rules to: RAMS-K9CJU, 3620 N. Oleander Ave., Chicago, Illinois 60634.

FLEA MARKET. June 6, 1976 at Nick's Grove, 318 William St., Piscataway, N. J. Opens at 10 a.m. Admission $1. Tables $4; half tables $2. Door prizes. Talk-in: 146.52, 147.855/147.255. For further information call 201-725-0778 or 201-752-4307 or write to TCRA, P. O. Box 412, Scotch Plains, N. J. 07076.

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SPECIFICATIONS —
MODEL CC7:

A. Recording Mode: Tape saturation binary. This is not an FSK or Home type recorder. No voice capability. No modem. Runs at 2400 baud or less Asynchronous and 4800 baud Synchronous. (Simple external Synchronizer diagram furnished.) Runs at 3.1"/sec. Speed mechanically regulated ±.5%.

B. Two channels (1) Clock, (2) Data. Or two data channels providing four (4) tracks on the cassette. Can also be used for NRZ, Bi-Phase, etc.

C. Inputs: Two (2). Will accept TTY, TTL or RS 232 digital.

D. Outputs: Two (2). Board changeable from TTY, RS232 or TTL digital.

E. Erase: Erases while recording one track at a time. Record new data on one track and preserve three or record on two and preserve two.

F. Compatability: Will interface any computer using a UART or ACIA board. (Altair, Sphere, M6800 etc.)

G. Other Data: 110/220 V, 50/60 Hz; 2 Watts total; UL listed #955D; three wire line cord; on/off switch; audio, meter and light operation monitors. Remote control of motor optional. Four foot, seven conductor remoting cable provided.

H. Warrantee: 90 days. All units tested at 110 and 4800 baud before shipment. Test cassette with 8080 software program included. This cassette was recorded and played back during quality control.

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11C05DC	1 GHZ Counter Divide By 4	$74.35
11C05DM	1 GHZ Counter Divide By 4	$110.50
11C06DC	UHF Prescaler 750 MHz D Type Flip/Flop	$12.30
11C24DC	Dual TTL VCM	$2.60
11C44DC	Phase Freq. Detector	$2.60
11C58DC	ECL VCM	$4.53
11C70DC	600 MHz Flip/Flop With Reset	$12.30
11C83DC	1 GHZ 248/256 Prescaler	$29.90
11C90DC	650 MHz ECL/TTL Prescaler	$16.00
11C90DM	650 MHz ECL/TTL Prescaler	$24.60
11C91DC	650 MHz ECL/TTL Prescaler	$16.00
11C91DM	650 MHz ECL/TTL Prescaler	$24.60
95H90DC	250 MHz Prescaler	$9.50
95H90DM	250 MHz Prescaler	$16.55
95H91DC	250 MHz Prescaler	$9.50
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RCA 40290 12.5v, Ft. Typ. 500MHz 2 watts min. at p. in 0.5 watts $2.48

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2N3375	$7.00	2N6081	$8.60
2N3866	$1.08	2N6082	$11.25
2N4072	$1.50	2N6083	$12.95
2N4427	$1.20	2N6084	$13.75
2N5179	$.68	2N6166	$85.00
2N5589	$4.60	MRF511	$8.60
2N5590	$6.30	MMCM918	$2.50
2N5591	$10.35	MMT2857	$2.50
2N5637	$20.70		

TUBES

IP21	$19.95	6146B/8298A	$5.50
2E26	$4.00	6360	$5.50
4X150C	$18.00	6661	$1.00
4X150A	$15.00	6680	$1.00
4CX250B	$24.00	6681	$1.00
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572B/T160L	$22.00	8072	$32.00
811A	$7.95	8106	$1.95
813	$19.00	8156	$3.95
931A	$9.95	8950	$5.50
4652/8042	$6.95	6LQ6	$3.95
5894	$32.00	7289/2C39A	10/$12.50
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flea market

QSO PARTY. Amateurs the world over are invited to take part in the 17th Annual New Jersey QSO Party sponsored by the Englewood Amateur Radio Association. Saturday, August 21 and Sunday, August 22. Send SASE to Englewood Amateur Radio Association, Inc., 303 Tenafly Road, Englewood, NJ 07631 for rules.

MISSOURI: Antique Aircraft and Amateur Radio Show, July 24 and 25, 1976. Slater Memorial Airport. Registration $1.00 in advance: $1.50 at the door. Buffalo burger feed Saturday night and Sunday noon. Talk-in 3963 kHz, 146.94 and 146.28/.88. Information, advance tickets, Dale Beilsmith, W0KNF, 807 North Broadway, Slater, Missouri 65349, (816) 529-2173.

