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ham radio magazine

JANUARY 1976

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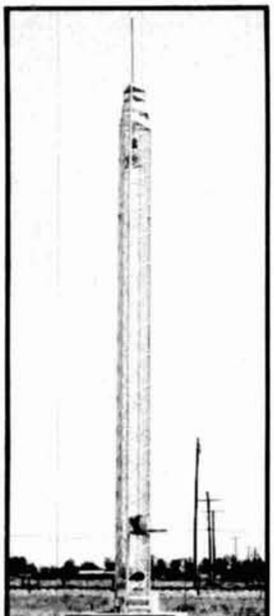

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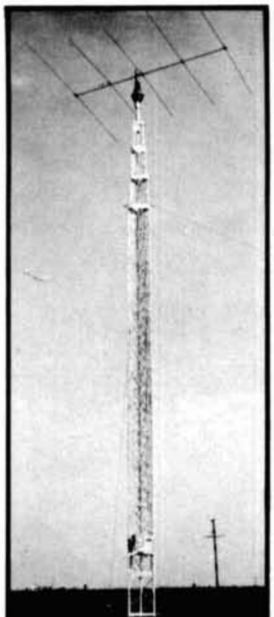

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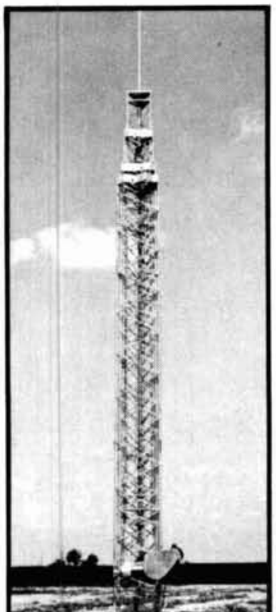

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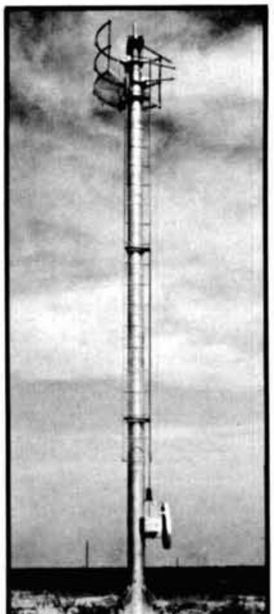

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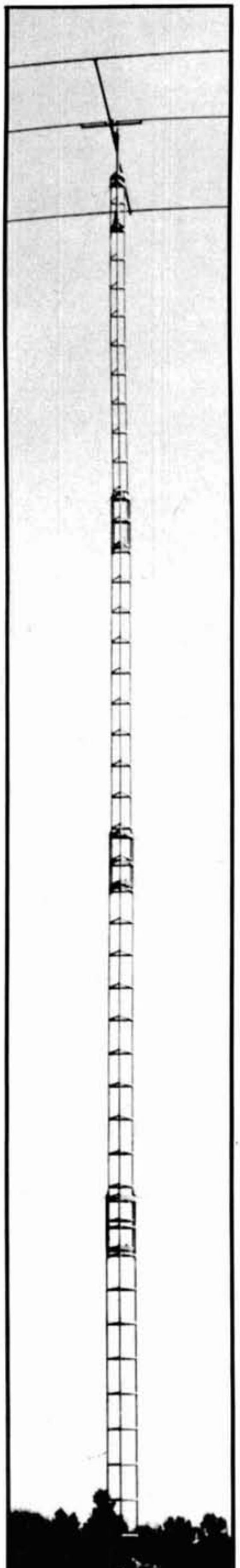

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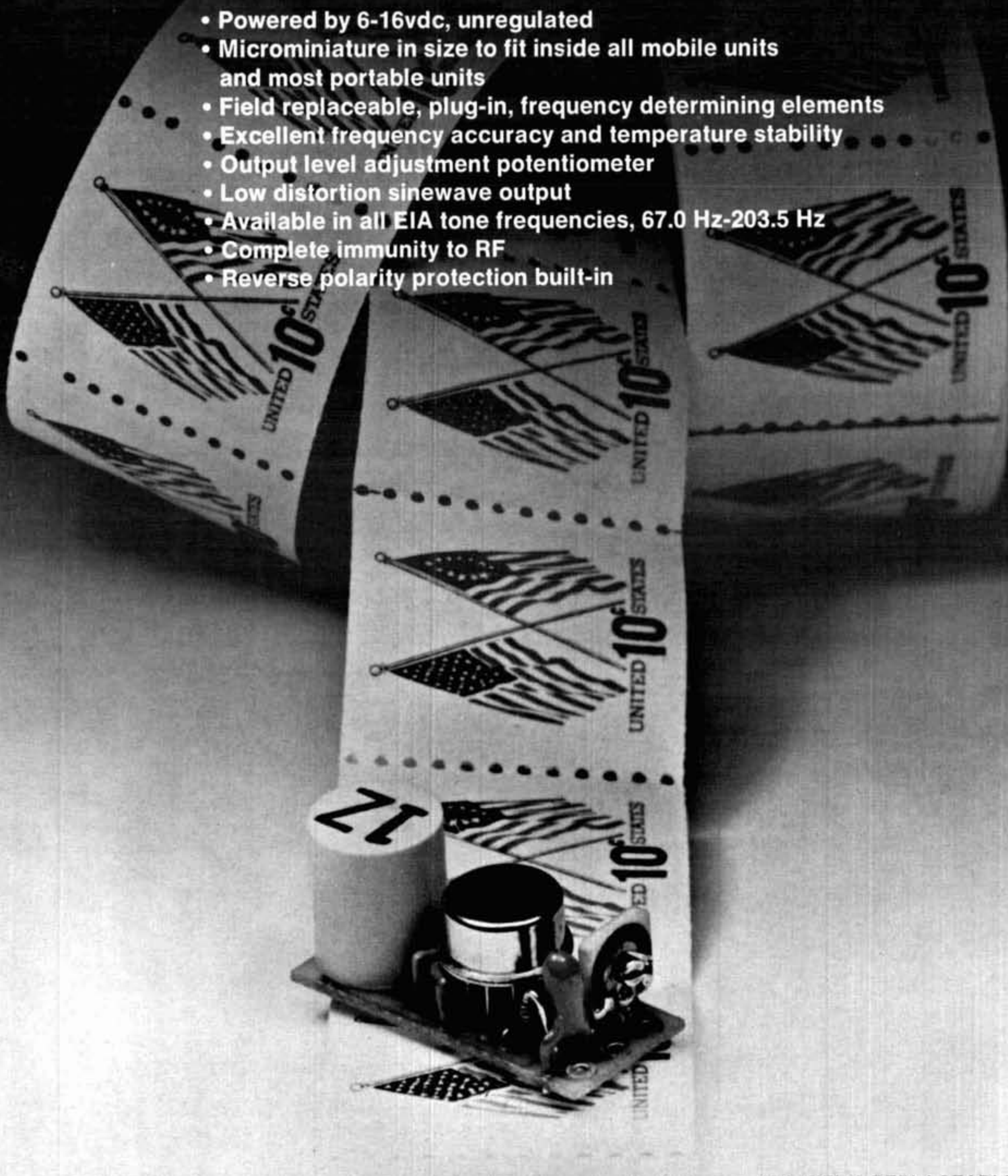

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contents

a second look

by Jim Fisk

Although this new, larger edition of *ham radio* may seem like a nuisance if your shelves are designed for the old size, I think you'll soon discover that the advantages of the larger format far outweigh the slight inconvenience of storage problems. For one thing, the larger page size allows us to present larger schematics, so there will be less segmented drawings than there have been in the past. If you're building a project or tracing out a circuit diagram, switching from one page to another as you go through a schematic can be annoying, and often leads to wiring errors. The larger page size also means that the photographs will be larger, so you will be able to more clearly see how the author layed out his original circuit.

However the graphical advantages of the larger page size are small potatoes when compared to the big bonus of the larger format: more available space for technical and construction articles. This 104-page issue, for example, contains as much reading material as any two of our previous issues – the more than 50 pages of technical articles in this issue, if scaled down to the old size, would fill nearly 90 pages. This not only means that we've got to work twice as hard to keep *ham radio* filled with the kind of articles you want to read, it also means that we can provide more basic construction articles and tutorial material that we didn't have room for in the old format. While we will continue to publish the latest technical developments in amateur radio, the increase in editorial space will allow us to broaden our horizons to include features which will appeal to a wider audience. Some of those new features are included in this issue – others will be added in the months ahead.

One of those new features is *repair bench*, a monthly column devoted to troubleshooting your own equipment. We have had many requests for such a column but until now, because of the nearly weekly changes in modern communications technology, there simply wasn't room in the magazine. The first few *repair bench* columns will be geared to basic troubleshooting techniques, while future columns will attack such subjects as receivers, transmitters, ssb equipment, vhf fm, RTTY, logic systems, slow-scan television and much more. The column won't be written by one person, but by different authors who have proven expertise on the topic covered by a particular column. Although I have several authors already lined up, I'm looking for others with troubleshooting experience who would be interested in writing some columns. If you have suggestions for topics, or would like to contribute, please drop me a line.

The *circuits and techniques* column which we have published irregularly for the past several years will once again become a monthly feature beginning with this issue. *Circuits and techniques* will also take on a different look in the coming months as we use it as a vehicle for presenting new circuits, technical developments and construction techniques which come to our attention. If you develop a simple circuit for a special task, are using a well-known circuit in an unusual application, or run across an interesting circuit or technique in a foreign publication, we'd like to hear about it.

The popular *ham notebook* column which we've been publishing since 1968 will continue to be a monthly feature, as will the *microprocessor* column which we introduced last month. We're also looking for amateur-oriented construction projects which are built around microprocessor chips.

We have several other new features being developed which will be published in the coming months. One of these will be the *weekender*, a simple project that can be built in a few hours time over one weekend. A unique feature of the *weekender* is that we will arrange to have all components and a circuit board available from one easy-to-reach commercial source. The first of the *weekender* projects is scheduled for publication in the February issue, and we're busily rounding up future *weekender* candidates from our authors. If you have a project which you think might qualify as a *weekender*, we will be glad to consider it for publication. Suggestions for future *weekender* projects are also welcome – we may be able to place your idea in the hands of an author who can come up with a finished product.

Our editorial staff is very excited about the many possibilities of the new, larger size, and we're looking forward to making *ham radio* bigger and better than ever before. Your comments and suggestions are always welcome.

Jim Fisk, W1DTY
editor-in-chief

The First Base Hit!

The 450MHz-FM game now has one on base! ICOM is on with the first 440-450 radio built specifically for base operation, the **IC-31.** You're going to be hearing a lot from this promising young newcomer following in the footsteps of that popular veteran, the **IC-30A** mobile unit.

Impressively built for 26 channels and 10 watts output, this unit is the perfect teammate of the **IC-30A,** which has proven itself to be the biggest 450 winner on the road. With the S.W.R. bridge built right into the front panel and a forward mounted 9-pin socket, the new **IC-31** base unit provides the flexibility necessary to good UHF operation, and its compact size and styling match the other ICOM base radios.

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More Details? CHECK—OFF Page 102

publisher's log

skip tenney
W1NLB

A look through this issue will quickly show that *ham radio magazine* is at a significant turning point in its eight year history. This is by far the biggest magazine we've ever published. Not only are the pages larger, but it also has far more editorial matter, more columns, more color and yes, even more ads than ever before.

This change is typical of what's happening throughout Amateur Radio. The whole hobby appears to be at a turning point which will lead to many changes over the next few years which could well make today's Amateur world seem quite unfamiliar.

When we started only eight years ago VHF fm was unknown to most Amateurs. Slow-scan TV was in its very infancy. Almost no Amateur gear was solid-state at the time, while digital concepts and integrated circuits were virtually unheard of in amateur work.

Now we suddenly find ourselves at a new starting point as digital techniques are coming at us in a rush led by the exciting new microprocessor chips which are scheduled to change much of our daily world as they take charge of your kitchen, automobile and workplace. It goes without saying that their effect over the next few years on even a relatively simple Amateur station will be significant.

Arriving almost simultaneously with the birth of *ham radio magazine* were the long awaited rules outlining *Incentive Licensing*, which have provided the basic framework of the Amateur licensing structure for the past seven years.

Again during the past year the Amateur community has had an excellent opportunity to debate at length another major step in our regulatory history commonly known as *Restructuring*. At this writing it appears that within the next few months these new ideas will become reality, but possibly in a very different form than originally proposed just a year ago, but definitely including the much discussed no-code license. The concept of *Reregulation* has also been introduced by Commission officials and should further influence regulations by which we must conduct ourselves.

The Amateur Radio business community has also seen many changes. Your all time high acceptance of Amateur products is permitting many exciting and useful new products to be offered which would have been out of the question just a few years ago. Attention to our advertising pages in the months ahead will show many outstanding surprises waiting for you.

Both *ham radio magazine* and *hr report* will be right there in the middle of these many exciting new developments and will bring them to you step by step as they unfold. We'll be doing our best to show you what is happening and just what can be done to insure that both you and Amateur Radio realize maximum benefit from these many changes.

Skip Tenney, W1NLB
publisher

presstop

JOHN JOHNSTON REPLACED Prose Walker as chairman of the World Administrative Radio Conference Amateur Radio working group at the group's December meeting in Washington. Prose had been a prime mover in getting this very important activity organized and going, and despite his retirement from the FCC in July had headed up its September meeting during the ARRL national convention in Reston and seemed likely to continue with it on a consultant basis with the FCC. However, the staffing and budget crunch in the Amateur and Citizens Division brought on by the CB landslide workload put a crimp into those plans so Division Chief John Johnston will be taking it over.

Though Prose' Expertise will certainly be missed, John is expected to carry the WARC preparation effort ahead with minimal interruption. Under Prose' direction the basic organization had been firmly established and the various task force chairmen and their groups moving along nicely, so the transition should be a relatively painless one.

900 MHZ AMATEUR BAND is receiving consideration both in and out of the FCC. The recent opening of 115 MHz of spectrum in that region to commercial two-way users will accelerate technical development in that frequency range, and Amateur Radio (and/or possibly Class E CB) has at least a chance to pick up a portion of the remainder.

Amateur Space And Satellite Communications would find a new band in the 900 MHz region particularly valuable — it's high enough to get away from a lot of noise and low enough that atmospheric absorption is not a problem. The possibility has already been explored in WARC meetings and a proposal for such a band will probably become a WARC group recommendation.

OSCAR 7 is being seriously affected by users putting signals much stronger than needed into it on Mode B. Overloading is causing excessive battery discharge and may be responsible for mode switching and shutdowns. Area coordinators and others are asked to watch for signals causing "pumping," report calls of offenders to W3HUC c/o AMSAT and advise those nearby of their abuses.

Demonstrating Mode B Sensitivity, W6CG made over 20 contacts in one week running 500 mW to a dipole antenna! Bud's QSOs included Hawaii and Maryland.

REPEATER CROSSBANDING, DOCKET 20113, has been approved and became effective December 15. Report and order will permit unlimited crossband operation of repeaters in the authorized repeater subbands, covers several related topics.

Definition Of "Automatic Retransmission" has been added to the rules, characterizes an "automatic retransmission" as one initiated by a received signal. Automatic retransmission is restricted to repeaters, auxiliary links or remotely controlled stations such as a remote base which has an auxiliary link station as a part of its system. In the latter case, the remote base is limited to retransmitting the signals of its auxiliary link station only.

PAPERWORK FOR REPEATERS and other remotely-controlled Amateur stations will be simplified greatly by an FCC action adopted in November. As of December 1, technical showings will no longer be a required part of the license application for such a station and technical information will be required only as part of the permanent station log. Repeater license applicants, for example, need only specify that their proposed station will be remotely controlled. System block diagrams, control details and the like need not accompany the application but must be entered in the permanent station log. Similarly, repeater-control stations will not even need to specify what repeater they intend to become a control station for — that's entered in their control station log and the log of the repeater they control.

Net Result of this important change is to speed up license processing greatly since technical evaluation will no longer be a part of the license granting procedure.

Note That All Information previously required as part of the FCC file record is still required in the permanent log. This is spelled out in new Part 97.103b, which replaces 97.41c and 97.41e. Control station requirements are spelled out in new Part 97.103d.

Prohibition Against Portable Or Mobile operation of a remotely controlled station in Part 97.88e has also been deleted. However, during portable or mobile operation a positive control system is still required and the usual requirements for ID, logging and notification must still be observed. Note too that the prohibition against portable or mobile operation of auxiliary link stations has not been relaxed.

REPEATER AND CLUB STATION TRUSTEES should be aware that group organization plans and constitutions are being checked by FCC legal people to be sure funding of group Amateur stations is not in violation of Part 97.112. All new applications are checked as a matter of course, and files on old licenses are sometimes pulled for review on a random basis. Groups whose fund raising systems seem to ask money for operation or use of the station are very likely to be cautioned.

BICENTENNIAL PREFIX LIST in last May's Presstop had a typo which should be corrected. WN1-WNØ can use AK1-AKØ — not AG1-AGØ as shown. Use of the alternate bicentennial prefixes is entirely optional, but remember that they don't go into effect until 0500Z January 1, 1976, and are good until January 1, 1977.

ALL IRCS IN CIRCULATION will be honored for first class overseas postage regardless of date of issue through the end of 1976, according to latest post office info. After that all earlier IRCs will be void and only latest issue will be valid.

CANADA GOES AFTER IGNITION NOISE with a new Radio Interference Regulation that takes effect next September 1. The new regulation will severely limit the permissible radiation from any spark ignition engine, includes autos, chain saws and snow mobiles, with the one exception of aircraft engines. The regulation will eventually be extended to include other RFI sources such as power tools and high voltage transmission lines.

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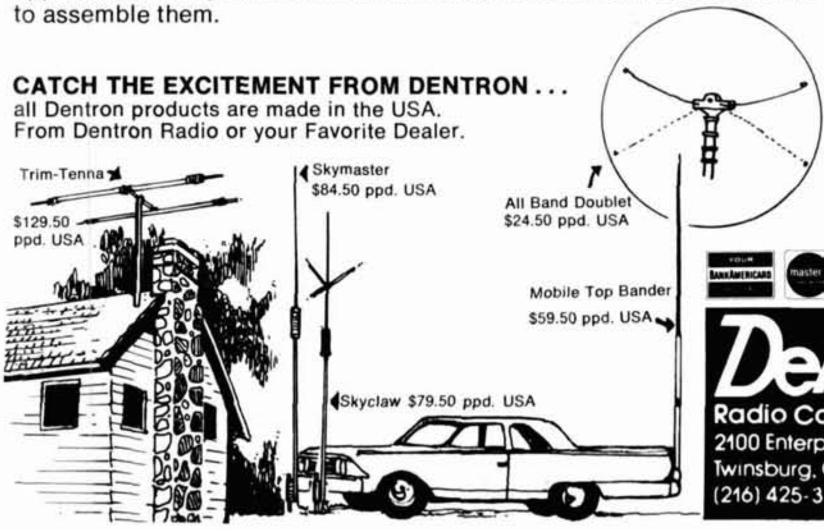

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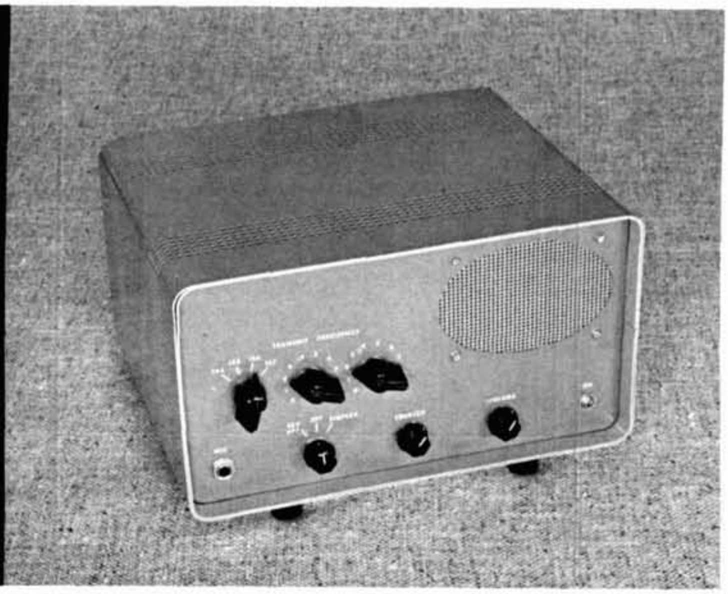


synthesized two-meter fm transceiver

Frequency heterodyne techniques, synthesizer modulation and modular construction are combined in this novel design

This article describes a two-meter fm transceiver containing a 400-channel frequency synthesizer. The transceiver is designed to operate from a 12-volt dc source. By using heterodyne techniques rather than frequency multiplication, only one frequency at a time is generated by the synthesizer, which is used for both transmit and receive modes. Lock-up problems are avoided by eliminating the need to generate the offsets in the synthesizer. With the heterodyne scheme, the synthesizer changes frequency directly in 10-kHz increments, which greatly simplifies its design; you need only dial in the desired transmit frequency along with the desired receive mode. The receiver offset, ±600 kHz for repeater or zero kHz for simplex operation, is generated by a separate crystal-controlled oscillator. An interesting feature of the transceiver is that the modulation is applied directly to the synthesizer, which results in excellent-quality audio with simple circuitry.

general description

Fig. 1 shows the functional elements. The synthesizer tunes from 12.01 to 16 MHz in 10-kHz steps. Modulation is applied directly to the voltage-controlled oscillator (VCO) control line from a clipper preamp. In the receive mode, the clipper preamp is disabled by switching the B+ line. The VCO output is buffered after which the signal is split and fed to two double-balanced mixers,

By Robert W. Wilmarch, W1CMR, and William R. Wade, K1IJZ, Roberts Road, Wellesley, Massachusetts 02181

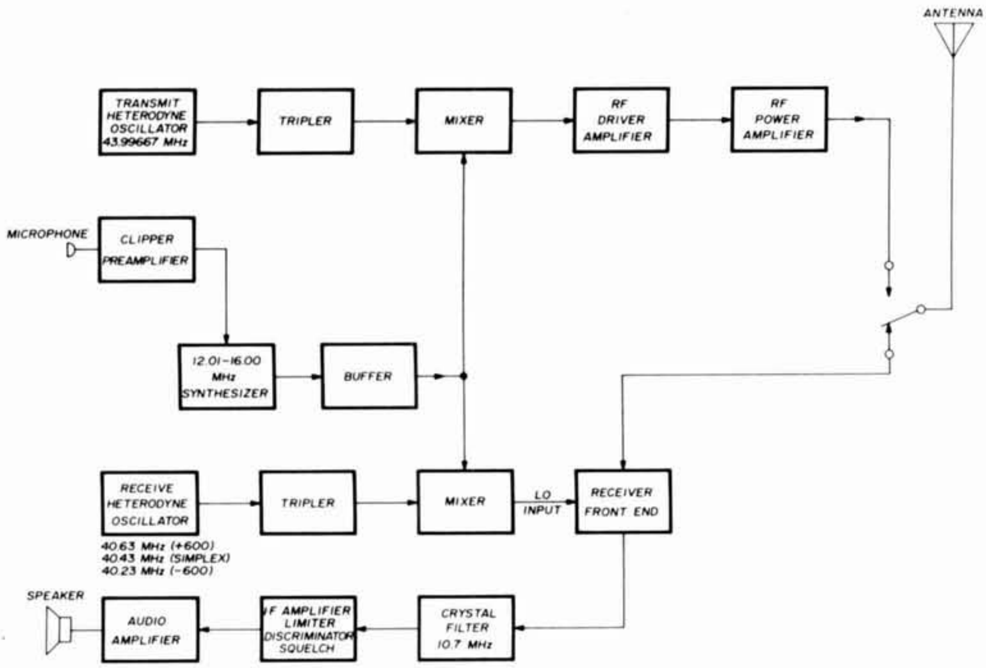
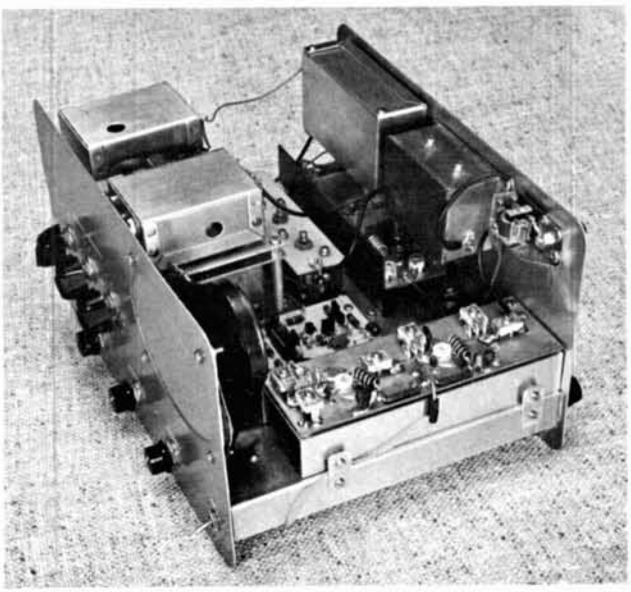


fig. 1. Block diagram of the synthesized 2-meter fm transceiver.

one in the transmit line; the other in the receive line. In both cases the synthesizer signals are fed into the local oscillator (LO) ports of the mixers.

In the transmit mode a signal at 131.99 MHz is added to the synthesizer signal so that the resultant signal covers 144 to 148 MHz. The front-panel controls are marked to indicate the transmit frequency. The mixer output is fed into a driver amplifier where the signal level is raised to about 2 watts. This signal in turn drives a 15 to 20 watt power amplifier. In the receive mode the transmit heterodyne oscillator and mixer stage are disabled through the B+ line. Voltage is left on the driver and power amplifier stages since these stages are run in class C and consume negligible power without drive.

Overall view. The audio amplifier and optional power amplifier are shown immediately behind the speaker.



On receive, the synthesizer signal is mixed with one of three crystal-controlled frequencies depending on the desired operating mode. The resulting sum frequency is the LO frequency required to heterodyne the receive frequency to the (nominal) 10.7 MHz intermediate frequency. This i-f signal is fed through a crystal filter which determines receiver selectivity. The circuits following the filter are conventional. In the transmit mode only the audio amplifier is disabled, again through the B+ line. Two small relays are used. One switches the antenna from receive to transmit. The other, in the B+ line, turns various circuits on and off as described above. A double-pole, double-throw relay may be used for switching.

synthesizer

The synthesizer generates frequencies between 12.01 and 16.00 MHz in 10-kHz steps. During transmit this output is heterodyned with a 131.99-MHz signal to produce transmit frequencies between 144.00 and 147.99 MHz. On receive, the required LO frequency is obtained by heterodyning the synthesizer output with either 121.29 MHz for simplex operation, 121.89 MHz for normal repeater operation, or 120.69 MHz for reverse repeater operation. Because of the heterodyning scheme, this synthesizer is simplicity itself. It requires none of the 1-count detectors, out-of-lock detectors, or count offset circuits of synthesizers used in multiplier service.[1]

Above 7 MHz the programmable divider chain of SN74192s swallows a count due to propagation delays. This action causes a 1 count (10 kHz) offset in the synthesizer output frequency from that to which the divider is set. This offset is compensated in the heterodyne process to yield the correct transmit or LO frequency with respect to dial setting at the mixer output.

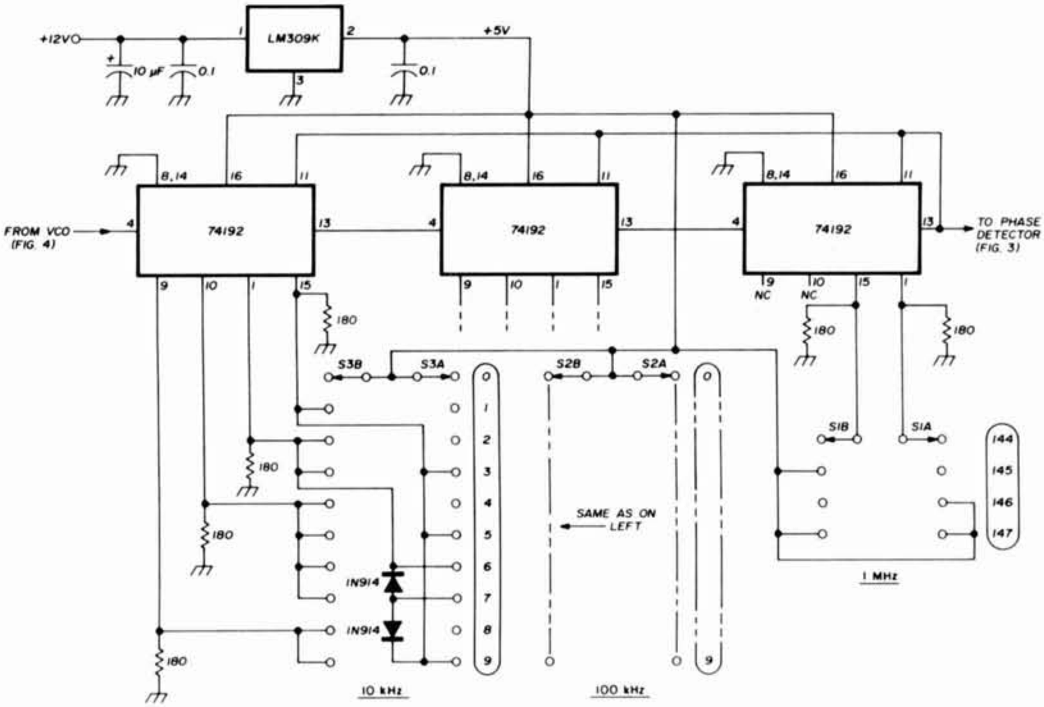
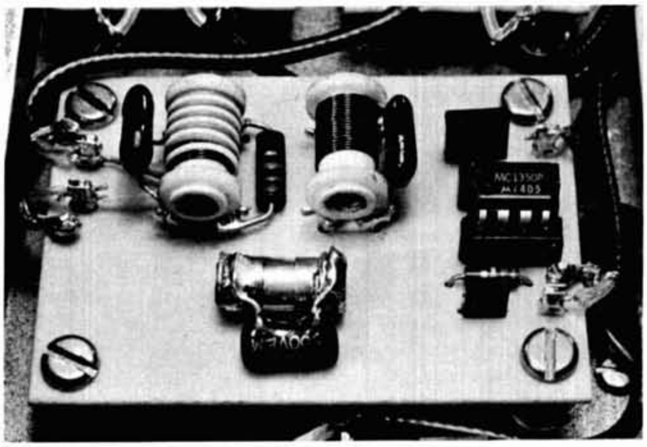


fig. 2. Programmable divider.

The programmable divider, **fig. 2**, is unique in that the ÷12 through ÷15 functions are obtained from a single decade counter chip. This bit of magic is accomplished by using the last 74192 as a downcounter, which is preset to a 12, 13, 14, or 15. The decade limitation on the 74192 holds only in an upcount mode. The other two counters are presettable from 0 to 9, and the string of three 74192s divides the VCO frequency by a number between 1201 and 1600 with the programmed inputs set between 1200 and 1599.

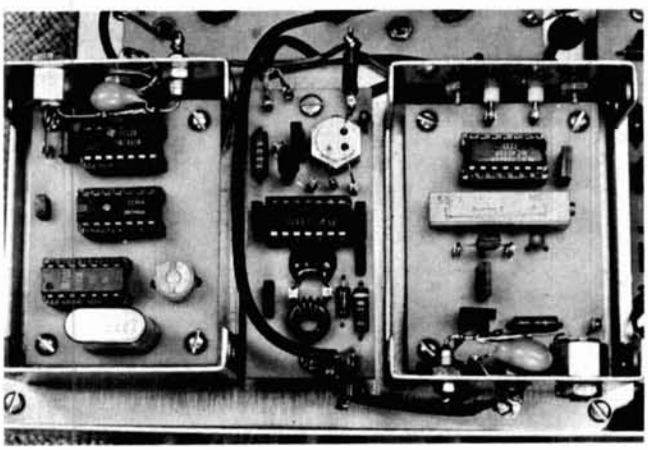
The phase detector and filter, **fig. 3**, are straight from the MC4044 data sheet with an extra capacitor on the filter output to help supress the 10-kHz ripple on the VCO control line. Adjustment of the 10k pot in the filter is accomplished by listening to the VCO on a receiver, tuning 10 kHz off to find a VCO sideband and tweaking the pot for minimum sideband signal.

The VCO, **fig. 4**, is an LC oscillator using the MC1648 as the active element. This circuit proved superior in performance to any of the available multivibrator type VCOs. Watch out for the MV1401! It's an expensive ($9) wide-range varicap, and again it proved superior to the less-expensive diodes. A glance at the synthesizer schematics shows that the phase detector, reference oscillator, programmable divider, and VCO each has its own LM309 5-volt regulator. A regulator is mandatory in phase-locked loops to decouple the circuits from each other. Any modification of this decoupling scheme should be avoided. Usual RC and LC decoupling techniques do not compare with the use of three-terminal regulator ICs.



Synthesizer buffer amplifier.

Top of synthesizer showing, left to right, phase detector and filter; VCO, and reference oscillator.



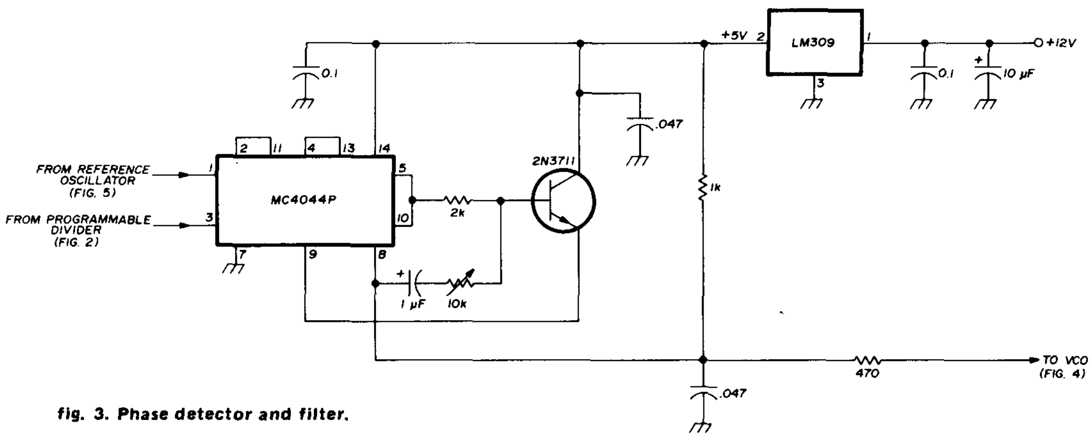


fig. 3. Phase detector and filter.

The programmable divider is constructed on double-sided board with the wiring side at ground and the component side at +5 volts. The V_{cc} pins of the IC sockets are bent out and soldered directly to the 5-volt side, while the ground leads are brought through the boards and soldered directly to the foil. This approach provides a low impedance V_{cc} line, which prevents possible erratic synthesizer behavior.[2]

The reference oscillator, **fig. 5**, is a 1-MHz crystal oscillator followed by two decade dividers to yield the 10-kHz reference frequency. The synthesizer output is buffered as shown in **fig. 6**. A double-tuned output circuit provides a flat response over the full 4-MHz range. A single-tuned output stage will suffice if the transceiver is set up to operate over a 2-MHz range. In this case the MHz switch may be replaced with a single-pole, single-throw switch.

From the VCO buffer amplifier the signal is split and fed to two separate mixer stages. These stages, (**fig. 7**), are identical except for minor differences in the tuned circuits. In each case, the stage is used to add the synthesizer output to that of a heterodyne oscillator. In one case the sum frequency is the transmit frequency, while in the other it is the receive LO frequency. Double-balanced mixers are used because they happened to be available. Suitable mixers may be built[3] or purchased for about $7.00 new and perhaps for considerably less on the surplus market. A mixer stage using a dual gate 40673 mosfet was tried with apparently satisfactory results; however, the suppression of the other mixing product was not verified. Other approaches should work equally well.[4]

Care was taken to provide 50-ohm terminators to each mixer port. The synthesizer buffer is fed into the LO port, and with the coupling arrangement shown, the buffer provides an LO signal of +7 dBm. The heterodyne oscillator signals were adjusted by varying the position of the output links so that the power at the mixer was near zero dBm. These adjustments did not appear to be critical. By using an in-line layout for the mixers, no instabilities were encountered.

