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magazine

JANUARY 1975

random
access
memory
RTTY
message
generator



this month

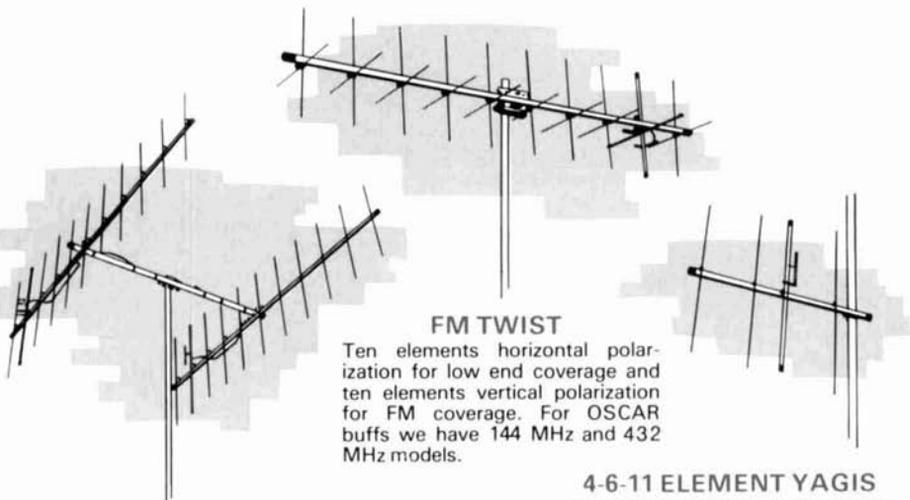
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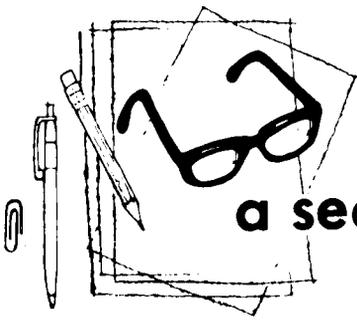
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a second look

by jim
fisk

With more than 50-million hand-held digital calculators already in the hands of consumers, and predicted sales of another 34-million units in 1975, it's easy to understand why the simple four-function machines that sold for nearly \$100 only two or three years ago are now going for \$25 or so — less at large discount outlets. The prices have been slashed on the more sophisticated scientific calculators, too, and with each new model that is introduced the price of the models it replaces falls still further. The Hewlett-Packard HP-35 Electronic Slide Rule, for example, originally sold for \$395, but when the more sophisticated HP-45 appeared the price was cut to \$295. It has since dropped to \$225 with some discount stores selling it for even less. Similar price cuts (or larger) have been posted by practically all the manufacturers.

New integrated circuits which were on the drawing boards at major semiconductor manufacturers in October and November, 1974, promise a whole new generation of scientific calculators will be available within the next few months. Price and performance breakthroughs in this fast-moving industry have generally lagged the development of new calculator chips by only three or four months, and since several new circuits are scheduled to appear this month or next, you can expect to see newer, smarter electronic slide rules on the market by early summer. Many of their features are still closely guarded secrets, but look for basic scientific calculators capable of evaluating expressions that include transcendental functions and one or more levels of paren-

thesis for less — perhaps substantially less — than \$100.

Typical of the new calculator circuits is the two- or three-chip Senior Scientist set introduced by MOS Technology in late 1974 which makes it possible to build a more powerful non-programmable hand-held calculator than any now available. Recently this firm also introduced single-chip, 28-pin scientific calculator arrays which offer full scientific functions, algebraic entry, two parenthesis levels and full feature memory. Another of the new calculator chips is the Rockwell Microelectronics 4802, which will go into full production this month and will be priced at under \$20. It offers, among other things, degree-radian conversion and factorials.

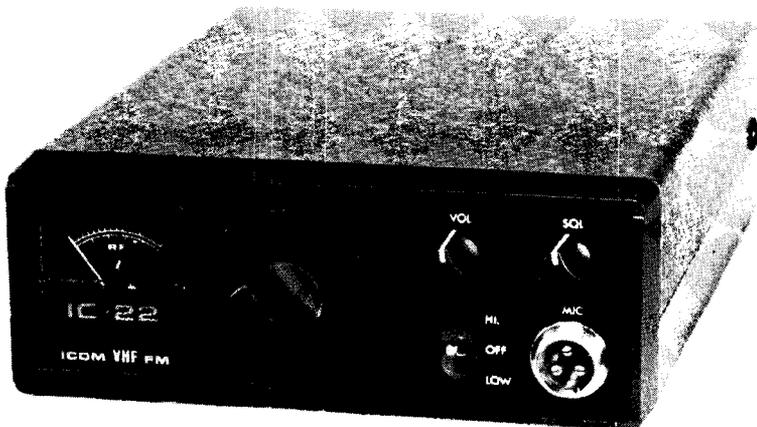
Programmability, which is now available only in relatively expensive calculators such as the Hewlett-Packard HP-65 (\$795) and the Monroe/Compucorp Beta 326 (\$695) should be available in other pocket-sized calculators in the \$200 to \$300 price range sometime later this year. However, don't expect these machines to have the sophisticated magnetic card reader featured in the HP-65 — they will probably require that you key in the program each time you wish to use it. Future models will probably overcome that small detail, and will probably offer interface with a variety of peripheral devices such as printers as well, but with the powerful, multi-function calculators that are available now at reasonable prices, can you afford to wait?

Jim Fisk, W1DTY
editor-in-chief



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presstop

OSCAR 7 LAUNCH WAS PERFECT, and it ended up where it was supposed to be when it was supposed to be there. Both telemetry beacons are working perfectly, and the only hitch is a marked lack of sensitivity in the 2- to 10-meter translator. The 432-MHz to 2-meter translator, on the other hand, is working much better than expected -- predictions were that 350 W effective radiated power would be required for a consistent signal through it, and it's doing so well that a maximum of 80 W ERP is being requested!

A Number of European Stations have been copied in the midwest coming through the translator from 432, and despite a somewhat narrower than expected bandwidth (about 80 kHz) the efficiency is quite high. The two-meter beacon is somewhat lower in frequency than expected -- despite uncertainties from doppler shift, it appears to be about 145.972 instead of 145.980 MHz.

The Two-To-Ten Meter Translator is a disappointment, so far. It takes a lot more signal to get into than Oscar 6, and very deep fades are frequent during its passes. The beacon is very strong, and bandwidth is considerably greater than the planned 100 kHz (signals as high as 29520 kHz have been copied thru it).

Complete Computed Orbital Data for Oscars 6 and 7 will be available monthly as an added slip-in sheet to HR Report. Copies of these predictions will be provided to interested readers upon receipt of an SASE (one SASE for each month).

AMATEURS RESPONSIBLE FOR "CODED" TRANSMISSIONS should have certain information on file with local FCC offices, according to recently released FCC policy letter. This includes coded control signals for repeaters or telemetry data from a remotely controlled amateur station, for example. The required information must be filed with the Engineer-In-Charge of the FCC district from which the coded transmissions will be made. Compliance of the operators involved is requested at the "earliest possible convenience."

CURRENT FCC AMATEUR DOCKETS have as yet received no formal attention from the commissioners. Each docket requires a good deal of staff work prior to consideration in the form of evaluating the comments and reply comments and incorporating them into a proposed action. It looks like the first amateur docket to be put before the commissioners will be 20001, Commemorative Callsigns. Somewhat later will be 20092, Permitting Extra Class licensees to request specific callsigns. But then again, both could be held up along with 19658, License fees. Not only are various pending dockets inter-related, but the possible effects of "restructuring" must also be considered.

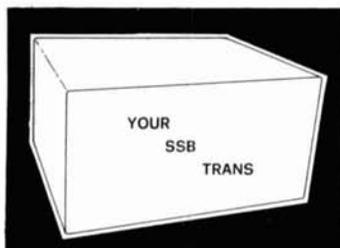
RECENT HOT 10-METER CONDITIONS have pointed up the value of beacons as propagation indicators. Gary Hendrickson, W3DTN, has been talking up establishment of two-meter beacons on some "little-used" FM simplex channels -- but finding such a channel nationally would be an almost impossible task.

Consider Adopting a "split-split" channel for this purpose, for example 146.655 or 146.625 MHz. Stock crystals could be pulled on-frequency in most receiver circuits, and with a very narrow deviation MCW ID every two or three minutes, little if any problem would be felt by nearby simplex activity.

Repeater Council and Frequency Coordinator Reactions to the idea are solicited; some very interesting and potentially valuable information could result from a comprehensive beacon net.

BEHIND-BARS HAM RADIO POSSIBLE, according to a reply by A. Prose Walker to a question posed by Mid-Oklahoma Repeater Inc. (MORI) officer. Idea behind the question was that amateur radio could be a powerful rehabilitation tool, both in prisons and in "halfway house" environments. Position of FCC is that conviction for a crime -- particularly if radio was not involved -- should not bar one from holding a license.

VLF BUFFS HAVE AN SWL GROUP -- Long Wave Club of America -- with much useful info for ham VLF experimenters. Club has a free monthly newsletter, Lowdown, and club President John Clements also offers a useful list of over 2500 VLF stations for sale at \$2.00, postpaid. Contact John Clements, LWCA, 11425 Albers Street #5, North Hollywood, California 91601.



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random access memory RTTY message generator

Construction of a
solid-state memory
that replaces the
tape distributor
and reperforator
used in amateur
RTTY stations

This RTTY accessory uses Random-Access Memory (RAM) ICs in an easy-to-build, compact package that replaces both the tape reperforator and transmitting distributor for station call-ups, CQs or special applications such as RY generation. It is considerably easier to

program than other devices. The message (data) is entered into four RAM chips using the station teleprinter keyboard — it can be recalled instantly at the touch of a button.

Operation is noiseless and there is, of course, no tape to handle. The memory will record (write) from a TD, off the air or the keyboard of any five-level teleprinter such as the model 15 or 28. As an RY generator, line feeds and carriage returns may be added to prevent end-of-line pile up, a convenience the usual RY generator lacks. Although this RTTY memory is designed to be used with ST-5 or ST-6 demodulators,¹ flexible input and output circuits permit use with other demodulators or simple teletype loops.

Random access memories using mos technology are available in surplus at quite reasonable prices. While other chips are available with large capacity memories, the 1101, a 256-bit chip, is selling at \$2.56 at time of writing, or one cent a bit. The effective memory capacity of 1024 bits is obtained by ORing four

Bert Kelley, K4EEU 2307 South Clark Avenue, Tampa, Florida

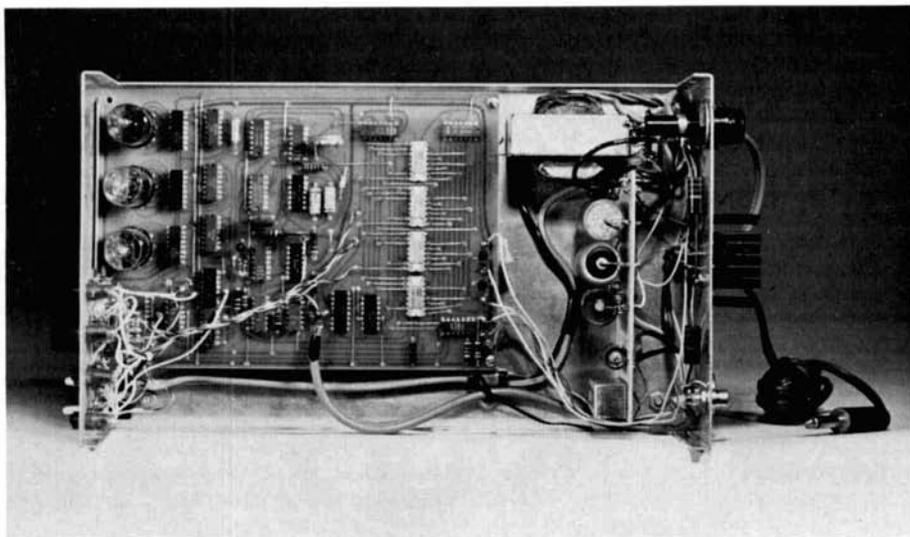
chips together and sequentially entering and retrieving the RTTY signal. The output is a regenerated, low-distortion signal, and playback proceeds smoothly as operation transfers from chip to chip.

operating principles

Each RTTY character at 60 wpm is composed of a 22-millisecond start pulse, five 22-ms coding pulses which determine the character, and a 31-ms stop pulse. These seven pulses are converted to TTL logic levels and serially entered into the RAMs at bit locations in the memories determined by the binary status of eight

write mode and cause the memories to read out an accurately-timed 60-wpm signal during read.

It is easy to generate the 22-ms intervals, but the odd 31-ms pulse poses a small problem. One solution is to generate the stop pulse as two 22-ms pulses. This will work, but the playback is slower than standard speed and there are now eight instead of seven bits to make up each character, reducing the total memory capacity. Also, it would not be possible to record a properly operating TD because the memory could not keep up with it.



Layout of the RTTY memory showing printed-circuit board and Minibox chassis. Relay and power-supply filter capacitors are mounted on piece of perforated board to the right.

address lines. Data transfer is accomplished by a positive write pulse at the center of each 22-ms interval. Since a short time is specified^{2,3} before the write pulse is applied after memory address, and because of marking and spacing bias present in many signals,⁴ a short write pulse positioned at the center of each bit is most immune to these sources of distortion and provides best results.