RADIO EXPO '76, September 18, 19, near Chicago. Exhibits, seminars, giant flea market open Friday night. Campers welcome. Advance ticket $1.50. Box 1014, Arlington Heights, Ill. 60006.

SHANGRI-LA '76 — ARRL Hudson Division Convention, November 13-14. Great Gorge Resort Hotel, McAfee, New Jersey. Full program, flea market, exhibits, banquet. A vacation for the family and a hamfest for the ham. For information write to Al Piddington, WA2FAK, 4 Acorn Drive, East Northport, N. Y. 11733.

DES MOINES HAWKEYE HAMFEST, 4th Annual will be held on Sunday, June 13th, 1976 in the Varied Industries Building at the Iowa State Fair Grounds, Des Moines, IA. Plenty of free parking. Flea market, display booths available. Dealer displays, XYL activities, $2.50 at the door. 8:00 a.m. to 4:30 p.m. Write Des Moines Radio Amateur Association, Box 88, Des Moines, IA 50301.

MEMPHIS IS BEAUTIFUL IN OCTOBER! The Memphis, bigger and better than the 3,500 who attended last year, will be held at State Technical Institute, Interstate 40 at Macon Road, on Saturday and Sunday, October 2 and 3. Demonstrations, displays, MARS meetings, flea market, ladies' flea market, too! Hospitality room, informal dinners, XYL entertainment, many outstanding prizes. Dealers and distributors welcome, too! Contact Harry Simpson, W4SCF, Box 27015, Memphis, TN 38127, phone 901 358-5707.

Stolen Equipment

DRAKE ML2 #11512. BNC connector on rear for T/T pad, inside connected to green coax. White miniature coax coming out hole connected to dev. xtals for 10 channels. Frank WA1MJI.

KENWOOD TS520. Serial 140579 engraved WA7WDC, and ICOM 230 Serial 2405651 also engraved WA7WDC. In addition about $7000.00 worth of tools and test equipment. If anyone has any information please notify the Phoenix city police.

ATLAS 210X, ser. #TH3214 xcvr with Lafayette mobile mike modified with 3-conductor ¼" dia. plug. Does not have dc power cord or ac supply. Also Lafayette, ser. #1111, HA-146 2-mtr xcvr with mike and dc power cord. If any info call collect (213) 374-8528, Les Goddard, WB6URL.

GENAVE GTX-200, serial 13-79. (W2MPT). Engraved back of set. Call collect CID Agent, W. L. Yarnall, Ft. Mon., N. J., area 201-532-1181 or your local FBI. I. J. Gordon, W2MPT, 25 Norma Ave., Lincroft, N. J. 07738. 201-741-6182.

DRAKE TR22, S/N 640995 from car located 2121 East 63rd Street, Kansas City, Mo. between 8 a.m. and 11 a.m. CST on Thursday, April 8, 1976. Is marked on chassis SS# and call. Anyone with information contact the Kansas City, Mo. police department (816-842-6525) or K0IDJ.

FROM CAR PARKED AT RAMADA INN, 1900 Fort Myer Drive, Arlington, Virginia, night of March 31, 1976. Serial number 04-02604 with nicad battery pack attached, S/N 7157; with microphone. Rig had modifications for Topeka pre-amp and extra 6-channel crystal deck. Many identifying marks. If you have any information please contact: A. D. Abercrombie, W2GJS. 1002 Merrymount N., Turnersville, N. J. 08012. (609) 227-1383.

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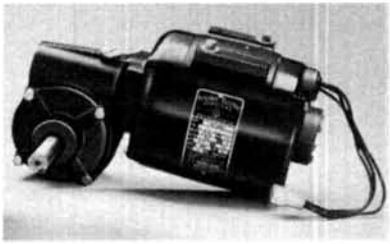

