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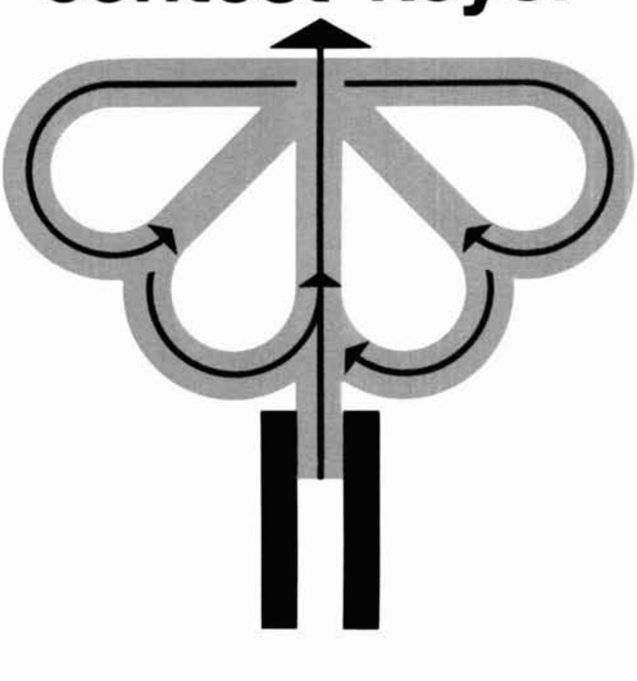
ham radio magazine

APRIL 1976

programmable contest keyer



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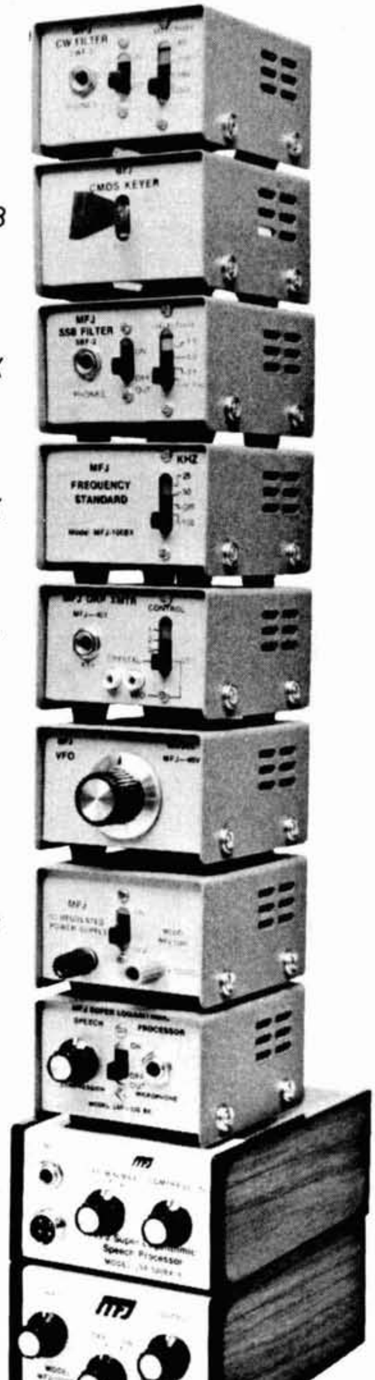

CWF-2BX

CMOS-8043

SBF-2BX

MFJ-200BX

MFJ-40T

MFJ-40V

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LSP-520BX

LSP-520BX11

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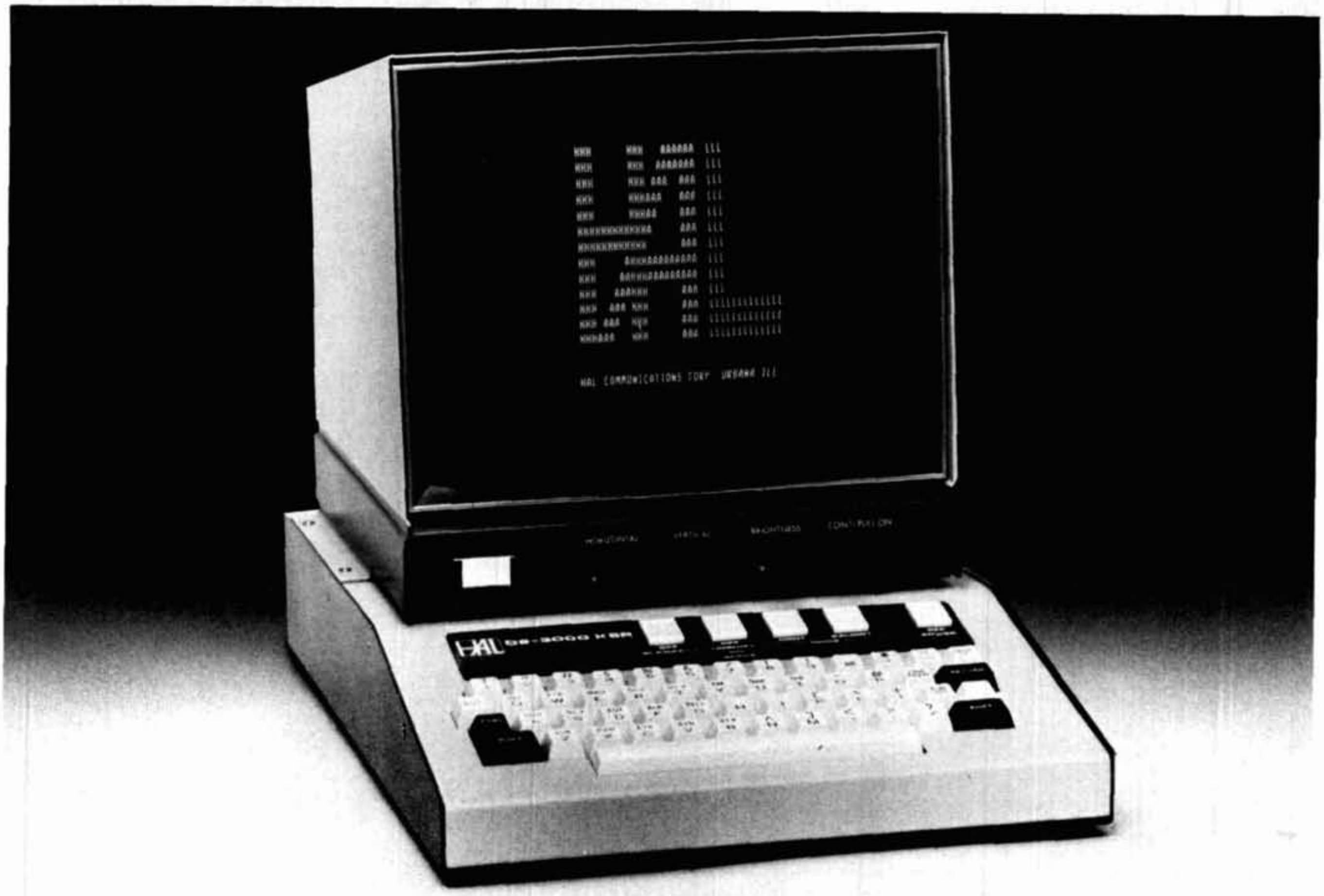

The HAL ST-6000 demodulator /keyer and the DS-3000 and DS-4000 KSR/RO series of communications terminals are designed to give you superlative TTY performance today —and in the future. DS series terminals, for example, are re-programmable, assuring you freedom from obsolescence. Sophisticated systems 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.

HAL

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contents

a second look

by Jim Fisk

Now that 16-kilobit random-access memories are starting to appear on the market, it shouldn't be too long before we see some of these devices in amateur products. Its predecessor, the popular 4k RAM, evolved rather slowly because manufacturers were forced to switch from p-channel to n-channel designs to reduce cell size. Since 16k RAMs use the same basic technology, prices can be expected to race down the curve at a much faster pace -- some manufacturers are predicting the price will drop to less than $10 by early next year. Others see a much slower pace, with the magic $10 price at least three years away. All agree, however, that once it's in production, the 16k RAM will dominate the solid-state memory market well into the early 1980's.

One of the reasons the 16k memory will be with us for awhile (as opposed to the relatively short-lived 1k, 2k and 4k devices) is because the next level of RAM integration, 65,536 bits, is probably beyond the reach of the n-channel MOS process. In the 16k RAM each bit is squeezed into a site about one-thousandth of an inch square ($0.025 mm^2$) – about half the area required in 4k designs – by placing the cell's switching transistor and storage capacitor on top of one another instead of side by side as in the 4k layout. However, most researchers are convinced that the switched-capacitor or single-transistor cell used in present RAMs won't be good enough for 65k devices – it will probably peter out well short of 0.3 to 0.5 mil^2 ($0.0005 inch^2$ or $0.013 mm^2$) cell sizes needed for the 65-kilobit chips. The innovations in technology and circuit design that will be needed to reach the 65k level, such as bit sharing, charge coupling, or multi-level memory planes, will resist quick translation into production devices.

Of the several options which show promise for 65-kilobit cell integration, attention is presently being focused on the charge-coupled device (CCD) technique that Texas Instruments has used to build an experimental RAM cell. Known among insiders as the no-transistor RAM the device stores bits in switchable CCD capacitors implanted under the MOS gate. One reason the CCD approach is so attractive is that it lends itself to the same silicon-gate process used in 4k RAMs. The CCD memory cell, which meets the necessary size requirements for 65k integration, can switch as fast as a conventional MOS transistor so no speed is lost. More significantly, the CCD RAM requires only two access lines per cell: one for storage and a sense line for reading. This further reduces chip size (all of today's RAMs need three lines per cell). The question that remains is whether the CCD memory cell can be manufactured in large chips with high yields – if it can't, designers will have to come up with other designs or further develop semiconductor technology.

Although the new 16k random-access memories received a good deal of attention at this year's Solid State Circuits Conference in Philadelphia, a number of other new developments were described which will have great impact on future electronic circuitry. Among the new circuits are Fairchild's new I^2L RAM which puts 4096 bits of bipolar memory on a single chip, a 16-bit minicomputer controller on a single chip from Toshiba, Intel's n-channel static RAM which breaks the 100-ns speed barrier, and a 4k static RAM from American Micro Devices which operates from 5 volts (a first at that density level). Also described was a continuously-charge-coupled random-access memory (C^3RAM) from Siemens in Germany that shows promise for 65k integration. It all adds up to another exciting year for digital electronics.

Jim Fisk, W1DTY
editor-in-chief

the little surprise

The **IC-22A** has caused some pretty big surprises since it first started making waves in VHF-FM. Veteran operators have been delightfully surprised by its sophisticated styling and ease of operation; FM beginners, by its versatility, large number of possible channels, and its great value as a starter unit for FM transceiving; and all owners, by its unexcelled high quality construction and low maintenance problem record, ICOM traditions. The competition was in for a big surprise as it raced past everything in its field to become the most popular two meter crystal controlled radio on the market. Surprise. Surprise.

But the **IC-22A**'s best surprise is the little surprise, its price. surprise. The little radio with all the big surprises is also the best FM transceiver value available. Engineered for versatility and sophistication: priced within the reach of the most modest beginner. Whether the **IC-22A** is your first FM or your last, you're in for a little surprise.

SEMICONDUCTORS	
TRANSISTORS	22
FET	4
IC	3
DIODES	16
FREQUENCY RANGE	146-148MHz
CHANNELS	22
MODULATION	Phase, F3
VOLTAGE	13.8 (15%)
SIZE	58x156x2305 (dim in MM)
WEIGHT	1.7 kilos

POWER OUTPUT	HI 10 Watts, LO 1 Watt
BANDWIDTH (TRANSMITTED)	15KHz with 5KHz deviation
MICROPHONE	DYNAMIC 500 Ohms.
SENSITIVITY	.4 microvolts for 20DB quieting .3 microvolts for 12DB SINAD
INTERMEDIATE FREQUENCIES	10.7MHz First I.F. 455KHz Second I.F.
MODULATION ACCEPTANCE	7KHz peak dev. freq. less than 3KHz
RECEIVER BANDWIDTH	+/− 13KHz more than −6DB +/− 23KHz more than −60DB
AUDIO POWER	1 Watt into 8 Ohms

VHF/UHF AMATEUR AND MARINE COMMUNICATION EQUIPMENT

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presstop

EXCELLENT AMATEUR RADIO PR has resulted from Amateur Operators' extensive on-going contribution in Guatemala. For example, WB2JSM at the Hall of Science Radio Club in Flushing, N.Y. got coverage in both the New York Daily News and New York Times plus CBS TV nationwide exposure for what ended up as a 'round the clock message handling operation. The Red Cross put out an extremely laudatory press release on the Amateur's role in the disaster, and those Amateurs who called their local papers and broadcast stations found very receptive ears.

LONG AWAITED RACES DOCKET has finally received FCC approval and in effect gives the Radio Amateur Civil Emergency Service to Radio Amateurs. In their Report and Order on Docket 19723 the Commissioners discontinued the requirement for RACES communications plans, FCC certifications and authorizations. It also permits RACES station Licenses to be issued directly to civil defense organizations, and provides for the shared use of all the Amateur frequencies by RACES on a first-come, first-served basis except during emergencies requiring invocation of the President's War Emergency Powers.

Control Operators of RACES stations will have to be licensed Amateurs, and operating privileges for RACES operators will be identical to those of the Amateur Service. Use of RACES stations will be limited to bona fide emergencies plus up to one hour per week of drills and tests.

Existing RACES Stations may continue to operate under existing authorizations and the old rules until their present licenses expire. Any presently licensed RACES station whose license expires less than 18 months after the March 23, 1976 effective date of the Report and Order is also permitted to renew the present license for one additional year.

10 METER REPEATERS will now be permitted according to an Order just released by the FCC. Inputs and outputs for in-band ten-meter machines must lie between 29.5 and 29.7 MHz, and cross banding to ten meters will be tricky since the rule change specifically prohibits repeating the transmissions of an Amateur not authorized to operate on the 28-MHz band.

AMATEUR EXTRA CLASS licensees who wish to have the Extra Class certificate should make a written request to the FCC Field Office at which they took the examination. Requests must include a photocopy of the Extra Class license — any requests that go to Washington or Gettysburg will be returned without action.

OSCAR ARTICLE by K3RXK in February Popular Mechanics is a beautifully presented, outstanding presentation of the Amateur space program. Highly recommended reading.

Too Much Power May be being used by as many as 95% of OSCAR users responding to the AMSAT Newsletter poll. Based on equipment and antennas reported, most users should cut back to avoid exceeding the design ERP levels.

OSCAR Users Should start checking 29510 during stateside passes for current news. That frequency has been suggested as an "AMSAT traffic" frequency, primarily for control stations, but general users would profit by learning of schedule changes and other operating modifications as they occur.

Regular "QRP Nights" on the two OSCARs have been suggested by K1HTV — Rich has worked 13 countries while running 1 watt input and recently QSOed W2BXA with only 0.1W ERP! He'd like user suggestions as to how an on-going low power program could be set up for satellite users — write his Callbook address.

OSCAR 8 Projected Launch period is now starting to shape up, will probably occur sometime in the winter of 1977-1978.

IDENTIFYING YOUR GEAR now increasingly important. For starters, make your markings deep enough that they cannot be easily polished away and place them on the outside where they can be seen without tearing the radio apart. Then use:

1. Your Callsign: not much help to police, but best mark of all at a hamfest — particularly one at which you and your loss are known; plus,
2. The rig serial number: too many radios have easily removed serial plates or tags; plus,
3. Your drivers license number with state as "(NH)ABC-XXX-1234" — this gives police anywhere a path back to you for your recovered gear; plus (optional),
4. Your telephone number with area code — another good way for police tracing, but some don't like it because the thief might also be able to follow it; or,
5. Your name and address — easy to follow by police but just as easily by the thief.

Selling Or Buying — equipment so marked should not be a problem provided both buyer and seller get and keep copies of a descriptive bill of sale. Buyers should also insist that the seller verify his identity, since you're the one stuck if the rig is hot and you can't get back to him.

TWO MAJOR DX CONVENTIONS have settled on September meeting dates — DXPO 76 is set for September 25 in Reston, Virginia, and W9-DXCC will be September 11 in Chicago.

either way is the right way

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the TR-7200A

Kenwood's superb 2-meter FM mobile transceiver. Designed to withstand the most severe punishment while providing consistently excellent performance.

Packed with features like the PRIORITY function . . . Put your favorite crystals in channel 7, and the 7200A automatically returns to that frequency when it senses activity there. 146-148 MHz coverage, 22 channels, 6 supplied. Completely solid state. Voltage required: 13.8 VDC. Antenna impedance: 50 ohms. Frequency adjusting trimmers on every crystal. RF output power: 10 watts (or 1 watt at low power). Adjustable frequency deviation (factory set at ±5 kHz). Automatic VSWR protection. Receiver sensitivity less than .5 uV for 27 dB. Selectivity: 12 kHz/ –6 dB and 24 kHz/–70 dB. Size: 7-1/16" W x 2-3/8" H x 9-7/16" D, 5-1/2 lbs.

Complete with dynamic mike, DC power cord, mobile mount, mike hanger, auxiliary connector and external speaker plug. Amateur net . . . $249.00.

The perfect companion to the TR-7200A is the PS-5 AC/DC power supply. Together they provide an efficient and handsome base station. The PS-5 is complete with a digital clock and automatic time control feature built in. Amateur net . . . $79.00.

the TR-2200A

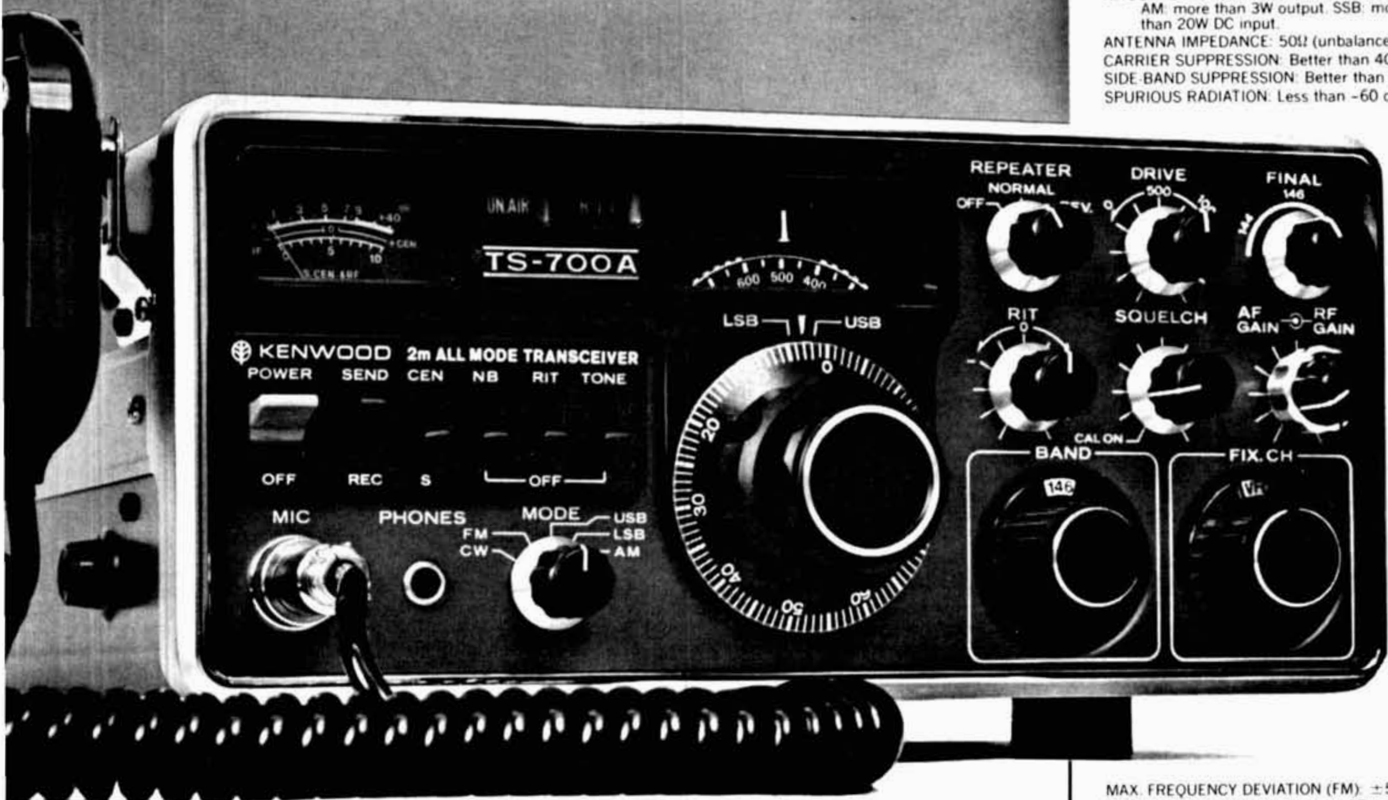
Kenwood's high performance portable 2-meter FM transceiver . . . completely transistorized, rugged and compact.

12 channel capacity. Built in telescoping antenna can be easily replaced, or stored in carrying case. Connector for external antenna also. External 12 VDC or internal ni-cad batteries, complete with 120 VAC battery charger. 146-148 MHz frequency coverage. 12 channels, 6 supplied. Battery saving "light off" position. Hi-Lo power switch (2 watts –400 mW). Sensitivity: 0.5 uV or less/26 dB S+N/N. Built-in speaker. Size: 5-3/8"x 2-5/16"x 7-1/8", 3-3/4 lbs.

Complete with Dynamic mike, O-T-S carrying case, all cables, speaker/headphone plug and 10 Ni-Cad batteries. Amateur net . . . $229.00.

TRIO-KENWOOD COMMUNICATIONS INC.

When you get tired of compromises...



TS-700A Specifications

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
AUDIO OUTPUT: More than 2W at 8Ω load (10% distortion)
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).
POWER REQUIREMENTS: AC 120/220V, 50/60 Hz. DC 12-16V (13.8V as reference).
DIMENSIONS: 278 (W) x 124 (H) x 320 (D) mm
WEIGHT: 11 kg
SUGGESTED PRICE: $700.00

Prices subject to change without notice

KENWOOD'S TS-700A finally fulfills the promise of 2-meters...more channels, more versatility, tunable VFO, SSB-CW and, best of all, the type of quality that has placed the Kenwood name out front.

- Operates all modes: SSB (upper & lower), FM, AM, and CW
- Completely solid state circuitry provides stable, long lasting, trouble-free operation
- AC and DC capability. Can operate from your car, boat, or as a base station through its built-in power supply
- 4 MHz band coverage (144 to 148 MHz) instead of the usual 2
- Automatically switches transmit frequency 600 KHz for repeater operation. Just dial in your receive frequency and the radio does the rest . . . Simplex repeater reverse
- Or do the same thing by plugging a single crystal into one of the 11 crystal positions for your favorite channel
- Outstanding frequency stability provided through the use of FET-VFO
- Zero center discriminator meter
- Transmit/Receive cabability on 44 channels with 11 crystals
- Complete with microphone and built-in speaker
- The TS-700A has been thoroughly field-tested. Thousands of units are in operation throughout Japan and Europe

The TS-700A is available at select Kenwood dealers throughout the U.S. For the name of your nearest dealer, please write.

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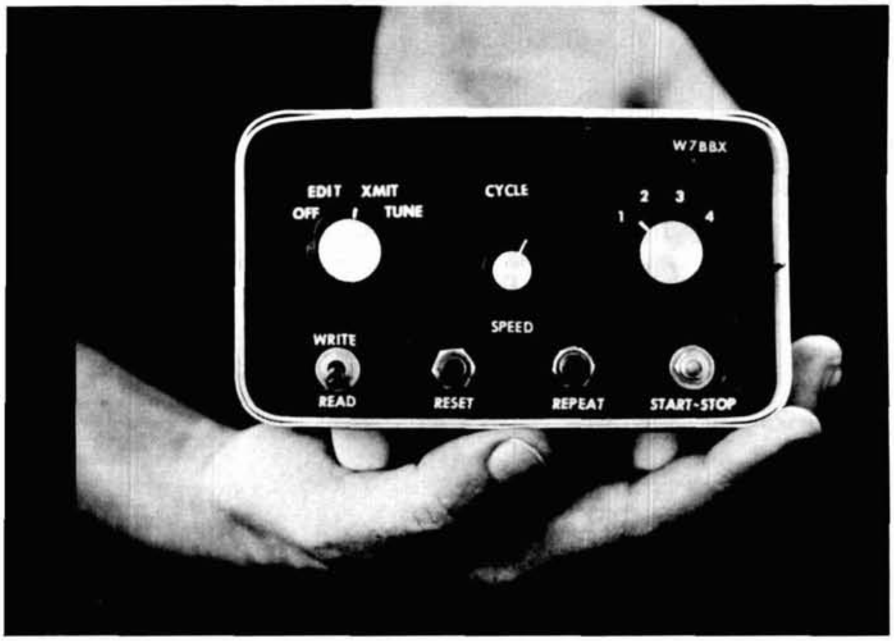


programmable contest keyer

A CW man's keyer featuring high memory capacity, operating convenience, and reasonable cost

A programmable memory keyer is a desirable asset in contest work. It can handle much of the repetitive work while you check dupes, fill out the log, or just take a break. The few programmable keyers on the market all have some desirable features, but they lack the capacity and automatic memory control necessary for smooth, high-speed contest operating. A programmable memory keyer is also needed that the average amateur can afford. The keyer described here has been designed to meet these needs.

Major design objectives included high memory capacity, low cost, and operating simplicity for both program and readout modes; manual, semiautomatic, or fully automatic operation; nonvolatile, nondestructive memory readout; and convenient size. The design is centered around the Intel P2102, a 1024-bit static programmable random access memory (PRAM) in a 16-pin package.* This IC was selected because it requires no refresh circuitry as do dynamic PRAMS, only a single +5 volt power supply is required, all inputs and outputs are fully TTL compatible, and it's readily available at reasonable cost.

description

The keyer (**fig. 1**) is designed so that manual operation with a paddle or bug will always override the mem-

*Intel, 3065 Bowers Avenue, Santa Clara, California 95051.

By **Howard F. Batie, W7BBX**, 12002 Chevoit Drive, Herndon, Virginia 22070

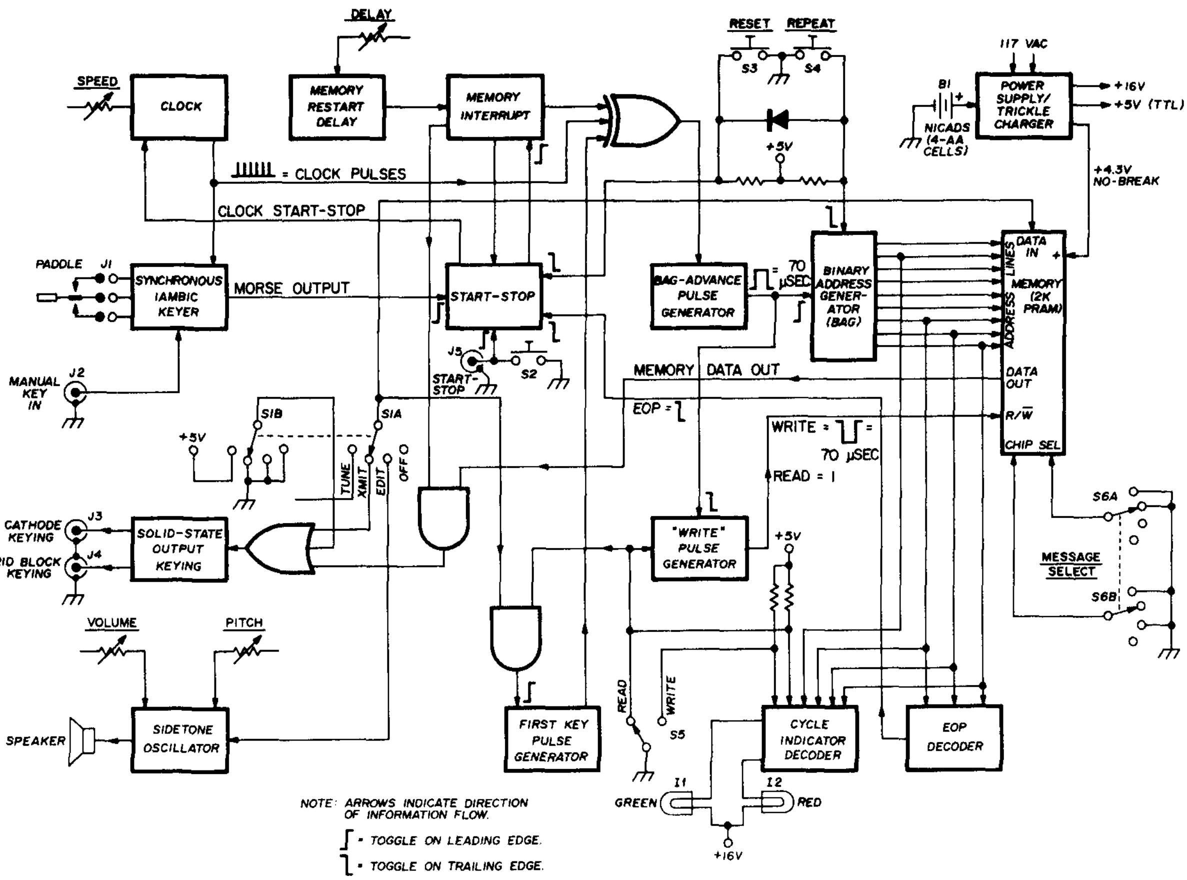


fig. 1. Simplified block diagram of the programmable contest keyer designedby W7BBX. Features include iambic keying, four selectable 512-bit memories, built-in sidetone oscillator, and solid-state transmitter keying.

ory readout. Operation is identical to that of a conventional digital iambic keyer when the memory section isn't used. The popular clock and iambic keyer described by Garrett[1] were modified slightly to interface with the memory. The synchronous clock begins at the instant the paddle is closed and runs for two clock pulses after character generation ceases. The self-completing characters are perfectly formed and spaced throughout the speed range, and character generation is jam-proof. Speed is continuously and smoothly variable from about 8 wpm to well above 60 wpm. The dot memory allows automatic insertion of a dot while holding the dash paddle closed. Similarly, a dash may be inserted while holding the dot paddle closed. Iambic operation allows alternate perfectly spaced dots and dashes to be generated when both paddle arms are simultaneously closed. An external manual key or bug can be used directly instead of the paddle and will control all keyer and memory readout functions.

Solid-state output keying for all inputs (paddle, external manual key and memory readout) is incorporated. The keyed output is directly compatible with most popular cathode-keyed and sidetone/vox actuated and grid-block-keyed transmitters; two output keying jacks, one for positive-keyed voltages up to +150 volts and one for negative-keyed voltages up to −150 volts, are simultaneously available on the rear panel. However, if your transmitter is cathode keyed and 100 mA or more flows through the keyed circuit, an external pass transistor or keying relay may be required. A twin-T audio oscillator and amplifier provide a sinusoidal sidetone waveform that drives an internal 8-ohm permanent-magnet speaker with sufficient audio to perform well in a moderate ambient noise environment. Volume is adjustable, and the pitch is variable from about 400 to 1500 Hz. The internal sidetone oscillator is activated only during the edit mode; that is, for off-the-air programming or checkout of a programmed message. During transmit, or while programming on the air, the transmitter sidetone oscillator would be used in the usual manner. If your transmitter doesn't have an internal sidetone oscillator, a minor wiring modification to the function switch S1A terminals will permit the keyer's internal sidetone oscillator to be used in both edit and transmit modes. A *tune* position is incorporated for tune-up purposes.

memory readout

With S5 in *readout* (**fig. 1**) and the stored message to be transmitted selected by S6, readout is initiated by depressing S2. This starts the clock, and the clock pulses are fed to the binary address generator (BAG), which includes nine tandem flip-flops. As the flip-flops cycle

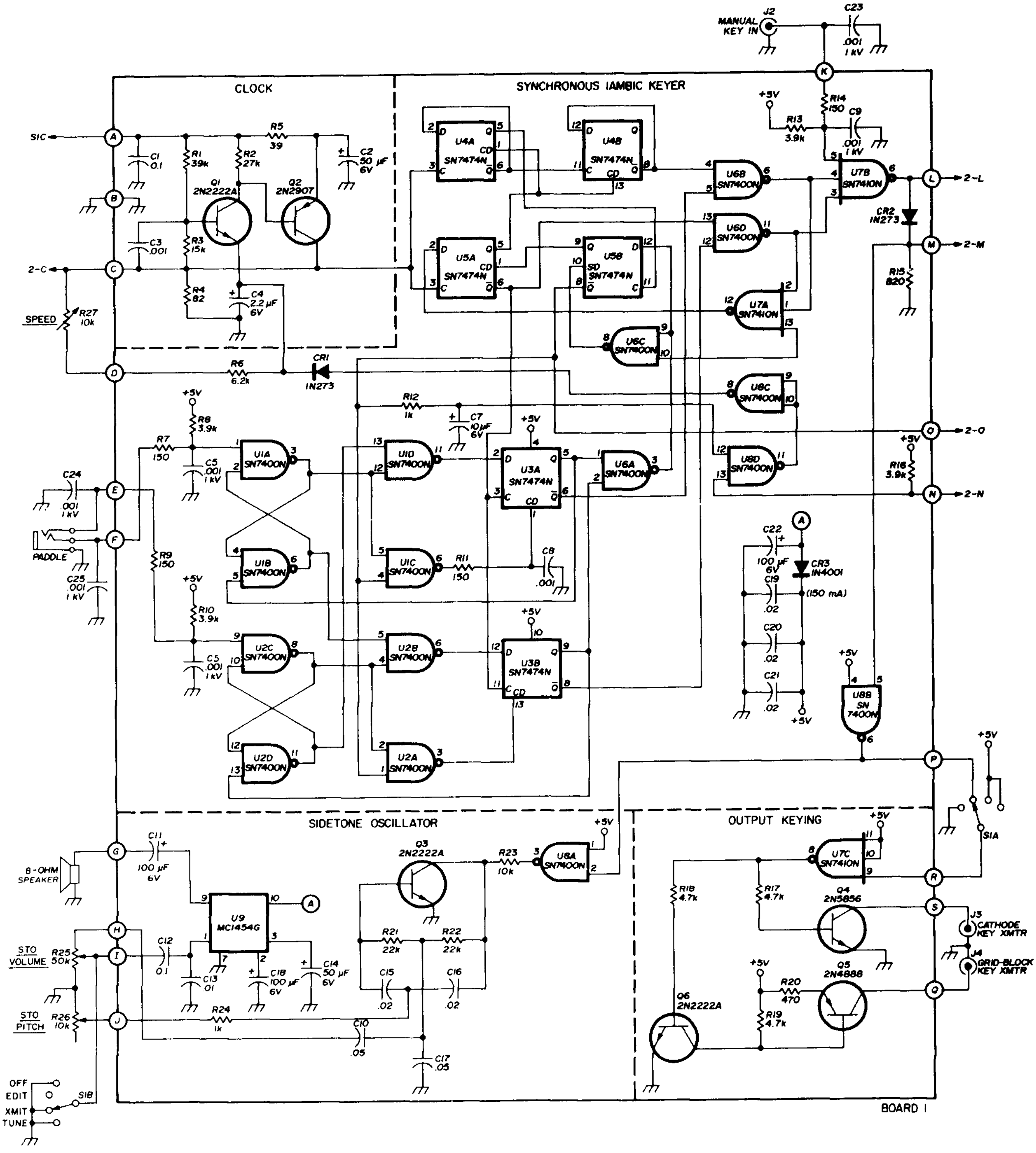


fig. 2. Logic diagram of the keyer board for the programmable contest keyer. Designations 2-C, 2-L, etc., indicate connections to board 2 (fig. 3). S1 is a 3-pole, 4-throw shorting-type rotary switch. All resistors are ¼ watt, 10%.

through 511 successive counts, their BCD output is applied to the nine address lines of the selected memory section, and the addressed information stored in each memory cell is automatically presented to the memory chip data out terminal. If desired, memory readout can be halted in mid message by depressing S2 again before completion of the entire readout sequence. Further memory readout is inhibited until S2 is again depressed;

memory readout will then continue from the point at which it was interrupted (semiautomatic operation). On the 511th clock pulse fed to the binary address generator, the BAG returns to all zeroes on the nine output

erator. Depressing S4 during the first seven-eighths of the message readout sequence resets only the binary address generator to the message beginning, which is then automatically repeated. Thus, if "CQ TEST DE W7BBX/4"

Controls and receptacles on rear panel. Although not labelled, one jack is for grid-block keying; the jack labelled "to xmtr key" is for cathode-keyed transmitters.

lines (end of program readout). The downward transition of the highest significant memory address line is unique and signifies "end of program," or EOP. This EOP transition automatically stops the clock, and all control circuitry is simultaneously reset to begin another readout sequence when S2 is next depressed.

Rear-panel provisions are made for remotely starting the memory readout sequence. A separate spst switch in parallel with S2 at J5 can control both *start* and *stop* functions; for example, a simple foot switch can be used to free your hands for the paddle or logging. Alternatively, any external circuit that provides a negative-going TTL-compatible pulse can trigger *readout*. (One possible application might be synchronization to WWV for moonbounce, meteor scatter, or satellite relay operations.)

When the memory readout cycle is initiated, the green *cycle* indicator (I1) lights continuously until 87.5% of the memory contents have been read out; at which point it begins to flash to indicate "nearing end of program." When the message has been completely read out, the green light extinguishes. Depressing S3 at any point in the message *readout* cycle stops the clock and resets all control functions and the binary address gen-

were programmed into the memory, selective repeats by S4 can modify the transmitted message to, for example, "CQ CQ TEST CQ TEST DE W7BBX/4." The increased memory capacity over that of many presently available keyers allows a message length up to that of "The quick brown fox jumped over the lazy dogs back" to be programmed into each of the four separate memories.

An essential feature of a contest keyer is the ability of the paddle to override the memory readout to insert exchange number and/or signal reports in the middle of a programmed message (fully automatic operation). The memory interrupt feature allows you to manually break into any point of the memory readout cycle merely by activating either the paddle or external manual key during memory readout; memory readout is instantly interrupted and remains interrupted as long as manual keying continues. When manual keying stops, an adjustable 1-second delay is introduced by the memory restart delay before the keyer automatically allows memory readout to continue from the point at which it had been interrupted. Memory restart does not have to be manually commanded. Thus, a programmed contest message of "DE W7BBX/4 NR 599 VA BK" can be sent correctly by manually inserting the contest exchange number be-

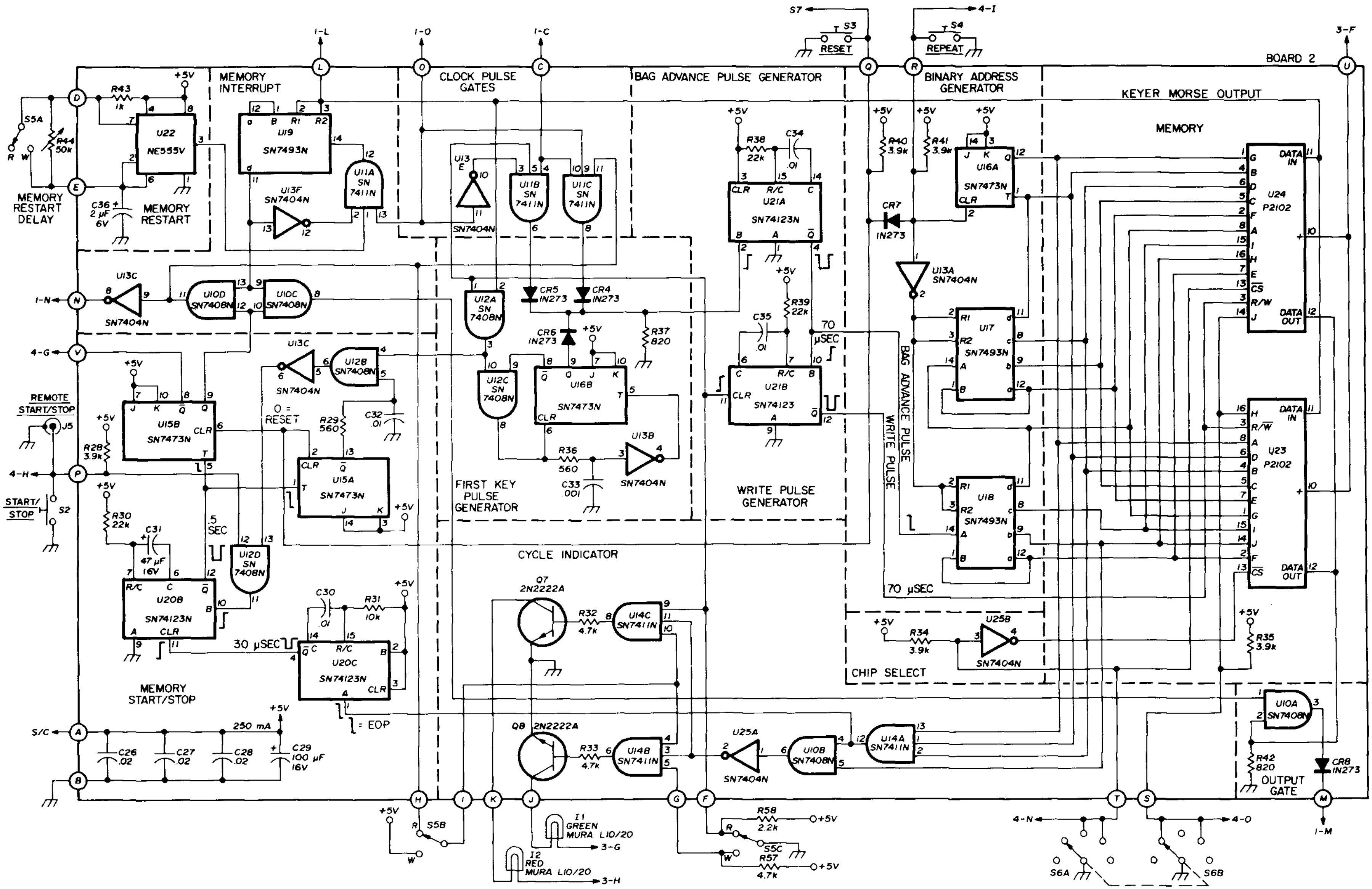
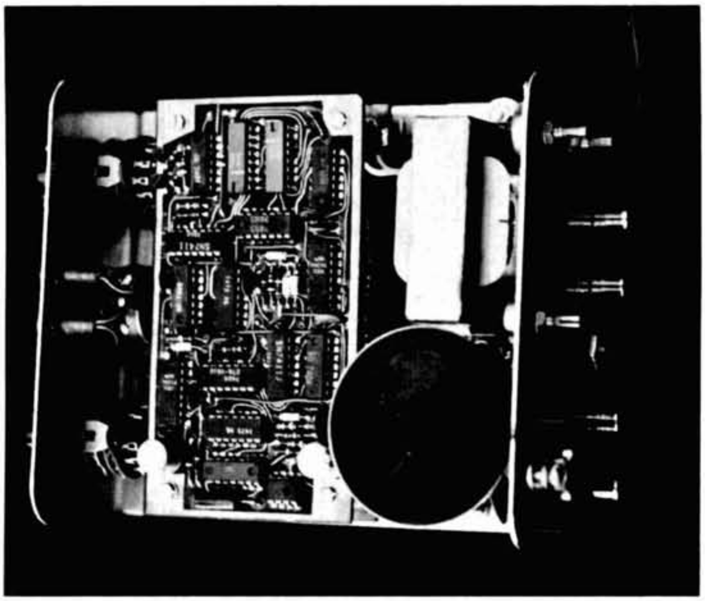


fig. 3. Memory circuit for the programmable contest keyer. Designations 1-L, 1-O, etc., designate connections to board 1 (fig. 2.) Connections 3-F, 3-G go to the power supply, and 4-N, 4-O go to the remote control unit. S2, S3 and S4 are spst push buttons. S5 is a 3pdt toggle switch; S6 is a 2-pole, 5-throw rotary switch (shorting or non-shorting okay). All resistors are ¼ watt, 10%.

tween NR and 599 during memory readout. Memory contents previously stored in the array are automatically prevented from being inadvertently transmitted while the memory is in a hold condition during manual keying.

memory programming

Placing S5 in the *write* position automatically programs a logic zero in the first cell, steps the binary



Chassis top view showing memory board, sidetone oscillator speaker, and power supply transformer.

address generator to the second cell, and causes the red *cycle* indicator (I2) to light immediately, even though the clock is not yet running and nothing is being written into the memory register. The clock is started and programming begins automatically merely by activating the paddle. During the *write* sequence, the clock operates in a "semi-synchronous" mode: while keying normally with the paddle, operation is fully synchronous; if character generation ceases, the clock continues to run asynchronously through the remainder of the message capacity, and logic zeroes are programmed to erase any previously stored message.