Most of the ICs in the circuit are used to generate timing pulses and waveforms which coincide in time with the input signal from the keyboard during the

I decided to generate the required 31-ms stop pulse by writing the 11-ms into the memory with the clock, then generate an additional 20-ms stop pulse with a one-shot multivibrator to stop the clock oscillator. For a character seven bits long, each 256-bit memory chip has a capacity of 36-4/7 characters. For example, a message that exceeds the capacity of the first memory transfers into the second memory at the 37th character by writing the start pulse and the first three coding bits in the first chip, and the last two coding bits and stop

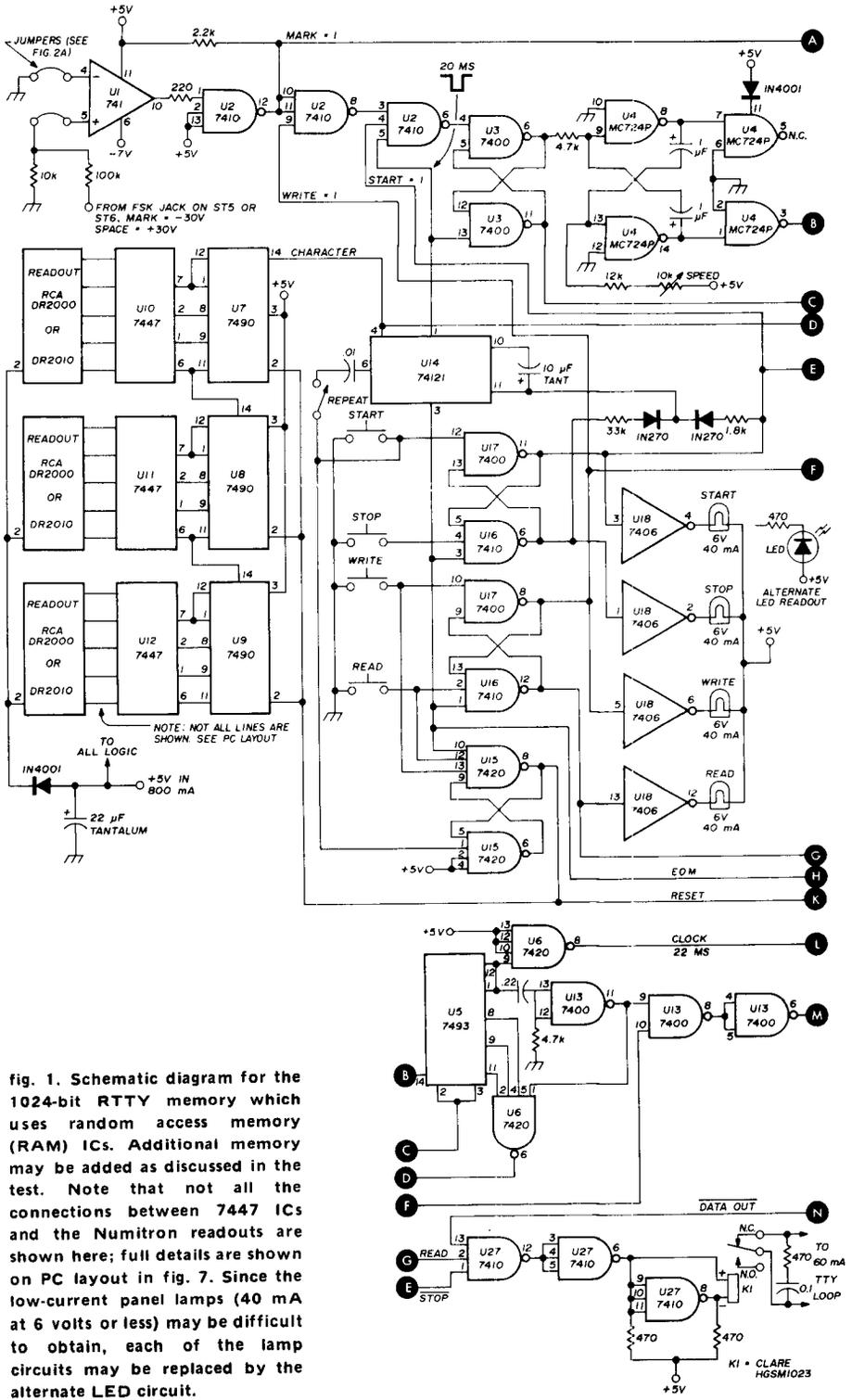
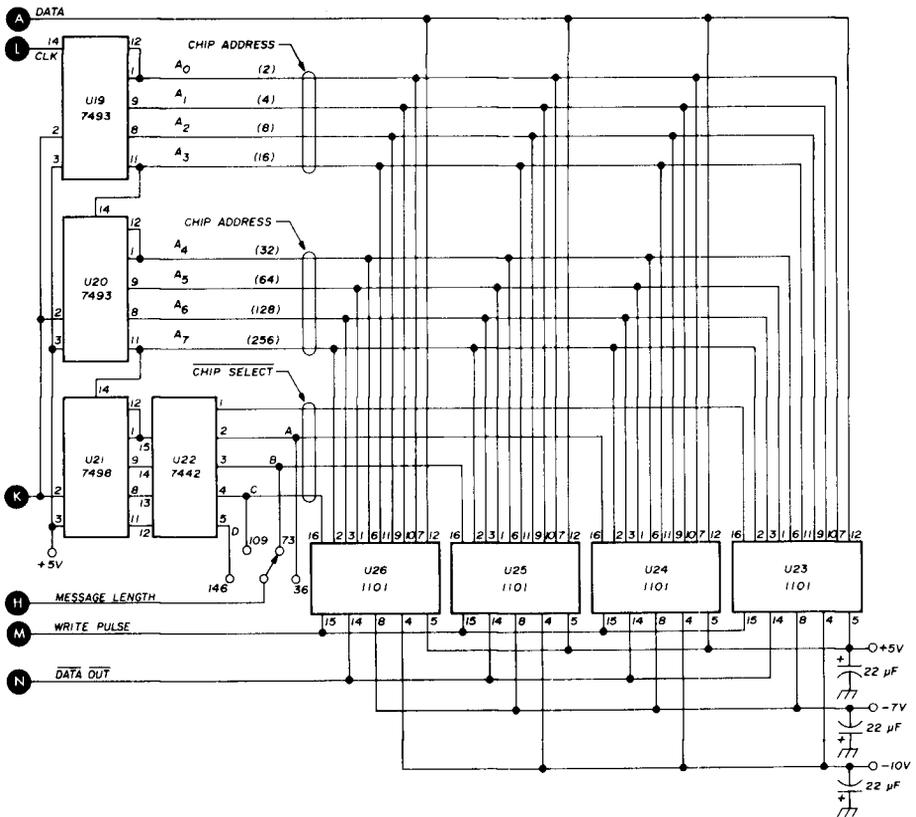


fig. 1. Schematic diagram for the 1024-bit RTTY memory which uses random access memory (RAM) ICs. Additional memory may be added as discussed in the text. Note that not all the connections between 7447 ICs and the Numitron readouts are shown here; full details are shown on PC layout in fig. 7. Since the low-current panel lamps (40 mA at 6 volts or less) may be difficult to obtain, each of the lamp circuits may be replaced by the alternate LED circuit.



pulse on the second chip. Additional circuits are provided to control the functions of read, write, stop, start and repeat. A three-digit character counter indicates the exact position of the memory in use.

circuits

A 741 operational amplifier is used in a versatile input circuit which can be used with positive/negative or positive-only keying voltages. This device has high gain and tolerates unbalanced supply voltages well. The differential input of the 741 amplifies the difference between the voltages on pins 4 and 5. The main requirement is that the input voltage swing should not exceed the supply voltage in either direction — the 100k resistor should be changed as necessary to comply with this requirement.

The input connections to pins 4 and 5 should be made so that the output of U1 (pin 10) pulls U2 (pin 1) to logic zero during mark, and logic 1 on space. The FSK keying voltage of the ST-5/6 swings both positive and negative (referenced to ground). Therefore, if the input is connected to U1 (pin 5) and U1 (pin 4) is grounded, proper drive results at the TTL gate.

Fig. 2A shows pin 4 of U1 biased above ground so positive-only keying voltage will result in a negative output at U1 (pin 10) during mark-hold. An FSK voltage that is positive during mark-hold should be connected to the inverting input of U1 (pin 4) through a voltage divider. TTL nand gates have built-in diodes to limit voltage reversals at the input, and the resistor limits the diode current.

The RTTY signal is translated to TTL

logic levels at U2 (pin 12). The next section of U2 acts as a gate to prevent incoming signals from affecting the clock when in the read mode. When recording into the memory, both U2 (pin 9) and U2 (pin 4) are high and the incoming start pulse from the keyboard goes to logic zero at U2 (pin 6), setting the R/S flip-flop U3. U3 (pin 6) goes to logic 1, the RTL clock multivibrator U4 immediately starts oscillation at 91 Hz and U5 divides this to a 22-ms square wave which drives the address counters U19 and U20 through U6 (pin 8).

The negative-going center of the symmetrical square wave at U5 (pin 12) is used to generate a positive pulse at U13 (pin 11). The other section of U6 generates a negative-going pulse (at U6, pin 6) when U6, pins 1, 2, 4 and 5 are all high at the same time. This occurs eleven milliseconds into the seventh bit, i.e., the stop pulse. This pulse then triggers U14 (pin

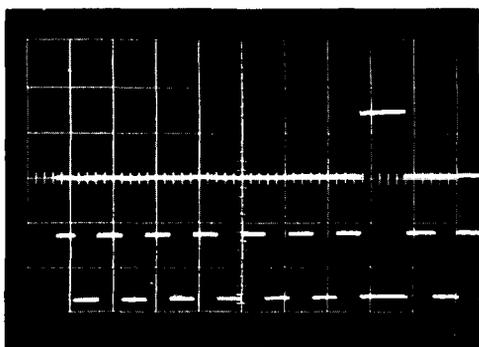


fig. 3. The top trace shows the single output pulse at U14, pin 6. The bottom trace shows the clock signal at U6, pin 8. Horizontal scale is 20 ms per division; vertical scale is 2 volts per division.

4), the monostable multivibrator, which stops the clock by generating a 20-ms pulse which resets U3. The scope traces (fig. 3) show the pulse-timing relationship between the clock, write pulses and the output of U14.

U13 also generates a positive pulse train during the write mode only (fig. 4). U19 and U20 generate the binary address voltages for the RAMs which are applied to all four memories. The RAMs are three-state devices that have a logic, zero, logic one and a third inactive state which is maintained as long as there is a logic 1 on the chip select line, pin 16. As each RAM is addressed at all 256 locations, the voltage on U20 (pin 11) falls, advancing memory ICs U21 and U22 ahead to select the next memory chip, or activate the End of Message (EOM) circuit.

The EOM pulse stops playback or recording, resets the character counter to 000, resets all address counters, and triggers U14. Pulse lengths from U14 are determined by the status of the start/stop latch, and U17 (pin 11) is normally high during operation so U14 generates the 20-ms pulse. However, U16 (pin 6) goes high when playback stops and a long stop pulse is generated because the 33k resistor now sets the timing. This allows partially entered characters at EOM to clear the page printer before the new readout and another start pulse.

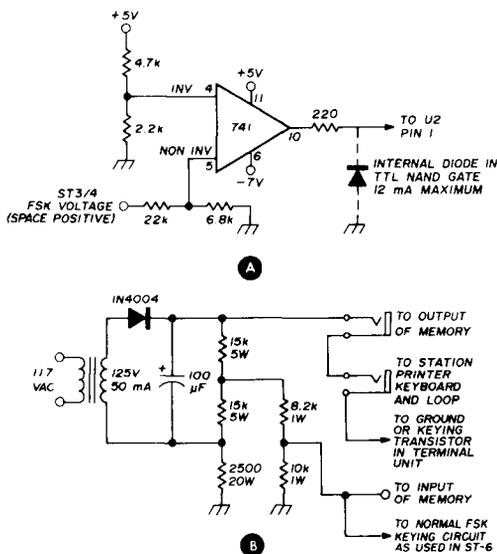


fig. 2. Circuit in (A) shows how op amp input circuit can be changed for positive-only keying voltage such as the ST-3 or ST-4. Printed-circuit connections to pins 4 and 5 of the 741 are designed so they can be jumpered for the desired input configuration. Circuit in (B) shows how RTTY memory can be connected to ST-6 terminal unit, or a circuit built for local loop operation. The input to the memory does not load the ST-6 and affect the normal FSK connection at the same point.

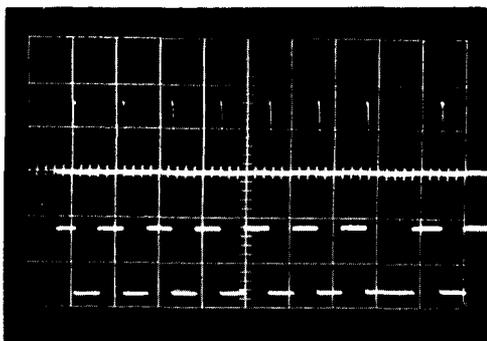


fig. 4. Narrow pulses on upper trace are output at U13, pin 11, during read and write (same output at U13, pin 6, during write only). Bottom trace shows clock signal at U6, pin 8. Horizontal scale is 20 ms per division; vertical scale is 2 volts per division.

At EOM the sequence is as follows: generation of a long stop pulse at U14, momentarily readout stop, then the start latch is re-triggered by the trailing edge of the pulse from U14 (pin 6). During read the clock is gated by the output of U14, gate U27 is enabled, and the data output operates the high-speed keying relay. During write, U27 is placed in mark-hold, keeping the loop closed.

The TTL logic and Numitrons are operated from the same 5-volt power supply (fig. 5). The readout voltage is reduced by using the fixed voltage drop across a silicon diode since the full 5 volts is not needed. The LM309K regulator should be mounted on a heatsink with a small amount of silicon grease applied to help heat transfer. Measure the supply voltage under load and reject the regulator if it does not supply 4.8 to 5.2 volts. It appears that some devices sold as LM309Ks will not meet this test.

Two negative supplies are shown for the mos devices because the Intel 1101 RAMs I used arrived with a spec sheet showing -7 volts V_{DD} , and -10 volts for V_D . The Texas Instruments TMS 1101NC is similar but requires -10 volts on both pins 4 and 8, and the Signetics 2501 calls for -9 volts. Since you may have different devices available, it is a simple matter to change the power-supply voltage by installing a different zener diode.