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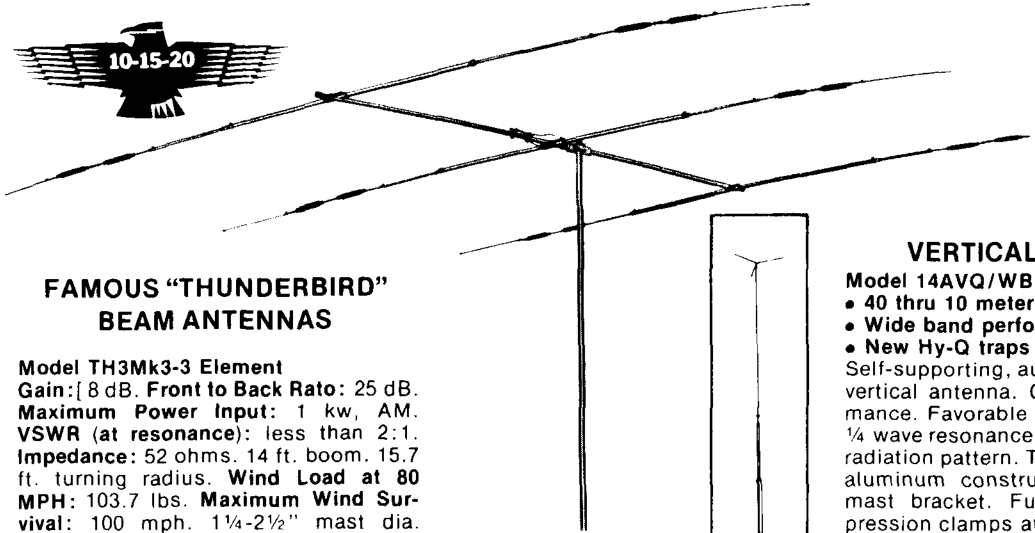
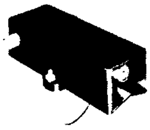


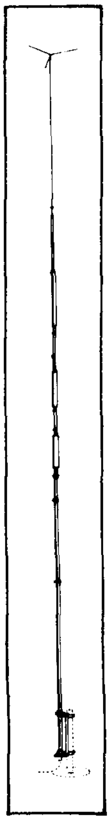
FAMOUS "THUNDERBIRD" BEAM ANTENNAS

Model TH3Mk3-3 Element
Gain:[8 dB. **Front to Back Rato**: 25 dB. **Maximum Power Input**: 1 kw, AM. **VSWR** (**at resonance**): less than 2:1. **Impedance**: 52 ohms. 14 ft. boom. 15.7 ft. turning radius. **Wind Load at 80 MPH**: 103.7 lbs. **Maximum Wind Survival**: 100 mph. 1¼-2½" mast dia. **Weight**: 39.9 lbs.
Model TH3Mk3

Model TH3JR-3 Element
For top performance in cramped spaces. 12 ft. boom. 14.3 turning radius. **Gain**: 8 dB. **Front to Back Ratio**: 25 dB. **Maximum Power Input**: 300 w AM; 600 w PEP. **VSWR** (**at resonance**): less than 2:1. **Impedance**: 52 ohms. **Wind Load at 80 MPH**: 87 lbs. **Weight**: **20.2 lbs.**
Model TH3JR



Ferrite Balun BN-86
3-30 Mhz continuous.
VSWR: 1:1. 1 kw DC.
Size: 3¼ x 6¼".
Weight: 1.3 lbs.
Model BN-86 . . $15.95



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Model 14AVQ/WB
- **40 thru 10 meters**
- **Wide band performance**
- **New Hy-Q traps**

Self-supporting, automatic band switching vertical antenna. Omni-directional performance. Favorable L/C ratio. High Q. True ¼ wave resonance on all bands. Low angle radiation pattern. Taper swagged seamless aluminum construction. 12" double-grip mast bracket. Full circumference compression clamps at tubing joints. Weight: 8.2 lbs.
Model 14AVQ/WB

Model 18AVT/WB
- **Automatic band switching**
- **Completely Self-Supporting**
- **Omni-Directional Performance**

Three beefed-up Hy-Q traps permit automatic switching. 5 band capability. Favorable L/C ratio. Top loading coil. Across the band performance with one furnished setting for each band (10 thru 40). True ¼ wave resonance on all bands. SWR of 2:1 or less at band edges. Low angle radiation pattern. Extra heavy duty tapered swaged seamless aluminum tubing with full circurmference, corrosion resistant compression clamps at tubing joints. Antenna can be mounted without guide wires. 25' high. Weight: 10.7 lbs.
Model 18 AVT/WB

CDR ANTENNA ROTORS
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50 assorted 14 and 16 pin IC packages containing precision resistors and capacitors-no data available **$1.98**

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Buy 5 pacs for $9.90 and pic-a-pac for 10¢

The above are special offerings from Babylon Electronics, and will be shipped third class. See bottom of ad for ordering instructions.

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PCB vertical mount tantalum capacitors- shown actual size.