The red *cycle* indicator begins blinking when 87.5% of the memory has been programmed and returns to steady red at the end of the programmable capacity; this reminds you to place S5 to the *read* position before initiating a *readout* sequence with S2, or again activating the paddle before a new memory register is selected by S6. Otherwise, the message contents just programmed might be erased.

With S5 in the *write* position, the *write* pulse generator is activated. The binary address generator "advance" pulses toggle the BAG on the leading edge of each positive-going pulse, while each trailing (falling) edge triggers the *write* pulse generator to provide the negative-going *write* command to the memory array. Thus, correct timing occurs for accurate memory cell selection and for writing into the selected cell the logic level that appears on the data-in line (keyer output) at the instant of the *write* pulse. S1 and S5 are independent, so the keyer may be programmed on the air (S1 in *transmit* mode) or off the air (S1 in *edit* mode).

power supply

Although the Intel P2102 has nondestructive memory readout (stored information is not lost during readout), loss of power to the memory chip causes loss of the entire stored information (the memory chip is volatile). To keep Murphy and his despicable laws out of the memory, a no-break trickle-charged nicad supply is recommended. Such a charger will preserve keyer memory contents for about 2 to 3 hours, which will eliminate reprogramming when your Field-Day generator runs out of gas. Completely discharged nicads will be recharged in about 20 hours.

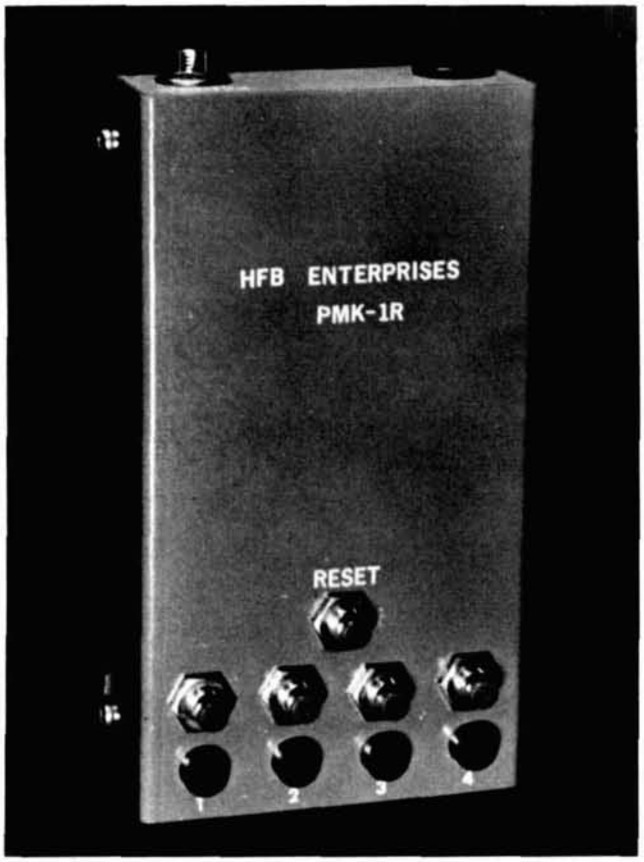
remote operating control

Provisions can be made on the rear panel of the contest keyer to accommodate a remote operating control which can be conveniently placed next to your paddle or bug.* The remote unit controls those keyer readout functions which are most necessary during a contest: message selection, message start, message repeat, and message reset. Depressing any one of the four message select pushbuttons antomatically selects that message, resets the memory to the message beginning and starts meassage readout. Since message selection is

Front panel of programmable contest keyer. Set and forget controls, and input and output jacks, are on rear panel.

*Schematic diagrams for the power supply and remote-control unit will be sent to interested readers upon receipt of a stamped, self-addressed envelope.

independent of the last message sent, successive selections of the same message immediately repeats that message from its beginning. A separate *reset* pushbutton is included to immediately stop the readout sequence.



Remote control unit for the programmable contest keyer provides control of all major keyer functions.

The remote cabinet selected (LMB CR-531) is approximately 1x3x5 inches (2.5x7.5x1.3cm) and houses the five pushbuttons, the printed-circuit board and four optional panel lights which indicate the selected message. Connection to the keyer is made by a plug-in, shielded, 8-conductor cable. All power for the remote is derived from the keyer, and removal pf the remote cable from the keyer does not affect keyer operation.

construction

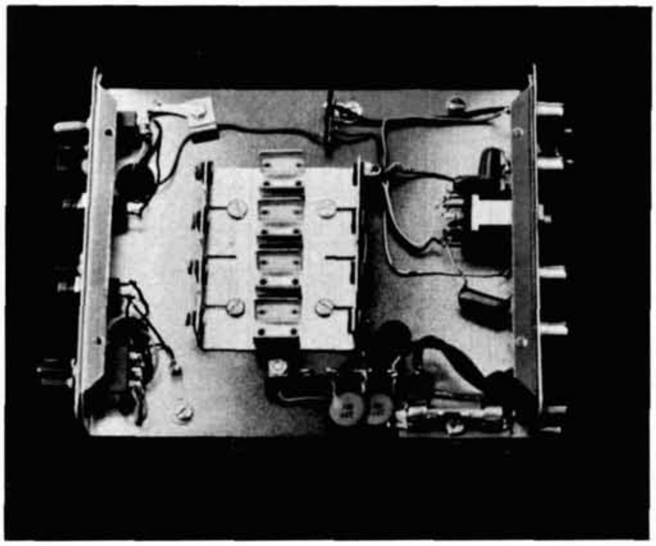
Panel clutter was avoided by automating as many memory-control functions as possible. Most-used controls are on the front panel; others are mounted on the rear of the keyer. An LMB CO-3 enclosure was used. The circuit is mounted on three PC boards: one for the basic iambic keyer, output keying, and sidetone oscillator; one for all memory functions; and one for the power supply.†

If desired, the keyer may be built without the memory board and used as a conventional iambic keyer and the memory may be added later. No keyer-board changes will be required and only four wires need be interconnected between keyer and memory board. The PC-board layout allows all memory-board wires and connections to be added without removing either keyer board or power supply from the cabinet.

A high degree of rf immunity is achieved by a) using TTL instead of CMOS devices, b) providing rf bypassing on all paddle and keying leads, and c) providing a grounding bond between cabinet sections. The keyer has been successfully kilowatt tested at a 3:1 vswr from 80 through 10 meters.

summary

The trade between performance, cost and circuit simplicity is sometimes difficult. For this project it was decided to opt for a capacity of four 512-bit messages and gain the advantages of paddle-programming and fully-synchronous operation at the expense of increased circuit complexity. This decision has been proved by the keyer's flexible, reliable, and unconfusing operation. This keyer has been a most useful operating aid both at home and in the field under generator power (thanks to the nicads). I'd like to thank the members of the Potomac Valley Radio Club for their constructive comments, suggestions and support.



Underchassis view showing battery receptacles and power-supply wiring.

†A set of double-sided PC boards with plated-through holes plus assembly and operating instructions are available from HFB Enterprises, Post Office Box 667, Herndon, Virginia 22020. The price is $30.00 post paid. Included are step-by-step assembly instructions, a complete parts list, operating instructions, and a full set of drill templates for the LMB CO-3 and LMB CR-531 cabinets.

reference

1. James Garrett, WB4VVF, "The WB4VVF Accu-Keyer," *QST*, August, 1973, page 19.

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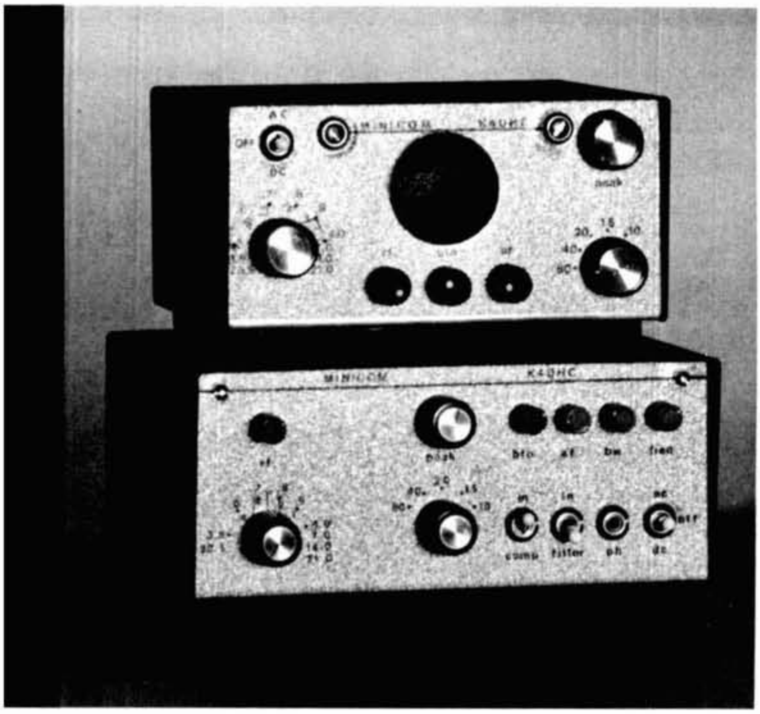


design ideas for miniature communications receivers

A collection of miniaturized receiver circuits including the Minicom Mk III, a five-band converter, an 80-meter tuner and two complete i-f and audio systems

I wrote my first article for an amateur publication in 1971.[1] Writing was something I had always wanted to do but until then I had never gotten up enough courage to try it. After several weeks of writing, rewriting and drawing circuit diagrams, I felt I had something that might be accepted by the editor. When it was finally published I discovered what the real rewards were: letters came in from all over the country and from many DX locations. I not only had a great time answering all these people and swapping ideas with them, I made many new friends with whom I still correspond.

Of all the articles I've written since then, only my most recent one generated as much enthusiastic response as the first. Both of these articles discussed receivers and miniaturization; evidently this is a favorite topic with the majority of readers. If you found the Minicom[2] interesting, read on.

The original Minicom packed a lot of performance into a small package, but even before the article had been published a new version was on my workbench. It packed even more performance into the same space and was called the Mk II. If you were among those who

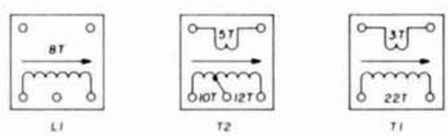


fig. 2. Bottom view of inductor L1 and transformers T1 and T2. All coils are wound with salvaged wire on standard 3/8" (10mm) i-f transformers.

Ray Megirian, K4DHC, Box 580, Deerfield Beach, Florida 33441

wrote to me regarding parts for the Minicom, you already know about the Mk II as an information package was made available to interested builders. Since then the Mk III has been devised and will be discussed here along with several other useful assemblies for ssb/CW receiver construction.

Minicom Mk III

My particular use for the Minicom has been as a tunable i-f for use with an external converter for all-band coverage up to 30 MHz. Several such converters have been built in very compact form so that, when teamed up with the Minicom assembly, it results in a very diminutive multi-band communications receiver.

Development of the Mk III receiver was undertaken for several reasons. First, I was interested to see if the receiver could be made smaller without resorting to techniques that would be impossible to duplicate. I also wanted to determine the feasibility of substituting varactor tuning for the three-gang tuning capacitor. If successful, the latter would not only eliminate a major hard-to-find component, it would make miniaturization a reality.

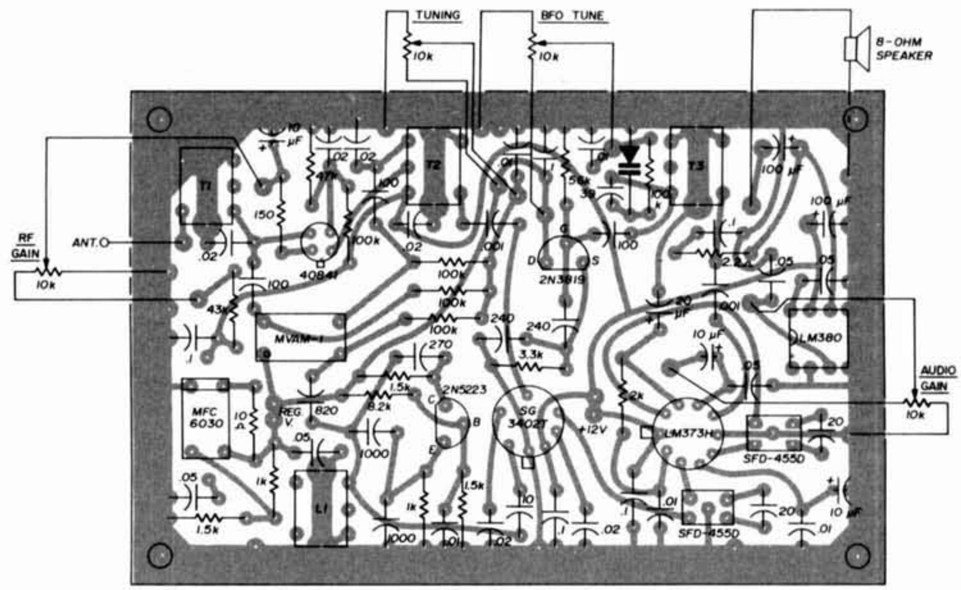
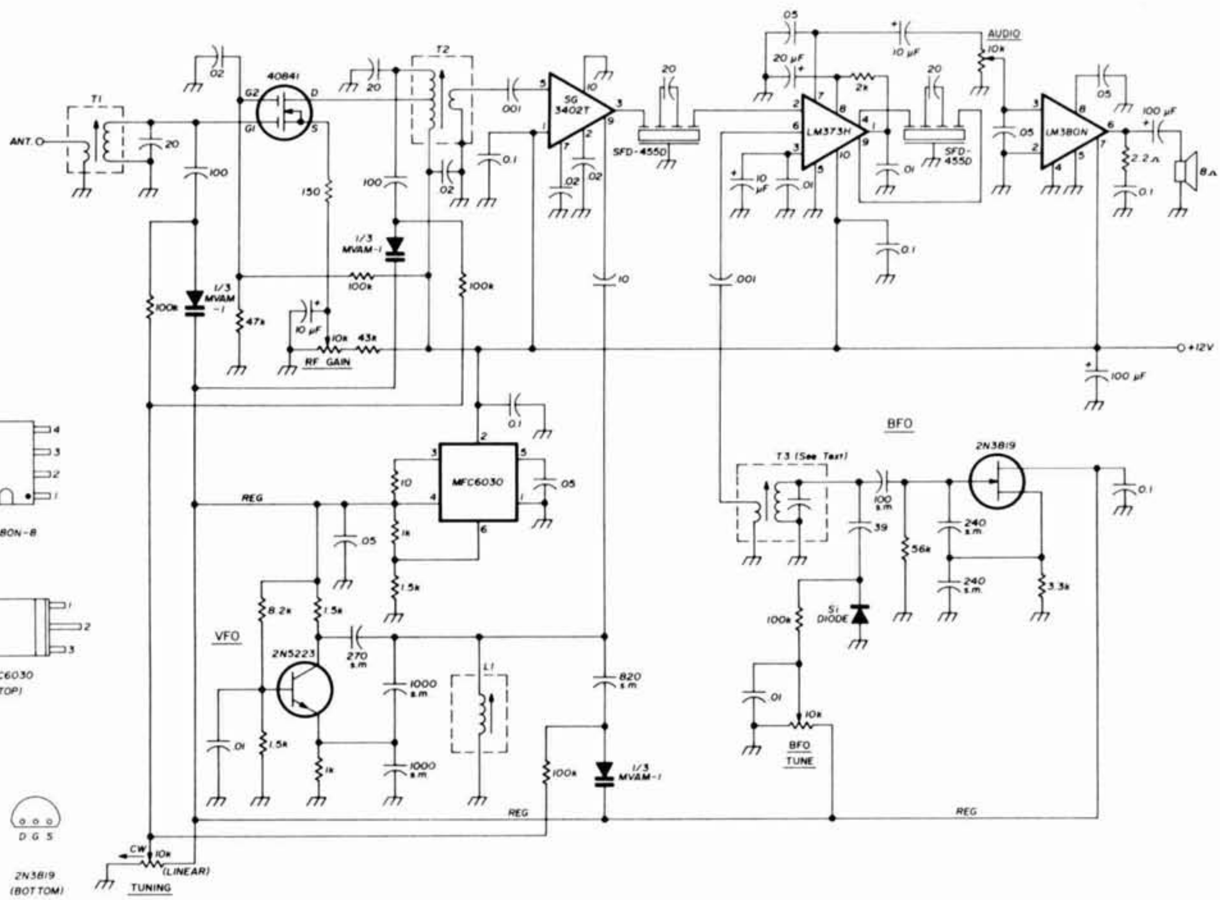
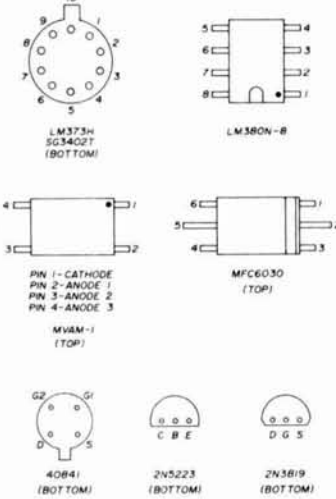


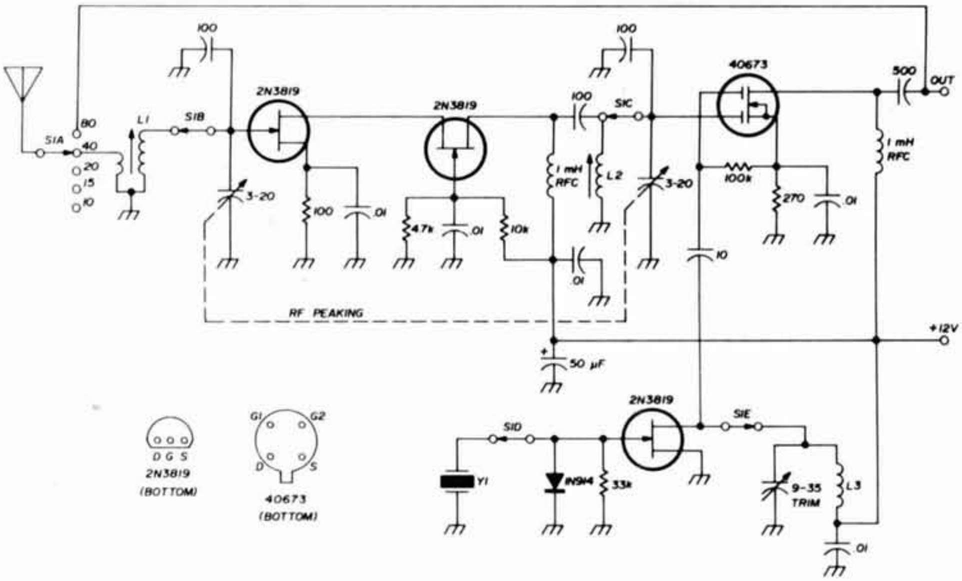
fig. 3. Printed-circuit layout for the Mk III communications receiver.

Some time ago Motorola announced their MVAM-1 triple tuning diode and it was this item that encouraged me to go ahead with my investigation of an electronically-tuned Minicom. Although designed for tuning a broadcast-band receiver, a study of the MVAM-1 data sheet led me to believe that diode Q

fig. 1. Circuit diagram of the MkIII communications receiver which uses tuning diodes. Remove pins 4, 6 and 8 from the SG3402T IC before installing it on the circuit board. Details for L1, T1 and T2 are shown in fig. 2. All resistors are ¼ watt, 5%.



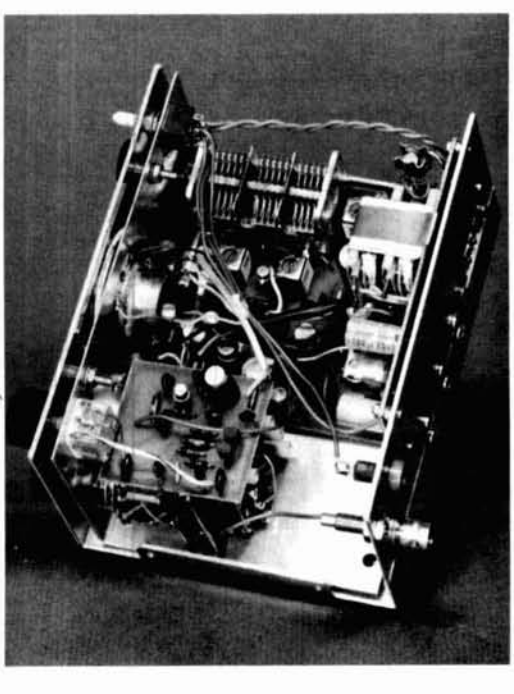




band	L1	L2	L3	Y1
40	20 turns no. 36 (0.13mm), 2 turn link	20 turns no. 36 (0.13mm)	4.7 µH	11 MHz
20	12 turns no. 28 (0.3mm), 1.5 turn link	12 turns no. 28 (0.3mm)	2.2 µH	18 MHz
15	7 turns no. 28 (0.3mm), 1 turn link	7 turns no. 28 (0.3mm)	1.5 µH	25 MHz
10	4 turns no. 28 (0.3mm), 1 turn link	4 turns no. 28 (0.3mm)	1.5 µH	25 MHz

fig. 4. Five-band converter for use with the Mk III communications receiver. In this design the 25-MHz crystal is used for both 10 and 15 meters. Complete coverage of the 10-meter band requires additional crystals. Inductors L1 and L2 are wound on 0.215" (5.5mm) diameter PC-mount coil forms with Carbonyl-E (red) cores. Molded rf chokes are used at L3.

Interior of the smaller receiver. The Mk II board assembly is mounted on standoffs to the sub-chassis (top). The converter is in the foreground and the power supply is on the rear panel.

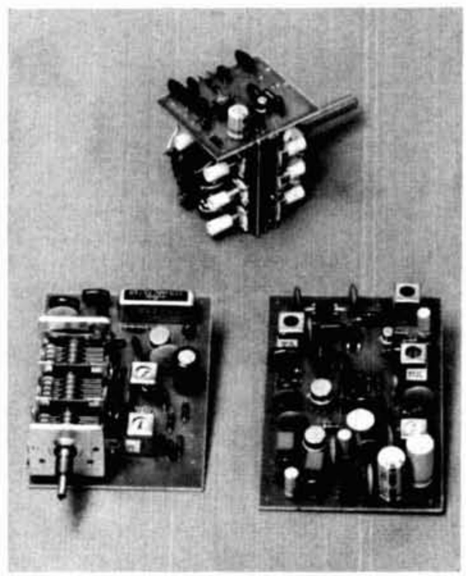


would be high enough at 4 MHz to produce a pretty good receiver. The final results achieved with a breadboard receiver were quite satisfactory and led to the layout shown here. The board is 2.5 inches (65mm) wide by 3-7/8 inches (100mm) long. The Mk II is 3.75 inches (95mm) square. The schematic of **fig. 1** shows the circuitry for the receiver which tunes from 3.5 to 4.0 MHz using approximately 80 percent of the tuning pot rotation. Tracking is good within these limits but starts to deteriorate at the extreme ends of the resistance element.

One big advantage of the diode tuning system is mounting flexibility. Since tuning is accomplished with a potentiometer at the end of a three-wire cable, the receiver may be mounted anywhere in the cabinet without worrying about exact positioning or shaft alignment.

To make tuning easier, some sort of reduction drive is needed, just as with conventional tuning systems. Perhaps the reduction drives that are the easiest to find are the small Japanese vernier dials which have better than 7:1 reduction. The built-in stops which limit travel to 180 degrees can be eliminated by snipping off the stop pin, thus allowing continuous rotation.

Except for the mixer, which uses a Silicon General SG3402T IC, the circuitry of the Mk III is quite conventional. Good results with this mixer were achieved in the Mk II so it was used in the Mk III as well. The LM373H once again does a commendable job in the i-f section where two Murata SFD-455D ceramic filters provide selectivity. An LM380 replaces the MC1454 in the audio portion, adding the advantages of electrical and thermal overload protection. The bfo remains unchanged.



The 40-, 20-, 15- and 10-meter converter is at the top. The electronically-tuned Minicom Mk III is on the right; on the left is the 80-meter tuner.

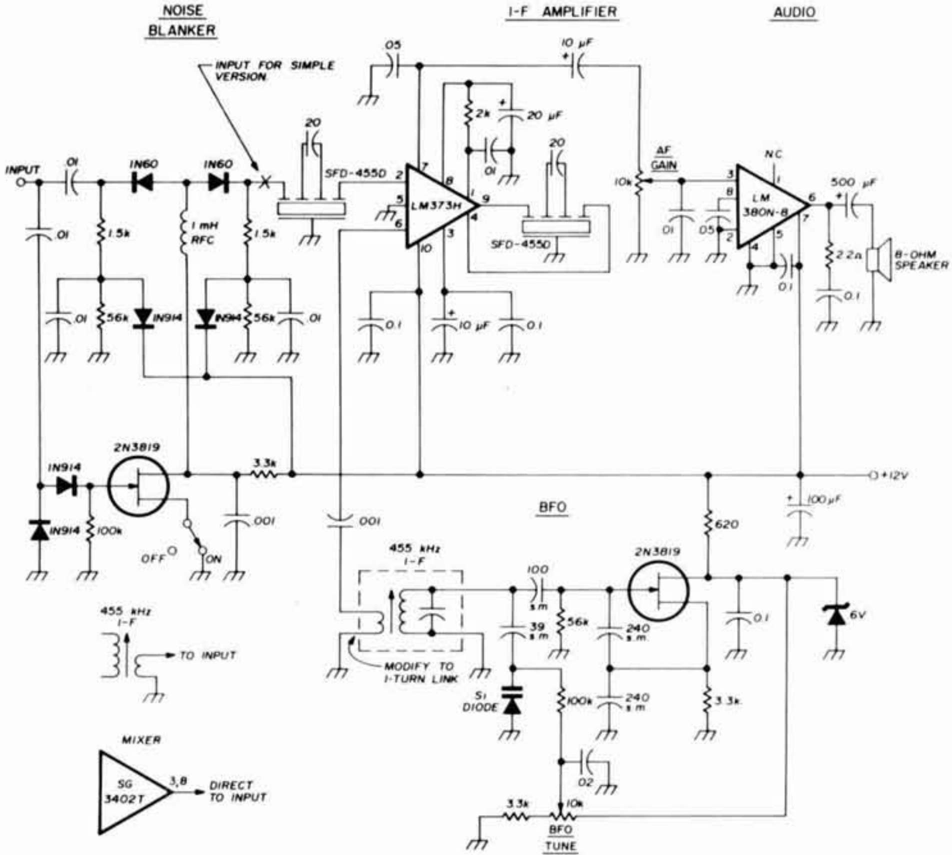
diode tuning

A few words about the MVAM-1 might be worthwhile at this point since that's what the Mk III receiver is all about. The three diodes are wired with a common cathode lead and housed in a tiny four-pin plastic package. Typical capacitance at 1.0 volt reverse bias (V_R) and f = 1.0 MHz is 480 pF. The capacitance ratio is 15 (minimum) for reverse bias between 1 and 25 Vdc. The three diodes are matched within ±1.5 percent over the entire capacitance vs voltage curve. Typical Q at V_R = 1.0 Vdc and f = 1.0 MHz is more than 500.

Because of the large capacitance rating of these diodes, it was possible to change the vfo configuration to a more drift-free design. This new vfo circuit drifts very little; so long as the receiver is operated in a relatively stable temperature environment, drift is practically nonexistent. The diode capacitance temperature coefficient could be a problem, however, if the receiver were operated under widely varying ambient temperature conditions. The diode capacitance temperature coefficient given in the data sheet is typically 435 ppm/° C at V_R = 1.0 Vdc and f = 1.0 MHz.

Another consideration requiring strict attention with diode tuning is voltage regulation. It stands to reason that since the diodes are voltage-controlled devices, the source of control voltage must retain a high degree of stability. A simple zener diode is far from satisfactory in this application so an IC voltage regulator (MFC6030) was included on the circuit board to provide the needed regulation. With the values shown in **fig. 1** the output is around 7 volts and the minimum input voltage to maintain regulation is 10 volts. Spare terminals on the circuit board allow access to this regulated voltage for use with other external circuits, if needed. On the board the regulator supplies power to both the vfo and bfo besides providing a stable control voltage for tuning purposes.

Standard 455-kHz transistor i-f transformers were stripped and used for coil forms as in all previous models of the Minicom receiver. If you've forgotten how to strip these devices, refer to the original Minicom article for details.[2] Any of the transformers (white, yellow or black core) may be used for the bfo transformer after one simple modification. Unsolder the secondary (link) leads from the base pins and gently break off the wires where they disappear into the bobbin. Substitute a single-turn link wound over the existing coils using a piece of salvaged wire from the rf coils (see **fig. 2**). This change assures proper bfo injection level for the LM373.



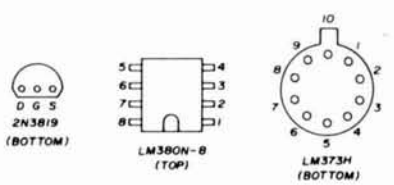
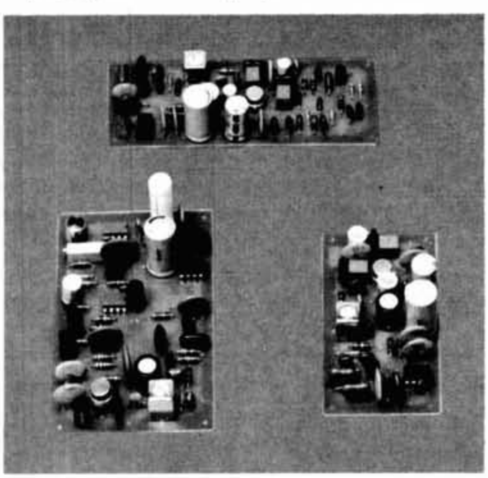


fig. 5. I-f and audio amplifier circuit. Two methods are shown for coupling into the amplifier. The noise blanker may be deleted, if desired. Printed-circuit layouts are shown in fig. 6 (with noise blanker) and fig. 7 (without noise blanker). All resistors are ¼ watt, 5%.

The three versions of the i-f amplifier. With noise blanker (top), without (right) and compressor/filter version (left).



multi-band converter

A suitable mechanical design for the converter proved to be the most difficult problem of all to solve. After numerous attempts it looked as if the converter would occupy as much space as the Minicom; this put a big dent in my miniaturization program. I finally solved the problem by using three separate circuit boards instead of one. The heart of the assembly is the bandswitch, around which everything else is built. The miniature bandswitch was a surplus item originally manufactured by Oak and has seven 1-inch (25mm) wafers, six of which were single pole, eight position devices. The seventh wafer had a weird switching arrangement which was of no use. Since only five poles were needed, this last deck plus one of the others were removed. The added space was taken up by two of the circuit boards and some suitable spacers. A shield was also installed between sections.

Unfortunately, these surplus switches were a one-time deal and I don't know where you can get any of them now, so any detailed assembly instructions for the converter would be useless. However, if you have the skill required to build any of this equipment, you shouldn't find it too difficult to come up with a layout to fit your own components. A schematic of the converter I used is shown in **fig. 4**.

In my converter only the 28.5 to 29.0 MHz segment of 10 meters is covered. For additional coverage, you'll need additional crystals. The rf section should require no changes to cover the entire 10-meter band. The two-gang tuning capacitor used to peak the converter front end is a tiny film dielectric type removed from a transistor fm radio. If you use one of these, a shaft has to be made.

i-f and audio

Occasionally the need arises for an i-f system which you can use for testing new tuners or front ends. At other times this sectionalized construction technique is the only one which will allow cramming everything into the available space. In either case, one of these i-f modules may be just what you need.

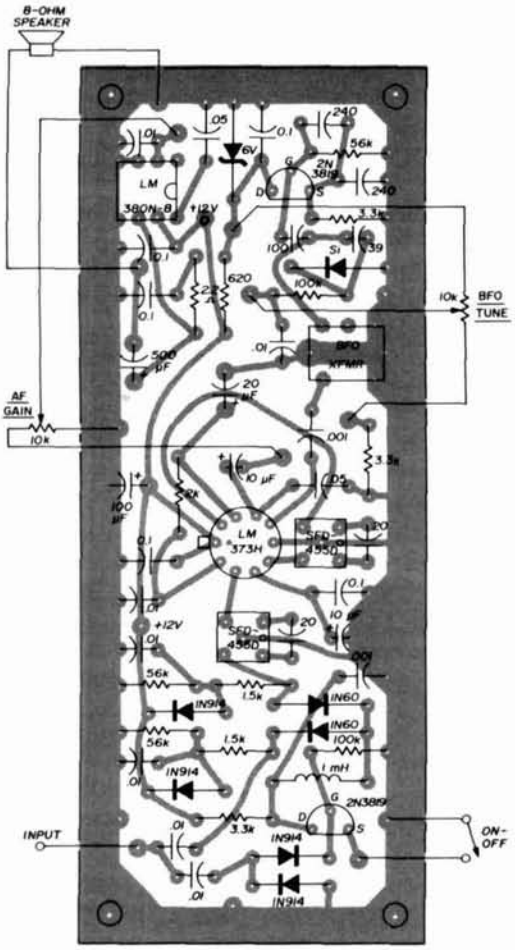


fig. 6. Printed-circuit component layout for the i-f and audio amplifier with noise blanker.

An inspection of the schematic in **fig. 5** reveals that the circuit is identical to that used in the second half of the MK III. An LM373H IC with two Murata SFD-455D ceramic filters fulfills the requirements for i-f amplifier, detector and agc functions. The bfo is identical to the Mk III as is the LM380 used for the audio amplifier.

If desired, a noise blanker may be included ahead of the i-f input by making the circuit board slightly longer. In either case, the board is 1.75 inches (45mm) wide with a length of 3-3/8 inches (86mm) for the simple version and 4-5/8 inches (117mm) with the noise blanker.

The circuit for the noise blanker is similar to one used in a commercial Japanese two-meter ssb transceiver. A reader in West Germany, Earl Lagergren, sent me the circuit after reading my article on a solid-state noise blanker.[3] Since this noise blanker circuit requires no special components and works at various i-f frequencies, I've included it here as a worthwhile addition to your potpourri of receiver circuits.

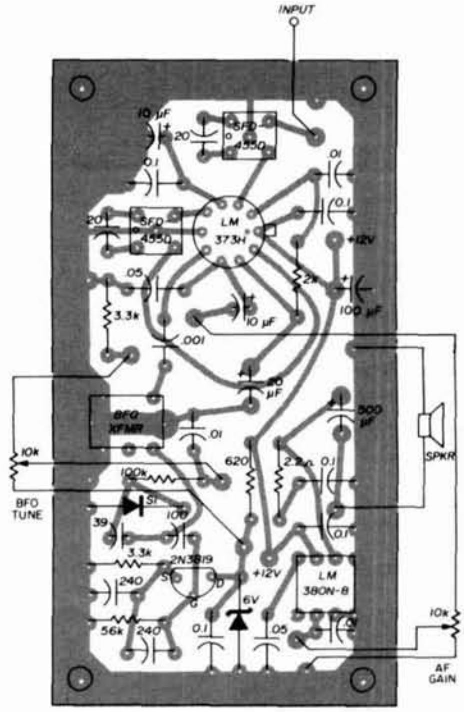
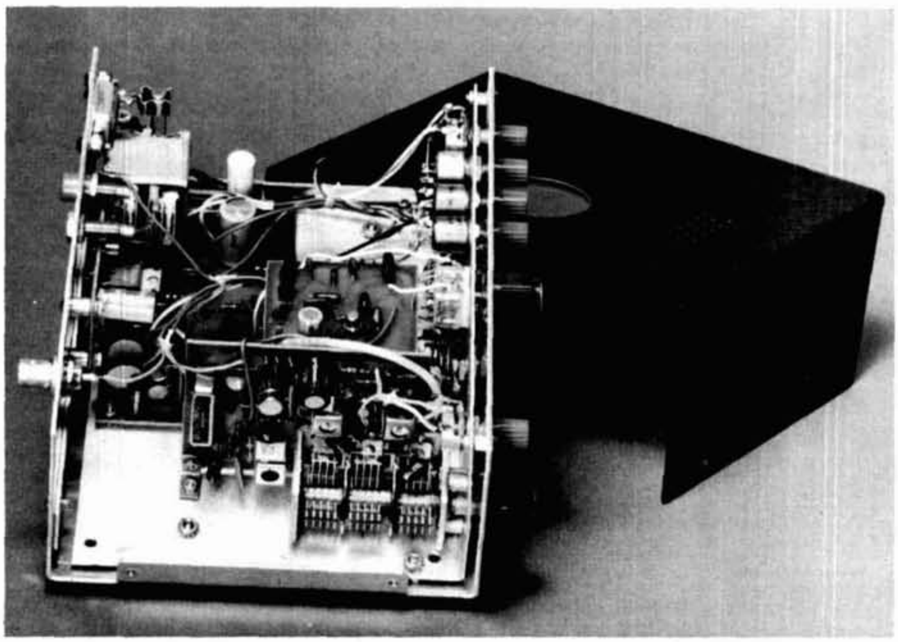


fig. 7. I-f and audio amplifier printed-circuit layout. Circuit board which includes a noise blanker is shown in fig. 6.

One of the complete receivers shown in the photos uses this tuner, the four-band converter and an i-f and audio system (described later). It is identical to the rf and mixer stages of the Mk II which some of you are familiar with.



Interior of the larger receiver. The tuner was mounted on edge with the converter right behind it. The i-f, compressor/filter assembly is mounted on the sub chassis to the rear. A power supply is installed on the rear panel.

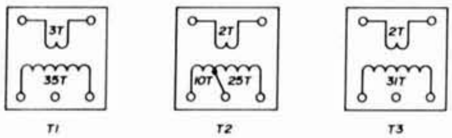


fig. 9. Bottom view of transformers T1, T2 and T3 used in the 80-meter tuner. All coils are wound with salvaged wire on standard 3/8" (10mm) i-f transformers.

Included on the tuner board is a Murata CFS-455J ceramic ladder filter which provides 3 kHz bandwidth at 6 dB down and superior skirt selectivity to systems using the SFD-455D filters.