In the process of testing this unit, memory ICs were obtained from different supply houses. Many were unmarked, others had different numbers on them. Results of tests showed most devices operated better with a single negative

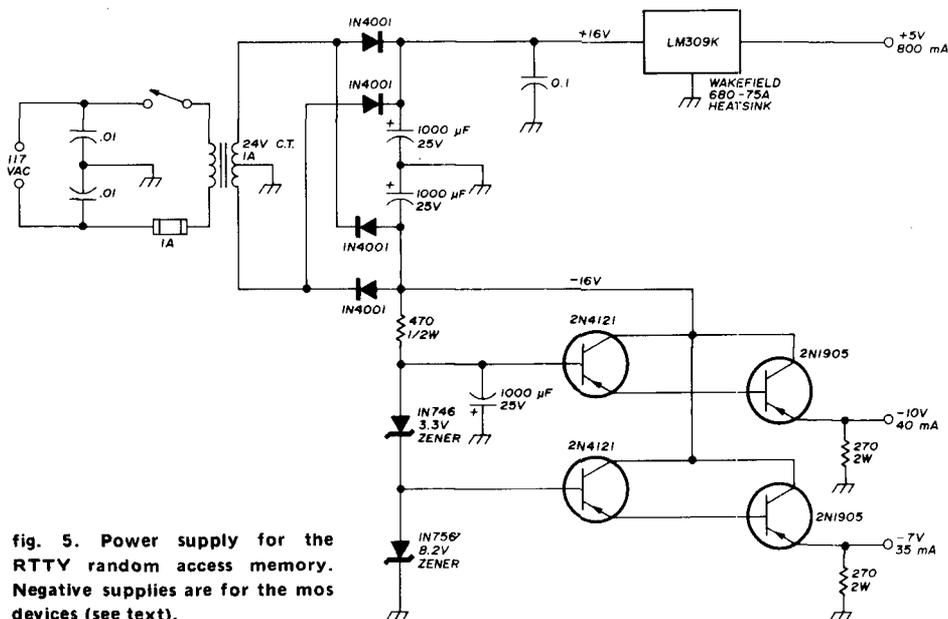
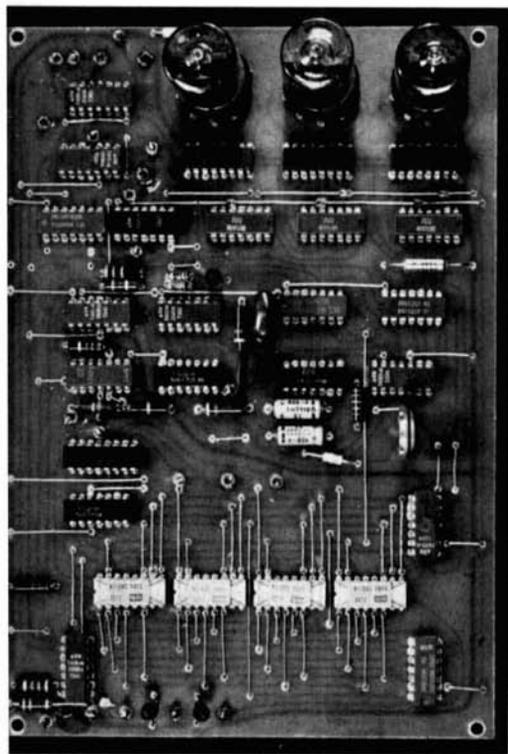


fig. 5. Power supply for the RTTY random access memory. Negative supplies are for the mos devices (see text).

grounding the soldering iron and advises against bending leads close to the IC package. The possibility of damage is reduced considerably if sockets are used and all power-supply voltages checked before connecting the board.

checkout

When the unit is turned on, the read or write pushbuttons should set the character readout to 000, and the teletype machine should not run open since U27 (pin 12) should be at logic one, or mark-hold. It may be necessary to reverse the coil leads of the relay. Start the memory in the read mode and set the period of the square wave at U19 (pin 14) to 22 milliseconds and confirm that the stop pulse at U14 (pin 6) is 20-ms long. The character counter should be operating and the printer will print garble, if turned on.



Component layout of the printed-circuit board. Most capacitors are low-voltage tantalum units. Numitron readout tubes are plugged into sockets. Printed-circuit layout is shown in fig. 7.

With the input of the memory connected to a suitable FSK or keyboard output, type a short test into the unit and test the playback. The character counter should follow both the entry of the test into the memory on write, and the playback. If all is well, perfect playback will result. However, it's likely that there will be some small problems.

It is important that the clock be operating at the right speed. If the device prints a few errors, this should be checked. Note where consistent errors occur in the print, if at the same position. This may be caused by a defective memory chip. It is not unusual for a low-priced surplus memory to have two or three defective cells out of the possible 256. These will cause substitution of a different letter from the one entered in the write mode. A five-level coding chart can be used to determine what is happening, for those interested. A faster and more practical solution is to plug in a spare memory chip. Also, don't overlook the possibility of a defective input signal from a noisy printer keyboard.

general

Construction cost should be about \$80. This can be reduced, at some loss in operating convenience, by omitting the character counter. The memory capacity can be more than doubled by adding five more RAM chips on an external board, running parallel address lines, and using the spare outputs of U22 for chip select lines.

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ham radio

low-cost printed-circuit boards

A simple technique
for building
low-cost
printed-circuit boards
for your homebrew
amateur equipment

Many older amateurs and a surprising number of beginners are reluctant to try building their own printed-circuit boards. Many feel that PC boards are too inflexible to permit circuit changes or the cost of materials and equipment is high. Others think PC board layouts require special knowledge, skills and equipment.

Let's consider the first charge: Inflexibility. If you make a complete receiver layout on one board it will certainly be inflexible! Look at **fig. 1**. That curious mess is actually a pretty hot 20-meter receiver. Notice that it consists of a number of small modules. Most important, it will perform beautifully just as illustrated. In short, stop thinking in terms of wiring components together, and think about wiring complete stages together.

With this technique you can build progressively, and need not invest in high-cost items such as crystal-lattice filters until you are satisfied that performance is what you desire. Obviously,

this is a good way to avoid mistakes in planning chassis layouts. With a complete receiver running on the bench you will be able to envision layouts that will eliminate the need for conventional chassis design.

An example of this is shown in **fig. 2**. This ssb receiver was originally built as in **fig. 1**. Instead of buying an expensive enclosure, it was housed, as shown, in bent-up aluminum scrap with a steel wraparound. When I find a reliable and stable circuit and layout, I usually etch a number of boards "for stock." This results in terrific time savings later. For example, I wanted to experiment with a variation of the KY crystal filter which is popular in Europe but had no receiver to match the available crystals. With all but one board in stock it took only two evenings to build the receiver shown in **fig. 1**.

With this building technique, if you don't need the receiver, or tire of it and want to make something more sophisticated, your loss is zero. Simply disconnect the boards and put them away, intact, for the next project. Another advantage is this: Many circuit boards can be designed as multipurpose boards. Certain transistors and ICs, for example, can be arranged as rf and i-f amplifiers, mixers, product detectors or audio amplifiers. As will be shown later, the circuit board can also be devised to accommodate quite a variety of circuit variations and component selections.

Is the cost really high? The best circuit-board material is the relatively expensive G-10 fiberglass-epoxy material. This runs about \$2.00 per square foot (929 square cm) from surplus houses such as Jefftronics, Meshna and others. The "universal" circuit board which I use

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(described later) requires 2.35 square inches (15.2 square cm) of material. With the G10 material at 1.4 cents per square inch (6.5 square cm) the universal board will cost 3.4 cents. At that price it hardly pays to economize by using the less expensive phenolic board.

etching circuit boards

The etching supplies and equipment you will need are shown in **fig. 3**. The two-pound coffee can houses a 40-watt light bulb. This is a heater for the

prepared solution for your initial work. It will give you a feel for the proper mixture and proper etching action. Two widely available sources include Radio Shack and any dealer handling the popular GC (General Cement) line of radio and TV service products.

The GC etchant is about the highest priced at six fluid ounces (177 cc) for \$1.20, so let's use it as an example. That bottle will etch about 100 square inches (645 square cm) of copper. The universal board to be described requires only 0.85

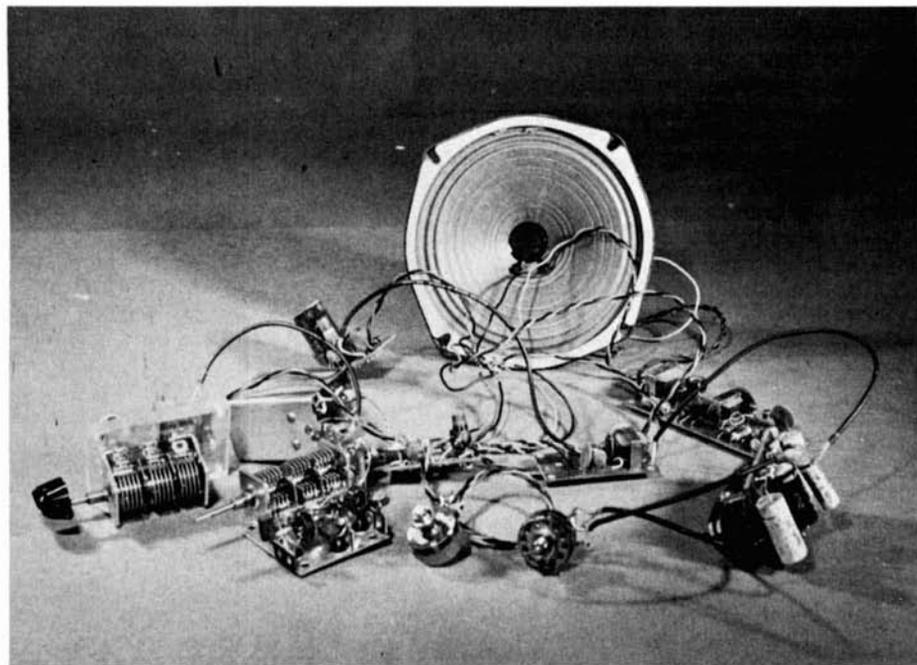


fig. 1. Twenty-meter receiver built with low-cost printed-circuit boards. Careful attention to circuit design provides high performance, even in this haywire condition (see text).

etchant, and a stand to hold the plastic cereal bowl firmly while etching. Etchants are very corrosive, so a spill can be messy. The household cleanser is needed for scrubbing boards, and the masking tape is about the cheapest and most convenient resist available. The plastic funnel is used to pour the etchant back into its container.

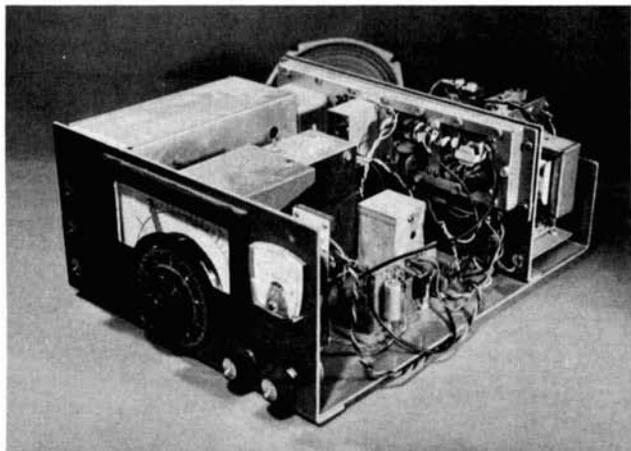
All of your etchant-handling equipment should be plastic. If you have had little or no etching experience, buy a

square inches (5.5 square cm) of the total 2.35 square inches (15.2 square cm) to be etched away. This is typical. Including waste it comes to about one-third the total board area. Thus, the little bottle will actually handle about 300 square inches (1935 square cm) of board material, or about 0.4 cent per square inch (6.45 square cm). The universal board will require about 1-cent to etch, making total board cost about 5 cents. This is pretty inexpensive for an entire stage.

Be sure to select ferric chloride for your etchant. Ammonium persulphate is also available. It works well with photoresist techniques, but with our cheap masking-tape resist, it will do a ragged job, tending to etch under the masking tape. Ferric chloride will do a clean, neat job everytime — even with an old, loaded solution.

board production is more a matter of common sense than specialized skills or knowledge. I usually start with a schematic of a board, and try to include any expected variations to make the board fit different components and circuit variations. For the sample board I will use four circuits that are similar. All use a low-cost dual-gate, gate-protected mosfet.

fig. 2. Packaged single-sideband receiver using the components shown in fig. 1.



Two items not shown in the photograph are the drills you will need, and a pad of cross-ruled paper or graph paper (available in most discount stores). The drills most needed are numbers 60 and 54. If you are in an area where numbered drills are not available, you can use 1/32-inch (0.8-mm) and 3/64-inch (1.2-mm) drills. If possible, use industrial quality drills. Cost is about a dime more, but the life of the drills is often twice or three times that of discount store grades. If you have a choice, use high speed steel instead of high carbon. Many of the imported drills are just case-hardened, cold-rolled steel, poorly formed, and a poor investment.

The cross-ruled paper is a great help in making up layouts, and for maintaining a permanent record of your boards. From the foregoing it is obvious that the cost of materials and equipment is small.

circuits

As you will see, the layout work and

These devices aren't as fussy as the older non-protected mosfets and can be handled as easily as conventional transistors.

Fig. 4 shows the circuit for a mixer stage. This circuit is shown connected to a hot tank circuit where you must isolate the +12 volt supply from the gate. Where the tank circuit is at ground potential, C1 and R1 are unnecessary. The output is tuned with a small compression trimmer capacitor. Two types of output coupling are also shown. For convenience I usually use miniature coax (RG-174/U) to bring the vfo signal to the mixer board.

Notice that the +12 volt line is decoupled with R4, C5 and C6. This extra precaution results in greater stability, and is one of the things that provides stability in a haywire mess like that in fig. 1.

The circuit of fig. 5 can be used as an rf or i-f stage. Due to the extremely high gate impedance, feedback can be troublesome when high-Q tuned circuits are used. An i-f amplifier usually depends on the first filter for its selectivity so you

can afford to swamp the input with a 2200- or 2700-ohm resistor. This will make a completely stable system.

The receiver in **fig. 2** uses two of these stages. The first is swamped with the filter terminating resistor, the second stage with 2200 ohms — the two stages become very docile. As an rf amplifier the circuit will require careful shielding of input and output circuits. By reducing the value of C5 and adding a "gimmick" capacitor or small adjustable capacitance between the junction of C5, R4 and L2 to gate 1 you can include neutralization with the same layout. Agc or mvc can be included as shown. Limit this voltage to ± 4 volts on gate 2. Maximum gain requires about +4 volts from gate 2 to the source.