The receive mixer stage is powered at all times, while the transmit mixer stage and its heterodyne oscillator are powered only during transmit, which is necessary to prevent a receiver birdie in the simplex mode.

modulator

The first attempts at modulating the transmitter were along conventional lines; the modulating voltage was applied to a tuning diode in the transmit heterodyne oscillator crystal circuit. While this method worked, the audio quality left something to be desired. After a number of attempts to improve matters, this approach was abandoned in favor of directly modulating the VCO in the synthesizer. The results were indeed gratifying, with reports of excellent audio quality. Full deviation is

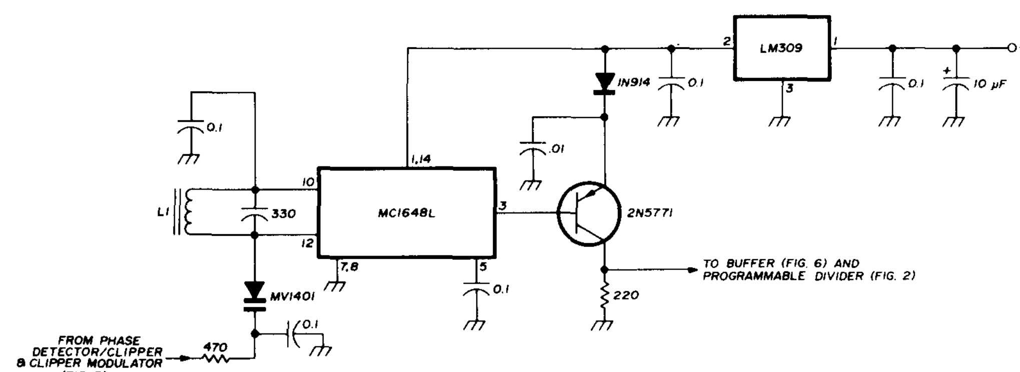


fig. 4. Voltage-controlled oscillator. L1 is 4 turns on Amidon T50-6 toroidal core.

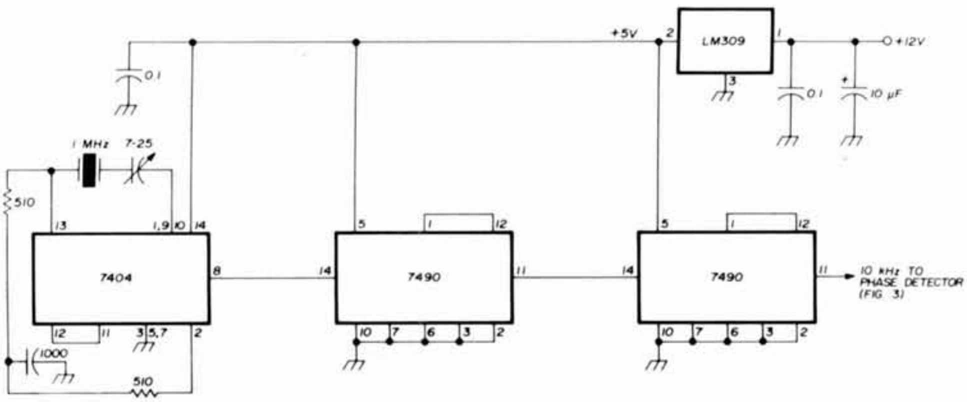
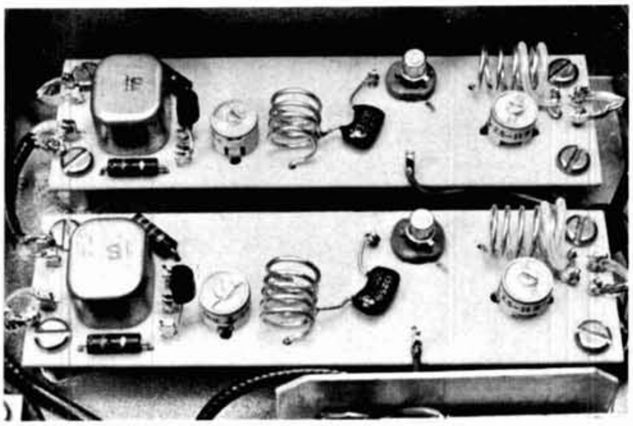


fig. 5. Reference oscillator.

obtained with only a few millivolts of modulation superimposed on the VCO line. This signal level is many times below that required to disturb the phase-locked-loop stability.

The clipper preamp, **(fig. 8)** is a modification of a circuit originally designed to modulate a tuning diode[5]



Transmit and receive mixers.

where several volts of modulation were required. Since only millivolts are now required, the output stage was changed to a simple emitter follower, eliminating several components.

heterodyne oscillators

The heterodyne oscillators are shown in **figs. 9** and **10**. The circuits differ only in the number of crystals and the addition of a zener regulator in the transmit oscillator. Overtone crystals in the 40-MHz range are used. The second stages are conventional triplers using a mosfet to minimize oscillator loading. Tripler stage output is through a one-turn link.

During tuneup, remember that a final frequency is the sum of the synthesizer frequency and that of the heterodyne oscillator. The reference oscillator should be adjusted first, then the transmit heterodyne oscillator, to produce the desired output transmit frequency. A frequency counter is recommended for this procedure. The receive heterodyne oscillator crystals should be adjusted by tweaking their series capacitors for best received audio.

receiver front end

The receiver front end **(fig. 11)** is similar to a circuit described in 1968.[6] Only minor changes were made in the rf and mixer stages. The original fets were replaced with 40673s, and the mixer output matches a crystal filter. Gate-protected fets eliminate the need for diodes at the antenna. With gate protection no special precautions are necessary in handling these transistors; however, the 3N128 is not protected and care must be exercised. The mixer output impedance is determined primarily by the resistor across the output tank and is chosen to match the crystal filter.

The front end and i-f stages show a direct connection to the crystal filter. This is fine if the physical layout is close and there is no dc return in the filter. If a dc return is present, a blocking capacitor must be used to prevent

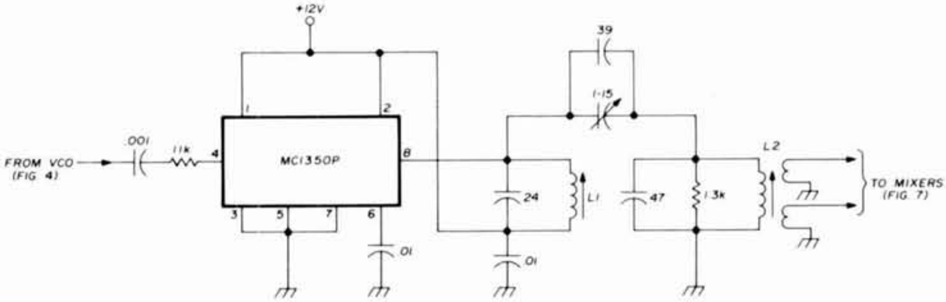
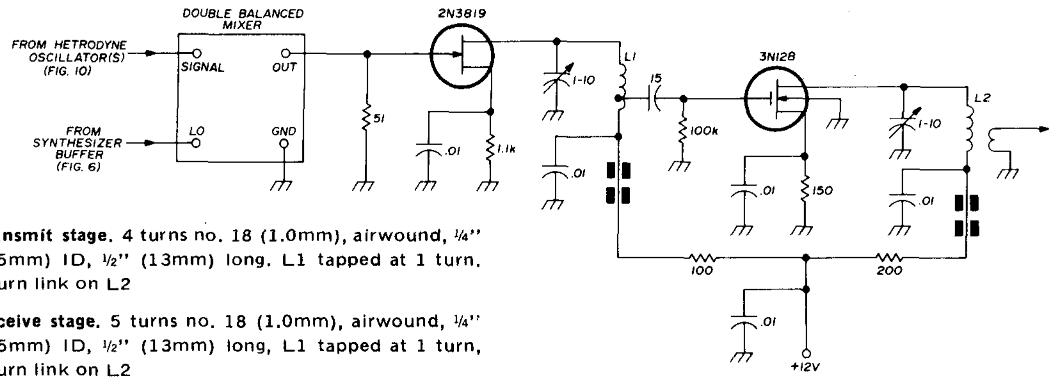


fig. 6. Synthesizer buffer amplifier. L1 and L2 are 20 turns no. 28 (0.3mm) on ¼" (6.5mm) form. Output links on L2 are each 5 turns.



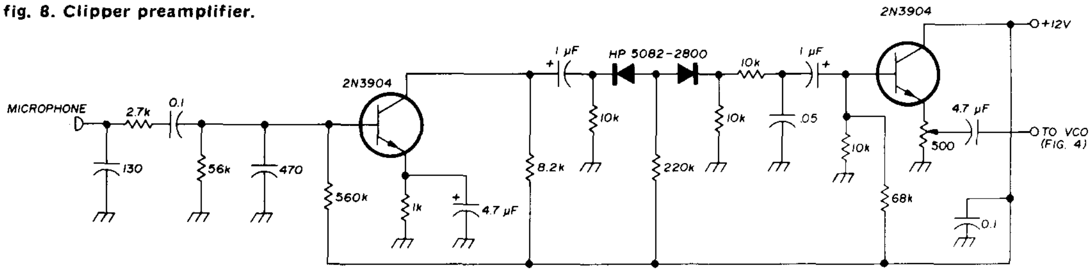
L1,L2 **Transmit stage.** 4 turns no. 18 (1.0mm), airwound, ¼" (6.5mm) ID, ½" (13mm) long. L1 tapped at 1 turn, 2-turn link on L2

L1,L2 **Receive stage.** 5 turns no. 18 (1.0mm), airwound, ¼" (6.5mm) ID, ½" (13mm) long, L1 tapped at 1 turn, 2-turn link on L2

fig. 7. Mixer. One each is required for transmit and receive. L1 and L2 are 4 turns each on the transmit board and 5 turns each on the receive board.

short circuiting the mixer drain voltage. If the circuits are to be separated physically, a coaxial line must be used for shielding. In this case the line becomes part of the mixer tank circuit, thus requiring a smaller tank capacitor than the 56 pF shown. A good rule of thumb for coaxial cable is 30 pF per foot. The LO input from the receive mixer stage is amplified and applied to the 40673 front-end mixer through a 5-pF coupling capacitor. Signal level should be about 1.5 volts.

fig. 8. Clipper preamplifier.

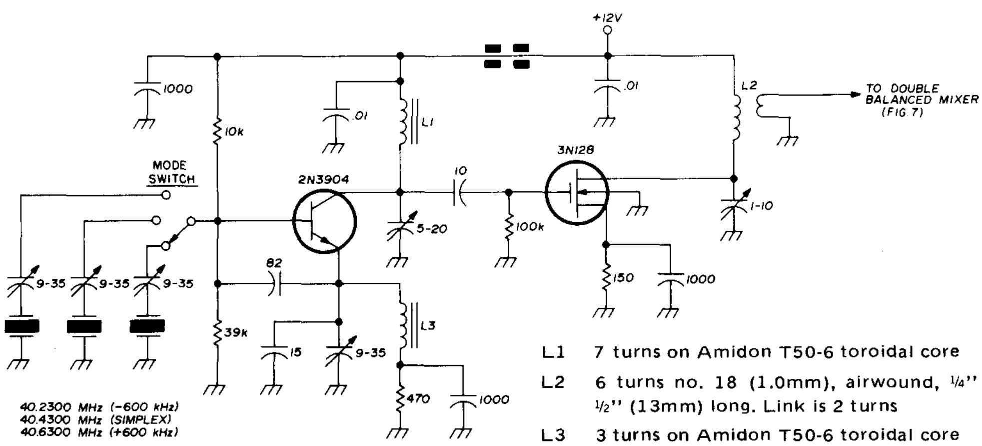


i-f subsystem and audio

The receiver is a single-conversion device. While single conversion has certain advantages, the trick is to recover sufficient audio in narrowband fm service. The RCA CA3089E linear integrated circuit is a complete fm i-f subsystem (**fig. 12**). While this IC was designed for wideband use, it's possible to realize 290 millivolts of recovered audio for +5-kHz deviation,[7] which is ample to drive the audio stage to full output. The squelch control operates smoothly with this device and doesn't have the annoying pop-out characteristics as in some circuits. A tuning or signal-strength meter may be used with the circuit. However, it was decided not to include this feature. Instead, pin 13 is used as a test point for receiver front-end tuneup.

The Q of the quadrature coil across pins 9 and 10

fig. 9. Receive heterodyne oscillator.



L1 7 turns on Amidon T50-6 toroidal core

L2 6 turns no. 18 (1.0mm), airwound, ¼" (6.5mm) ID, ½" (13mm) long. Link is 2 turns

L3 3 turns on Amidon T50-6 toroidal core

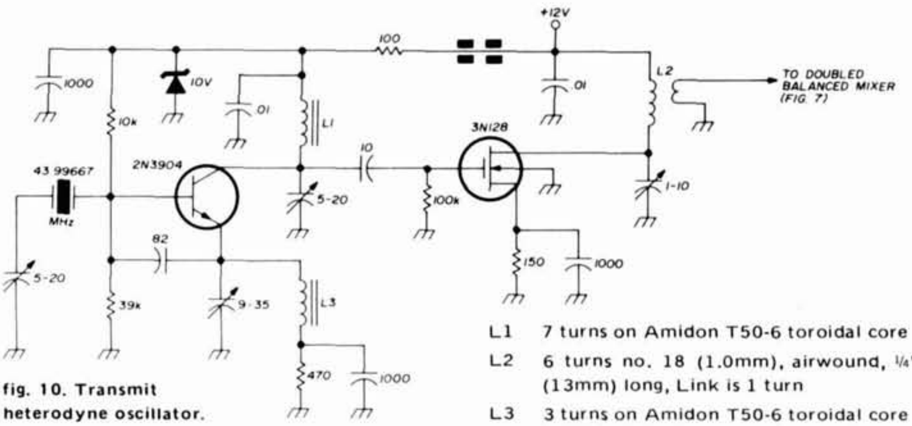
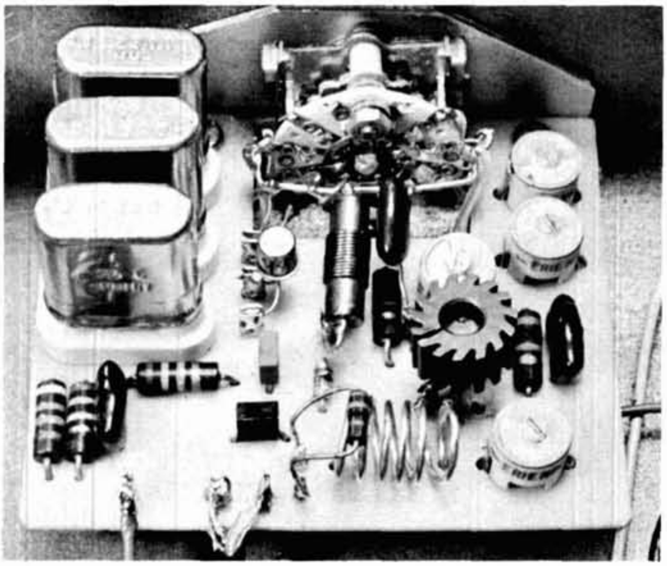


fig. 10. Transmit heterodyne oscillator.

L1 7 turns on Amidon T50-6 toroidal core

L2 6 turns no. 18 (1.0mm), airwound, 1/4" (6.5mm), 1/2" (13mm) long, Link is 1 turn

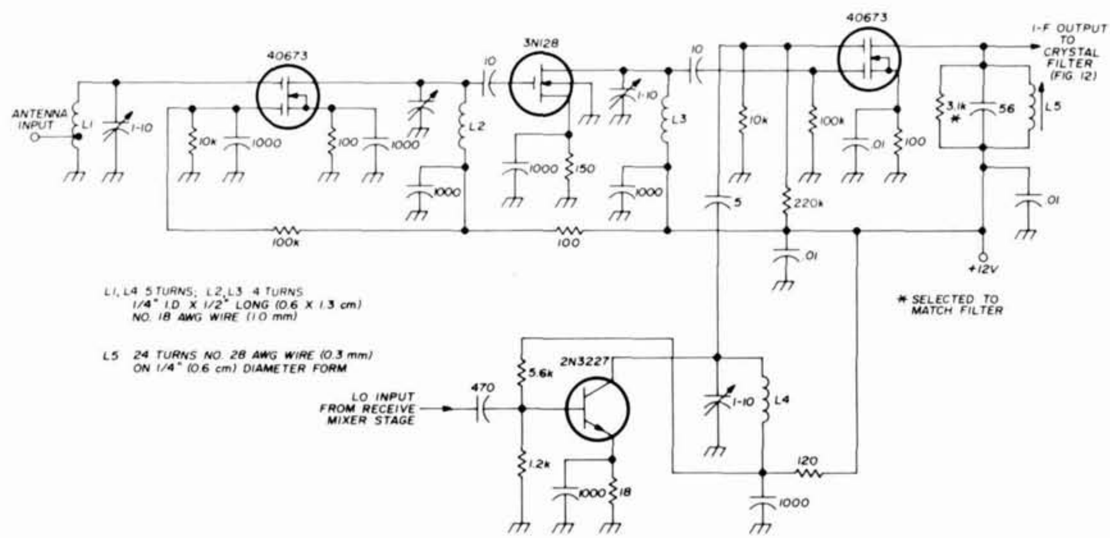
L3 3 turns on Amidon T50-6 toroidal core



Receive heterodyne oscillator.

determines, to a great degree, the level of recovered audio. The RCA test results[7] were for a Q of 120. Using an available core, a value of 220 was measured, which resulted in somewhat more recovered audio. This value of Q, however, was reduced to a value consistent with the sensitivity of the audio amplifier by simply padding the coil with a suitable resistor. The effect is to greatly reduce the sensitivity of the circuit to temperature changes. Stability of this stage may be checked by looking at pin 9 with an oscilloscope. If the circuit is oscillating, a square wave will be seen.

A 2N3819 junction fet matches the crystal filter to the CA3089E. Because of the very high input impedance of this transistor, the filter load resistor from gate to ground is chosen according to the requirements of the filter. Stage gain isn't critical and need not be more than necessary to overcome the filter insertion loss. Any audio stage with sufficient sensitivity may be used. The MFC9020 is a 2-watt amplifier requiring only 200 millivolts of drive.



L1,L4 5 turns no. 18 (1.0mm), airwound, 1/4" (6.5mm) ID, 1/2" (13mm) long

L2,L3 4 turns no. 18 (1.0mm), airwound, 1/4" (6.5mm) ID, 1/2" (13mm) long

L5 24 turns no. 28 (0.3mm), on 1/4" (6.5mm) slug-tuned form

fig. 11. Receiver front end.

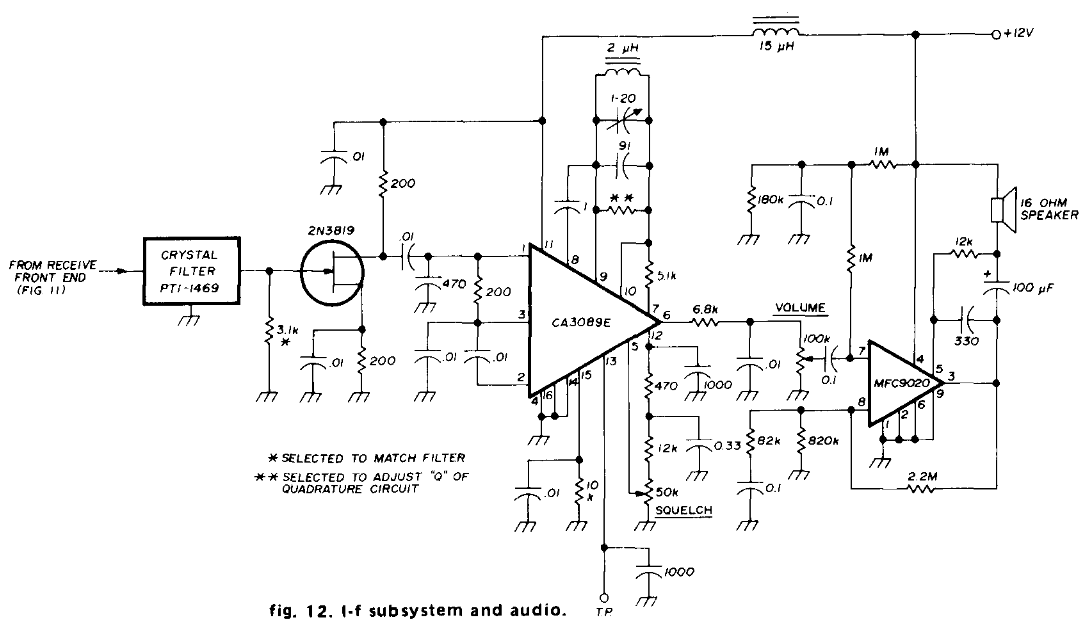


fig. 12. I-f subsystem and audio.

The rf driver amplifier, **fig. 13**, is conventional and is driven directly from the transmit mixer stage. Output is about 2 watts and the circuit will match a 50-ohm load. If 2 watts is sufficient, the output chain may be terminated at this point. For additional power, an amplifier such as the *VHF Engineering* unit shown in the photo provides output in the 15 to 20-watt range.

construction

Standard copper-clad board and point-to-point wiring are used. A minimum of tools are required and the difficulty of making printed boards is avoided. An advantage of the modular approach is that a circuit can be completed, tested, and set aside until the overall unit is ready for assembly. All interconnecting lines use small coaxial cable where length is not critical, which permits flexibility of the final layout. Rotary wafer switches were chosen for the frequency select controls. While significant space saving can be achieved by using BCD-coded thumbwheel switches, a rotary format affords a definite ease of operation.

This transceiver has given trouble-free operation for about a year with excellent signal reports. While heterodyning, digital-frequency synthesizers, and synthesizer modulation are all well-known processes, the combination of these features offers an attractive approach to those who like to try something different.

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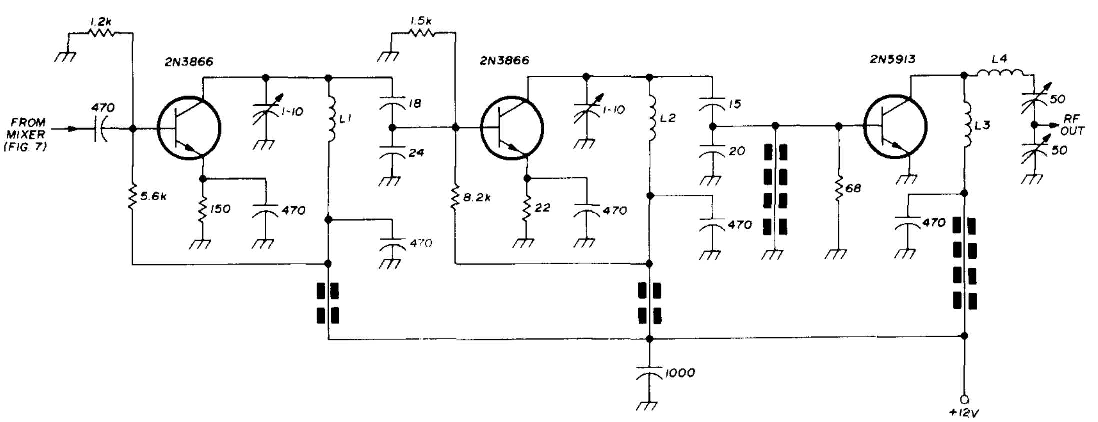
ham radio

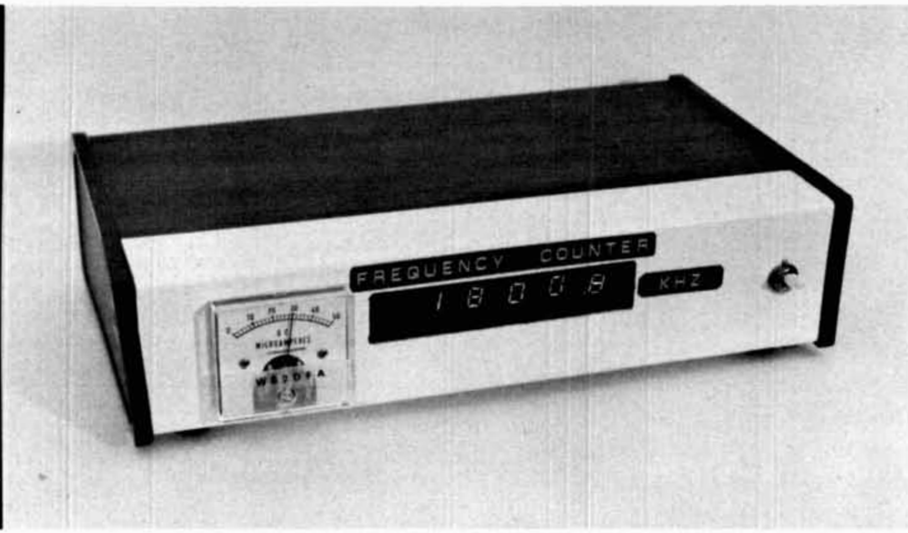


L1,L2 2 turns no. 16 (1.3mm), airwound, 5/16" (8mm) ID, 3/16" (5mm) long

L3 12 turns no. 22 (0.6mm) enamelled wire, closewound on 3/16" (5mm) mandrel

L4 5 turns no. 16 (1.3mm), airwound, 5/16" (8mm) ID, ½" (13mm) long

fig. 13. Rf driver amplifier.



six digit 50-MHz frequency counter

A frequency counter has several advantages over a frequency standard. Instead of listening and tuning for crystal-oscillator harmonics on a receiver, a counter can provide a direct readout in frequency from the signal being measured. An instrument such as this can be a very valuable asset for the amateur who likes to build his own variable-frequency oscillators, transmitters, and receivers. With this frequency counter I was able to align a homemade crystal filter for an ssb rig, using the counter to pinpoint the exact location of the filter passband. When the counter is used with signal generators, precision alignment of amateur equipment is a snap.

The frequency counter described here and shown schematically in **fig. 1** is designed for use in the hf spectrum to 50 MHz, with a signal at the input having an amplitude of about 50 mV rms. The digital readout displays the frequency in kHz with resolution to the nearest 100 Hz. Construction cost of the counter is about $50 including the power supply and cabinet. The cost will be lower if the ICs are in your goodie bin. Printed circuit boards are not available for this project. The entire counter, with the exception of the power supply, was built on perfboard – the kind with holes on a 0.1-inch (2.5mm) grid.

The goal of this article is to present a working design for a high-performance instrument that requires a minimum of ICs. However, I'd like to offer some observations based on experience with the project. I've noticed that the 50-MHz response is largely device-dependent. I had to select SN74S00 devices to get the counter to squeak up to 50 MHz. The ICs used in the counter were obtained from Poly Paks, as was the SN74196 decade counter. With the prescaler circuits published in *ham radio*[1,2,3] the counter should work well into the 432-MHz range.

The heart of the counter is a crystal-controlled oscillator. This 1-MHz source is a free-running multivibrator made up of two NAND gates (U1A and U1B) with a crystal as the frequency determining element. The 220-ohm resistors bias the gates in a class-A amplifier condition so that the oscillator is self starting and sustaining. The remaining two gates in the quad NAND package are used as buffers to isolate the oscillator from the loading effects of the IC stages that follow. U1D provides a buffered 1-MHz output to a BNC jack on the rear panel of the counter. The 1-MHz output is a very close approximation of a square wave, rich in harmonics, and provides a means of checking the oscillator with WWV. It also can be used for checking out the counter itself. If the 1-MHz output is coupled to the input jack, the counter will display 1000.0 kHz. The trimmer capacitor in series with the crystal is used in the zero beating process.

The frequency counter performs by sampling the input signal for a finite period of time. For example, if we were to couple a 1-MHz signal to a chain of decade counter stages for exactly one second, then 1 million pulses will have been counted. If the sampling time is reduced two orders of magnitude to 0.01 second, then the counter will register 10,000 pulses. Thus if 10,000 pulses are counted for each 1 MHz, the least-significant digit on the counter would represent 100 Hz. It's easy to see the importance of having a device that will perform the function of gating the unknown frequency with great precision.

The time-base divider chain is composed of four cascaded decide counters (U2-U5) followed by a flip-flop

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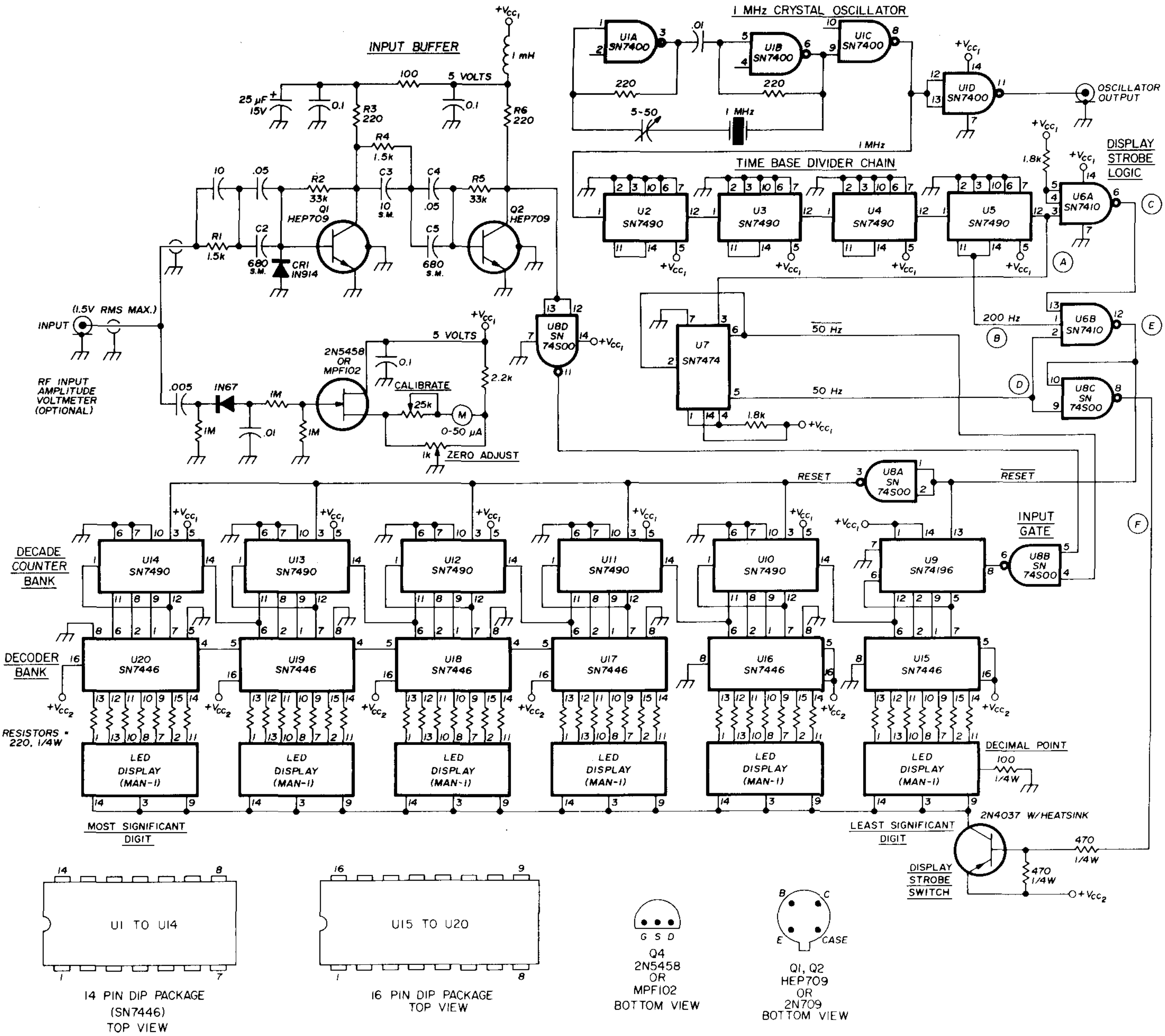


fig. 1. Frequency counter schematic.

(U7) that divides the crystal oscillator down to a frequency of 50 Hz. The flip-flop has two oppositely phased outputs, 50 Hz and $\overline{50\text{ Hz}}$. The $\overline{50\text{ Hz}}$ output is 180 degrees out of phase with the 50 Hz output. Each output is a symmetrical square wave that is logic 1 for 10 milliseconds, and logic zero for 10 milliseconds, for a total time period of 20 milliseconds. The $\overline{50\text{ Hz}}$ from flip-flop U7 controls the input gate (U8B). U8B will only pass the amplified input signal from the unknown source when the $\overline{50\text{ Hz}}$ at pin 4 of U8B is logic 1. Thus U8B gates the unknown frequency for 10 milliseconds.

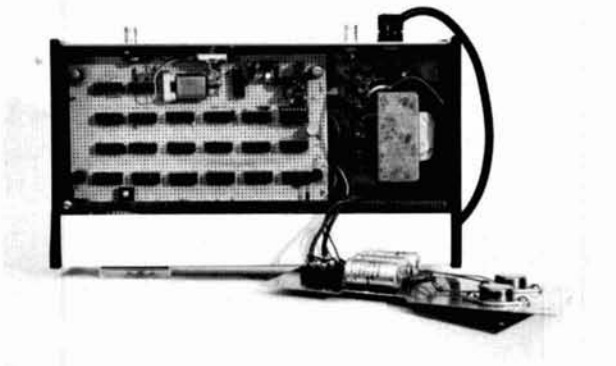
The decade counters in the time-base divider chain are connected in a divide-by-5, divide-by-2 configuration. The output frequency of each decade counter is 1/10 the frequency of the input. The output of each decade counter is a symmetrical square wave. The schematic of **fig. 2** shows in detail how the decade counter functions when connected in this fashion.

display strobe logic

The display strobe logic (U6, U7, U8) synthesizes the timing sequence for sampling the input frequency, resetting the decade counter bank before each sampling period, and strobing the LED displays once for each completed sampling period. The timing diagram, **fig. 3**, illustrates the relationship between these signals. "F" is derived from the output of U8C, pin 8. The total time period for F is 20 milliseconds, which is determined by flip-flop U7, as discussed earlier. The duty cycle of F is determined by gating the B, C, D, and E signals together. You'll note that F is high for 11 milliseconds and low for 9 milliseconds, and that the displays are blanked out during this 11 milliseconds of each sampling cycle. The display strobe switch, Q3, is held in cutoff as long as F is logic 1.

The $\overline{RESET}$ pulse, E, goes low for the first 1 millisecond of the sampling cycle resetting decade counter U9 to the 0000 state. E is inverted by U8A to provide the proper reset signal for the remaining decade counters (U10-U14).

During the 10 milliseconds that follow the trailing edge of E, the input frequency to be counted is registered by the decade counter bank. The LED displays are



Logic circuitry for the 50-MHz frequency counter is built on a section of perf-board. Voltage regulator ICs are mounted on aluminum panel which is sandwiched above the perf board on standoffs.

blanked out during the count-up cycle; otherwise, the displays would show a blur of 8s from the fast count rate. When the sampling has been completed, the input gate is opened, and the decade counter bank no longer receives pulses from the input buffer. At this point in time F goes low; Q3 is switched into saturation, and the LED displays indicate the results accumulated during the sampling period. This process is repeated 50 times per second. Because of the persistence of the human eye, the displays seem to be on continuously. Since the counter gets an update 50 times per second, the counter will follow rapid changes in frequency, such as those encountered when tuning across the band. The counter will update changes in frequency with no apparent time lag.

decade counter bank

The decade counter stages (U9-U14) are cascaded in a manner that allows them to function as a system for counting a series stream of pulses. U9 is the most important link in the counter chain and is an SN74196, a high-speed device capable of performance in the 50-MHz region. The SN7490 decade counters are rated at 15 MHz. Therefore, the frequency range is very dependent upon the input buffer and the SN74196. Since U9 will operate at 50 MHz, the frequency propagated to the next stage will be, at most, 5 MHz. Each succeeding stage will receive decreasing orders of magnitude of the frequency presented to U9.

The SN7490s are connected in a divide-by-2, divide-by-5 format for use in the decade counter bank. Pin 14 is used as the clock input, and the output of the first flip-flop (pin 12) is connected to pin 1 to drive the divide-by-5 portion. The counting function is performed in the binary coded decimal format. Pin 3 is used as the reset input for initializing the decade counters to the 0000 state. A logic 1 at this input will reset the SN7490. When pin 3 is logic 0, the SN7490 advances into each succeeding count state as dictated by the clocking signal at pin 14.

The SN74196, on the other hand, is nothing more than a super-fast SN7490 and operates in much the same manner. The subtle differences are in the pin configuration and the resetting scheme. Unlike the SN7490, the V_{CC} and ground pins on the SN74196 are 14 and 7 respectively; on the SN7490, they are 5 and 10 respectively. Pin 13 on SN74196 is the reset input; a logic 0 as this input will jam the counter into the 0000 state. The counter can only advance when pin 13 is logic 1. This one criterion is opposite that of the SN7490. NAND gate U8A solves this dilemma by providing oppositely phased reset signals for U9 and the remaining counters in the decade counter bank.

decoder bank

U15 through U20 are BCD-to-seven-segment-decoder ICs. These SN7446s translate the BCD information from their respective decade counters to form digits in the seven-segment format. The SN7446s feature leading-zero blanking, which is employed to eliminate any ambiguity caused by one or more zeros preceding the most-significant digit. For example, a frequency of 00142.7 kHz is more recognizable when presented as 142.7 kHz. Blanking out the unnecessary zeros makes the display much easier to read. Special logic is designed into the SN7446 to provide this feature. The ripple blanking logic looks for a logic 0 from the ripple blanking output (RBO) from the next most-significant digit. This condition occurs when the next most-significant digit above that one is also a zero. The ripple blanking signal propagates from the most-significant digit to the least-significant digit desired in the zero blanking scheme.