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4.7 µfd 16V

10 µfd 25V

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STATIC SHIFT REGISTERS			
MM504	dual 16	bit	$1.50
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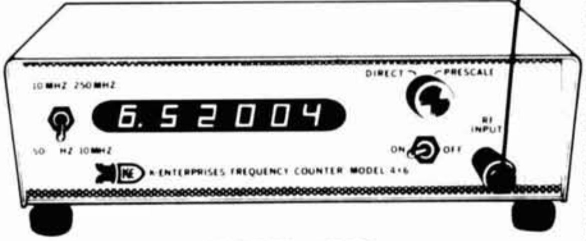

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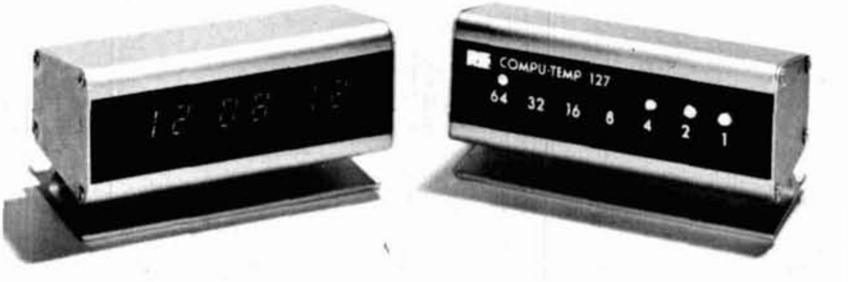

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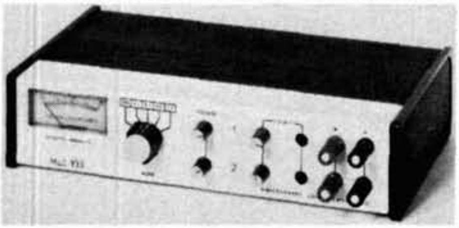

Whether in the lab or workshop the Mcc103 beats the rest with the following features:

- Two independent 0-25 volt, 250 MA regulated power supplies in one enclosure.
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- LED type current limit indicators.
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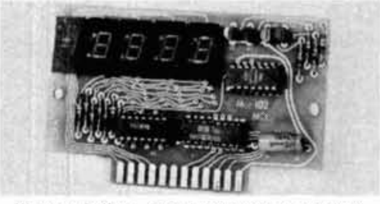
- Assembled only $99.95.

If you need a larger supply, up to 2 amps, then build your own using the Mcc101 regulator board. Just $19.50.

Mcc102 DIGITAL COUNTER BOARD



Want to build a digital voltmeter or counter? Then use the Mcc102 Digital Event Counter Board and save time and money. The board consists of a four digit counter and latch IC driving .30 inch LED displays. The counter will typically count to 3 MHz and the counter board will operate from a single 5 volt supply. Assembled board is $35.00. Postage and handling not included in prices.

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All cabinets are completely assembled and supplied with four rubber feet riveted in. Individually packed in a heavy-duty, corrugated mailer carton.

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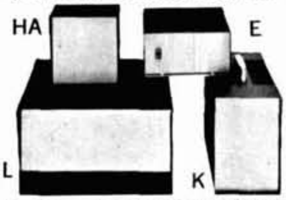

MODEL	WIDTH-HEIGHT-DEPTH	RESALE NET
A	5-⅝ x 2-½ x 3	4.25
AA*	4 x 3-7/16 x 3-⅛	5.50
B	5-11/16 x 3-⅜ x 3-¾	5.55
BB*	9 x 2-½ x 3-⅛	5.90
C	7-¼ x 3-⅜ x 5	7.80
D	8 x 2-½ x 8**	9.85
E	6-½ x 3-15/32 x 7-1/16	9.25
F	7-½ x 4-½ x 10	11.15
G	10-1/16 x 3-5/16 x 9	11.15
HA	5-⅛ x 5-½ x 4	7.85
D1	Mtg. bracket set for D	.40
J	5 x 3-½ x 5-¾	8.35
K	4-¾ x 7-⅜ x 11	15.00
L	11-⅛ x 6-⅛ x 12-¾	22.95
M	11-⅛ x 6-⅛ x 16-¾	24.40
NA	12-⅛ x 5-⅞ x 12-1/16	23.80

*.050 aluminum cover & chassis w/grained panel
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"L"

package enclosure "Shadow Box" machined with: 2-SO239, 1-Pilot Light, 3 Rocker Switches, and 2-Knobs

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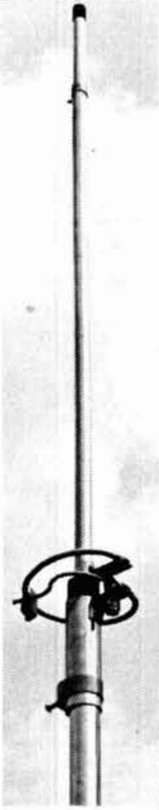
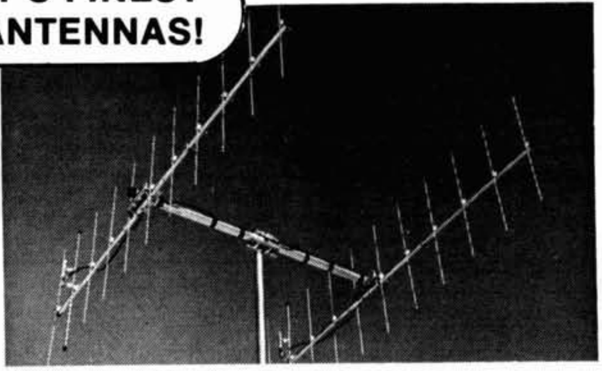