Fig. 5 includes another form of output circuit. The slug-tuned coil can be a TV i-f coil rewound for your frequency. For this service you must provide space to drill a 5/16-inch (8-mm) hole to mount the coil. If you don't need a low-impedance output, capacitor C9 can be connected across the coil and C10 can be eliminated.

Fig. 6 shows the circuit as a high-gain product detector. This circuit has good dynamic range and a microvolt input will deliver about a millivolt output. Notice that this circuit is identical to **fig. 4** except for the details of the output circuit. The output transformer is a regu-

lar Radio Shack item. The 500-ohm output is convenient if you go into a low-pass audio filter built from 88-mH toroids, as it provides a good impedance match.

Notice the volume control hookup. If the volume control is located remotely it is not desirable to ground the low side of the control to the chassis at the remote

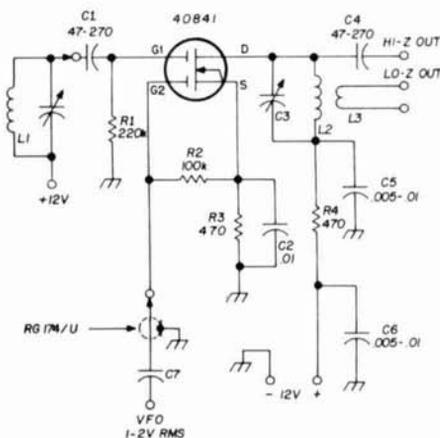


fig. 4. Mosfet mixer stage designed for printed-circuit use.

point. This can lead to ground loops. Instead, carry the ground to the control with the shield of the miniature coax, and from the control to the next stage on the shield of that same piece of coax. This ground loop problem is very easy to control in a modular setup like this. You can mount the boards on pieces of bakelite or plastic when necessary and have full control of the ground situation without any radical rebuild.

Notice that the output is bypassed for both rf and audio (C5 and C10). Also notice C9. This capacitor can roll off the high-frequency audio components. That little transformer is quite efficient out to 70 kHz or more, and there is no need for response above about 2.5 kHz. In fact, if you use a 0.05- μ F capacitor at C9, you will have a definite peak around 1 kHz that is helpful for CW work, but still results in useable ssb performance. Again, the bfo voltage is brought in with RG-

fig. 3. Etching supplies and equipment you need for making your own low-cost printed-circuit boards.



174/U coax. With a high-gain i-f strip, it may be helpful to locate the bfo well away from the strip — or shield it.

The receiver in **fig. 1** shows some i-f overload, but by tucking the bfo module behind the speaker, operation is completely satisfactory. Slightly more gain will result if C2 is paralleled with an

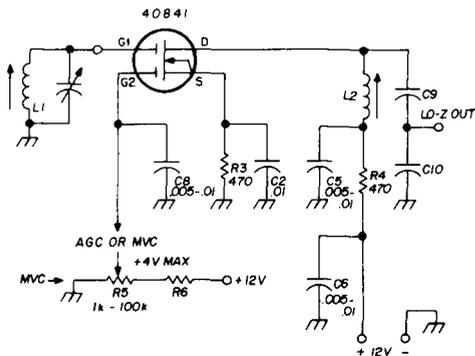


fig. 5. This circuit can be used as an rf or i-f amplifier and uses same printed-circuit layout as the circuit of **fig. 4.**

audio bypass capacitor, although it might be more worthwhile to go to a Motorola MC1550 (HEP 590) or RCA 3028 IC. They will deliver considerably greater gain if you need it.

The circuit in **fig. 6** can also be used as a *synchrodyne* detector. Tune L1 to the operating frequency, feed in a vfo signal at the operating frequency, add an audio filter to the output and use a high-gain audio amplifier. You now have a simple, direct-conversion receiver.

Fig. 7 shows the circuit for a grounded-gate rf stage. Note that gate 2 must still be biased to +4 volts for full gain. You can feed gate 2 from the agc line if desired. This stage is very stable without much shielding.

board layout

If you can lay out a single circuit board to accommodate these four circuits you will have a really useful board! **Fig. 8** is the result. The simple square layout makes it easy to cut out. Notice the fat ground bus. This is a big help in achieving

stability in rf equipment. In my layouts I usually make any unused board space a part of the ground bus, rather than etch it away. You save etchant and gain stability.

Circle B is the location for a 5/16-inch (8-mm) hole for TV-type slug-tuned coils, or a 3/8-inch (9.5-mm) hole to clear the mounting tabs on compression trimmers. If you allow the tabs to protrude through the board at this point, it's advisable to scrape away the copper foil so the tabs are not grounded. Just a tiny chamfer is sufficient.

Locations A and C are for the leads of compression trimmers. These are usually 25/32-inch (20-mm) apart. By relocating A and C to the right so their center line lies 9/16-inch (14-mm) from the right edge of the board instead of 3/4 inch (19 mm), and drilling them 7/8-inch (22-mm) apart instead of 25/32 inch (20 mm) you can accommodate the small surplus Erie ceramic trimmers. If you make up boards in advance these holes can be left undrilled so that the board can fit any combination of output parts later.

Fig. 9 shows the mounting of the little Radio Shack transformers. The mounting tabs are pushed through the holes and bent over. It's best to solder one or both tabs to the ground foil. This will result in a quieter circuit. Use 4-40 screws to mount the boards. Spacers can be scrounged from broken rotary switches, switching TV tuners, 1/4-inch (6.5-mm) OD steel or copper tubing, etc. Keep the input and output sections apart when laying out the boards. If you lay out a

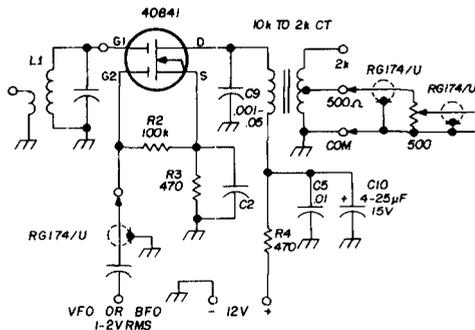


fig. 6. High-gain product detector. Except for the output this circuit is identical to **fig. 4.**

multi-stage board, don't use a U-shaped layout! This is asking for trouble. Keep the circuit in a straight line from input to output.

It's best first to plan your layout on the cross-ruled paper. Have typical parts available so you can allow for correct clearances. Once you have your final plan, keep the drawing for future reference. You would be amazed how fast you can forget what a particular board is used for, or where a particular part mounts. I keep a copy of the board, layout, schematics, and notes on performance or unusual characteristics together in a loose-leaf binder. That was one reason I could build a complete receiver in a couple of evenings.

When working with the TO-5 can integrated circuits, it is desirable to mount them for removal without damage. Fig. 10 shows a method I use. Drill a 7/16-inch (11-mm) hole through the board, bend the leads as shown, and the IC can be soldered in and removed rapidly without damage.

circuit board fabrication

Now let's get to the actual board work. First, cut the board to size. A fine tooth hacksaw is best. File the edges smooth. Now thoroughly clean the copper side. Copper cleaner, other household cleansers or steel wool are all effective. It is very important to prevent fingerprints on the cleaned board surface. Often the film from a fingerprint seriously retards etching.

Next, cover the copper foil with masking tape. Choose a width of tape that will completely cover the board, if possible. Where tape is lapped, etchant often creeps under the tape. Press the tape down thoroughly all over the board. Draw the complete layout on the masking tape using a soft pencil. Be sure to indicate points to be drilled (I draw a tiny cross at these points). Cut through the tape with a very sharp jack-knife or X-acto modelmakers' blade. Peel the tape off from areas to be etched. Here, too, avoid getting your fingers on the exposed copper. Finally, when all the areas to be

etched are exposed, again firmly press down the remaining tape with a clean pencil eraser.

Now, place the board in the cereal bowl, foil side up, and pour in enough etchant to cover the board to a depth of 1/4 inch (6.5 mm) or more. Place the bowl on your "heater" and relax. After

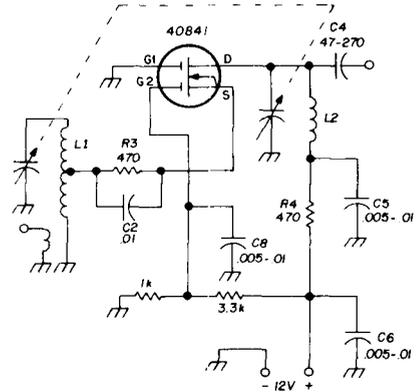


fig. 7. Grounded-gate rf stage.

about five minutes lift one end of the board out of the etchant using the plastic stick. As you lift it, you will see a dirty, dark residue draining from the board. Lift the end of the board in and out of the solution several more times to flush away this spent etchant, then lean back for several minutes more. Again flush away the loaded etchant. In about 20 minutes the board should be completely etched.

You can now remove the board from the etchant, rinse it in water (preferably not in your wives' stationary tubs because this stuff stains badly). If you object to stained fingers, or have sensitive skin, use a plastic glove to handle the board.

Carefully check the board to make sure it is completely etched. If not, dump it back into the etchant. When it is completely etched, rinse it in water and damp-dry it with a clean cloth. Before removing the tape, drill the holes. Now you can peel off the tape and thoroughly clean the board with household cleanser to remove any vestige of etchant. If you are sloppy in this respect, a slight residue

of etchant can attack electronic components later.

Be very careful when handling the etchant! A tiny drop on a good tool will cause the tool to rust almost before you can blink your eyes! An accidental spill on the workbench will create an area that is saturated with etchant, and any tool or part that you leave on that area will be attacked — even months later! I use a little homemade stool in the middle of the basement floor for etching. When etching is completed, don't throw away the solution. Return it to its bottle. Use a plastic funnel.

After etching many boards you will notice that the etchant seems to be thicker, and it will be difficult to see the flushing action as you lift one end of the board. You may suspect the etchant is no longer usable, but a certain amount of water is vaporized as you heat the solution so if this condition appears, gingerly add water — usually a very small amount is necessary — to restore the solution to its original state. You will again be able to see the flushing action clearly, and etching speed will be better.

As you use your original bottle you will develop a good feel for proper consistency and etching action. Finally you'll reach a point where a properly thinned solution requires 45 minutes to an hour to do one board. Your masking tape will be badly discolored and it will be very difficult to see your drill location marks. By now you will be a pro with the stuff. You can buy the ferric chloride powder much cheaper, dissolve it in water, and be sure of your mix. Don't be surprised if you find others who are willing to pay for your services. Take the time to learn to do a craftsmanlike job and if your radio budget is low, you can probably stretch it a long way by doing circuit boards for other amateurs.

drilling boards

The drills for circuit boards are very small, but can be used in any kind of a drill motor. I have successfully used inexpensive hand drills (the eggbeater kind). If you buy one, take a 1/32-inch

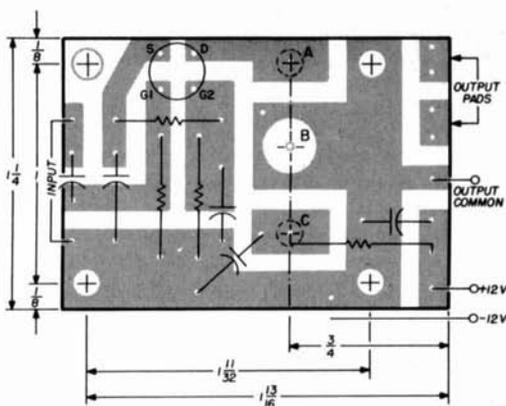


fig. 8. Printed-circuit layout which will accommodate the circuits of fig. 4, 5, 6 or 7. Mounting of the transformer for the product detector is shown in fig. 9.

(0.8-mm) or number-60 drill along to be sure that the chuck will close on a drill this small. Select one that turns smoothly. A drop of oil on the gears and bearings often does wonders. When using such a drill, chuck it so only a short section protrudes from the chuck. Rotate the chuck smoothly and evenly, and don't try to rush the job or you'll break the drill.

If you use a drill motor, it is best to use fairly slow speeds. It may be worthwhile to make up an SCR speed control. Again, allow as little as possible of the drill to protrude from the chuck. Of course, if you have a drill press, there is very little trouble. When drilling circuit boards, however, you will find that drills do not last as long as they do when

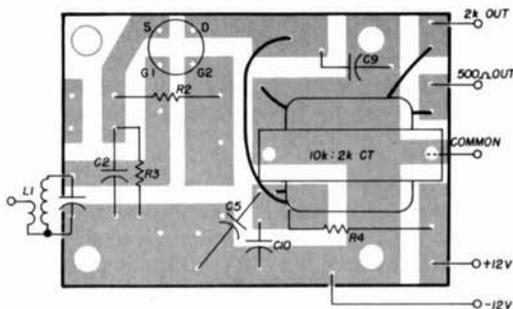


fig. 9. Method of mounting the product-detector output transformer on the universal printed-circuit board.

drilling steel. Fiberglass and phenolics are both abrasive materials. You may get only 100 holes with good grade drills, then the drill begins to turn up an excessive burr (see fig. 11). This makes soldering difficult because the solder doesn't want to climb the burr. Also, when a drill gets to that stage, it will often wobble as it cuts, producing an oversize hole.

If you want to take a whack at this sort of construction, but are unsure about your success, and you want to cut parts cost, don't overlook scrap TVs, radios, surplus computer boards, etc. Usually nothing more than an ohmmeter check is

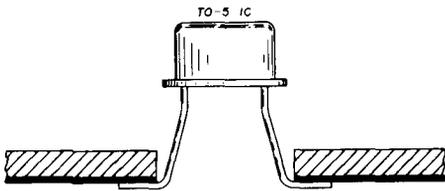


fig. 10. This method of mounting TO-5 packaged ICs allows them to be removed from the circuit board without damage.

necessary. With this type of construction you can use components with very short leads. The receiver in fig. 1 was built with almost all scrounged parts and represents a total cost of about \$7.00.

soldering

Your soldering techniques are very important for good PC board work. The economical Ungar soldering iron with a 37- to 47-watt heating element and 1/8-inch (3-mm) wedge-shaped tip is a good combination. An SCR controller or Variac can be used to regulate the heat. For smaller foil areas you can cut the voltage back to about 70 volts, but for large foil areas the iron will require full voltage. Use small diameter solder. Either 0.032-inch or 0.040-inch (about 1 mm) is satisfactory.