If you refer to **fig. 1**, you'll notice that the ripple blanking originates from U20 (the most-significant digit) and is passed down the line to U17. The ripple blanking output (RBO) appears at pin 4 of U20 and is fed to the ripple blanking input (RBI), pin 5 of U19, and so on.

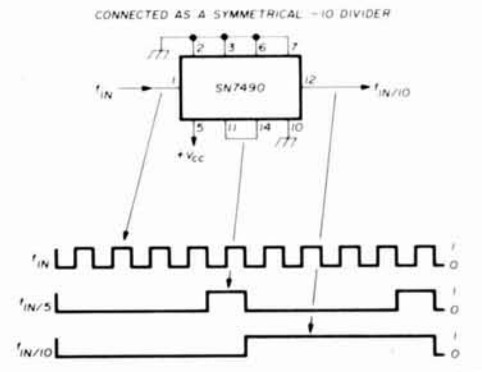


fig. 2. The type SN7490 connected as a symmetrical divide-by-10 counter.

Pin 5 of U20 is grounded since the ripple blanking process originates at U20. The ripple blanking feature can be disabled by simply connecting pin 5 on U20 to $+V_{CC2}$. Pin 5 (RBI) on U15 and U16 are tied to $+V_{CC2}$; therefore, with no signal present at the input gate the counter will display only the least two significant digits as zeros.

Unlike the other ICs in the project, the SN7446s are enclosed in a 16-lead dual inline package. Pin 16 is the $+V_{CC}$ input and pin 8 is ground. The output pins, 9 to 14, are open-collector outputs capable of sinking 20 mA

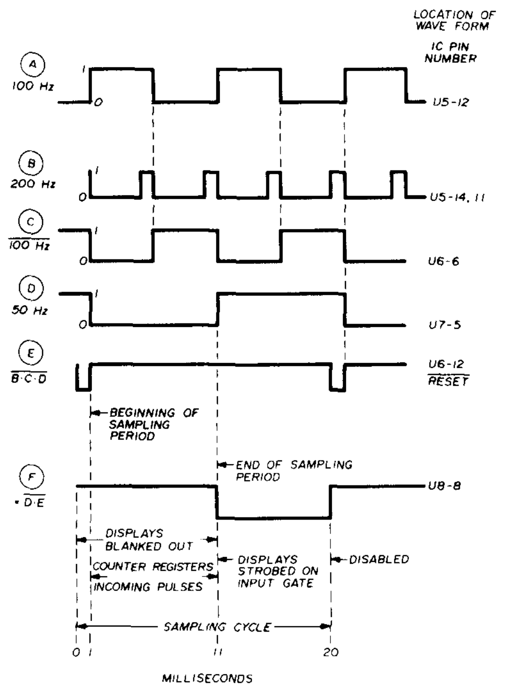


fig. 3. Timing diagram showing display strobe logic, reset, and input gating.

when switched on. The 220-ohm resistors in series with each segment on the LED displays limit the current to a peak value of 15 mA per segment. However, since the displays are strobed on for 9 milliseconds in each 20 millisecond sampling cycle, the average current per segment is (9 milliseconds/20 milliseconds) (15 mA) = 6.75 mA.

led displays

The LED displays used in this project are equivalent to the famous MAN-1. The pinout configuration and schematic are shown in **fig. 4**. The forward-bias threshold on each segment is slightly more than 1.6 volts. This property alone makes it virtually impossible to check out junction continuity and performance with multimeters equipped with an ohms-scale voltage source of 1.5 volts. The best way to check out the LED displays is to use a 4.5- to 5-volt supply with a series current-limiting resistor of 220 ohms. If purchase of MAN-1s from some of the surplus dealers is contemplated, this setup will prove valuable in judging display performance on a segment-by-segment basis. The displays will appear to be a little dimmer in the finished counter because, as pointed out earlier, the average dc current through the segments is 6.75 mA.

The MAN-1s are common-anode displays. Common-anode displays can only be used with decoder ICs like the SN7446 because of the polarity of the open-collector outputs. Common cathode displays will not work in this project. The MAN-1 display has its segments partitioned into three groups. It is necessary to tie all three common elements together (pins 3, 9 and 14) to get all of the segments to light up on command. Litronix Data Lite 707 and the Opcoa SLA-1 are excellent substitutes.

input buffer-counter preamp

The input buffer stage is designed to amplify low-level signals to the amplitude necessary to drive TTL logic circuitry. The transistors chosen for this two-stage amplifier are the HEP 709s by Motorola. The gain-bandwidth product of these devices is 600 MHz, which makes them well suited for this application. Their low saturation voltage ($V_{ce(sat)}$) is on the order of 0.3 volt, low enough to ensure a logic 0 at the input of a TTL device.

Resistor R1 acts as a buffer between the transmission line input and the base circuit of Q1 so that the incoming signal is not clipped or loaded down by the base-emitter junction of Q1. The parallel combinations of C1-C2 and C4-C5 provide coupling from several kHz through the vhf region. Ceramic capacitors become somewhat lossy and inductive at high frequencies, so silver-mica capacitors (C2 and C5) are used to provide additional coupling at the high-frequency end of the counter range.

Diode CR1 is a high-speed switch that protects Q1 from negative-going peaks appearing at the base-emitter junction. Resistor R4 matches the collector circuit of Q1 to the base circuit of Q2, and also contributes to overall amplifier stability. C3 is a 10 pF silver-mica capacitor that compensates for the base-to-emitter capacitance of Q2.

To keep stray capacitance to a minimum, short com-

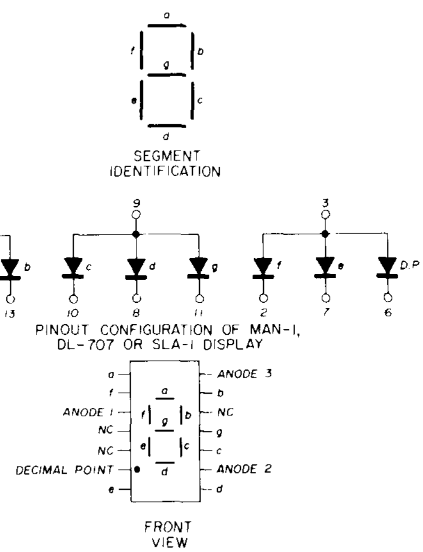


fig. 4. Pinout connections and schematic of the MAN-1 LED display.

ponent lead lengths are of prime importance. The braid of the coax cable should be soldered as close as possible to Q1's emitter to prevent ground-loop problems. *Printed-circuit boards with the customary ground planes* are not necessary if the layout is as neat and compact as possible. The amplifier should be near U8 since the collector of Q2 drives pins 12 and 13 of U8.

input amplitude voltmeter

Since digital logic has a threshold with respect to triggering levels, a means of monitoring the input signal level

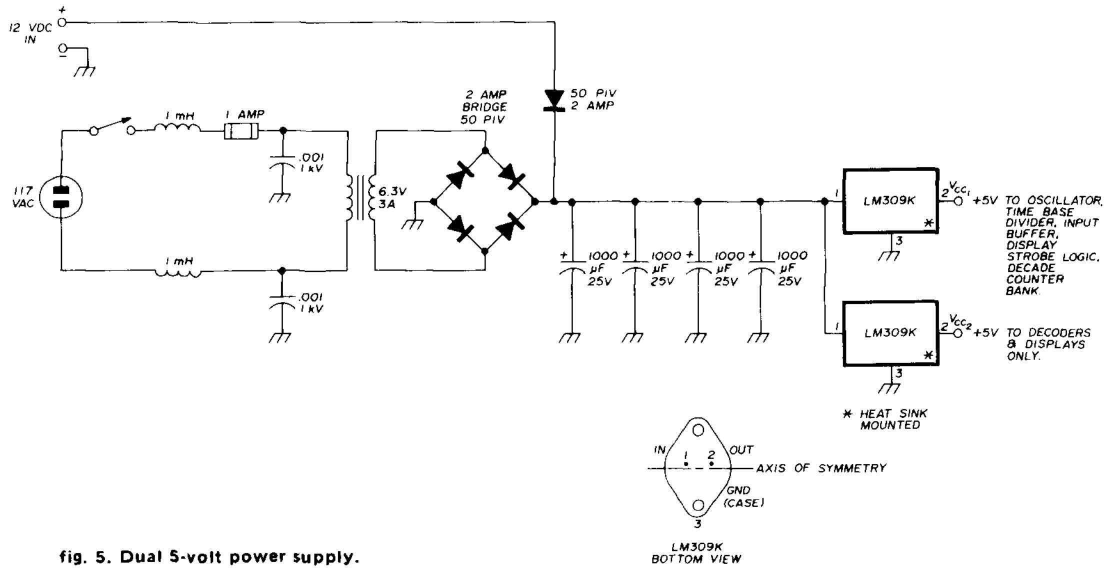


fig. 5. Dual 5-volt power supply.

is necessary to ensure that the counter chain is receiving enough drive to operate reliably. Insufficient drive level can cause triggering errors, in which case the counter counts only a few pulses that happen to break the threshold level.

This circuit consists of an fet voltmeter equipped with an rf probe. The meter is calibrated to read 5 volts peak-to-peak or 1.78 volts rms full scale. The 25k trimpot in series with the 0-50 microammeter is used to calibrate the circuit. The 1k trimpot provides an electrical zero adjust. Calibration can be done with any high-frequency source of known amplitude. The 1-MHz output at pin 11 of U1 has an amplitude of about 3.6 volts peak-to-peak, which can be used if no other calibrated source is available. Before beginning the calibration, the meter should be both mechanically and electrically zero adjusted. The zero adjust on the front panel of the meter should be checked before you apply supply voltage to the fet voltmeter circuit.

power supply

The power supply, **fig. 5**, is straightforward thanks to the LM309K voltage regulators. Two 5-volt supplies are derived from the 9-volt dc supply. The V_{CC1} supply is connected to the V_{CC} pin of all the ICs except the decoders. The V_{CC2} supply powers the decoder ICs and the LED displays only.

The purpose of splitting up the power supply in this fashion is to divide the current demand of the frequency counter so that the regulators operate well below their maximum ratings. The dual power supply also provides excellent decoupling between the decoders, display switching circuitry, and other parts of the counter logic.

sensitivity measurements

These measurements were made with a Tektronix 191 constant-amplitude rf generator, a Hewlett-Packard audio oscillator, and a Tektronix 7000 series scope. The following results were observed with a sine wave input. Upper and lower cutoff frequencies of the counter were noted with respect to a given input amplitude. These numbers represent input levels necessary to ensure reliable triggering of the decade counter stages.

amplitude (mV rms)	lower cutoff frequency (kHz)	upper cutoff frequency (MHz)
5 mV	200	10.20
10 mV	150	14.00
15 mV	100	18.15
20 mV	33	23.00
50 mV	20	45.70

The counter works well with signal levels up to 1.5 volts rms (4.5 volts p-p). At greater amplitudes, the base-collector junction of Q1 is forward biased during the positive peaks of the input signal thereby degrading its vhf performance.

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ham radio

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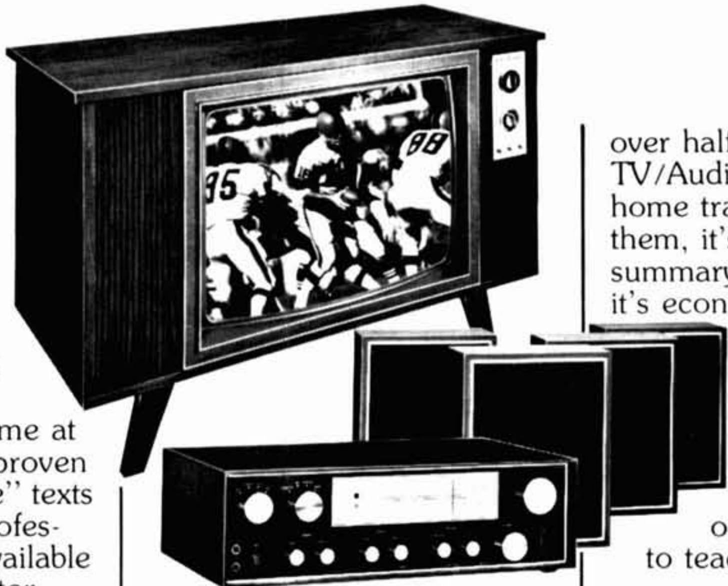

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antenna and tower restrictions

A complete discussion of deed restrictions, zoning ordinances and building codes, and how they may affect that new antenna system you want to install

When planning to buy or build a new home an amateur's first thoughts are inevitably of antennas. How many towers, and how tall shall they be? He may remember stories of amateurs who have been faced with lawsuits because of deed restrictions or zoning regulations, but rarely is this an overriding consideration in the choice of a house or lot. Let the wife pick out the house first -- he can worry about those things later. This should not be. The dangers to ham operation are real, and unfortunately seem to be getting greater.

No one can assume that he has an inalienable right to do whatever he wishes with his property. Like all of our rights, they are subject to many limitations. If you take the attitude that some vaguely-worded deed restriction or zoning ordinance will be decided in your favor by the courts, you *may* be right. However, it could still cost you thousands of dollars in legal fees to establish your rights, and unless you are inedpendently wealthy and enjoy litigation, it could by a Pyrrhic victory.

I recently bought a lot and built a house, and in the course of doing this learned a great deal about the subject. Because of various restrictions, I rejected lots that were otherwise very desirable from the standpoints of location and price. Eventually I found a lot that was satisfactory from all standpoints, but it was not easy. This article will describe the nature of the problems you may be faced with, and what you should do to minimize your risk.

Perhaps the best way to describe deed restrictions is to demonstrate how they work: The owner of a tract of land wants to subdivide it into building lots and sell them. If the owner of the tract is also a builder, he wants to sell you a house with the lot. It is naturally his desire to get as high a price as possible for his lots, and it is therefore in his interest to impress you with the desirability of living in his development. He wants to convince you that the area is definitely high-grade, and will, furthermore, remain that way and not deteriorate. He drafts a "Declaration of Restrictions." This document generally describes the type of house, garage, etc., you may erect on the property, the minimum setback, type of fence, and other items. The developer submits his plat and restrictions to the local zoning commission or other cognizant authority, and if they comply with local planning and zoning laws, they are approved and recorded. The deed to your property will probably say "Subject to any restrictions of record" or something similar. The restrictions are now legal.

Anyone who buys property in this subdivision is, in effect, signing a contract to abide by these restrictions, and if he violates them he can be sued by any property owner or group of property owners in the subdivision.

Of course, there is no certainty that you will be sued if you violate the restrictions. But you are certainly subject to lawsuits. If the development is new, the developer himself may sue, since he may feel that the presence of a 70-foot tower makes it more difficult for him to sell his remaining lots. But even after the subdivision is all sold out, at which time the original developer rapidly loses interest in the character of the neighborhood, any property owner can sue if he finds your tower objectionable, and, depending on the exact wording of the restrictions, would probably have a good chance of winning. The result would be a court order for you to remove your tower.

In my search for a lot, I accumulated quite a collection of sets of restrictions. Every one of them, to a greater or lesser degree, implied restrictions on the erection of antennas although the wording varied. In fact, most of them made no mention of antennas as such. These specified in detail what you *could* put on the property – and an amateur antenna was *not* one of the permitted things. Typical wording was, "No structure other

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than a single-family dwelling . . . garage, swimming pool, etc . . . shall be erected or permitted to remain on this property.

One local amateur was sued by a developer for violation of a restriction like that. He won his case because his tower was mounted on top of his carport, and the court ruled it was part of the house and not a separate structure. Presumably if the tower has been mounted on the ground apart from his house, he might have lost. This victory cost the ham $2500 in legal fees. Some victory.

Other restrictions specify a maximum height above ground or roof level that no structure can exceed; 35 feet (11 meters) above ground level or 3 feet (1 meter) above roof level are common values.

Some restrictions do mention antennas. One actually specifically permitted amateur radio antennas but said that the towers must be of the retractable type and lowered when not in use. One planned community in the Phoenix area bans all outdoor antennas including TV antennas (this community has a master antenna and cable distribution system).

Another common type of restriction states that anything erected on the property must be approved by the "Architectural Committee" of the development.

When considering lots, I always asked the agent whether there were any restrictions on the erection of amateur antennas, and was usually assured that there were none. This frequently turned out to be not quite true. Very rarely, in fact, did the agent have a knowledge of what the restrictions actually said. Ask the agent to get a copy of the restrictions, which he can easily do, and read them yourself. You can get copies yourself as most of the large title insurance companies have this information on file. Alternately, you can get copies at the County Recorder's office (to be valid, the restrictions must be a matter of record).

All of this sounds pretty discouraging, but there are subdivisions that do not have any restrictions. This is more likely to be true of older areas since it has been only relatively recently that restrictions of this sort have become widespread. There are also many odd pieces of property that have never been part of subdivisions. If you look hard enough, you can find a suitable house or lot that has no restrictions.

In any event, you should have your attorney insert a clause in the sales contract that your money will be returned if any restrictions on the erection of ham antennas are found to exist.

The restrictive covenants, zoning ordinances and building codes which affect amateur radio antennas vary widely from one locale to another, and much of the law is case law which varies greatly from state to state. Some states, for example, have given substantial weight to aesthetics while other states have held that aesthetics cannot be considered at all. And, although the law on restrictive covenents is much more uniform from state to state, there are conflicting opinions in amateur radio cases. Furthermore, the application of common and statutory laws on nuisances is a rather new development which is certain to become more of a problem in the years ahead.

This article is based on the author's experiences in the Phoenix, Arizona, area, so the restrictive covenants, zoning ordinances and building codes may be considerably different then in your own area. Nevertheless, his basic guidelines are applicable in practically every case. Following these guidelines may not keep you completely out of trouble (witness the nuisance cases of WØMYN and W2OVC), but they should give you a foot up on the problem.

Editor

zoning ordinances

Unlike deed restrictions, which are in the nature of private contracts, zoning regulations are a matter of law. Zoning is an attempt by a municipality or county to control the usage of land within its boundaries for the purpose of orderly growth and development. Sections of the incorporated area are designated residential, commercial, industrial, etc., and within these classifications are sub-classifications.

The various types of residential zoning control the number of residences per acre, whether single-family or apartment buildings, maximum height, setback from the street and property line, street and utility easements, and similar matters. Depending on the exact wording, zoning regulations can imply prohibition of the erection of antenna towers, or can expressly forbid them. Some even expressly permit them. The zoning regulations of Scottsdale, Arizona, for example, specifically permit antenna towers up to 70 feet (21 meters).

In contrast, Paradise Valley, a bedroom community adjoining Phoenix, forbids *all* towers. An amusing sidelight to this is that Paradise Valley's most distinguished citizen is Senator Barry Godlwater, K7UGA. Senator Goldwater's home is equipped with two tall towers mounting quite an array of beams, including a very impressive log-periodic.

The Phoenix Zoning Ordinance controls building height, but a paragraph specifically excludes antennas, flagpoles, water towers, etc., from the height restrictions.

In general, amateurs are in less danger from zoning ordinances than from deed restrictions. One reason is the natural slowness of democratic governments to react except in the face of political pressure. Another is the fact that most municipal or county attorney's offices are very understaffed, and are not anxious to undertake such suits, which do not have the glamour of, say, criminal prosecutions. Nevertheless, city and county attorneys are usually elected officials, and if one of your neighbors objects to your antenna, and he is politically well-connected, you could be in for trouble.

The amateur does have one thing going for him. There seems to be an unofficial legal principle that says what others have done in the past without legal interference, you can do too. If there are a number of amateurs in your city who have towers and have never been threatened with legal action, regardless of the exact wording of the zoning regulations, you are probably on safe ground.

In any event, it is a good idea to become familiar with your local zoning regulations. These can be obtained from your local planning and zoning commission, usually located at city hall or nearby. The complete Phoenix Zoning Ordinance, a sizable book, costs $5.00, and by paying an additional $5.00, you can be placed permanently on the mailing list for changes and additions. Other cities probably have similar arrangements.

building codes

Building codes are designed to protect the health and safety of the citizens of a political division. Antenna towers come into this because an improperly designed or installed tower could collapse and cause damage to life or property. I have personally seen antennas that seemed to stay up by sheer faith, and it seems reasonable that anyone erecting a tower should be able to demonstrate that it will not be a hazard to himself or his neighbors.

Relatively few amateurs apply for building permits for towers. I strongly recommend it. In principle, at least, if you do not get a permit with its attendant inspections, you could be forced to take your tower down. It's difficult to say just how likely this is to happen as it is highly dependent on your local administration, but it can and has happened. In any event a building permit is a nice piece of insurance against that possibility.

In some localities obtaining a building permit is mere formality. Some areas even have special provisions in their local codes for amateur radio towers. In others it is more difficult. A typical requirement would be a set of plans and stress calculations approved by a registered professional engineer. First find out from your local building inspection department what is required, and then attempt to supply it.

One problem that you may run into is that the personnel in your local inspection department have never been asked to issue a permit for a tower before, and like true bureaucrats, assume that since they have never done it before, it must be illegal. Don't stop there.

"They're recalling your outside antenna."

An experience of mine is enlightening. When I was interested in buying a piece of property in a local community, I went to the inspection office and asked the man behind the counter how to apply for a permit for a 50-foot (15-meter) antenna tower. He informed me very positively that such a tower was not permitted and he could not issue me a permit. I then asked him why the local zoning ordinances permitted antenna towers up to 70 feet (21 meters) if they were illegal (I had already checked this). I then showed him the wording of the ordinance, and he confessed that he had never seen that paragraph. He allowed as how he probably could issue a permit, but would have to check with the city engineer about the actual requirements. I did not pursue the matter at that time, and I eventually bought my lot elsewhere, but an amateur friend of mine subsequently received a permit for a 60-foot (18-meter) tower from the same office merely by supplying a set of the tower manufacturer's plans and specifications.

Don't stop at the first "No." Building inspection departments are bound by law and cannot act arbitrarily. If the zoning laws do not prohibit towers and if you can demonstrate that the tower design and installation are sound, they are bound to issue you a permit. The cost is usually about five dollars.

It would be a good idea to read the sections of your local building code dealing with towers. You can do this at the inspection office. If you run into any problems it would be a good idea to request a personal talk with the city or county engineer. They are usually pretty reasonable.

In the city of Phoenix the law requires that the tower stress calculations be checked by a registered professional engineer in the *State of Arizona* and that he supply a letter saying that he has done this, duly stamped with his seal. I don't know how widespread this requirement is, but it could mean a fee of $50 or more. In my own case, the tower I was planning to erect had already been approved for a previous applicant. Some areas have approvals for specific makes and models of towers on record; this constitutes a sort of type acceptance. It would be a good idea to find out which types have previously been approved, and if one of these suits your requirements, getting a permit should present no problems.

Another thing to do is to find a local amateur who has successfully obtained a building permit and find out what procedure he followed. When dealing with the law, precedent is highly important.

conclusions

While it may be troublesome and frustrating to run the gauntlet of deed restrictions, zoning ordinances and building permits, it can be done — the most important ingredient is persistance and it is worth it. Amateurs have been ordered by the courts to remove their antennas for violation of all of these, and it gives you a comfortable feeling to know that you are completely protected.

ham radio

diode detectors

A comparison of the operating characteristics of various diode detectors and how they can be improved through modern circuitry

From the earliest days of radio the subject that received the most attention of radio amateurs (first unlicensed, and later with amateur calls) was the detector. The antenna-ground system, although it allowed for a good deal of innovation, was generally size-limited by the amateur's real estate or by the basic laws of physics. Also, antennas are fun to work on only in decent weather; little antenna work is done during the winter months. The transmitter was also straightforward: you simply bought as large a transformer as you could afford. The spark gap and its coupling to the antenna-ground system were relatively simple.

The detector, however, didn't cost much and could be worked on at any time so thousands of experimenters tinkered away their winter evenings trying to improve their detectors. Eventually they had enough success that the detectors became known as "receivers." Another nice feature of experimenting with detectors was that you could receive signals to "get a foot in the door" of radio, even if you had no transmitter. All sorts of devices were tried by these early experimenters: flame ionization detectors, coherers, electrolytic detectors, thermoelectric detectors, magnetic hysteresis detectors, crystal detectors and the early Fleming valve (vacuum diode).

Of all the early detectors the crystal type received the most widespread usage and "crystal set" eventually became a household word. Various types of mineral and man-made crystals such as galena, silicon, perikon (copper pyrites and zincite), molybdenite and carborundum were used. **Fig. 1** shows a simple crystal set using one of the crystals of the period. This same circuit could still be used today, but a modern signal diode would be used in place of the crystal and catwhisker.

Galena (lead sulphide), an important lead ore found here and in Europe, was the most popular of the crystals used in the early days of radio because it was the most sensitive. Steel galena, so called because it resembles a piece of broken steel rod, contains a small percentage of silver and, although not quite as sensitive as plain galena, became popular in later years because it was somewhat easier to adjust.

The crystals used as radio detectors were mounted in clips, held in tin-foil cups, floated in mercury, or more commonly, mounted in a small "pill" of a low-melting-point alloy. (Some experimenters who tried to mold their own crystal holders used a too-hot mixture of lead, only to discover that the heat destroyed the sensitivity of the galena.) The catwhisker, a length of fine, stiff wire,* was moved about the surface of the crystal until an "active" spot was found. This metal-to-semicon-

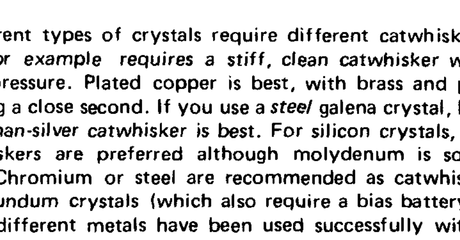

fig. 1. Simple crystal set typical of those used in the early days of radio.

*Different types of crystals require different catwhiskers. Galena, for example requires a stiff, clean catwhisker with very little pressure. Plated copper is best, with brass and platinum running a close second. If you use a *steel* galena crystal, however, a German-silver catwhisker is best. For silicon crystals, tungsten catwhiskers are preferred although molydenum is sometimes used. Chromium or steel are recommended as catwhiskers for carborundum crystals (which also require a bias battery), while many different metals have been used successfully with molybdenite crystals.

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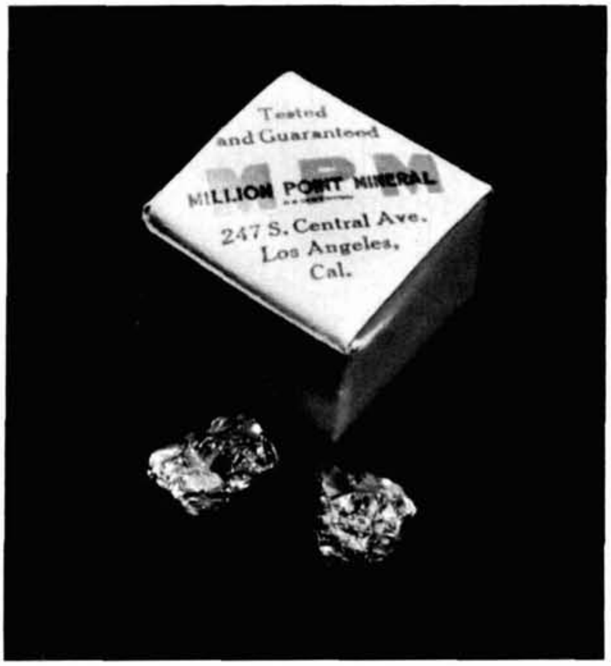
ductor interface is similar in many ways to the point-contact diodes of today. A typical galena-catwhisker assembly is shown in **fig. 2**.

The success of the vacuum tube, first as a diode (Fleming valve) and later as a triode (Deforest Audion) eclipsed the crystal detector commercially after about 1921. Crystal sets continued to be used by experimenters, however, as they still are today. Also, work continued in the laboratory on silicon crystal detectors as power detectors for microwave measurements.[1] This laboratory experimentation was greatly refined and expanded during World War II as engineers tried to solve the microwave radar mixer problem. This concentrated research effort on crystal detectors eventually led to a huge body of knowledge on basic silicon and germanium crystal physics and how various impurities affect the semiconducting properties of these materials.



Steel galena crystal offered to amateurs in the 1920s.

The high-inverse voltage germanium point-contact diode came directly out of these wartime research efforts, and most of the other semiconductor developments we know today came indirectly from this same research. The twenty-eight volume MIT Radiation Laboratory Series includes one whole volume which describes the semiconductor diode developments for radar usage which occurred during this period.[2]

Based upon the research done during the war, germanium point-contact diodes became available to industry in the late 1940s. The 1N34 was offered by Sylvania,

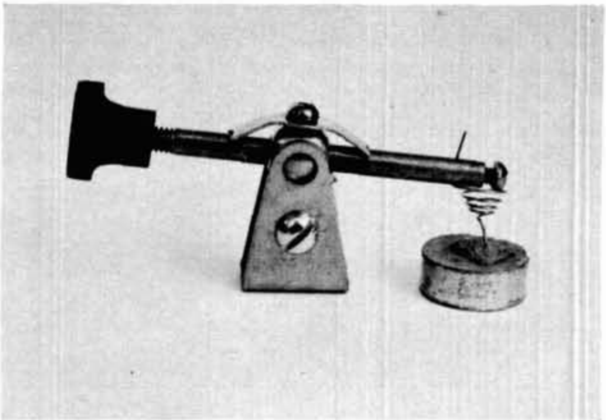


fig. 2. Commercial galena-catwhisker assembly. These units can still be obtained at some radio distributors.*

immediately became popular with experimenters, and started showing up in everything from absorption wavemeters to a-m speech clippers.[3]

The alloyed-junction silicon and germanium diodes came along in the early 1950s.[4,5] The germanium junction diode achieved some degree of popularity as a rectifier (1N91 – 1N93) but is considered obsolete today while the silicon junction diode came into its own *both* as a signal diode and power rectifier. An example of an early alloy-junction rectifier is the 1N536-1N540 family; the 1N482-1N485 family are typical early alloy-junction signal diodes.

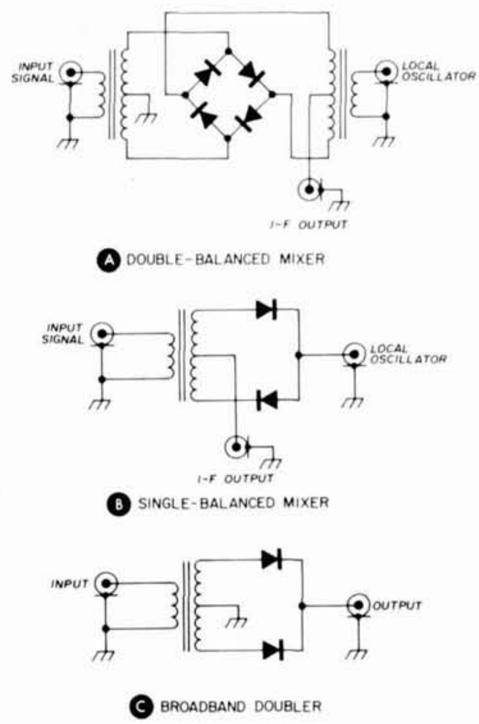


fig. 3. Three diode circuits which use Schottky diodes. Shown in (A) is a typical double-balanced mixer. A single-balanced mixer is shown in (B) while (C) shows a broadband doubler circuit.

*Mounted galena crystals, crystal stands and catwhisker assemblies are available from Modern Radio Laboratories, Post Box 1477, Garden Grove, California 92642. Their catalog, available for 25¢, also lists an assortment of crystal-set kits and other hard-to-find items such as carborundum detectors and coil sliders.

While most modern silicon junction rectifiers are still made by the alloy process (1N4001-1N4007, for example), newer silicon junction signal diodes are usually made by the planar epitaxial process (1N4454, for example). If you insist on a germanium junction signal diode, the base-emitter elements of a germanium junction transistor (2N404 or 2N5043) could be used.

There have been many other types of diodes developed since the silicon and germanium types discussed above. Tunnel, PIN, step-recovery, varactor, zener, Gunn, IMPATT and TRAPATT are some of these special types, but are not, in general, used as detectors of the common, rectifying type.

One newer type of diode, the Schottky-barrier or hot-carrier diode, has characteristics similar to the point-contact device. Like the point-contact diode, the Schottky diode uses a metal-semiconductor junction; in the Schottky diode, however, the metal is deposited on the semiconductor by sputtering in a vacuum. Examples of the Schottky diode are the Hewlett Packard 5082-2800 and the Motorola MBD501.

Virtually all Schottky diodes are silicon types, and their advantage over point-contact types is that their characteristics are closely matched and *stable*. This stability quality is quite important because it allows the close *matching* of diode pairs or quads which make it possible to build really good double-balanced mixers. The double-balanced mixer and its related single-balanced mixer and broadband doubler have made an enormous impact on modern vhf, uhf, and microwave systems.

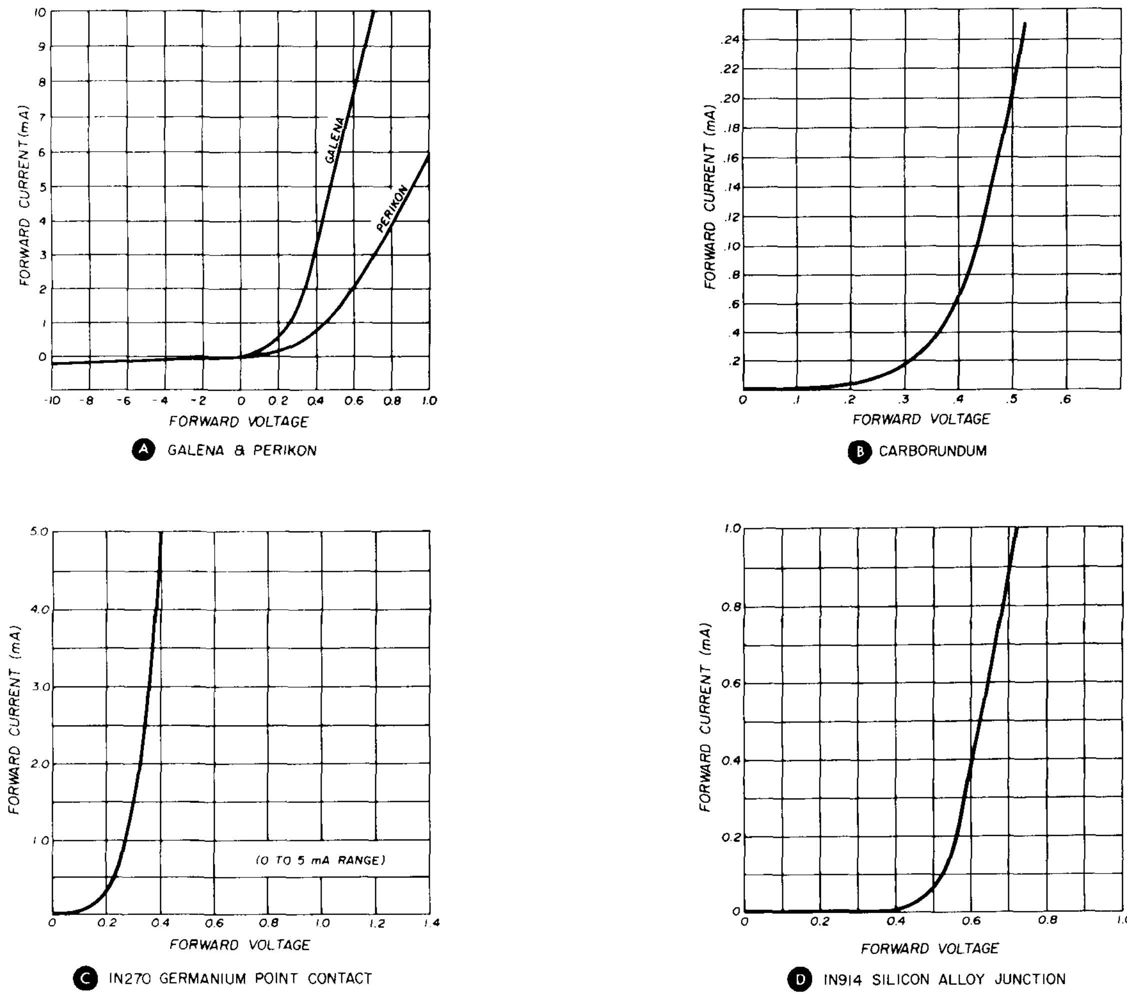


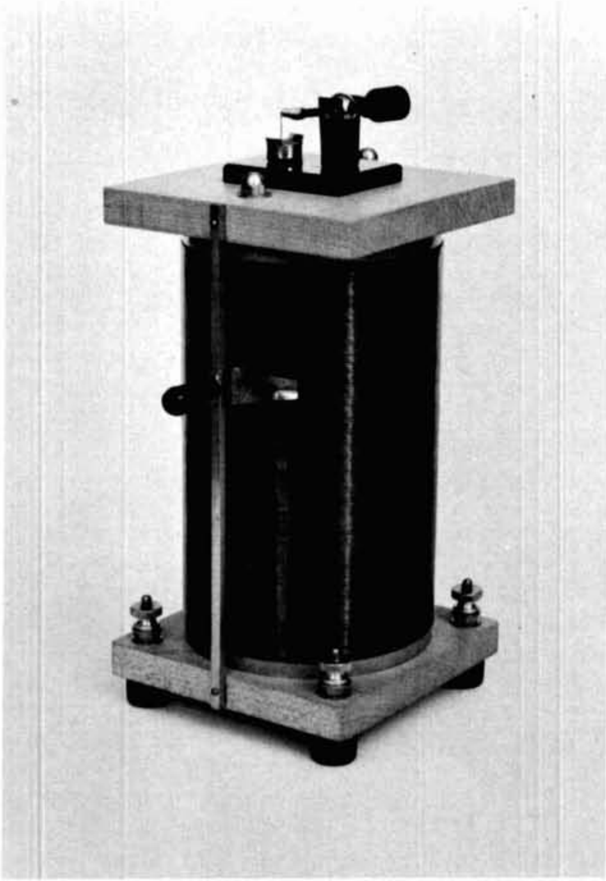
fig. 4. Forward conduction characteristics of several different diode types *including galena and perikon* (A), carborundum (B), germanium point contact (C) and silicon alloy junction (D).