AM-FM RINGO

There are more Ringos in use than all other FM antennas combined. 3.75 dB gain. Low angle of radiation with 1-1 SWR. Easy to install.

MODEL NO.	FREQUENCY MHz	POWER HDLG. WATTS	WIND AREA SQ. FEET
AR-2	135-175	100	.21'
AR-25	135-175	500	.21'
AR-6	50-54	100	.37'
AR-220	220-225	100	.20'
AR-450	440-460	250	.10'



4, 6 or 11 ELEMENT YAGIS

Cut for FM and vertical polarization. 1000 watts.

Model Number	A147-11	A-147-4	A449-11	A449-6	A220-11
Gain/F/B Radio dB	13.2/28	9/20	13.2/28	11/25	13.2/28
1/2 Power Beam	48°	66°	48°	60°	48°
Wind Area Sq. Ft.	1.21	.43	.39	.30	.50
Frequency MHz	146-148	146-148	440-450	440-450	220-225

D-POWER PACK

Dual A-147-11 Yagis, with horizontal mounting boom, coax harness and all hardware. 16 dB gain, 24 dB FIB ratio, 146-148 MHz, 1000 watts.

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SPECIFICATIONS

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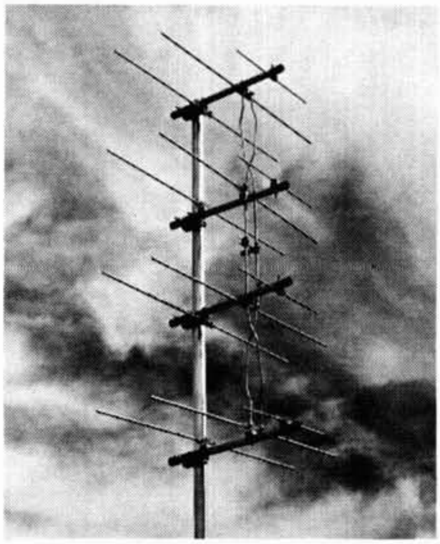
Forward Gain	14.2 dB	17 dB	20 dB
F/B Ratio	20 dB	20 dB	20 dB
VSNR at Frequency	1-1	1-1	1-1
Power Handling	2 KW PEP	2 KW PEP	2 KW PEP
FWD Lobe @ 1/2 PWR. PT.			
Horizontal	48°	32°	32°
Vertical	26°	26°	12°



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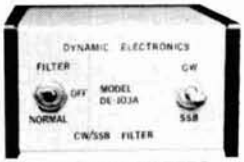

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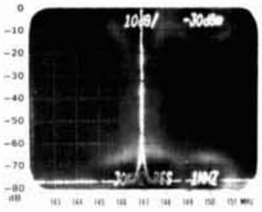

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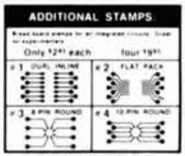

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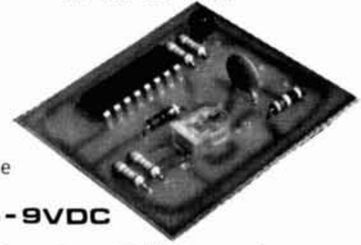

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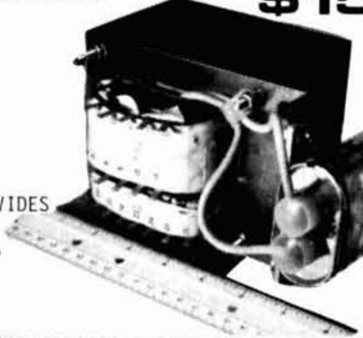

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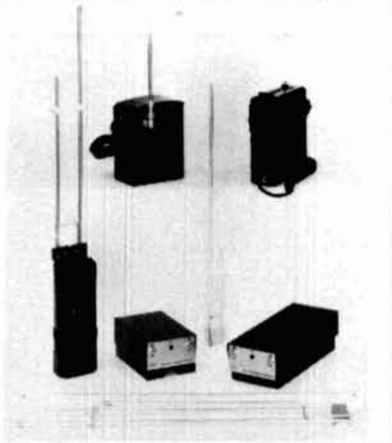