Clean the leads of the components before mounting them through the board holes and place the tip of the soldering iron against both the board and lead as

shown in fig. 12. Feed a little solder to the same junction to set up a thermal path from the soldering iron to both lead and foil. Then wipe the solder in a circle around the junction. The solder should creep out evenly all around and form a nice fillet as shown in fig. 13A. If you get a lumpy joint as shown in fig. 13B it could be due to lack of heat, dirty board or lead, dirty iron, excessive solder, or a combination of these items. It may or may not be a good joint.

On large copper areas the heat is dissipated so fast that it might require a heavier iron. As soon as the joint is made, wipe the tip of the iron on a damp rag or sponge. Clean the soldered joint with isopropyl alcohol (the discount drugstore variety is ok). The flux residue will absorb moisture and form flux bridges between adjacent foil strips. The alcohol will leave a whitish film which can be removed later by washing the completed board with plain soap and water.

For cleaning the boards I use the inexpensive acid brushes obtainable from good hardware stores. I cut the bristle length in half to stiffen the brush. If your hardware store doesn't stock these brushes, try your local sheetmetal shop. They are a common tinsmith's tool for brushing flux onto a joint.

The foregoing instructions may sound tedious and unnecessary, but you will soon find that they do not take any great deal of time, and the results are worth the effort. A dirty soldering iron and a dirty lead will require many seconds of heating to get a satisfactory joint. Often the first impulse is to feed in more solder. The end result is, commonly, solder so overheated it crystallizes into a grayish mass, may

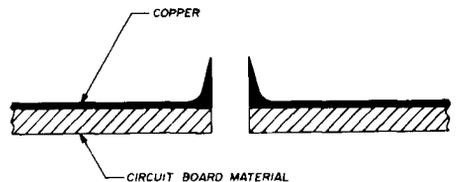


fig. 11. When drilling printed-circuit boards, a dull bit will produce an excessive burr as shown here.

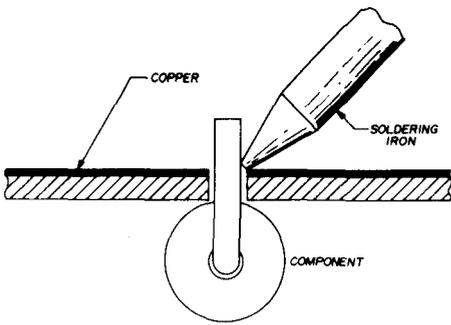


fig. 12. When soldering components to a printed-circuit board place the tip of the soldering iron between the component lead and the copper foil.

not be bonded to the lead, and a copper foil strip so overheated it peels off the board. Follow the four main rules and save trouble:

1. Absolutely clean board, no fingerprints.
2. Keep the soldering-iron tip clean.
3. Use the right heat to get a nice fillet on your soldered joints with little solder buildup.
4. Clean the finished joint.

Incidentally, too little *or* too much heat will produce a grayish, porous solder joint. A proper joint is shiny. If you want to clean up a lumpy joint, you can wick

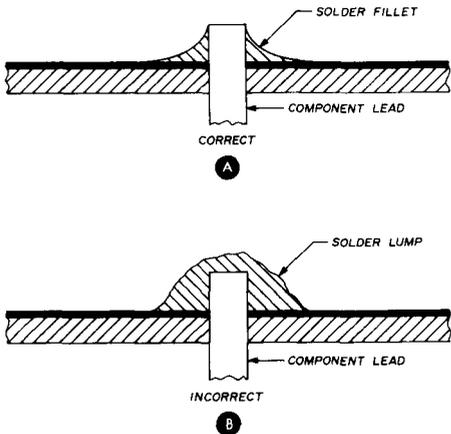


fig. 13. A properly soldered component lead will produce a smooth, shiny fillet around the lead as shown in (A). A lumpy, gray blob as in (B) is usually a poor electrical joint.

the solder nicely as follows: Mix a solution of rosin and alcohol. Dip the end of a small diameter shield braid (about 1/8 inch or 3 mm) into the flux. Lay this fluxed braid on the joint and place a clean, hot soldering iron on top of the braid — the excess solder is sucked up into the braid. This solder wick is obtainable in rolls of untinned braid saturated in flux, but you can find lengths of suitable braid in shielded leads to phonograph pickups, on volume controls of some TV sets, etc.

Do not try to use the so-called non-corrosive soldering pastes! Their flux residues are difficult to get rid of. A tiny quantity in a lead hole can become an insidious time bomb.

Those of you who started in radio along with me — way back when — re-



fig. 14. Proper method of wrapping a component lead around a terminal.

member the old cardinal rule was: First make a rigid mechanical connection and then solder a joint. Leads were tightly wrapped round and round a terminal before soldering. Many fellows applied plenty of solder for extra strength — particularly men who worked in the marine or mobile services. Then came the space and missile age, and the need for extreme reliability in soldered connections. The extreme vibration and G forces soon proved the old ways were inadequate. For high-reliability work you are forbidden to wrap a wire completely around a terminal. You do it as shown in fig. 14 and use a gimmick like an alligator clip on a rubber band to hold the wire secure against movement until the solder cools. You use only enough solder to form a fillet, and the lay of the strands of wire show clearly above the fillet.

Of greatest importance is the appearance of the solder. It must be shiny, indicating correct heat and no movement of the wire while cooling. This insures maximum strength in the joint, and low-

est resistance. With excess solder, an inspector can't be sure of the quality of bond to the strands of wire, so you wick it, clean it and do it over again. I don't mean to imply that you should produce aerospace quality boards, I merely want to stress the cleanliness requirements. By following those four little steps you will find it easy to get the one feature you *do* want: Shiny solder joints. Solid-state devices are relatively high-current, low-voltage devices. A poor solder joint is more likely to be troublesome under those conditions.

And don't give up the ship because your eyes aren't what they used to be. I just finished a one year stint on an experimental spacecraft, and the stalwarts on that job were all in their fifties, members of the bifocal crowd, and I had

circuit feeding a simple capacitance-multiplier circuit. The result is a fair degree of regulation and very low ripple. A supplementary benefit is that the pre-regulator will provide considerable immunity from power-line transients and voltage variations.

For checking vfo drift you need a supply which is stable with respect to power-line variations. This circuit will provide 12 volts at about 300 mA, with some voltage droop at loads over 300 mA. The circuit can be simplified by eliminating the pre-regulator (C2, R1, CR1) and changing R2 to 470 ohms, 2 watts. Since the transistor will be dissipating about 3.5 watts it can be mounted on the chassis to provide a heatsink. The zener, CR1, will dissipate about 6 watts under no-load conditions so it should also

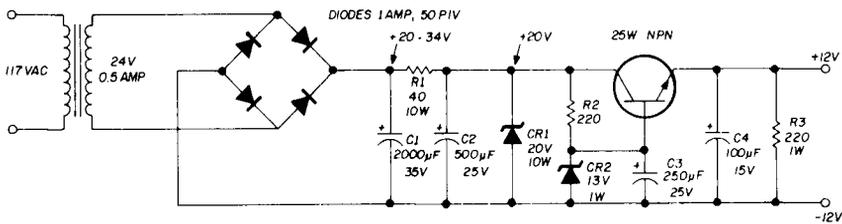


fig. 15. Regulated power supply with low ripple voltage suitable for many solid-state circuits.

been away from Hi-Rel work for many years.

Now for a few tips: Install your semiconductors *last*. That way they are heated only once. Don't be afraid to leave full-length leads on the transistors on the universal board. It won't degrade performance, and until you are used to PC board work it will help you avoid overheating transistors.

If your station is close to the seacoast you may want to protect your boards from salt-air corrosion. Mask the edges of the board and spray the foil side with clear acrylic.

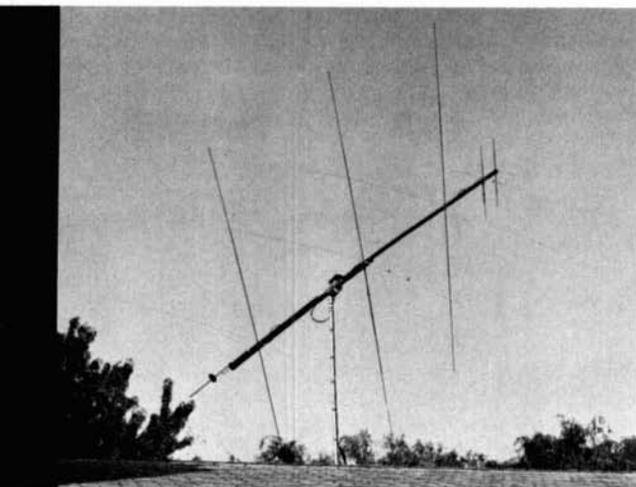
Finally, use a regulated power supply with low ripple voltage. If you have a junkbox full of surplus semiconductors, the power supply in fig. 15 will be quite adequate. Basically it is a pre-regulator

be mounted on a heatsink capable of dissipating this kind of power. Scrap car radios often can be a source of such heatsinks. If your junkbox doesn't contain the transistors and zener diodes, it may be more economical, simpler and less bulky to purchase a three-terminal voltage regulator for 12 volts.

conclusion

Although I still build a fair amount of vacuum-tube gear, I find solid state a great deal more fun. I have never been able to obtain such high performance as easily in homebrew gear. Construction today is less a machine-shop job and more of a card table variety of work. I hope these notes will help you, too, to have the pleasure I've found in this field of tinkering.

ham radio



automatic azimuth/elevation antenna control for satellite communications

How to build
an automatic
az-el antenna
control system

Anyone who has operated through Oscar 6 using a directional receive antenna is aware of the difficulties involved in spotting the transmitter, conducting a coherent conversation, keeping the log and orienting the antenna. This article shows how to eliminate one of these problems, antenna orientation.

The array used here consists of two 3-element, 10-meter receive antennas and two 2-element, 2-meter transmit antennas, all on the same boom. The 10-meter antenna beamwidth is about 60 degrees so alignment, while not critical, has to be readjusted numerous times on any pass of the satellite. This procedure became tiresome, and finally resulted in the design and construction of the automatic azimuth-elevation rotor control system described here. A block diagram of the system is shown in fig. 1.

This particular rotor control was designed to handle a CDE TR-44 azimuth rotator and an Alliance C-225 elevation rotator. However, any antenna rotators with position-sensing pots can be adapted for use. Basically, the system consists of a cassette tape recorder playing pre-recorded digital information into the rotor control where it is decoded and loaded into two shift registers. The register output is then converted into two analog signals which are propor-

George R. Bailey, WA3HLT, Bethesda, Maryland 20014

tional to the desired antenna azimuth and elevation. The desired position signal is compared with actual rotor position, and if the error is excessive, the rotators are driven to null this error. Manual operation of either rotator is still possible by use of the mode switch and position metering.

pre-recorded information

Approximately every two minutes, every minute for close passes, a ten-bit

position correction. A typical tape format is given in fig. 2. Bit spacing is not critical, but should be no faster than five times that shown.

At least two external audio oscillators are required to record the tapes. The circuit used to control the audio signal generators is shown in fig. 3. Presently, due to operating schedule limitations of Oscar 6, only South to North passes are available. Consequently, five cassettes, 30 minutes on

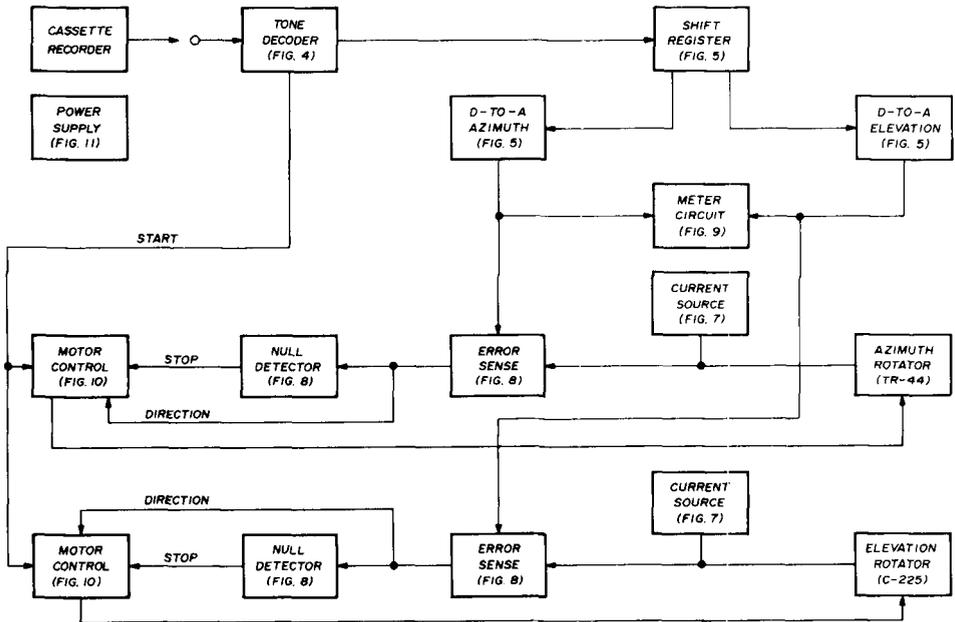


fig. 1. System block diagram of an automatic azimuth/elevation control system designed for satellite communications.

binary word is fed to the rotor control. A zero is represented by a 1585-Hz tone, a one by the absence of this tone. A shift signal is also required, and the presence of a 228-Hz tone is used for this purpose. Six bits have been allowed for azimuth information and four bits for elevation. Thus, the minimum change in antenna position is six degrees about either axis. Following each word is a 700-Hz tone which initiates rotator

each side, provide sufficient alignment accuracy for any useable pass from my station.

control circuit

The interface between the tape recorder and the TTL logic circuitry is shown in fig. 4. The peak frequency of each selective amplifier is shown on the schematic. Since close-tolerance components are not used, your frequencies

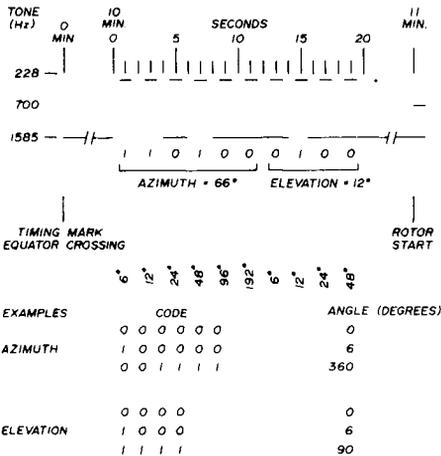


fig. 2. Tape format for cassette tapes used to control the automatic az/el system. A zero is represented by a 1585-Hz tone, a one by absence of this tone. A 228-Hz tone is used to shift the digital information from the shift registers into the D-to-A converters, and a 700-Hz tone initiates rotator position correction. A tone encoder for encoding the cassette tapes is shown in fig. 3.

may be somewhat different. As a result, it is best to build and test at least this part of the rotor control before recording the program tapes. There is one half

of a 558 op amp left over which, if you wish, can be used as an audio input buffer. All three of the amplifier-drivers produce a negative-going pulse when the appropriate tone is applied.