Three basic diode circuits which use matched Schottky diodes are shown in **fig. 3**. Note that the transformers in **fig. 3** are usually built with a few turns of wire on ferrite toroids, so the circuits are often useful over a three-decade frequency range (200 kHz to 200 MHz is common).

The forward conduction characteristics presented in **fig. 4** will give you an idea how some of the various semiconductor diodes compare. The curves in **fig. 4A** for galena and perikon are from reference 6, the carborundum curve (**fig. 4B**) is from reference 7, while the forward characteristics for the 1N270 (**fig. 4C**) and 1N914 (**fig. 4D**) were taken from the data sheets of currently manufactured diodes. As can be seen, the forward current characteristic of any diode semiconductor diode is far from linear.

diode detectors

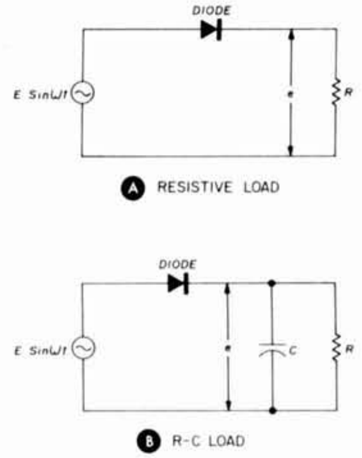
An early article by Colebrook exhaustively describes crystal rectifiers and their use as detectors of radio signals.[6] Although the author had only early galena and perikon diodes to work with, his mathematical analysis and conclusions are as fresh today as they were when written in 1925. The basic diode detector shown in **fig. 5** is the same as that used in reference 6.



Crystal receiver of the type used by amateurs sixty years ago. Station was tuned in by moving the slider along the tuning coil. Selectivity was very poor, but there were few stations on the air and a local spark transmitter wiped out the DX anyway.

Fig. 5A shows a resistive load while **fig. 5B** shows the more usual case where there is a capacitor in parallel with the load resistor (this increased detector efficiency). The capacitor should present a low impedance at the carrier frequency (as compared to resistor R), and a high impedance at the modulation frequencies. In the circuit of **fig. 1** a 0.002 μF capacitor is placed in parallel with a set of 2000-ohm headphones. At 1 MHz (the center of the broadcast band, for which this crystal set

fig. 5. Basic diode detectors showing simple resistive load (A) and more usual case where a capacitor is placed in parallel with the load resistor (B).



was designed) a 0.002 μF capacitor has about 80 ohms reactance. At 1000 Hz, a typical audio test frequency, the reactance of this same capacitor is nearly 80 kilohms.

The circuit shown in **fig. 6** was built to demonstrate how a shunt capacitor increases efficiency, and also to show how several common diode types compare. The 51-ohm resistor at the input simply terminates the amplitude-modulated signal generator. The LM318H IC and associated capacitors and resistors comprise a lowpass filter with a cutoff frequency at 2000 Hz. In this circuit the 2200-ohm resistor, R1, is the detector load and the 510-ohm resistor at the output of U1 is to prevent oscillation of the op amp when using a length of coax to the vtvm. The 0.002 μF capacitor can be switched in or out; the results are shown in **fig. 7**. For higher input signal levels the capacitor increases the output audio voltage level by 8 to 10 dB (enhancement with the 6AL5 vacuum tube diode is even more marked at some input levels).

Note that since the plots of input rf level vs audio output level presented in **fig. 7** are on log-log coordinates (since the abscissa and ordinate are both in dB) two straight lines may be drawn on the plots, one representing a linear relation and the other a square-law relation. For large input signals, say above −20 dBm, all the detectors approach a linear slope. It should also be noted that

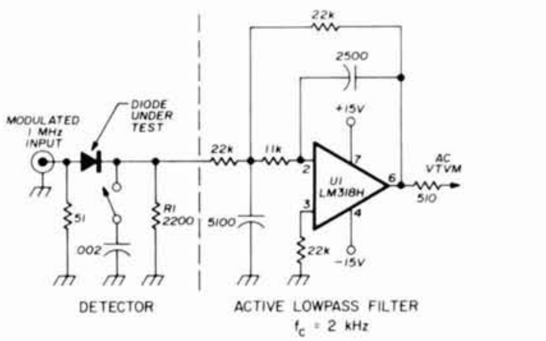


fig. 6. Circuit for testing the operation of various diode detectors. Test results are plotted in fig. 7.

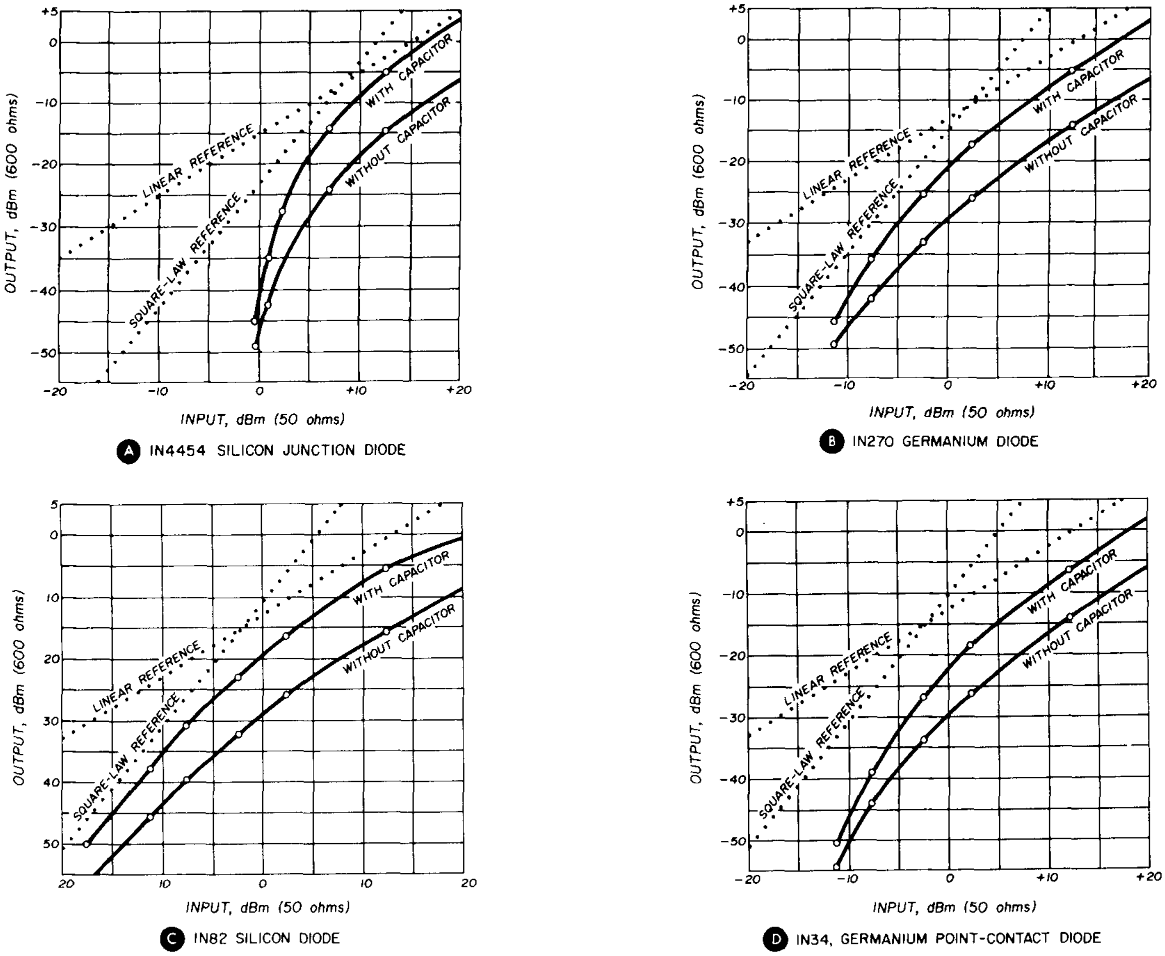


fig. 7. Rf input level vs audio output level for various types of diodes, with and without parallel load capacitor. Linear and square-law references are shown for comparison.

at input levels below -20 dBm a square-law or larger exponent relationship is usual. The point is that although some diodes are more nearly linear over a larger range of input voltage than others, none of them could remotely be considered as linear detectors at input signal levels below -20 dBm. A 6AL5 detector circuit with capacitor, comes closest, perhaps, to the textbook explanation that "diodes are square-law devices for small signals and linear devices for larger signals."

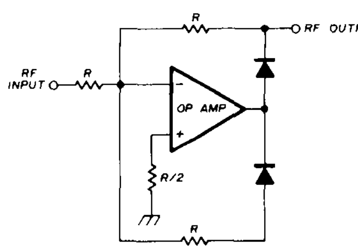


fig. 9. Precision half-wave detector using semiconductor diodes and an operational amplifier.

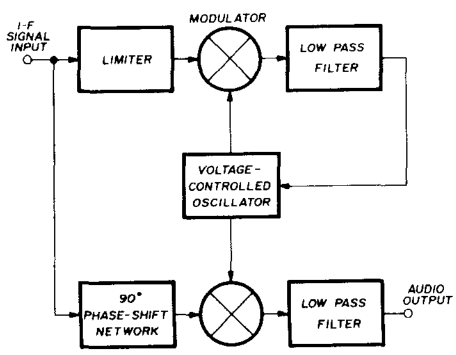
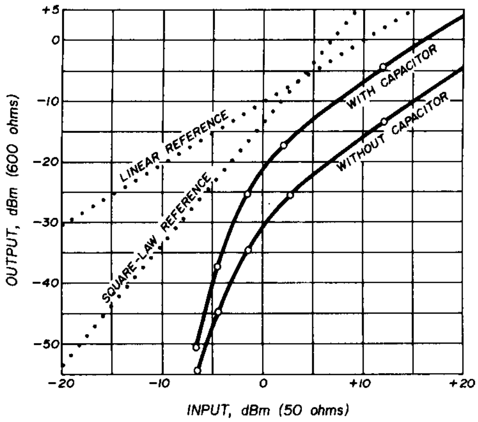
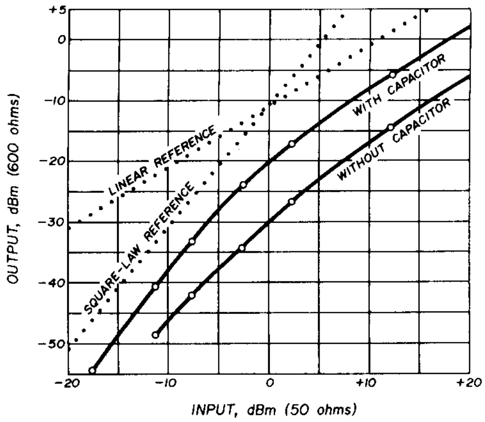


fig. 8. Using a phase-locked loop as an a-m detector (see text).

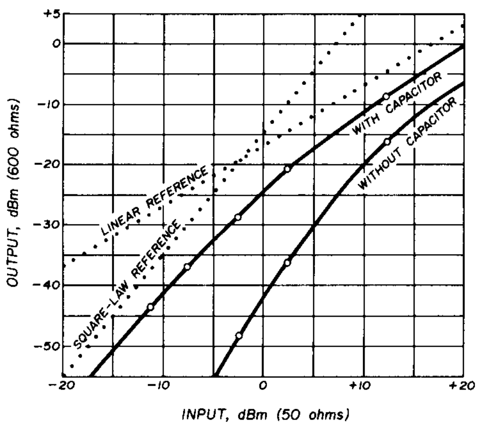
In a receiver, operation of the diode detector in its square-law region means that for every 10 dB weaker a signal may be, the output is 20 dB down. This is clearly not a good way to operate. Not only does it waste stage gain, it also degrades the signal-to-noise ratio. To avoid the square-law region most receivers use enough rf and i-f gain to keep the input voltage level to the diode detector up in the region where it behaves linearly. Unless agc is used this usually means that the last i-f amplifier must be a small transmitting tube or other large-signal device if reasonable dynamic range is to be achieved.



E H-P 5082-2800 SCHOTTKY DIODE



F GALENA-CATSWHISKER



G 6AL5 VACUUM DIODE

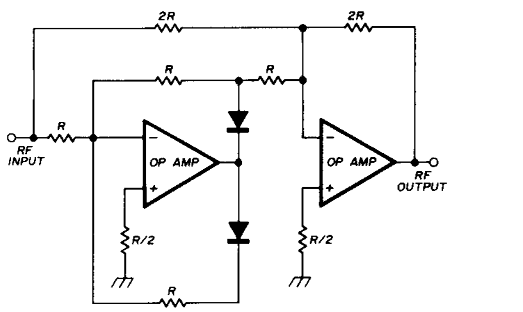


fig. 10. Precision full-wave detector using semiconductor diodes and two operational amplifiers.

linear diode detectors

Few commercial receivers bother with such luxuries as large-signal capability in the last i-f stage – they either rely on agc or *accept* detector non-linearity. Fortunately, the modern extensive use of ssb on the high-frequency bands has forced receiver manufacturers to use the inherently more linear product detector. The linearity of product detectors, which are essentially mixers with an audio output, is due to the fact that the oscillators which drive them completely control the conduction of the nonlinear devices used as mixers.

The product detector does not make a very satisfactory detector for a-m because the bfo never quite matches the receiver carrier frequency. This results in a beat note being present in the audio output unless a phase-locked loop is used to synchronize the bfo to the

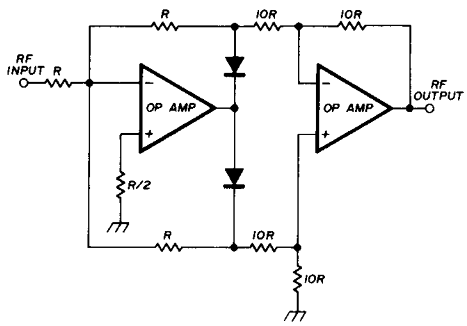


fig. 11. Improved version of the full-wave detector provides better linearity than previous circuits.

received carrier frequency. This phase-locked loop form of a-m detection is shown in **fig. 8**; with the modern phase-locked loop ICs that are now available the circuit is not unreasonably complex.

Another technique for linearizing an a-m detector involves the use of an operational amplifier. Although this

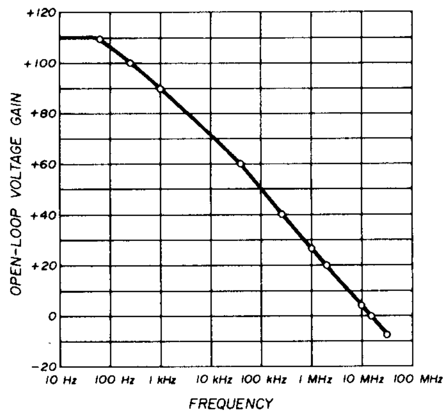


fig. 12. Open-loop gain vs frequency of the LM318H operational amplifier IC.

technique has been around for quite some time, it has only recently become practical with the availability of low cost, high-frequency IC op amps.[8,9] **Fig. 9** shows the basic precision diode detector using an op amp. **Fig. 10** shows a full-wave version of the detector (from reference 9). The full-wave version has the disadvantage that the delay for positive input signals, which are inverted and amplified two times, is twice that for composite signals. Because of the delay difference, the signals don't subtract in phase, so high-frequency performance suffers. **Fig. 11** shows a precision full-wave diode detector, attributed to Dr. Nick Cianos of SRI, that solves the problem.

only expect about 24 dB improvement in linearity at 1 MHz. To check this I built the circuit shown in **fig. 13.** The test results are plotted in **fig. 14.** The improvement at low input signal level linearity is quite apparent. The principle of op amp/diode detection is used in the National LM372, an IC that combines the functions of i-f amplifier and a-m detector.

summary

The diode detector has been the standard a-m detector almost since radio began. Today we essentially have only two choices of semiconductor material: germanium and silicon. Germanium has lower offset voltage while

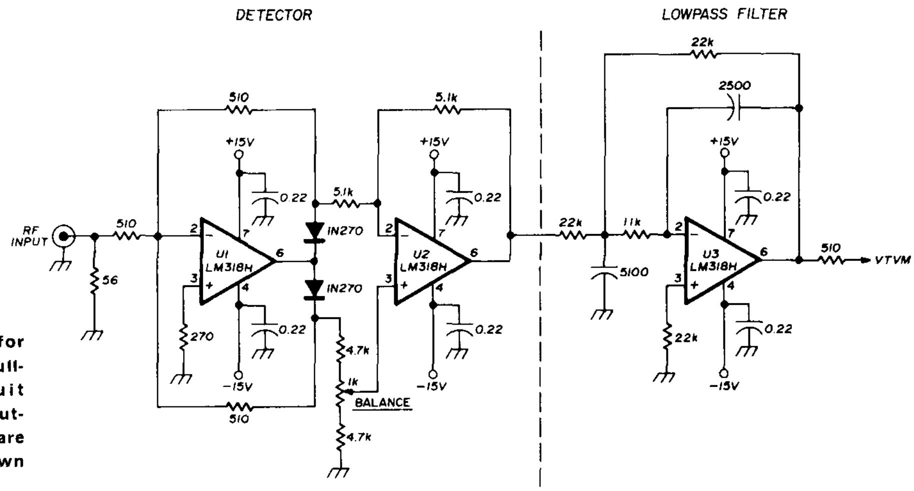


fig. 13. Test setup for checking the improved full-wave detector circuit shown in fig. 11. Input-output characteristics are extremely linear as shown in fig. 14.

Diode detectors which use an op amp in the circuit reduce the input voltage at which the transfer curve (input to output relation) becomes non-linear by a factor equal to the open-loop gain of the op amp. Since op amp voltage gains can be more than 100 dB at the lower frequencies this can make a significant difference in detector performance.

The performance curve of a good monolithic IC op amp (National LM318H) is shown in **fig. 12.** Note that the open-loop gain drops as frequency increases so you can

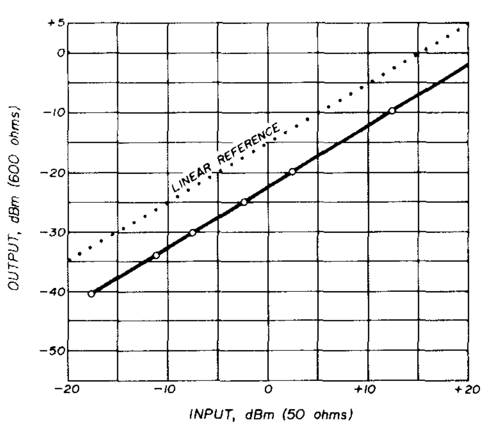


fig. 14. Input-output characteristics of the improved full-wave detector circuit shown in fig. 13 coincides very closely to linear reference.

silicon has the benefit of improved technological processing. A semiconductor diode of either type, used in combination with a modern IC op amp, can greatly improve the linear dynamic range of the detector. When used as an integral part of an IC the silicon diode holds great promise in the future.

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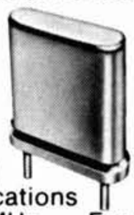

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More Details? CHECK—OFF Page 102

MICROPROCESSORS

A discussion of microprocessors and how they fit into the scheme of computers and controllers that exist today

By now, most amateurs are aware of the fact that a revolution is occurring in the electronics industry: *microprocessors*. If you had held stock in companies that manufacture microprocessors, this fact would have become quite apparent after RCA's misinterpreted announcement several months ago that microprocessors will soon be incorporated into U.S. automobiles. Rather than rehash an electronics revolution after it is over, we believe that it would be fun to jump into the middle of the one that is occurring at this moment and closely observe events that will have a profound influence on electronic measurement, laboratory instrumentation and amateur station control. Therefore, over the next few months this column will be devoted to the subject of microcomputers: what they are, how they operate, and what they can and cannot do for the electronic experimenter, engineer or laboratory scientist.

We shall use microprocessor operation and interfacing as a vehicle to probe more deeply into the detailed concepts and techniques of computer interfacing. Please keep in mind that the microprocessor, when complemented by memory, buffers, and input/output (I/O) devices, is as much a computer as its larger and usually faster rivals, the minicomputers and full-size computers. By learning how to interface a microprocessor, you will simultaneously learn the concepts of how to interface a minicomputer or full size computer. The use of interrupts, device selects, software generated strobes, timing loops, and the like are common to all.

To gain full value from some of our forthcoming columns, it would be beneficial to have an understanding of the basic principles of digital electronics. Some very important terms and concepts that you should master include the following: gate, logic element, counter, gated counter, monostable, enable, disable, inhibit, strobe, decoder, multiplexer, demultiplexer, timer, clock pulse,

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positive edge, negative edge, flip-flop, latch, bus, Tri-State™, shift register, dynamic RAM, static RAM, ROM, programmable ROM, up/down counter, AND, OR, NAND, NOR, exclusive OR, arithmetic element, and more. Our pair of books on digital electronics, *Bugbooks I and II. Logic & Memory Experiments Using TTL Integrated Circuits*, will bring you to the level of understanding in digital electronics required to interface microcomputers; other digital books, such as the pair marketed by Hewlett-Packard in conjunction with their logic lab, will also help you develop the skills that you will need. Digital electronics is a rapidly expanding field, and new texts and reference manuals are appearing at the rate of one every several weeks.

As we currently envision them, future columns will offer a tutorial on the operation and interfacing of a very popular microprocessor, the Intel 8080 8-bit microprocessor, which can perform a simple logic or arithmetic instruction in only 2 μsec and can directly address 65,536 different memory locations, each containing eight bits of data. Originally priced at $360 in quantities of one, you can purchase an 8080 now for about $50 from selected supply sources and its cost will be no more than $5 two or three years from today. The 8080 has some important rivals, e.g., the Motorola 6800 and the Fairchild F8, but it is a worthy selection nevertheless. Each microprocessor has its special features. However, the general concepts developed in this column will be applicable to any microcomputer system.

Standing alone, a microprocessor chip can do nothing. It functions only in the context of a microcomputer system, in which appropriate integrated-circuit chips are incorporated to complement the basic function of the microprocessor (μP): to serve as a central processing unit (CPU) in which logic and arithmetic operations and data transfers between register, memory, and the outside world are performed. In some columns, we will need to focus upon a specific microcomputer system. For this purpose, we have chosen a new system that is specially designed to instruct individuals in all of the details of microprocessor operation and interfacing: the Mark 80 microcomputer (**fig. 1**). This particular system, shown with 4k of solid-state memory and a control panel, is built around the Intel 8080 microprocessor chip. Except for a power supply, it is completely operational. The system is bus structured and has all important inputs and outputs connected to a solderless breadboarding socket, permitting interfacing concepts to be learned, tested, and breadboarded into a digital circuit of your own design.

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microprocessors: where do they fit?

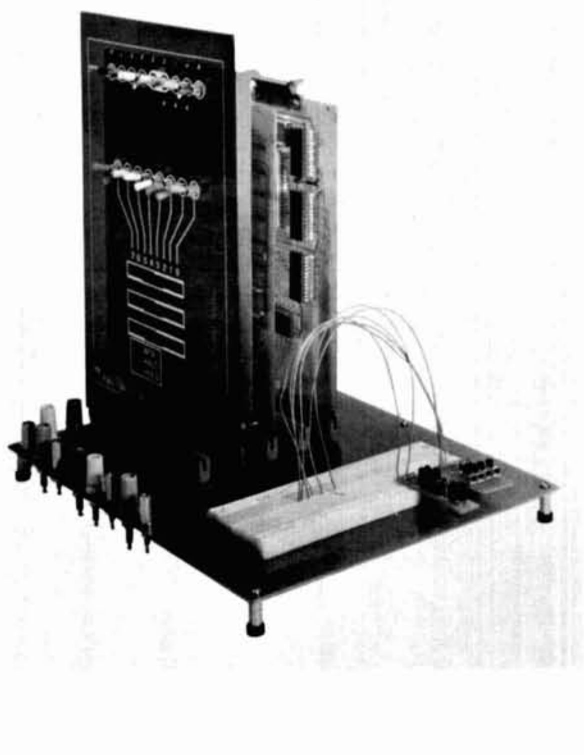
We would first like to discuss what a microprocessor is and how it fits into the general scheme of computers and controllers that exist today. Eadie, in his book, *Introduction to the Basic Computer*, has defined the term *data processor* as "a digital device that processes data. It may be a computer, but in a larger sense it may gather, distribute, digest, analyze, and perform other organization or smoothing operations on data. These operations, then, are not necessarily computational. Data processor is a more inclusive term than computer."[2]

A *microprocessor* is a single integrated-circuit chip that contains at least 75 percent of the power of a computer. It usually cannot do anything without the aid of support chips and memory, however, and therefore can be distinguished from a *microcomputer*, which is a full operational system based upon a microprocessor chip that contains memory, latches, counters, input/output devices, buffers, and a power supply in addition to the microprocessor chip. A microcomputer may be a "black box" with only a single switch: *operate/reset*. The 8080 microprocessor, a 40-pin LSI chip, is shown in **fig. 2**. A typical system based upon this chip is shown in **fig. 3**; the 8080 chip is located on the CPU board on the left.

A microcomputer possesses all of the minimum requirements of a computer. For example:

It can input and output data, which is usually in the form of digital electronic signals. Common I/O devices include teleprinters, CRT displays, paper

fig. 1. The Mark 80 microcomputer system.



tape readers, floppy disks, magnetic tapes, cassette tapes, laboratory instruments, and process control devices.

It contains an arithmetic/logic unit (ALU) that can perform arithmetic and/or logic operations such as add, subtract, compare, rotate left, rotate right, AND, OR, negation, and exclusive OR.

It contains a minimum amount of "fast" memory such as RAM, ROM, PROM, or core, but usually not cards or paper tape, in which data and program instructions are stored. The data and instructions are stored as 4-bit, 8-bit, 12-bit, or 16-bit words.

It is programmable. The data and program instructions can be arranged in any sequence desired, in contrast to the programmable calculator, in which the precise manner that a keyboard function is executed cannot be changed by the operator.

It is fast, with an ability to execute a simple instruction in ten microseconds or less. All existing microcomputers are digital and TTL compatible, where logic 0 corresponds to ground potential and logic 1 corresponds to +5 volts.

There appears to be some misunderstanding concerning the role of current microprocessors and microcomputers relative to other types of computers. The temptation is great to order a modest microcomputer system and then to surround it with $5000 worth of I/O devices such as floppy disks and line printers. At this point we would like to provide a bit of insight concerning the most likely role of microcomputers. **Fig. 4** graphically depicts where microcomputer applications fit today, and **table 1**, taken from an article by Riley,[2] depicts the spectrum of computer-equipment complexity from simple hard-wired systems to high-performance general data processing equipment.

Microprocessor and microcomputer applications fall between relay logic and discrete random logic (gates and flip-flops) on one hand and small minicomputers such as the PDP 8A and the LSI 11 on the other. Microcomputers built from microprocessor chips are not as sophisticated as some of the popular minicomputers and cannot easily perform certain types of data processing problems. They are simply not set up at this time to run FORTRAN, COBOL, or other high-level computer languages. Those microcomputers that can, in principle, handle high-level languages still suffer in comparison with minicomputers supplied by Digital Equipment Corporation, Hewlett Packard, Data General, Varian, and other manufacturers in the amount of available high-level software.

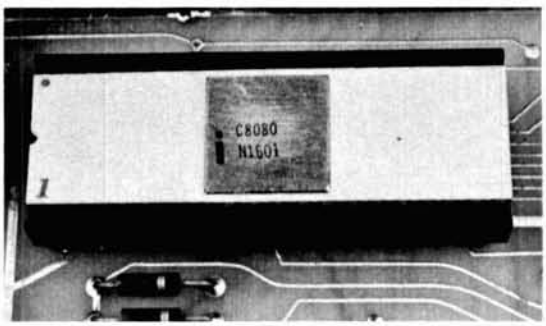


fig. 2. The 8080 microprocessor chip.

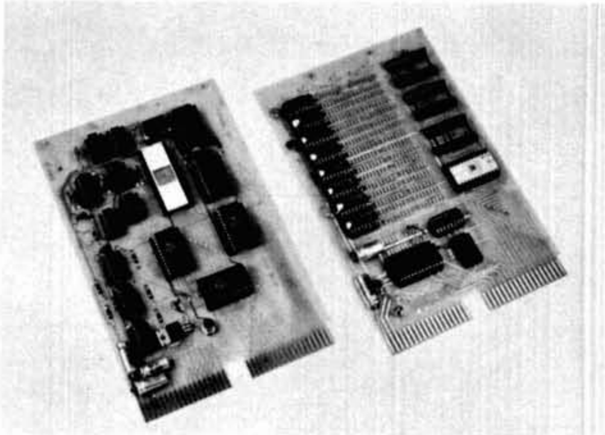


fig. 3. A typical microcomputer system. Shown on the left is the central processing unit (CPU), which consists of input/output buffer chips and miscellaneous control logic. Shown on the right is the microcomputer memory, in this case 1k of RAM and 256 words of ROM. Decoder chips permit the memory to be located anywhere within 65k of microprocessor addressable memory.

If you want to solve tomorrow's problem, you can consider the purchase of a microcomputer system and develop your own high-level software. If you want to solve today's problem, pay particular attention to software support. Your time is valuable. If you are not careful, software costs can easily equal and exceed the total hardware costs of your data acquisition system.

For the moment, then, it would be more appropriate to call systems built around microprocessor chips *microcontrollers* or *logic processors*. They can sequence events in response to decisions upon input data. As the price of individual microprocessor chips drops from several hundred dollars per chip to $10 to $30 per chip, it will be clear that the dominant application for today's microprocessors will be as sophisticated control elements in instruments and machines of all types. We forsee minicomputer-microcomputer and computer-microcomputer hierarchies in which one to twenty instruments, machines, or devices, each containing its own microcomputer, will all be tied to a single minicomputer or computer.

the anatomy of a microcomputer

The "anatomy" of a typical microcomputer system is shown in **fig. 5**. This system is based upon the 40-pin 8080 microprocessor chip and possesses all of the minimum requirements for a computer:

It can input and output data.

It contains an arithmetic/logic unit (ALU), located within the 8080 chip, that performs arithmetic and logical operations.

It contains "fast" memory.

It is programmable, with the data and program instructions capable of being arranged in any sequence desired.

It is digital.

Fig. 5 shows the important data paths within the microcomputer. In the sub-sections below, we shall dissect this diagram and discuss each of the individual data paths.

Random access A semiconductor memory into which logic 0 and logic 1 states can be written (stored) and then read out again (retrieved).

Read-only memory A semiconductor memory from which digital data can be repeatedly read out, but cannot be written into, as is the case for random access memory.

table 1. Spectrum of computer-equipment complexity. Reprinted from *Electronics*, October 17, 1974; copyright © McGraw-Hill, Inc., 1974.

Word length	1	2	4	8	16	32	64
Complexity	hard-wired logic	programmed logic array	calculator	microprocessor	minicomputer		large computer
Application	———	control	———	dedicated computation	low-cost general data processing		high-performance general data processing
Cost	under $100	———	$1000	———	$10000		$100000 and up
Memory size	very small 0-4 words	small 2-10 words		medium 10-1000 words	large 1000-1 million words		very large, more than 1 million words
Program	read-only						reloadable
Speed constraints	real time	slow		medium			throughput-oriented
Input-output	integrated	few simple devices		some complex devices			roomful of equipment
Design	logic	logic + microprogram		microprogram macroprogram			macroprogram high-level language software system
Manufacturing volume	large						small

Memory. Let us first consider the data communication between the 8080 central processing unit, also known as an MPU, and memory. You will require some definitions which will be useful in the ensuing discussion:[1,2]

Memory Any device that can store logic 0 and logic 1 bits in such a manner that a single bit or group of bits can be accessed and retrieved.

Memory cell A single storage element of memory.

Memory word A group of bits occupying one storage location in a computer. This group is treated by the computer circuits as an entity, by the control unit as an instruction, and by the arithmetic unit as a quantity. Each bit is stored in a single memory cell.

Memory address The storage location of a memory word.

Memory data The memory word occupying a specific storage location in memory, or the memory words collectively located in memory.

Programmable read-only memory A read-only memory that is field programmable by the user.

Volatile memory In computers, any memory that can return information only as long as power is applied to the memory. The opposite of novolatile memory.

Read To transmit data from a semiconductor memory to some other digital electronic device. This term also applies to computers and other types of memory devices.

Write To transmit data into a semiconductor memory from some other digital electronic device. This term also applies to computers and other types of memory devices. A synonym is *store*.

The 8080 microprocessor employs 8-bit words that are stored in memory with the aid of a 16-bit memory address bus. With the aid of a quick calculation, you can conclude that there exist 2^{16} = 65,536 different memory locations which can be accessed by the microprocessor. This access to memory is direct, which means that you don't have to engage in any special tricks or digital electronic gimmicks to access any given memory location within the 65,536 possible locations. Forty-pin integrated circuit chips do have their advantages, and this is one of them. The total memory capacity of the 8080 microprocessor is known in the trade as "64k." This is far more memory than you will ever need for most applications, but it is nice to know that you have such power in reserve.

Data is transferred between the 8080 CPU and the memory over 8-bit input and output buses, both of which are shown in **fig. 5**. By input we mean "input into the CPU." The term, "output," is defined in a similar fashion. Our point of reference is always the CPU. Data leaving the CPU is always considered to be "output data;" data entering the CPU is always "input data." **Fig. 5** shows that the input and output data is transferred between the *accumulator* and memory. This is frequently the case, but in a more detailed look at the 8080 chip, you will discover that data stored in memory is transferred to other internal *registers* within the 8080 chip as well.

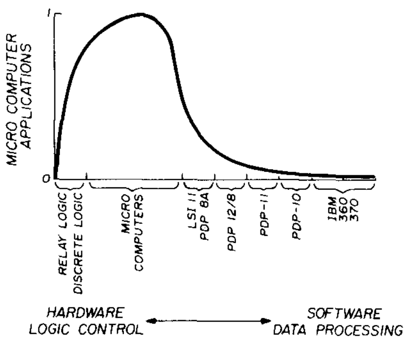


fig. 4. Where microcomputers fit: between relay and discrete logic and inexpensive minicomputers.

The most obvious such register is the *instruction register*, from which the decoding of the instruction occurs. Other registers, known as *general purpose registers* are classified by the letters B, C, D, E, H, and L. We regard the accumulator register to be the heart of the entire microcomputer. Arithmetic and logic operations are always performed to or on the eight bits of data present in the accumulator. All input and output data passes through the accumulator with the aid of two computer instructions called IN and OUT.

Between the 8080 CPU and memory there exists a single output line called memory READ/WRITE. When this line is at logic 1, you are able to READ data into the CPU either from memory or from an external device. When this line is at logic 0, you are able to WRITE data from the CPU into memory or an external output device.

As a final point, you can employ any type of "fast" digital electronic memory device, including random access memory (RAM), read-only memory (ROM), and programmable read-only memory (PROM). What do we mean by "fast" memory? Simply that the memory can perform either a read or write operation during a single microcomputer instruction. A typical 8080 microcomputer system operates at a clock rate of 2 MHz and a read or write operation takes only 3.5 microseconds. Thus, RAM, ROM, and PROM all need an access time of about one to two microseconds to allow you to take full advantage of the maximum clock speed. Slower semiconductor memories can be used, but the microcomputer will have to wait while a read or write operation takes place.

data output

The 8-bit output bus between the 8080 CPU and memory also serves as the output data bus to an external output device. When you provide output to an external device, there are several important points to remember:

> You must select the specific output device that will receive eight bits of data from the CPU.
>
> You must indicate to this device when output data is available on the output data bus.
>
> The device must capture this output data in a very short period of time, typically 1.5 μs.