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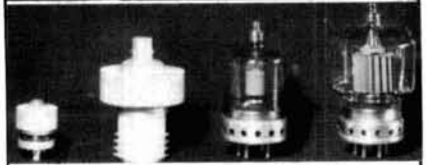

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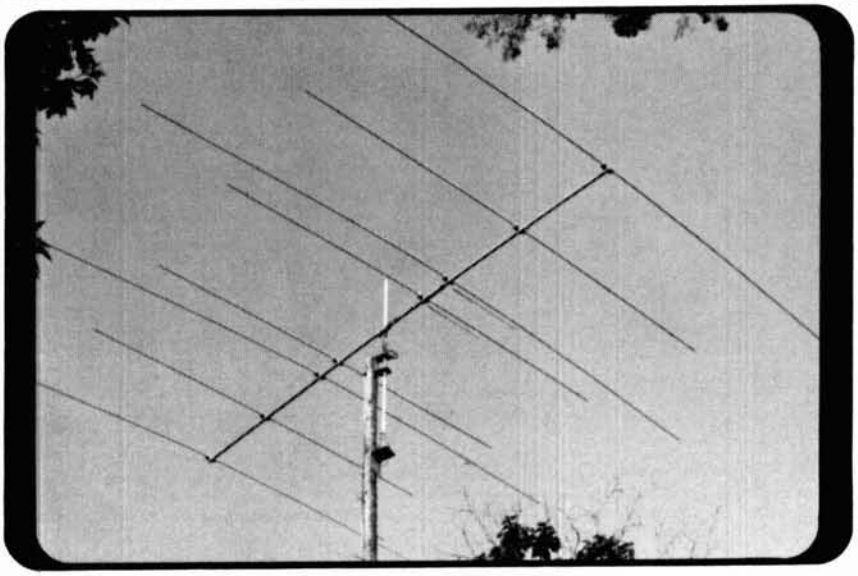

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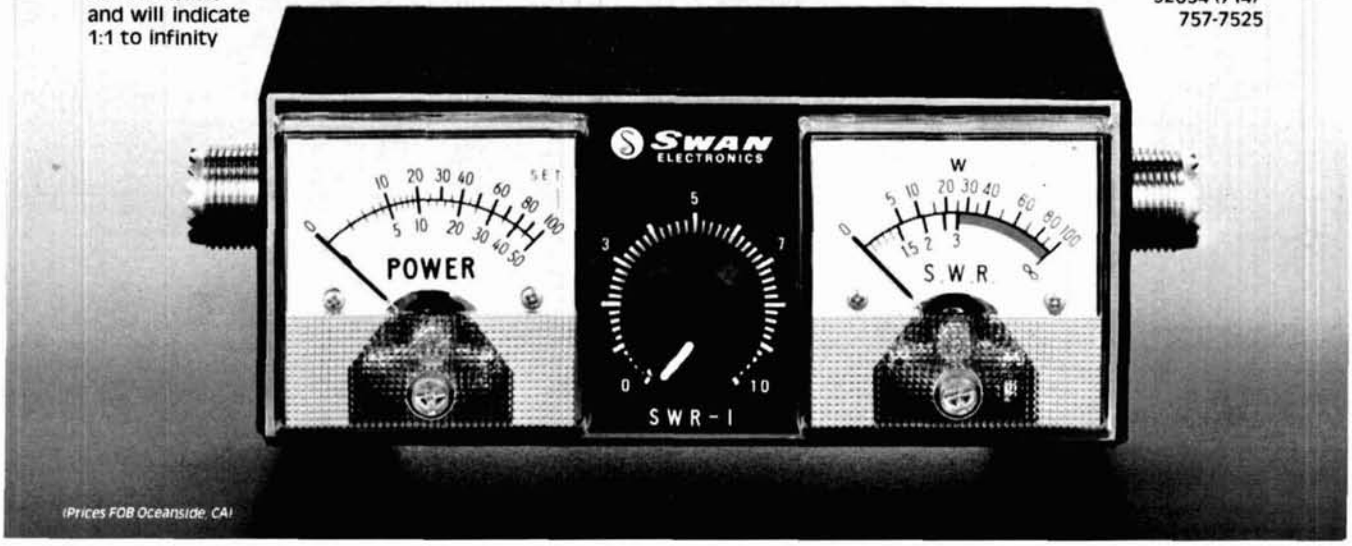

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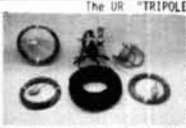