The shift registers and digital-to-analog converters are shown in fig. 5. The unmarked resistors must be hand picked to insure not their absolute value, but their relative value. The condition to be met for the elevation D-to-A converter is that: $R_2 = 2R_1$, $R_3 = 4R_1$ and $R_4 = 8R_1$ where R_1 is approximately 4700 ohms. Similarly, for the azimuth D-to-A converter: $R_6 = 2R_5$, $R_7 = 4R_5$, $R_8 = 8R_5$, $R_9 = 16R_5$ and $R_{10} = 32R_5$ where R_5 is approximately 3300 ohms. The selection of parts to meet these conditions is done with the aid of the test circuit shown in fig. 6. The 7496 ICs shown in fig. 5 are unplugged, and the leads indicated in the test circuit are patched to the 7496 sockets. Next turn both ramp minimum pots to zero, and the ramp size pots to mid-range. An oscilloscope is then connected to first one and then the other desired position outputs. The observed stepped ramp is adjusted for linearity by changing resistors R_1 through R_4 for

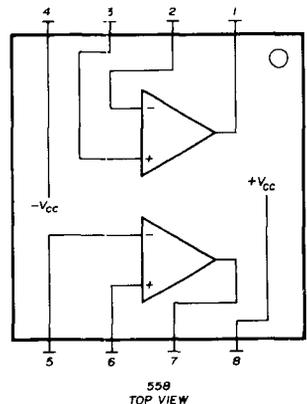
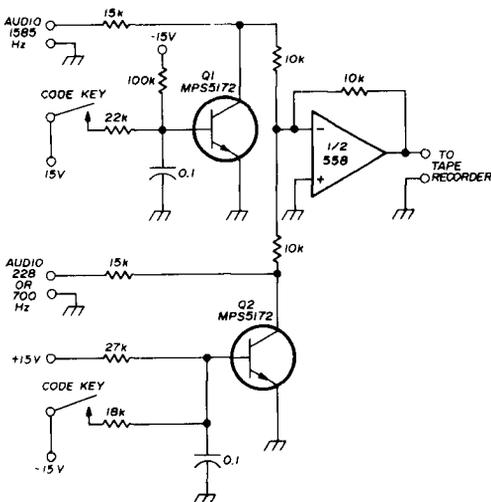


fig. 3. Tone encoder for encoding the cassette tapes required for the automatic az/el system. Tape format is shown in fig. 2.

the elevation ramp and R5 through R10 for the azimuth ramp. After linearity is established, the ramp size pots are adjusted for an elevation ramp size of 1.25 volt peak-to-peak, and for an azimuth ramp size of 5.25 volts peak-to-peak. The ramp minimum pots will be adjusted later.

Two identical current sources are used in the system, one for each rotator

resistor and adjust the current pot for 10 mA output current. Open the short across the load resistor and adjust the linearity pot again for 10 mA. If the milliammeter has significant internal resistance, it may be necessary to repeat the above steps.

The null detector circuit is shown in fig. 8. The output of U9 is an indication of the sense of the error between

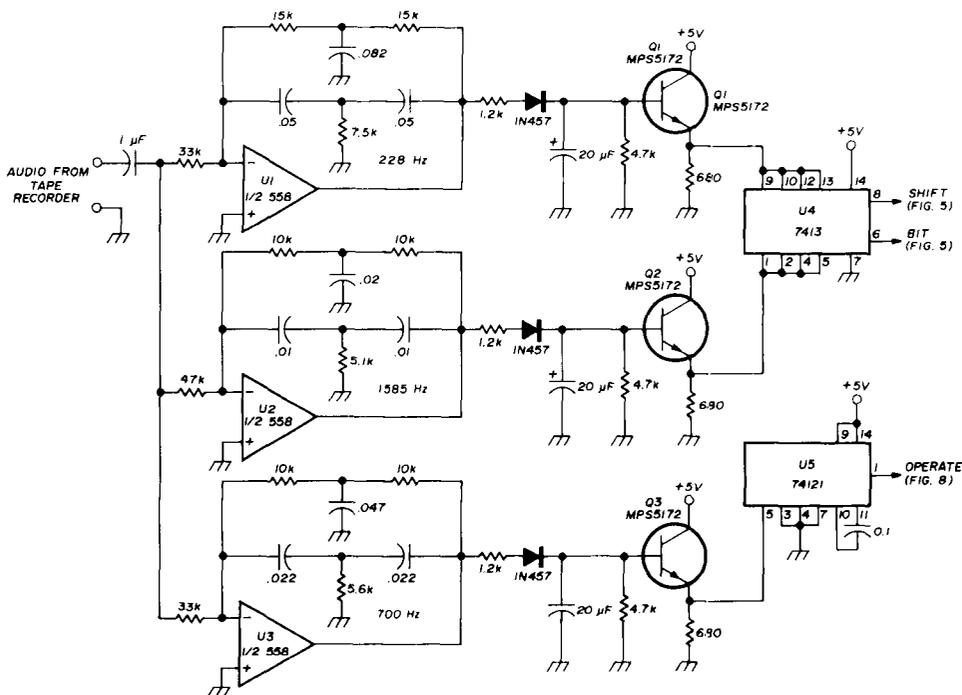


fig. 4. Tone decoder and TTL driver interfaces the cassette tape recorder with the shift registers and D-to-A converters.

position sensing pot. Exactly 10 mA is passed through each 500-ohm pot, regardless of its setting. Thus the return voltage from the sensing pot in each rotator is proportional to that rotator's position. The current source schematic is shown in fig. 7.

To adjust the current source, temporarily connect a 560-ohm resistor in series with a milliammeter from the output to ground. Then short the

desired and actual rotator position. Op amp U10 drives the rotator direction relay so that the next time the rotators start, the error is reduced. As the antenna turns, the error decreases and eventually passes through zero. This zero crossing is converted by a Schmitt trigger, U12, into a fast risetime edge which is used to turn off the RS flip-flop U11C - U11D. An identical null detector is used for the second axis

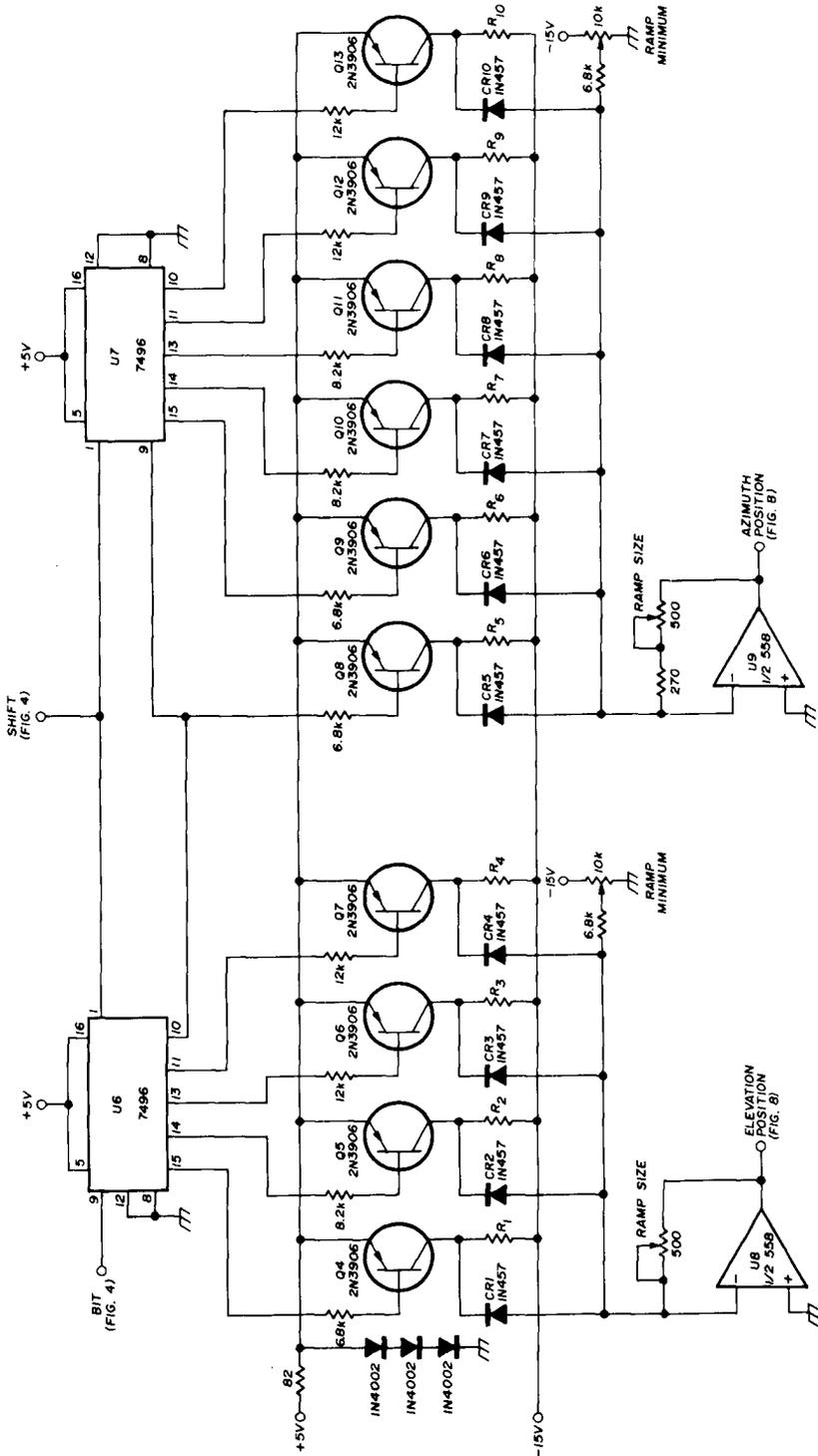


fig. 5. Shift registers (U6 and U7) and digital-to-analog (D-to-A) converters. Transistors Q4 through Q13 are all 2N3906s; diodes CR1 through CR10 are 1N457s. A simple test circuit for aligning the D-to-A converter is shown in fig. 6.

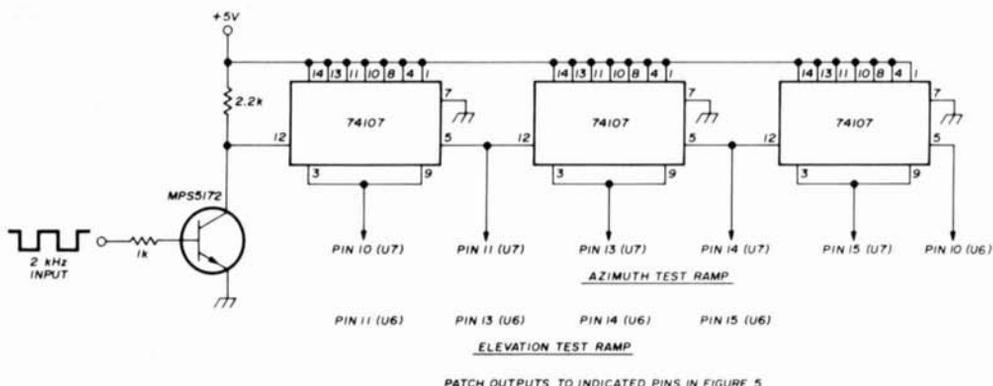


fig. 6. Test circuit for aligning the D-to-A converter of fig. 5. Outputs from test circuit are patched to indicated IC pins in fig. 5 (see text).

which uses the remaining half of U12. The RS flip-flop of each null detector controls the appropriate motor-run relay so that when a null is detected, the rotation about the axis indicating zero error stops. Since the rotator motors are turned off at the error null, the antenna slightly overshoots its desired position.

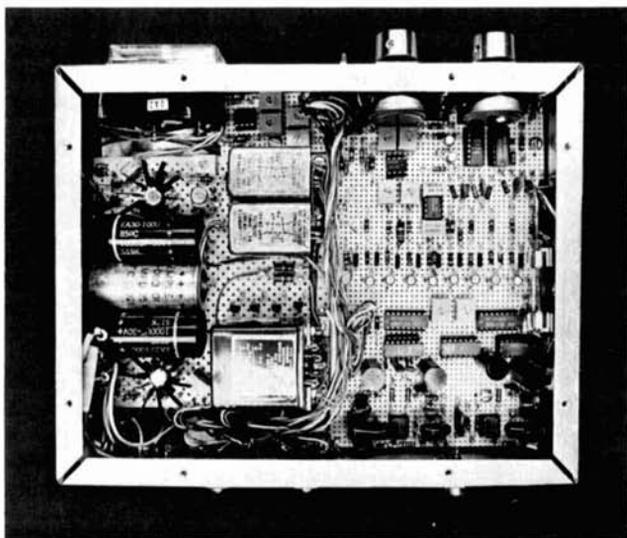
When the mode switch is in the manual position, the D-to-A converter output is ignored and an externally adjustable pot is substituted, allowing manual entry of the desired rotator

position. The rotators are driven to null when the appropriate manual start button is depressed.

The metering circuit is shown in fig. 9. In the azimuth position the meter reads 0 to 400 degrees, and in the elevation position the meter reads 0 to 100 degrees. Calibration will depend on the specific rotators used, and will be described later.