The rf stage shown in **fig. 8** incorporates one of the newer types of mosfet, a dual-gate n-channel enhancement mode, Signetics type SD304. These transistors operate with all-positive bias which may be of interest to anyone who has been looking for an agc system not requiring a dual polarity power supply. About 40 dB of agc range is possible with 0-6 volts applied to gate 2. This circuit, however, uses a manual rf gain control.

The three-gang tuning capacitor is the same as that used in the original Minicom receiver. The two 22 pF padding capacitors for the rf and mixer tank circuits are mounted directly on the variable capacitor before it is installed on the board. These two sections also have built-in mica trimmers for tracking adjustment.

An extra stage of i-f was included on the tuner board to overcome the insertion loss of the ladder filter. A SG3402T IC is used in the mixer section; pin 6 must be removed before mounting the IC on the circuit board.

i-f and audio system

Some time ago I wrote an article describing a complete audio system for use in a communications receiver.[4] This system consisted of a tunable filter, an audio agc system and a power output stage and drew pretty good response from readers. In the version shown in **fig. 11** the i-f stages have been included along with the compressor and tunable audio filter. The notch function, however, has been deleted and the circuit has been modified for single supply operation.

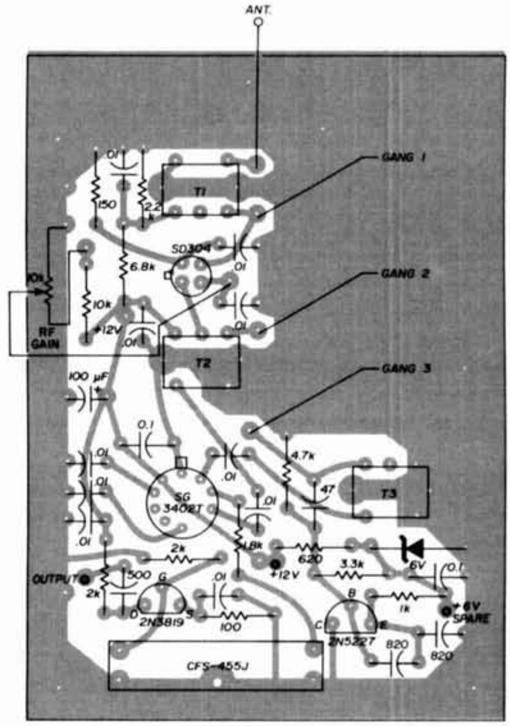


fig. 10. Printed-circuit layout for the 80-meter tuner.

In this circuit two op amps are used in the compressor and two more in the filter. Dual type N5558V units were used and any of the equivalents from other manufacturers may be substituted. An LM380 is once again used for the audio output stage. The i-f portion is the same as all previous LM373 configurations except for the SFD-455D filters. Since I used this assembly in conjunction with the tuner which incorporates the ladder filter, the other units were not required.

The trimmer resistor in the audio filter may be very simply adjusted for proper operation. First set the trimmer for maximum resistance by turning the adjusting screw counter-clockwise. Then turn the *frequency* control to the high end and set *bandwidth* to sharp. Hold your ears, turn on the power and flip the filter switch to *in*. The filter should take off with ear-shattering feedback. Start turning the resistance trimmer clockwise until oscillation ceases (add an additional half turn for good measure). Throw the filter switch back and forth a few times to see how stable things are and adjust the trimmer some

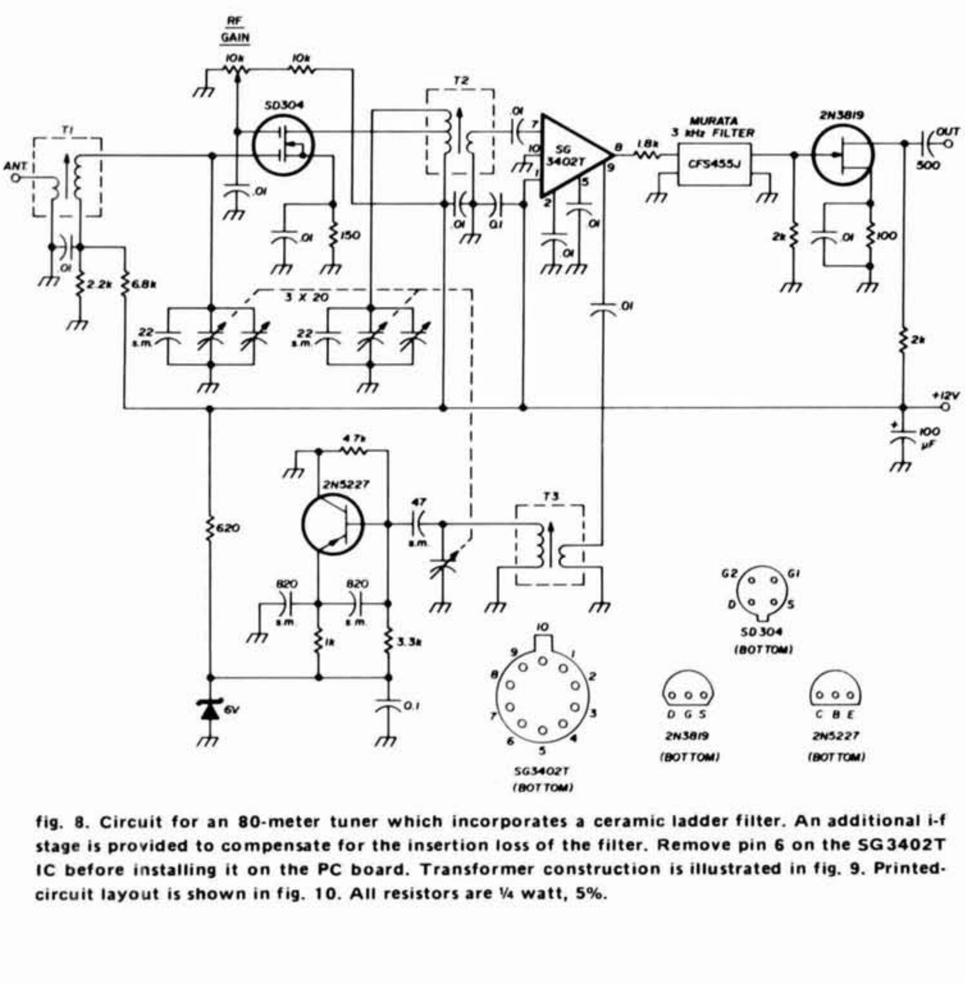


fig. 8. Circuit for an 80-meter tuner which incorporates a ceramic ladder filter. An additional i-f stage is provided to compensate for the insertion loss of the filter. Remove pin 6 on the SG3402T IC before installing it on the PC board. Transformer construction is illustrated in fig. 9. Printed-circuit layout is shown in fig. 10. All resistors are ¼ watt, 5%.

more if needed. The tuning range of the filter should cover from about 500 to 2000 Hz.

It should be pointed out that caution must be used when coupling into this assembly. Note that the i-f input goes directly to pin 2 of the LM373. A dc path must be avoided at this point to prevent damaging the LM373. When used with the 80-meter tuner described above, a coupling capacitor is provided on the tuner board to prevent shorting pin 2 to ground.

Printed-circuit layouts are provided here for all modules except the converter. This should make it easy to duplicate any of the assemblies. The main goal of this article, however, was to present the widest selection of proven and reliable circuits as possible in a single package so that the greatest number of readers could make use of at least one of them. There is nothing sacred about any of the circuits so if you feel like sneaking a piece from one and adding it to another, it will give you a chance to practice your skill at laying out new circuit boards.

No tuning or adjustment procedures will be covered since it is assumed that the average builder can accomplish that on his own.

The photos show the various printed-circuit assemblies which have been described plus two receivers built from some of this equipment. The smaller receiver uses a Mk II with the converter described here for five-band coverage. A small ac power supply is attached to the rear panel inside the receiver and a plug is provided for feeding in an external 12-volt dc source. A small speaker is mounted on the front panel to make the unit completely self-contained. The cabinet is 3x5x6 inches (76x127x152mm). The larger receiver uses the tuner, converter and i-f, audio filter and compressor board described above. It also has a built-in ac supply. Cabinet size is 3x6x7 inches (76x152x178mm).

All of the circuits operate from 12-volt supplies and function well down to 9 volts or up to about 14 volts. The Mk III, however, includes a regulator requiring a minimum of 10 volts for proper operation. The copper border around all the circuit boards is the common or supply negative and should be grounded.

With the exception of the board containing the audio filter, the only external components are operating controls. In the case of the audio filter a resistor and capacitor are wired point to point between the front-panel controls.

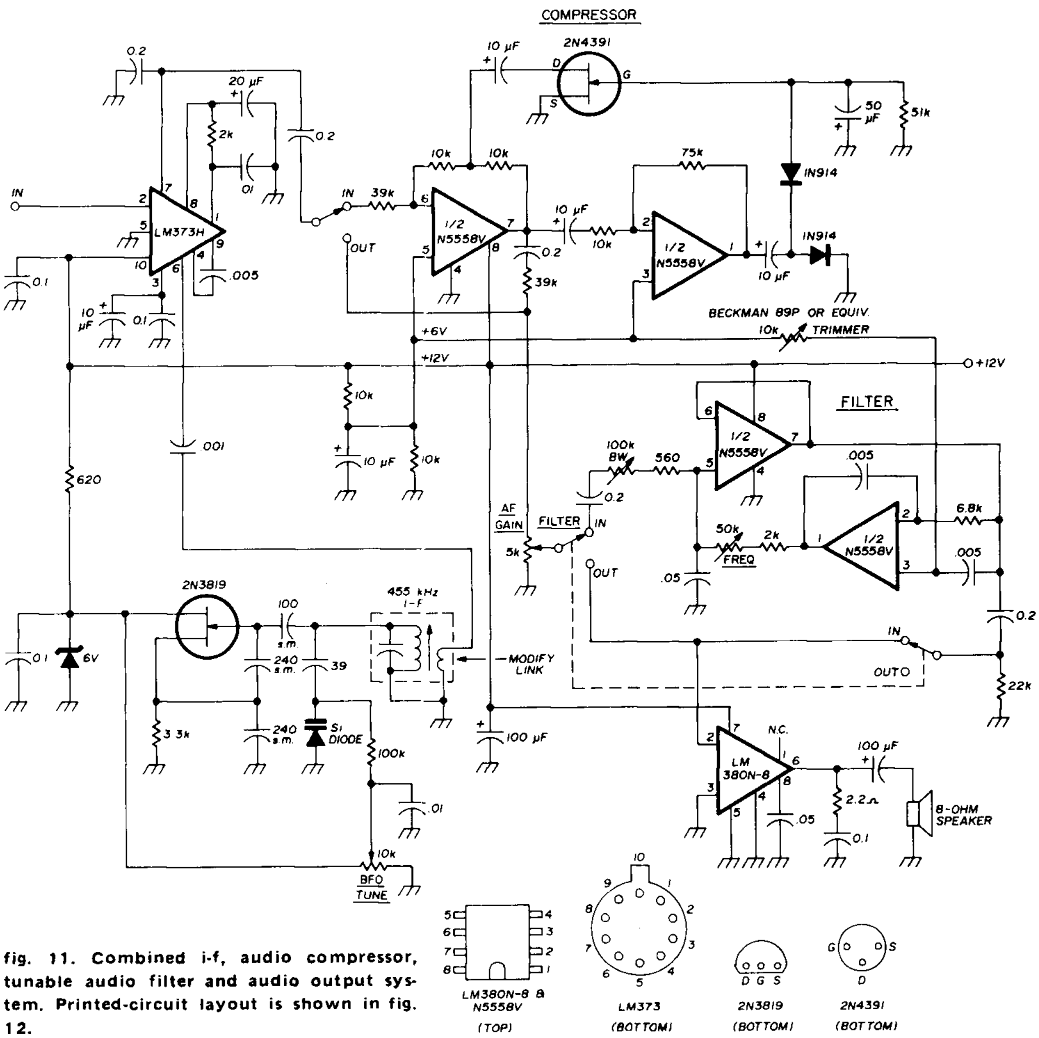


fig. 11. Combined i-f, audio compressor, tunable audio filter and audio output system. Printed-circuit layout is shown in fig. 12.

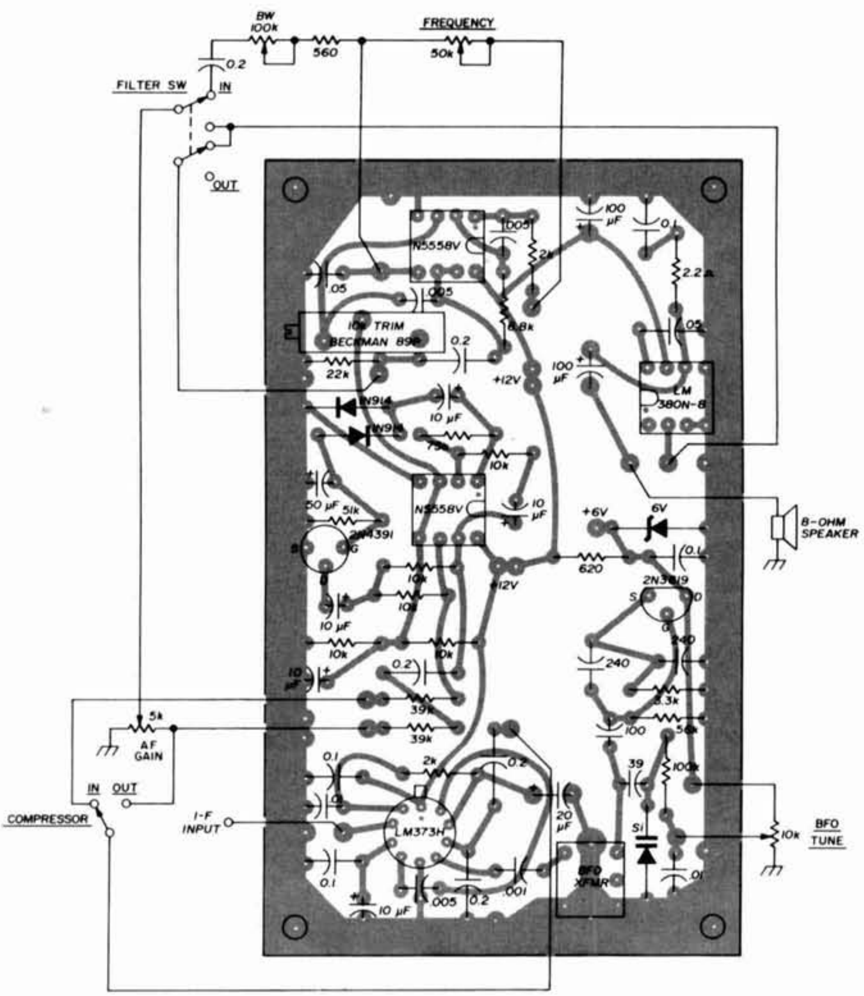


fig. 12. Printed-circuit layout for the combined i-f, audio compressor, audio filter and audio output system.

This saves the extra leads that would be required for going back and forth from the board for these two items.

Before concluding, I should say something regarding parts. Some substitution is possible since there is nothing special about a 2N5227, a 2N3819 or a 2N5223. The 40673 and 40841 can be interchanged but not with the Signetics SD304. The silver mica capacitors should be small case sizes in most instances to fit the PC layouts. The ceramic bypass and coupling capacitors should be small, low-voltage discs. These, as well as 1/4-watt resistors, are readily available and should present no procurement problems.

If you are interested in purchasing some of the more elusive components such as ICs, filters or whatever, drop me a line with a self-addressed, stamped envelope and advise what and how many you need. If there is sufficient demand for particular items, I'll try to obtain what is needed.

references

1. Ray Megirian, K4DHC, "Using The LM373," *73*, April, 1972, page 37.
2. Ray Megirian, K4DHC, "Miniaturized Communications Receiver," *ham radio*, September, 1974, page 24.
3. Ray Megirian, K4DHC, "Solid State Noise Blanker," *ham radio*, February, 1973, page 38.
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ham radio

missent ID

During intruder watching and observance of amateur signals, I've noticed a considerable number of RTTY transmissions that have ended with an inaccurately sent identification. In some cases, these IDs were repeated in the same incorrect manner on a later transmission. In one occurrence the signature was "W6MTMAI," but W6MTM doesn't have RTTY equipment. I recorded the audio signal on the mark side, then ran off an ink-line tape that clearly showed the five-letter call sign but with more than normal spacing between letters.

It appears that a local station had some rf getting into an IC identifier, causing problems. The operator bypassed the leads to the identification unit, which cleared up the problem. It would be well for anyone using an IC device to send his call and get help to listen to the resulting ID. It should be sent on full power and on every band on which the device is used. Only in that way can one be sure that the call always is sent correctly.

Bill Conklin, K6KA

simple circuit replaces jack patch panel

Shown in **fig. 1** is my solution to the ever-present phone jack patch panel used in amateur RTTY stations. I became tired of the conventional panel with cords breaking, so after a little thought, I developed this circuit. The diodes provide the necessary isolation to allow the switch to select the loop desired for a particular piece of equipment.

Dr. Paul Lilly, K4STE

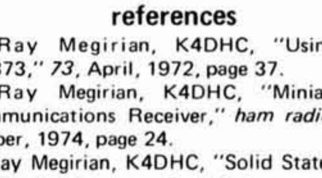

fig. 1. Simple jack patch panel replacement for RTTY stations. Diodes CR1-CR4 provide the necessary isolation. RTTY equipment (printer, keyboard, etc.) is connected to A terminals.

circuit design with the 741 op amp

The inexpensive 741 op amp IC is finding extensive application in electronics — here are some tips for using this versatile device in your own circuits

For several good reasons, the 741 operational amplifier is enjoying wide popularity among amateur circuit designers. It is inexpensive and readily available; several mail-order supply houses are currently selling them for about 35 cents each. The 741 requires no external frequency-compensation networks, and this significantly enhances the ease with which it may be used in circuit development. However, there are several facts about 741s which, if known and understood, can minimize surprises and make their use more predictable.

Those unfamiliar with op-amp theory are referred to a rather extensive article that previously appeared in *ham radio*.[1] That article covers general op-amp circuit design criteria as well as several specific applications. I will attempt here to concentrate on the peculiarities of the 741 and not duplicate material already presented.

The 741 op amp is available in several different packages, but the TO-5 metal can, much like a transistor with eight leads, and the plastic eight-pin minidip package seem to be the most popular. I prefer the minidip because it easily plugs into a dual-inline IC socket. Two 741s can be inserted in a 16-pin IC socket.

Fig. 1 shows the schematic symbol for the 741 op amp with appropriate power supply and null pot circuitry. The null pot is used to set the dc output voltage to zero in certain situations; however, in many circuits

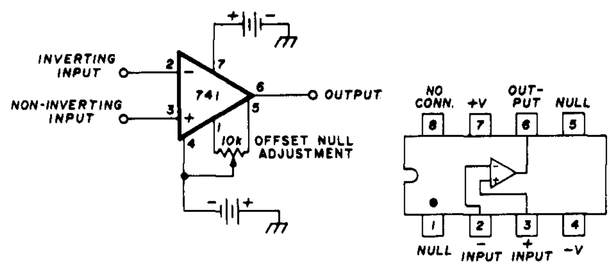

fig. 1. Schematic symbol for the 741 op amp showing power supply and null pot connections. Connections to popular 8-lead minidip package are also shown.

it's not necessary to use a null pot. When the null pot isn't needed, just leave pins 1 and 5 open. **Fig.1** also shows the pin numbering and identification for the 741 minidip when viewed from the top. Either a notch at one end of the package, or a dot in one corner are used to index the pin numbers. The +V and −V pins are for power supply connections.

The maximum rated power supply voltages for the commercial version of the 741 are plus and minus 18 volts, but lower voltages may be used. Two 9-volt batteries will do nicely, but higher supply voltages will permit a larger output signal swing. Current drain will depend on load resistance and output signal amplitude, because the output circuit of the 741 is a class B complementary emitter follower. Under zero-signal conditions,

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however, the quiescent power supply current should be about 1 mA or less.

dc offset problems

Since the 741 is a dc amplifier, any dc voltage which exists between the two input terminals will be multiplied by the gain of the amplifier and can result in a large dc offset at the amplifier's output. This offset prevents maximum linear output signal swing. In some cases, the dc offset can force the output to its limit, and no signal will appear at the output.

The two input terminals of the 741 are connected internally to the two base leads of a bipolar transistor differential amplifier, **fig. 2**. Therefore, some transistor base biasing current must flow through each input terminal of the 741. This input bias current can be as high

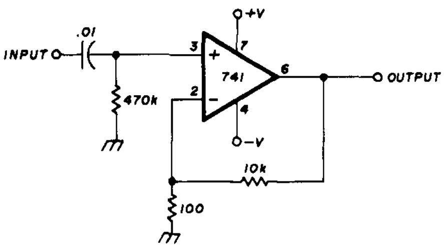

fig. 3. 741 op amp with feedback network selected for a gain of 100. Dc output offset of this circuit will be unacceptably high because the inputs see a large difference in resistance.

as 0.5 μA in the 741, but may be typically 0.1 μA or less. Ideally, the two input bias currents should be equal, but due to differences in transistors, they may differ by as much as 0.02 to 0.2 μA. This difference in input bias current is called input offset current.

To see how this input bias current can effect output offset voltage, consider the circuit of **fig. 3**. This amplifier is designed to have a voltage gain of 100 and an

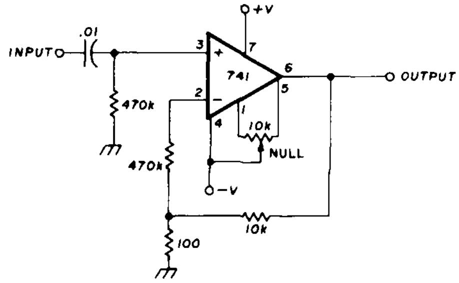

fig. 4. Both input terminals of this 741 circuit see about the same resistance, and output offset may be nulled to zero. Gain of the circuit is 100.

input resistance of 470k. Power supply and null circuits are omitted for clarity. Suppose the input bias current for both input terminals is 0.1 μA. The voltage drop across the 470k resistor connected to pin 3 will be 47 mV. At pin 2, however, most of the input bias current will flow through the 100 ohm resistor, because that is the path of least resistance. The voltage drop caused by 0.1 μA flowing through 100 ohms is only 10 μV, so the input bias current flowing through these resistors produces a dc voltage difference between pins 2 and 3 of nearly 47 mV. Since the gain of the amplifier is 100, the dc output level of the 741 will be 100 times 47 mV, or 4.7 volts under no-signal conditions. This is hardly a desirable situation.

The offset null adjustment pot (shown in **fig. 1**) can only compensate for about 15 mV, typically, of input offset, so it would be unable to correct for the 47 mV offset and bring the output level of the 741 back to zero.

To avoid such problems as this, it is good practice to arrange the circuitry so that each input terminal of the 741 sees approximately the same amount of resistance; this will minimize input offset due to input bias current.

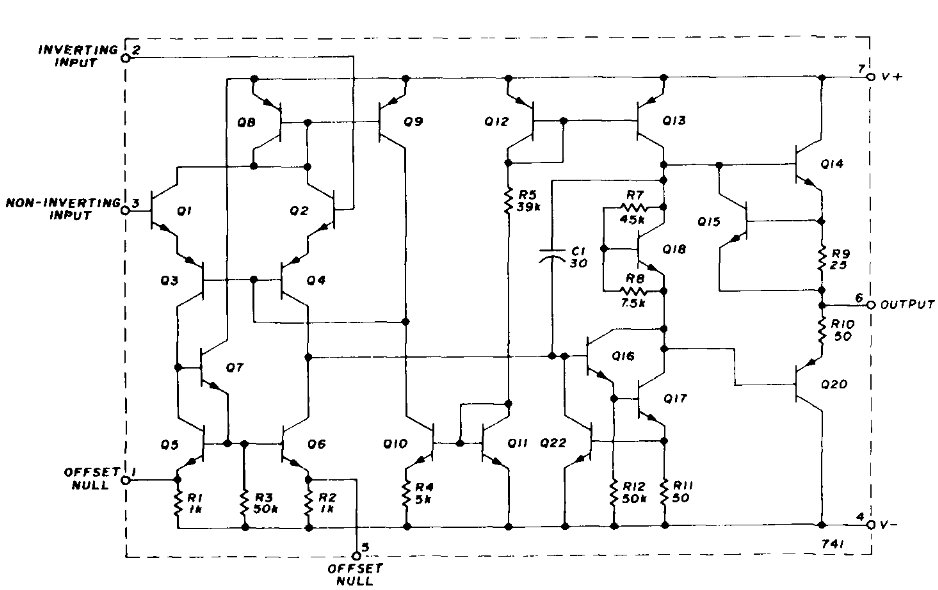

fig. 2. Internal circuitry of the 741 frequency-compensated operational amplifier.

Fig. 4 shows how a resistor may be added to accomplish this. With this circuit, the dc output level may be zeroed with the null pot, and voltage gain is still 100. Keeping all input resistors as small as possible also helps to reduce input offset, but when a high input resistance amplifier is needed, this is not feasible. In calculating the resistance that each input terminal sees, find the equivalent resistance that all the resistors connected to that input terminal would have if they were connected in parallel.

Another approach to the dc offset problem is to reduce the dc gain of the amplifier to unity while maintaining the ac gain at 100. **Fig. 5** shows how to do this. Here the dc input offset due to input bias currents of 0.1 μA is 46 mV, but the dc gain of the amplifier is unity, so this will result in only 46 mV offset at the output. Such a small dc output level is insignificant in many cases, and the null pot would be omitted. The 5 μF capacitor should be a non-polarized type. Its value was selected to have a reactance of 100 ohms at 300 Hz, to produce a lower 3 dB cutoff point for the amplifier at this frequency.

bandwidth and slew rate

Fig. 6 shows a typical plot of the 741's open-loop voltage gain vs frequency. According to this graph, if

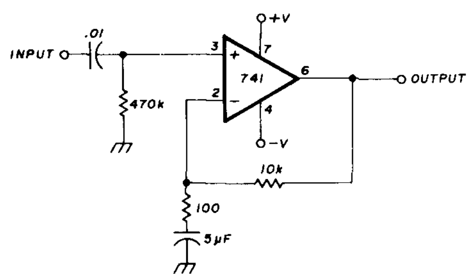

fig. 5. In this 741 circuit the dc gain has been reduced to 1.0, reducing offset problems, but ac gain is still 100.

you designed the feedback network so the op amp had a gain of one, the bandwidth would be 1 MHz. For a gain of 10, the bandwidth would be 100 kHz; with a gain of 100, the bandwidth would be 10 kHz, and so on. That's all well and good, but it's not the whole story when considering gain vs bandwidth tradeoffs.

Slew rate is another parameter of the 741 which requires consideration at the higher frequencies. It is a measure of how fast the output voltage can change; for the 741 it is typically 0.5 volt-per-microsecond. This means that if you design a 741 op amp circuit to have a voltage gain of one, its bandwidth will effectively be 1 MHz only if the signal level is kept small enough to comply with the slew rate limitation. Suppose you feed a 5-volt p-p sine wave signal into this gain-of-one amplifier and start increasing the frequency. At low frequencies, the output voltage would be 5 volts p-p, but by the time you get to 1 MHz, the output would be down to the order of 0.25 volt p-p. This is quite a drop with the input still at 5 volts p-p. Thus the bandwidth is effectively much less than 1 MHz, even though the gain

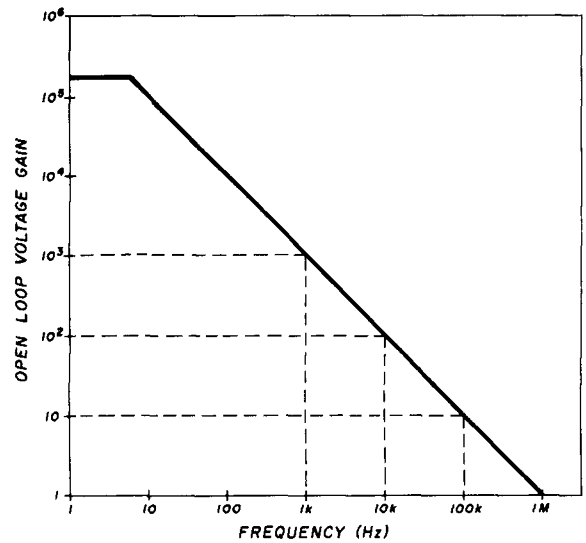

fig. 6. Open-loop frequency response of the 741 operational amplifier.

is only one. Moreover, the apparent bandwidth will be a function of how large a signal you use to measure the bandwidth!

Fig. 7 shows a typical curve of 741 output voltage swing as a function of frequency. Below 10 kHz, output swing is determined by power supply voltage; above 10 kHz, however, output voltage swing falls off rapidly due to slew rate limitations.

Of course, slew rate directly controls rise and fall time in non-linear applications. If the power supply is two 9-volt batteries, then the output of a 741 would typically be able to swing between -7 and +7 volts. At a slew rate of 0.5 volt-per-microsecond, it would take 28 microseconds to rise or fall between these two levels.

Simple audio amplification is the most obvious use for 741 op amps, and reference 1 covers most of the other applications which come to mind. **Fig. 8** shows how simple gain blocks can be cascaded to provide any desired amount of gain. In order to obtain a 10 kHz bandwidth for each 741 op amp, its gain is set at 100, which is equivalent to 40 dB. When two amplifiers hav-

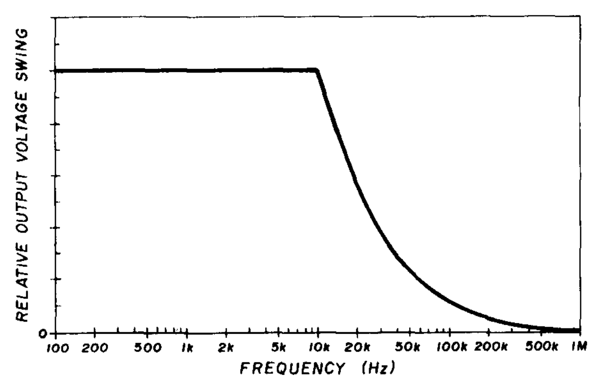

fig. 7. Output voltage swing of the 741 op amp falls off at higher frequencies due to slew rate limitations.

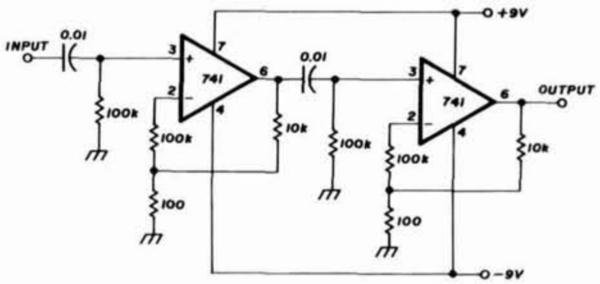

fig. 8. In this circuit two 741 op amps have been cascaded to provide 80 dB of audio gain with bandwidth of about 300 Hz to 6 kHz.

ing 10 kHz bandwidth are cascaded, the overall bandwidth drops to about 6.4 kHz; bandwidth of three stages would be 5.1 kHz. Null pots are not used as the dc output of each amplifier is typically less than 1.0 volt. Capacitor coupling should be used between each stage, however, to prevent the dc offset of the first amplifier from being amplified by the second.

If volume requirements are not too great, 741 op amps will drive a speaker at a comfortable room level. **Fig. 9** shows a simple means of matching the output of the 741 to an 8-ohm speaker. If the peak-to-peak audio swing at the output of the 741 is 12 volts, the power into the primary of the output transformer will be about 36 mW. With larger, more efficient speakers, this is adequate for many applications. The 1.0 μF output coupling capacitor provides low-frequency cutoff of about 300 Hz. This capacitor should be a non-polarized type.

conclusions

One ground rule for using 741 op amps is to make both input terminals see the same amount of dc resistance. Another is that audio bandwidths for voice communication require that each 741 op amp stage have a gain not much more than 40 dB. Also, don't expect much output signal swing above 10 to 30 kHz.

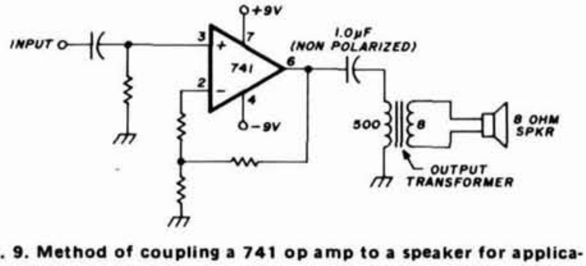

fig. 9. Method of coupling a 741 op amp to a speaker for applications where moderate speaker volume is required.

The 741 op amp is inexpensive, readily available, and easy to use, but, like everything else, it has its limitations. Knowing these limitations will help you decide when and where to use it.

reference

1. Donald Nelson, WB2EGZ, "Operational Amplifiers," *ham radio,* November, 1969, page 6.

ham radio

corner-fed loop antenna for low-frequency dx

Design data for a triangular loop antenna covering 80 through 10 meters

For those amateurs who can't erect a beam antenna for one reason or another, a triangular-shaped wire antenna provides a fair compromise. On these pages you'll find details of such an antenna that has given a good account of itself on all the high-frequency bands. It requires little more space than an inverted vee. However, the antenna does require some means of support that is at least 70 feet (21.3m) high. Advantages of the antenna are:

A. Feedline can be coax cable, TV twin lead, or open wire line.

B. Only one support is needed.

C. Vertical radiation angle seems to be quite low, which is needed for DX work.

D. Results on all bands (except 160 meters) appear to be better for long-haul DX than with the sloping dipole, or inverted vee, which is band limited.

triangular antennas

Several triangular wire antennas have been described.[1,2] These are single-band antennas that are variations of the full-wavelength loop. Such antennas, when mounted vertically and excited at the center with second and other even-harmonic energy, radiate straight up -- not the best for DX work.

G3AQC conducted tests of loop antennas close to ground using vhf modeling techniques.[3] He found that full-wave quad and delta loops mounted in the vertical plane with their highest points one-quarter wavelength above the ground, fed symmetrically with the feed point halfway along the base or at the apex, produced high-angle, horizontally polarized radiation and showed little superiority over a simple dipole or inverted vee at one-quarter wavelength height. These configurations are shown in **fig. 1**.

If a delta loop is inverted so that it has a flat top and its apex points down, as in **fig. 2**, a low-angle, vertically polarized lobe appears, which is omnidirectional in the horizontal plane. G3AQC gives details of a practical antenna of this type, which is said to perform well on all bands from 80 to 10 meters and to have a radiation resistance of around 200 ohms.

corner-fed loop

Even more interesting is the result obtained when a delta loop is fed at one end of the horizontal section, as

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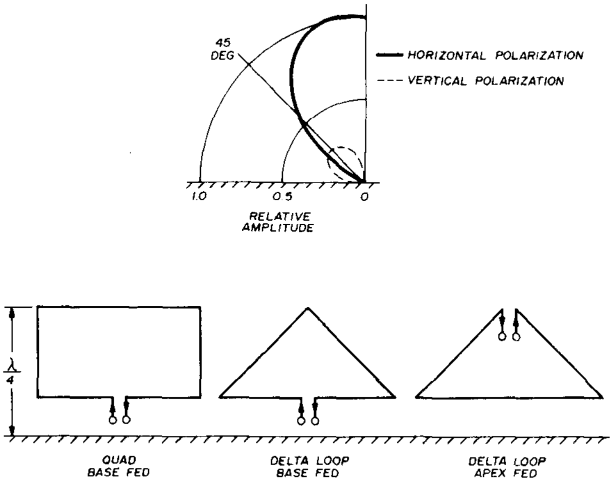

fig. 1. Full-wave loops close to ground. Radiation pattern is little different from a dipole at 1/2 wavelength above ground.

in **fig. 3.** In this case the horizontally polarized radiation is suppressed. The signal is concentrated into low-angle, vertically polarized radiation. The radiation patterns are much the same for both upright and inverted loops; hence the upright delta loop seemed to be the configuration of choice since it required only a single supporting mast.

G3AQC gave no information on the performance of such an antenna on harmonic frequencies. Since the configuration looked attractive, I decided to try such a loop (270 feet, or 82.3m overall) as an all-band antenna.

A triangular 275-foot (83.6m) loop of insulated hookup wire was erected with the apex at 70 feet (21.3m), and the corners of the base were suspended by insulated cords to nearby trees at 15 feet (4.6m). The droop of the base section was within 10 feet (3m) of ground level at the lowest point, which was directly below the apex. Using a simple rf bridge, the length of wire in the loop was adjusted for resonance slightly above 3.5 MHz, where the radiation resistance was 65 ohms. On the second harmonic (resonance in the 7-MHz band), radiation resistance was about 200 ohms and increased slightly on the higher bands, approaching 300 ohms on 28 MHz.

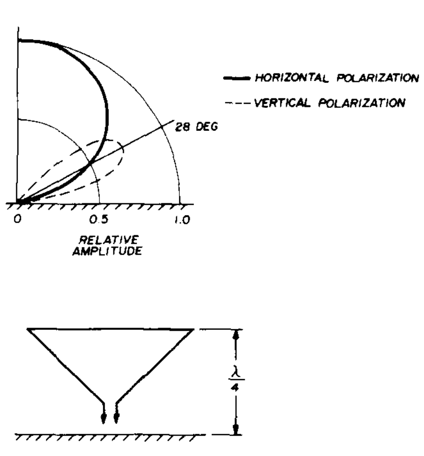

fig. 2. Inverted delta loop at 1/4 wavelength above ground showing vertical radiation pattern in the plane of the loop. Note the low-angle vertical lobe. (After G3AQC.)

feed system

The antenna was fed with 300-ohm line. An antenna coupler of the Z-Match type was used to couple the line to the transmitter, as in **fig. 4.** The side of the line connected to the base of the antenna loop was grounded at the antenna tuner, mainly for lightning protection. (Little or no discernible change occurred in loading or performance on transmit or receive with the ground connection on or off.)

G3AQC states that this antenna is fundamentally unbalanced. If it is fed with coax line, the braid should be attached to the horizontal leg of the antenna.

The antenna can be fed with coaxial cable, twin lead, or open-wire line with minimal loss and moderate impedances occurring at the transmitter end of the line. An antenna coupler is recommended, not only for improved efficiency and hamonic reduction but to prevent out-of-band signals from overloading the receiver.

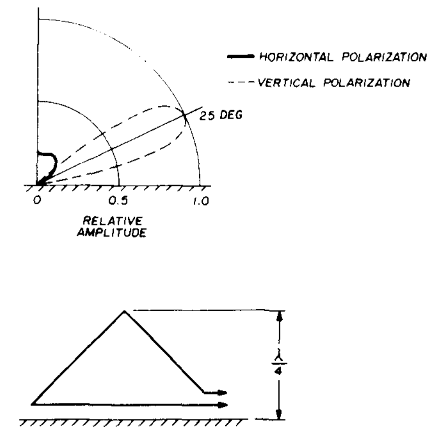

fig. 3. Delta loop, corner fed, showing low-angle, vertically polarized radiation.

evaluation

Antenna evaluation is difficult because of the variables involved. The task is even more difficult because of the patchy band conditions that have prevailed since the loop was erected. The antenna is located on a typical suburban site, which is cluttered with buildings, small trees, and power lines. A low ridge is between my station and the major DX propagation paths: northwest to Europe and northeast to North America. Comparative results with other amateurs in Auckland when using other antennas at ZL1BN indicate that the location is only fair for DX on these paths, although it is quite good on the long path to Europe. The antenna is oriented along a line 110-290 degrees true, which puts it end-on to Rome and Lima and broadside to Alaska and South Africa.

On 80 meters, DX seems at least as good as with an inverted vee at the same apex height. Too few DX openings have occurred to evaluate directivity, although theoretically directivity should be almost omnidirectional on the long haul. At intermediate ranges, out to about 3000 miles (4800 km) the loop is clearly superior to anything ever used at this station.

On 40 meters performance appears superior to a ground plane used previously. Exceptionally good reports have been received both from Europe and the USA, especially under marginal conditions, which indicates that low angle propagation exists both broadside and end-on on this band.

Reports from South America have been good, but it's

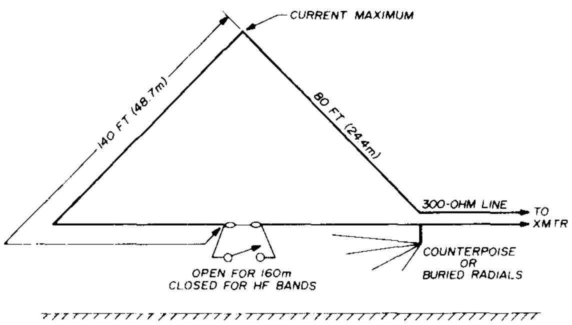

fig. 5. Possible conversion of loop for 160-meter DX operation. Counterpoise or buried radial system should be as extensive as possible. Fanout of ground system below antenna will assist operation on all bands.