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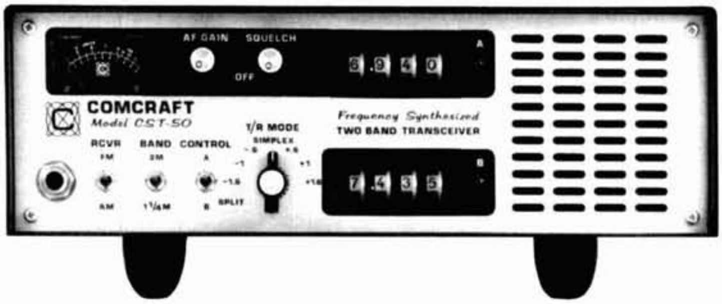

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- TWO BANDS, 2 METERS AND 1¼ METERS
- DIGITAL FREQUENCY SYNTHESIS
- WORKS ANY REPEATER SPLIT
- EXTENDED FREQUENCY COVERAGE

FEATURES: Covers entire 2 meter and 1¼ meter bands ☐ Covers MARS, CAP and CD frequencies from 142 to 149.995 MHz ☐ Full digital frequency synthesis with 5 kHz steps ☐ No crystals to buy—ever ☐ Built-in repeater offsets of 600 kHz, 1 MHz and 1.6 MHz both plus and minus ☐ 25 watts output on each band ☐ No transmitter retuning across either band ☐ FM-AM receiver ☐ 8 pole crystal filter ☐ Front mounted speaker ☐ PTT microphone and mobile mount included ☐ Operates on 12 volts DC ☐ Front mounted speaker for better sound ☐ Accessory connector for tone burst and tone coded squelch ☐ Lighted thumbwheel switches —a Comcraft exclusive

SPECIFICATIONS

GENERAL

Frequency Coverage—
2 M; 142.00 MHz to 149.995 MHz
1¼ M; 220.00 MHz to 225.00 MHz

Frequency Resolution— 5 kHz

Frequency Stability— 0.0005%

Power Input— 11 VDC to 15 VDC

Dimensions— 10.5"W x 3.375"H x 10"D

Warranty— 90 days, parts and labor

RECEIVER

Sensitivity—
FM; 0.4 μv for 20 dB quieting
AM; 4 dB noise figure, nominal

Squelch Threshold— 0.3 μv

Bandwidth— 13 kHz

Image Rejection— 60 DB minimum

Adjacent Channel Rejection— 80 dB (30 kHz)

Audio Output Power— 2 watts

TRANSMITTER

Power Output—
2 M; 144 to 148 MHz; 28 watts typical
1¼ M; 220 to 225 MHz; 28 watts typical (25 watts guaranteed over both amateur bands)

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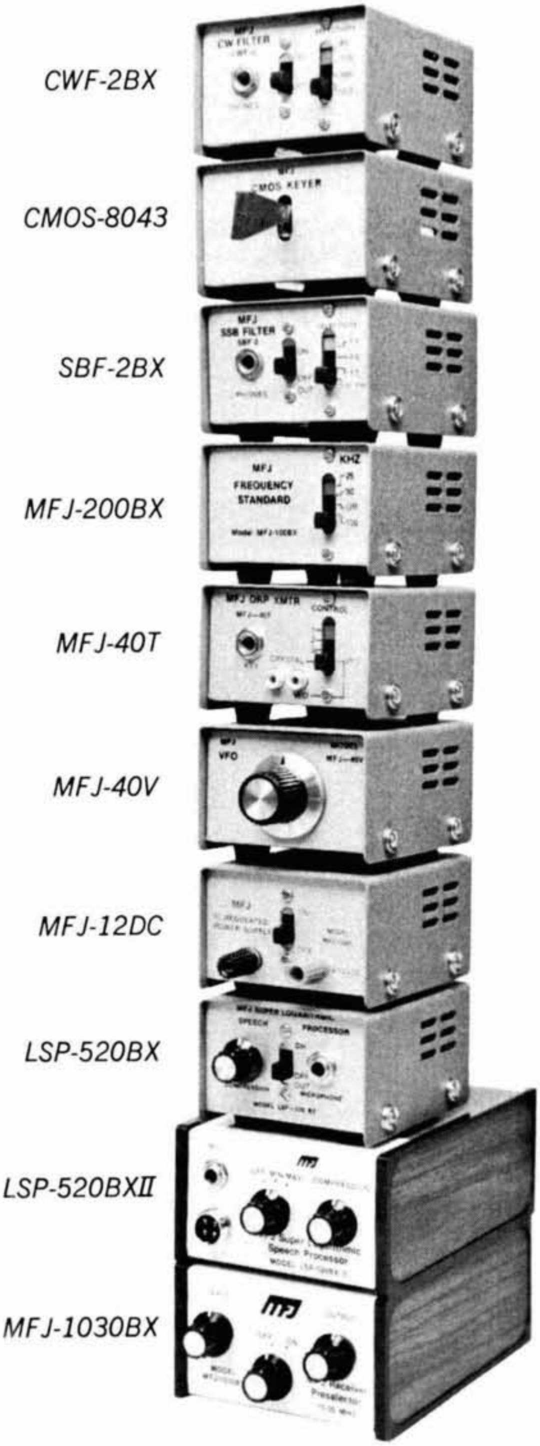