The circuit in fig. 10 is for use with the CDE and Alliance rotators. Other rotators may require circuit modifica-

Layout of the automatic azimuth/elevation control circuitry, showing location of major components.



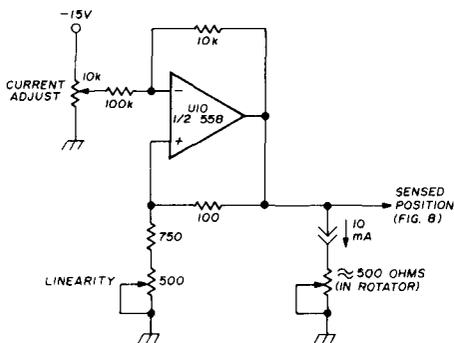


fig. 7. Current source. Two are required, one for azimuth, the other for elevation.

tions. The relays were obtained surplus, and have 28-volt coils with a pair of 5-amp contacts.

One modification is needed on the TR-44 rotator. If you have a series-1 or -2 rotator, remove the sensing pot lead attached to terminal 7 and move it to the previously unused terminal 8. If you have a series-3 rotator, remove the motor common lead from ground and connect it to the previously unused

terminal 2. For both axes of rotation, when the rotator direction relay is energized the rotator should rotate in the direction that increases the return voltage from the position sensing pot. If this is not the case, reverse the motor winding leads at the control unit.

power supply

Three separate regulated supplies are used in the system. The +15 and -15 volt supplies use 723 regulator ICs with a finned heatsink on each. The +5 volt supply uses another 723 IC in conjunction with a 40312 pass transistor which is screwed to the chassis. The circuit is shown in fig. 3. After the power supply section has been built and adjusted, it is important that the +15 and -15 volt regulators not be readjusted after completion of the remaining circuits. If these voltages are changed, recalibration of the entire system will be necessary.

calibration

Connect both rotators to the rotor

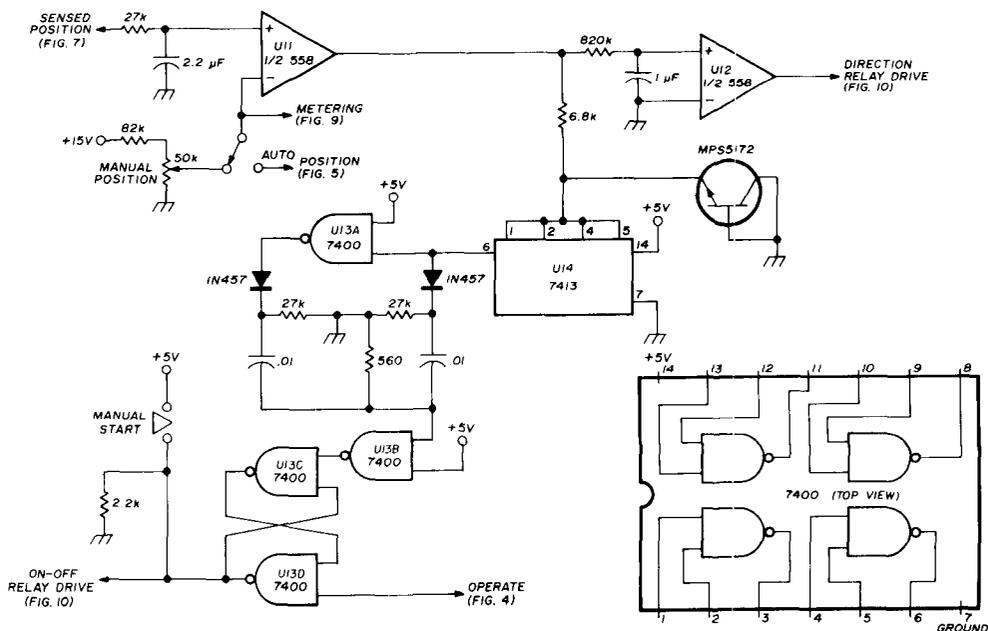


fig. 8. Null detector. Two circuits are required, one for azimuth, the other for elevation.

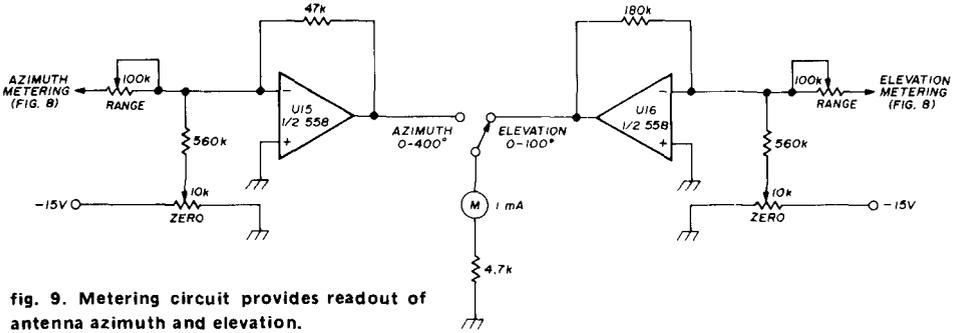


fig. 9. Metering circuit provides readout of antenna azimuth and elevation.

control. Set the mode switch to automatic. With a test tape, enter all zeros into the shift registers. Push the azimuth rotor start button and allow the rotator to stall. Now, slowly rotate the azimuth ramp minimum pot until the azimuth run LED extinguishes. Next, enter 001111111 into the shift registers and allow the azimuth rotator to either finish rotation or stall. If the rotator is stalled, retouch the azimuth current source adjustment until the azimuth run LED extinguishes. If the rotator stops before rotating 360 degrees, decrease

the azimuth current source current and restart the rotator. Continue doing this until the rotator stalls. Then increase the current slowly until the azimuth LED turns off. Again enter all zeros, and then adjust the azimuth meter zero pot for zero meter reading. Again enter 001111111, and adjust the azimuth meter range pot for a meter reading of 360 degrees (400 degrees full scale).

The rotor control will position the elevation rotator over a 90-degree segment with zero degrees displaced from the low sensing pot resistance end of

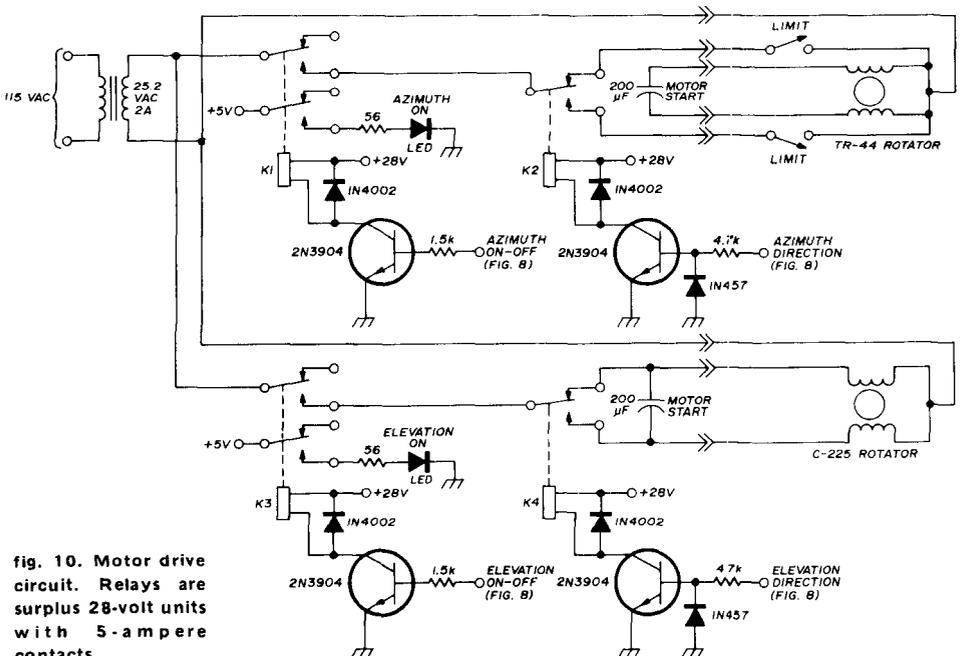


fig. 10. Motor drive circuit. Relays are surplus 28-volt units with 5-ampere contacts.

rotation by as much as 30 degrees. Mark the desired zero-degree point on the rotor shaft, somewhere in the first 30 degrees of shaft rotation. Mark another point on the shaft corresponding to the 90 degree position.

Enter all zeros in the registers and initiate the elevation rotator. The rotator should stall. Turn the elevation ramp zero pot through the point that the

enter all zeros and adjust the elevation meter zero for zero meter reading. Finally, enter 001111111 and adjust the elevation meter range pot for a 90-degree meter reading (100 degrees full scale).

operation

For manual operation the mode switch is set to manual and the azimuth

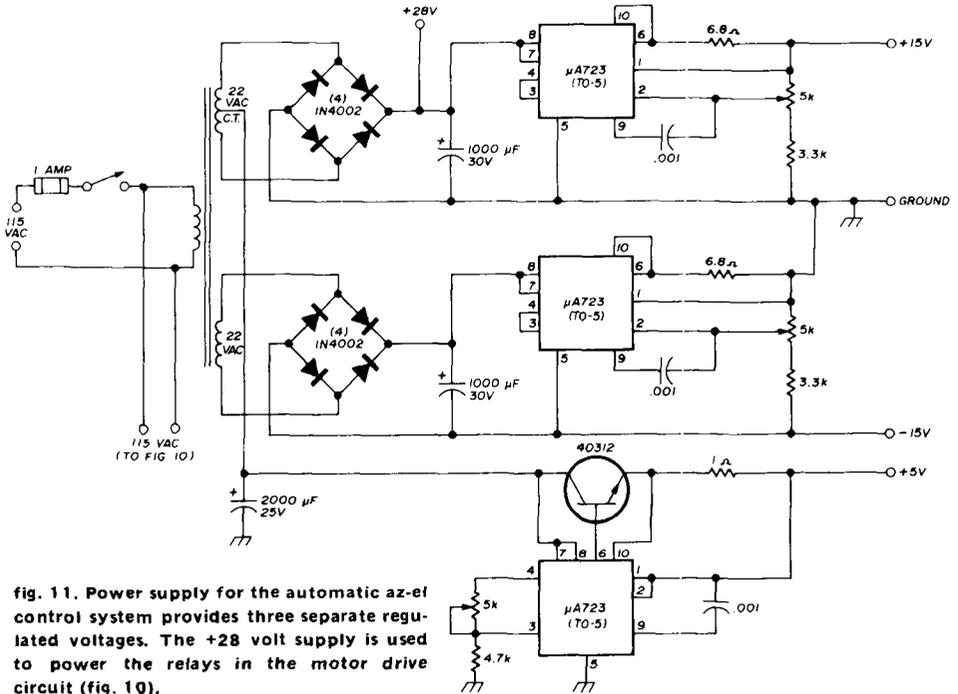


fig. 11. Power supply for the automatic az-el control system provides three separate regulated voltages. The +28 volt supply is used to power the relays in the motor drive circuit (fig. 10).

elevation LED extinguishes. Restart the rotor. It should stop somewhere between the limit of rotation and the desired zero-degree mark. Continue re-adjusting the elevation ramp zero pot, and restarting the rotator until it stops at the desired zero-degree mark.

Now enter 001111111 in the registers and initiate the elevation rotator. It should stop near the desired 90-degree position. Readjust the elevation current source current until the rotor does stop at the desired 90-degree point. Again

and elevation pots are adjusted to the desired antenna position. Start the rotators with the pushbuttons. Rotation is complete when the LEDs extinguish. For automatic operation simply place the mode switch in automatic and select the pre-programmed tape most suitable for the next satellite pass. When the satellite crosses the equator, start the tape at the zero-minute timing mark. Then forget about the antenna and enjoy good solid communications.

ham radio



-ISC *Clegg* **DIVISION**

3050 Hempland Road
Lancaster, Pennsylvania 17601
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audio oscillator

Wide range
sine, triangle
and square-wave
generator using
the versatile
Signetics NE566
integrated circuit

If dollars are scarce and shrinking on your workbench but you need a utility audio oscillator, find a Signetics NE566 function-generator IC. Then put it into a simple circuit to get triangle, approximate sine, and square wave outputs over 10 Hz to 25 kHz, in two bands. That basic range extends to 200 or to 500 kHz, if you add one component to the circuit described here.

Total cost for your audio oscillator could run as low as five dollars, if you're an efficient shopper or your junk box is well stocked. Its performance won't be critically sensitive to parts quality — the original model proves that.

The NE566 is a versatile IC, almost as easy to find as the μ A741, if it's

priced higher yet. Check the electronics magazines to find several sources at under three dollars. When you're buying, the DIP package is best. For NE566 details, see fig. 1.

Its 1-MHz maximum is well above what's needed on most amateur workbenches. The band is set by one capacitor at pin 7. Pin 6 offers a 25:1 control range, depending upon resistance, and pin 5 a 2:1 range, depending upon voltage. The circuit described here uses both together for the 50:1 range needed to cover 10 Hz to 25 kHz in two ranges.

Looking at outputs, the triangle wave is best for all-around application since it's nearly a sine wave. See power spectra facts in table 1. There's also a good square wave, if you're interested in digital work.