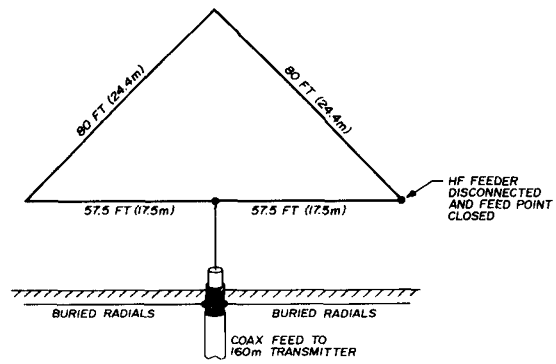

fig. 6. Possible conversion of loop to a vertical monopole radiator for 160 meters.

top band

No attempt has been made to try the loop on 160 meters. If the loop were opened opposite the feed point, it would resonate as a dipole on that band, but results would not be good, since the current point would be close to the ground. It might be better to open the horizontal leg of the loop so that the current point would be at the apex, and the other side of the feeder could be connected to a radial or counterpoise ground, as shown in **fig. 5**.

Another possibility might be to feed the lower geometric center with a single wire and work it against

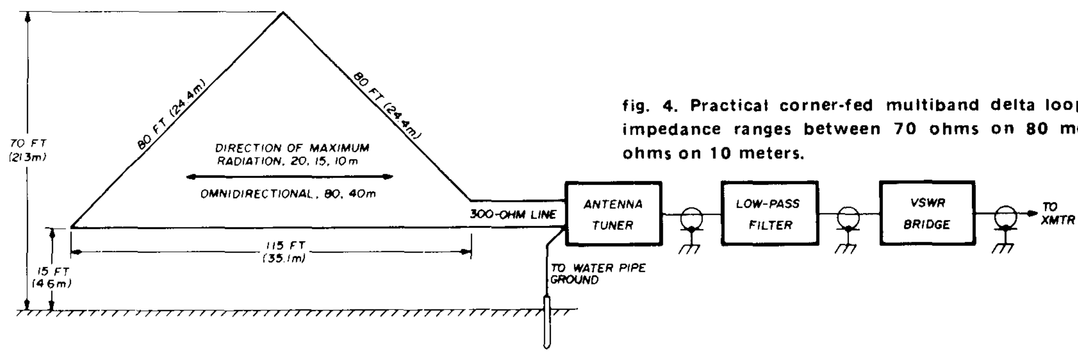

fig. 4. Practical corner-fed multiband delta loop. Feedpoint impedance ranges between 70 ohms on 80 meters to 300 ohms on 10 meters.

possible that radiation is better in the direction away from the point of connection of the feedline. Signal strengths from the loop run about 3 dB below antennas of nearby amateurs using Yagis at 40 to 60 feet (12-18m) above ground. Signals are weaker broadside to the plane of the antenna. The answer might be to suspend a bisquare array or quad loop for 20 meters in the plane of the big loop. This combination could give good coverage on 20 meters and would be inexpensive and easy to install.

Poor band conditions have prevented an adequate evaluation of performance on 21 and 28 MHz. The relatively few contacts made indicate that the pattern is similar to that on 14 MHz with broad lobes off the ends of the loop and nulls on the sides.

ground (**fig. 6**). According to Krause[4] a half-wave loop fed in this way should show true resonance as a vertical quarter-wave antenna against ground without loading coils. All such experiments can be carried out at ground level.

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ham radio

1929 - 1941 the golden years of amateur radio

An informal review of the technical aspects of yesterday that form the basis of modern communications technology

Once upon a time, in an era seen through an opaque veil of memory, there existed a Golden Age of amateur radio. Forged in the boom-and-bust year of 1929, the period ran until December 7, 1941, when amateur radio was closed down "for the duration".

These dozen years encapsulated important technical developments that form the basis of amateur radio today. The period opened with the demise of the battery-operated radio and closed with amateur radio into the developmental stages of vhf fm techniques, single sideband, double-conversion receivers and high-gain beam antennas. It was a period of confusion and technical advancement, with the shadows of the great depression and the coming World War always in the background.

It was during the Golden Years that the amateur population of the United States exploded (**fig. 1**). The number of amateurs jumped from 16,829 in 1929 to 54,502 in 1941, the greatest growth being in the years between 1929 and 1934. Before 1929, the American public was bemused by radio broadcasting, which reached the proportions of a craze. New radio stations were coming on the air daily, battery receivers and do-it-yourself kits were popular, and the general public adopted the new sport of radio listening much in the manner of later fads such as miniature golf and the hula hoop. However, by 1929 the broadcast craze was over. The battery radio had given way to the ac operated receiver, which was rapidly becoming a piece of household furniture instead of a seven-day wonder, and commercial broadcasting was a way of life. Until then amateur radio had been overshadowed in the public eye by broadcast listening (an immensely larger hobby) and had remained an esoteric retreat for a few dedicated individuals and eccentrics — a compact group shielded from the general public by their reticence, and by a widespread interest in broadcast reception.

Gradually the general public became aware of short-wave radio, due partly to the publicity given radio amateurs who pioneered the advance into the shorter wavelengths and led the way on long-distance, high-frequency communications. About the same time, international short-wave broadcasting was started by a few pioneering stations and the American public was thrilled to hear the sounds of Big Ben in London rebroadcast across the country via a transatlantic short-wave relay.

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At the depth of the great depression in 1932, with over one-third of the work force unemployed, young men with idle time on their hands discovered amateur radio and the exciting short waves. Almost overnight short-wave listening and amateur radio caught the public eye and boomed. Short-wave reception, a quick fad, was featured in weekly newspaper columns and the new radios of 1933, in their pristine cathedral-shaped cabinets, boasted at least one short-wave band on their multi-colored dials.

the radio amateur of 1930

The radio ham of 1930, probably unemployed, with little money and plenty of spare time, faced the serious problem of getting on the air at little or no cost to his flat wallet. His technical background was that of a high-school graduate, or a graduate of an electrical correspondence or trade school. Only a small percentage of amateurs were college engineering graduates. Many of the older radio amateurs, of course, worked in the radio industry or in broadcasting, but the just-licensed amateur did not seem to follow the pattern set by his elders.

The task of assembling a ham station was formidable. While many radio stores existed — many more than today — credit was unknown and all purchases were for cash. The price of components and equipment was startlingly high considering the state of the economy. A high school graduate would be pleased to get a job paying $5 a week for 50 hours of work, and radio technicians, on the average, earned from $20 to $30 a week. Most radio components and tubes, however, cost more in 1930 then their modern counterparts do today! It was not until about 1934, when the radio industry geared up for large scale production of inexpensive household radios, that the cost of components dropped sharply.

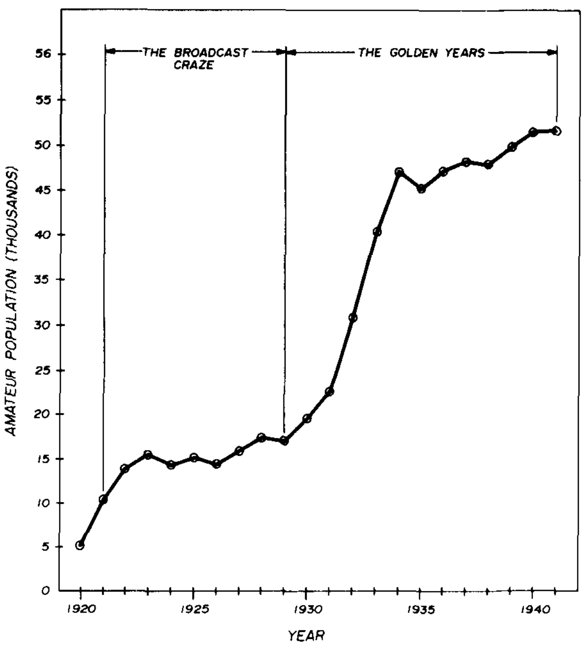
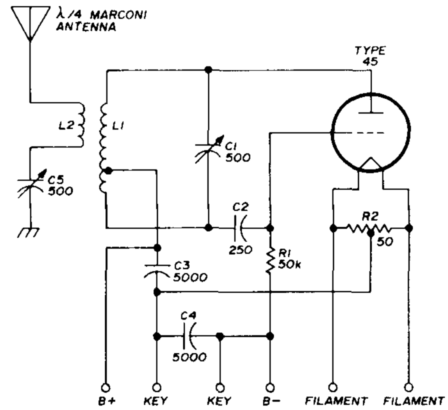


fig. 1. Amateur radio experienced five years of explosive growth between 1929 and 1934, the "population" going from 17000 to 47000. This was due, in part, to the end of the broadcast craze and the introduction of the ac-operated, entertainment broadcast radio. All through the 1920s the American public had a love affair with broadcasting and building broadcast receivers was a popular pastime. When the great depression arrived in 1929 many young men found themselves unemployed with plenty of time on their hands. Short-wave radio provided the next great interest, and amateur radio grew accordingly. By the start of World War II, the U.S. amateur population stood at about 53000.



C1,C5	500 pF variable (Cardwell)
C2	250 pF mica
C3,C4	5000 pF mica
L1	10 turns no. 12 (2mm) enamelled wire on 2-1/8" (5.4cm) diameter bakelite form. Winding length is 2½" (6.4cm)
L2	Same as L1. Adjust spacing between coils for proper coupling
R1	50k, 2-watt IRC metallized resistor
R2	50-ohm wirewound resistor, center tapped

fig. 2. The series-fed Hartley oscillator. Operating in the 80-meter band with a plate supply of 300 volts, this transmitter provides a 7-watt signal. In addition to the components listed above, also needed are five Fahnestock clips, a 4-prong tube socket, and two brown "beehive" insulators to support the coil. Antenna is connected to a series-tuned circuit which is inductively coupled to the oscillator coil.

Nevertheless, the newcomer was not without sources of radio parts. He scrounged from his friends, haunted the dusty back room of the local radio repair shop for castaway battery receivers, and took an occasional trip to the "radio row" of the nearest big town. With a free, broken-down battery receiver, a few used tubes and a cheap B-eliminator power supply he was ready to build his station and get on the air. Many of today's old timers remember this adventure well. This is the story of how it was done, and the results.

1930 beginner's transmitter

The development of the amateur receiver will be discussed at a later date, but here we'll concentrate on a representative beginner's transmitter of the early 1930s. One or two basic circuits were widely popular at that time, circuits that were easy and inexpensive to build and sure-fire in operation. Both were single tube, oscillator-style transmitters.

The transmitter was designed around available parts and a good starting point was the readily obtainable, defunct battery receiver of the late twenties. During the lean years of the early 1930s the great majority of amateurs worked CW with a power input of 50 watts or less and many amateurs enjoyed operating with a power level of only 5 or 10 watts. With luck, then, a beginner could join this group and have a lot of fun. The old battery receiver could be torn down for parts, and it was easy to buy a second-hand B-eliminator power supply that, for a dollar or less, would provide about 180 volts at 40 milliamperes. That would suffice for a 5-watt transmitter and a lot of amateur stations all across the U.S. could be worked with that power and a good antenna!

For a few more dollars a 300-volt power supply could be assembled from junk parts to provide the amateur with a *real* transmitter – upwards of 20 watts input. The possibilities were limitless!

One of the most popular transmitter circuits of the time that was passed hand-to-hand among the newer amateurs was the simple series-fed Hartley oscillator, a simple one-tube transmitter that worked well with many of the triode receiving tubes then available for a few cents (**fig. 2**). The whole transmitter used only one tube and eight parts including the tube socket! This rugged and reliable circuit used inductive feedback coupling between the grid and plate of the tube to sustain oscillation. A very high-C tuned tank circuit minimized the effect of capacitance changes and provided dynamic stability to the oscillator. The simple components were firmly screwed to a heavy board which was isolated from the operating table so that any vibration caused by manipulation of the key would not be imparted to the oscillator. When run from a power supply that had reasonably good regulation, and used with a taut antenna that did not swing in the wind, the little transmitter sounded as good (or better) than some of today's more sophisticated equipment.

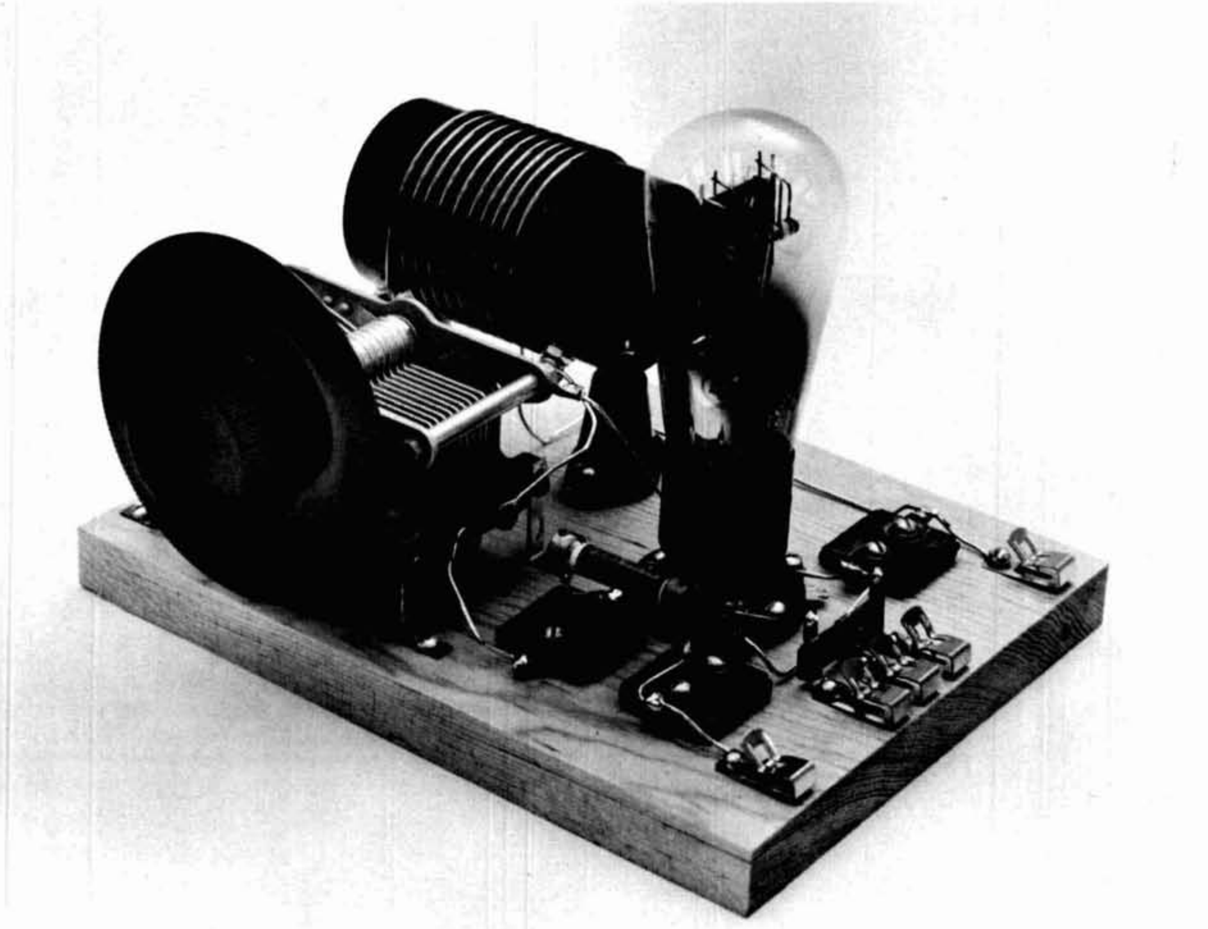


fig. 3. The way it was done in 1930. Using a single 45 tube, this little transmitter gives a good amount of itself in 1976. Built of parts taken from a defunct battery receiver, the Hartley transmitter cost little or nothing to build. High-C circuit provides good stability and when run from a regulated 300-volt power supply, the rig provides a good 1976-style signal. A 160-meter version of this transmitter is shown in the May, 1932 issue of *QST*.

A re-creation of the famous 1930s Hartley transmitter is shown in the photograph of **fig. 3.** Built in 1976 with hard-to-find 1930 components, this rig has been on the air and has been used to work a number of stations on 80-meter CW. Using a 245 triode at 300 volts and 50 milliamperes plate current (15 watts input), the transmitter puts out a solid 7 watts with good stability. The 245 was a popular tube because it could often be obtained free, for a few cents used, or as a manufacturer's "second" for 39 cents.

A *Cardwell* receiving-type variable capacitor is used, and the tank coil is wound on a genuine bakelite form. The bypass capacitors are uncased mica units, rugged and reliable, but already going out of style as bakelite-cased capacitors came into vogue in 1930. Time to assemble and test the transmitter is about three hours, including giving the "breadboard" a coat of shellac.

The transmitter is keyed in the filament return circuit. Since no waveshaping is included, the keying is *hard* so the resultant waveform may distress a nearby amateur who is operating close to the frequency of the midget transmitter. Any attempt to include a keying filter should be approached with caution as softening of the keying tends to place a "yoop" on the signal. A slight amount of filtering, however, can be used to advantage without disturbing the crystal-like note of the transmitter.

The rf plate impedance of the 245 oscillator is about 3000 ohms. The L/C ratio of the plate tank circuit provides a Q of about 30. The circulating current in the tank circuit, therefore, runs about 6 amperes. The tank coil and leads to the variable capacitor are made with number-12 (2mm) wire to carry this amount of current. The oscillator runs well into the class-C region as the rms grid voltage is close to 140 volts. The μ of the 245 is 3.5 so a cutoff voltage of about 85 volts is required at a plate potential of 300 volts.

The simplest antenna for the little transmitter is a 66-foot (20m) end-fed Marconi, working against ground. A series-tuned circuit, consisting of a coil and capacitor (whose values are approximately the same as those in the main tank circuit) can be used. Alternatively, the same series-tuned circuit can be used to match into a coaxial feed system for a dipole or inverted-V antenna. At W6SAI, a simple 66-foot (20m) wire is used for contacts up and down the West Coast.

transmitter power supply

A bonanza existed for the penny-pinching 1930's amateur in the flood of obsolete B-eliminator power supplies which were rendered useless by the advent of ac operated broadcast receivers. These units provided up to 180 volts dc at 30 to 50 milliamperes and were intended as a replacement for the messy and short-lived B-battery.

Reaching the market in quantity about 1926, the B-eliminator solved the rectifier problem by side-stepping the vacuum diode, going instead to a unique gas rectifier which required no filament. The *B-H tube*, designed and manufactured by the Raytheon Company was the answer, and multitudes of these tubes were available to the 1930 amateur for as little as five cents apiece in the storage bins on radio row **(fig. 4)**.

The B-H tube operated on the principle of electron conduction in a gas. Basically, when a potential difference exists between two cool metallic surfaces separated by a gas, the few free electrons in the gas move toward the positive (anode) terminal at a rate which is depend-

fig. 4. An early full-wave rectifier: the Raytheon BH tube. Designed for B-eliminator service, the BH tube provided up to 180 volts dc at a maximum current of 50 milliamperes. A late production BH tube is shown at left, with an early, brass-based predecessor, the B tube at right (the H standing for "heavy duty"). The larger B tube was rated at 30 milliamperes. Both tubes were gas types with no filament. Shortly after the BH tube was designed it was made obsolete by the 280 (later type 80) vacuum rectifier.

ent upon the potential gradient. As the gap is decreased, the gradient is increased to a point at which the electrons attain sufficient velocity to knock an electron off a gas molecule, thus multiplying the number of negative particles. The gas now becomes a conductor.

When one electrode is larger than the other, the current will flow from the large electrode to the small one, and when one electrode is point-size, the current flow is practically unidirectional. This means that the anode must be very small in size compared to the cathode and, unfortunately, the anode dissipation is high per unit area. As a result anode material and insulation assume critical proportions.

The problem of building a gas rectifier tube that would work, and deliver reasonable life, was finally solved by a research team under the direction of Dr. Vannevar Bush at the Massachusetts Institute of Technology in 1924.* A special, heat-treated alloy was used for two pin-point anodes, which were surrounded by the larger cathode (**fig. 5**). The "short-path principle" was

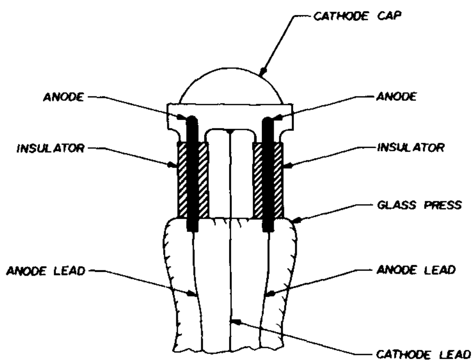


fig. 5. Interior of the BH gas rectifier. In a gaseous atmosphere electrons flow between two conducting points. If one electrode is larger than the other, the current flows from the large electrode (negative) to the small electrode (positive). With a point-type anode the reverse current flow is very small but anode dissipation is severely limited by the small area of dissipation. The "short-path" principle (discussed in text) is used to insure that electrons strike the tips of the anodes. Special, high-temperature lava insulators are used to insulate the tips from the cathode "hat" and glass press.

used to provide a good insulating ring between the anodes and the cathode. This postulate states that a rarefied gas is an insulator between two areas in close proximity if other *points* exist in greater proximity. Thus, to provide a good insulating ring around the anodes and the cathode, the hat-shaped cathode was shaped so as to completely pass around the cathode supports to utilize the "short path" principle as an insulator. Since the discharge cannot pass between the areas in close proximity, only the points of the anodes are struck by the electrons, leaving the insulating material far enough away from the anode heat and the possible disintegrating effect of high temperature. A complete description of the BH tube appeared in the November, 1925, issue of *QST*.[1]

Viewing those days from these days, it is difficult to see why this round-about approach was taken to develop a full-wave rectifier as diode conduction had been known for many years and various companies were manufacturing vacuum diodes as rectifiers for telephone equipment.

*The BH tube was developed from pioneering work in the field of gas conduction done in 1916 by Charles G. Smith of Raytheon, aided by J. A. Spencer and M. Andre of *La Radio Technique* of Paris, France. By 1926 more than twenty companies in the United States were licensed by Raytheon to manufacture B-eliminator units using the BH tube.

A logical guess is that a patent problem existed in this area. Looking back, it appears that oxide-coated filaments were generally used by the Western Electric Company and thoriated tungsten filaments were used by RCA and their licensees. Since, by agreement, the Western Electric Company was not in the home-entertainment radio business, the possibility exists that the oxide-coated filament was denied RCA and one of the licensees (Raytheon) turned to the gas tube as the only alternative.

Regardless of the actual reasons, technical or otherwise, the first ac power supplies sold to the general public in large quantities used the Raytheon B-H tube and these, in turn, were obsoleted by the double diode, oxide-coated filament 280 rectifier tube which shortly became available through some mysterious inner workings of the infant entertainment electronics industry.

on the air

And so the amateur newcomer was finally on the air! The receiver, a two-stage job using a 201A detector and 201A audio amplifier, was also built from a defunct battery receiver and could be run from the same B-eliminator as the transmitter. An old automobile storage battery provided the filament power. Sometimes a pair of 199 tubes would be used in place of the 201As — then a no. 6 dry battery would suffice for filament power. With luck the whole station could be assembled for less than five dollars.

The results? Since most amateurs ran low power in those days, the 7-watt transmitter provided a good, workable signal. Looking back through old copies of *QST* reveals that many amateurs, with a transmitter of this type, worked hundreds of stations on 80 meters including contacts with Canada, Mexico and Alaska. Several W6 stations maintained schedules with New Zealand on 80 meters using 10-watt transmitters of this same general type. Some adventurous amateurs put the little Hartley transmitter on 40 and 20 meters and worked real DX, but the problem of drift and stability became onerous at those frequencies.

Building and operating a transmitter of this type is an adventure in itself: the search for authentic parts, the assembly and test, and on-the-air operation. When you tell a station you're working about the transmitter the usual reaction is one of amazement — amazement that such results can be obtained with such simple equipment. When you work an old-timer who remembers the little Hartley the reunion is dramatic and brings back a flood of memories.

So hats off and a silent salute to the beginning amateurs of yesterday, many of whom used the little Hartley, and many of whom are the engineers, innovators and industry leaders of today.

reference

1. *Miles Pennybacker, "The Raytheon Rectifier," QST*, November, 1925, page 38.

ham radio

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More Details? CHECK—OFF Page 110

CIRCUITS & TECHNIQUES

Ed Noll
W3FQJ

low-noise two-meter preamp

There has been increased interest in weak-signal DX on 144-MHz recently, and some amateurs who have limited their vhf activity to fm for the past several years are rediscovering ssb activity on the lower sections of the band. Part of this renewed interest in vhf ssb is a result of the commercial multi-mode vhf rigs which are now available, and some is a direct spin-off from OSCAR. In any event, interest in vhf ssb and CW is growing, and in several parts of the country two-meter "activity" nights are being sponsored by local vhf groups to encourage ssb activity. (In the Northeast the two-meter activity night is on Monday evening, beginning about eight o'clock; calling frequencies are 144.110 and 145.010 MHz.)

While many two-meter operators are using modern solid-state converters, a great number have simply dusted off their old vacuum-tube converters and placed them back in service. Hence there is increased interest in low-noise preamplifiers. The two-meter mosfet preamp shown in **fig. 1**, which was presented at the New England ARRL Convention last fall by K2RTH, is a straightforward, easy-to-build design with a maximum noise figure of about 2 dB (1.7 dB typical). The complete preamplifier is built on a piece of copper-clad circuit board 4½ inches long by 2 inches wide (11.4 x 5.1cm). The transistor is mounted in a shield, also made from 1/16 inch (1.5mm) thick circuit board, which is 1-3/4 inch (4.5cm) square. The preamp is assembled on the main board and all grounds are made by soldering directly to the copper foil (do not use ground lugs). All 470 pF bypass capacitors are also soldered directly to the copper foil with leads no more than 1/16 inch (1.5mm) long.

After the preamp is assembled and all circuit connections have been checked, connect 12 Vdc (maximum) and measure the current drain. It should be 9 to 11 mA. If higher than this, reduce the supply voltage slightly. If your low-voltage dc supply is not variable, you can install a resistor in series with the dc supply line (between C1 and and power supply) and adjust the resistance value for 9 to 11 mA total current drain.

Install the completed preamp in front of your two-meter converter and adjust the two 10 pF trimmers for maximum signal. Gain of the circuit should be about 18 dB and noise figure is 2 dB maximum, so it will really improve the performance of your receiving setup if you're using an old tube-type preamp or converter. You can check the stability of the preamp by touching the transistor with your finger -- nothing should happen. If there's any effect on the received signal when you touch the transistor, check for a bad bypass capacitor (or excessive capacitor lead length).

audio filters

As was pointed out to me recently by WA4KAC, the lowpass audio filter described by OD5CG in the January, 1974, issue of *ham radio*[1] suffers from a loss of attenuation at frequencies beyond the frequency of "infinite" attenuation. This "hump" behavior is characteristic of m-derived filters.

Using the same number of inductors as the original (three), WA4KAC built the lowpass, pi-section filter shown in **fig. 2** from the description given by W8YFB in the August, 1972, issue.[2] In WA4KAC's circuit a four-pole, double-throw switch provides the selection of two cutoff frequencies: 650 or 2000 Hz. The filter capacitors were matched to obtain the response shown in **fig. 3.** The use of two additional 1 μF capacitors for the CW section of the filter(W8YFB used only the two center 2 μF capacitors) results in a sharper cutoff in the CW position and less loss within the passband. With pi-section filters there is no loss of attenuation beyond the frequency of "infinite" attenuation – response continually decreases beyond the cutoff frequency. Cascading filters results in a sharper cutoff response.

OD5CG's audio filter, however, has the advantages of using smaller values of capacitance and provides sharper frequency cutoff. His m-derived filter has an attenuation of 50 dB at 1.5 times the cutoff frequency (-3 dB point on the response curve), whereas the pi-section filter of **fig. 2** has 50 dB attenuation at approximately 1.8 times

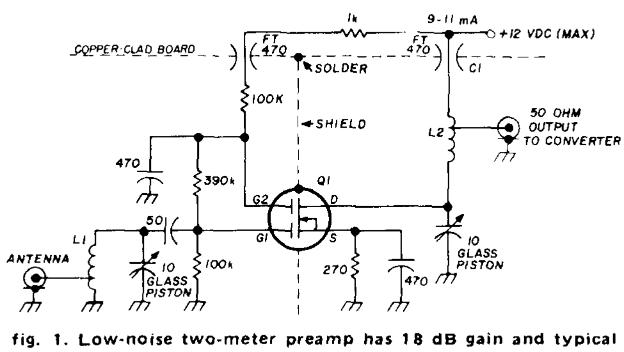

fig. 1. Low-noise two-meter preamp has 18 dB gain and typical noise figure of 1.7 dB. L1 and L2 are each 3½ turns no. 18 (1.0mm) tinned, 3/8" (9.5mm) diameter, 1/2" (6.5mm) long, tapped 1 turn from cold end. Mosfet Q1, in order of preference, is a MEM554C, 3N159, 3N140 or 3N141. These are all unprotected dual-gate mosfets, so use care when handling them.

the cutoff frequency.

A very simple variable audio filter that can be used on both CW and ssb, submitted by KH6AQ, is shown in **fig. 4**. Although KH6AQ uses this filter with a tube-type audio power stage, a similar arrangement should be suitable for solid-state audio power stages.

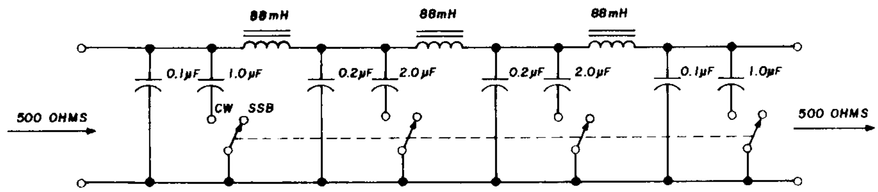

fig. 2. Lowpass audio filter built by WA4KAC has switch for selecting one of two cutoff frequencies: 650 Hz for CW or 2000 Hz for ssb operation. The filter capacitors were matched to obtain the response shown in fig. 3.

dry cell life

Since the power provided by a dry cell is generated by a chemical reaction, and that reaction continues even when the battery is sitting on the shelf, dry cells begin losing power the moment they are produced. Furthermore, batteries discharge faster and faster as time goes on, and the warmer the storage temperature, the shorter the shelf life. Although D-size batteries shouldn't lose more than about 15 per cent of their capacity during the first year after manufacture, smaller batteries (such as the 9-volt transistor radio batteries which are made up of six 1.5-volt cells) may lose 20 to 40 per cent of their charge in the first year. The more expensive alkaline batteries are less sensitive to temperature changes but their shelf life is only a little longer than ordinary carbon cells.

One way to extend the shelf life of dry batteries is to store them in a refrigerator (the chemical reaction slows at lowered temperatures). According to industry experts, new batteries which are placed in a freezer may retain most of their capacity for as long as three or four years. To keep the batteries dry they should be wrapped in plastic before putting them in the freezer — when they are removed from the freezer they should be left in the plastic wrapping until they have warmed up to room temperature. This prevents condensed moisture from forming on the outside of the battery.

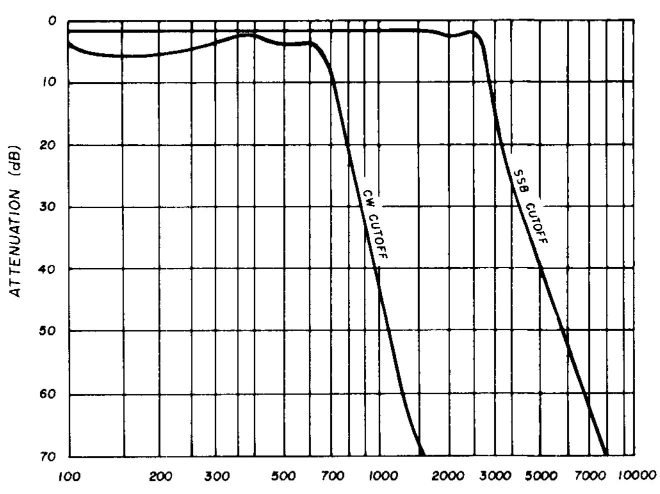

fig. 3. Response curve of WA4KAC's lowpass audio filter shows 650 Hz cutoff (CW) and 2000 Hz cutoff (for ssb operation). Filter capacitors were matched to obtain this response curve.

replacing selenium rectifiers

Although there are direct silicon rectifier replacements for most popular vacuum-tube rectifiers, replacing selenium rectifiers in older electronic equipment poses more of a problem because operating data for these devices is seldom available. However there are two rules of thumb which can be used to determine the correct rating of a silicon diode replacement. The reverse voltage rating of selenium rectifiers is approximately 75 volts per plate. Thus a two-plate selenium rectifier has a voltage rating of 150 volts; three plates, 225 volts; four plates, 300 volts; etc.

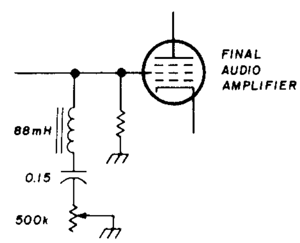

fig. 4. Simple tunable audio filter built by KH6 AQ for use with a tube-type audio power stage.

The current rating of selenium rectifiers is determined by the area of the plates and is given approximately by the relationship

$$\text{current rating } (mA) = 450S^2$$

where S is the length of one side in inches* (assumes square plates). Thus a selenium rectifier with plates which are 3/4 inch (19mm) wide are rated at 250 mA; 1 inch (25mm) wide, 450 mA; 1¼ inch (32mm) wide, 700 mA; etc. This is the maximum current the selenium rectifier can handle at 75 per cent efficiency (the efficiency of seleniums decreases with age). For added reliability, of course, you should choose a silicon replacement with ratings that exceed these calculated voltage and current values.

*In metric dimensions, the current rating in mA is given by $70S^2$ where S is the length of one side in cm.

12 to 6 volt converter

There is still a good deal of used vhf-fm equipment on the market which was originally designed for operation from 6-volt mobile power supplies. Although some amateurs have converted this equipment to 12 volts by rebuilding the power supply, an easier and less expensive solution for medium-powered gear is to build the simple 12 to 6 volt converter shown in **fig. 5**. With the devices mounted on a suitable heatsink the maximum output current of this circuit is about 15 amperes. If the positive and common lines are isolated from the chassis, the circuit may be used with either negative- or positive-grounded mobile systems.

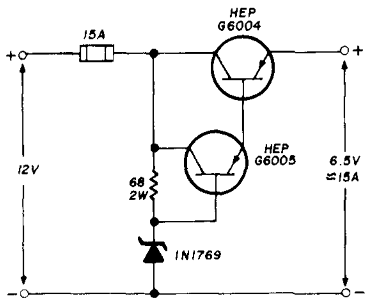

fig. 5. 12- to 6-volt converter suitable for operating low- and medium-powered 6-volt vhf-fm equipment from a 12-volt power supply.

saving your mobile rig

There's little you can do to prevent a thief from breaking into your car and ripping off your mobile rig, but you can slow him down a bit. Burglar alarms, for example, don't prevent thefts – they're only guaranteed to let you know that a theft has already taken place! Since most successful thieves can disarm an alarm in a matter of seconds, commercial auto burglar alarms are little more than an annoyance -- they're certainly not a deterrent. It may be more difficult for a professional thief to disarm a homebrew alarm that he knows nothing about, but since he can break into your car, rip out your gear and be on his way within 20 or 30 seconds, alarms offer little protection. An alarm may scare off an inexperienced thief, but all too often the owner neglects (or forgets) to turn on the alarm when he leaves the car, or doesn't even roll up all the windows and lock the doors.

When you get right down to it, aside from locking your mobile rig in a bank vault, there's very little you can do to completely protect it from departing to points unknown. However, here is a circuit from *The Atlanta Ham* (published by the Atlanta, Georgia, Radio Club) which might help you to recover your mobile gear if it does get ripped off (see **fig. 6**). In almost all cases when the thief leaves your car with your rig he has your microphone, your Touch-Tone pad and the power cord from the fuseholder down. Unless, of course, you put your mike and Touch-Tone pad in the trunk (highly recommended). Usually the rig is simply ripped out, wires dangling. If you build this latch circuit into your rig, however, the thief has a radio that won't push-to-talk when he does and, furthermore, transmits all the time. If you were thoughtful enough to put your mike in the trunk, whenever he attaches power the rig will put an unmodulated carrier on the air, making it easier to track him down. This is especially true in metropolitan areas where local fm operators have been advised to be on the lookout for your "speechless" fm transceiver.

If the circuit is carefully installed in your rig, and the new wiring is worked into the existing wiring harness, it's unlikely that the thief will be able to locate the trouble. And even if you don't recover the rig you may get some satisfaction out of the fact that the thief couldn't get any use out of it and had to junk it!

While we're on the subject of mobile radio gear, are you absolutely sure that your rig is covered by your auto insurance? Some amateurs who have lost their equipment to thieves discovered after the fact that the loss was not completely covered. With many mobile rigs now costing upwards of $500 or more, it's comforting to know that any loss is completely covered. If you're not sure, check with your agent, and make sure the extent of the coverage is in writing. You may be surprised to learn that your policy has only limited coverage – expensive items such as mobile radios and cameras may require additional coverage to be fully insured against loss.

european semiconductors

I have had a number of requests for information on the system used for numbering European semiconductors. Unlike the 2N-system used in the United States, the European numbering system gives a good deal of basic data without resorting to a transistor data book. In their system the first letter indicates germanium (A) or silicon (B), the second letter gives the general construction or application, and the remainder is the device serial number. For the second letter, C indicates an audio type (not power); D, audio power; E, tunnel diodes; F, small-signal rf; L, rf power; P, photosensitive; R, controlling and switching (not power); S, switching transistors (not power); T, switching and controlling devices with specified breakdown characteristics; U, power switching transistors; Y, power diodes; and Z,

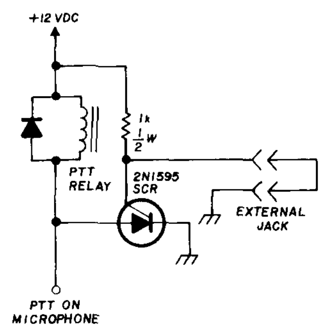

fig. 6. SCR latch turns on your mobile rig when power is applied if external circuit is broken when the rig is stolen. External wires can be run under the dash so thief must cut them when removing the rig from your car. If the PTT relay doesn't have a protective diode across the coil, install one. The SCR is a 100 PIV, 1 amp device such as the 2N1595. SCRs such as the HEP R1003 (0.8 amp) or R1217 (4 amps) should also be satisfactory.

zener diodes. For the serial number, three numerals are used for entertainment types; one letter – X, Y or Z – plus two digits indicate industrial types. The AF117, for example, is a small-signal germanium rf transistor for entertainment purposes; the BCZ11 is an industrial silicon audio transistor.

original which used the optical coupler. In his circuit W2CQH also used a short piece of miniature coaxial cable for the 1-turn output link — the outer shield is grounded only at the coaxial connector so the braid acts as a Faraday shield, eliminating any capacitive signal (and noise) pickup from the circuit.

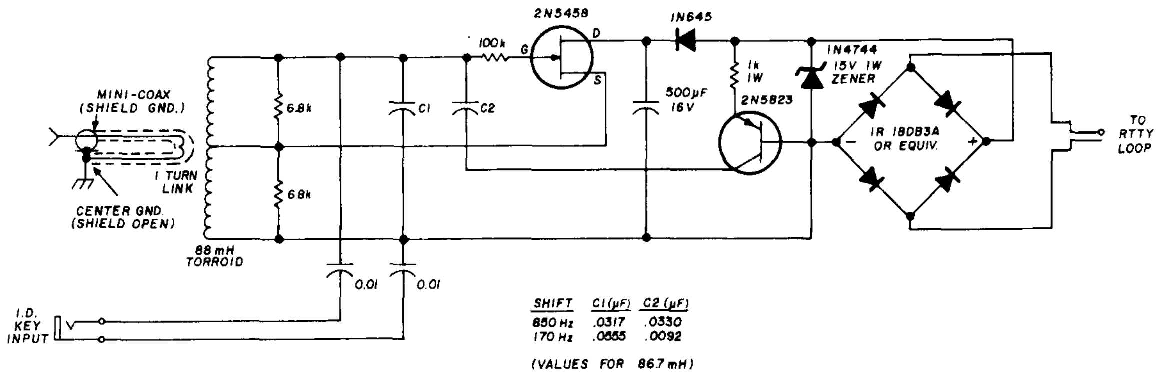

fig. 7. W2CQH's modification of W2LTJ's simple audio-frequency keyer uses silicon pnp transistor switch instead of an optical coupler. Shield on 1-turn coaxial loop acts as Faraday shield.

audio-frequency keyer for RTTY

Several readers have had difficulty obtaining the MOC1002 optical coupler which was used in the simple audio-frequency RTTY keyer described in the August, 1975, issue of *ham radio*.[3] W2CQH faced this problem and solved it with the silicon pnp transistor switch shown in **fig. 7**. Author W2LTJ has also built this version of the circuit and reports that it works as well as the

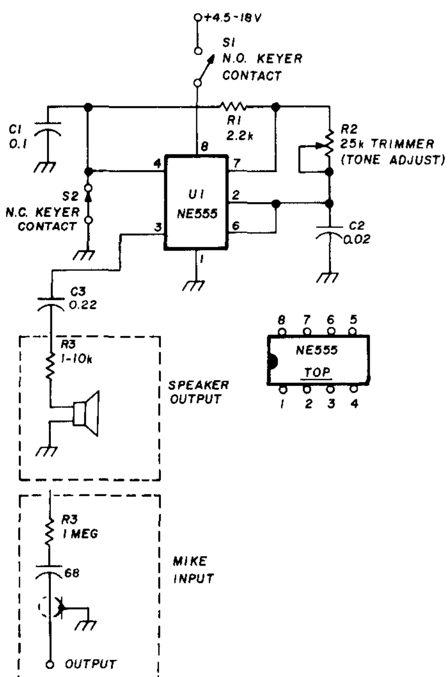

fig. 8. Autopatch keyer oscillator is based on NE555 IC timer. Either normally-open or normally-closed keyer contacts may be used to activate the oscillator. Line to microphone input must be shielded.

keyer oscillator

Shown in **fig. 8** is a circuit for a simple keyer oscillator submitted by KH6IHT and KH6IEL which they designed for autopatch use. Since the autopatch system in their repeater has a decoder bandpass from 2980 to 3080 Hz, R2 is adjusted to 3042 Hz for best results. However, R2 can adjust the output tone over a rather wide audio range for other applications. Two output options are available: speaker or microphone (the microphone input line must be shielded). R3 is adjusted for the required output/input level and may be replaced by a variable resistor, if desired. Normally-closed keyer contacts can also be connected between pin 7 of the NE555 and ground. A 9-volt transistor radio battery (NEDA 918) is recommended for the oscillator.