The third point is perhaps the most important. Keep in mind that the microcomputer is operating at a clock rate of 2 MHz. Each computer instruction is executed in a very short period of time which ranges from 2 to 9 μs. Thus, accumulator data designated as "output data" to an external device is not available for very long. You must capture it while it is available. We will discuss the techniques that you would employ in a subsequent column; this topic is certainly among the most interesting topics that can be discussed in the field of computer interfacing.

data input

The basic considerations that apply to data output also apply to data input into the CPU from an external input device. Thus:

> You must select the specific input device that will transmit eight bits of data to the CPU.
>
> You must indicate to this device when the CPU is ready to acquire the input data.
>
> You must insure that the CPU acquires this data in a very short period of time, typically 1.5 μs.

input/output device addressing

The 16-bit memory address bus is time shared so that it can provide, at certain times, an 8-bit device identification number called a *device code*. Eight bits of information allow you to decode $2^8 = 256$ different devices. When used in conjunction with two output function pulses called IN and OUT, the microcomputer system can address 256 different input devices and 256 different output devices. We might point out here that a "device" can be a complex machine such as a teleprinter or cathode-ray tube (CRT) display, or a simple device such as a single integrated-circuit chip. This is another interesting topic for discussion that we will reserve for a subsequent column.

microcomputer interrupt

Not shown in **fig. 5** is a single input line to the microcomputer that generates a program *interrupt* during microcomputer operation. Such an interrupt would be generated by an external device that wishes to transfer data to or from the computer. This particular topic is quite complex, and it will be a number of months before we tackle it in this column.

The above is about the best that we can do to describe the general "anatomy" of a microcomputer in one-thousand words or less. Microcomputers are fascinating machines. They are small and relatively inexpensive, so you are less likely to be intimidated by them. They are far simpler than their minicomputer and computer counterparts and can be readily repaired by the simple process of chip substitution. They appear to be the proper answer to your childhood question, after the *Erector Set*, what?

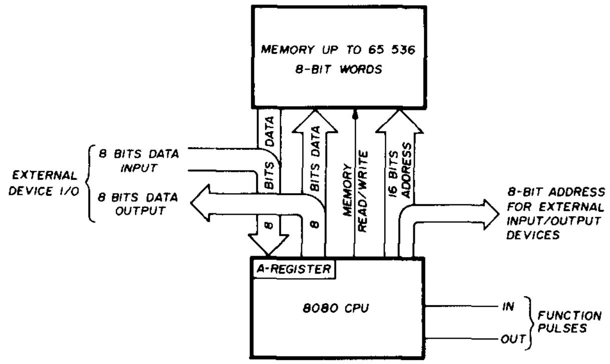


fig. 5. A typical 8080-based microcomputer system.

If you do not wish to stretch out your learning process on microcomputers for twelve months or more, we might indicate that we have just completed *Bugbook III* entitled *Microcomputer Interfacing Experiments Using the Mark 80®, an 8080 System*. It contains approximately 600 pages of text and experiments on interfacing and programming 8080-based microcomputers.[6]

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5. J. Blukis and M. Baker, *Practical Digital Electronics*, Hewlett-Packard Co., Santa Clara, California 1974.
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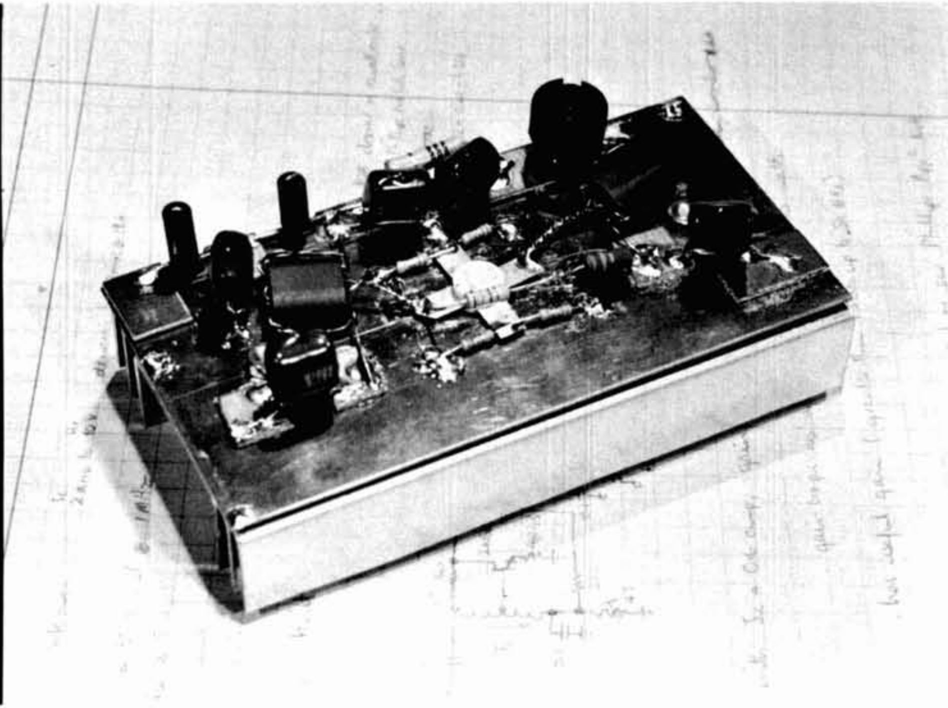


four-watt wideband linear amplifier

A stable rf amplifier for QRP use or as a driver for higher-power linear amplifiers over the frequency range from 300 kHz to 30 MHz

There is no problem these days in building high-frequency, transistorized ssb exciters that produce outputs in the milliwatt range. However, there seems to be a dearth of information on how to get these low-level signals up to a more useful level. Articles I've seen in the amateur magazines seem mostly to use one of two extreme methods. One is to make use of the rather exotic high-priced transistors designed especially for linear power amplification; the other is to use some of the newer audio power transistors — usually with great difficulty and often with not very satisfactory results.

features

This linear amplifier uses the widely available and inexpensive (about $7.00) 2N5590 transistor to produce a power output of 4 watts across the high frequency rf range. This power level is suitable for the output of QRP rigs or as a driver for a final amplifier in the hundred-watt range.*

*This amplifier will drive the high-power linear amplifier described by Chalmers[1] to full output.

J. A. Koehler, VE5FP, 2 Sullivan Street, Saskatchewan, Canada S7H-3G8

The amplifier gain is flat over the high-frequency rf range, being only 3 dB down at 300 kHz and 30 MHz. In fact, the amplifier still produces useful gain at six meters. The exact gain will depend somewhat on the transistor used, but the version I built had a midband gain of 22 dB. This means that full output on the amateur bands up to 15 meters can be obtained with only 25 milliwatts of drive; 40 milliwatts is required at ten meters. The amplifier output may be either shorted or left open indefinitely with no damage even with full drive. The amplifier is also very stable and shows no tendency to oscillate.

circuit

The amplifier schematic is shown in **fig. 1**. The stability and wide frequency response are achieved by adding considerable negative feedback to an otherwise conventional broadband amplifier. The small inductance in series with the 560-ohm feedback resistance decreases the feedback at the higher frequencies. The exact value is not critical. About 25 turns of number 30 (0.25mm) wire closewound on a ½-watt resistor will do very well.

The amplifier operates in the class-A mode, and the transistor has a quiescent power dissipation of 5 watts. A fairly efficient heat sink is required. While commercial heatsinks are good, an acceptable one can be made from three sheets of 0.06-inch (1.5mm) aluminum formed and assembled as shown in **fig. 2**. After all holes are drilled, they should be deburred so the pieces will make good contact with each other. It's a good idea to put silicone grease or heatsink compound between the pieces before final assembly.

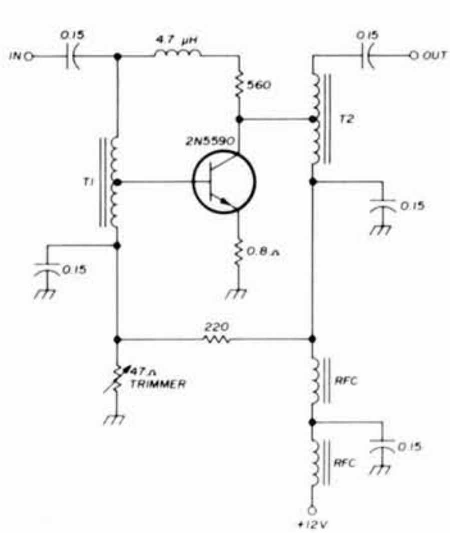
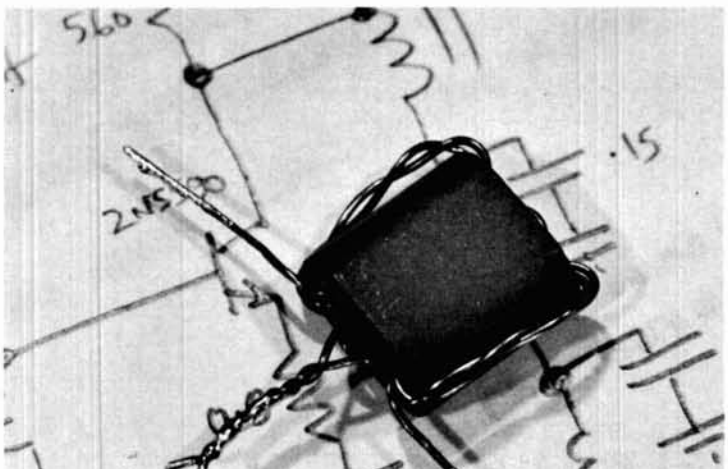


fig. 1. Rf amplifier schematic. T1, T2 are wound on two-hole balun cores as found in TV-set input circuits. Emitter resistor is made from four 3.3-ohm, ¼-watt resistors in parallel. All capacitors are 100-volt plastic; rf chokes are 1 or 2 turns through a ferrite bead.

One of the broadband transformers used in the input and output circuits.



construction

The circuit is built on a piece of single-sided circuit-board material mounted copper side up on the heatsink. A large clearance hole for the transistor is drilled in the center so that the transistor can be mounted directly on the heatsink. It's important to put silicone grease or heatsink compound on the mounting surface of the transistor before assembly. It's also important *not* to overtighten the transistor mounting nut. Components are mounted between pads of PC material approximately 0.39 x 0.39 inch (1 x 1cm) cemented to the main circuit board. Pad locations may be found by laying out the components you wish to use on the board. The general appearance of the amplifier (before adding components) is shown in **fig. 3**.

The transistor tabs are fragile, so the transistor should be mounted in its final position first and the components soldered to the tabs later. *Do not* reverse this order or the tabs will be stressed when you tighten the tran-

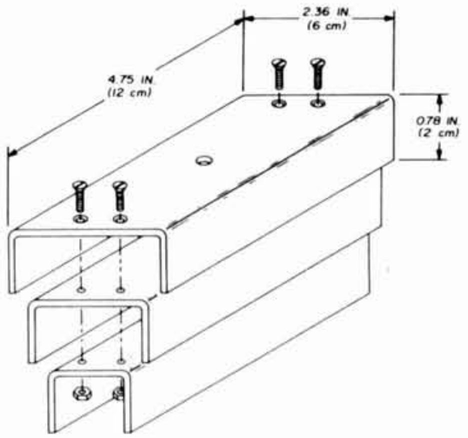


fig. 2. Method of constructing transistor heatsink. Aluminum sheet is formed to approximate dimensions shown, then assembled. Hardware is 4-40 (M3). Top holes are countersunk. Transistor stud clearance is drilled after assembly.

sistor mounting nut. The 0.8-ohm emitter resistor must have a very low inductance, which may be achieved by paralleling several higher-value resistors. I used four 3.3-ohm, ¼-watt resistors soldered symmetrically between the emitter tabs and the ground plane as shown in the photograph.

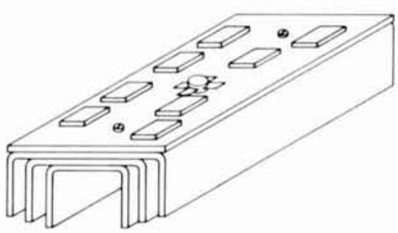


Fig. 3. Printed-circuit board and heatsink mounting details. Mounting pads for components are made of PC board material.

The input and output transformers are wound on two-hole balun cores as found in TV sets. The ones I used are manufactured by Phillips; their type number is 4322-020-31520. The windings are made by twisting two pieces of number 22 (0.6mm) enamelled wire together about three twists per inch (one twist per cm). This twisted pair is then wound through the core as shown in **fig. 4** and the photograph. Using an ohmmeter to identify the wires, one end of one wire is connected to the opposite end of the other wire, which is the center tap of the transformer. The wide frequency response of the amplifier is due to these transformers, and the general method of construction should be followed, although wire size, number of twists and number of turns through the core are not too critical.

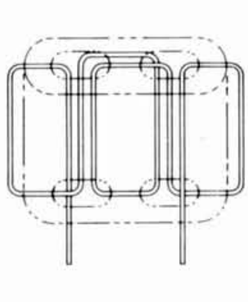
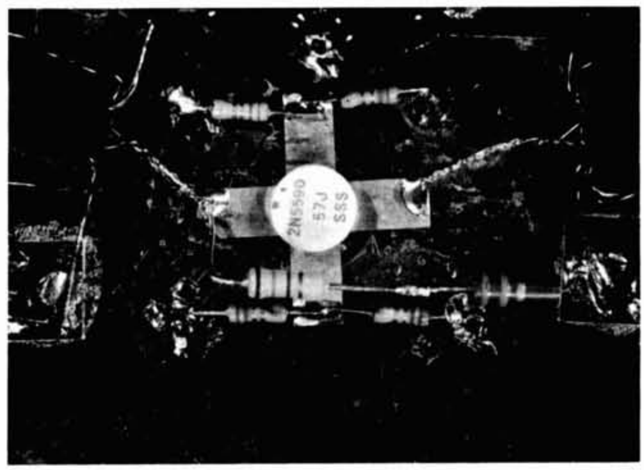


fig. 4. Transformer winding details. No. 22 (0.6mm) enamelled wire twisted pair is wound through a two-hole balun core.

Chokes in the main supply line are made by winding one or two turns through any of the widely available ferrite beads. I used one turn through a two-hole bead for each of the chokes. Large values of inductances are not required here since the power-supply line operates at very low impedance.



Underside of amplifier. Emitter-resistor assembly is shown paralleled between emitter tabs and ground plane. Input and output transformers are at extreme right and left.

No tuning is required, so the amplifier is made ready for use merely by adjusting the quiescent current level. First set the 47-ohm trimmer to minimum resistance then connect the 12-volt power supply and adjust the trimmer so that the total amplifier current drain is 0.4 ampere.

At the one-watt output level, the second harmonic measured 30 dB down with respect to the fundamental. I wasn't able to measure the intermodulation distortion with the test equipment I had available. From the measured performance of similar amplifiers,[2] I'd expect it to be about -40 dB. For CW use, the quiescent current may be lowered to reduce wasted power; however, the output harmonic content will increase and the overall gain will decrease.

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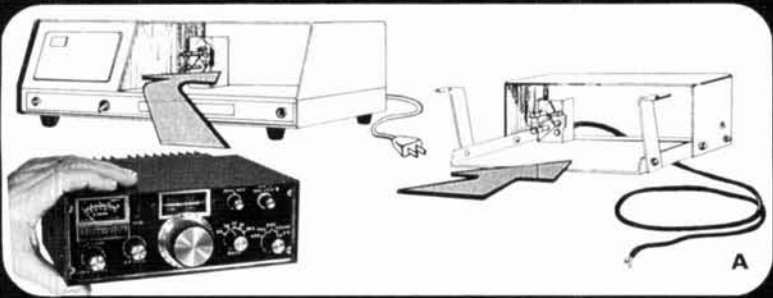
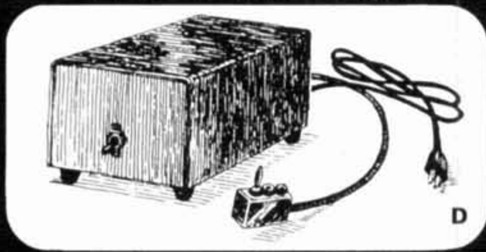
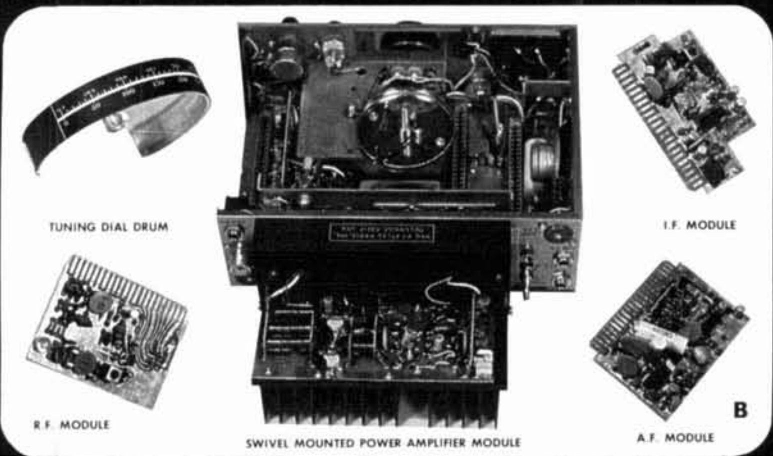
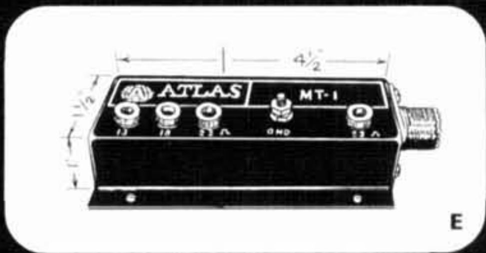
ATLAS' SUCCESS HAS MANY FACETS









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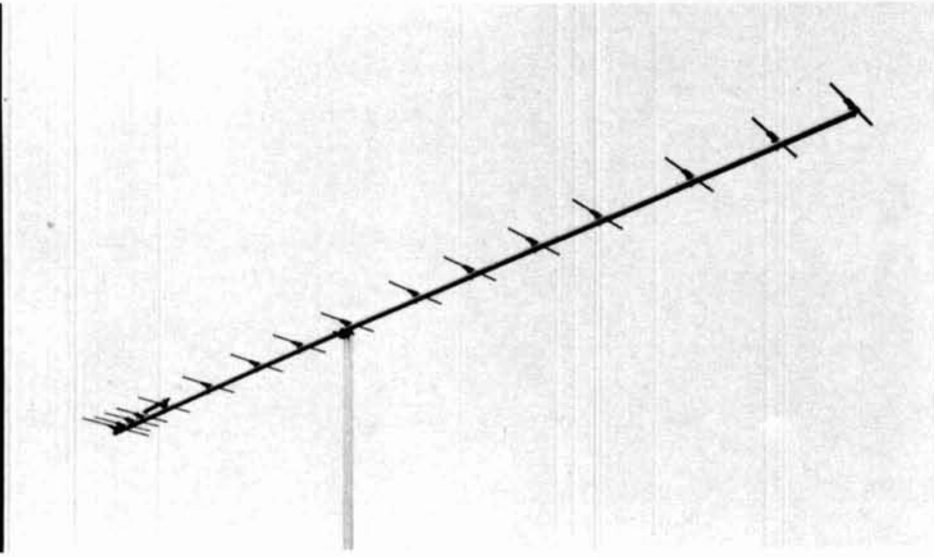

high gain yagi

for 432 Mhz

A new long-boom
16-element Yagi design
for 432 MHz
that provides
15 dB gain
over a dipole

For years the amateur uhf community has been trying to come up with a reproducible, high-gain Yagi beam for 432 MHz. At one time it was generally agreed among amateurs that the dimensions of a really long uhf Yagi antenna were so critical that it was impossible to build a practical, reproducible, high-gain, multi-element beam, and most uhf operators switched to the less critical colinear array. Unlike the long-boom Yagi, the colinear is a low-Q antenna, so none of the dimensions are overly critical and it is easily reproduced for uhf operation.

However, as has been pointed out by Ed Tilton, W1HDQ,[1] it is possible to build Yagi antennas for 432 MHz (and other uhf frequencies) if *all* dimensions are properly scaled. Most experimenters scaled element length and spacing, but failed to scale either the element or boom diameter – this resulted in antennas that exhibited little more gain than a dipole, or worse. W1HDQ's 11-element, 432-MHz Yagi design was the first that proved to be reproducible, and although it uses a wooden boom, large numbers are being used by amateurs on the 432-MHz band. The gain of the Tilton Yagi has consistently measured about 13 dBd (gain over a dipole).

Other successful 432-MHz Yagi designs are those of WØEYE[2] and K2RIW.[3] WØEYE's 15-element design, which uses a 10-foot (2.9m) metal boom, attracted wide attention, but not everybody who tried to build it was successful. K2RIW's 13-element Yagi, which uses insulated elements (8-foot [2.4m] boom), has been quite popular in the East, and has consistently been shown to provide about 15 dBd gain.

Described here is another long-boom Yagi for 432 MHz which provides about 15 dBd gain. This has been confirmed at antenna measurement contests on both the East and West Coast. This Yagi, which was designed by Mike Staal, W6MYC, and Mel Farrer, K6KBE, of KLM Electronics, is based on successful design techniques

By Ken Holladay, K6HCP, 2140 Jeanie Lane, Gilroy, California 95020

proven on hf and vhf and uses a broadband driven structure which consists of three elements (**fig. 1**). This provides a reasonable operating bandwidth and ease in coupling to the 12 directors and one reflector. The broadband structure, in addition to providing optimum coupling to the directors, is the key to reproducibility. Small variations in dimensions can be tolerated without significantly changing the operating characteristics of the antenna.

construction

As is shown in **fig. 1**, the antenna is based on a 1-inch (25cm) diameter boom, 12-feet (3.7m) long. Each of the elements is 3/8-inch (9.5mm) diameter aluminum tubing, insulated from the boom except for the single mounting screw (this type of element mounting *must* be used for the dimensions given in **fig. 1**). The driven elements are cross connected using ¼-inch (6.5mm) wide aluminum strap. The feedpoint impedance is 50 ohms (balanced) and must be connected to a balun using low-inductance copper strap 5/16 inch (8mm) wide.* To prevent aluminum-to-aluminum and aluminum-to-copper corrosion, all joints should be coated with *Penetrox A* or equivalent weatherproofing. An acceptable balun can be made as described by K6HCP and WA6GYD in the ARRL *Radio Amateur's VHF Manual*.[4]

performance

At my station I have two of these antennas mounted side by side, and they have provided the expected results. Los Angeles is about 300 miles (483km) away, over mountainous terrain, and good solid contacts on 432 MHz are a nightly occurrence. Activity on 432 is starting to increase, and I feel confident that this new antenna, which is easy to build, will do a great deal to stimulate growth on this band.

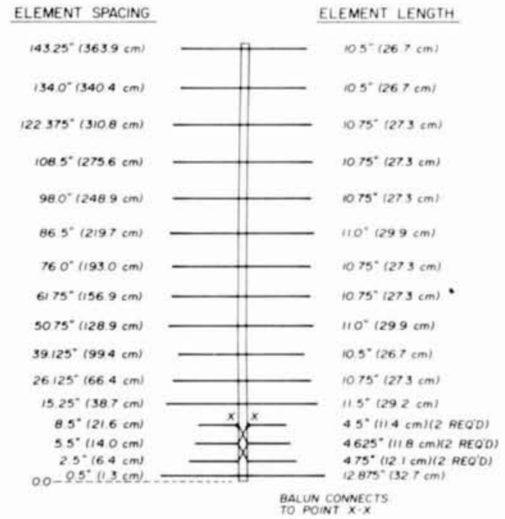

fig. 1. Layout of the 16-element Yagi for 432 MHz. Elements are 3/8" (9.5mm) diameter aluminum tubing, insulated from the boom except for the single mounting screw as shown in fig. 2.

*For those readers who do not have the time or material to build their own, this antenna is available from KLM Electronics, 17025 Laurel Road, Morgan Hill, California 95037.

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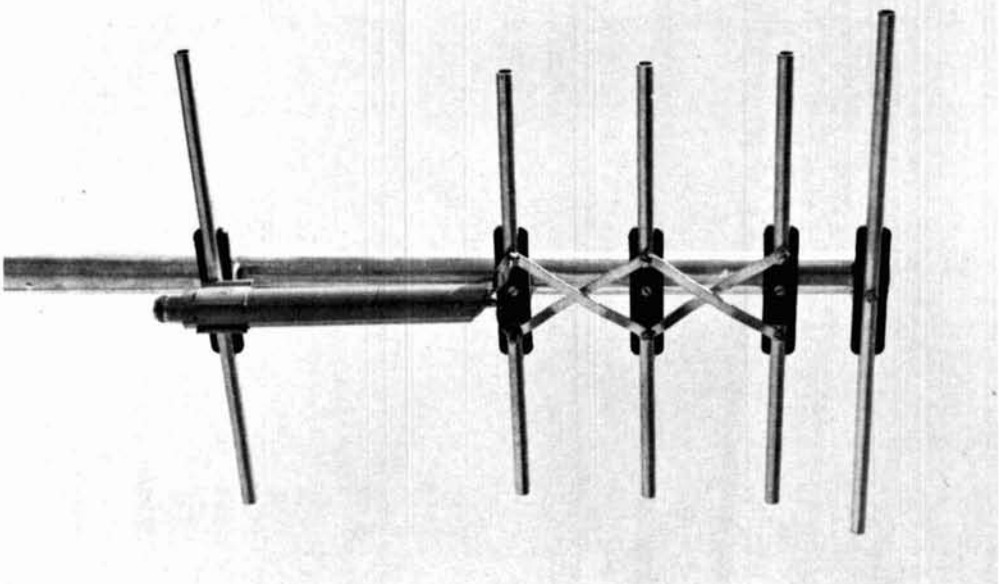

fig. 2. First five elements of the high-gain 432-MHz Yagi, showing element mounting and balun installation. The three-element, cross-connected driven structure is at the center.

More Details? CHECK—OFF Page 102

More Details? CHECK—OFF Page 102

telephone controller

for remote repeater operation

Using a modified RTTY autostart circuit to activate a repeater without a telephone

An earlier issue of *ham radio* described a telephone controller that could be used to turn any device on and off, such as a repeater.[1] Hopefully you've already read that article, so we won't go into the actual telephone controller; instead we'll show you how to operate the controller without a telephone. Many have asked us how this can be done, so we designed a circuit that will decode a tone and change it to a dc voltage that will allow the controller to be operated without a telephone.

We already had a circuit board that would do this.* This circuit was originally designed for RTTY autostart, and by simply retuning it to a chosen audio frequency, we found that it worked perfectly as a tone decoder. The RTTY autostart circuit is shown in **fig. 1.** All we had to do was omit the relay, bring out the lead from Q2 collector, and route it to the telephone controller junction of U1, pins 14 and R8.[1] On the original telephone controller you can omit Q1, Q2 and Q3; CR1, CR2 and CR3; R1-R7; C1-C4; and K1. (These parts were used to validate the telephone line only.)

The circuit is a tone decoder that turns transistor Q1 on and off. A tone of your choice is fed into the circuit from your receiver through R1 and decoupling capacitor C1. The tone is decoded by L1, C2. Q1 is a voltage amplifier. The amplified tones are rectified by diodes CR1 and CR2. The resulting dc voltage is fed to the base of Q2. Capacitor C7 requires about two seconds to charge and discharge, resulting in Q2 turning on and off at a rate similar to the ring rate from the telephone, as decoded by the original circuit in the telephone controller. Therefore, assuming the telephone controller circuit has been properly programmed, one would ring three times, hang up, wait twenty seconds, and ring three more times. The same thing would be done with the tone encoder on your mobile or base rig; i.e., push the button three times for one second each (or longer); stop; wait twenty seconds; then push the tone button three more times.

The only thing that will take a little time is tuning the toroid for the audio frequency you desire, which is done with the aid of an oscilloscope or vtvm on the ac volts scale.

Put the plus lead of the scope or vtvm to the gate of Q1. Dc voltage need not be applied to the circuit. Apply your desired tone to the input and open R1 all the way. Adjust C2 for maximum ac volts or peak-to-peak voltage on the oscilloscope. Remember, the better the tuning, the narrower will be the bandpass.

After it's all hooked together, apply a dc voltage between +12 and +24 volts to the decoder board and

*Available from Circuit Board Specialists, 3011 Norwich Avenue, Pueblo, Colorado 81008. RTTY autostart printed circuit board $3.50 each. Complete kit, less power supply (+18 to 24 Vdc) $14.50. (Specify approximate tone frequency.)

By Robert C. Heptig, KØPHF, Robert D. Shriner, WAØUZO

Robert C. Heptig, KØPHF, P.O. Box 969, Pueblo, Colorado 81002, Robert D. Shriner, WAØUZO, 1740 E. 15th St., Pueblo, Colorado 81001.

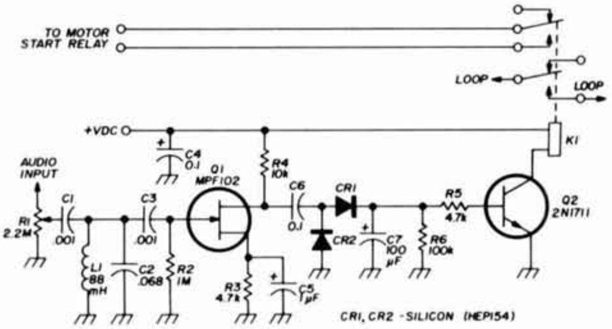

fig. 1. RTTY autostart circuit, which is used with IC U1, the SN7490 in the original article (reference 1), as a tone decoder. A tone of your choice is fed into the circuit through R1, C1 and is decoded through L1, C2. K1 is a Potter & Brumfield SC-4332.

telephone controller board, then test it as described in reference 1 (with the exception of the validating circuit). Adjust R1 of the decoder board to allow just enough audio to do the job with respect to the amount of deviation of your tones.

tone access

Just for the fun of it we added a tone access for your repeater to the circuit. Simply put the relay back into the circuit of the RTTY autostart as shown in **fig. 1** and wire it into your repeater as shown in **fig. 2**. In this configuration the COR cannot be keyed unless a brief tone is applied to your carrier, which will cause the modified RTTY autostart circuit to provide a ground for

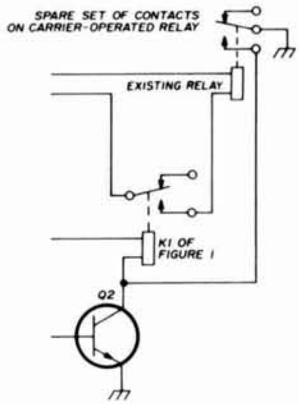

fig. 2. Tone-access circuit for repeaters. A brief tone applied to your carrier causes the modified autostart circuit to ground your COR as long as the carrier is present.

your COR; then a spare set of contacts on your COR will maintain ground as long as your carrier is present. By tuning the decoder as a broadband amplifier (increase values of C1 and C3), this circuit could be used for a vox-operated repeater. With a little imagination, you can probably come up with many possibilities for this decoder.

reference

1. Robert C. Heptig, KØPHF and Robert D. Shriner, WAØUZO, "Automatic Telephone Controller for Your Repeater," *ham radio*, November, 1974, page 44.

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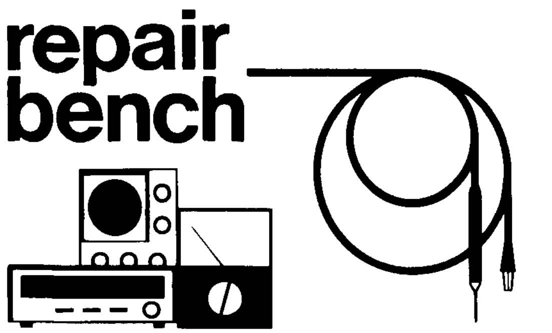


Michael James

basic troubleshooting

Troubleshooting and equipment repair are two of the toughest problems faced by radio amateurs today. Part of the difficulty is due to the fact that modern ssb equipment is much more complex than the old a-m and CW gear of twenty years ago, but perhaps more important, few amateurs build major pieces of their station equipment anymore so they are probably not as familiar with its circuitry as they should be. When your receiver or transmitter starts giving you trouble, more than likely it will be returned to the factory to be repaired. If the problem isn't too severe, you may avoid using that function which is affected or overlook it altogether. In some cases you may not even be aware of a problem unless another amateur brings it to your attention (distorted speech, poor sideband suppression or splatter, for example).

Although there *may* be some equipment repair problems that are best sorted out by the factory, in most cases you can save yourself a lot of time and money by fixing it yourself. Once you send your gear back to the factory, you may have to wait a month or more until you can get back on the air. In addition, you will probably have to pay the factory ten dollars an hour or more for their technician's time.

Troubleshooting electronic equipment is not difficult, nor does it require a bench full of test equipment. A large selection of test equipment may simplify the task, or allow you to solve a problem more quickly, but 90 per cent of all troubleshooting can be accomplished with a volt-ohmmeter and other simple test equipment you already have on your workbench. In those cases where you need a calibrated signal generator or an oscilloscope, you can often borrow one from your local radio club or from an amateur who lives nearby.

In the coming months this column will be devoted to troubleshooting techniques and how you can use them to fix your own equipment. Although much of the initial discussion will be in general terms that are applicable to practically any electronic equipment, future columns will discuss specific pieces of equipment and unique or unusual circuitry that requires a somewhat different procedure. If you have solved a particularly difficult equipment problem, we would like to hear about it. There may be others who will be helped by your success.

basic troubleshooting

There are three basic troubleshooting techniques which can be used to locate and fix circuit malfunctions: signal tracing, resistance measurements and voltage measurements. In receivers and transmitters the problem area is usually located with signal tracing, then pinpointed with resistance and/or voltage measurements. Although some electronic circuits such as gain-control circuits don't lend themselves to signal tracing, the majority of receiver and transmitter circuits can be quickly checked with this method. Once you know how to use signal tracing, in fact, you will probably agree that it's one of the quickest ways to track down a circuit problem.

Basically, signal tracing consists of injecting a signal at the input to a piece of equipment and checking its path through the equipment. If the signal appears at the input to a stage, but not at the output, that stage is the culprit. It may not be the only culprit, but once it's been fixed, you can locate other problem areas along the signal path.

The signal tracer is essentially a very quiet, high-gain audio amplifier with headphone or speaker output. One commercial version which is available at modest cost is shown in the accompanying photograph. If you wish, you can build a simple high-gain audio amplifier around an op amp IC as shown in **fig. 1**, and in a pinch you could even use one channel of your stereo system. This is all you need if you're working with audio systems, but if you're troubleshooting rf and i-f stages, you will also need a simple demodulator probe such as that shown in **fig. 2**. The one I use is built into a discarded plastic ballpoint pen. You can also use one of the rf probes which are available for vacuum-tube voltmeters.

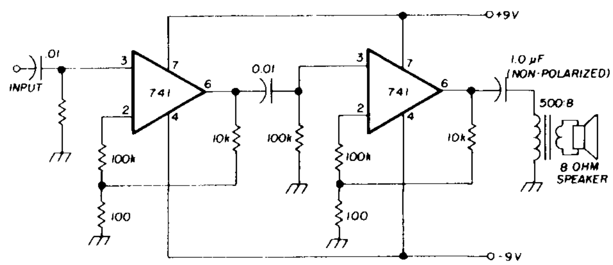


fig. 1. Signal tracer circuit which is based on the 741 op amp ICs. Gain is about 80 dB; audio power output is approximately 40 mW, sufficient for most signal tracing.

In addition to the signal tracer (audio amplifier and rf probe) you will also need a signal injector — a device which has a broadband signal output from audio through vhf. There are several pencil-sized signal injectors on the market for less than ten dollars. Most consist of a simple 1 kHz multivibrator which has high harmonic content well above 30 MHz. The circuit in **fig. 3**, which uses inexpensive high-speed switching transistors, can be used for signal tracing through at least 50 MHz. Built on perfboard, this unit is small enough to fit inside the aluminum cases in which expensive cigars are sold (you could also use a plastic pencil holder or toothbrush case).

signal tracing

Whatever kind of signal tracer you decide to use, you'll want to get the most out of it. Many people who already use signal tracers seem to think that signal tracing is limited to localizing trouble in one section of a receiver or transmitter. However, as will be shown later,

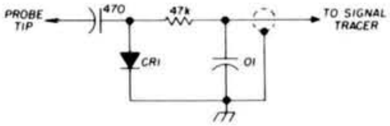


fig. 2. Demodulator rf and i-f probe for signal tracing. Diode CR1 can be practically any signal diode such as 1N34A, 1N60, 1N67A, etc.

the signal tracer can also be used to pin down defective components. All you have to do is know how to use it.

Fast troubleshooting with a signal tracer demands logic, and you'll have to supply that. But even if you haven't done any troubleshooting before, you'll be amazed at how quickly you can track down a faulty circuit with a signal tracer. Fixing the bad circuit after you've located it may be another story, but if you use logic, and the resistance and voltage measurements we will discuss in future columns, you can probably repair any electronic circuit ever built. Things are simplified tremendously if you have a copy of the schematic or the manufacturer's maintenance instructions, but even without these you can, with persistence, be successful.*

As a starter I'll show you how to use a signal tracer to troubleshoot the sophisticated amateur communications receiver shown in **fig. 4**. This block diagram is fairly typical of modern superheterodyne receivers although some models may use only one frequency-conversion stage, or may not be equipped with a crystal calibrator or a separate a-m detector. I should also point out that it doesn't make any difference if your receiver uses vacuum tubes, transistors, or some combination of these – the basic signal tracing technique is the same.

First of all, take a look at the schematic and mentally divide it up into blocks representing each stage or function in the set. **Fig. 4** has been divided into four basic sections: rf, high i-f, low i-f and audio. In some cases you might want to consider the detectors separately, but they are usually included as part of the last i-f.