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SIZES: Units Above are 4 x 3¼ x 3 3/16; Units Below 5 9/16 x 3⅝ x 2⅛.

SUPER LOGARITHMIC SPEECH PROCESSOR — This option includes all the features of the unit above plus a rotary function switch, an uncommitted 4 pin mic jack and an extra special enclosure. Uses 9 V Transistor battery.
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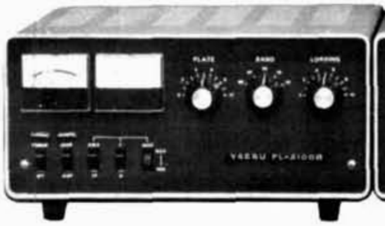

FL-2100B
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FV-101B
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SP-101PB
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FTV-250
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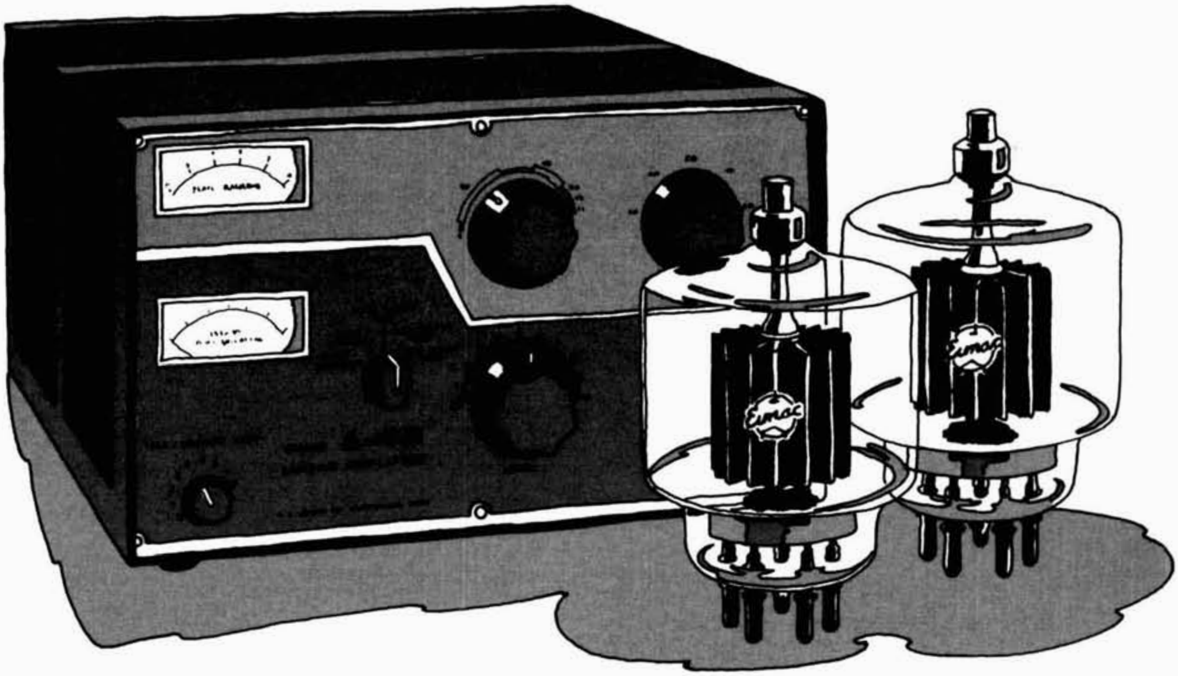

EIMAC 3-500Z triodes.

The good guys at Drake are proud to tell you about their L-4B linear amplifier. They won't hide the fact that precision design insures continuous operation at one kilowatt power input on CW, AM and RTTY; and two kilowatts PEP on SSB. You won't have to ask twice about the L-4B's features like the transmitting AGC circuit to control exciter gain, the standby switch or the built-in RF directional wattmeter.

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To find out more about the reason Drake's first choice is EIMAC, or to ask about our design flexibility to meet individual applications, drop us a line or call. We have no secrets.

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