75A4 noise limiter noise

Some time ago W4ZKI mentioned to the editor that the 6AL5 noise limiter in Collins 75A4 receivers tends to be regenerative, contributing unwanted noise to the receiver. Since the noise limiter is not too effective on ssb or CW, and few operators use it, W4ZKI recommended that the circuit be disabled and the tube removed. This information was passed along to W9KNI who solved the problem very neatly by removing the 6AL5 and plugging in a jumper between pins 2 and 7. On my 75A4 this simple modification reduced the no-signal noise level by about 3 dB, a worthwhile improvement.

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ham radio

MICROPROCESSORS

generating input/output device-select pulses

The preceding column in this series on microcomputer interfacing discussed the 16-bit *out* instruction contained within the 78 instruction set of the 8080 microprocessor chip. The *out* instruction comprises two successive 8-bit bytes and can be written in binary notation as*

$$11010011_2 \; XXXXXXXX_2$$

in 8-bit octal code, 323_8 YYY_8

or in 8-bit hexadecimal code, $D3_{16}$ ZZ_{16}

A discussion of how you convert the 8-bit binary code into either octal or hexadecimal code can be found in reference 1. In the above notations, $XXXXXXXX_2$ represents an 8-bit byte that can range in value from 00000000_2 to 11111111_2; YYY_8 represents a three-digit octal code that can range from 000_8 to 377_8; and ZZ_{16} represents a two-digit hexadecimal code that can range from 00_{16} to FF_{16}. A quick calculation will demonstrate that 11111111_2, 377_8, and FF_{16} all represent the same 8-bit binary word.

The choice of a coding system is up to you. The binary code is awkward to write and difficult to remember. Octal code is used in the popular Digital Equipment Corporation PDP-8 and PDP-11 minicomputer software and is easy to remember. Hexadecimal code is a more natural code for an 8-bit binary word and is currently quite popular among microprocessor manufacturers.

We should emphasize the fact that the manner in which you write the code on paper will not affect the way in which the microcomputer will execute a program. Both octal and hexadecimal code must eventually be converted back to binary code, which is stored in successive 8-bit memory locations. The code conversion can be accomplished in several ways, e.g., by hand or by a computer program.

The second 8-bit byte, $XXXXXXXX_2$, in the 16-bit *out* instruction is the *device code* for the output device. As indicated in previous columns, 256_{10} different devices can be addressed with the aid of such a code. The manner in which this is done is shown in full detail in **fig. 1**, which provides a device decoding circuit consisting of seventeen SN74154 TTL 4-line to 16-line decoder/demultiplexer IC's. Since this is a rather complicated circuit, we would first like to discuss the simpler decoding circuit shown in **fig. 2.**

The SN74154 IC is a 4-line to 16-line decoder that allows you to input any 4-bit binary word ranging from 0000_2 to 1111_2 and select any single output among sixteen different output channels labeled 0 to 15_{10}. G1 and G2 are the *strobe* or *gating* inputs to this chip; when they are both at logic 0, the SN74154 chip is said to be *enabled* – it is operative, and one of the sixteen output channels, that which corresponds to the binary input at pins 20 to 23, is at logic 0. When either G1 or G2 is at logic 1, the SN74154 chip is said to be *disabled* – it is inoperative, and all sixteen output channels are at logic 1 irrespective of the binary input at pins 20 to 23.

The basic trick that the 8080 microcomputer employs is to *enable* the SN74154 chip for a very short period of time, 500 nanoseconds to be exact. This is done with the aid of a negative clock pulse at G1. This negative clock pulse, called $\overline{\text{IN}}$ or $\overline{\text{OUT}}$ in reference 1 or $\overline{\text{I/O R}}$ or $\overline{\text{I/O W}}$ in the Intel Corporation literature,[2] is generated by the microprocessor chip with the aid of some additional circuitry. $\overline{\text{IN}}$ and $\overline{\text{I/O R}}$ refer to the 16-bit *in* instruction, whereas $\overline{\text{OUT}}$ and $\overline{\text{I/O W}}$ refer to the 16-bit *out* instruction that we are discussing here. During this 500 ns period of time the device code appears on the *memory address bus* and can be used as inputs to the SN74154 chip to select a desired output channel.

The memory address bus is a group of 16 output pins on the 40-pin 8080 IC (**fig. 3**). A *bus* can be defined as follows:[1]

Bus. A path over which digital information is transferred, from any of several sources, to any of several destinations. Only one transfer of information can take place at any one time. While such transfer is taking place, all other sources that are tied to the bus must be disabled.

The important point here is that two types of informa-

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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.

*The subscript 2 indicates binary notation, a subscript 8 denotes octal code, a subscript 10 designates decimal notation, and a subscript 16 indicates hexadecimal code.

tion can appear on the 16-bit memory address bus: a) the 16-bit memory address for a memory location addressed by the 8080 microprocessor chip, or b) the 8-bit device code present in the second 8-bit byte of an *in* or *out* microprocessor instruction, but not both at the same time. The *in* or *out* microprocessor instruction requires 5 μs for execution, and the device code appears only during the last 1.5 μs of this time.

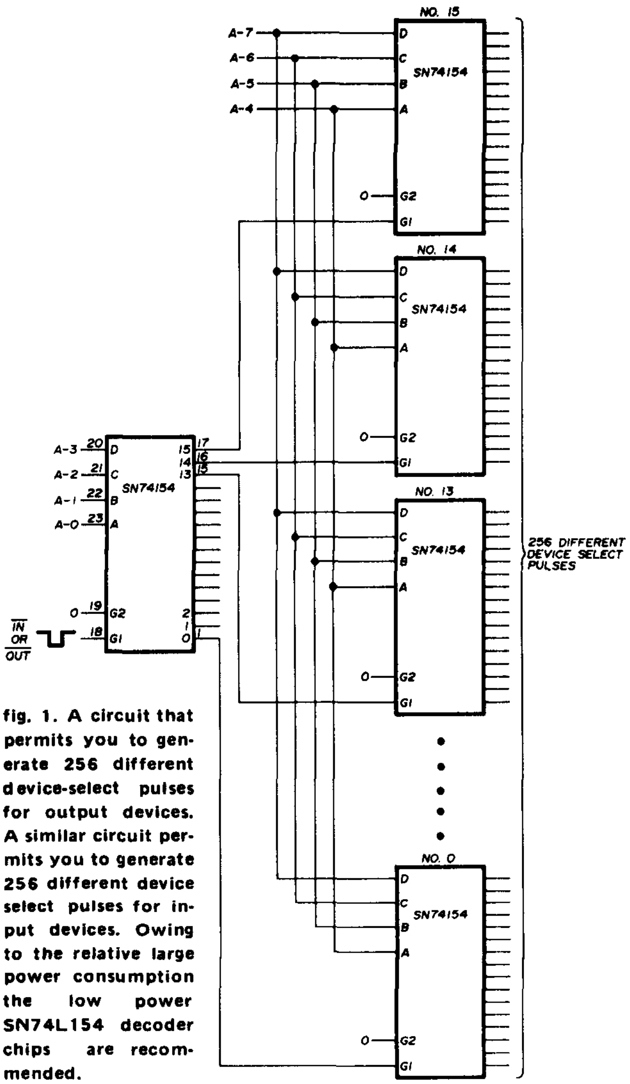

fig. 1. A circuit that permits you to generate 256 different device-select pulses for output devices. A similar circuit permits you to generate 256 different device select pulses for input devices. Owing to the relative large power consumption the low power SN74L154 decoder chips are recommended.

When the device code appears on the memory address bus, the bus is subdivided into two 8-bit bytes, each byte containing the address code. Thus, you have your choice of bits A-0 through A-7, or A-8 through A-15, for the device code. This 8-bit device code is connected directly to one or a group of SN74L154 chips, as is shown in figs. 1 and 2. In fig. 2, only four of the eight device code bits are used, whereas in fig. 1, all eight device code bits are decoded into 256 different output or input device code negative clock pulses.

Each output device is addressed uniquely by the $\overline{OUT}$ function pulse and a corresponding 8-bit device code. The same is true for each input device; only the $\overline{IN}$ function pulse is employed instead of the $\overline{OUT}$ function pulse at the gating input G1 to the SN74154 chip. Each device-select pulse lasts for only 500 ns, the time that the SN74154 chip is gated at G1.

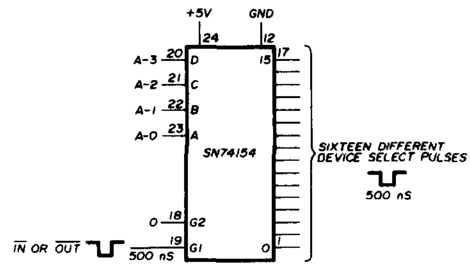

fig. 2. A simpler circuit that allows you to generate sixteen different device-select pulses for either input or output devices but not both simultaneously.

Fig. 4 provides a set of timing diagrams that summarizes the external consequences of the 16-bit *out* instruction:

- An 8-bit device code appears on the memory address bus, in this case the code for device 11010001_2 or 321_8, for a period of 1.5 μs.
- During this 1.5 μs, an out function pulse is generated for a period of 500 ns.
- These nine output lines are used as inputs to the seventeen SN74154 IC circuit shown in **fig. 1**. This circuit generates a 500 ns negative device-select pulse for device 321_8. All the remaining 255 outputs from the decoders remain at logic 1.

This device select pulse can be used to turn on the solid-state relay shown in the circuit in last month's column.

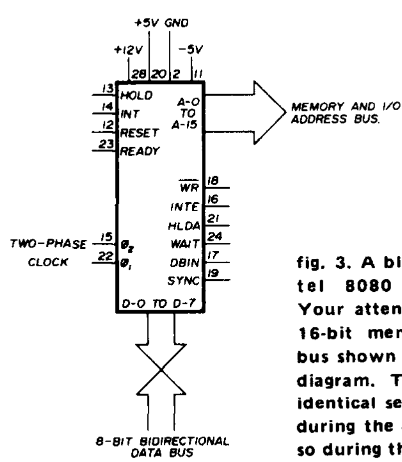

fig. 3. A block diagram of the Intel 8080 microprocessor chip. Your attention is directed to the 16-bit memory and I/O address bus shown at the top right of the diagram. This bus provides two identical sets of 8-bit device codes during the *out* instruction and also during the *in* instruction.

The program, which is analogous to one given previously, is simply:

memory address	octal instruction	description
0	323	Send device select pulse to device given by the following 8-bit device code
1	321	Device code for clear input to SN7474 flip-flop
2	166	Halt the microcomputer

For further information, please refer to last month's column.[3]

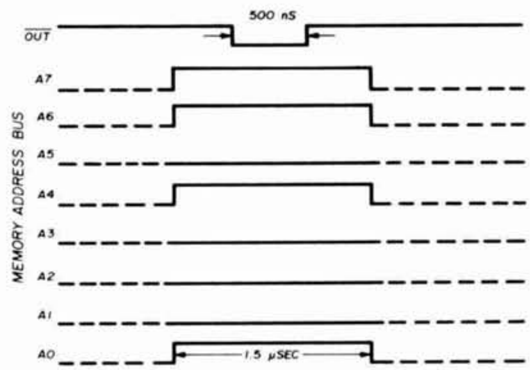

fig. 4. A set of timing diagrams that depict the relationship of the $\overline{OUT}$ function pulse and the device code information appearing on the memory address bus. This information is applied to SN74154 decoder circuits such as those shown in figs. 1 and 2.

In the above paragraphs, we have discussed the interfacing technique called *accumulator I/O*, which is also known as *isolated I/O* in the Intel Corporation literature.[2] A much more exciting interfacing technique is *memory I/O,* which is also known as *memory mapped I/O,*[2] in which an I/O device appears to the microcomputer CPU as a simple memory location. Without question memory I/O will be the most popular interfacing technique among all of the different microprocessor families. One important advantage of this technique is the considerable number of integrated circuit chips that have already been designed for memory I/O applications. Included among such chips are the 8255 programmable peripheral interface, the 8251 universal synchronous/asychronous receiver/transmitter (USART), the MC6820 peripheral interface adapter, and the XC6850 asychronous communications interface adapter. We shall discuss this alternative I/O technique next month.

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1. *Bugbook III. Microcomputer Interfacing Experiments Using the Mark 80® Microcomputer, an 8080 System*, E&L Instruments, Inc., Derby, Connecticut, 1975.
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integrated circuit ssb transceiver for 80 meters

The versatile LM373 IC is the heart of this single-band sideband transceiver that also features some novel diode switching of the signal path

The increasing availablilty and sophistication of integrated circuits has prompted the publication of a number of solid-state transceiver designs.[1,2,3] The transceiver design presented here uses readily available ICs and includes varactor tuning of the variable oscillator and transmitter buffer stages. The receiver's performance is enhanced by a dual fet cascade rf amplifier, and the transmitter provides about 8 watts output from an inexpensive rf power transistor.

circuit

Except for the varactor tuned oscillator (vto), bfo, rf amplifier, transmitter driver and final amplifier sections, all functions are performed by integrated circuits. With the exception of the B+ switching, which is accomplished with a single miniature relay, all other switching between receiver and transmit is done by high-speed 1N914 switching diodes. The transceiver's i-f frequency is 455 kHz, and the vto tunes from 3.045 to 3.545 MHz. Sideband selectivity is provided by a 455-kHz Collins mechanical filter.

Two MPF102 fets in cascade configuration with high-Q toroidal inductors serve at the receiver's rf amplifier (**fig. 2**). The first design attempts excluded an rf amplifier, but the LM373 used in the front end displayed such poor cross-modulation characteristics and overloaded so easily that an additional high-Q tunable rf stage was necessary. However, even with an rf preselector an occasional strong local station overloaded U1. To protect against this kind of interference a manual second rf gain control, consisting of R1B in a voltage dividing network to provide adjustable bias to pin 1 of U1, was included.

The received signal is fed through relay K1 to the dual fet rf amplifier, through another tuned circuit, and then to U1, a LM373 serving as both the second rf amplifier and the receiver mixer. The vto input is injected at pin 6 of U1 during receive, and the mixer output is then diode switched into pin 2 of U2, the common i-f amplifier (**fig. 3**).

In addition to serving as the receiver/transmitter i-f strip, U2 also functions as the receiver product detector. Sideband selectivity is provided by FL1, a 455 kHz Collins mechanical filter, inserted between pins 2 and 9 of U2. The LM373 adequately compensates for the filter insertion loss, and it does triple duty as the product detector when the 456.35 kHz bfo output is diode switched onto pin 6 during receive. The audio output of U2 is switched into the audio amplifier, U3, an MFC9010 IC capable of producing two watts of audio output with low distortion.

beat-frequency oscillator

The bfo is a rather conventional bipolar crystal oscillator coupled to a fet source follower by a miniature 455 kHz i-f transformer, T2 (**fig. 4**). The rf output is made adjustable (through R7A) so that the bfo injection voltage can be set for maximum carrier suppression. The bfo frequency is 456.35 kHz for lower sideband operation or 453.75 kHz for upper sideband.

variable oscillator

The variable oscillator is varactor tuned using a 1N594 diode and incorporates an MPF102 fet source follower buffer (**fig. 5**). With the values given, the oscillator tunes from 3.045 to 3.545 MHz with the full excursion of potentiometer R8. The +12 volt source for the vto should be well regulated, preferably with a three-terminal 12 volt IC regulator such as the Fairchild 7812. In the transceiver I built, the vto output shifted frequency by a few hundred hertz when switched between receive and transmit, probably due to the difference in load resistances placed on the vto in the two modes. However, by adding R9 and associated circuitry, the receive and transmit frequencies may be synchronized.

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transmitter circuits

A 741 operational amplifier is used at U4, the speech amplifier (**fig. 6**). A Motorola MC1496 is used as the balanced modulator after attempts with a LM373 proved unsuccessful. The circuit shown does an excellent job, despite its simplicity, and was borrowed from previous designs.[3,4]

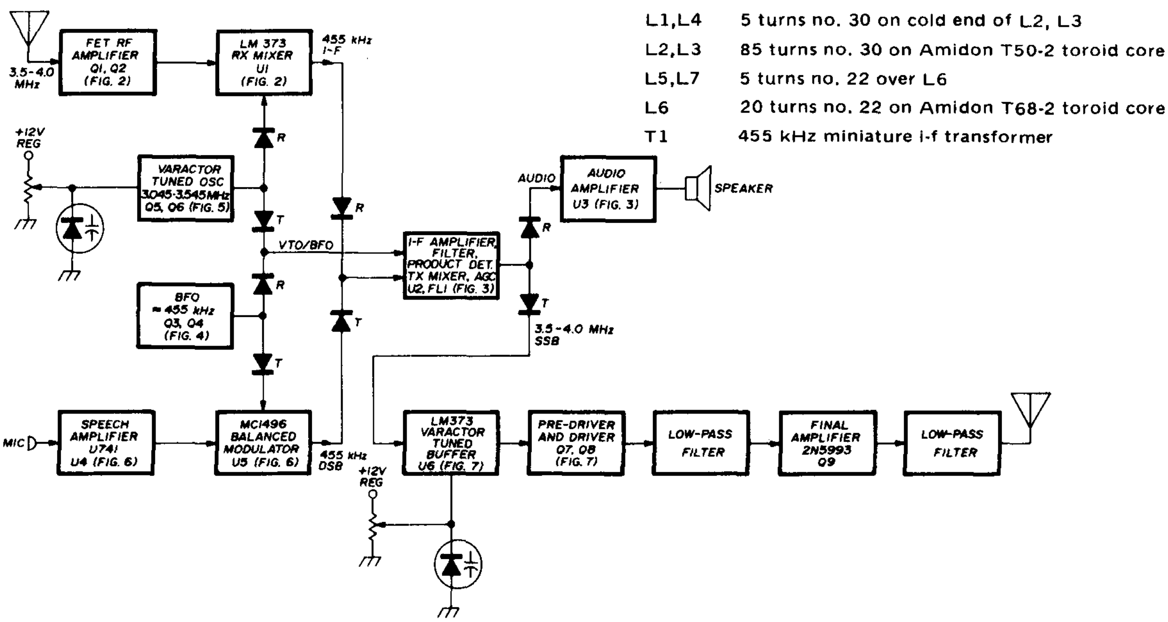
The 456.35 kHz carrier oscillator signal is diode switched during transmit to U5, the balanced modulator, and the resulting double sideband output is switched into the common i-f amplifier U2. U2 passes the dsb signal through FL1 and mixes the filtered ssb output with the injected vto frequency. The resultant 3.5 to 4.0 MHz ssb signal is finally switched during transmit to the chain of transmitter buffer and amplifier stages.

to have one available. A rather elaborate zener-regulated bias network was needed to operate this device in a reasonably linear fashion. The collector tuned circuit is similar to that of the driver stage.

The rf output passes through another low impedance lowpass filter which attenuates the harmonic output and also provides an impedance match for a 50-ohm load.

control circuits

All B+ voltages in the transceiver are switched through a single 4pdt relay. One pole switches +12 volts between the receive and transmit switching diodes, and also between the rf amplifier and U1 (on receive) and the speech amplifier, balanced modulator, and transmitter driver amplifiers on transmit. A second set of



L1,L4	5 turns no. 30 on cold end of L2, L3
L2,L3	85 turns no. 30 on Amidon T50-2 toroid core
L5,L7	5 turns no. 22 over L6
L6	20 turns no. 22 on Amidon T68-2 toroid core
T1	455 kHz miniature i-f transformer

fig. 1. A simplified block diagram of the transceiver. The diodes marked R are biased into conduction during receive; those marked T conduct during transmit. All T-R switching is handled in this manner except the final rf amplifier output. Varactors are used in the tuned circuits of the vfo and buffer stages.

The ssb signal at the output of U2 is extremely weak and requires a number of stages of linear amplification to reach an rf voltage capable of driving the final amplifier, Q9. The output from U2 is first amplified by varactor-tuned buffer U6, also an LM373; the output of U6 in turn excites pre-driver Q7; its output is tuned to the center of the 80-meter phone band by C5 and link coupled through L3 to the driver transistor, Q8, a 2N3553 bipolar transistor (**fig. 7**).

Several transistor types seem to work well in the driver stage (of which the 2N2102 is the least expensive). An adjustable voltage-dividing network utilizing a 3.6 volt zener regulator biases the final into the linear range (**fig. 8**). The driver's output is link coupled via L15 to a 4 MHz lowpass filter.

The final amplifier, Q9, is a 2N5993 rf power transistor. This device is intended for CW and fm use and was reluctantly forced into linear service because I happened

contacts switches +12 volts from a separate supply to the transmitter final amplifier stage on transmit. The remaining two poles function as an antenna T-R switch and as the receiver offset tuning disable.

construction

The heart of the transceiver is built on an 8x10 inch (20x25cm) single-sided copper-clad circuit board. The board is pre-drilled and hand etched to incorporate all circuits and components except the vto, audio amplifier, speech amplifier and final amplifier; these are built as small sub-modules on boards which are mounted with L-brackets onto the main circuit board.

The vto is mounted in a small aluminum enclosure. The 2N5993 final amplifier is built on a small circuit board with the rf power transistor mounted on a 2x5 inch (6.3x15.2cm) finned heatsink which is bolted flush with the phenolic side of the circuit board. A shield

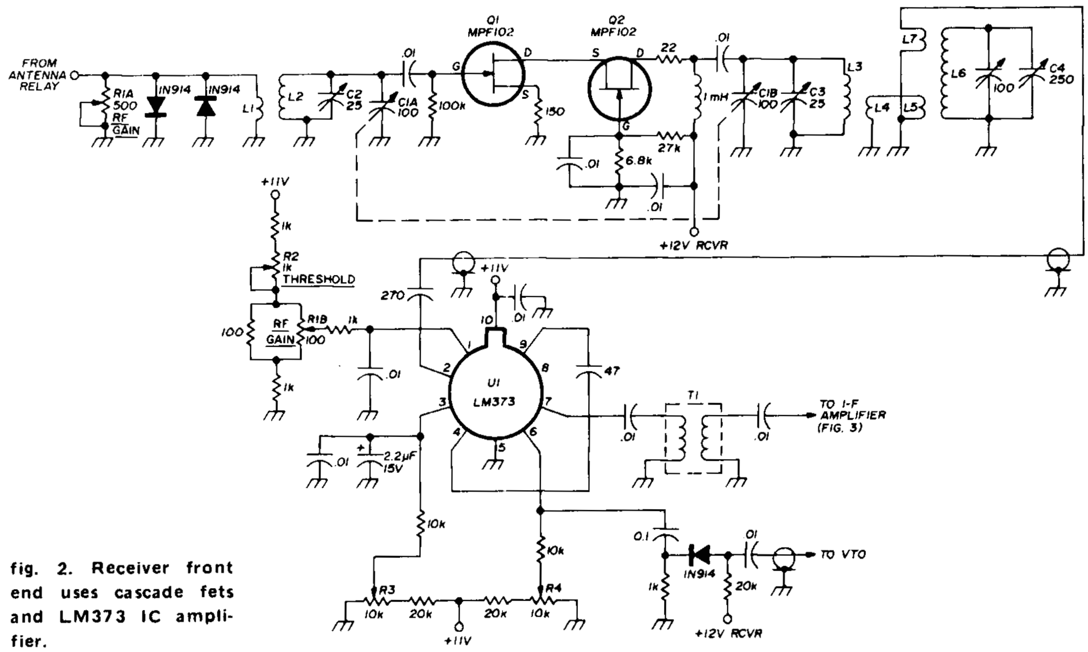


fig. 2. Receiver front end uses cascade fets and LM373 IC amplifier.

separates the final amplifier stage from the main circuit board.

All tuning controls are mounted on aluminum brackets secured directly to the main circuit board's front edge. Finally, the main board is mounted with standoffs to a 10x12x2 inch (25.4x30.5x5.1cm) aluminum chassis. All tuning controls are brought out through the front panel by shaft couplers and universal joints. The output meter is mounted on the front panel; the gear drive assembly was harvested from an old ARC-5 receiver and is mounted on the right side of the panel as the vto tune control.

receiver alignment

The vto was aligned first. Inductor L8 is adjusted so that the desired frequency range of 3.045 to 3.545 MHz occurs at the extremes of rotation of R8. A grid-dip meter and general-coverage receiver were helpful in this

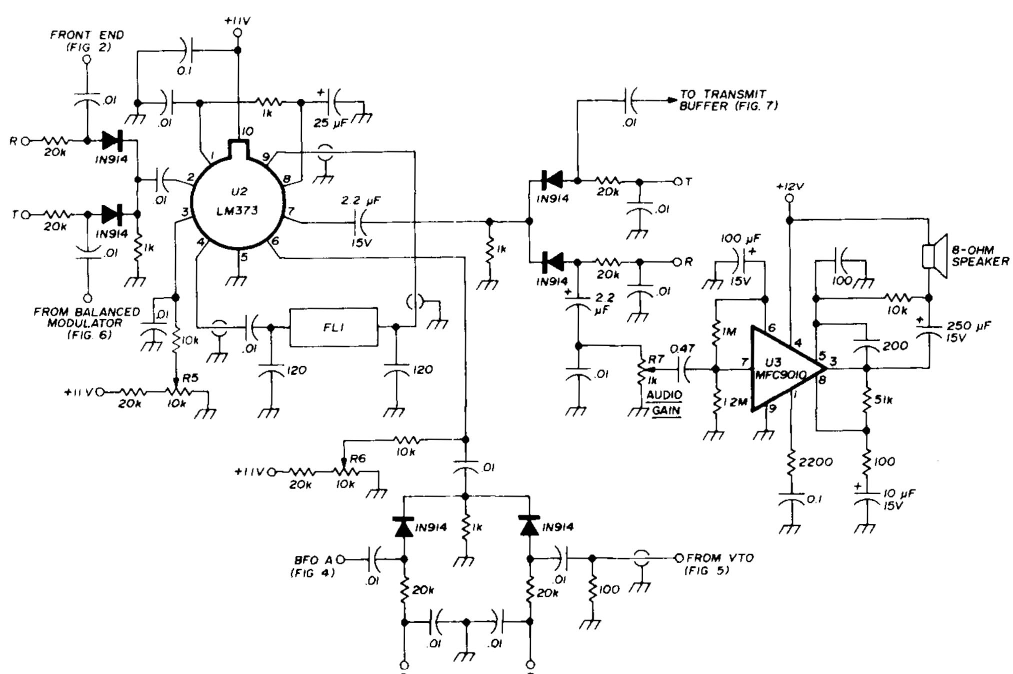


fig. 3. Common i-f amplifier, filter, product detector/transmitter mixer stage. By applying +12 volts to the T or R terminal, the various inputs and outputs are switched by 1N914 diodes. FL1 is a 455 kHz Collins mechanical filter.

alignment. The bfo requires no adjustment and can be easily checked for oscillation with a vtvm and rf probe.

The receiver is easily adjusted by tuning in a strong local signal and alternately adjusting trim pot pairs R3, R4 and R5, R6 for maximum signal strength. Final peaking is accomplished with C1, C4, and the rf tune and receiver tune capacitors.

transmitter alignment

To begin the transmitter alignment, first check the operation of the speech amplifier by monitoring its output with a pair of headphones. Next, loosely couple pin 7 of U2 to a receiver tuned to the transceiver's frequency. A clear, crisp ssb signal should be heard. To null the carrier, adjust R11 for minimum carrier, while at the same time setting R7, the bfo output level adjust, to obtain maximum carrier suppression possible with adequate signal gain.

Shift the receiver coupling to L13, and place a number 42 pilot lamp across that inductor as a dummy load. Set the vto to 3.8 MHz and peak the buffer tune control (R12) and the pre-driver tune control (C5) for maximum signal at the receiver.

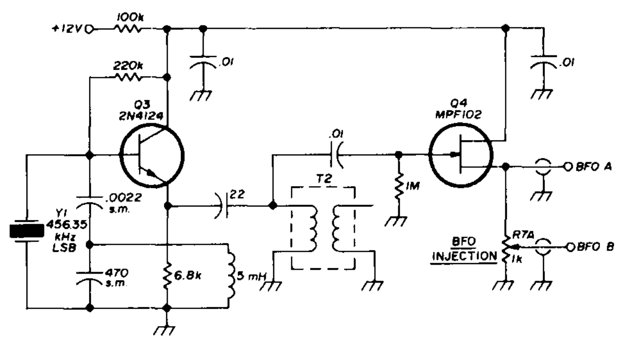


fig. 4. Bfo and carrier oscillator. T2 is a miniature 455 kHz i-f input transformer.

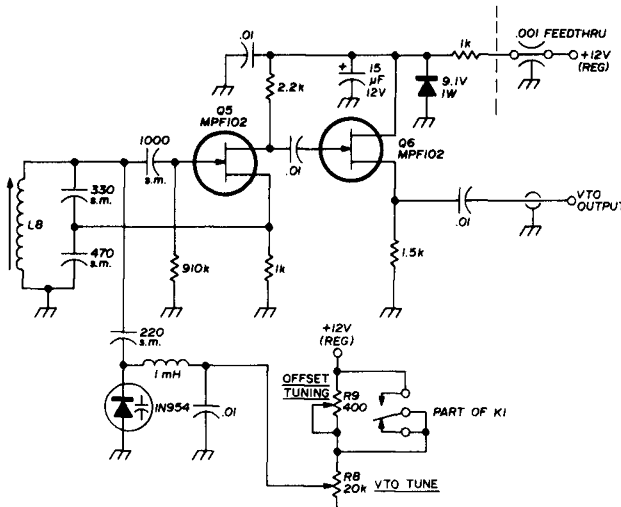


fig. 5. Varactor tuned oscillator (vto) is built in a separate enclosure which is attached to the main circuit board. L8 is 40 turns no. 32 on ¼" (6.5mm) slug-tuned form.

Remove the pilot lamp from L13 and place it across L15, coupling this stage to the receiver. Adjust R14 for about 5 to 10 mA of quiescent collector current at Q8. Then tune capacitor C6 for maximum signal strength in the receiver and maximum lamp brilliance.

To tune the 2N5993 linear amplifier, Q9, place a 10 watt, 50 ohm resistive dummy load across the antenna output, very loosely coupling this to the receiver and an oscilloscope. The easiest way to adjust the bias of Q9 is to monitor the modulation envelope on the oscilloscope while adjusting potentiometers R15 and R16 for the best ssb oscilloscope pattern and cleanest audio. In my transceiver, the quiescent collector current of Q9 was on the order of a few hundred milliamperes.

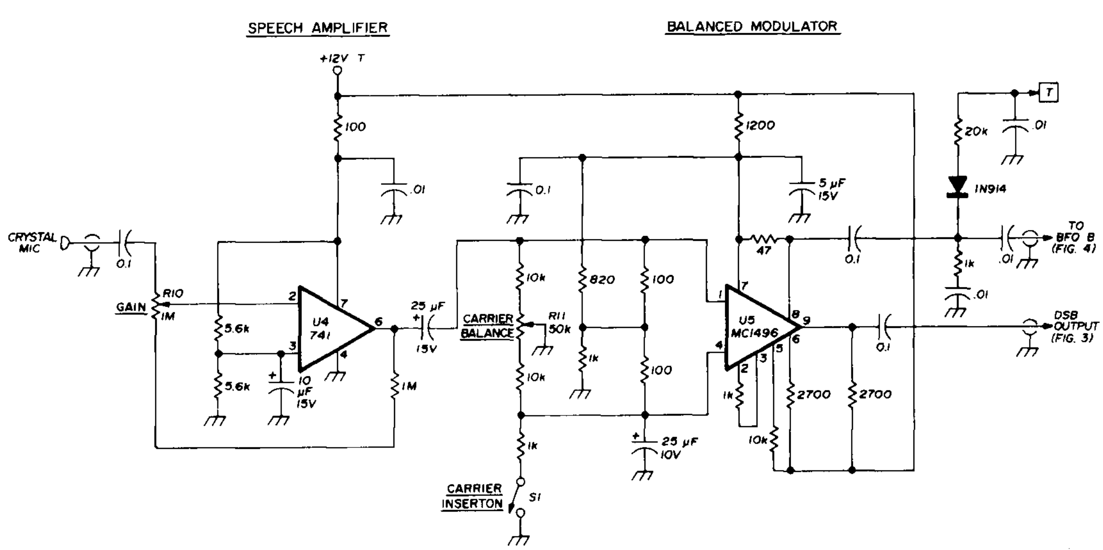
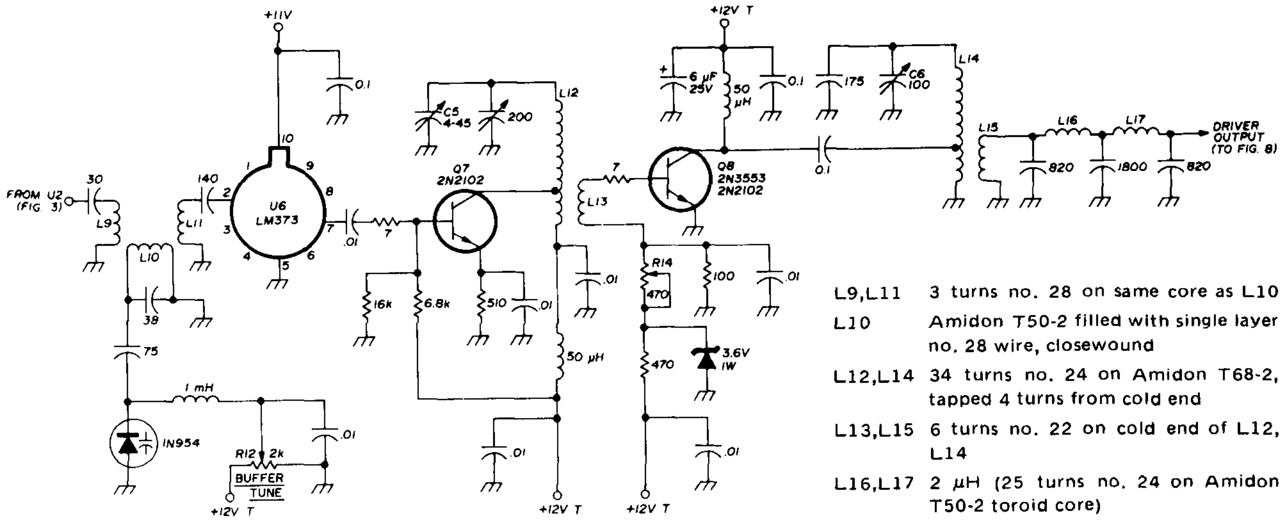


fig. 6. Speech amplifier and balanced modulator.



L9,L11	3 turns no. 28 on same core as L10
L10	Amidon T50-2 filled with single layer no. 28 wire, closewound
L12,L14	34 turns no. 24 on Amidon T68-2, tapped 4 turns from cold end
L13,L15	6 turns no. 22 on cold end of L12, L14
L16,L17	2 µH (25 turns no. 24 on Amidon T50-2 toroid core)

fig. 7. Buffer, pre-driver and driver stages.

The transceiver is easy to tune and operate, and it puts out a good ssb signal. Its modular design and construction make troubleshooting less frustrating and alignment simple. Although, with 7 to 8 watts output, this is really not a QRPp rig (according to the purists), it cannot compete with higher powered stations. However, by using good operating skill, tempered with patience, the operator will be rewarded with many contacts.

For those whose resources are unlimited, an rf power transistor specifically designed for linear ssb service could be substituted for the 2N5993 used at Q9. A 2N5992 would deliver about 10 watts PEP with a 12 volt supply, while a 2N5070 or a 40936 would deliver about 25 watts PEP using a 28 volt collector supply.

I wish to thank Charles Hill, W5BAA, whose article and personal communications helped in the formulation and design of this ssb transceiver.

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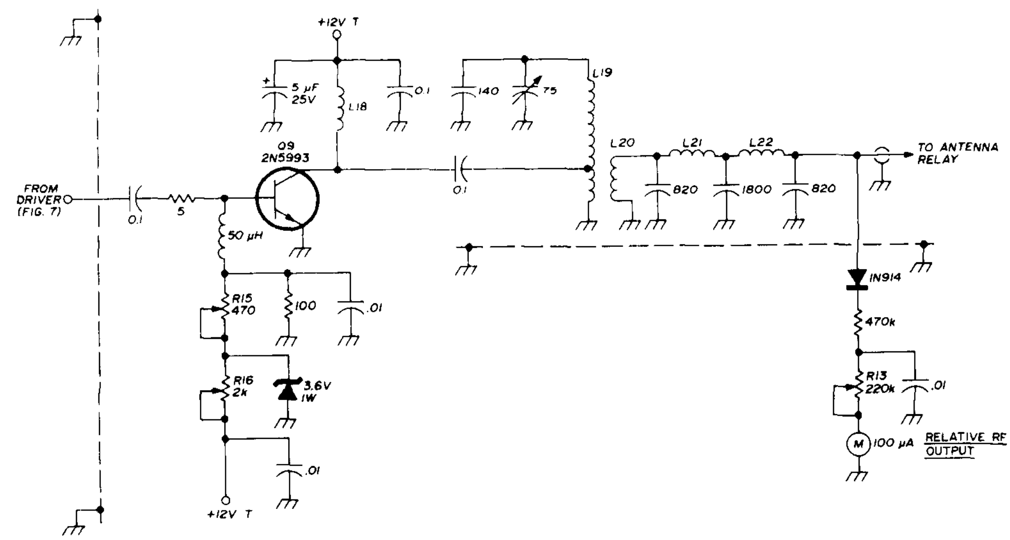

L18	2 layers no. 28, closewound on Amidon T37-2 toroid core	L20	6 turns no. 22 on cold end of L19
L19	34 turns no. 24 on Amidon T68-2	L21,L22	2 µH (18 turns no. 20 on Amidon T68-2 toroid core)

fig. 8. Final amplifier stage. The 2N5993 works well in this circuit, although not intended for linear service. Other transistor types may be substituted for increased output and linearity.

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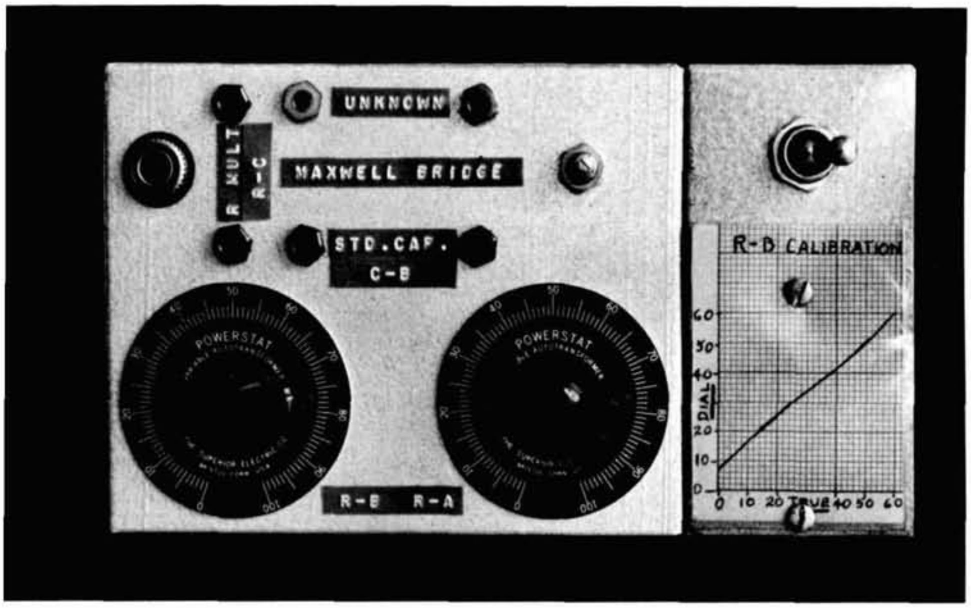

universal L, C, R bridge

Here's a useful instrument for test equipment that won't strain your imagination, credulity, or pocketbook. The idea isn't new; in fact it's of about the same era as the Wheatstone bridge. But for some reason, it seems to have been overlooked by the amateur fraternity. Known as the Maxwell bridge, it provides in one instrument the capability of measuring inductance, capacitance, and resistance.

Ohmmeters and capacitance meters are available in all price ranges. But not generally available (or familiar) to amateurs is a means of readily measuring inductance between 1 μH and 1 henry. The investigation of inductance bridges narrowed to the Maxwell bridge as by far the simplest, and also revealed its flexibility for resistance and capacitance measurements. The advantages of the Maxwell bridge are minimum number of components, calibration simplicity, measurement simplicity, driving-frequency independence, and measurement accuracy.