First, the rf section. When signal tracing here you'll have to use the demodulator probe. If the receiver is connected to an antenna you will hear a mismash of incoming signals because most receivers don't have sufficient front-end selectivity to pick out any one signal –

*Manuals for most amateur equipment manufactured between 1940 and 1965 are available from Hobby Industry, WØJJK, Box H864, Council Bluffs, Iowa 51501. Send self-addressed, stamped envelope for quote.

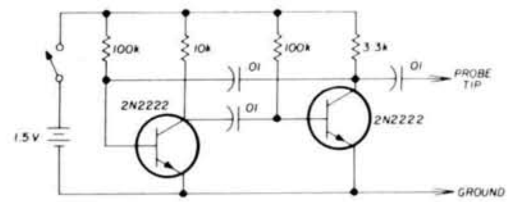
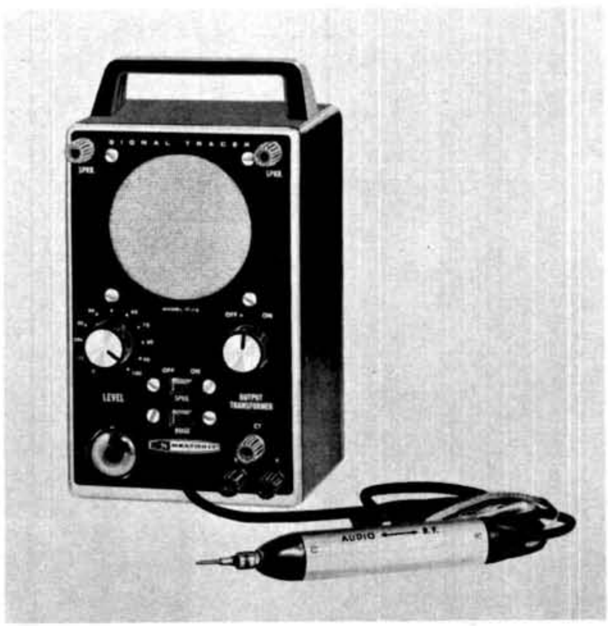


fig. 3. Signal injector is basically 1 kHz multivibrator which has high harmonic output. Circuit shown here has usable output up through 50 MHz. Practically any npn transistors will work in this circuit.

that's done further on, in the low i-f. If all the rf stages are normal, once you set the bandswitch all the signals within several-hundred kHz will be heard through the signal tracer. The collectors of the rf amplifier and mixer transistors (plate circuits in vacuum tube receivers) are the points to check with your probe. If you don't get any signal output from the mixer, something in the rf section is dead.

The high i-f processes the output of the first mixer and consists of a bandpass filter, the second mixer and the variable frequency oscillator. If any of the circuits in the high i-f isn't working properly, the signal picked up by your tracer at the output of the second mixer will reflect it. The low i-f includes the selective filter, i-f amplifier amplification and the detectors. You'll need your demodulator probe for the i-f stages, but the quickest test point for the whole section is after either of the detectors. Here you should hear a clear, undistorted audio signal without the probe. The audio section can also be checked without the probe. If the receiver is okay, you should hear a nice strong signal at the output of the last audio stage.

If the receiver isn't working properly, the quickest



Heathkit IT-12 signal tracer has both visual (eye tube) and audio output. A switchable audio-rf probe is included with the kit, which sells for $32.95.

way to find the bad circuit is to check signal output about halfway through the set. A good point is the output of the second mixer. If the receiver is connected to an antenna the signal you hear should change as you tune the vfo (since the demodulator probe is an a-m detector, ssb signals will be unintelligible). If your receiver will tune to one of the WWV channels, this makes an excellent test signal, or you can use your signal injector. The pitch of the wideband injector signal, however, will not change as you tune the vfo.

If the signal is okay at the output of the second mixer, you have cleared the front-end circuits of any suspicion and can proceed to the last half of the set – the output of the low i-f amplifier is a good point. If you don't get an output from the second mixer, the low i-f and audio sections are probably okay.

Assume you get nothing at the output of the second mixer. Divide the front end roughly in half and use the tracer and demodulator again. The output of the first mixer is a good check point. If you have the proper signal there, there's something amiss in the bandpass filter, vfo or second mixer. If there's no signal output from the first mixer, the rf amplifier, crystal oscillator or first mixer stage must be at fault.

The last half of the receiver can be attacked with similar logic. If the signal was okay at the second mixer, the next logical dividing point is the output of the detector, which can be checked directly, without the probe. A signal in the tracer means that everything is okay up to there and the trouble is in the audio section. If you don't get a signal, check the output of the other detector. No signal means it has been blocked between the second mixer and the detector – the crystal filter or one of the i-f amplifiers is the problem.

Note that with only two signal tracer checks you have ioslated the problem to one small, functional section of the receiver. If the signal is okay at the input to a stage and not at the output, it's obvious the trouble is between those two points. It's a simple matter to check each of the individual stages within a section to pinpoint the offending one.

The divide-and-conquer technique of stage isolation works just as well for other symptoms as it does for a radio that is completely dead. You can hunt noise or hum, for example, tracking down the stage where the trouble first appears. It also works for distortion.

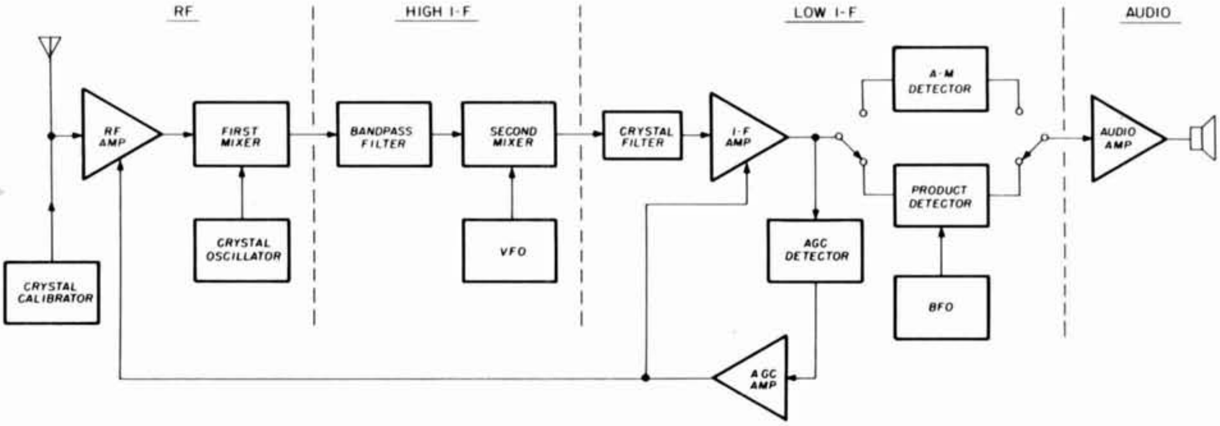


fig. 4. Sectionalizing an amateur communications receiver by functions. Dividing it up this way makes it easy to track down trouble with the signal tracer.

other checks

If the receiver is suffering from poor sensitivity, the problem can be signal traced by the "straight through" method. If reception is poor, the fastest way to determine which amplifier isn't doing its job is to check the gain of each stage by touching the signal-tracer probe to the input and output; if there is little or no increase in signal strength, the amplifier is weak. Although transistor mixer stages usually have some gain, vacuum tube mixers seldom exhibit gain and may often have a small signal loss, so keep this in mind. The filters introduce loss, too, but you can judge if it's too much after you have a little practice.

There are other little tricks of troubleshooting logic that make it easy to find troubles. If your receiver works alright on a-m but not on ssb or CW, for example, the difficulty is probably with the product detector or bfo –

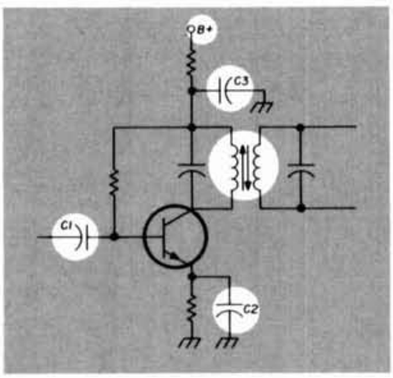


fig. 5. You can check these components with your signal tracer without even unsoldering them from the circuit.

they are the only stages which are not common to a-m. If weak signals sound okay, but strong ones distort, a good suspect is the agc stage which may not be controlling the rf and i-f gain as it should, letting strong signals overload the receiver. Likewise, frequency jumping or drift can usually be traced to the vfo; audio distortion eliminates all but the detector and audio stages; and poor selectivity is usually caused by a bad crystal or mechanical filter.

getting closer

After they've pinpointed the stage which is causing the problem, many technicians put away their signal tracer and reach for their voltmeter. However, the signal tracer can still tell you things about the circuit you can't find out with a voltmeter. In the amplifier circuit of **fig. 5**, for example, the highlighted coupling and bypass components can be tested right in the circuit without even unsoldering them.

The coupling capacitor, C1, and the interstage transformer, T1, should pass the signal along with very little attenuation. Whether they are large, as in audio stages, or small, between rf or i-f amplifiers, there should be about the same amount of signal on both sides. If there is any attenuation, it should be small. To check, touch the tracer probe to the input side of the component, then to the output side — if the output is much weaker than the input, the part is defective.

The bypass capacitors, C2 and C3, shunt the signal to ground and their values are chosen to short out practically all the signal at the emitter (C2) and at the power supply end of the interstage transformer (C3). The tracer should hear very little signal at either point. If there's any substantial signal the capacitor isn't doing its job. Even if the transistor is in good health, bad bypass capacitors at C2 or C3 will seriously degrade the gain of the stage.

Sometimes, when checking stage gain or components, you'll find that you don't have sufficient signal strength to determine if a component is doing the job it should. In this case it's helpful to place the signal injection directly at the input to the stage. This will bring the signal level up to the point where you can make meaningful measurements. You can also use the signal injector to quickly move through the receiver to determine which stage is causing the problem. Simply touch the probe of the signal injector to the input of each stage, starting at the audio output stage, and move back toward the front end, stage by stage. If everything is working properly you will hear the 1 kHz modulation through your receiver's speaker as you inject signal into each stage.

Finally, you can check the B+ line with your signal tracer for any traces of hum. Power supply filter capacitors are like any other bypass capacitors in that they should shunt all signal voltages to ground (power supply ripple in this case) and leave only pure dc. If one of the filter capacitors is weak, you'll hear a considerable amount of hum in the signal tracer. If the dc line isn't properly decoupled you may hear a whistling or hissing sound that is an rf or i-f signal if you could unscramble it. This can usually be traced to a bad bypass (decoupling) capacitor somewhere along the B+ line.

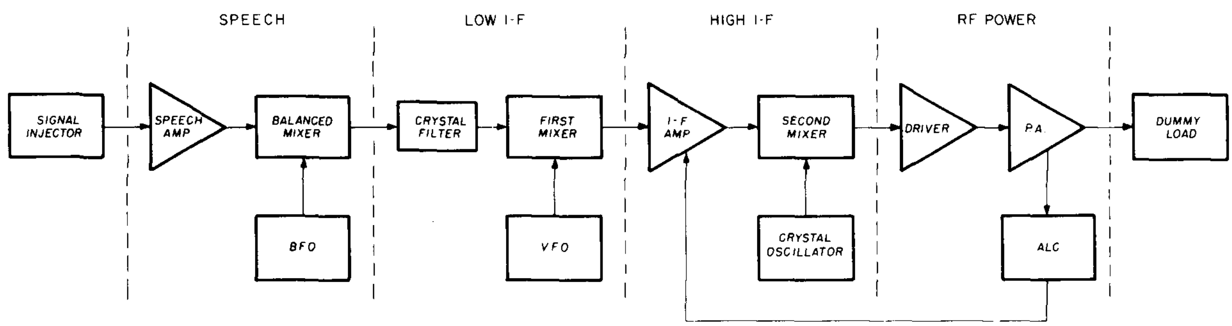


fig. 6. Modern ssb transmitter can be sectionalized by function for troubleshooting purposes.

transmitter signal tracing

A modified form of signal tracing is also suitable for tracking down problems in ssb (and a-m) transmitters. In this case the signal injector is connected to the microphone jack and the transmitter is terminated in a dummy load as shown in **fig. 6**. Except that the position of the stages is reversed (audio front-end, rf output), the functions of the various stages in a modern ssb transmitter are not that much different than those in a superheterodyne receiver.

By using the signal tracer to track through the stages of the transmitter, you can quickly locate a stage which is blocking the signal (use the demodulator probe for the balanced modulator output and all following stages). The rf output from the final amplifier may be a little too much for the detector diode in the probe so don't connect it directly to the output — placing the probe tip next to the power amplifier compartment should provide enough signal for tracing purposes.

Although the signal tracer won't track down distortion, poor sideband suppression, or vhf parasitics in the transmitter, it's useful for quickly isolating a nonfunctioning stage or component. The signal tracer can also be used to eliminate hum and locate bad decoupling capacitors which are causing unwanted rf feedback. Other transmitter troubleshooting techniques will be discussed in a future column.

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RAM keyer update

Circuit improvements for the random access memory electronic keyer described in a previous issue

This is a followup report on the two-RAM programmable keyer article in the October, 1973, issue of *ham radio*[1] and my correction note[2] in the December, 1974, issue. Many inquiries have been received concerning possible parts procurement and solutions for faulty keying. This article will enable you to build this keyer with a minimum of frustration.

printed-circuit board

The majority of inquiries were about the procurement of the printed-circuit board. As indicated in the original article, the board, as well as the kit of parts for the keyer, could be obtained from the indicated address. It now appears that this company is no longer the source for the parts or the printed-circuit board. If you have a lot of time and patience the circuit can be hand wired. In **fig. 4** a full sized view of the etched board, from the foil side, is shown for those who would like to build one. The layout of the components and external connections are shown in **fig. 5**. This board diagram is free from the errors of the original version and incorporates the circuit change as described in reference 2.

clock circuit

Clock pulses are derived from a NE555 timer connected for astable operation; i.e., as a free-running multivibrator. Using the values of the original article, the maximum theoretical keyer speed will be about 17 wpm. Redesign of the keyer for higher speeds is easily accomplished by noting **fig. 1**. The IC manufacturer gives the clock frequency in terms of R_A, R_B, and C as:

$$f(Hz) = \frac{1.44}{(R_A + 2R_B)C}$$

where R_A = 1k ohm, R_B = 6.8k to 56.8k ohms and C = 6.8 μF. Converting the clock frequency to keying speed,[3]

$$Speed\,(wpm) = 1.2f$$

$$Speed\,(wpm) = \frac{1.73}{(R_A + 2R_B)C}$$

so that the speed range is expected to be from 2.2 to 17.4 wpm. **Fig. 2** shows the values of C and ($R_A + 2R_B$) for the desired speeds. Using C = 6.8 μF the graph shows that the speed varies when the resistance changes from 14.6k to 114.6k ohms. In my case, a 3.3k resistor was used in place of the 6.8k, and a 5 μF capacitor was used. Maximum keying speed was then 32 wpm, and a slight reduction in the duty cycle of the clock pulses (8%) occurred, which didn't affect the keyer performance. The 50k pot should have a log rather than a linear taper to permit a linear speed range; otherwise the higher keying speeds will crowd together near the upper portion of the pot rotation.

random-access memories

The second largest number of inquiries was about the RAM devices. The (Signetics) 25L01B is the low-power dissipation, pin-for-pin equivalent of the popular 1101 256-bit RAM (National Semiconductor and others). I first used the 25L01B* without any problems. If its price is a little too high for you, you can try the 1101 version as advertised by large discount houses in the amateur literature (about $2.50 each). My experience has been that you get what you pay for. I bought a half dozen of these bargain specials and only one worked correctly. If you expect a cheap bargain, you'll probably get a cheap device. *Caveat emptor*.

faulty keying

Even after incorporating the changes in the correction note,[2] some readers still had problems with sending code

*Obtained from Schweber Electronics, 5640 Fisher Lane, Rockville, Maryland 20852 at $6.50 each.

By **Howard M. Berlin, K3NEZ,** 2 Colony Boulevard, Apt. 123, Wilmington, Delaware 19802

characters. This annoying problem arises from stray rf and spikes generated from the TTL logic. In his article on the Accu-Keyer,[4] WB4VVF discusses some possible cures. *It is essential that all external leads be shielded from rf.* Use RG-174/U or similar coax from the keyer output to the transmitter. If an external paddle is used, use shielded three-wire cable from the paddle to the keyer. As a further precaution, add 0.1 µF bypass capacitors on the three inputs of the paddle at the input jack. TTL spikes can usually be eliminated by adding 0.01 µF capacitors from each IC chip's +5 volt pin to ground. In more stubborn cases it may be necessary to place a number of 0.01 to 0.1 µF capacitors around the edge of the printed circuit board (ground) to +5 volt points. I used about eight additional capacitors and have the keyer right next to my kilowatt linear without any trouble in keying.

Another tip on bypassing to cure faulty keying was received from Ken Beck, K3DW. He found that false

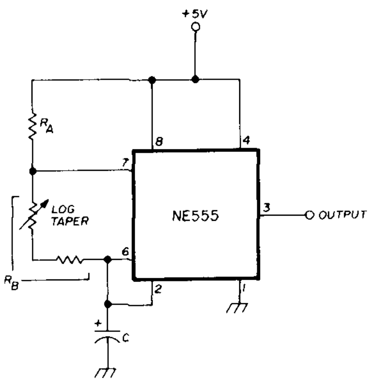

fig. 1. NE555 timer IC connected for astable operation.

dash generation occurred due to transient triggering of the master flip-flop in the 7473 IC. To eliminate the transients requires the addition of a disc capacitor bypass (0.02 to 0.05 µF) directly between pins 4 and 11 of this 7473. Similar bypassing of the 7473 that controls the address cycle also helps to prevent unwanted cycle starts caused by transients. Also disc capacitors (0.02 µF) connected from each key lead to chassis (installed right at the key jack) helped to reduce false triggering. In any case, bypassing is necessary to eliminate keying transients.

Another possible cause of faulty keying is in the clock circuit. As mentioned before, the clock is free-running and will continue to run until power is disconnected. Faulty keying *may* occur if the pulses of the individual Morse code characters are not in synchronization with the rest of the logic. The only way to cure this is to redesign the clock to run only when the desired characters are being sent.

momentary clear switch

A useful addition to this keyer circuit, offered by K3DW, is a momentary switch to clear the memory during either read or write operation, **fig. 3**. The 6.8-µF timing capacitor for the NE555 clock IC is grounded

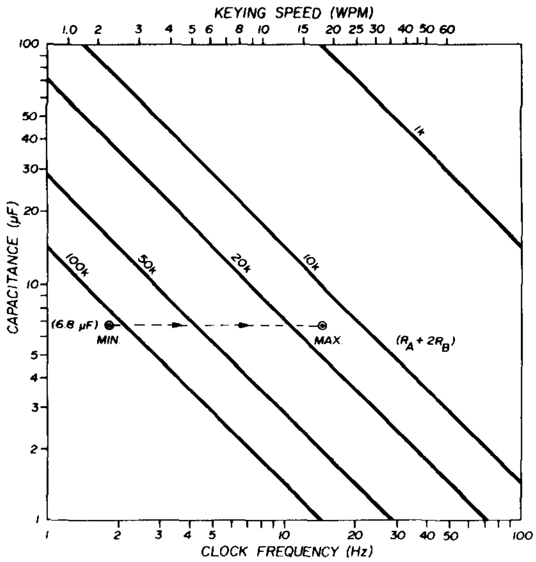

fig. 2. Capacitance, C, and resistance, $(R_A + R_B)$, required to obtain desired keying speeds.

through a normally closed switch, which is bypassed by a 0.01 µF capacitor. When the clear switch is depressed, a 0.1 µF capacitor discharges into the reset input of the 7473 that controls the address cycle. This ensures that not only will the remainder of the address cycle during which the switch was operated be cleared, but that a new cycle will be started and cleared. In the write mode, complete memory erasure is provided.

transmitter keying and sidetone

A relay output to key the transmitter can be used to replace the 2N4888 keying transistor shown in the original circuit (see **fig. 6**). The 5-volt reed relay, which is similar to that provided by Electronics Applications Company part no. 1A5AH,* provides excellent keying even at speeds above 35 wpm.

An improved keying monitor to replace the 7413 NAND Schmitt trigger[5] is also shown in **fig. 6**. This

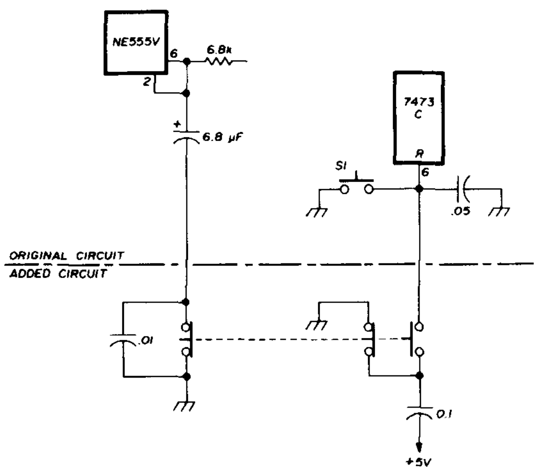

fig. 3. Addition of clear switch to clear keyer memory during read or write mode (contributed by K3DW).

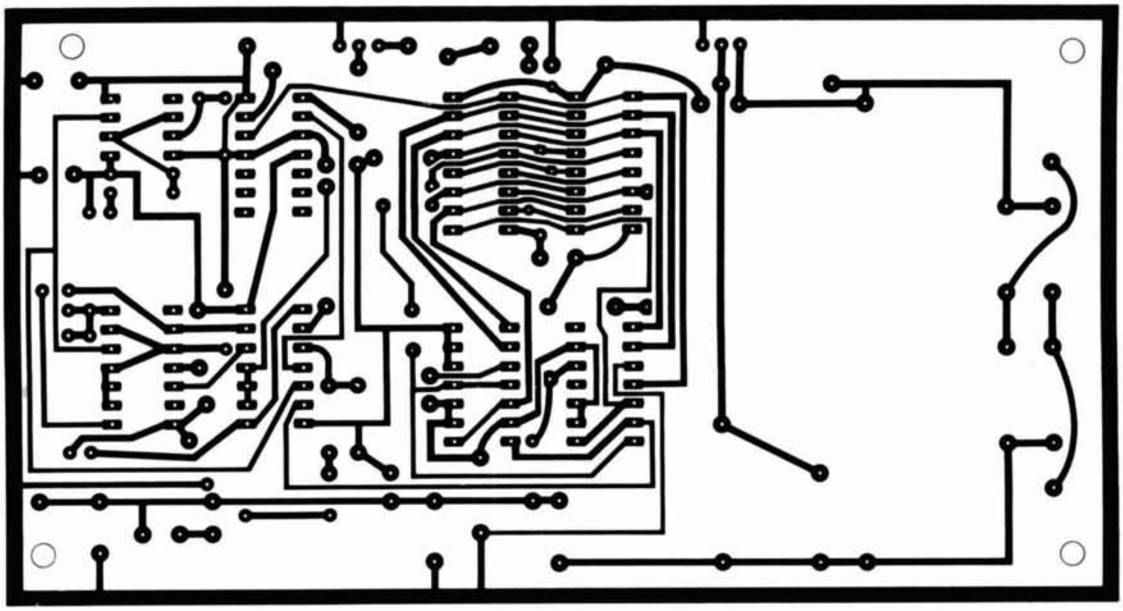

fig. 4. Full-size etched circuit board layout. Component placement is shown in fig. 5.

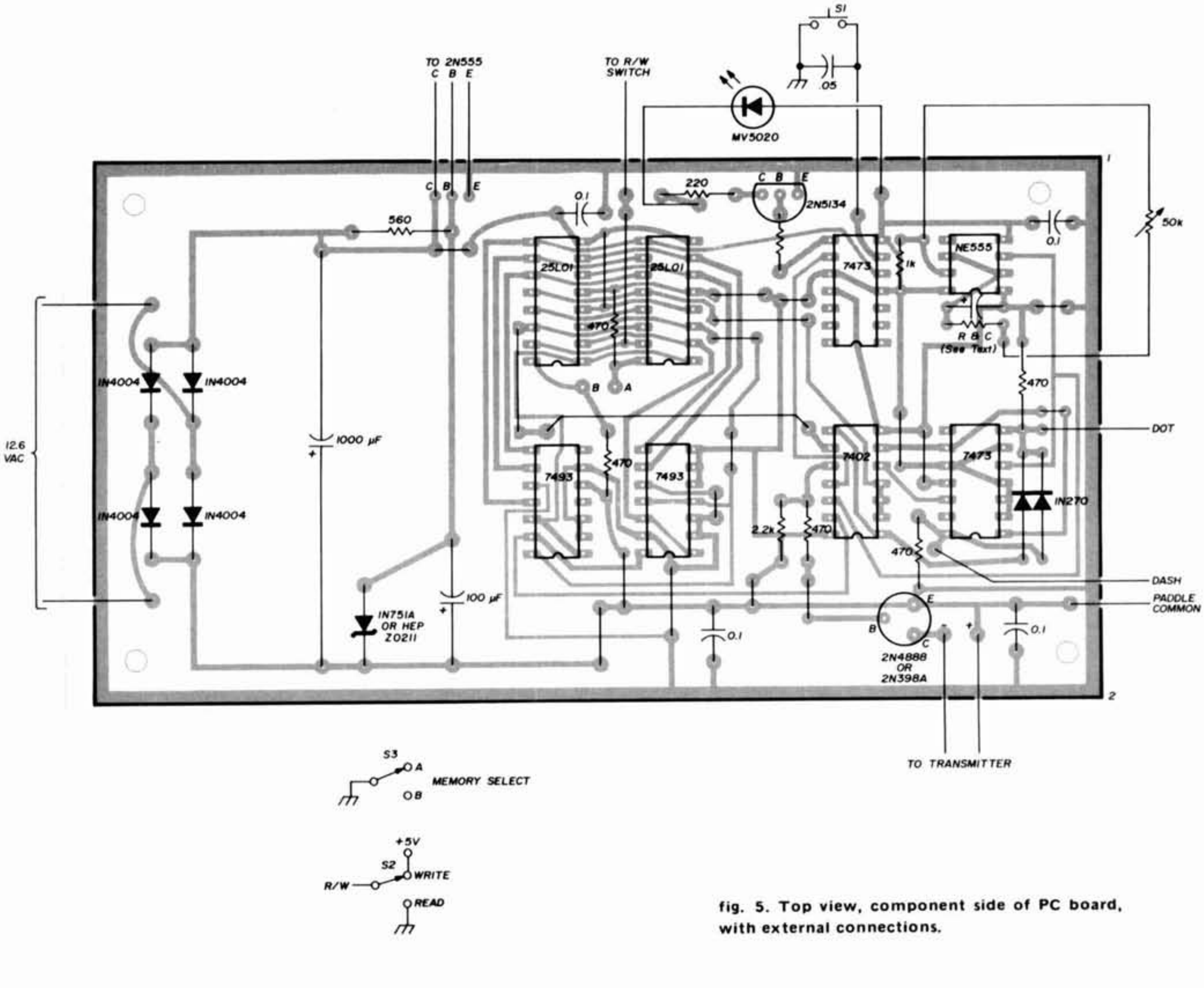

fig. 5. Top view, component side of PC board, with external connections.

circuit uses a NE555 wired as an astable multivibrator similar to a circuit used by WA5TRS.[6] If you don't want the added expense of the 500k pot, a resistor of about 150k ohms should provide a pitch pleasing to the ear, with the components shown.

construction notes

The printed-circuit board must be insulated from the metal cabinet by short standoff insulators. Also, if the keying paddle input jack is not insulated from the chassis, the PC board must be insulated from the cabinet. If you ground the board, insulate the input jack. In either case the keyer output jack should be insulated.

summary

All the troubleshooting concepts mentioned resulted from approximately 170 manhours debugging this keyer *after* it was assembled. Troubleshooting was done with a four-channel storage oscilloscope and a lot of patience.

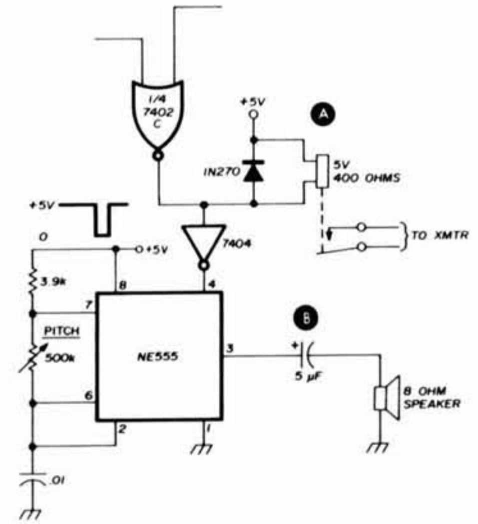

fig. 6. Alternative method for keying transmitter using a reed switch, (A). A simple keying monitor is shown in (B).

If you don't have access to this equipment, this article will be of use to you. You might want to include the additional memories described in reference 5.

*Electronics Applications Co., 2213 Edwards Avenue, South El Monte, California 91733.

references

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2. Howard M. Berlin, K3NEZ, "Memory Keyer," (Comments), *ham radio*, December, 1974, page 58.
3. *The ARRL Radio Amateur's Handbook*, ARRL, Newington, Connecticut, 1973 Edition, page 356.
4. James M. Garrett, WB4VVF, "The WB4VVF Accu-Keyer," *QST*, August, 1973, page 19.
5. Howard M. Berlin, K3NEZ, "Increased Flexibility for the Memory Keyer," *ham radio*, March, 1975, page 64.
6. Joe Buswell, WA5TRS, "Simple Integrated-Circuit Electronic Keyers," *ham radio*, March, 1973, page 38.

ham radio

CIRCUITS & TECHNIQUES

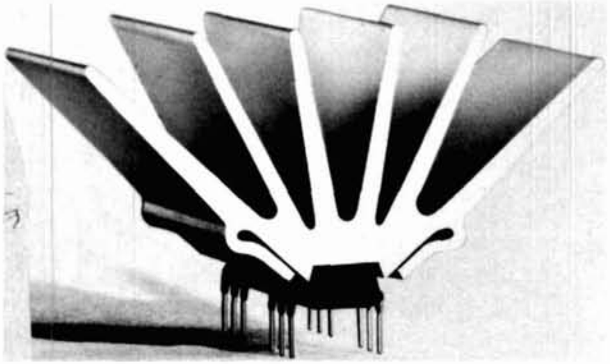
Ed Noll
W3FQJ

audio-power integrated circuits

Audio-power ICs are available in the 5-watt and higher ranges for many applications. Some include an integrally designed heatsink as part of the package (**fig. 1**). These devices are convenient for making inboard or outboard amplifiers when you need some additional audio punch. Most will drive 8- and 16-ohm speakers. For QRP work they can be used as a complete speech amplifier/demodulator for a-m, ssb, and fm. A modulation transformer can be added to match their low-impedance output to the transmitter. At the QRPP level, these ICs can be used as a single-module class-AB or class-B a-m modulator.

The RCA CA3131 and CA3132 (**fig. 2**) are two audio-power ICs that include preamps, power amplifier, and integral heatsink. The CA3131 has an internal feedback network that maintains an overall gain of approximately 48 dB. The CA3132 has no feedback network but has facilities for connecting one externally, depending on specific application. In this case the external feedback network usually connects between terminals 6 and 16. The package is a 16-pin dual-inline with the four center pins removed.

fig. 1. Sinclair IC-12 audio power IC provides up to 6 watts power output into an 8-ohm load. Voltage gain is about 250; input impedance is 250k.



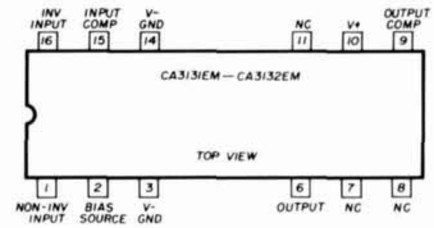


fig. 2. Pin-out diagram of the RCA CA3131 and CA3132 audio power ICs. The CA3131 has an internal feedback network that maintains overall gain at about 48 dB. The CA3132 has no internal feedback but one can be connected externally (see text).

Power output is 4 watts minimum and is typically 5 watts. Recommended supply voltage is 24 volts dc. The load can be either 8 or 16 ohms, with 8 ohms providing higher output. Zero-signal supply current is only 10 mA – certainly a favorable attribute for solar- and battery-power applications. Inverting and noninverting inputs are included. Output is single-ended; minimum input impedance is 200k but typically 1 megohm.

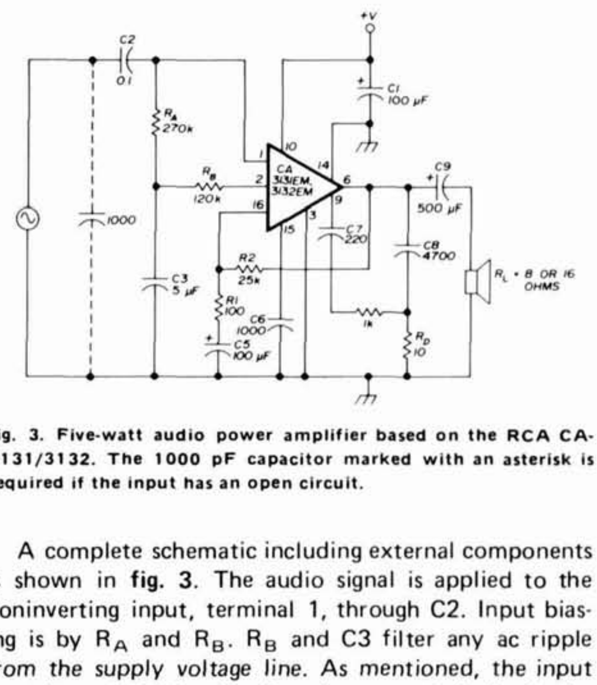


fig. 3. Five-watt audio power amplifier based on the RCA CA-3131/3132. The 1000 pF capacitor marked with an asterisk is required if the input has an open circuit.

A complete schematic including external components is shown in **fig. 3**. The audio signal is applied to the noninverting input, terminal 1, through C2. Input biasing is by R_A and R_B. R_B and C3 filter any ac ripple from the supply voltage line. As mentioned, the input impedance is high; therefore in a practical circuit the input impedance is largely set by the ohmic value of R_A.

Filter capacitor C1, an electrolytic, should be placed as near as possible to terminal 10. C6 sets a 46 dB closed-loop gain point at 200 kHz. C7 ensures equal gain characteristics on positive and negative signal swings. C9 sets the amplifier low-frequency response.

R1 and R2 are a part of the feedback network and need only be inserted when the CA3132 is used. C8 compensates for speaker inductance, with R_D limiting any current surge. Closed-loop gain equals the ratio (R1 + R2)/R1. The low-frequency 3-dB-down point occurs when C5 reactance equals the ohmic value of R1.

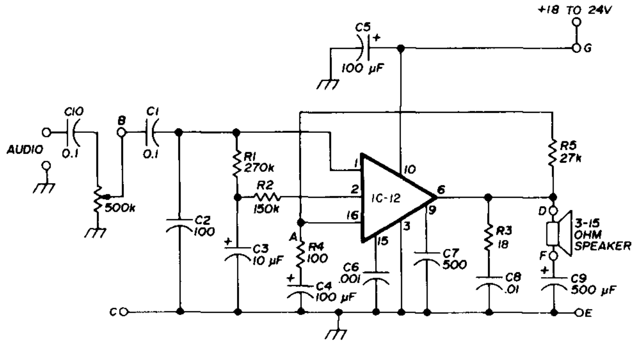


fig. 4. Five-watt audio power amplifier featuring the Sinclair IC-12 audio power IC. Zero-signal supply current is a low 10 mA.

The British Sinclair IC-12* (**fig. 1**) has a power output up to 6 watts with a 30 mV input when its output is connected to an 8-ohm load. Permissible output load impedance is 3 to 15 ohms. Voltage gain is approximately 250; input impedance, 250k. Zero-signal supply current is a low 10 mA. I've used the circuit of **fig. 4** successfully for many receiver and modulator applications. Again, a modulation transformer can be substituted for the speaker if the modulated system reflects a 3 to 15 ohm impedance.

One of the more unusual applications of the IC-12 was in a broadcast-band receiver (**fig. 5**) using a phase-locked loop (PLL) detector. The PLL output was connected directly to the IC-12 audio-input terminals (**fig. 4**). Good performance and acceptable selectivity were obtained.