Most other bridges in common use have more than one reactive element as compared to one in the Maxwell bridge. Over a fixed range, R_a (see **fig. 1**) can be calibrated to read inductance values directly; and at a specified fixed driving frequency, R_c can be calibrated to read Q directly. In addition, R_a and R_b can be calibrated initially over their variable ranges by means of standard resistors. All measurements are direct products or quotients of direct readings. In the derivation of the basic equations for bridge balance, it is found that $2\pi f$ appears on both sides of the equation and cancels, with the result that bridge measurements are not affected by the driving source frequency. Finally, the nulls are unmistakable so that if the resistance arms are ±1%, the worst-case error would be approximately 3%, with the probability being 8 to 1 that the error would be less.

Referring to **fig. 1**, which is the setup for inductance measurement, and neglecting for the moment the potentiometer across the transformer, the equation for balance is $L_x = R_a \times R_c \times C_b$, where L is in millihenries, R in kilohms and C in microfarads. For the series resistance of L, $R_x = R_a \times R_c$ divided by R_b. Then $Q = 2\pi f L$ divided by R_x. Note that if L_x were vanishingly small, leaving R_x; and if C_b were removed, the bridge would be a straightforward Wheatstone type for resistance measurements with the same resistance balance equation as above. If a standard inductance is used in place of L_x, an unknown capacitor in the position of C_b can be measured. For this measurement, $C_x = L_{standard}$ divided by the product of R_a and R_c, with the units the same as for the inductance measurement. The series resistance of a capacitor is usually so small and the Q so large as not to be determinable with this bridge.

construction

All you need for layout and wiring is shown in the photo and the schematic. (The calibration curve in the photo was made because of nonlinearity in the low-resistance end of R_b in **fig. 1**.) I recommend a Bud 7x5x3 inch (17.8x12.7x7.6cm) Minibox box, which is about the smallest space into which you can squeeze the parts. Partition a 2-inch (5.1cm) space at one end to hold the signal-driving source, which consists of the

By J. H. Ellison, W6AOI, 1720 Holly Avenue, Menlo Park, California 94025

transformer, the IC and its components, and the switch and battery. The IC is a Signetics NE555 connected as an astable oscillator running at approximately 1000 Hz with the R and C values shown. The IC draws 6.5 mA. The battery is a 9-volt transistor battery. The transformer is a small audio type to provide dc isolation. Try to stay in a 3 to 1 ratio or less, but don't go down to the transistor interstage size. The pin jacks for the plug-in parts are Cinch-Jones with an all-Nylon body. For pins to match, find some plugs from any old Command set and saw out miniature banana-type pins by the handful.

The IC puts out a square wave at approximately 40% duty cycle, and you want some inductance to round off that square wave with its high harmonic content. Run the transformer secondary leads through a hole in the partition and connect them to the small pot, whose rotor is grounded. This arrangement is called a Wagner ground, a method for balancing stray internal capacitances to ground to get a perfect null. A first balance is made with R_a and R_b, then the Wagner ground is adjusted to deepen the null. Usually only one adjustment is required, then the R_a and R_b balance is perfect.

Bridge accuracy will depend on the linearity of R_a and R_b and the success you have in finding dial plates with graduations that match the angular range of your pots. If you can't match the two, the alternative is to make your own calibrated dial plates. The difficulty is that no uniformity exists among manufacturers in the angular range covered by the resistance winding. It goes without saying that the pots must be wire-wound to ensure reliable calibration and resetting. I found some surplus 1.75-inch-diameter (4.4cm) precision pots made by Technology Instruments, Acton, Massachusetts, and dial plates labeled "Powerstat" made by Superior Electric, Bristol, Connecticut, which matched exactly. You should be so fortunate!

Other manufacturers with models approximating these are Spectrol, Helipot Division of Beckman Instruments, CTS Corporation, Clarostat, and Mallory. Mallory has an inexpensive model designated MG, which might be satisfactory if you make your own calibrated dial plates. You'll find that the angular measurement of the resistance windings will range from 255 to 335 degrees, depending on construction. It's desirable, although not

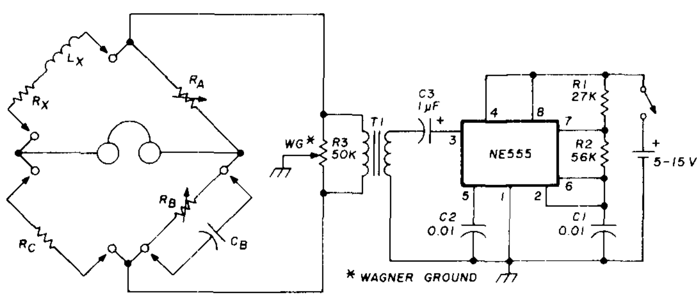

fig. 1. Maxwell bridge setup for inductance measurements. Wagner ground balances stray internal capacitances to ground to obtain a perfect null. Measurement ranges are shown in table 1.

R_a 1k wirewound linear pot
R_b 10k wirewound linear pot
T1 3:1 or less audio transformer

necessary, that the pots be metal enclosed to provide shielding. This shielding adds about 15 pF capacitance across the windings, which is equivalent to more than a megohm at the bridge driving frequency and may be neglected for all practical purposes. The phone jack should be insulated from the case, and for best sensitivity high-impedance phones should be used.

standards

You'll need resistance standards to plug into the R_c position and capacitance standards to plug in the C_b

table 1. Measurement ranges for the L,C,R bridge.

L (mH)	R (ohms)	C_b (μF)	R_c (ohms)
0.01 - 0.1	1 - 10	0.01	10
0.1 - 1.0	10 - 100	0.01	100
0.1 - 1.0	1 - 10	0.1	10
1.0 - 10.	10 - 100	0.1	100
1.0 - 10.	1 - 10	1.0	10
10. - 100.	100 - 1000	0.1	1000
10. - 100.	10 - 100	1.0	100
100. - 1000	100 - 1000	1.0	1000

position. The minimum resistances will be 10, 100, and 1000 ohms, and minimum capacitances will be 0.01, 0.1, and 1.0 μF. Juggling the formulas will show that you can cover the same inductance range with different combinations of R_c and C_b, but the inductor series-resistance range will be different. For example, a C_b of 0.1 μF and an R_c of 100 ohms will cover the inductance range of 1.0 to 10 mH and a series resistance range of 10 to 100 ohms. A C_b of 1 μF and an R_c of 10 ohms will cover the same inductance range, but the resistance range will be 1 to 10 ohms.

If you can't get a distinct null, you have the wrong combination of C_b and R_c. You can work out other R and C combinations to expand the bridge range. You should make a table of combinations with the corresponding L_x and R_x ranges.

Using the plug-in method for C_b and R_c provides the greatest versatility and most compact bridge size. If you used internal switching systems, you'd add considerable mechanical complexity and stray capacitive coupling. Some of the components are external to the enclosure and some are within, which adds to mutual shielding. No proximity hand effects should occur when balancing the bridge.

The standards mentioned will cover inductances between 10 μH and 1 henry, with corresponding resistance ranges between 1 and 1000 ohms. For capacitance measurements between 10 pF and 10 μF, you'll need a 1 mH standard and two additional resistance standards, which you can calculate. These same resistance standards will be useful in making resistance measurements, which can be determined with much greater accuracy than with an ohmmeter.

A final word: an unavoidable interaction exists between the reactance and resistance balances. Care must be taken to ensure a *complete* null to avoid measurement errors. If the approximate R_x is known beforehand, correct measurements are expedited.

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troubleshooting by resistance measurement

In addition to the signal tracing, signal injection and voltage measurement techniques which I have discussed in previous columns, troubleshooting by resistance measurement in another basic technique which can be used to pinpoint circuit problems. One of the best arguments for resistance troubleshooting, of course, is safety. You can check out many of the stages in your transmitter, for example, without any lethal voltages applied, and when you must work on high-voltage power supplies resistance troubleshooting is the *only* method which is recommended.

A few amateurs will contend that resistance measurements don't give the complete story because some components in a high-voltage circuit that check out okay by resistance measurement may break down under stress. That's true, but you can usually spot these problems by a visual inspection – they smoke, or arc. Some short circuits occur in transmitters only after high voltage and drive have been applied, so resistance or voltage measurements are of little use, but once again, you can usually *safely* track down the difficulty by a visual inspection and the process of elimination.

Resistance troubleshooting can be done with a simple volt-ohm-milliammeter or vom, and most amateurs have one. In addition to being relatively inexpensive, rugged, and simple to operate,the volt-ohmmeter doesn't have to be plugged into the power line so it's completely portable. Some of the new solid-state electronic volt-ohmmeters are also portable, but they're considerably more expensive and can sometimes give erroneous readings when used in operating rf equipment.

There are any number of good quality volt-ohm-milliammeters on the market which are suitable for amateur use, ranging from miniature, imported models that sell for less than $10 to more accurate instruments which go for $100 or more. Although many of the pocket-size meters are good investments, if most of your troubleshooting is done on the workbench, you'd probably be better off with a larger vom with an easy-to-read 4 or 5 inch (10-13cm) scale. Insist on dc accuracy of at least 2%, and don't be misled by the fact that 1% resistors are used in its construction. The use of 1% resistors doesn't necessarily mean that the readout is very accurate – the meter movement itself may be non-linear.

Other features to look for are 20,000 ohms/volt sensitivity (minimum) and a meter protection circuit. Some meters are completely burnout proof, and you pay extra for this premium, but it might save you money in the long run.The meter shown in the photographs, a Triplett model 60, is both burnout proof and shockproof, so I should never have to replace it. (It once got knocked off my bench on to the concrete floor and sustained absolutely no damage.)

When selecting a vom the most important factor is accuracy. Dependable ohmmeter measurements are not much use if you can't read them accurately, and you can't begin to interpret their meaning unless the measurements are accurate. Following are four suggestions which will help you to obtain accurate measurements with your ohmmeter:

1. Calibrate the instrument before using it. Place the vom in the position you're going to use it, standing upright or lying down, with the function switch in the *off* or *dc voltage* position, and with the test leads plugged in but not shorted together, make sure the meter needle rests exactly on the zero mark at the left edge of the scale. You may have to adjust the mechanical zeroing screw that is just below the meter face (see **fig. 1**). If it's been awhile since you've made the zero adjustment you

fig. 1. Before making any resistance or voltage measurements, make sure the meter needle is zeroed. If it's not, adjust the mechanical zeroing screw just below the meter face on the front of the vom. This adjustment shouldn't be required very often, but you should always check the mechanical zeroing before you use the instrument.

fig. 2. The needle should move up scale to the zero ohms mark when the test leads are shorted together. If the needle doesn't align with the zero ohms mark, adjust the "ohms" or "zero ohms" control on the front of the instrument.

fig. 3. The meter pointer should rest somewhere near midscale for best accuracy when making resistance measurements. This can be accomplished with the "range" switch which is calibrated in decade increments.

may have to lightly tap the meter glass to jar loose any needle friction.

2. Zero ohms adjust. Turn the function switch to the *ohms* position and short the two test leads together. The needle should move up to full scale (since the ohms scale reads from right to left, zero ohms is at full scale). If the pointer doesn't line up with the zero ohms marker, adjust the *zero ohms* control on the front panel of the instrument (see **fig. 2**).

3. Range switch. For accurate resistance measurements the range switch should be set so the meter operates in the upper two-thirds of the resistance scale. This is because the resistance scale is non-linear and the scale on the left edge is compressed, making it difficult to read accurately. Moving the range switch up one or two positions will move the needle toward the right into a portion of the scale where the calibration marks are further apart.

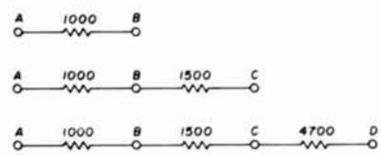
4. Properly interpolate the scale reading. Most errors in resistance measurements are due to simple technician error in properly multiplying the ohms scale reading by the *multiplier* indicated by the range switch. It's pretty easy to drop a zero (or add one) and end up with the wrong measurement. When the pointer is on the left side of the scale you'll have zeroes in the scale reading as well as in the multiplier, so be particularly careful and use scratch paper if you're unsure.

series resistance circuits

Before you can troubleshoot an electronic circuit with resistance measurements you have to recognize the different kinds of resistance paths which you may find in an actual circuit. There are dozens of resistors in practically every electronic circuit and, in addition to resistors, there are a number of other components which will show readings on an ohmmeter such as transformer windings, electrolytic capacitor leakage, forward and backward resistance of semiconductor diodes, vacuum tube filaments and, of course, transistors.

One of the tricks of resistance troubleshooting is finding resistance paths that aren't where they should be, or paths that have too little (or too much) resistance. To do this you'll have to learn how to spot the resistance paths on a schematic diagram, and how to figure out where and what they should be at different points in the chassis wiring.

fig. 4. When resistances are in series their values add directly.



Simple series resistance paths, such as those shown in **fig. 4**, are both the easiest to spot and the simplest to analyze. It would be difficult to mistake the A-B path shown first – it's 1000 ohms between points A and B. In the second series path the 1000 ohms between A-B adds to the 1500 ohms between points B-C for a total resistance of 2500 ohms. The third series path, between points A-D, is also pretty easy, adding up to 7200 ohms.

It's important to recognize in the simple series circuits of **fig. 4** that adding the B-C and C-D resistance paths had no effect on the A-B resistance. In all three cases an ohmmeter connected to points A and B would indicate 1000 ohms. You can add as many series resistors as you want and A-B will remain at 1000 ohms.

Another important point concerning series resistances is that you can measure each of the individual paths independently (B-C or C-D, for example) and the other series paths will not interfere with the reading. You can also directly measure path A-C if you wish(2500 ohms), or a path A-D (7200 ohms).

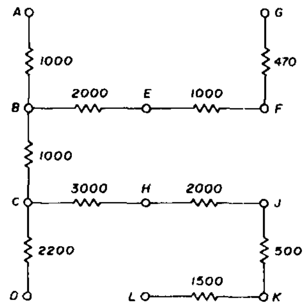


fig. 5. These resistances, although not arranged in straight lines as those in fig. 4, are in series and can be added directly.

Resistance paths don't necessarily have to be drawn in a straight line to be in series. An example is shown in **fig. 5**. An ohmmeter connected between points A and D measures the A-D path directly; the resistance is 4200 ohms. None of the other resistances in the circuit has any effect on path A-D because they are not in series with it (or shunted across it). The same thing is true about path A-L. In this series circuit only the resistance between points A and L have a bearing on the resistance of the path – it can be measured directly by simply connecting the ohmmeter leads to points A and L (9000 ohms). The resistances in paths B-G and C-D are ignored because they're not in series with path A-L. If you're in doubt, trace path A-L: A to B, to C, to H, to J, to K, to L.

Now consider the path from F to K (9500 ohms). It goes from F to E, to B, to C, to H, to J, to K. An ohmmeter connected between F and K measures only that path, and indicates 9500 ohms. None of the other paths in the circuit have any effect because they are not in series with path F-K.

Suppose you were troubleshooting a circuit like **fig. 5** and measured 8000 ohms between B and J. The schematic shows series resistances totaling only 6000 ohms in the B-J path. At least one of the resistors has changed value and you have to determine which one it is. One way to find the answer is to individually measure each resistance. Since there are several resistors in the circuit, that can take a fair amount of time. A better way is to work your way through the circuit from one end to the other. Leave one ohmmeter lead on B and move the other lead from J to H. If the reading drops to 4000 ohms it means that path H-J is at fault. If the reading only drops to 6000 ohms, however, it means that H-J is okay and the trouble is in the B-H path. One more measurement should locate the bad resistor.

Those are the basic principles of troubleshooting around series resistance circuits. There are plenty of series resistance circuits in electronic equipment, and as long as the resistors are in series, tracking down trouble is pretty easy. If the resistors are in parallel, however, as will be discussed next, the task is a bit more difficult – at times it can be downright confusing.

parallel resistors

Three very simple parallel resistance paths are shown in **fig. 6**, but you're not likely to find anything as simple as this in any electronic equipment. Nevertheless these simple circuits are a good starting point. So far as an ohmmeter is concerned, the path between points A and B is merely path A-B. As you can see from the diagram, however, it isn't nearly that simple because there are actually two resistance paths in the first two circuits (A-B and C-D) and five actual resistance paths in the third.

The resistance of path A-B is 500 ohms because the resistance of two parallel resistances of the same value is half the resistance of either resistance by itself, (similarly, the parallel resistance of three equal-value resistors is one-third the value of one resistance, and the parallel resistance of four equal-value resistors is one-fourth the value of one resistance, etc.). This is another way of saying that resistances in parallel add inversely. A general equation which can be used to calculate the parallel resistance of any number of resistors, of any value, is

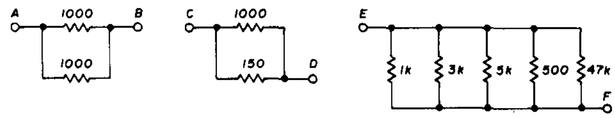


fig. 6. Parallel resistance paths are more difficult to calculate. A formula is given in the text below for calculating the equivalent resistance of a parallel resistance network.

$$\frac{1}{R_T} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3} + \frac{1}{R4} + \frac{1}{R5} + \cdots \frac{1}{R_n} \quad (1)$$

where R_T is the parallel resistance and $R1$, $R2$, $R3$, etc. are the values of the resistors in each of the parallel branches. If only two resistors are in parallel, **eq. 1** can be rewritten into the form

$$R_T = \frac{R1 \cdot R2}{R1 + R2}$$

Although it may not be immediately obvious by looking at the parallel resistance formulas, whenever a resistance is added in parallel to a circuit, it always lowers the resistance between two points. In fact, the parallel resistance is always less than the lowest resistance in any branch of the parallel path. The C-D path in **fig. 6** shows a situation where one branch of the parallel circuit has much lower resistance than the other. Calculated by the parallel resistance formula, path C-D has a resistance of 130.4 ohms. This would be the resistance measured between points C and D with an ohmmeter.

If you should run into this circuit in a bench test, consider what it means if you measure path C-D and find a reading of 150 ohms. You can assume the 1000-ohm resistance has opened up or has changed value to some extremely high resistance (*in general, if a parallel resistance is 100 times higher than the other resistor in the circuit, it will lower the parallel resistance by approximately 1%*). Conversely, if you check path C-D with your ohmmeter and find that it measures 1000 ohms, the 150-ohm resistor is at fault.

To check the use of the parallel resistance formula, calculate the resistance between points E and F in **fig. 6.** Your answer should be 281.32 ohms. If you remove the 47k resistance and run through the calculation again, you'll find the parallel resistance of the circuit has increased only slightly, to 283.02 ohms. This is because the 47k resistance is nearly 100 times greater than the smallest resistance in the circuit.

One of the problems with parallel resistance paths in electronic equipment is that they are seldom as obvious as those in **fig. 6.** In practice parallel resistance circuits may have branches all over the chassis, and they are often arranged in rather strange shapes as shown in **fig. 7.** At first glance, for example, path A-B looks like a

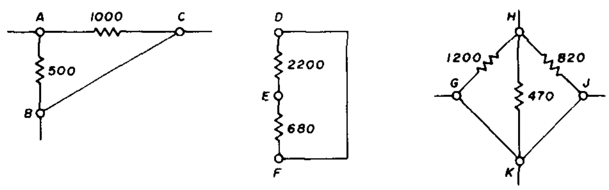


fig. 7. Although it might not be readily apparent, these three circuits are actually parallel resistance circuits. In practical circuit work there may often be hidden parallel circuits which can fool the unwary.

simple 500-ohm path. Since B is connected to C, however, resistance A-B is actually in parallel with resistance A-C for a total parallel resistance of 333 ohms. Connect an ohmmeter between points A and B (or between A and C) and this is what it would indicate.

Now consider the D-E-F resistance path in **fig. 7.** Although the two resistors appear in series, they're really not by virtue of the fact that D is connected directly to F. Any current which enters the circuit at D flows through both resistors to reach E. An ohmmeter connected at points D and E measures the combined parallel resistance of the two and indicates 519 ohms.

Now that you're looking for sneak parallel paths it should be easy to sort out the parallel resistors in path H-K. Points G, J and K are electrically the same so the three resistors are in parallel, and an ohmmeter connected between points H and K would measure 239 ohms.

These simple parallel resistance hookups are illustrated primarily so you won't overlook a parallel resistance connection just because it isn't obvious. In many circuits, in fact, many of the hidden parallel resistance paths are through other types of components and don't actually appear on the schematic as resistance paths. In every case, however, any parallel resistance path always *lowers* the ohmmeter reading to a value less than the lowest value in any branch of the parallel path. If you *forget that one simple fact, resistance troubleshooting* can be very confusing – remember it, and you can use this technique to pin down some very elusive faults.

series-parallel resistors

In most electronic circuits you won't find only series or parallel resistance, but a combination of the two. A few of the possibilities are shown in **fig. 8.** In the first

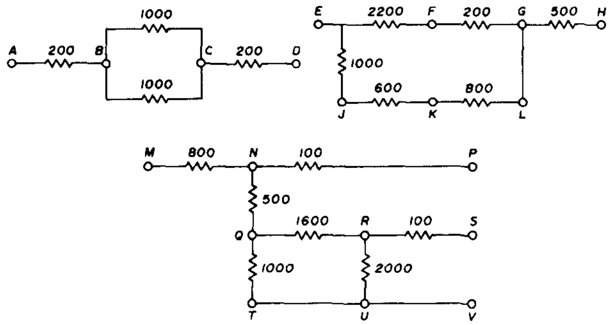


fig. 8. These series-parallel resistance networks are more like those which you will find in real circuits. To figure out the total path resistance first calculate the equivalent parallel resistance, then add the series resistance. Examples are given in the text.

circuit paths A-B and C-D are in series with the two-*branch parallel path, B-C. To find out what resistance to* expect if you connected your ohmmeter between points A and D, first calculate the resistance of path B-C; it's 500 ohms. Therefore, the total resistance from A-D is 200 + 500 + 200, a total of 900 ohms.

The second series-parallel circuit in **fig. 8** is slightly more complicated, but it's not difficult to figure out if you look at it carefully. The path from E to G is made up of two parallel branches, both of which have more than one series resistance. To calculate the parallel resistance of path E-G, first add the series resistance in each of the parallel paths E-F-G and E-J-K-L-G, calculate the parallel resistance, and then add the series path G-H:

path E-F-G = 2400 ohms
path E-J-K-L-G = 2400 ohms
path E-G = 1200 ohms
path E-G-H = 1700 ohms

The third series-parallel circuit in **fig. 8** looks even more complex, but if you study it carefully for a moment you'll see that it's quite easy to figure out the total resistance between any of the points of the circuit. Path M-P, for example, is a simple series path equalling 900 ohms. None of the other resistors in the circuit have any effect because they're not in series or parallel with that path. Path M-S, however, has a parallel branch which must be considered (Q-R is in parallel with Q-T-R); *1600 ohms in parallel with 3000 ohms or 1043* ohms parallel resistance. The total resistance between points M and S is

800 + 500 + 1043 + 100 = 2443 ohms

This is what your ohmmeter would measure if it were connected across M and S.

There is one other resistance path to consider in this circuit: M to V. In this circuit path Q-R-U is in parallel with path Q-T-U (3600 ohms in parallel with 1000), for equivalent parallel resistance of 783 ohms. Therefore, the total series resistance between M-V is

$$800 + 500 + 783 = 2083 \text{ ohms}$$

hidden resistance paths

There are two components which will most likely give you false ohmmeter readings: semiconductors and electrolytic capacitors. Since electrolytics are used for power supply filters and decoupling, they are spread throughout any electronic circuit, so it's pretty hard to avoid them and their dc leakage currents which register as resistance on your ohmmeter. In solid-state equipment many of the coupling capacitors are also electrolytic types (as opposed to paper or plastic capacitors used in vacuum-tube circuits), and these can give you a lot of grief if you don't know what you're looking for. Bipolar transistors also give problems because each of the junctions looks like a diode to your ohmmeter, with greater resistance in one direction than in the other.

Fortunately capacitance leakage paths and semiconductor resistance paths follow certain patterns. If you know the patterns you won't be fooled -- and even if you are fooled at first it shouldn't take you too long to get back on the right track. Here are a few of the patterns to keep in mind:

1. **Diode action** can usually be checked by simply reversing the ohmmeter leads. Consider the circuit of **fig. 9**. Suppose the resistance reading from the 12 Vdc terminal to ground (power *off*, of course) measures about 150 ohms. It looks like filter capacitor C1 has shorted. To check, move the test lead to the junction of R1-C1 -- a very low resistance there seems to confirm that capacitor C1 is shorted. Before you jump to conclusions, however, reverse the test leads and repeat the measurement. The low reading will probably disappear. Why? Because the internal battery of the ohmmeter has forward biased the rectifier diodes, causing them to provide a low-resistance path to ground through the transformer center tap.

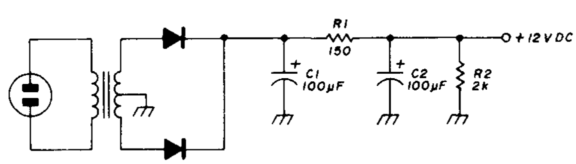


fig. 9. Simple solid-state power supply. Measured resistance from the 12 Vdc terminal to ground may be lower than expected because of a hidden path to ground through forward-biased rectifiers.

Whenever the negative side of the ohmmeter battery (sometimes the black test lead, but not always) is connected to the cathode end of a semiconductor diode and the positive lead is connected to the anode, the ohmmeter reads the diode's forward resistance (usually less than a few ohms). Reversing the test leads reverse biases the diode and measures the diode's back resistance which is typically 100k or more. Therefore, if you find a resistance path which is much lower than it apparently should be, reverse the test leads to make sure a semiconductor diode (or bipolar transistor) isn't causing the lowered resistance reading.

2. **Transistor leakage** can cause the same sort of measuring problems as diodes because both the base-collector and base-emitter junctions are, in essence, diodes so a transistor junction that is forward biased by the ohmmeter battery looks like a low-resistance path. Consider the circuit of **fig. 10** where an npn transistor is used in a typical rf mixer circuit. Suppose you connect your ohmmeter across resistor R2 to measure it. Instead of the expected 2700 ohms the meter reads about 50 ohms and you figure R2 has changed value. If you reverse the meter leads, however, you measure about 2100 ohms.

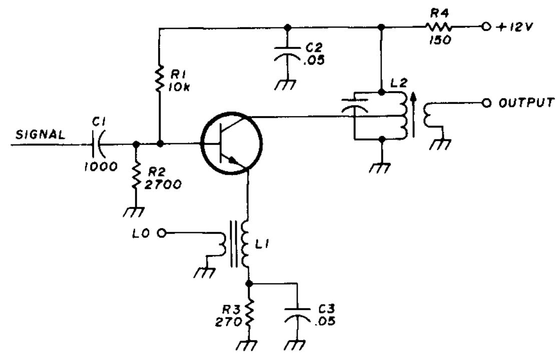


fig. 10. Rf mixer circuit using a bipolar transistor. There are many hidden resistance paths in this circuit which can be confusing if you're not aware of them.

The reason the ohmmeter indicated 50 ohms in the first case, of course, is because the base-emitter and base-collector junctions were forward biased, so the base-emitter junction resistance (about 50 ohms) provided a parallel path to ground through the 270-ohm emitter resistor, R3, and the forward-biased base-collector junction provided a path to ground through L2. When the test leads are reversed the two transistor junctions are reverse biased and your ohmmeter measures the parallel resistance path provided by R1 *and* R2 (about 2125 ohms).

When checking npn transistor circuits remember that the base-emitter (or base-collector) junction is forward biased when the base is positive and the emitter (collector) is negative. In pnp transistor circuits the two junctions are forward biased when the base is negative and the emitter (collector) is positive.

3. **Electrolytic capacitors** have leakage currents which the ohmmeter reads as resistance. The leakage resistance of most electrolytics is in the range of 50 kilohms or so, so learn to allow for it when you're checking resistances along power supply lines. One clue to hidden resistance circuits which are caused by electrolytic capacitors is

that the resistance reading tends to increase if the test prod remains on the point. This is because the ohmmeter battery is charging the capacitor, and as the capacitor nears full charge it draws less current, which the ohmmeter interprets as a higher resistance. Reversing the test leads will cause most electrolytics to instantaneously measure as short circuits, but if the leads are left in place the capacitor will once again begin to charge and the meter pointer will move up scale to 50 kilohms or so, the normal leakage resistance of the capacitor.

Hidden resistance paths which are drawn elsewhere on the schematic can also cause erroneous resistance measurements. If you were to measure the resistance from the plate of V1 to ground in **fig. 11** you might expect to find an infinite reading. Instead you find a low resistance reading caused by the voltage-dividing network in the screen circuit of V12 which is located on the other end of the schematic (**fig. 11B**). Hidden circuits such as this

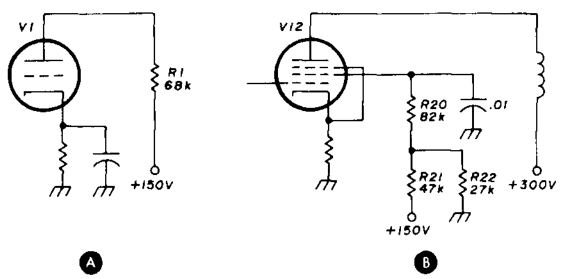


fig. 11. You might expect a resistance measurement from the plate of V1 to ground to be 100k. Actual measurement is much lower because of voltage-dividing screen network for V12 — a parallel resistance path which is hidden because of the way the schematic is drawn.

are usually a bigger problem in vacuum-tube equipment than they are in solid-state gear because base-bias networks are common practice in transistor circuits and you'll learn to work around them. Bias networks are less common in tube circuits, however, but when they do occur you'll probably find them at some remote point on the schematic where they're easily overlooked.

These are the four most common hidden resistance paths which can give you erroneous readings when you're troubleshooting by resistance measurements. When your ohmmeter readings are different from what the schematic leads you to expect, here are some quick checks to pinpoint the cause.

1. If a reading is low, reverse the ohmmeter leads. If the reading increases, there's diode action in the circuit which can be traced to a diode, transistor or a power supply rectifier. Only slight differences in readings when you reverse the test leads can usually be traced to electrolytic capacitors which don't form under reverse polarity.

2. If an ohmmeter reading starts at the low end of the scale and builds up slowly, an electrolytic capacitor is causing it through normal charging action. Reversing the test leads gives an even lower reading (often off scale) which builds back up again to the higher one. The final reading should be 50 kilohms or greater and depends upon the condition of the capacitor. The clue here is the charging action.

3. If you're still looking for the cause of a low resistance reading, have eliminated semiconductors and electrolytic capacitors, and can find no hidden parallel paths at other points on the schematic, you're probably on the trail of the circuit problem.

Sometimes it's faster and easier to eliminate the effects of parallel resistance paths than it is to get around them. One troubleshooting trick that often helps is not to make resistance measurements with respect to ground — don't clip the common lead of the ohmmeter to the chassis. Make each resistance measurement between points *in the circuit*. This won't eliminate all the hidden parallel circuits, but it will isolate some of them, which is a help.

If necessary, disconnect unwanted parallel resistance paths when they get in your way. If you carefully plan your point-to-point resistance measurements, this shouldn't be required very often, but when it does happen it's usually a simple matter to temporarily unsolder the parallel component or resistance branch which is giving you fits.

On printed-circuit boards you can often unsolder one lead. Another technique the professionals use is to cut a slit across the copper foil with an Xacto knife to disconnect the offending circuit branch. The circuit is easily restored by a solder bridge across the narrow slit.

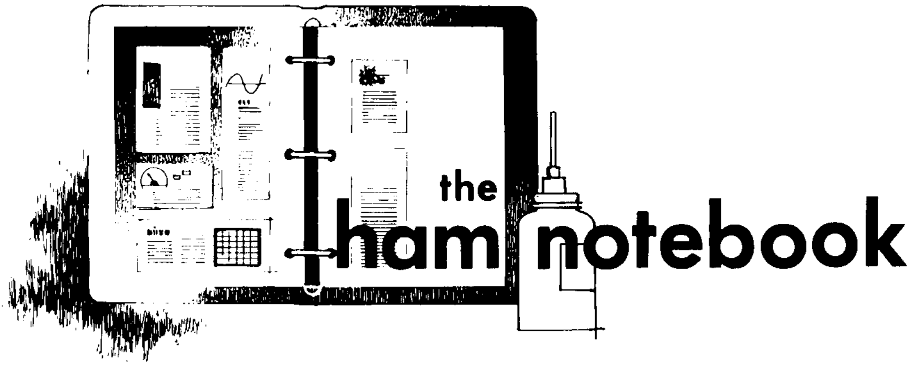
You can sometimes eliminate parallel circuit paths by pulling a tube or a transistor out of its socket. However, with fewer and fewer sockets on modern printed-circuit boards, this isn't always possible. In those cases it's easier to cut a slit in the circuit trace.

As a *final* resort, when you can't analyze a circuit any other way, you may have to disconnect and test each component in the circuit one at a time. This is a time consuming process, but if you've done your premiminary testing carefully, and eliminated most of the parallel resistance paths by one of the previous techniques, you'll have the problem narrowed down to a small section of the circuit so there shouldn't be too many parts to test individually.

conclusion

Although most manufacturers provide resistance charts in their instruction manuals, in those cases where charts are not available resistance troubleshooting is based entirely on figuring out from the schematic diagram just what a particular resistance path should be, and then measuring it with your ohmmeter. If the resistance isn't what you expect it to be you must isolate the one that's incorrect. In the coming months I will show how the technique of resistance troubleshooting, when coupled with voltage measurements and signal tracing, can be a very valuable tool for locating circuit problems in amateur equipment.

ham radio



Mini-Mitter II modifications

The Mini-Mitter II* is no longer available in kit form. American States Electronics is now building an assembled MM-2C for sale primarily to government agencies for approximately $600.00. I was able to pick up a used unit with a broken whip antenna. The following is offered on replacing the antenna together with some data on replacements for in-house brand ICs and transistors.

The stock antenna is 65 inches (1.65m) long. The manufacturer reports that his supplier no longer makes this length rod and has substituted a smaller one, as found in CB sets. No replacements are available. Lafayette Radio in their latest catalog lists a 67½-inch (1.7m) antenna (stock no. 99F32070), which is the only close replacement I've found. The base diameters differ, but replacement can be accomplished as follows:

1. Cut off the heat-shrink tubing covering the loading coil. Be careful not to nick any turns of the coil.

2. Two screws will be exposed, which hold the antenna rod and collar. Remove these two screws and pull off antenna and collar.

3. The collar is soldered to the antenna rod. Clamp the rod in a vise, heat the collar with a torch, and remove.

4. To accommodate the Lafayette rod, the collar must be bored out to 0.375 inch (1cm). Resolder the new antenna to the bored-out collar and reassemble to the loading coil.

5. Obtain a piece of 1½-inch (3.8cm) heat-shrink tubing to fit over the coil. Finding tubing this large may be the hardest part of the whole job.

*Ken Pierce, W6SLQ, "Mini-Mitter II," *ham radio*, December, 1971, page 72.

Equivalents for the Mini-Mitter house-brand ICs and transistors are listed below:

FE5245	2N4416
A158C	HEP737
ASE77	TRW PT2677B
ASE400	RCA 3020A
ASE401	RCA 3021
ASE408	RCA 3028A

ASE's latest transceiver is the model MM-2C. Apparently there have been some modifications to decrease standby current drain in the audio output circuit and to increase transmitter output power. Perhaps a reader with a newer unit might comment on this.

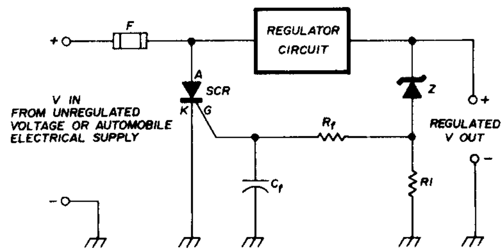
Charles King, K1ETU

overvoltage protection

Most solid-state electronic equipment in use today specifies an input voltage of 13.8 Vdc ±15%. This represents a range of 11.475 to 15.525 Vdc. If the series element in the regulated power supply short circuits, the entire output from the rectifier (typically 18 to 30 Vdc) will appear at the input to your equipment. Few semiconductor circuits in popular use can withstand such abuse.

The crowbar (overvoltage protection circuit) shown in **fig. 1** can be added easily to your power supply or automobile electrical system for just a few dollars. It will detect any overvoltage condition and immediately shut down the supply voltage before it fries your equipment.

Operation is simple. When V_{out} reaches a set value (determined by Z), the scr gate triggers, conducting heavily, and the fuse blows. This circuit has the advantage of not loading the regulator should the scr fire because of some transient condition. More important, the fuse immediately opens because of the short circuit condition. This fast-turn-off feature is important, because the time required to open a fuse is a function of the load current, **fig. 2**. A typical 10-watt transceiver may draw 2 to 3 amps on



F	fast-blow fuse, typically 150% of nominal equipment load current
R1	1000 ohms typical. Provides leakage current for zener diode
Rf, Cf	lowpass filter to prevent noise spikes from turning on SCR. Rf - 100-1000 ohms typical, Cf = 0.10-0.05 µF typical
SCR	rating determined by voltage and short-circuit current requirements
Z	zener diode voltage as required to detect over-voltage condition

fig. 1. Overvoltage protection (crowbar) circuit for regulated power supplies.

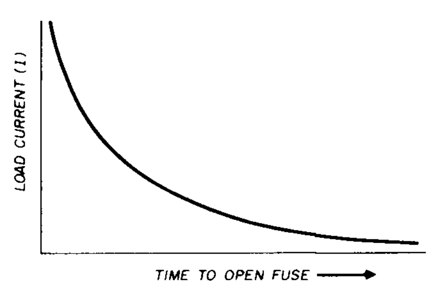


fig. 2. Relationship of load current and fuse rupture.

transmit but only a tenth or so of this value in receive, permitting a potentially damaging situation.

To check the crowbar, temporarily install a 500-ohm resistor in the scr anode circuit (**fig. 3**). Increase output voltage to the maximum desired and check to see if the scr fires properly, which will be indicated by a sudden voltage increase as measured across the 500-ohm resistor.

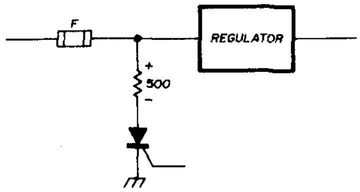


fig. 3. Test circuit for checking crowbar.

If necessary change Z or add diodes in series (germanium 0.3 V or silicon 0.6 V) to obtain the desired trip voltage. When all is well, remove the resistor. The scr will conduct until power is removed from the circuit. This circuit is analagous to buying insurance: you may never use it, but you may be sorry someday without it.

Ed Pacyna, W1AAZ

R-392 receiver mods

The R-392 receiver is hot, stable, and provides full coverage between 0.5 and 30 MHz. However, the compromises involved in modifying it for 28 Vdc on filaments and plates need shaping up. Here are some suggestions.

First bring out the plate and filament leads separately. The receiver is happier with somewhat more than 24 volts on the plates, somewhere between 30 and 35 volts. Build a supply that will provide over 30V from a bridge rectifier. Filter the supply with 3000 μF or more (the receiver tolerates 2 to 4 V of hum). Power the entire receiver this way first. The tubes in my set withstood 37 V for a few hours. Next add a dropping resistor (2 ohms, 20 watts) to the filament lead. Leave the plate lead on the higher voltage.

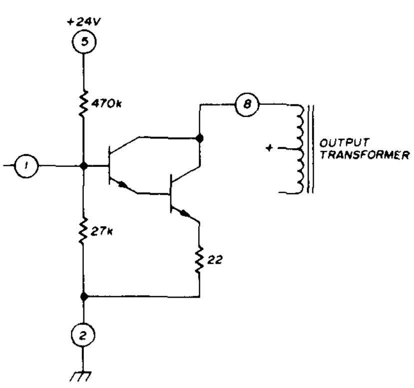


fig. 4. Simple audio replacement for V608.

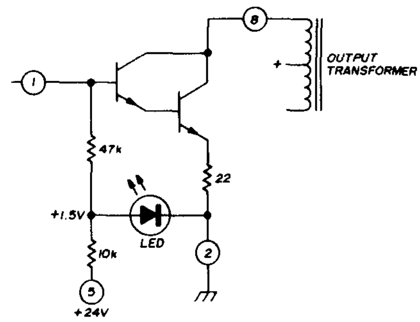


fig. 5. Improved audio replacement.

The audio output tube has to go. This tube pulls a total of 1.3 watts, plate and filament. The designers must have known it had to go: the manual shows a plug-in transistor substitute.

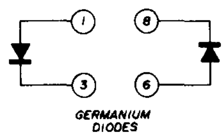


fig. 6. V602 and V603 replacements.

However, their substitute uses 15 components including four transistors and two transformers. A better substitute is shown in **fig. 4**. Use a single Darlington power transistor with no extra heatsink; connect the collector to existing pin 8, emitter through 22 ohms to existing pin 2 and ground, and base to existing pin 1. Bias the Darlington with 27k to pin 2 and ground and 470k to pin 5 (+28 V, formerly the screen supply). Build this assembly on an octal plug. Adjust the 470k resistor to obtain 0.2 to 0.7 V across the 22-ohm resistor.

An improved circuit is shown in **fig. 5**. A LED makes an excellent 1.5 V zener — much better than a zener at low current. I used 10k to a LED to obtain 1.5 V and 47k from the LED to the Darlington base. That's a total of five components. The dropping resistor in the power supply can now be increased to 4 ohms. You have removed 16 watts from the filament string.

Next we operate on the detectors. V602, V603 are 12AU7s with filaments in series. They are used as four diodes for detectors and agc. Pull out V603 and insert two germanium diodes into the socket holes, one with anode to pin 1 and cathode to pin 3 (see **fig. 6**), and the other with anode to pin 6 and cathode to pin 8. The set should work, even with V602 dead. Insert two more diodes in the same places on V602 socket to get the squelch rectifier and agc working again.

You can now increase the power-supply dropping resistor to about 8 ohms, and the filament string will have decreased from 3 to just over 2 amps. The radio has now become practical, and you haven't had to take the chassis apart. The next step should involve fet substitutes, a very practical possibility with only 30 volts on the plate bus.

N. J. Thompson, KH6FOX

selecting white noise diodes

Several articles have appeared in *ham radio* on how to build an rf noise bridge for measuring antenna impedance. The following method for finding a suitable noise diode is the utmost in simplicity.

The equipment needed is a variable voltage supply between 5 and 10 volts, a variable resistor box or potentiometer, and your communications receiver. If you don't have a variable power supply, use a 9-volt battery. However, if you wish to know more about the characteristics of each diode, a variable supply will be needed and each diode can be catalogued. The test setup is shown in **fig. 7**.

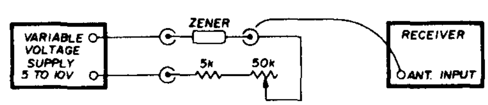


fig. 7. Setup for testing "noise generator" zener diodes.

Turn on your communications receiver and run a short antenna wire to within a few inches of the diode under test, apply 9 volts to the diode with a series resistor of about 10k to 40k. If no noise is heard, reverse the diode polarity. When the noise has been maximized for the range of 7½ to 9 volts, use an ohmmeter to measure the total resistance of the variable resistor plus the fixed resistor. About ten per cent of the diodes tested gave an output sufficient to produce a roar from the receiver loudspeaker, and the optimum resistance was 33k.

With a variable power supply you can optimize and catalog each diode for voltage and resistance. I selected my diodes for the noise bridge using 9 to 7½ volts at some given resistance, which provides the greatest use of a 9-volt battery.

Lloyd Jones, W6DOB

goral oscillator notes

The Goral crystal oscillator circuit described by Don Stoner in *ham radio** appears to be excellent in many respects. I have found, however, that the proper value of C2 in **fig. 4** of the original article is a critical function of the capacitance for which the crystal is calibrated. Crystals for the GE Progress Line, for example, are ground to operate into a 10-pF load and will not oscillate on their proper frequency using 20 pF as the value of C2. Data on two different crystals for a GE Progress Line receiver are shown in **fig. 8**. A value of 12 pF for C2 is more suitable as it allows the crystal to be netted using an 8-pF trimmer capacitor at C1. The data also illustrate the wide frequency range over which the oscillator will operate when different values of C1 and C2 are used.

Robert E. Cowan, K5QIN

*Donald L. Stoner, W6TNS, "High-Stability Crystal Oscillator," *ham radio*, October, 1974, page 36.

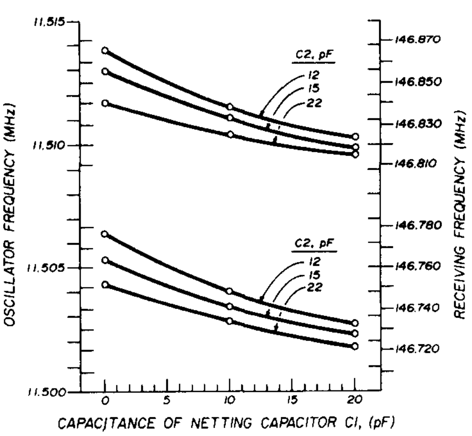


fig. 8. Effect of netting capacitor C1, and capacitor C2 on oscillator and receiving frequencies using a Goral oscillator. Crystals were ground for 11.5050 (146.160) and 11.5125 (146.850) MHz use when operated into a 10 pF load in a GE Progress Line receiver.

simple crystal oven

This unit can be added to existing equipment, such as a frequency counter, that uses a crystal oscillator as a reference frequency. It provides proportional rather than on-off control. All components are mounted on the crystal with several advantages. All heat produced (2 watts maximum) is used in maintaining the crystal temperature, so power consumption is low. All oven components except the trimpot operate at the crystal temperature, aiding stability. Parts layout and schematic are shown in **fig. 9.**

Installation is simple. Note that the TO-5 transistor case is at ground potential. The crystal socket and a simple tie around the foam insulation are sufficient support because of the light weight.

The thermistor, which was from a transistor amplifier bias circuit, is about 1k at room temperature. Values much different from this might require circuit changes. For correct operation the current through the thermistor (about 1 mA) should be much more than the base current of transistor Q1 (0.1 mA). Q1 and Q2 should have low leakage currents. If Q2 is a silicon type, increase the 150-ohm resistor to 680 ohms.

The supply voltages may be available in the existing equipment power supply, and maximum drain is only 200 mA. An unregulated voltage higher than 9 volts would require higher-value heating resistors. Power transistor Q2 supplies some of the heat when the operating temperature is reached and proportional control occurs.

Temperature stability depends on the 5-volt supply and the efficiency of the foam insulation, which can be attached neatly with masking tape. Some heat unavoidably leaks through the crystal socket.

The oven should operate a little above the maximum temperature expected inside the equipment, which should be well ventilated. Set the trimpot so the current from the unregulated supply is about 30 mA with the equipment at maximum temperature. My unit reaches operating temperature in 5 to 10 minutes, depending on the ambient temperature.

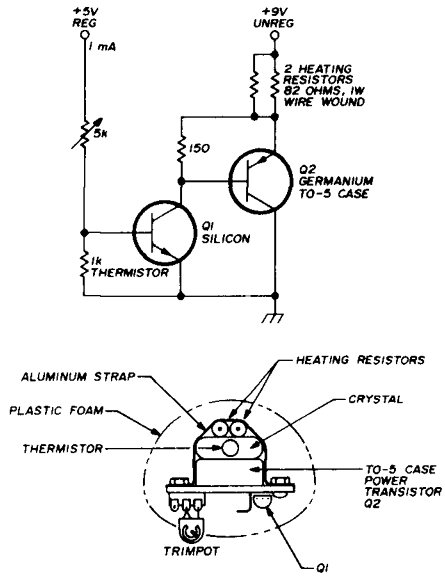


fig. 9. Simple crystal oven.

P. H. Mathieson

notes on 3-400Z, 3-500Z filament circuits

The popular 3-400Z and 3-500Z zero-bias triodes used in cathode-driven amplifiers require 5 volts for the filament supply. A pair will draw 29 amps of filament current. This relatively high current can lead to a series of problems all having the same net result: low filament voltage from excessive resistance somewhere in the filament circuit. Let's assume that in the filament circuit an undesired resistance of only 0.01 ohm is caused by a poor solder connection. At 29 amps, this resistance will result in a voltage drop of 0.29 volt. It will also result in 8.4 watts being dissipated as heat in the already poor connection.

The practical result of this situation was seen in a commercially made amplifier using a pair of 3-400Zs. After about a year of operation, the amplifier gradually started losing output power. The problem has all the appearances of one or both tubes going bad. The amplifier was upended for a close examination of the filament circuit. The connections from the filament choke had the appearance of cold solder joints. A voltmeter check (performed with the high voltage disabled) showed less than 4.5 volts on the filaments, measured right at the tube pins. A voltage drop of more than 0.1 volt was measured across each of the four solder connections for the filament choke. Enough heat had been generated to soften the solder at each connection. When the four connections were cleaned and resoldered, 5 volts were measured at the tube filaments. Not only was the lost power regained; the amplifier actually put out more power than it had when brand new! In this case the connections were marginal from the start, and enough heat had been generated to continue oxidizing the solder, resulting in a slow deterioration of the connections until finally there was a noticeable degradation in performance.

Every soldered connection in the filament circuit is a potential source of trouble in this regard as are the pressure contacts between tube pins and socket. So if your amplifier has lost some of its pep, check the filament voltage at the tube socket before investing in new tubes. A good solder connection should have no appreciable voltage drop across it, even at 29 amps, but there may well be a drop of 0.1 volt or more across each half of the filament choke, depending on wire size. Prolonged operation with low filament voltage can result in a loss of some of the filament emission. Should this occur, it may be restored by operating the tube at normal filament voltage with no drive or plate voltage for about an hour.

If it appears that the filament has burned out, try resoldering the filament pins and you may be pleasantly surprised. It's not unheard of for the tube pin to develop a poor solder connection and open up completely. Another tube problem that occasionally occurs is a filament-to-grid short.* If this happens while the tube is still in warranty, of course it should be returned to the manufacturer for a replacement. Even if the tube is out of warranty, the situation is not necessarily hopeless. Often it's possible to burn out the short by discharging a large capacitor through it. Measure the resistance from each end of the filament to the grid. Use the filament pin that gives the lower reading, which will allow more current to flow and is more likely to melt the short. One 3-400Z was successfully repaired in this manner four times using a fully charged 2500 μF 200-volt capacitor. Each time this was done, no doubt some of the thin wires in the grid structure were damaged. On the fifth occasion the filament burned out, but the need to purchase a new tube was successfully delayed for over a year.

John E. Becker, K9WEH

*A filament-to-grid short can occur if the filament is allowed to sag against the grid. When upending the chassis to make voltage measurements, make certain the tube is oriented vertically. **editor**

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More Details? CHECK—OFF Page 110

NEW products

144- and 220-MHz fm transmitters

VHF Engineering has just announced two vhf fm transmitter kits for 144 and 220 MHz, the TX-144B and TX-220B. These new kits offer state-of-the-art design using pre-wound coils, epoxy-glass circuit board, temperature-compensated crystal trimmer, and have a nominal output of 1.5 watts.

Both construction and tune-up have been simplified through the use of pre-wound coils and tune-up test points, making these units one-evening projects. Special tools or equipment are not required. Only a low-wattage soldering iron, solder, wire cutters, and long-nosed pliers are needed for construction. Tune-up requires only a VOM, a small light bulb, and a non-metal hex tuning tool.

The basic transmitters are offered as single channel units, but may be multi-channeled through the use of a simple switch or by using the inexpensive ten-channel option. Companion receiver kits and power amplifier kits are available so that the average amateur may build his own vhf fm transceiver at a very nominal cost. These units may be ordered directly from VHF Engineering, 320 Water Street, P.O. Box 1921, Binghamton, New York 13902 or from one of their many dealers throughout the country. The TX-144B and TX-220B kits sell for $29.95 each plus shipping. New York State residents should add sales tax.

programmable-memory keyer

If you're a contest operator you'll be interested in the MK-75 keyer by Brown and Simpson Engineering of Ontario, Canada. The MK-75 features design innovations especially tailored for serious competition work. The best features of the Accu-Keyer and the TO-type keyer have been incorporated into the MK-75, making it easy to use for those familiar with either of these keying methods.

The MK-75 features self-completing characters, dot/dash memory (Iambic), as well as automatic letter and word spacing. A sidetone oscillator is also provided, with volume and tone controls. Speed range of the MK-75 is 5-65 wpm.

The MK-75 memory is quite versatile. To program a message, you place the READ/WRITE switch in WRITE position, press any one of the four quadrant buttons with its LED display, key in your message, and return the switch to READ position. To read a message, just press a quadrant button.

Suppose you wish to enter an insert into the preprogrammed message. Merely program the first part of the message as described above, press the INSERT button, program the remainder of the message, and return the READ/WRITE switch to READ. The memory is now ready for your insert message. To insert a message, such as W8XYZ NR 682, just press the appropriate quadrant button. The memory stops at the point where you wish to insert the message and waits while you insert the message manually. The memory then finishes the preprogrammed message after your insert.

The MK-75 includes many other features such as insert-function bypass, disable or delay of automatic restart capability, instant message interrupt, and message editing.

These are only the basic operations of the MK-75; the user's manual has more detailed information. Price is $249.00, which includes shipping and handling in the U.S.A. and Canada. More information is available from Brown and Simpson Engineering, 17 South Edgeley Avenue, Scarborough, Ontario, Canada M1N 3K9, or use *check-off* on page 110.

rf power and swr meter

The model C1277 broadband power/swr meter by Werlatone is an inexpensive instrument for amateur use in the hf and vhf range. The C1277 covers 27 to 450 MHz continuously and features dual power-range scales for 15 and 50 watts. A unique broadband coupler provides a useful bandwidth approximately eight times greater than previously available. No plug-in units or separate indicators are required. Wattmeter accuracy is ±10% when used with a 50-ohm antenna system. Sensitivity for swr measurements is less than 5 watts. ICAS power capability is 50 watts CW, 27 to 200 MHz; 25 watts CW, 200 to 300 MHz, and 15 watts CW, 300 to 450 MHz. Single-sideband power capability over the entire range is 50 watts maximum.

The model C1277 is attractively packaged in a 4x4x5 inch (10x10x12.5cm) enclosure and is equipped with a two-color, wide-view meter. The wideband directional coupler, which is weather-tight, may be removed from the enclosure for remote location.

More Details? CHECK—OFF Page 110

No other environmental protection is needed.

The wattmeter is an in-line instrument and is a useful addition to your station for monitoring transmitter and antenna performance. Amateur net price of the model C1277 is $89.50. If you'd like more information, write to Werlatone, Inc., Brewster, New York 10509, or use *check-off* on page 110.

semiconductor curve tracer

Hickok's new model 440 curve tracer, with exclusive *Insta-Beta* display, dynamically tests all types of semiconductors under actual conditions – in or out of circuit. Used with any scope having an external horizontal input, it generates calibrated characteristic curves that can be accurately scaled right from the screen. It safely tests jfets, mosfets, diodes, zeners, transistors, UJTs and SCRs – silicon or germanium, power or signal.

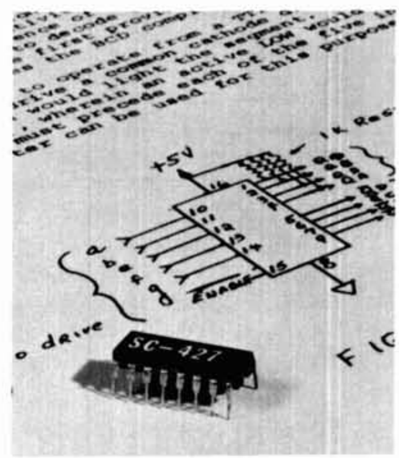
Insta-Beta takes the guesswork out of transistor beta and fet parameter calculations. In the transistor mode, *Insta-Beta* displays a single, full range I_C/I_B curve from which ac and dc beta can be instantly determined without interpolation. This curve also shows beta linearity at a glance. In the fet mode, *Insta-Beta* displays the entire transfer curve including pinch-off voltage, full-on current, and active portion for easy calibration of transconductance.

In normal semiconductor testing, a variable step control provides characteristic curve displays with up to ten steps per family (steps of base current for transistors and steps of gate voltage for fets). Maximum sensitivity of 1 volt per division is especially useful for measurements in the semiconductor threshold or turn-on region.

Controls are logically arranged on the front panel and use color coding and fast set-up marks where applicable. A handy pull-out card provides ready reference information for calibration, set-up and operation of the instrument.

For more information on the Model 440 Curve Tracer contact Tom Hayden, Instrumentation & Controls Division, Hickok Electrical Instrument Company, 10514 Dupont Avenue, Cleveland, Ohio 44108 or use *check-off* on page 110.

decoder ic



The SC-427 is a new decoder chip available from Scarpa Laboratories in a standard 16-pin DIP which accepts TTL conditioned inputs from a seven-segment display driver and converts them back onto a BCD output.

The device was designed to take advantage of the powerful computing capability of low-cost calculator chips which, in their present form, dead end into a visual digital display. By converting back into BCD format, the engineer is able to break out this extraordinarily economical data-reduction ability into useful computer, controller, time-clock or print-out functions. The unit can also be used to interface LSI clock chips to computers, controllers or printers.

The TTL-Schottky device operates from a single 5 volt supply and has a conversion speed of 25 nanoseconds, thereby requiring only one device for multiplexed displays. For more information, write to Scarpa Laboratories, Inc., 46 Liberty St., Metuchen, New Jersey 08840, or use *check-off* on page 110.

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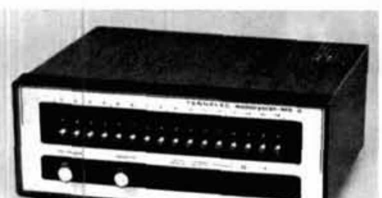
vhf transverter

The new Europa B from Solid State Modules is a linear transmit and receive converter from 28-30 MHz to 144-146 MHz or 50-52 MHz and is suitable for use with either a transceiver or separate receiver/transmitter. It is ideal for Oscar operation as well as normal tropo work. A crystal switch and extra crystal can be installed to extend the frequency coverage. Although designed primarily for ssb operation, the Europa B will receive and transmit any mode which the hf equipment is capable, ssb, a-m, fm, FSK or CW.

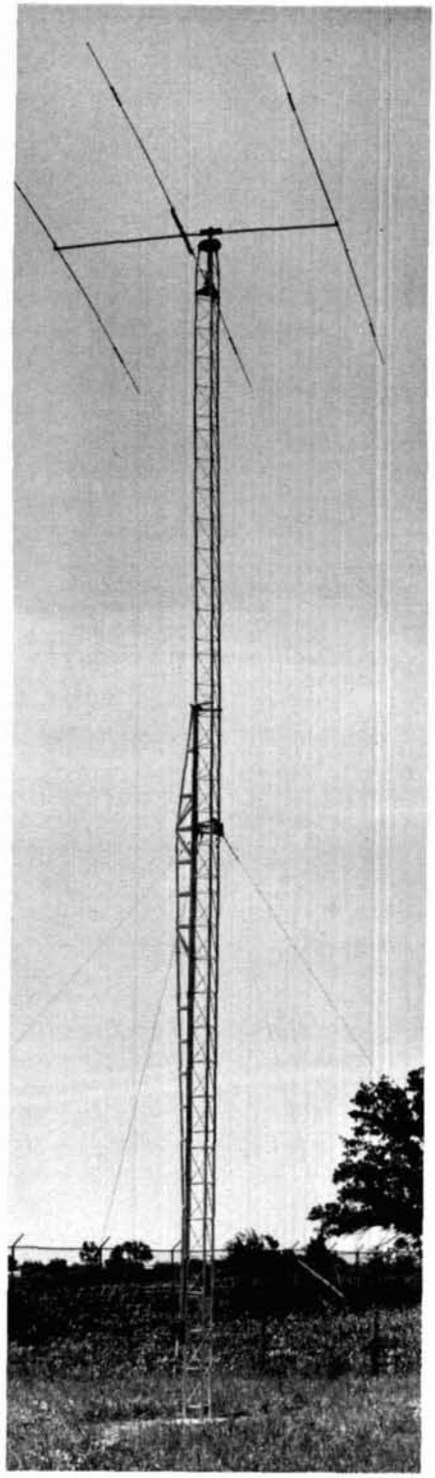
The receiver converter is broadbanded to cover the entire vhf band without any tuning, It uses dual-gate mosfets for optimum sensitivity, gain and low cross-mod. The noise figure is 2 dB; converter gain is 30 dB. The trans mit converter uses tubes to provide high power, good linearity and high rejection of spurious signals. Power input is 200 watts (50% efficiency, minimum), drive requirement, 200 mW. An optional ac power supply is available.

For more information on the new Europa B Vhf Transverter, write to Solid State Modules, 1624 Kaweloka Street, Pearl City, Hawaii 96782, or use *check-off* on page 110.

fm scanning receiver



Tennelec, Incorporated, is now offering an improved version of their Memoryscan fm scanning receiver, the Memoryscan MS-2. With this receiver you can monitor up to 16 low/high vhf and uhf channels without buying expen-



sive new crystals. Memoryscan MS-2 has been updated to include new fet rf stages and an effective new filter, all of which mean higher sensitivity, better adjacent-channel isolation, and cleaner, crisper audio.

The MS-2 may be programmed to receive any of 4000 frequencies by punching the appropriate code, listed in Tennelec's code book, into the scanner. Manual scan override is provided, as well as channel lockout switches and squelch. Visual frequency verification capability allows you to check whether the proper code has been programmed. An optional mobile kit is also available. The MS-2 retails for $339.95. More information is available from Tennelec, Incorporated, 601 Turnpike, Oak Ridge, Tennessee 37830, or use *check-off* on page 110.

frequency counter

A portable high-sensitivity frequency counter designed specifically for telecommunications applications was recently introduced by the Fluke Counter Division. This all-new frequency counter, Fluke model 1920A, incorporates many new and innovative features including advanced LSI/MOS circuitry which makes a major contribution to the counter's exceptional electrical specifications while permitting a significant reduction in the unit's size and weight.

The 1920A features a nine-digit LED display, sensitivity to 15 mV, AGC standard, and a frequency range from 5 Hz to 520 MHz. Optional internal prescalers to 1000 MHz and 1250 MHz cover uhf television, 900-MHz telecommunications, and TACAN/DME.

Direct and prescaled inputs are color-coded to match their corresponding function switches to facilitate operation, while the large, seven-segment nine-digit LED display incorporates full leading zero suppression, automatic an-

More Details? CHECK—OFF Page 110

nunciation, overflow and a self-check mode which lights all digit segments.

Measurement delays have been eliminated in the 1920A through a "rapid-access gate" which free runs in the absence of input signals to be in a position to open the gate for the selected gate time as soon as a signal is sensed. An auto-reset circuit initiates a new measurement every time any front panel switch is activated, ensuring that the first measurement obtained is always correct.

In addition to normal frequency measurements, a burst function switch is provided, permitting the measurement of rf bursts having a duration of 2 ms or more. To avoid erroneous reading, the display is automatically reset to zero if the burst width is less than the gate time selected. An optional resolution multiplier is available which coherently multiplies audio tone signals by 1000, providing a resolution of 0.001 Hz in 1 second.

The 1920A frequency counter is backed by Fluke's full warranty and coast-to-coast service, and is priced at $859, FOB Buffalo, New York. For more information, write to John Fluke Mfg. Co., Ltd., Counter Division, Post Office Box 1094 Station D, Buffalo, New York 14210, or use *check-off* on page 110.

QSL display album

To organize, display and protect your QSL cards, Ace Art Company offers the NuAce QSL Card Display Album. Available in blue, black or ginger binder, the album has 23 chrome steel rings which hold up to 25 pages or 150 cards. Crystal clear pages of durable vinyl give protection from handling, dampness, and fading. Each page has 3 pockets sized 3-7/8 x 7 inches (9.8 x 17.8 cm) and will hold six cards back to back. (Also available is a two-pocket page with 5-5/8 x 7-inch pockets (14.3 x 17.8 cm) for oversize cards, and a one-pocket page sized 12 x 7 inches (30.5 x 17.8 cm).

The binder and 10 pages holding 60 QSL cards may be purchased for $5.95 (plus $1.50 shipping and handling) from Ace Art Company, Inc., 24 Gould Street, Reading, Massachusetts 01867. Extra vinyl pages are 49 cents each.

More Details? CHECK—OFF Page 110

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The Swan Model 742 Triband Mobile, the only automatic amateur radio antenna, eliminates coil changing, tap adjusting, switch flicking and all the rest of mobile antenna inconvenience.

Now for the first time ever you just sit behind the wheel and change from 20 to 40 to 75 meters while your 742 automatically loads itself for each band—perfectly.

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More Details? CHECK—OFF Page 110

Hy-Gain 270 2-meter antenna.

A great mobile that's also a great base.

The same state-of-the-art qualities that make the Hy-Gain 270 antenna a great 2 meter mobile, make it a great 2 meter base.

Hy-Gain design has eliminated hard tuning, high VSWR and poor pattern due to irregular ground plane. The 270's slim mobile configuration makes it ideal for apartment or urban installations where space is at a premium.

Fiberglass 270 develops gain through the use of 2 stacked 5/8 wave radiators with a self-contained 1/4 wave decoupling system. Gain that helps reach distant repeaters.

Since the antenna and feedpoint are sealed in fiberglass, the Hy-Gain 270 delivers top performance year after year without corrosion loss.

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For information on Hy-Gain 2 meter and other amateur products contact your Hy-Gain distributor or write.

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Hy-Gain Electronics Corporation: 8601 Northeast Highway Six;
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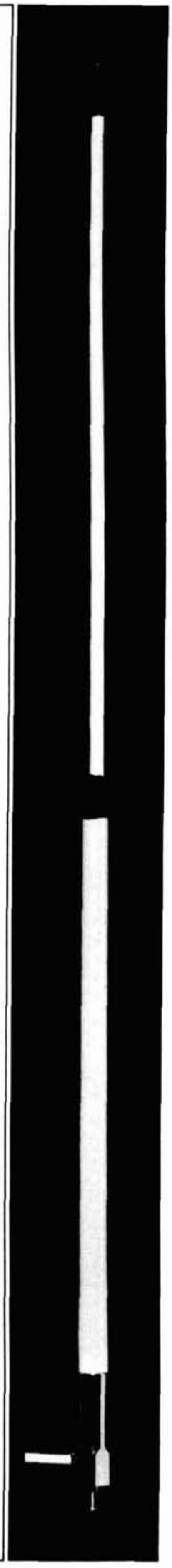

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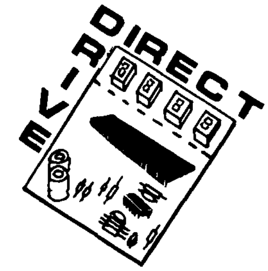
4 DIGIT ALARM CLOCK

$15.95

KIT No. 1 (with PC Board)



Features the only LED direct drive clock chip on the market. Kit includes all parts (except transformer)* for a 4 digit alarm clock kit. Uses .25 inch LED readouts.

Transformer for Kit No. 1 .... **$ 2.00**

Kit No. 2 - Complete Kit With Woodgrain Case and Display Window **$21.50**
Kit No. 3 - Same as Above but with ½ inch Readouts **$22.50**

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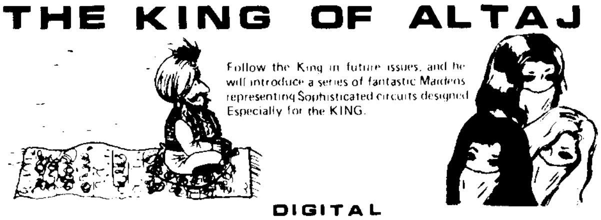
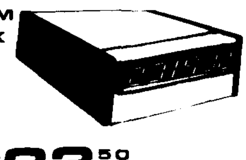


Follow the King in future issues, and he will introduce a series of fantastic Maidens representing Sophisticated circuits designed Especially for the KING.

DIGITAL ALARM CLOCK



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4.) Single 12v. supply and a minimum of interface components.
5.) AM-PM and automatic power failure indications
6.) 10 minute snooze
7.) Complete data and construction manual enclosed.

$23.50

Kit No. 70250	1R (Red readouts)		
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Kit No. 70250	1G (Green readouts)		$23.50
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Kit No. 70250	3R (DL747 readouts)		$28.50

Upon conclusion of our introductions you will have the most advanced timepiece on the market. Watch next issue for the King's first addition to his harem.

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Jumbo .6 in. high, and only 20mA. per segment Common Anode

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Red, .30 in high 15mA per segment Common Anode

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727

Common Anode

One of our best Readouts. .5 in. high, 20mA per segment

3.75

NEW HP7730 **1.20**

.33 in. high read very bright readout, 25mA per segment Common Anode

DL33

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We like it, you will love it, our new .5 in. common cathode type by Fairchild.

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BURROUGHS 12 DIGIT DISLAY

.25 in. high, Orange digits Ionization voltage 160V DC. We will encl. a free socket as a bonus **3.25**

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A perfect choice for your mini 6 digit clock or why not a stop watch Fully multiplexed, common cathode. 1 Class and goldplated

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MAN5 GREEN
MAN7 RED
MAN8 YELLOW

Why not make a clock in 3 diff. colors, we tried it and it looks nice. .27 in. high digit Common Anode

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Nixie B5861ST by Burroughs, .56 in. Orange Digit 160V Ionization potential. Only a limited supply in our stockroom

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TTL

7400	16
7402	16
7404	16
7406	.24
7408	.16
7410	.16
7413	49
7420	.16
7427	.24
7430	.16
7437	.39
7438	35
7440	16
7442	69
7447	.89
7448	.89
7453	37
7473	37
7474	37
7475	65
7476	39
7483	85
7490	69
7492	75
7493	75
7495	75
7496	.75
74121	38
74123	75
74151	75
74153	89
74154	.95
74161	99
74163	1.19
74164	1 89
74165	1 49
74174	1 29
74175	1.39
74181	2.75
74192	1 25
74193	1.25
74195	79
74197	.79

C-MOS

CD4000	.24
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CD4007	24
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CD4012	24
CD4013	59
CD4014	1 49
CD4015	1 19
CD4016	59
CD4017	1 29
CD4018	1 49
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CD4020	1 59
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CD4023	24
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CD4025	24
CD4026	1 49
CD4027	59
CD4028	99
CD4029	1 39
CD4030	49
CD4032	24
CD4033	1 49
CD4035	1 39
CD4040	1 59
CD4041	89
CD4042	79
CD4044	59
CD4049	59
CD4050	59
CD4066	99
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74C02	29
74C04	29
74C107	1 29

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2N3055 NPN 115W TO3 Power	0 85
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Chip 7020 with direct Segment Drive. 8 digit

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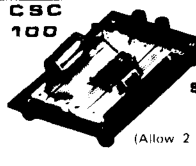
Includes FORD 19 KHZ, 38 KHZ, Osc Coils, etc. Used in AM FM car radios. All New 10 PC ASSMT

FREE! 9 Volt Battery with $10.00 or more purchase

CSC 100 NEW **Proto Board**



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ALTAJ THANKS YOU

Like to have a weekend affair?

We'll send you a beauty...

This beautiful Walkie-Talkie Kit is easy to build and can be assembled in one weekend. You save hundreds of dollars by building it yourself. The HT-144B offers exceptional performance at a budget price.

- 2 Watts minimum
- 4 Channels
- .35uV for 20dB of quieting
- Low battery drain . . . less than 10 Ma
- Now you can build a commercial quality walkie talkie at home at half the price.
- Designed with the ham in mind. Average assembly time, just 10 hours.
- Small and handy, yet large enough to be assembled with conventional tools.
- Attractive, scratch resistant textured finish.
- Lightweight, sturdy aluminum case.
- Black textured case 1-1/2 x 2-1/2 x 9-1/4
- All tunable coils are prewound
- Transceiver is on one G-10 predrilled board
- Parts layout silk-screened on boards for easy construction
- Crystal deck is separate predrilled board
- Weight less batteries – approximately 15 oz.
- Battery-case is AA size – accepts alkaline or nicad
- External battery charging/power supply jack furnished
- 1 dual gate mosfet 2 I.C.'s 15 transistors 7 diodes
- Antenna – collapsible 17" whip
- Covers any 2 Mhz segment between 140 and 170 Mhz
- Plenty of room in case for add ons (PL and tone)

HT-144B RECEIVER SPECIFICATIONS: SENSITIVITY better than .35uV for 20db quieting. SQUELCH THRESHOLD better than .25uV. STABILITY .002 typical (depends on crystal). ADJACENT CHANNEL REJECTION 60 db. SPURIOUS RESPONSES down 70db. FIRST IF 10.7 Mhz SECOND IF 455 Khz. FILTER 4 pole monolithic 10.7 Mhz crystal. DISCRIMINATOR pretuned ceramic 455 Khz. BANDWIDTH 15 Khz at 3db points. CRYSTAL 45 Mhz parallel at 20pf. CRYSTAL FORMULA receive frequency minus 10.7 divided by 3. AUDIO OUTPUT .5w typical. CURRENT DRAIN 10 ma squelched, 100 ma on voice peaks.

HT-144B TRANSMITTER SPECIFICATIONS: OUTPUT 2 watts minimum. 3 DB BANDWIDTH 2 Mhz typical. STABILITY .002 typical (depends on crystal). SPURIOUS outputs down 30db or better. MODULATION true FM with varactor in crystal circuit. NETTING separate trimmers for each channel. DEVIATION adjustable to 7 Khz. AUDIO limiter and active low pass filter. MICROPHONE speaker type. CRYSTAL 18 Mhz parallel at 20 pf. MULTIPLICATION FACTOR frequency times 8. CURRENT DRAIN 500 ma typical.

LIMITED OFFER

Now an even better buy . . .

$129.95 includes Walkie Talkie Kit, 1 set of crystals for 146.52 simplex and rubber duck antenna. Battery charger included free with purchase of $29.95 ½ amp NICAD Pack.

ORDER FORM

Item	Price Each	Quantity	Total Price
HT-144B Walkie Talkie	$129.95		
Rubber Duck Antenna	No charge*		
Crystals (pair) 146.52	No charge*		
12 Volt NICAD Battery	$29.95		
Battery charger (for HT-144B)	No charge**		

*With purchase of HT-144B Walkie Talkie **With purchase of HT-144B Walkie Talkie and NICAD Battery

Name ________ Total ________

Address ________ Shipping ________

City ________ NYS Resident Sales Tax ________

State ________ Zip ________ Total Enclosed ________

Master Charge or BankAmericard No. ________

Bank No. ________ Expiration Date ________

SHIPPING INFORMATION: All shipments are F.O.B. Binghamton, N.Y. 13902. Shipments will be made by the most convenient method. Please include sufficient funds to cover shipping and handling. Figure shipping charges on a minimum weight of 2 pounds per unit. Allow 3 to 4 weeks for delivery.

TERMS: C.O.D., cash or check with order. We also accept BankAmericard and Master Charge.

CLAIMS: Notify VHF *and* the carrier of damage within seven (7) days of receipt of shipment.

RETURNS: Obtain authorization from VHF before returning *any* merchandise.

PRICES AND SPECIFICATIONS: Subject to change without notice.

Export prices are slightly higher.

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Vhf engineering

DIVISION OF BROWNIAN ELECTRONICS CORP.

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More Details? CHECK–OFF Page 110

More Details? CHECK—OFF Page 110

7400N TTL

SN7400N*	13	SN7453N	27	SN74150N	1.10
SN7401N	16	SN7454N	41	SN74151N	1.25
SN7402N	21	SN7459A	25	SN74153N	1.35
SN7403N	16	SN7460N	22	SN74154N*	1.25
SN7404N*	16	SN7470N	45	SN74155N	1.21
SN7405N	24	SN7471N*	69	SN74156N	1.30
SN7406N	45	SN7472N	39	SN74157N	1.30
SN7407N	45	SN7473N*	37	SN74160N	1.75
SN7408N	25	SN7474N*	32	SN74161N	1.45
SN7409N	25	SN7475N*	59	SN74163N*	1.35
SN7410N*	16	SN7476N*	32	SN74164N	1.65
SN7411N	30	SN7479N*	5.00	SN74165N	1.65
SN7412N	42	SN7480N	50	SN74166N	1.70
SN7413N	85	SN7482N	1.75	SN74167N	5.50
SN7414N	70	SN7483N	1.15	SN74170N	3.00
SN7416N	43	SN7485N	1.12	SN74172N	18.00
SN7417N	43	SN7486N	45	SN74173N	1.70
SN7418N	25	SN7488N	3.50	SN74174N	1.95
SN7420N	21	SN7489N	3.00	SN74175N	1.95
SN7421N	39	SN7490N*	49	SN74176N	90
SN7422N*	1.50	SN7491N	1.20	SN74177N	90
SN7423N	37	SN7492N	82	SN74180N	1.05
SN7425N	43	SN7493N*	57	SN74181N	3.55
SN7426N	31	SN7494N	91	SN74182N	95
SN7427N	37	SN7495N	91	SN74184N	2.30
SN7429N	42	SN7496N	91	SN74185N	2.20
SN7430N	26	SN7497N*	4.00	SN74186N*	5.00
SN7432N	31	SN74100N*	1.00	SN74187N	6.00
SN7437N	47	SN74107N	49	SN74190N	1.50
SN7438N	40	SN74121N*	45	SN74191N	1.50
SN7439N	25	SN74122N	49	SN74192N*	1.19
SN7440N	21	SN74123N*	70	SN74193N*	99
SN7441N	1.10	SN74125N	60	SN74194N	1.45
SN7442N	1.08	SN74126N	81	SN74195N	1.00
SN7443N	1.05	SN74132N	3.00	SN74196N	1.25
SN7444N	1.10	SN74136N	1.80	SN74197N	1.00
SN7445N	1.10	SN74141N	1.15	SN74198N	2.25
SN7446N	1.15	SN74142N*	4.00	SN74199N	2.25
SN7447N*	79	SN74143N*	4.50	SN74200N	7.00
SN7448N	99	SN74144N*	4.50	SN74279N*	90
SN7450N	26	SN74145N	1.15	SN74251N	2.50
SN7451N	27	SN74147N	3.00	SN74284N	6.00
SN7452N*	27	SN74148N	2.50	SN74285N	6.00

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

CMOS

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

LINEAR

LM300H	80	LM377N	4.00	LM1351N	1.65
LM301H*	3/1.00	LM380N	1.39	LM1414N	1.75
LM301CN*	3/1.00	LM380CN	1.05	LM1458C	65
LM302H	75	LM381N	1.79	LM1496N	95
LM304H	1.00	LM382N	1.79	LM1556V	1.85
LM305H	95	NE501K	8.00	LM2111N	1.95
LM307CN	35	NE510A	6.00	LM2901N	2.95
LM308H	1.00	NE531H	3.00	LM3065N	69
LM308CN	1.00	NE536T	6.00	LM3900N	55
LM309H	1.10	NE540L	6.00	LM3905N	60
LM309K	1.25	NE550N	79	LM3909	1.95
LM310CN	1.15	NE553	2.50	LM5556N	1.85
LM311H	90	NE555V*	45	MC5558V	1.00
LM311N	90	NE560B*	5.00	LM7525N	90
LM318CN	1.50	NE561B*	5.00	LM7528N	2.20
LM319N	1.30	NE562B*	5.00	LM7534N	2.20
LM319D	9.00	NE565H*	99	LM7535N	1.25
LM320K-5	1.35	NE565N*	1.25	8038B*	4.95
LM320K-5.2	1.35	NE566CN*	1.95	LM75450	49
LM320K-12	1.35	NE567H*	1.25	75451CN	39
LM320K-15	1.35	NE567V*	1.50	75452CN	39
LM320T-5*	1.75	LM703CN	45	75453CN	39
LM320T-8*	1.75	LM709H	29	75454CN	39
LM320T-12*	1.75	LM709N	29	75491CN	79
LM320T-18*	1.75	LM710N	79	75492CN	89
LM323K-5*	16.00	LM711N	39	75494CN	89
LM324N	1.80	LM723N	55	**RCA LINEAR**	
LM339N	1.70	LM723H	55	CA3013	1.70
LM340K-5	1.95	LM733N	1.00	CA3023	2.15
LM340K-12	1.95	LM739N	1.29	CA3035	2.25
LM340K-15	1.95	LM741CH*	3/1.00	CA3039	1.35
LM340K-24	1.95	LM741CN*	3/1.00	CA3046	1.15
LM340T-5	1.75	LM741 14N	39	CA3059	2.46
LM340T-6	1.75	LM747H	79	CA3060	2.80
LM340T-8*	1.75	LM747N	79	CA3080	85
LM340T-18*	1.75	LM748H	39	CA3083	1.60
LM340T-12	1.75	LM748N	39	CA3086	59
LM340T-15	1.75	LM1303N	90	CA3089	3.25
LM340T-24	1.75	LM1304N	1.19	CA3091	8.25
LM350N	1.00	LM1305N	1.40	CA3123	1.85
LM351CN	65	LM1307N	85	CA3130*	1.49
LM370N	1.15	LM1310N	2.95	CA3600	1.75
LM370H	1.15			RC4194	5.95
LM373N	3.25			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	1.35	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-210	5.20	XR-2207CP	3.85
XR-215	6.50	**MISCELLANEOUS**	
XR-567CP	1.95	XR-2211CP	6.70
XR-2567CP	2.99	XR-2261	3.79
		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

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-WS
Chrome Plate Bezel
$27.95

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 shooze alarm, a power failure indicator, and even an A.M., P.M. indicator.

NOT A KIT **$19.95**

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MONSANTO

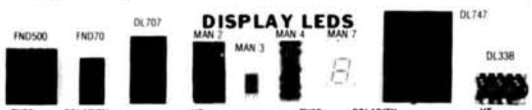
R - RED
G - GREEN
Y - YELLOW
O - ORANGE

DISCRETE LEDS

.125" dia.		.185" dia.		.190" dia.	
XC209R	5/$1	XC526R	5/$1	XC111R	5/$1
XC209G	4/$1	XC526G	4/$1	XC111G	4/$1
XC209Y	4/$1	XC526Y	4/$1	XC111Y	4/$1
XC209O	4/$1	XC526O	4/$1	XC111O	4/$1

.200" dia.		.200" dia.		.085" dia.	
XC22R	5/$1	XC556R	5/$1	MV50	
XC22G	4/$1	XC556G	4/$1	.085" dia. Micro	
XC22Y	4/$1	XC556Y	4/$1	red led	
XC22O	4/$1	XC556O	4/$1		6/$1

DISPLAY LEDS



TYPE	POLARITY	HT		TYPE	POLARITY	HT	
MAN 1	COMMON ANODE	270	$1.95	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	1.95
MAN 4	COMMON CATHODE	187	1.95	DL750	COMMON CATHODE	600	2.49
MAN 7	COMMON ANODE	300	1.50	DL338	COMMON CATHODE	110	1.95
MAN 7G	COMMON ANODE-GREEN	300	2.50	FND70	COMMON CATHODE	250	50
MAN 7Y	CLAMMON ANODE-YELLOW	300	2.50	FND500	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				

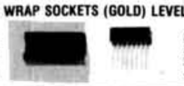
SOLDERTAIL STANDARD (TIN)

	1-24	25-49	50-100		1-24	25-49	50-100
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)

	1-24	25-49	50-100		1-24	25-49	50-100
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



	1-24	25-49	50-100		1-24	25-49	50-100
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.