External parts values can be selected according to desired performance. For example, C1 (**fig. 4**) can be used to control bass rolloff. The 3-dB-down point is located approximately at the frequency at which C1

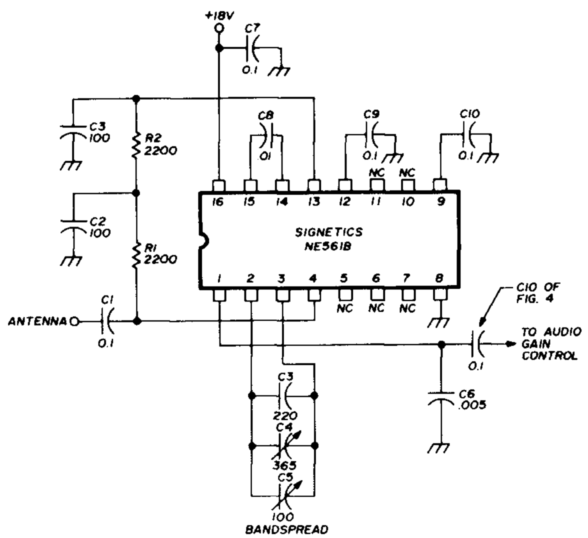


fig. 5. Phase-locked loop a-m detector which uses the Signetics NE561B. In a commercial broadcast-band receiver this detector was used with the IC audio power amplifier of fig. 4.

reactance equals the ohmic value of R1. C2 is needed only if the input signal source is from a very high impedance. C3 ensures good power-supply ripple rejection and low-frequency stability. Low-frequency rolloff is also influenced by R4 and C4. Rolloff frequency is that frequency at which reactance equals resistance. C5 is the power supply filter. High-frequency performance is influenced by C6 and C7, with C7 having its greater influence on the negative-swinging excursions. The value shown for C6 ensures low distortion up to 50 kHz. As in the previous schematic, **fig. 3**, C8 and R3 compensate for loudspeaker inductance, while C9 can be used to limit the bass response. R4 and R5 set the voltage gain:

$$V_G = \frac{R4 + R5}{R4}$$

The value of R5 can be increased to bring up the gain. For example, with a value of 470, the gain is 5000. In this case the input signal need only be 1 millivolt to produce rated output, but distortion is higher and careful layout is important to minimize stray feedback.

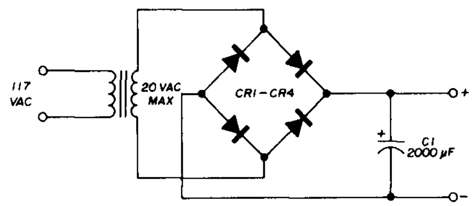


fig. 6. Suggested power supply. The diodes should be rated at 30 PIV, 1 amp. Transformer secondary voltage above 20 volts ac is not recommended.

However, if only a limited increase in gain is desired, the ohmic value of R5 can be increased gradually to meet specific needs and perhaps need not be increased to the point at which instability becomes a problem. If battery operation is not desired, a simple power supply can be built around a filament transformer as in **fig. 6**. Use a solid-state bridge rectifier, with each diode having a rating of at least 1 ampere and 30 volts PIV. A secondary voltage above 20 volts ac is not recommended.

multimode detector

The Plessey SL624C IC can be used to detect a-m, fm, ssb or CW signals. In ssb and CW reception it functions as a product detector with built-in oscillator. Operation as a quadrature detector recovers fm while a-m signals are demodulated with a synchronous detector. As an a-m detector, the SL624C is capable of rejecting broadband i-f noise as compared to a conventional envelope detector. The SL624C has been designed specifically for use in mobile, hf, and vhf transceivers. With a suitable circuit arrangement it can also be used to demodulate fm broadcast or TV audio signals.

The SL624C IC is shown in **fig. 7**. At left is an audio amplifier with input at pin 1 and outputs at pins 15 and

*Available from Audionics, 8600 NE Sandy Boulevard, Portland, Oregon 97220.

16. This amplifier has a gain of 12 dB. Included also is a limiting amplifier with input at pins 3 and 4 and output at pins 6 and 7. This amplifier operates up to 30 MHz and starts limiting with a 100-mV input level. Loop gain is about 70 dB. The limiting amplifier can be operated as

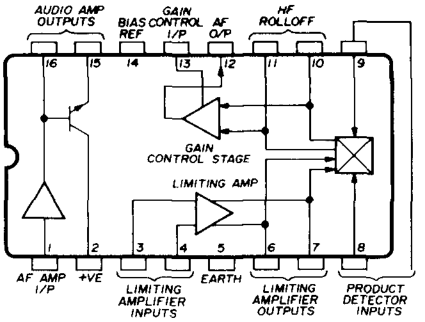


fig. 7. Plessey SL624C multimode detector can be used to detect a-m, fm, ssb or CW signals. Practical detector circuits using this IC are shown in fig. 8.

a beat-frequency oscillator as in the demodulation of an ssb signal.

The detector is a double-balanced modulator (like the Plessey SL640C). The limiting amplifier output is applied to the detector. The detector output connects to the audio gain control stage input. This gain can be regulated with a control voltage at pin 13. Audio output is removed from the gain stage and made available at pin 12. If desired, the output can be muted by connecting pin 13 to ground with a switch or electronically with a squelch circuit.

Practical detector circuits are given in **fig. 8.** In the sideband demodulation mode, the limiting amplifier is operated as a crystal oscillator. Its output is applied to the detector. Note the external crystal and the connection to pins 6 and 7. The sideband signal to be demodulated is applied through a coupling capacitor to pin 8. After passing through the gain control stage, the recovered audio is removed at pin 12 and applied through the 0.1 μF capacitor to the audio amplifier input through pin 1. Audio can be taken at either pin 15 or 16. The signal input requirement is 50 mV maximum, but good performance at a lower audio level can be obtained with an input as low as 5 mV.

In the synchronous detection of an a-m signal, input is applied to the detector through pin 8. Signal is also applied into the limiting amplifier through pin 3. In the limiting amplifier, the carrier is separated from the modulation and is used to generate a demodulating carrier component, which is applied to the detector and used to demodulate the incoming a-m signal. Adequate signal must be applied to permit limiting during modulation troughs to avoid distortion. The input signal should be 5 to 50 mV. An external agc system is recommended for this detection mode.

In fm detection, the signal is applied to the limiting amplifier input at pin 3, then through a phase-shift network to the detector input. Also the quadrature component is applied to the detector input through pins 8 and 9. Note the resonant circuit C1-L1. The detector output is proportional to the relative phase of the two inputs, with the quadrature component (which does not deviate) serving as a reference phase. The recommended input signal should be at least 200 μV, although demodulation occurs with an input signal as low as 100 μV. The only adjustment required is that of the phase-shift circuit. An external squelch circuit is used to reduce high-level noise when no signal is being received.

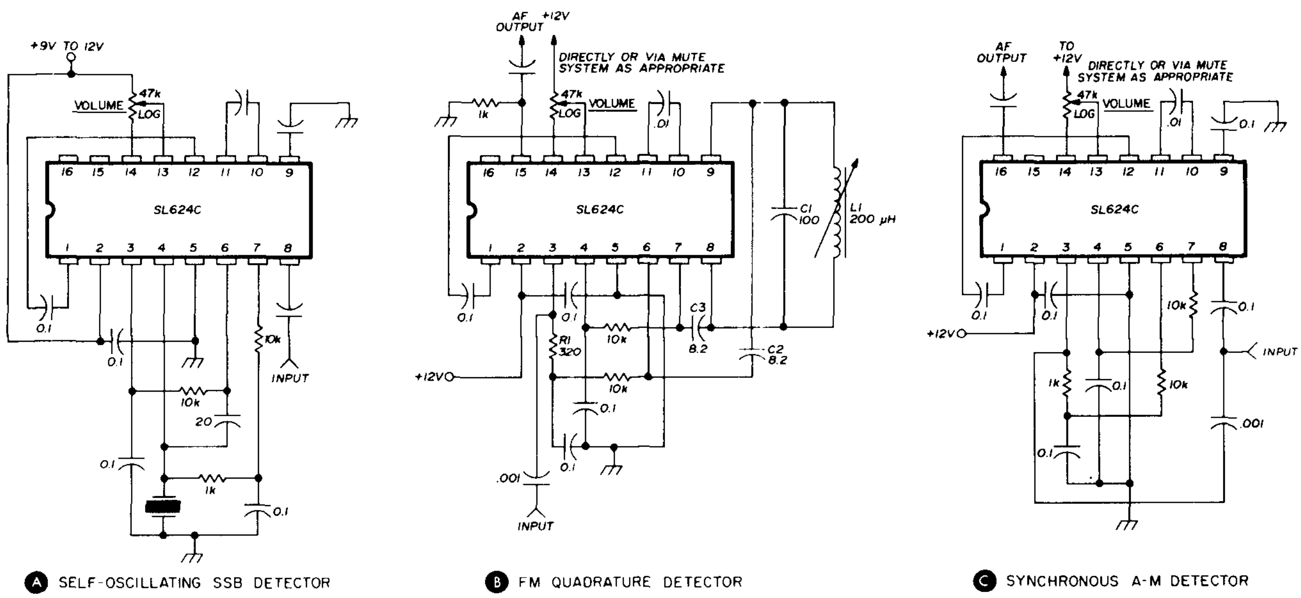


fig. 8. Practical detector circuits using the Plessey 624C include a self-oscillating ssb detector (A), fm quadrature detector (B), and synchronous a-m detector (C).

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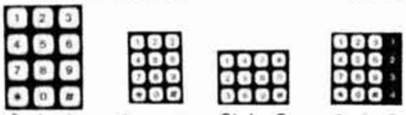

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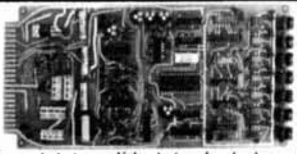

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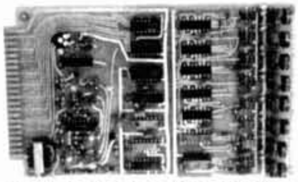

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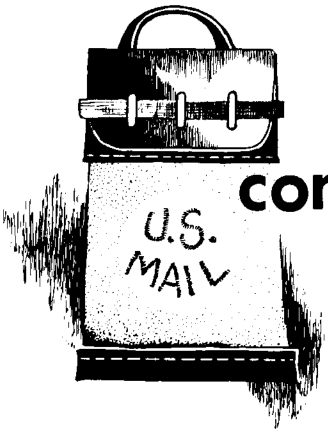


comments

microstripline preamplifiers

Dear HR:

WA6UAM's article on "Microstrip Preamplifiers for 1296 MHz,"[1] with a few exceptions explained below, is an excellent article. Having worked with stripline for several years, especially in development of the TIROS-ESSA antenna matching circuitry, I can attest to the value of such a practical construction article for the uhfer. It was also very timely, as more and more amateurs are starting to use stripline techniques to build uhf equipment.

However, in the design section of the article, several unfortunate errors and contradictions appear in the treatment of the S-parameter reflection coefficients and impedances, which are confusing and misleading, even to one who is familiar with S-parameter techniques. The confusion begins in the first paragraph on page 22, where the author states that complex impedances are generally shown in polar form, but can be converted to rectangular form through use of the Smith chart, as per instructions in the caption of **fig. 12**. The inference is quite clear that the conversion intended is between the polar and rectangular forms of an equivalent value of *impedance*. However, it is not *impedance* which is being converted, and furthermore, the Smith chart cannot perform this type of conversion. Therefore, the inference is incorrect.

The confusion is compounded in the next paragraph, where it is stated that **table 1** lists complex *impedances* in both polar and rectangular forms, while in the table itself both the polar and rectangular forms are stated to be *reflection coefficients*. This contradiction needs clarification, and the statements emphasize the previous, erroneous inference that the associated values appearing in polar and rectangular form in the table are numerically equivalent, while in fact they are not.

The confusion can be easily cleared up as follows: First, it is evident that the author is randomly interchanging reflection coefficient and impedance, confusing the polar-form reflection coefficient with the polar-form equivalent of the rectangular-form impedance. The two are not the same!

Impedance, $Z = E/I$, describes the relation between voltage and current in a circuit. Reflection coefficient, ρ, on the other hand, is the relationship between two voltages (the reflected and the incident) in a circuit containing *two* impedances at a junction, or two currents in the same circuit:

$$\overline{\rho} = \frac{E_{reflected}}{E_{incident}} = -\frac{I_{reflected}}{I_{incident}}$$

Accordingly, to clarify the first paragraph on page 22 of WA6UAM's article, the phrase "complex *impedances* in polar form . . . " is a mistatement which should be changed to read "complex *reflection coefficients* are generally shown in polar form, which can be converted to *impedance* in rectangular notation (R ± jX) on a Smith chart as indicated in **fig. 12**" (after the caption of **fig. 12** is also corrected).

Second, the complex numbers appearing in *polar* form in **table 1** are reflection coefficients, and the rows containing the polar-form values should be so labelled. Third, the complex numbers appearing in *rectangular* form in **table 1** are the *impedances* which will give rise to the accompanying value of reflection when terminating a line or source having an impedance of 50 ohms. In other words, taking an example from the second HP-25826E column, the 12.5 + j0.5 value is *not* the rectangular equivalent of the polar value 0.61 ∠178°, but is the complex impedance which will *yield* the complex reflection coefficient $\overline{\rho}$ = 0.61 ∠178° when the impedance 12.5 + j0.5 terminates a 50-ohm line or source. The rows containing complex numbers in the rectangular form should therefore be specifically labelled *impedance* S_{11} or S_{22}, as appropriate. Proof that the rectangular-form impedance is not equivalent to the listed polar value is further shown by the fact that the polar equivalent of the impedance 12.5 + j0.5 is actually 12.51 ∠2.29°, and *not* 0.61 ∠178°.

Fourth, as constructed in **figs. 9, 10, 11** and **13**, the graphs containing the S_{11} and S_{22} plots should be labelled *impedance*, not "reflection coefficient" because the only loci-identifying coordinates in the graphs are the resistance and reactance circles. The S-parameter graphs in the Hewlett-Packard design catalog[2] from which the figures in the article were taken contain *two* sets of coordinates by which the loci may be identified: resistance- and reactance-circle coordinates to identify the loci as impedances, *and* radial magnitude and angle coordinates to identify the loci as reflection coefficients. Thus the user could use whichever set of coordinates he desired to read the loci as impedances or reflection coefficients.

It is apparent in unravelling all this confusion that a misunderstanding also exists concerning the basic functions of the Smith chart. The function which the Smith chart is really performing in **fig. 12** is the conversion from the complex

1. H. Paul Shuch, WA6UAM, "Microstropline Preamplifiers for 1296 MHz," *ham radio*, April, 1975, page 12.

2. "Diode and Transistor Designers Catalog," Hewlett-Packard, May, 1974.

reflection coefficient in the polar form to the *normalized impedance* in the rectangular form. The magnitude (radius) and angle $0.8 \angle -50^\circ$ in **fig. 12** define a specific point in *reflection-coefficient* coordinates of the chart, while normalized impedance is found at this same point where the *r* and *x* impedance coordinates of 0.6 and 2.0 intersect, respectively. It cannot be emphasized too strongly that the chart is *not* converting impedance in the polar form to its equivalent impedance in the rectangular form.

Polar-to-rectangular conversion of equivalent impedances is relatively simple to calculate using the Pythagorean theorem. However, conversions between reflection coefficient and impedance are more difficult to calculate, hence the Smith chart is used to simplify reflection-to-impedance conversions. As a point of interest, polar-to-rectangular impedance conversions *can* be performed with an overlay combination of Smith and Carter charts having the same diameters (the Carter chart has impedance coordinates arranged to identify impedance in polar form). With the Smith-Carter overlay the user may enter the Smith chart in rectangular form and the corresponding point on the Carter chart is the polar-form equivalent. As a further point of interest, here is the expression for calculating the conversion from a complex reflection coefficient $\overline{\rho}$ to *normalized* impedance:

$$\frac{Z}{Z_c} = \frac{R + jX}{Z_c} = \frac{1 + \overline{\rho}}{1 - \overline{\rho}} = \frac{1 + \rho \angle \theta}{1 - \rho \angle \theta}$$

$$= \frac{1 + \rho \cos \theta + j\rho \sin \theta}{1 - \rho \cos \theta - j\rho \sin \theta}$$

Going in the opposite direction, to determine the reflection set up by a given complex impedance loading a line of impedance Z_c, we have

$$\overline{\rho} = \rho \angle \theta = \frac{R + jX - Z_c}{R + jX + Z_c}$$

Two additional errors of lesser importance are, first, on page 25 at the beginning of column 2, the shunt equivalent value of the series impedance 40 + j25 ohms should be changed from 34.8 +j55.6 ohms, to read *55.6 + j89* ohms. And second, the NEC VO21 column of **table 1**, the reactance −j38.5 in the parallel-circuit input impedance should be changed to indicate a *positive* reactance.

As a final point of interest, in 1953 the American Standards Association (ASA) adopted the Greek letter rho, ρ as the symbol to represent reflection coefficient, and many textbook and periodical publishers, as well as manufacturers of S-parameter measuring instrumentation, conformed. Prior to 1953, ρ was often used to indicate swr, while gamma, Γ and k were used interchangeably to represent reflection. It would be interesting to know why the people at Hewlett-Packard who produce solid-state components continue to use Γ, while those who produce the instruction manuals for their impedance and S-parameter measuring equipment are using ρ.

Walt Maxwell, W2DU
Dayton, New Jersey

W2DU has raised a valid point with regard to the rather loose terminology which I used in my recent article, and I concede that reflection coefficient and impedance are not synonomous, although they are related.

Several readers have questioned my failure to consider the transistor's transfer coefficient in calculating the matching networks. Actually, my simplistic design method, which ignores S_{12} in particular, results in a minute matching error which may be compensated by adjusting the trimmer capacitors at the input and output of the preamplifier.

For the benefit of those readers who have inquired about Rollett's stability factor, I should mention that K calculates to greater than unity for all transistor/bias combinations presented in the original article so the amplifiers are unconditionally stable. Nevertheless, I caution the builder to treat them as though they were not. That is, do not apply power until the amplifier is properly terminated in an antenna (or dummy load) and a converter

H. Paul Shuch, WA6UAM

HP-65 oscar tracking program

Dear HR:

A program, written for the Hewlett-Packard HP-65 programmable calculator is available for computing both azimuthal and elevation coordinates for tracking either OSCAR 6 or 7. Once the satellite orbital data and individual station positional coordinates are inputed and stored, the routine will compute az/el antenna pointing coordinates for any number of arbitrary, specified times following the ascending node. Az/el coordinates computed with this routine for both ascending and descending passes agree favorably with the results of a FORTRAN program run on a CDC-3800 computer and with actual observed satellite trajectories. The program can be stored on a single HP-65 magnetic card. Documented copies of the program will be forwarded upon request and receipt of a self-addressed, stamped envelope; if a blank magnetic card is included with the request, a copy of the program itself will be sent.

Earl F. Skelton, WA3THD
Washington, DC

lower telephone rates

Dear HR:

I am sure many of the readers of *ham radio* have seen the recent ads run by the telephone company depicting the new, low long-distance rates. For the minimum of one minute for 56¢ (at times, even less, depending on the distance) one may call coast to coast. In the evenings, from Sunday to Friday, 8 pm to 11 pm, a one-minute telephone call costs 36¢ or less. For nights and weekends, every night from 11 pm to 8 am and Saturdays and Sundays, the first minute is only 22¢.

It occurs to me that many hams who wish to communicate with another ham anywhere in the U.S., may alert the other party by placing a one-minute call, which would be all the time necessary to convey information as to frequency and a scheduled time. Previously, minimum rates were for 3 minutes and at triple the price. It's a good point to keep in mind when wishing to get another station on the air.

David Greene, W2IAO
West Orange, New Jersey

the ham notebook

versatile audio oscillator

Here's a versatile audio oscillator which can be put to many uses including an audible logic indicator, sidetone oscillator, code-practice oscillator, square-wave signal generator and many others.

In the circuit of **fig. 1** transistors Q2 and Q3 are arranged as a basic collector-coupled astable multivibrator; power is taken from the collector of Q1 which acts as a switch for Q2 and Q3. With S1 closed and S2 open, Q1 is cut off and the B1 battery potential is furnished to Q2-Q3 through R1. With both S1 and S2 closed, Q1 is saturated and its collector potential drops to near ground; therefore, no voltage is available for Q2-Q3 and oscillation ceases.

The frequency of oscillation is essentially independent of the B1 supply voltage and is determined by:

$$f = \frac{1}{0.69(C1 \cdot R5 + C2 \cdot R4)}$$

If R4 = R5 and C1 = C2, then the output will be a symmetrical square wave. The frequency of oscillation can be varied by changing the value of either R4 or R5 or both; however, if R4 and R5 are not changed a like amount, output symmetry will be lost. With the circuit values shown, a 100k pot in series with a 20k resistor could be substituted for R5.

The oscillator output is taken from the Q3 collector via C3. The size of C3 has a marked effect on output volume when a low-impedance load, such as a speaker, is used. Values of 2 µF or larger are quite satisfactory for all impedance loads and will furnish ample audio volume. If only high-impedance loads are used such as 2k headphones, a 0.05 µF disc capacitor will provide adequate audio coupling. If a better impedance match and slightly more volume are desired, an audio output transformer may be used (**fig. 2**).

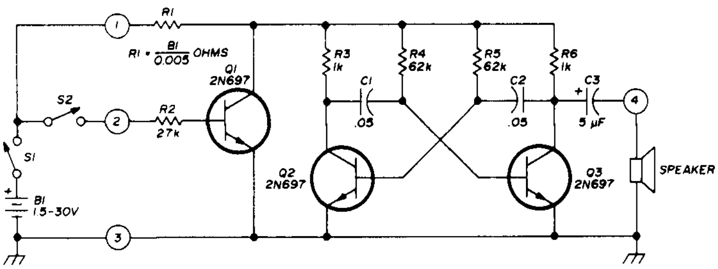


fig. 1. Versatile audio oscillator circuit which may be used as an automobile headlight indicator, audible logic indicator, sidetone oscillator or square-wave signal generator. Oscillation frequency can be varied by changing R4 or R5.

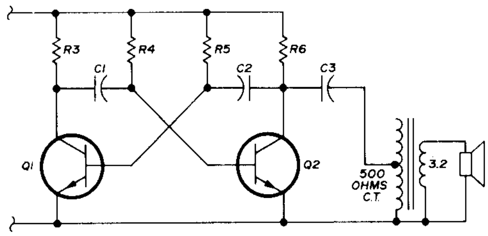
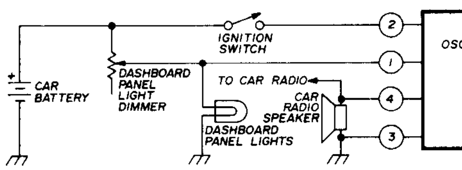


fig. 2. Slightly more audio output can be obtained from the oscillator of fig. 1 by using an audio output transformer.

When used as an automobile headlight reminder (with a negative-ground car) connect the circuit as follows:



Power for the oscillator is derived from the dashboard panel lights, which are turned on simultaneously with either the parking lights or headlights. If the ignition key is turned on, Q1 saturates and disables Q2-Q3; with the ignition off Q1 is cut off and the Q1 collector voltage rises, providing power to Q2-Q3. The audio output may be connected directly to the car radio speaker voice coil high side without affecting car radio operation.

By connecting the oscillator port 1 to the panel lights the oscillator may, if desired, be purposely disabled with

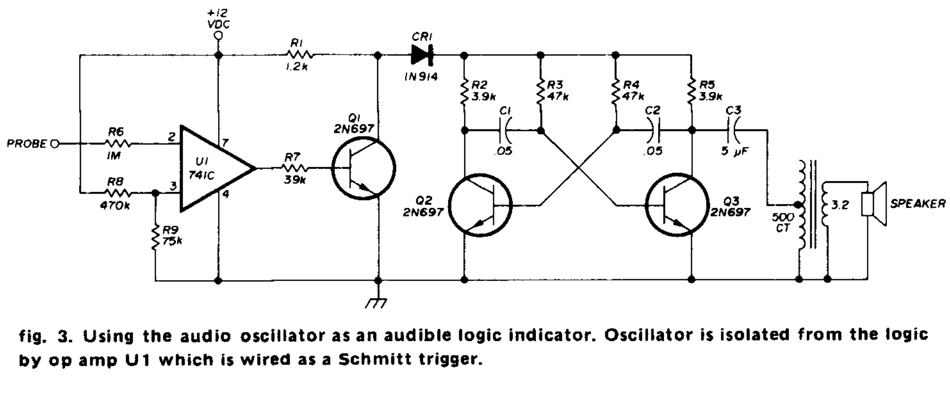
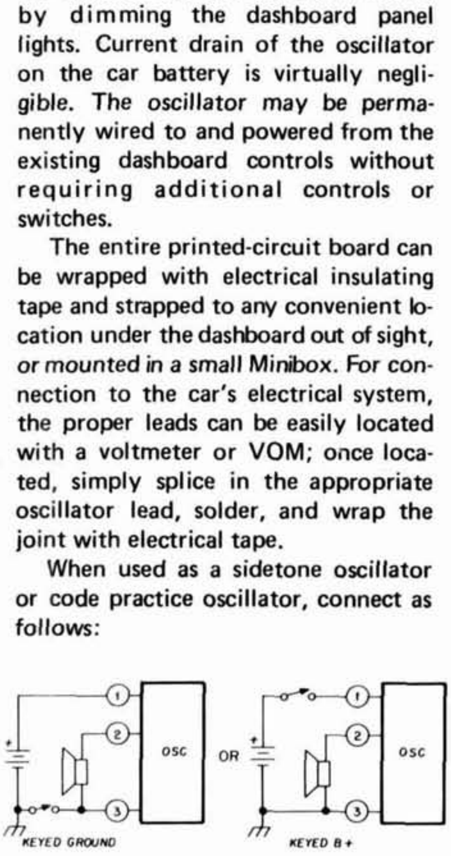


fig. 3. Using the audio oscillator as an audible logic indicator. Oscillator is isolated from the logic by op amp U1 which is wired as a Schmitt trigger.

the ignition off and lights on merely by dimming the dashboard panel lights. Current drain of the oscillator on the car battery is virtually negligible. The oscillator may be permanently wired to and powered from the existing dashboard controls without requiring additional controls or switches.

The entire printed-circuit board can be wrapped with electrical insulating tape and strapped to any convenient location under the dashboard out of sight, or mounted in a small Minibox. For connection to the car's electrical system, the proper leads can be easily located with a voltmeter or VOM; once located, simply splice in the appropriate oscillator lead, solder, and wrap the joint with electrical tape.

When used as a sidetone oscillator or code practice oscillator, connect as follows:



In the above configurations, Q1 and R2 may be eliminated, if desired. The entire oscillator may be constructed on a PC board measuring only 1-1/8 by 3/4 inch (29 by 19mm) if TO-92 transistors are used. For TO-5 transistors the board is slightly larger, 1¼ by 7/8 inch (32 by 22mm). Height of the board with components is about ½ inch (13mm). Since the circuit is very simple, point-to-point wiring on terminal strips is another alternative if automobile installation is not intended.

Layout of components is not critical, nor is selection of Q1-Q3. Although 2N697s are specified, unmarked npn transistors from surplus computer boards were used for the fifteen or so automobile headlight units I've built so far; all worked as intended the first time.

For the IC enthusiast, Q1-Q3 can be individual transistors in an array such as the CA3018 (TO-5 case) or the CA3046 (14-pin DIP). However, if ICs are used, a 1N914 diode will be necessary from the Q1 collector to R3; otherwise, it may be omitted.

When the oscillator is used as an audible logic indicator, or audible logic-state indicator, additional isolation of the oscillator from the probed circuit element should be provided to prevent loading the logic circuit. A high-impedance input op-amp is ideal for this application. **Fig. 3** shows the circuit.

The op-amp is configured as a poor-man's Schmitt trigger; i.e., a fairly rapid output transition occurs at a specific preset input voltage level by omitting the usual feedback resistor between pins 6 and 2. The op-amp acts simply as a very-high-input-impedance inverter with virtually no hysteresis about the preset transition reference voltage level appearing at the non-inverting input, pin 3. This reference voltage is easily provided by the resistive divider network R8-R9.

Since a TTL-compatible logic probe was desired, the reference level was set for +1.6 volts. The zero logic state maximum voltage for the SN7400 series TTL ICs is about 0.8 volt; the minimum 1 logic level is about +2.4 volts. The +1.6 volt reference level is an arbitrary selection between the two TTL logic levels. When the probe input voltage is below +1.6 volt the op-amp output is approximately 10.5 volts, which saturates Q1 and disables Q2-Q3; when the probe voltage is above +1.6 volt, the U1 output is about 2 volts, which cuts off Q1, and power is supplied to Q2-Q3. R7 must be selected to allow cutoff of Q1 when the U1 output is low, and permit saturation of Q1 when the U1 output is high.

These are just a few of the possible applications for this handy and inexpensive oscillator; further applications are left to the ingenuity and imagination of the reader.

Howard F. Batie, W7BBX

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More Details? CHECK—OFF Page 102

NEW products

two-meter fm transceiver

The new products announcement of Standard's new Horizon 2, a 12-channel, 25-watt vhf fm transceiver, in the November issue of *ham radio* contained a typographical error: the correct amateur price is $295.00 Contact your local dealer for further details.

vhf fm power amplifiers

The new M-Tech P50A1 vhf power amplifier is designed specifically for amateurs with low power two-meter fm transceivers or hand-held units – 1 to 3 watts input will deliver 40 to 65 watts output. The P50A1 is designed for operation with a 13.6-volt power supply (8 amps) and is rated for an 85% duty cycle. The unit includes COR switching with an LED indicator and a spurious output filter, and is priced at $139 postpaid.

Other 144-MHz fm power amplifiers in the M-Tech line include the P15A1 (1-3 watts input, 12-25 watts output, 100% duty cycle) which features solid-state switching and is priced at $59; the P50A10C (2-18 watts input, 14-60 watts output, 100% duty cycle), $98; the P100A10 (5-12 watts input, 60-100 watts output, 85% duty cycle), $198; the P100A20 (18-35 watts input, 80-100 watts output, 85% duty cycle), $155; and the P100A5 (2-5 watts input, 40-100 watts output, 85% duty cycle), $198. All amplifiers are vswr protected for *any* load, include a reverse current protection circuit, use microstrip inductors for stability, and carry a 1-year factory warranty. All amplifiers except the P15A1 feature COR switching with an LED indicator and a spurious output filter.

M-Tech also manufactures two solid-state power amplifiers for the 220-MHz band, the P30A1-220 (1-3 watts input, 30-45 watts output, 85% duty cycle) and the P30A10-220 (2-18 watts input, 12-40 watts output, 100% duty cycle). Both of these units feature COR switching with LED indicator.

For more information on M-Tech's *Quality Emphasis Line* of vhf-fm power amplifiers, write to M-Tech Engineering, Inc., Box C, Springfield, Virginia 22151, or use *check-off* on page 102.

random-wire antenna tuner

If you like portable operation and want to get on the air with the least amount of trouble, a random-length wire antenna is hard to beat. You'll need a tuner for the random wire, and SST Electronics has the answer with the SST T-1. The SST T-1 tunes from 80 through 10 meters and handles 200 watts. It matches the low-impedance output of your transmitter and the low-impedance input of your receiver to the high impedance of a random-length wire antenna. Simple and foolproof design features an LC circuit and neon-bulb tune-up indicator. It's compact, only 3 by 4¼ by 2-3/8 inches (7.6 by 11x1cm). The SST T-1 sells for $24.95 postpaid and is guaranteed for 90 days against defects in parts and workmanship. For more information, write SST Electronics, P. O. Box 1, Lawndale, California 90260, or use *check-off* on page 102.

power-line monitor

A new compact high-low power-line monitor with a convenient swivel plug for use directly in an ac outlet or through a standard multi-socket cube is now available from RCA. This small inexpensive test instrument is an ideal tool for every amateur's toolbox and reads from 50 to 150 volts ac (true rms), 50-60 Hz with a plus or minus 5 per cent accuracy. Circular in shape, the new monitor is only two inches in diameter and one inch deep (5x2.5cm), and weighs only three ounces (85g).

The RCA WV-548A Hi/Low power line monitor is priced at $9.95. For additional information on RCA Electronic Instruments contact RCA Distributor and Special Products Division, 2000 Clements Bridge Road, Deptford, New Jersey 08096, or use *check-off* on page 102.

test equipment

The 24-page Tucker Electronics Sales Bulletin lists a wide variety of reconditioned test equipment as well as a dozen different lines of new instruments. Although the bulletin shown above was released in May, new sales bulletins are issued periodically. For your copy, write to Tucker Electronics Company, Post Office Box 1050, Garland, Texas 75040, or use *check-off* on page 102.

volt-ohm-milliammeter

The Triplett Corporation has introduced an unconventional type of volt-ohm-milliammeter that gives the user an "extra-chance" after misuse . . . and not a repair bill. This virtually indestructible test instrument has built-in protection against accidental high energy overload, is shock resistant to accidental drops up to a five foot (1.5m) height, is of modular construction so that it can be easily and quickly serviced in the field and has been designed to the most rigid safety standards to prevent any hazard of electrical shock to the user. Triplett has aptly named it the "Extra-Chance" model 60.

The new vom has no exposed metal parts, providing complete insulation of the instrument itself, special test leads for increased safety and a three-fuse testing system which greatly reduces fire and explosion hazard under misuse conditions. Two 48-inch (1.2m) long safety test leads are supplied and connect to the control panel by special safety connectors.

A rugged case molded of black, high impact thermoplastic material in combination with a ruggedized suspension meter result in a vom that is virtually indestructible from accidental drops up to a five-foot (1.5m) height. The meter movement is protected by a diode module; fuses are used for normal overload conditions. A fuse plus two zener diodes are used to protect against high energy fault currents and protect the circuit up to 1000 volts. A separate, sealed battery compartment permits easy external access to batteries and fuses without having to remove other parts of the instrument.

A single range selector switch is used for selecting all 33 ac/dc voltage, ac output, resistance, dc current and decibel ranges from −20 to +52 dB plus the *off* and *test* positions. Accuracy on all dc and resistance ranges is ±2 per cent of full scale; ac accuracy is ±3 per cent of full scale. The Triplett model 60 (catalog number 3145) comes complete with a one-year parts and labor warrantee, safety test leads, batteries, spare fuses and instruction manual, and sells for $90. For additional information, write to the Triplett Corporation, Department, PR, Bluffton, Ohio 45817, or use *check-off* on page 102.

seven-segment displays

New high-efficiency solid-state numeric displays, as much as five times brighter than other displays at the same operating current, are now available from Hewlett-Packard. At one-fifth the current, they are equal in brightness to older displays. Their high brightness plus their 0.43 inch (11mm) height makes them ideal for applications in high ambient light conditions. Operating at currents as low as 3 mA, these large displays become practical for use in battery-powered portable instruments. They may also be operated in the strobe mode at currents up to 60 milliamperes peak.

The HP models 5082-7650, -7660, and -7670 are red, yellow and green, common-anode, seven-segment displays with lefthand decimal point. LED chips are optically magnified to form evenly-lighted segments. For improved on-to-off contrast, the bodies of the displays are colored to match the appearance of the unlighted segments.

For more information, contact your local Hewlett-Packard Sales Office, or use *check-off* on page 102.

fet multimeter

A new pocket fet multimeter offering full vtvm ranges and a 10-megohm input, completely protected against overload, is now available from Hickok. Packaged in a rugged, pocket-size case with attached cover the Model 350 provides features which include 1 millivolt resolution on three easy-to-read mirrored scales plus dB and battery condition, high/low ohms ranges, and true autopolarity with a polarity indicator.

High impedance fet circuitry permits vtvm type ranges in this compact unit. Nine voltage ranges of 0.1 to 1000 volts and seven high/low ohms ranges from 100 ohms to 100 megohms center scale make the Model 350 a versatile service tool. One-year service can be expected from the two 9-volt transistor radio batteries. The Model 350 comes complete with two test leads and instruction manual.

For more information, contact Tom Hayden, Instrumentation & Controls Division, Hickok Electrical Instrument Company, 10514 Dupont Avenue, Cleveland, Ohio 44108, or use *check-off* on page 102.

More Details? CHECK—OFF Page 102

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Look what happens to the RF Power Output on our NCX-3. It was tuned for normal SSB operation and then left untouched for these "before" and "after" oscillograms.

Fig. 1 SSB signal **before** processing. See the high peaks and the low valleys. Our NCX-3 is putting out only 25 watts average power.

Fig. 2 SSB signal **after** processing with LSP-520BX. The once weak valleys are now strong peaks. Our NCX-3 now puts out 100 watts of average power.

Three active filters concentrate power on those frequencies that yield maximum intelligence. Adds strength in weak valleys of normal speech patterns. This is accomplished through use of an IC logarithmic amplifier with a dynamic range of 30dB for clean audio with **minimum distortion.**

This unit is practically distortion-free even at 30dB compression! The input to the LSP-520BX is completely filtered and shielded for RF protection.

Size is a mere 2 3/16H x 3½W x 4D. Money back if not delighted and **ONE YEAR UNCONDITIONAL GUARANTEE.**

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LSP-520BX **$49.95**

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Here's another product from the plentiful MFJ line:

SSB FILTER

This filter, packaged very much like the Speech Processor above, allows you to select the optimum audio bandwidth to drastically improve readability.

SBF-2BX, assembled and tested **$29.95**

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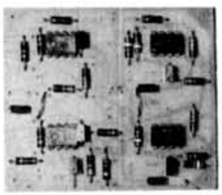

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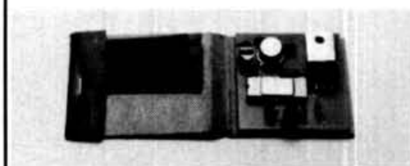

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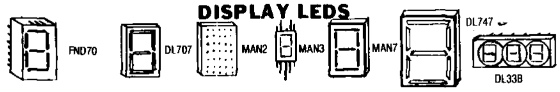

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	1-24	25-49	50-100		1-24	25-49	50-100
8 pin	$.17	.16	.15	24 pin	$.38	.37	.36
14 pin	.20	.19	.18	28 pin	.45	.44	.43
16 pin	.22	.21	.20	36 pin	.60	.59	.58
18 pin	.29	.28	.27	40 pin	.63	.62	.61
22 pin	.37	.36	.35				

SOLDERTAIL STANDARD (TIN)

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

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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

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10 pin	$.45	.41	.37	24 pin	$1.05	.95	.85
14 pin	.39	.38	.37	28 pin	1.40	1.25	1.10
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18 pin	.75	.68	.62	40 pin	1.75	1.55	1.40

50 PCS. RESISTOR ASSORTMENTS $1.75 PER ASST.

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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.

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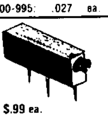
5-25 PCS: .05 ea. 30-95 PCS: .04 ea. 100-495 PCS: .03 ea. 500-995: .027 ea.

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.**

PRIME INTEGRATED CIRCUIT ASSORTMENTS

ASST 8	3 ea	SN7400 SN7410	7401 7430	7402 7438	7403 7440	7404 7472	SSL TTL	$5.95 ASST
ASST 9	2 ea	SN7447 SN74145	7490 74175	7491 74180	74100 74191	74121 74193	MSI TTL	$9.95 ASST
ASST 10	2 ea	CD4001 CD4016	4002 4017	4011 4019	4012 4023	4013 4030	CMOS	$7.95 ASST
ASST 11	2 ea	LM301T LM311T	301N 565T	302T 567T	307T 741T	309K 741N	LINEAR	$10.95 ASST

Satisfaction Guaranteed. $5.00 Min. Order. U.S. Funds.
California Residents — Add 6% Sales Tax
Write for FREE 1976 Catalog — Data Sheets .25¢ each

JAMES
P.O. BOX 822, BELMONT, CA. 94002
PHONE ORDERS — (415) 592-8097

74LS00 TTL

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

DPST
C & K ROCKER SWITCH
$0.69 Dim: 1"x1"x¼"

They are rated at 125 Vac @ 5A. They are excellent in applications such as Microcomputer Panel Switches

MINATURE TOGGLE

DPDT				JMT	1	2-9	10-29	30-99
	ON	OFF	ON	721	3.05	2.66	1.97	1.78
	ON	NONE	ON	723	2.65	2.26	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

Maintained Action Switch Push To Make Contact, And Push Again To Reserve Action

Momentary Action Switch Normally Open or Normally Closed. (For N C circuit use terminals 2 & 1; for N O, 2 & 3; for N C and N O, 1,2,& 3

Model Number	1 Each	Quanity net prices 2-9	10-29	30-99
PB-123	$2.35	$1.95	$1.47	$1.30
PB-126	$2.35	$1.95	$1.47	$1.30

5 AMP RATINGS

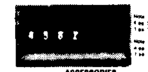
THUMBWHEEL SWITCHES

THUMBWHEEL SWITCH ONLY
SF - Front Mount SR - Rear Mount

Part No.	Description	Price
SF 12	Single Pole 10 Postion	$2.50
SR 12	Decimal	3.00
SF 21	10 Position BCD only	2.50
SR 21		3.00

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

SERIES SF Front Mount Assembly ($11.70)



Note: Picture to the left has the following 4 ea SF-12, 1 ea SF-EP, 1 ea SF-BB, 1 ea SF-DP and 1 ea SF-HB

Note: Picture to the right has the following 4 ea SR-12, 1 ea SR-EP, 1 ea SR-BB, 1 ea SR-DP and 1 ea SR-HB

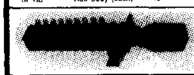
SERIES SR Rear Mount Assembly ($13.70)

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



6PDT SWITCH
HIGH QUALITY P.C. TYPE **69 ea.**
PUSH BUTTOM SWITCHES
FOR INSTRUMENT APPLICATIONS
¼" x ¼" x 3¼" .69c each

ZENERS–DIODES–RECTIFIERS

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
IN746	3.3	400m	4/1.00	IN4003	200 PIV	1 AMP	10
IN751A	5.1	400m	4/1.00	IN4004	400 PIV	1 AMP	10
IN752	5.6	400m	4/1.00	IN3600	50	200m	6/1.00
IN753	6.2	400m	4/1.00	IN4148	75	10m	15/1.00
IN754	6.8	400m	4/1.00	IN4154	35	10m	12/1.00
IN965B	15	400m	4/1.00	IN4734	5.6	1w	28
IN5232	5.6	500m	28	IN4735	6.2	1w	28
IN5234	6.2	500m	28	IN4736	6.8	1w	28
IN5235	6.8	500m	28	IN4738	8.2	1w	28
IN5236	7.5	500m	28	IN4742	12	1w	28
IN456	25	40m	6/1.00	IN4744	15	1w	28
IN458	150	7m	6/1.00	IN1183	50 PIV	35 AMP	1.60
IN485A	180	10m	5/1.00	IN1184	100 PIV	35 AMP	1.70
IN4001	50 PIV	1 AMP	09	IN1186	200 PIV	35 AMP	1.80
IN4002	100 PIV	1 AMP	10	IN1188	400 PIV	35 AMP	3.00

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	$.89	2N4013	3/$1.00	2N5209	5/$1.00
2N3392	5/$1.00	2N4014	3/$1.00	2N5951	5/$1.00
2N3398	5/$1.00			C106B1SCR	2/$1.00

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-49	50-100		1-9	10-49	50-100
10pf	.05	.04	.03	.001	.05	.04	.035
22pf	.05	.04	.03	.0047	.05	.04	.035
47pf	.05	.04	.03	.01	.05	.04	.035
100pf	.05	.04	.03	.022	.06	.05	.04
220pf	.05	.04	.03	.047	.06	.05	.04
470pf	.05	.04	.035	.1	.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	50	.15	.13	.10	.47	25	.15	.13	.10
1.0	50	.16	.14	.11	.47	50	.16	.14	.11
3.3	50	.15	.13	.10	1.0	16	.15	.13	.10
4.7	25	.16	.14	.12	1.0	25	.16	.14	.11
10	25	.15	.13	.10	1.0	50	.16	.14	.11
10	50	.16	.14	.12	4.7	16	.15	.13	.10
22	25	.17	.15	.12	4.7	25	.15	.13	.10
22	50	.24	.20	.18	4.7	50	.16	.14	.11
47	25	.19	.17	.15	10	16	.14	.12	.09
47	50	.25	.21	.19	10	25	.15	.13	.10
100	25	.24	.20	.18	10	50	.16	.14	.12
100	50	.35	.30	.28	47	50	.24	.21	.19
220	25	.32	.28	.25	100	16	.19	.15	.14
220	50	.45	.41	.38	100	25	.24	.20	.18
470	25	.33	.29	.27	100	50	.35	.30	.28
1000	16	.55	.50	.45	220	16	.23	.17	.16
2200	16	.70	.62	.55	470	25	.31	.28	.26

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DIGITAL DATA RECORDER
for
Computer or Teletype Use
Up to 2400 Baud

Uses the industry standard tape saturation method to beat all FSK systems ten to one. No modems or FSK decoders required. Loads 8K of memory in 34 seconds. This recorder enables you to back up your computer by loading and dumping programs and data fast as you go, thus enabling you to get by with less memory. Great for small business bookkeeping. Imagine! A year's books on one cassette.

Thousands are in use in colleges and businesses all over the country. This new version is ideal for instructional, amateur, hobby and small business use. Ideal for use by servicemen to load test programs. Comes complete with prerecorded 8080 software program used to test the units as they are produced. (Monitor)

SPECIFICATIONS:

A. Recording Mode: Tape saturation binary. This is not an FSK or Home type recorder. No voice capability. No modem.

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

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

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

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

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

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

H. Warrantee: 90 days. All units tested at 110 and 2400 baud before shipment. Test cassette with 8080 software program included. This cassette was recorded and played back during quality control.

COMING NEXT MONTH — IN KIT FORM

* Hexadecimal Keyboard — Load programs direct from keyboards' 16 keys and verifying display. Does not use Computer I/O.
* I/O for use with Computer Aid or other digital recorders. Variable baud rate selectable on externally located unit by one knob. Can load computer or accept dumps without software. Turnkey Operation. For any 8 bit computer.
* Record/Playback Amplifier
  Expanded version of our Computer Aid board for use with your own desk (cassette or reel to reel). Go to 9600 baud on reel to reel. Digital in, digital out, serial format.
* Interested in these? Send your name and address for brochure when released.

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South Plainfield, New Jersey 07080

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.... Data Recorder @ $149.95

.... Operating & Technical Manual (Schematics) @ $1.00

*.......... New Products, No Charge

Please enclose $2.00 Shipping & Handling

N. J. Residents add 5% Sales Tax

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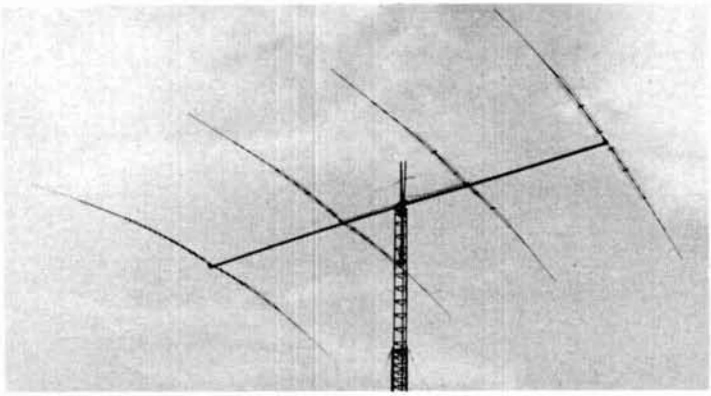
KLM BROADENS ITS BIG STICK LINE OF HIGH FREQUENCY ANTENNAS

4 ELEMENTS 40 METERS



INTRODUCING THE LONG AWAITED, PRACTICAL SIZED, HIGH PERFORMANCE 40 METER "BIG STICK" DUAL DRIVEN YAGI. NOW YOU CAN HAVE **CONSTANT GAIN** AND **LOW VSWR** ACROSS THE 40 METER BAND. **DUAL DRIVEN ELEMENTS** FOR **HIGH EFFICIENCY** AND **CLEAN PATTERN. LIGHTWEIGHT** BUT **STRONG** MATERIALS INCLUDING KLM EXCLUSIVE EPOXY INSULATOR DESIGN . . .

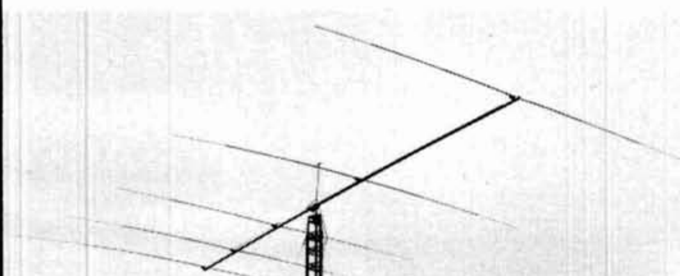
SPECIFICATIONS

FREQUENCY: 7.0-7.3 MHz
ELEMENTS: 4, LINEAR LOADED
46′ MAX. LENGTH
BOOM: 3″ DIA. X 42′ LONG
TURNING RADIUS: 32′
SHIPPING CONTAINER: WOOD CRATE 12′ LONG
125 LBS. TOTAL WEIGHT

GAIN: 7.25 dB/DIPOLE
F/B: 20 dB TYPICAL
FEED IMP.:200 OHMS BALANCED
(50 OHMS WITH OPTIONAL
KLM 5-31 4:1 BALUN — $13.95)
WEIGHT: 85 LBS.
WIND AREA: 10 SQ. FT.

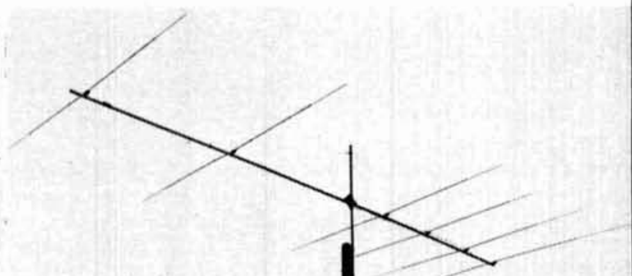
PRICE **$495.00**

20 METER 5 ELEMENT



KLM 13.9-14.4-5 **$249.95**
9.7dB GAIN 30dB F/B

15 METER 6 ELEMENT



KLM 21.0-21.5-6 **$224.95**
10.5dB GAIN 30dB F/B

WHEN YOU SPEAK OF PERFORMANCE IN ANTENNAS, AMPLIFIERS OR TRANSCEIVERS THE NAME IS:

KLM ELECTRONICS

17025 LAUREL ROAD
MORGAN HILL, CA. 95037
(408) 779-7363

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1976 BUYERS GUIDE

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NO GENERAL MAILING WILL BE MADE

YOU MADE US THE NATION'S FM LEADER . . . NOW LET US HELP FILL ALL YOUR AMATEUR NEEDS

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- QUALITY BRANDS

LOTS OF MOTOROLA GOODIES TOO!!

MOTOROLA FANS . . . NEW, SPECIAL GOODIES LIST FREE FOR S.A.S.E.

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HOURS

STORE HOURS:
Mon-Thurs 9:30-6:00, Fri. 9:30-800
Sat. 9:30-3:00, Closed Sun. & Holidays.

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flea market

RATES Non-commercial ads 10¢ per word; commercial ads 40¢ per word both payable in advance. No cash discounts or agency commissions allowed.

HAMFESTS Sponsored by non-profit organizations receive one free Flea Market ad (subject to our editing). Repeat insertions of hamfest ads pay the non-commercial rate.

COPY No special layout or arrangements available. Material should be typewritten or clearly printed and must include full name and address. We reserve the right to reject unsuitable copy. **Ham Radio** can not check each advertiser and thus cannot be held responsible for claims made. Liability for correctness of material limited to corrected ad in next available issue.

DEADLINE 15th of second preceding month.

SEND MATERIAL TO: Flea Market, Ham Radio, Greenville, N. H. 03048.

THE LARGEST SWAP AND SHOP IN MICHIGAN. Southfield Amateur Radio Clubs, January 18, 1975, Southfield High School, Ten Mile and Lahser Rds., Southfield, MI. Tickets $1.50. For more information regarding tickets and/or tables, write to Mr. Robert Younkers, 24675 Lahser Road, Southfield, Michigan 48075.

SELL THE FOLLOWING: Hallicrafters FPM300 Telerex 6 el beam. Winford Barnes, Box 28, Bunker Hill, In. 46914.

WISCONSIN — West Allis Radio Amateur Club annual Midwinter Swapfest, Saturday, January 24, 1976, 8 a.m. at the Waukesha County Expo Center. Directions: I-94 to Waukesha Co. F, south to FT, west to Expo Center. Talk-in 146.52 MHz. Tickets $1.50 advanced, $2.00 at door. (Dealers: advanced registration only.) Write: WARAC, P. O. Box 1072, Milwaukee, WI 53201.

STOLEN from Findlay Radio Club, Inc., club house in Findlay, Ohio, on Oct. 13 or Oct. 14 (it was on the nite or morn., 13 or 14 respectively 1975. 1 — TR-4, Serial No. 16457-A, Drake transceiver; 1 — AC-4, Serial No. 30557, Drake power supply; 1 — 250C, Serial No. E189109, Swan SSB transceiver; 1 — 117XC, Serial No. 015095, Swan power supply; 1 — Astatic D-104 microphone with UGB stand; 1 — FM-2X, Serial No. 11454, Swan transceiver with M-1002 microphone; 1 — FM-2X, Serial No. 11454, Swan matching supply; 1 — TV-2, Swan 6M to 2M transverter. Findlay Radio Club, Inc., P. O. Box 587, Findlay, Ohio 45840.

FREE Catalog. LEDS, microphones, nicads, IC's, relays, ultrasonic devices, precision trimmer capacitors, digital thermometers, unique components. Chaney's, Box 15431, Lakewood, Colo. 80215.

BAZOOKA. DIPOLE . . . Ready to use, with fiberglass center SO239, end insulator 80M, $29.50, 40M, $26.50, 20-15-10M, $23.50 Fiberglass central insulator with SO239, 1000 pound test, $5.95. Trap 2 KW 80/40, 40/20, $18.50 ppd. 1000 pound test. JAC-TENNA, 13850 Victorin. Tracy. P. Que. Canada.

ORIGINAL PETIT MORSE TO RTTY CONVERTER Inventory Closeout. Manufacturer discontinued production. Fantastic price reductions — semi-kit $95, parts kit $255, assembled and tested $380. Also Baudot to Morse (with 64 character buffer) $135 and Baudot to ASCII (perfect for TV typewriter!) $59. SASE for details. Walters, Box 563, Oak Harbor, Wa. 98277.

TRADE — Single channel VHF receiver 108-152 MHz Ex-FAA crystal control squelch double conversion, want R390 or R389 or R648. Bob Bose, 6821 Sally Lane, Edina, MN 55435.

WANTED: Couple "ICEMAN" 2 meter FM transceivers, advise condition, price. Ed Aymond, W5UHV, 6730 Westlake, Dallas, TX 75214.

SPECIAL DESIGNED P.C. BOARDS: Will quote and build special boards per customers specifications. For complete information contact Wayne Camp, Camp Control Co., P. O. Box 174, Garland, Texas 75040.

DX-60, HG-10, $50 plus shipping. SASE for other items. WB6PCV, Marty Bigos, 1926 Fell, S. F., Ca. 415-387-0409.

TELEVISION diagnostic repair course prepared by master technicians. Lessons only $6.00 each. Optional matching one hour cassette tape $6.00 each. Send for first lesson and master index. Guardian, 20 E. Main, Ramsey, N. J. 07446.

CUYAHOGA FALLS Amateur Radio Club Annual Auction and Flea Market. Date: February 27, 1976. Place: Bolich Jr. High - Cuyahoga Falls, Oh. Admission: $1.50 advanced registration. Deadline Feb. 1, 1976. $2.00 door night of auction. Talk-in frequency: 84/24-04/64-52/52. Call W8VPV. Advance Tickets: K8VAK & XYL, 3043 De Walt Dr., Akron, Oh 44312. 216-644-1213.

HOMEBREWERS: Stamp brings list of high quality components. CPO Surplus, Box 189, Braintree, Mass. 02184.

CANADIAN JUMBO SURPLUS and Parts Catalogs. Bargains Galore. Send $1. ETCO-HR, Box 741, Montreal "A" H3c 2V2.

ROCHESTER HAMFEST 1976 is Saturday, May 22. Your name added to mailing list or information — write: Rochester Hamfest, Box 1388, Rochester, N. Y. 14603.

PORTA-PAK the accessory that makes your mobile really portable. $59.95 and $39.95. Dealer inquiries invited. P. O. Box 67, Somers, Wisc. 53171.

WYOMING RANCH LAND. Wild horses, antelope, deer, elk. 10 acres $30 down, $30 month. FREE Maps - Photos -Info. Owner - K6ICS, Mike Gauthier, 9550 Gallatin, Downey, CA. 90240.

JAPANESE TRANSISTORS — All Transistors original factory made. Over 500 types available. Write for free catalog. West Pacific Electronics, P. O. Box 25837, W. Los Angeles, CA 90025.

TRAVEL-PAK QSL KIT — Send call and 25¢; receive your call sample kit in return. Samco, Box 203, Wynantskill, N. Y. 12198.

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

MODERN 60 MIN. CODE CASSETTES. Novice 0-5 wpm, Progressive 5-13 wpm, General 13-15 wpm, Extra 20-22 wpm. $3 each, 4/$10. Royal, Box 2174, Sandusky, Ohio 44870.

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

SOCIETY OF WIRELESS PIONEERS offers Life Membership to active and former C.W. operators on comm'l., military, gov't., etc. wireless/radio circuits. Contact: Society of Wireless Pioneers, Dept. H, P. O. Box 530, Santa Rosa, California 95402.

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

OSCAR SLIDES, set of 5, $1.25. Launch and spacecraft. Proceeds AMSAT. K6PGX, P. O. Box 463, Pasadena, CA 91102.

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

QSL'S — BROWNIE W3CJI — 3035B Lehigh, Allentown, Pa. 18103. Samples with cut catalog 35¢.

MOBILE IGNITION SHIELDING provides more range with no noise. Available most engines in assembled or kit forms, plus many other suppression accessories. Free literature. Estes Engineering, 930 Marine Dr., Port Angeles, WA. 98362.

WANTED: R-390A parts. W6ME, 4178 Chasin Street, Oceanside, Ca. 92054.

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

TELL YOUR FRIENDS about Ham Radio Magazine.

COMPUTER HOBBYISTS! Bargain hunt or sell via On-Line. 18 issues/year - $3.75. Free sample issue from: On-Line, 24695 Santa Cruz Hwy., Los Gatos, CA 95030.

"HAM BUY LINES" Send name and address for Literature. Vito Iacopelli, 1720 77 St., Brooklyn, New York 11214.

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.

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

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

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.

FIGHT TVI with the RSO Low Pass Filter. For brochure write: Taylor Communications Manufacturing Company, Box 126, Agincourt, Ontario, Canada. M1S 3B4.

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.

MICRO-TO MK II deluxe epoxy-glass drilled circuit boards. $4.00 postpaid; with semicons $11.80. K3CUW, 1304B Mass. Ave. S.E., Washington, D. C. 20003.

WANTED: tubes, transistors, equipment, what have you? Bernard Goldstein, W2MNP, Box 257, Canal Station, New York, N. Y. 10013.

QSL CARDS — Something **completely** different. Nothing even close to it on the market! Samples: 25¢. W5UTT, Box 1171D, Garland, TX 75040.

SELL: Drake ML-2, 2M FM. Absolute mint condx! Xtals for 9 channels. Complete - $219. WA3CUQ, 337 E. Main St., Kutztown, Pa. 19530.

TROPICAL HAMBOREE — Miami, Florida — January 24-25. The really international hamfest in a genuinely international city. Meet your island and Latin American DX friends in the only part of the USA — including most of Florida — with a 99 percent promise of January tropical sunshine. Hamboree traditional goodies plus — it's traditional! — always something new. The latest from the manufacturers — the not so late in the giant indoor flea market! At the ARRL forum, January Board Meeting results. Bicentennial QSO/QSL contest, sponsored by City of Miami, announcement and kick-off by Miami officials. Keep up with the state of the art at "Skip" Tenney's renowned microprocessor seminar (details from Skip at Ham Radio Magazine). For the lucky, an Atlas 210X, Heath HW104, Heath 2026, and an ICOM 230 plus much more. The YL's list includes a beautiful diamond ring! Registration $2.00. Hotel data on request. Dade Radio Club, P. O. Box 520073, Miami, FL 33152.

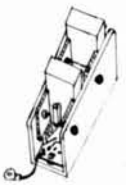
TELETYPEWRITER PARTS, gears, manuals, supplies, tape, toroids. SASE list. Typetronics, Box 8873, Ft. Lauderdale, Fl. 33310. Buy parts, late machines.

MANSFIELD, OHIO MID-WINTER HAMFEST/AUCTION — new day and location. Sunday, February 1, 1976, at Richland County Fairgrounds. Forums, indoor flea market, displays, door prizes, and auction; easy access from 171 and U.S. 30. Registration $1.50 in advance, $2.00 at the door. Tables for flea market $1.00 each. Doors open at 9 a.m.. auction at 2:00. No commission charged. Talk in 3,972.5 kHz, 146.52 and 146.34/94 MHz. Additional info from K8JPF, Harry Frietchen Jr., 120 Homewood Rd., Mansfield, OH 44906. (419) 529-2801 home; (419) 524-1441 work.

STOLEN Regency HR-212 transceiver with microphone and mobile bracket, serial 24-00521; a Vanguard Labs model 201 pre-amp, attached to the back of the HR-212, and a Collins radio logbook. Stolen from my car at Aurora College, Aurora, Ill., on Nov. 13. Randy Thompson, 842 Shagbark Lane, Apt. 302, North Aurora, IL 60542.

FT-101 #130153, w/mods and Shure 444, $525; HW-101 and HBPS, $250; SB220 10HRS, $350; HR-2A and GLB 400B, $275; IB-1100, $125. Call collect 501-843-7602, Glen. WB4ZNW 522 E. Main St. #3, Cabot, Ark. 72023.

NEW NEW 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.

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.1 MFD, 10V ⅜" dia., long leads.
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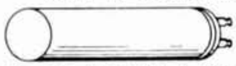

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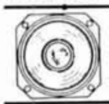

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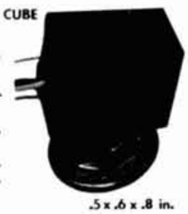

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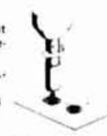

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DESOLDERING AIDS AND HAND TOOLS. R. L. Syphers Associates, Box 883, Dept. H, Bensenville, Illinois 60106.

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

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.

MICHIGAN CHERRYLAND AMATEUR RADIO CLUB annual Swap 'N Shop, Saturday, 14 February 1976. 9:00 a.m. to 4:00 p.m. at the Northwestern Michigan College campus in Traverse City. Talk-in will be 146.52 and 3935. Door prizes. Donation is $1.00. For information contact Bill Mader, WA8WWM, Box 2, Empire A.F.S., Mi. 49630.

FOR SALE: SB-100 with HP23A, $275; SB220, $350; 18AVT/WB, $40; DX-60B with VF-1 VFO, $40; HR-10B, $40. Wanted used tower, tri-band beam, ham-m rotator. John Merrill, WA1LZV, 8 Spruce Drive, Dover, N. H. 03820.

ANTENNAS: Dipole, multiple band arrays. 15 thru 75 meters from $59.50. Mobile Antennas — CB, 20M, 40M, and 2M from $19.50. Baluns: 1:1 and 4:1 - $12.95 ea. Data Available. Savoy Electronics, Inc., P. O. Box 5727, Ft. Lauderdale, Fla. 33310.

TELETYPE MODEL 28: 28RO bases, $35.00, 3/$100.00. New Ribbons, $1.50. Typeboxes (WX, COMM, or Fractions) $25.00 ea. ASR base for LXD TD, $25.00. Base - LXD standalone, $30.00. M28 cabinets, gears, gearshifts, reperf's, TD's, keyboards, terminal units, paper, tape, ASR's, KSR's. SASE for complete list. L. Pfleger, 532 W. Wilson St., #1, Madison, WI 53703.

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.

TTL 7400N 6/$1.00, 7402 5/$1.00, 7406 $.43 each, 7450N & 7453N 4/$1.00, 74121 2/$1.00. 75453 Peripheral Drivers 3/$1.00. 1000V 1 amp diodes 10/$1.00, 14 pin IC sockets 5/$1.00, 18 pin edge connectors 2/$1.00. National CMOS Data Book $1.00 each. Free Catalog. Some quantities limited, all products guaranteed. NuData Electronics, 104 N. Emerson St., Mt. Prospect, IL 60056.

WHEATON HAMFEST — The Wheaton Community Radio Amateurs mid-winter hamfest is Sunday, February 8, at the DuPage County Fairgrounds, Wheaton, Illinois (Manchester Road, near County Farm Road), 8 a.m. to 5 p.m. Tickets $1.50 advance, $2.00 at the door. For advance tickets send $1.50 each and a self-addressed stamped envelope to L. O. Shaw, W9OKI, 433 S. Villa Avenue, Villa Park, Illinois 60181. Advance tickets postmarked no later than February 1.

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INDIANA — THE FIRST HAMFEST OF 1976, the Fort Wayne Hamfest, is January 18, 1976, at Shiloh Hall, one-half mile west of Indiana 3 on the Carroll Road. More tables and space than last year. Flea market, food, drinks. Tickets are $1.50 at the door. XYL's and children under 12 free. Tables available at $1.00 for 4 feet. Talk-in on 28-8 and 16-76. Everyone welcome to start off 1976 with a bang! Write to the AC-ARTS, Inc., P. O. Box 342, Fort Wayne, IN 46801 for details.

WANTED: Cabinet for 51J-4 Collins. KP4BJM. 1713 Gardenia St., San Fco., Rio Piedras, P. R. 00927.

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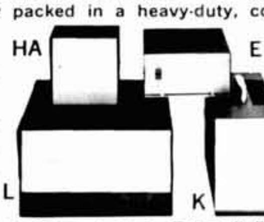

MODEL	WIDTH-HEIGHT-DEPTH	RESALE NET
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AA*	4 x 3-7/16 x 3-⅛	5.50
B	5-11/16 x 3-⅜ x 3-¾	5.55
BB*	9 x 2-½ x 3-⅛	5.90
C	7-¼ x 3-⅜ x 5	7.80
D	8 x 2-½ x 8**	9.85
E	6-½ x 3-15/32 x 7-1/16	9.25
F	7-½ x 4-½ x 10	11.15
G	10-1/16 x 3-5/16 x 9	11.15
HA	5-⅛ x 5-½ x 4	7.85
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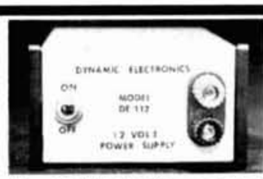

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MANUALS for most ham gear made 1940/65, some earlier. Send SASE for specific quote. Hobby Industry, WØJJK, Box H-864, Council Bluffs, Iowa 51501.

STOLEN: IC-230 (No. 240 1926), Heathkit HWA-202-6 Colinear, and Data Tone 2 touch tone encoder. Stolen from my car in Tampa, FL on Oct. 31, 1975. Report filed with Hillsborough County Sheriff Dept. Bud Holman, WA4ASJ, P. O. Box 698, Vero Beach, FL 32960.

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STOLEN in Chicago area on 10-25-75. KDK 144-10SX Serial #5446. Nick Kalafice, WØOZZ, 117 West Glencrest Drive, Mankato, Minn. 56001. 507-387-2279.

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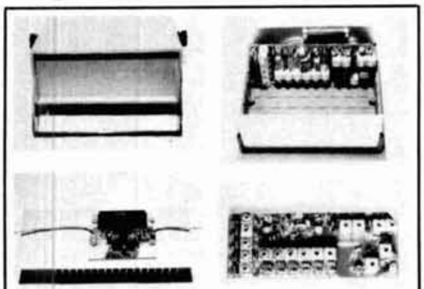

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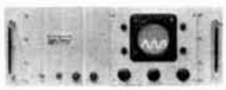

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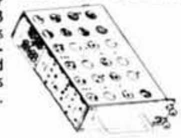

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FM-AM-CW-SSB MOBILE/BASE

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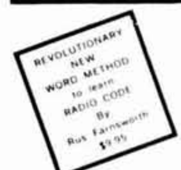

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FEATURES:

- 25 Watts out
- Hot, selective receiver
- 12 channels
- Single crystal R/T
- PL provision built in

SPECIFICATIONS:

Transmitter Power: 1W/25W
Receiver Sensitivity: .2uV
Power Requirement: .3 A receive, 7.5 A transmit (25W)
Size: 2¾x11x9¼ inches

Optional PL, AC power supply and multiple repeater offset kits available

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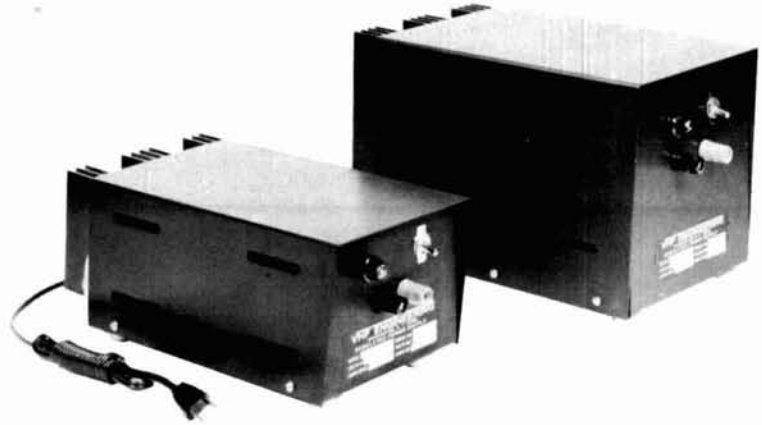

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- Over-voltage protection crowbar.
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- 115/220 volt input – 50/60 cycle.
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PS-15C SPECIFICATIONS

Voltage Output:
adjustable between 12-14V
Load Regulation:
2% from no load to 10 amps
Current Output:
15 amps intermittent (50% duty cycle)
10 amps continuous
Ripple:
50 mV at 10 amps
Weight:
11-1/2 pounds
Size:
11-1/4" x 5-1/2" x 4-3/4"

Kit $79.95
Wired and tested 94.95

PS-25C SPECIFICATIONS

Voltage Output:
adjustable between 10-15V
Load Regulation:
2% from no load to 20 amps
Current Output:
25 amps intermittent (50% duty cycle)
20 amps continuous
Ripple:
50 mV at 20 amps
Weight:
20-1/2 pounds
Size:
12-1/4" x 6-3/4" x 7-1/2"

Kit $129.95
Wired and tested 149.95

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Item	Part No.	Description	Price	Extension

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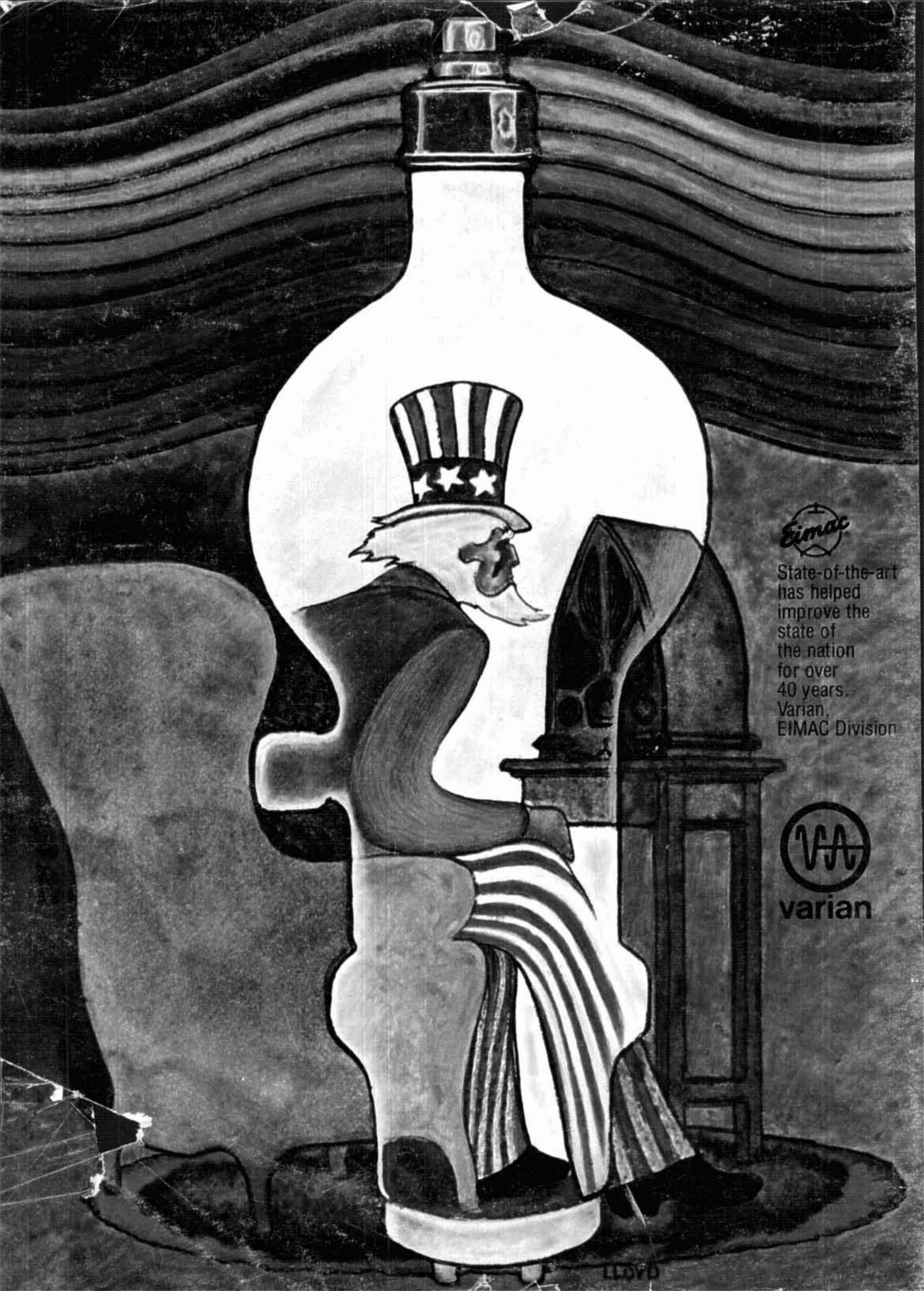
*FT-101EE $659.
FT-101EX $599.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