		10 OHM	12 OHM	15 OHM	18 OHM	22 OHM	
ASST. 1	**5 ea.**	27 OHM	33 OHM	39 OHM	47 OHM	56 OHM	**1/4 WATT 5% - 50 PCS.**
		68 OHM	82 OHM	100 OHM	120 OHM	150 OHM	
ASST. 2	**5 ea.**	180 OHM	220 OHM	270 OHM	330 OHM	390 OHM	**1/4 WATT 5% - 50 PCS.**
		470 OHM	560 OHM	680 OHM	820 OHM	1K	
ASST. 3	**5 ea.**	1.2K	1.5K	1.8K	2.2K	2.7K	**1/4 WATT 5% - 50 PCS.**
		3.3K	3.9K	4.7K	5.6K	6.8K	
ASST. 4	**5 ea.**	8.2K	10K	12K	15K	18K	**1/4 WATT 5% - 50 PCS.**
		22K	27K	33K	39K	47K	
ASST. 5	**5 ea.**	56K	68K	82K	100K	120K	**1/4 WATT 5% - 50 PCS.**
		150K	180K	220K	270K	330K	
ASST. 6	**5 ea.**	390K	470K	560K	680K	820K	**1/4 WATT 5% - 50 PCS.**
		1M	1.2M	1.5M	1.8M	2.2M	
ASST. 7	**5 ea.**	2.7M	3.3M	3.9M	4.7M	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

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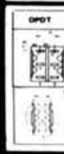
74LS00 TTL

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

DIP SWITCH
These switches feature four SPST Rocker switches in a molded dip. They are ideally suited for microprocessor applications. **$1.95**

MINATURE TOGGLE



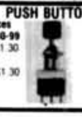
DPDT				ANT	1	2-9	10-29	30-99
	ON	OFF	ON	221	3.06	2.85	1.97	1.78
	ON	NONE	ON	223	2.85	2.25	1.68	1.51
	ON	OFF	ON	121	2.35	1.95	1.43	1.30
	ON	NONE	ON	123	2.05	1.65	1.21	1.10

PUSH BUTTON

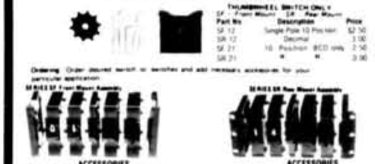
SPDT - SERIES PB, PB1

	Model Number	1 Each	2-9	10-29	30-99
Momentary 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	PB-126	$2.35	$1.95	$1.47	$1.30

5 AMP RATINGS



THUMBWHEEL SWITCHES



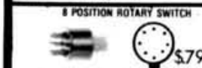
ACCESSORIES

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

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
1N746	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
1N485A	180	10m	5/1.00	1N1183	50 PIV	35 AMP	1.60
1N4001	50 PIV	1 AMP	12/1.00	1N1184	100 PIV	35 AMP	1.70
1N4002	100 PIV	1 AMP	12/1.00	1N1186	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	PN3567	3/$1.00	PN4249	4/$1.00
MPS A06	5/$1.00	PN3568	4/$1.00	PN4250	4/$1.00
2N2219A	3/$1.00	PN3569	4/$1.00	2N4400	4/$1.00
2N2221	4/$1.00	2N3704	5/$1.00	2N4401	4/$1.00
2N2222A	5/$1.00	2N3705	5/$1.00	2N4402	4/$1.00
2N2369	5/$1.00	2N3706	5/$1.00	2N4403	4/$1.00
2N2369A	4/$1.00	2N3707	5/$1.00	2N4409	5/$1.00
FN2415	5/$1.00	2N3711	5/$1.00	2N5086	4/$1.00
2N2484	4/$1.00	2N3724	$.65	2N5087	4/$1.00
2N2906A	4/$1.00	2N3725	$1.00	2N5088	4/$1.00
2N2907A	5/$1.00	2N3903	5/$1.00	2N5089	4/$1.00
2N2925	5/$1.00	2N3904	4/$1.00	2N5129	5/$1.00
2N3053	2/$1.00	2N3905	4/$1.00	2N5138	5/$1.00
2N3055	$.89	2N3906	4/$1.00	2N5139	5/$1.00
MJE3055	$1.00	2N4013	3/$1.00	2N5209	5/$1.00
MJE2955	$1.25	2N4014	3/$1.00	2N5951	5/$1.00
2N3392	5/$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
10 pf	.05	.04	.03	.001µF	.04	.035	
22 pf	.05	.04	.03	.0047µF	.05	.04	.035
47 pf	.05	.04	.03	.01µF	.05	.04	.035
100 pf	.05	.04	.03	.022µF	.06	.05	.04
220 pf	.05	.04	.03	.047µF	.06	.05	.04
470 pf	.05	.04	.035	.1µF	.12	.09	.075

100 VOLT MYLAR FILM CAPACITORS

.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22

+20% DIPPED TANTALUMS (SOLID) CAPACITORS

.1 35V	.28	.23	.17	1.5 35V	.30	.26	.21
.15 35V	.28	.23	.17	2.2 25V	.31	.27	.22
.22 35V	.28	.23	.17	3.3 25V	.31	.27	.22
.33 35V	.28	.23	.17	4.7 25V	.32	.28	.23
.47 35V	.28	.23	.17	6.8 25V	.36	.31	.25
.68 35V	.28	.23	.17	10 25V	.40	.35	.29
1.0 35V	.28	.23	.17	15 25V	.63	.50	.40

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

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flea market

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R/9 AND RADIO MAGAZINES needed to complete my library. Some duplicates available for trade with other collectors. Also have many early radio publications and Handbooks for sale or trade. Send SASE for list. Jim Fisk, W1DTY, Ham Radio, Greenville, NH 03048.

SCOTCH MAGNETIC TAPE for instrumentation. 3M-838, (NASA qualified). Unopened - Unused - excellent condition. $60.00 list, now $35.00. Write for list of surplus communication equipment. Colonel Wayne D. Russell, 9410 Walhampton, Louisville, Kentucky 40222.

VERY in-ter-est-ing! Next 4 big issues $1. "The Ham Trader," Sycamore, IL 60178.

WANTED: February 1974 Ham Radio Magazine. John Weber, K4JW, 102 Southgate Blvd., Melbourne, FL 32901.

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.

TELETYPES: Model 19, $175. Model 15, $75. 516-581-6509, Al Shapiro.

FOR SALE: Janel 6&2 FET converters, $75 ea./pair $135. Jim, W1VYB, 617-922-3850.

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

MICRO-TO MkII deluxe PC boards $3.50 ppd., with semicons $9.00. K3CUW, 1304B Mass. Ave. S.E., Washington, D. C. 20003.

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MOTOROLA HT220, HT200, Pageboy, and other popular 2M FM transceiver (Standard, Regency, etc.) service and modifications performed at reasonable rates. WA4FRV, (802) 272-8403.

SCANNER RECEIVER REGENCY ACT-R-10H/L/U 10 channels, 3 bands (covers 2 meters by retuning) AC/DC, 10 free crystal certificates, all for $169.00. Also all Regency, Cushcraft, Antenna Specialists products. All shipped UPS cash COD. Dealer inquiries invited. Radio Communications Service, 430 Maple Ave., Hodgenville, Ky. 42748.

PC BOARD negatives made photographically from your or magazine's art work. Now obtain professional results quickly, simply. 4 x 5, $3.00 or SASE for information. WA4FRV, 10139 Apache Road, Richmond, Virginia 23235. 804-272-8403.

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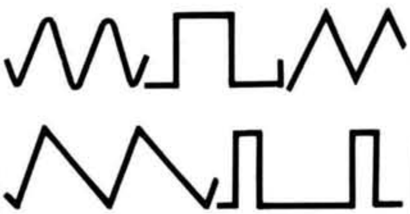

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Gray impact plastic case 5¼ x 6¾ x 2½. 115 Volts 60 cycle power supply included.

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QRP TRANSMATCH for HW7, Ten-Tec, and others. Send stamp for details to Peter Meacham Associates, 19 Loretta Road, Waltham, Mass. 02154.

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SIDESWIPER only $13. Airmailed USA. Kungsimport, Box 257, Kungsbacka, Sweden.

TOROIDS: 88 mtty, $3.00/5 ppd., HT-32, $200. Teletype equipment, parts, SASE for list.. Galleti, 342 Columbus, Trenton, N. J. 08629.

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IC APPLICATIONS MANUAL — Analog/Digital $3.95. Digital IC manual - latest edition-3000 latest types/pinout diagrams/cross references $6.95. Electronetics-HRM, P. O. Box 127, Hopedale, MA. 01747.

This Month's Specials

NEW
Fairchild VHF Prescaler Chips

Type	Description	Price
11C01FC	High Speed Dual 5-4 Input OR/NOR	$15.40
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
95H91DM	250 MHz Prescaler	$16.50

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2N2857	$1.85	2N5637	$20.70
2N3375	$7.00	2N6080	$5.45
2N3866	$1.08	2N6081	$8.60
2N4072	$1.50	2N6082	$11.25
2N4427	$1.20	2N6083	$12.95
2N5179	$.68	2N6084	$13.75
2N5589	$4.60	2N6166	$85.00
2N5590	$6.30	MRF511	$8.60
2N5591	$10.35	MMCM918	$2.50

TUBES

IP21	$19.95	6146A	$4.25
2E26	$4.00	6146B/8298A	$5.50
4X150C	$18.00	6360	$5.50
4X150A	$15.00	6661	$1.00
4CX250B	$24.00	6680	$1.00
4X250F	$22.00	6681	$1.00
DX415	$25.00	6939	$5.50
572B/T160L	$22.00	7984	$3.95
811A	$7.95	8072	$32.00
813	$19.00	8106	$1.95
931A	$9.95	8156	$3.95
4652/8042	$6.95	8950	$5.50
5894	$32.00	6LQ6	$3.95

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RM80 80 meter resonator	$16.95
RM20S Hi power resonator	$19.25
RM40 S Hi power resonator	$23.50
RM75S Hi power resonator	$28.95
RM80 S Hi power resonator	$28.95
CG144 6 db., 2 M. FM mobile	$26.75
SF-2 2 Mtr, 3 db, 3/8" thread	$12.75
SSM2 Ball mt	$13.50
QD1 Quick disconnect	$11.75
G6-144 2 meter 6 db base	$52.95

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C1 Doublet center insulator	$5.95
E1 End insulator, pair	$3.95
TH3JR 3 el. Tribander, 750w PEP	$144.50
215B 15 element, 2 meter beam	$67.00
BN86 Ferrite balun	$15.95
Hy Quad 10/15/20 M., 2 el. quad	$219.00
27N *BNC Rubber Duckie, 2 Mtr*	$9.00
270 Mobile 6 db., 3/8" mtg.	$39.95
28 8 element, 2 meter Yagi	$37.00
66B 6 element, 6 meter beam	$89.95
2BDQ 80/40 meter trap doublet	$49.95
5 BDQ 80-10 trap doublet	$79.95
12AVQ '10/15/20 vertical	$47.00
14AVQ/WB 40-10 meter vertical	$67.00
18AVTWB80-10 meter vertical	$97.00
TH3MK3 Tribander, 2 kw, PEP	$199.95
TH6DXX *6 element Triband beam*	$239.95
204BA 4 element, 20 meter beam	$179.95
402BA *2 element, 40 meter beam*	$199.95

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2 meter preapm kit	$9.50
2 meter preamp wired	$12.50
220 Mhz preamp kit	$9.50
220 Mhz preamp wired	$12.50
10 meter preamp kit	$10.50

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1796 Foreign Edition	$12.95
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Drake

R4C 1.8-3 Mhz Receiver
FL250 250 Hz filter
FL500 500 Hz filter
FL1500 1500 Hz filter
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TR4C 80-10 Xcvr
34PNB Noise blanker
AC4 AC supply
DC4 DC supply
MS4 Speaker
SSR1 Solid state Synt Rcvr
Accy Xtals for R4C/T4XC
TR22C 2 meter FM portable
AA10 10 watt amp for above
TV1000 Low pass to 52 Mhz
TV3300 Low pass to 33 Mhz
TV300 Hi pass filter

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IC230 Synthesized 2 meter mobile
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IC60 6 meter FM mobile
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DV21 Scanning Synthesizer
IC3PA Base power supply
TTH230 TT handset for IC230

When ordering, please remember— **All prices** are subject to change without notice.

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WE HAVE JUST GOTTEN A LIMITED SUPPLY OF HI BAND, 30 WATT T-POWER MOBILES. CONVERTIBLE TO 2 METERS WITH MOBILE ACC GROUP.

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50 WATT SOLID STATE MOBILE PA AMPS. UNUSED SURPLUS. COMPACT WITH MIC BUT NO SPEAKERS.

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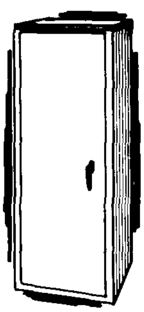
5' CABINETS



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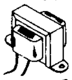
6.3 Volt 1 Amp Transformer. Fully Shielded. $1.75 Each ppd.

Transformer — American Made — 115V Primary — 12V sec. — 250 mils — for P.C. Board Mounting. Size: 1½" x 1⅛" x 1⅛", 3.5 ounces. Price: $1.40 ea. ppd.



TRANSFORMER. 115 volt primary, 12 volt ½ amp secondary. $1.68 ppd.

Transformer — 115 Volt Primary — 12 Volt 1.2 Amp Secondary $2.57 ppd.

Transformer — 115V primary. 12V, 3A Secondary $4.15 ppd.

Transformer, 115 VAC primary, 18 volt, 5 amp ccs or 7 amp intermittent duty secondary $6.60 ea. ppd.

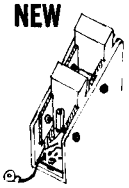
Transformer — American Made — Fully shielded. 115 V Primary. Sec. — 24-0-24 @ 1 amp with tap at 6.3 volt for pilot light. $3.15 ea. ppd.

30-0-30 V - 2.5 AMP SHIELDED TRANSFORMER — AMERICAN MADE — 3 pound. 2¼" w. x 3" h. x 3¼" deep, with 6.3 V - 1A winding. $5.15 ppd.

115 Volt Primary. Secondary #1: 32-0-32 Volt @ 1 Amp. Secondary #2: 6.3 Volts. Low Current for Pilot Lights. Size 2½" x 2½" x 3". Price: $2.65 Each 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.

General Purpose Germanium Diodes. Similar to 1N34a etc. All Cathode banded. Full leads. 16 for $1.00 ppd.

Small, glass, silicon diodes. Fairchild FD-type. Full leads and guaranteed. Price: 16 for $1.00 ppd.

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American made (CRL) Cermet sizes: 25K, 100K ohms. 5/$1.30 ppd CTS Blue wheel. Values: 750, 1000, 1500, 50K ohms. 5 for $1.20 ppd.

NEW MINI Imported vertical pots (½H, ⅜W, 1/16D) Values: 1000, 2.5K, 5K, 50K ohms. Slot adj. Price: 5 for $1.20 ppd.

BACK IN STOCK ONCE AGAIN

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

NEW NEW NEW

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

CRL DISC CAPACITORS

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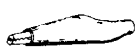
1¼ inch miniature alligator clips. Bright vinyl red or black insulator. Nickle plated. 9 for $1.00



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NCX-1000 KILOWATT TRANSCEIVER, mint — $600 (or make offer). Dr. M. F. Hash, 319 N. 26th Street, Billings, MT 59101.

NEW CANADIAN MAGAZINE. "Electronics Work Shop". $5.00 yearly, sample $1.00. ETCOB, Box 741, Montreal, H3C 2V2.

RADIO MUSEUM now open. Free admission. 15,000 pieces of equipment from 1850 telegraph instruments to amateur and commercial transmitters of the 1920's. Amateur station W2AN. Write for information. Antique Wireless Assn., Main St., Holcomb, N. Y. 14469.

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

WANTED: Collins mechanical filters 455 kHz center. High Z, 2.0 to 4.0 kHz width. Prefer 3.1 kHz. SM5CQT, Alf Thunstrom, Attingevagen 26, S-61100 Nykoping, Sweden.

DO-IT-URSELF DXPEDITION — Stay at ZF1SB — Cayman Is. Vertical antenna and Caribbean at your doorstep. Diving/fishing if band folds. Write Spanish Bay Reef Resort, Box 800K, Grand Cayman, B. W. I.

ETCHED CIRCUITS glass epoxy, drilled and plated. $.25/square inch. Send artwork to Ready Circuits, P. O. Box 34, Pinesdale, Montana 59841.

FERRITE BEADS: Ferroxcube beads w/specification and application sheet — 10 @ $1.00 postpaid. Includes latest catalog. CJO Surplus, Box 189, Braintree, Mass. 02184.

FT-101 SERIES OWNERS — Annoyed by blower running needlessly with filaments off? For simple no-parts fix send dollar (creditable towards dues) for February 1976 Newsletter of International Fox-Tango Club, 248 Lake Dora Dr., W. Palm Beach, FL 33411.

GIVE YOUR ASCII-BAUDOT KEYBOARDS, Morse Code keyboard generators, or keyswitch oriented master control stations a distinct professional appearance with the Univue keyboard and control center enclosure. The 24 x 12½ x 3" Univue enclosure gives you dimensional flexibility with a modern low profile appearance. The blank 23 x 8" removable aluminum front panel is easily cut to accommodate virtually any keyboard or control arrangement. Over 200 cubic inches of space in the rear is available for housing additional circuitry, allowing a complete and handsome desk top unit. The Univue enclosure body is precision machined welded steel, and is primed and surfaced light gray, ready for the color co-ordinated finish of your choice. Shipped complete with panel, heavy duty non-skid rubber feet, plated mounting hardware, and Money-Back Guarantee. $29.95 plus $4.50 shipping/handling. Send stamp for complete information and pictures to: Advanced Data Sciences, P. O. Drawer 1147B, Marion, Ohio 43302.

WANTED: Master Mobile Antenna parts, 1 set High-Q coils 80-10 meters. Master Matcher motorized rotary inductor, and Micro-Z Match. Prefer new or like new condition, state price and condition, No Junk Please. W3AEZ/W4JIQ, "Bud" Holderbaum, 331-102 West Side Drive, Gaithersburg, Maryland 20760. 301-948-1989.

COLLINS; 30S-1 in excellent operating and physical condx for Bendix R-1051B/E receiver. Sid Sidman, 3571 Gresham Court, Pleasanton, Calif. 94566.

CORE MEMORY system for sale. 16,000 words 32 bits per word, with schematics. 2 master units and 2 slave units available, also a small drum memory unit. Will sell real cheap to best offer I get in cash and/or equipment in trade. Call David Kohl, 212 253-3401 evs.

ENGRAVED RADIO LICENSE. Exact reproduction in solid brass. Permanent identification. Send good Xerox copy, with $5.00, to Metal Art Graphics, 1136 Potomac Ave., Hagerstown, Md. 21740.

SALE: Mod 15 TTY, XRT table, tape perf., two new keyboards, mod 14 TD, new typing reperf., no base, audio T.U. with A.F.S.K., KS-5988 supply, 120 V.D.C. @ up to 1.2A, 5A A.C. for motors, 255A relays. TTY manuals, mod 35 (281B), mod 32/33(273B), documentation for mod 14/15. Also: Robert dollar F.S.K. exiter mod 4722. 100-1000 cy shift 2-7 MHz. Need good HT-44 and P.S. 150AC. C. Fuhrman, 327 E. Walnut, Marietta, Pa. 17547. 717-426-1260.

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Extra Elements $90.00
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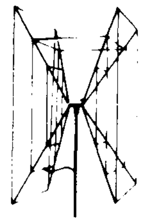

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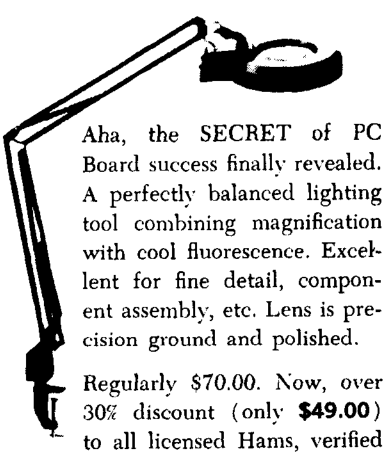

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Include $3.00 U.S. postage, or $4.00 in Canada. $5.00 elsewhere. California Residents include 6% sales tax. Or send stamped envelope for free brochure of other incandescent or fluorescent lamps suitable for all engineers, architects, students, etc.

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flea market

FIGHT TVI with the RSO Low Pass Filter. For brochure write: Taylor Communications Manufacturing Company, Box 126, Agincourt, Ontario, Canada. MIS 3B4.

300 MHz PRE-SCALER. Fairchild 95H90, $15.00. See Feb. issue, page 32. Colella, 105-18 131 St., Richmond Hill, N. Y. 11419.

TELETYPE PAPER NEW, Fresh from the mill! 4½" rolls white or canary. For all friction feed Teletype machines. $20/ case of 12. Buy 5 cases, only $18 each. ZTY-RTTY Paper Co., Box 147, Corunna, Mi. 48817.

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WANTED: Inoperative Collins R390A to repair and maintenance of my R-390A. Ed Wagner, 1018 Birch Haven Cir., Monona, Wis. 53716.

CLEGG FM27B. Latest, like new, never mobile, used very little, $349.50. SASE with check. KØEPJ, Morton Jacobs, M.D., 6416 Verona Road, Mission Hills, Kansas 66208.

TELETYPE EQUIPMENT FOR SALE for beginners and experienced operators. RTTY machines, parts, supplies. Special beginners package consists of Model 15 page printer and TH5-TG demodulator, $125.00. Atlantic Surplus Sales, 3730 Nautilus Ave., Brooklyn, N. Y. 11224. Tel: (212) 372-0349.

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FOR SALE: 2 to 432 Transverter to 14w output with manual $55.00. Jim, W1VYB, 53 Lothrop St., Beverly, Mass. 01915.

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DESOLDERING AIDS AND HAND TOOLS. R. L. Syphers Associates, Box 883, Dept. H, Bensenville, Illinois 60106.

QSL'S — BROWNIE W3CJI — 3035B Lehigh, Allentown, Pa. 18103. Samples with cut catalog 50¢.

EXCLUSIVELY HAM TELETYPE 21st year, RTTY Journal, articles, news, DX, VHF, classified ads. Sample 35¢. $3.50 per year. Box 837, Royal Oak, Michigan 48068.

MANUALS for Govt. surplus gear, $6.50 each: URM-25D, SP-600JX, TT-63A/FGC, TS-382D/U, ALR-5. Thousands more available. Send 50¢ (coin) for 22-page catalog. W3IHD, 7218 Roanne Drive, Washington, D. C. 20021.

OSCAR 7, SSB-CW TRANSMIT CONVERTERS. For 28 or 50 MHz input at 20 mw. 432 MHz output at 1 watt. Solid state, for 12 volt supply. 35 watt solid state amplifier available for this converter. Units designed and built by WØENC. Write for information. UHF-VHF Communications, 53 St. Andrew, Rapid City, S. D. 57701.

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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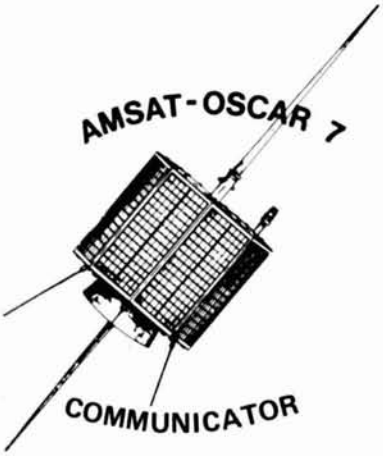

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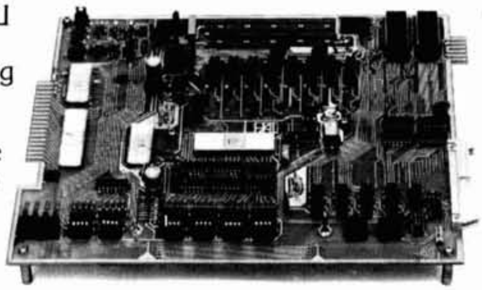

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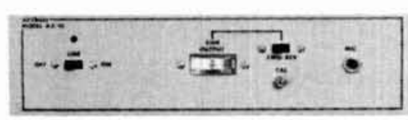
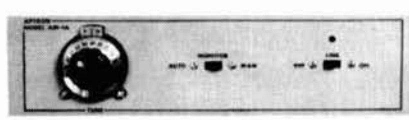


AX-10 TRANSMITTER



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Coming Events

MICROPROCESSORS AT DAYTON. Don't miss Ham Radio's exciting one day Microprocessor Seminars to be held on both Friday, April 23 and Saturday, April 24. Taught by professionals. Widely acclaimed as one of the outstanding parts of this year's SAROC. Full details in display ad in this issue or from Ham Radio, Greenville, NH 03048. 603-878-1441.

ROCHESTER HAMFEST, Official New York State ARRL Convention, May 21-23. Write Rochester Hamfest, Box 1388, Rochester, N. Y. 14603 for full details. See our display ad in this issue.

1976 MASSACHUSETTS BICENTENNIAL QSO PARTY, May 1 & 2, sponsored by the South Shore Repeater Assoc., WR1ACT, Scituate, Mass., and endorsed by the Massachusetts Bicentennial Commission. Begins on May 1 at 0000 UTC and ends on May 2 at 2400 UTC, no time limit. Contact Robert J. Doherty, W1GDB, 14 Pine St., RFD #1, Sandwich, MA 02563 for rules and scoring.

WEST LIBERTY, OHIO FLEA MARKET & AUCTION. May 16, 1976 at West Liberty Lions Park sponsored by the Champaign Logan Amateur Radio Club.

DELTA DIVISION CONVENTION & HAMFEST, April 24 & 25, Jackson, Mississippi State Fairgrounds. Details from WB5HAH.

HAM AUCTION. Hull, Massachusetts, April 17 at the VFW Hall. Sponsored by South Shore Repeater Association, WR1ACT. "Tag all gear, club share 10%." If you plan to bring equipment and wish a copy of the auction rules, contact WA1QWT, WA1RKT or W1FGI on 90/30, or write.

COLUMBUS GEORGIA HAMFEST, April 24 & 25, Fine Arts Bldg., Columbus Municipal Fairgrounds. Further information from Dennis Hands, Jr., K4ICR, Rt. #1, Box 172A, Cataula, GA 31804.

RARITAN VALLEY RADIO CLUB DUNELLEN, NEW JERSEY HAMFEST, June 19 — Rain date 20th. For information write: K2VHW, 1504 New Durham Road, South Plainfield, N. J. 07080.

THE MESILLA VALLEY RADIO CLUB sponsors Whitey's Bean Feed and Swap-Fest Sunday, April 25th, at 10:00 a.m. Located near Las Cruces, N. M. at La Mesa, with talk-in on 16-76 and 3940 KC. Fun for all the family with big prizes, plenty of food and the usual beverage truck. All included for $4.00 for adults and $1.75 for kid tickets. Eat, drink and win a prize with Whitey, K5ECQ as host. Free overnight parking at grounds so come for a spell! All correspondence should be made with the Chairman, W. E. Ratcliff.

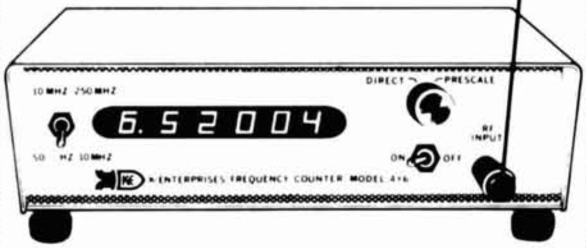
SAYREVILLE, NEW JERSEY, RBRA Indoor Electronic Flea Market. Sunday, April 25, 1976, 11:00 a.m.-4:00 p.m.. Sayreville Civic Center, (Old V.F.W. Hall), Dolan Street, Sayreville, New Jersey 08872. Tables available. Door prizes and refreshments. For information, contact: Rick Giacchi, WA2SAJ, 98 Kendall Drive, Parlin, New Jersey 08859. 201-727-7999.

CADILLAC, MICHIGAN SWAP & SHOP. The Wexaukee Amateur Radio Association 16th Annual Swap-Shop and Eyeball, May 1st in the National Guard Armory, Cadillac, Michigan starting 9 a.m. Open to all radio amateurs, citizens banders, and anyone interested in radio communications. Lunch available, lots of free parking. Tickets at the door. Hope to see you all.

FLEA MARKET/AUCTION, May 2, Trenton, New Jersey. The Delaware Valley Radio Association, W2ZQ/WR2ADE annual flea market and auction will be held Sunday, May 2, 1976, at the Pennington Road Fire Company, 1666 Pennington Road, Ewing Township, Trenton, New Jersey. Flea market begins 9 a.m. followed by auction at approximately 1:30 p.m. Registration $1.50, tailgating $2.00. Indoor flea market tables available. Follow signs from Rt. 1 or I-95. Talk-in W2ZO/2 on 146.07-67 and 146.52 MHz. Refreshments available. For further information write: D.V.R.A. - W2ZQ, P. O. Box 7024, W. Trenton, N. J. 08628, s.a.s.e. please.

More Details? CHECK—OFF Page 110

K-ENTERPRISES



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421	2-25	.55	464	25-280	.80
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More Details? CHECK—OFF Page 110

flea market

WESTMINSTER, MARYLAND HAMFEST. The Potomac Area VHF Society will hold their annual hamfest on Sunday, May 2, 1976, at the Agricultural Center in Westminster, Maryland. 9 a.m. to 5 p.m. Registration, $3. Talk-in 146.94 and 52. For information contact K3DUA or WA3NZL.

KENTUCKY HAM-O-RAMA — Sunday, May 30 (Memorial Day Weekend). Details in May issue. Info: NKARC, P. O. Box 31, Ft. Mitchell, Kentucky 41017.

HAMFEST Sunday, May 2, 1976 at the Kansas City Trade Mark, Exhibit Hall 3 (Old Municipal Airport Terminal Building) starting at 9:00 a.m. This is the 7th Annual Northwest Missouri Hamfest sponsored by the P.H.D. Amateur Radio Association, Inc. Admission $1.50 in advance, $2.00 at the door. Refreshments available; swap tables for a fee; forums, contests, prizes, commercial exhibits; women's and children's programs. Talk in on 34/94 and 3925. Contact Marti Dray, WBØERI, Rt. 2, Box 23, Lathrop, MO 64465 for further information.

MICHIGAN QSO PARTY, 1800 UTC, May 15 to 0200 UTC, May 17. Phone and CW are separate contests, but one may enter logs for both. Michigan stations can work Michigan counties for multipliers. A station may be contacted once on each band/mode. Portable/mobiles may be counted as new contacts each time county changes. Exchange RS(T), QSO #, County for Michigan; state or country for others. (Example: 579001 Oakland). Suggested frequencies: CW - 1810, 3540, 3725, 7035, 7123, 14035, 21035, 21125, 28035, 28125. Phone - 1815, 3905, 7280, 14280, 21380, 28580. VHF - 50.125, 145.025. Full details from Mark Shaw, WA8EDC, 3810 Woodman, Troy, Michigan 48084.

GREATER BALTIMORE HAMBOREE, Sunday, April 4th at 9:00 a.m. at Calvert Hall College, Goucher Blvd. and LaSalle Road, Towson, Maryland 21204. (1 mile south of Exit 28 Beltway - Interstate 695) Prizes, flea market, registration $2. 250 tables inside gym. Over 1000 attended last year. Info: Contact Brother Gerald Malseed, W3WVC at the above address.

MICHIGAN GOVERNOR'S ACHIEVEMENT AWARD, awarded on the following basis: A Michigan ham submits log information and names and addresses (if possible) of 15 or more contacts made to out-of-state or DX hams with information regarding Michigan. An out-of-state ham, including Canada, submits information and names and addresses (if possible) of at least 5 Michigan hams who relate facts to him about Michigan. A Foreign ham, excluding any resident of Canada, submits the call letters and name/address plus log information for at least (1) Michigan ham who has told him about Michigan. Only QSO's made during Michigan Week, May 15-22, will be considered valid. All applications must be postmarked by July 1, 1976 and mailed to Governor William Milliken, Lansing, Michigan 48902.

WØEEE PRESENTS! The University of Mo.-Rolla ARC, WØEEE, announces the 1st annual Triple-Letter QSO Party. 1700, April 24, 1976 to 2000 April 25. All bands 160-2 meters (no rptr QSO's), all modes (no cross-mode). Exchange signal report (RS(T)) and consecutive S/N, each station may be worked once per band per mode. Frequencies: Phone - 3950, 7215, 14290, 21375, 28600. CW - 45 kHz up from band edge (i.e. 3545 kHz). Send logs with usual data and declaration before 20 May, 1976 to: Ward Silver, WBØGQP, 590 Fieldstone, Ballwin, Mo. 63011.

HAMFEST! Indiana's friendliest and largest Spring hamfest. Wabash County Amateur Radio Club's 8th Annual Hamfest will be held Sunday, May 23, 1976, rain or shine, at the 4-H Fairgrounds in Wabash, Indiana. Large flea market (no table or set-up charge), technical forums, bingo for XYL's, free overnight camping with AC hookup, plenty of parking. Lots of good food at reasonable prices. Admission is $1.50 for advance tickets, $2.00 at the gate. For more information or advanced tickets, write Bob Mitting, 663 Spring Street, Wabash, Indiana 46992.

THE CHAMPAIGHN LOGAN AMATEUR RADIO CLUB is holding its 6th annual flea market and auction on May 16, 1976 starting at 12 p.m. at the West Liberty Lions Park at West Liberty, Ohio 43357. Free admission, trunk sales and tables $1.00. Door prizes. Talk-in on 146.52 and 146.13/73.

flea market

NORTHWESTERN PENNSYLVANIA Swapfest. May 1, Crawford County Fairgrounds, Meadville. Free Admission. $1 to display. Flea market begins at 10:00 a.m. Hourly door prizes; refreshments. Commercial displays welcome. Indoor if rain. Talk-in 146.04/64 and 146.52 MHz. Details, Crawford Amateur Radio Society, Box 653, Meadville, Pa. 16335.

F.M. BASH, DAYTON, OHIO, April 23, 1976, on the Friday night of the Dayton Hamvention. This is a social evening for all hams and their ladies from 9 p.m. til midnight. Free admission, free snacks, C.O.D. bar, live entertainment by TV personality Rob Reider (WA8GFF) and his group. The 11 p.m. prize drawing will feature a Clegg FM-DX and other prizes. A new larger location at the Dayton Biltmore Towers, (First and Main St. 45402) will accommodate the crowd and afford 3 alternate routes to the Hamvention Center. Make your reservation direct to stay where the action is. Milt Kohl, W8SLY, Miami Valley F.M. Association, 7575 McEwen Road, Dayton, Ohio 45459.

160 MTR. OPERATORS: Chiburban Radio Mobilers Net meets on 1.833 MHz every Wednesday 0200 UTC, Sunday 1700 UTC. All modes - AM, SSB, CW welcome. WB9FJJ, V.P., CRM.

ARRL SOUTHWESTERN DIVISION CONVENTION, April 9, 10, 11 in Tucson, Arizona. Under one roof in the Braniff Place Hotel, 4 blocks east of I-10 at Congress Street exit. Technical sessions, swap meet, banquet, Wouff Hong, exhibits, ladies program, and much more. Talk in on 146.22/146.82 and 146.82 simplex. H.F. talk-in on 7260 kHz. For details write ARRL Southwestern Division Convention, P. O. Box 12261, Tucson, AZ 84732.

POTTSTOWN, PA.: Pottstown Area Repeater Team Hamfest and Flea Market. Sunday, May 23, 9:00 a.m.-4:00 p.m., Rt. 422 Hiway Drivein, 8 miles east of Pottstown. Prizes, auction, contests, refreshments. Talk-in 52/52, 81/21, 66/06. Registration $2.00, tailgate $1.00. A. Jefferson, WA3VYS, 444 Roland Ave., Pottstown, Pa. 19464.

ROCK RIVER HAMFEST. April 25, Amboy, Illinois. Lee Co. 4-H Center, Jct. 30 & 52. Same place as last year. For further details see hamfest calendar. $1.00 advance, gate $2.00. Write Carl Karlson, W9ECF, Nachusa, Illinois

W6LS 11th BURBANK CALIFORNIA HAMFEST. Saturday and Sunday, May 15 & 16. Flea market, prizes. 2814 Empire Avenue, Burbank, California 91504.

MOULTRIE AMATEUR RADIO KLUB 15th annual hamfest, April 25, Wyman Park, Sullivan, Illinois. Indoor- outdoor market. Advance ticket sales by mail only, $1.25 or $1.50 at gate. Write: MARK, P. O. Box 327, Mattoon, Ill. 61938.

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Stolen Equipment

STOLEN: Heathkit HW 202 2 mtr. Transceiver. Series #07429. "Stolen from WBØAGT SSN 410-66-8452" engraved on back. Has home brew synthesizer installed on top of set, approx. same size as HW 202 and painted black. Notify any law enforcement agency or; Dick Cullen WBØAGT, 303-598-1849, 1515 Newcastle St., Colorado Springs, Colo. 80907.

STOLEN — RF Comm. Inc. RF-403 2mtr. Transceiver, Serial # unknown. 4 chan. 80 watts. Color is black. Please notify FBI, or: Wallace Moore, WBØAWH, 303-986-3909, 12053 W. Virginia Ave., Lakewood, Colo. 80228.

STOLEN. HR-2 Regency 2 mtr. Transceiver, SN 04-02689. Please notify police dept. or: Dick Sucher, WAØZLY, 303-473-4186, 3410 N. Prospect St., Colorado Springs, Colo. 80907.

STOLEN EQUIPMENT: SBE - Linear Systems #SB 36, Transceiver with #SB 36-ACP speaker and power supply. S/N 71128, base station. Courier # COP 50 HL, S/N ?, VHF monitor radio, hi & lo band. Courier # COP 75, S/ ? VHF automatic scanner, hi-band. Stolen January 26 or 27 from South Fork Electronics Corp., 36 Hampton Road, Southampton, N. Y. 11968, 516-283-8686. Taken without accessories or manuals. People possessing this equipment may be seeking information and/or accessories for same.

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HAM MART

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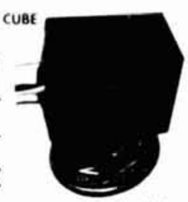

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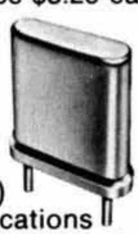

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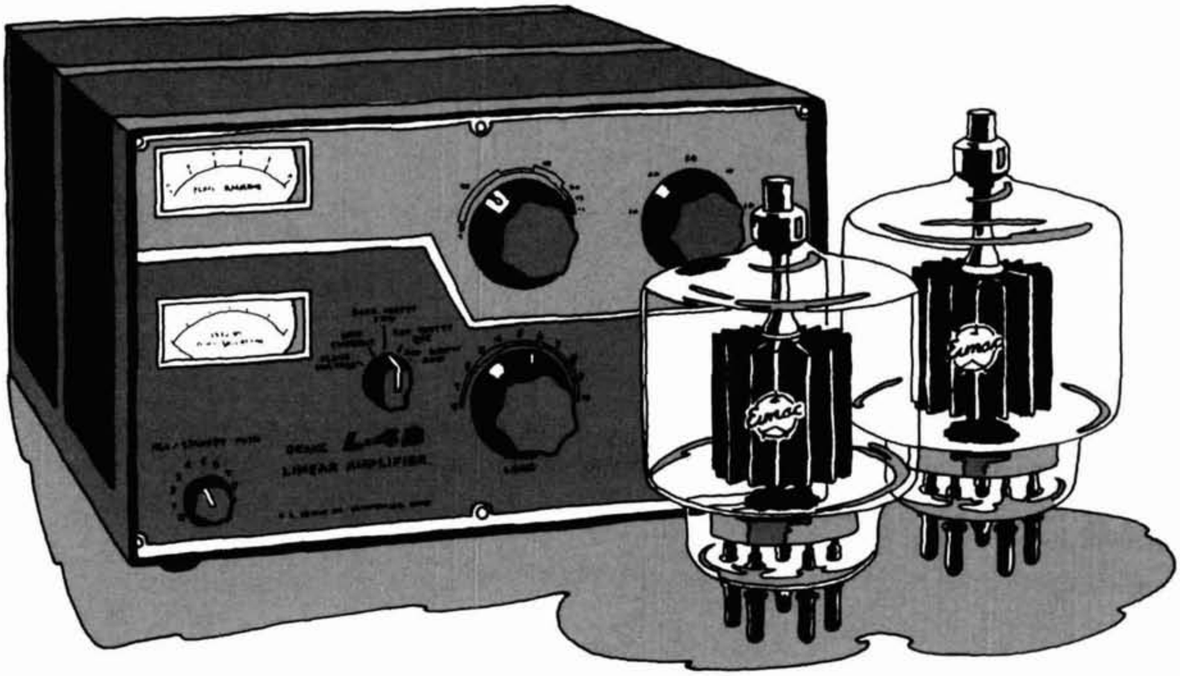

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