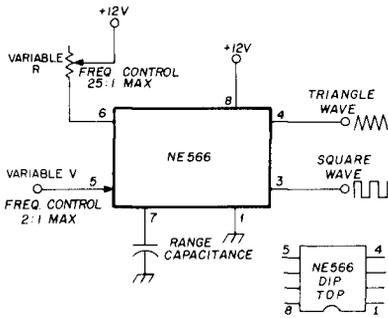
basic circuit

Fig. 2 shows the basic NE566 oscillator schematic. Its maximum 25-kHz output is 40 times under what the NE566 can do, which makes parts values noncritical. However, C2 and C3 should be the best quality available. That is because the NE566 uses constant-current circuits to charge and

table 1. Comparative analysis of sine, triangle and square waves (Fourier power spectra).

	sine	triangle	square
f	100%	84.5%	51.0%
2f	—	—	—
3f	—	9.4%	19.0%
4f	—	—	—
5f	—	3.4%	11.0%
6f	—	—	—
7f	—	1.7%	8.0%
8f	—	—	—
9f	—	1.0%	6.2%

Jim Ashe, W1EZT



Supply requirements

24 volts maximum, 7 mA typical. 12.4 mA maximum with 12-volt power supply

Input resistance

1 megohm typical (terminal 5)

Triangle output

50 ohms, 0.5% linearity

Square-wave output

50 ohms, 20 ns risetime, 50 ns falltime

Operating frequency

$$f_o = \left(\frac{2}{R6C7} \right) \left(\frac{+V - 5}{+V} \right)$$

R6 = resistance at terminal 6
 C7 = capacitance at terminal 7
 +V = supply voltage
 V5 = voltage at terminal 5

fig. 1. Basic specs of the Signetics NE566 IC function generator.

discharge a capacitor, generating the triangle wave output. If the capacitor's value depends upon voltage across the capacitor (ceramic bypass capacitors) or if it features appreciable leakage depending upon voltage (aluminum elec-

trolytics) then there will be some waveform distortion.

The diodes CR1 and CR2 play a dual role. They clip the triangle wave, and they set the clipping level. Uneven clipping can be improved by trying other diodes, and some diodes will generate a better sine approximation than others. You might want to try a variable resistance at R6 while you're at it, but wave shaping doesn't depend strongly on the value of R6.

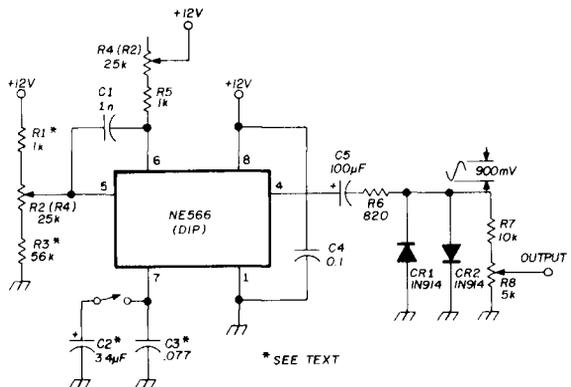
For some ideas about simplest construction at least cost, look at the breadboard construction shown in the photograph. This is a great alternative to perforated board assembly.

tuning up

Tuneup proceeds in four steps. First, verify a 50:1 tuning range. For this, put about 0.1 μF at NE566 terminal 7. This range can be adjusted by varying R1, R3 or both. You'll find R3 the most influential.

Next, set *minimum* frequency at 500 Hz by cut-and-try at C3, starting with the 0.077 μF value shown. Then set *maximum* frequency at 500 Hz with C4 added, by adjusting the value of C4. Finally, calibrate the tuning dial in 1, 2, 5 steps as shown in fig. 3. This calibration looks coarse, but it's adequate for most bench work. For example, in most radio applications you'll zero in on the desired frequency by ear, while the scale

fig. 2. The basic NE566 audio oscillator circuit provides sinusoidal and triangular outputs (see fig. 4) from 500 Hz to 23 kHz. Values of the components marked with an asterisk are set during the tuneup procedure described in the text. Frequency dial for this unit is shown in fig. 3.



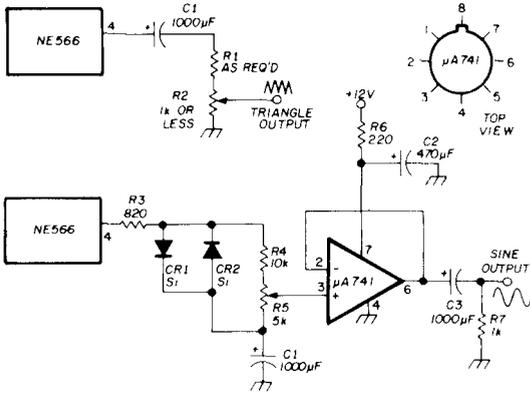


fig. 5. Optional circuits for triangle wave or voltage follower outputs.

Anybody can make a small signal by putting a large resistor in series with a small one, as a voltage divider. However, practical application brings in practical details. Test leads can pick up interference, and this becomes bad in the ac electric field from typically open house wiring. And if a series resistor isn't provided in the voltage divider it's possible to achieve deceptively good signal-to-noise ratios that don't show in real-life application. See fig. 7.

Here, long leads from the generator feed a voltage divider situated an inch at most from the small-signal input terminal. Any interference acquired by the leads is reduced along with the signal,

keeping the input signal-to-noise ratio high.

Then series resistance R3 imitates the nature of a real signal source, as the driven circuit sees it. Without R3, the small value at R2 loads the tested circuit's input terminals. That shorts out the noise the tested circuit generates in its own components and current flows. Test results taken without R3 or R8 will look very good, but they won't be true results.

power supply

This audio oscillator can be powered from the circuit it's testing, if the

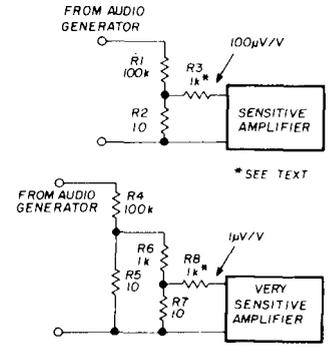


fig. 7. How to obtain interference-free micro-volt and nano-volt level outputs.

supply level is 12 volts. That saves finding another power supply – but you must make sure the generator and the driven circuit cannot interact through their common power source.

That's the purpose of R6/C2 in fig. 5, and of R5/C3 in fig. 6. An operational amplifier can impose a surprising amount of signal on its dc supply line if it's feeding a low-resistance load. These components decouple any roundabout output so that it cannot pass via supply lines through bias networks into a tested circuit, spoiling test results. As an extra precaution, one or two 1000-µF capacitors might be soldered across the generator's supply lines.

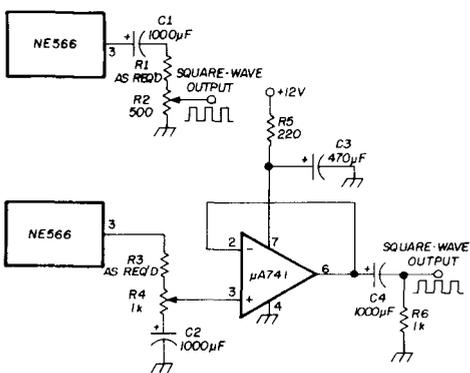


fig. 6. Optional circuits for providing a square-wave output.

ham radio

**regulated, variable
solid-state**

high-voltage power supply

Design and
construction of
a regulated
50- to 300-volt
power supply
with built-in
current limiting and
transient protection

Hank Olson, W6GXN, Post Office Box 339, Menlo Park, California 94025

The typical +150 to +300 volt regulated power supply (used for providing bias, screen or plate voltage for vacuum-tube circuits) has, until recently, most often been a tube-type design itself. This has been true because tubes are durable and have been inexpensive in the past. However, series-regulator tubes like the 6AS7G, 6080, and 6L6 are now becoming expensive (nearly \$10.00 each), and they age all too fast in regular use. The price of a set of tubes for a typical regulator (6L6, 6AU6, and 0A2) is roughly \$14.00. This makes some of the solid-state devices more attractive than they may have previously appeared.

The solid-state version of a regulated high-voltage supply may also have the built-in advantage of adjustable current-limiting, instant turn-on, and (barring accidents) virtually unlimited component life. Some users of the solid-state power supply may miss seeing the plates of the rectifier and series-tube glow red when the output terminal is shorted, as occasionally happens when testing circuits, but that is a minor disadvantage and affects only a few.

The regulated high-voltage supply described here is shown schematically in

fig. 1. It is continuously adjustable in output from 50 volts to 300 volts, at load currents up to 100 mA. The cost of the IC, two high-voltage transistors, and seven diodes (in the regulator portion) is as low as \$21.85. This is at least comparable to the price of an equivalent vacuum-tube regulator.

Note that there is a small variable auto-transformer in the primary circuit of the high voltage transformer. These variable auto-transformers are most often called "Variacs" by amateurs, but *Variac* is a registered trade name of the General Radio Company and cannot be properly used in describing the particular variable auto-transformer used in this circuit. This variable auto-transformer is mechanically ganged to the dc voltage-control potentiometer connected to pin 8 of U1.

This technique is one that I first observed on an older commercial tube-type regulated supply (a Hewlett-Packard 710A). The intent is to keep the input-to-output voltage difference, which is impressed across the series-regulator transistor (or tube), nearly constant. In the vacuum-tube model this was done to minimize tube dissipation, increase efficiency and make a smaller package possible without blowers.

In the solid-state version described here, the ganged primary variable auto-transformer and dc output voltage control pot have the same function. However, limiting the voltage across the series transistor is also of considerable importance. This is because the V_{ce} limitation of bipolar power transistors is about 300 volts (for transistors in the price range that most hams would consider reasonable).

If this mechanical complexity seems unnecessary, assume the case where you require 50 volts output at 100 mA. The unregulated input to Q1 would be about 350 volts so there would be 300 volts at 100 mA across this transistor. Not only

would this cause 35 watts dissipation in Q1, it would also stress the device to its V_{ce} limit. At load currents lower than 100 mA the input voltage would be even higher and the V_{ce} rating would be exceeded even though less power might be dissipated. With the variable auto-transformer in the primary of the high-voltage transformer, T2, the differential voltage across Q1 will never exceed 100 volts and the power dissipation of Q1 will be held to 5 watts maximum.

regulator circuit

The regulator circuit is designed around the Motorola MC1466L (or MC1566L) which is that company's *floating* regulator. This IC was designed with variable lab-type power supplies in mind and is powered by a 25-volt supply which "floats" (i.e., the power supply has no common connection to ground, but delivers its output only to pins 7 and 14 of the MC1466L IC). The only dc paths to ground that exist for the MC1466L are through the dc voltage-control pot, the load, and back through Q1 and Q2 to the unregulated high-voltage source. Note that transistors Q1 and Q2 act as if they were *one* high-beta transistor since they are connected in the Darlington-pair configuration.

The MC1466L/MC1566L regulator IC is one that has received some adverse publicity, but the past problems apparently have stemmed from lack of adequate transient protection. For instance, it was reported in *Electronic News* some time ago that Power-Mate (manufacturer of regulated power supplies) was suing Motorola over the MC1466L/MC1566L because their power supplies were failing in the field. I have not seen any further word of this problem so it is assumed that the two companies got together and solved the problem.

Next, at work I began to get modular power supplies (Lambda LCS-3 series)

back from the field with IC failures. These ICs were apparently MC1466L/MC1566L types, too, judging by their unique pinouts (although they were marked with an in-house number). A request for assistance from the manufacturer yielded not only advice, but

that agree on the method and a complete lack of field failures in the modified modular power supplies) that it seemed prudent to go ahead with a regulated high-voltage supply using the MC1466L/MC1566L. The discussion above is not meant to criticize

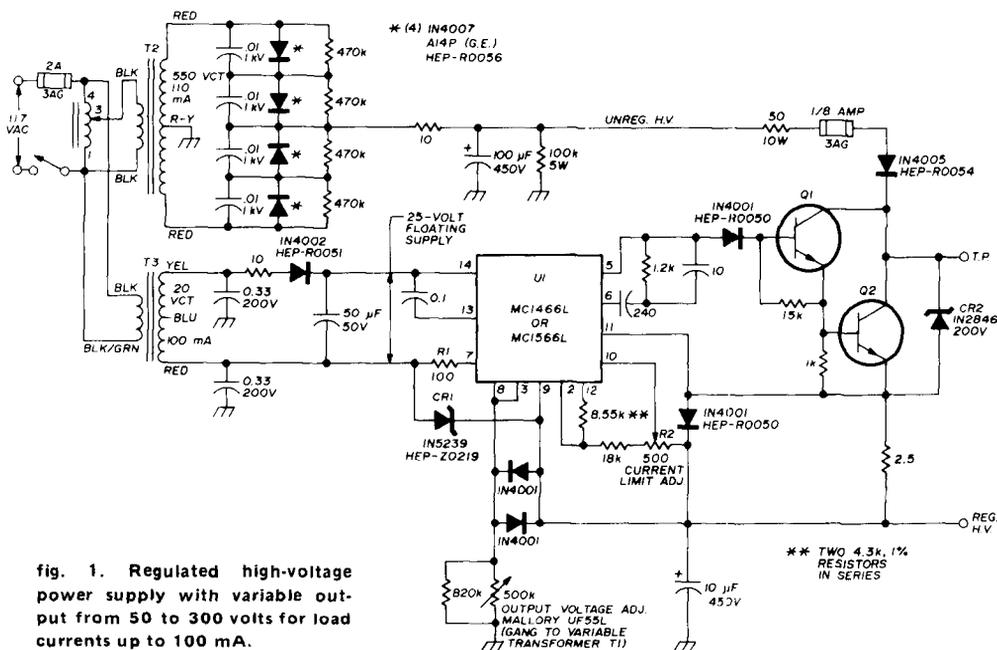


fig. 1. Regulated high-voltage power supply with variable output from 50 to 300 volts for load currents up to 100 mA.

- CR2 200-volt, 50-watt zener diode (heatsink to chassis)
- Q1 Motorola HEP244 or MJE340 (heatsink to chassis)
- Q2 Motorola HEP707 or MJ413 (heatsink to chassis)

- T1 0-132 volt, 2.25 A (0.3 VA) variable auto-transformer (Superior Electric 10B)
- T2 550 volts center-tapped, 110 mA (Triad R112A or R12A, filament windings not used)
- T3 20 volts center-tapped, 100 mA (Triad F90X)

modification kits (free of charge) that solved the problem. Subsequently, in the third edition of the Motorola *Linear IC Handbook* (1973) a note appeared on transient failures. In the fourth edition of this handbook the recommended transient-protective circuit was shown.

The transient protection picture was finally clear enough to me (two sources

Motorola, Power-Mate or Lambda, but rather points up how years of field experience are sometimes necessary before all the subtle points of a component are *really* understood. I'm sure that the same was true of the 6L6 and 807 in their early days.

circuit operation

Perhaps a more detailed look at the

circuit in **fig. 1** is in order. As outlined above, transformer T2 derives its primary ac voltage from terminals 1 and 3 of T1, the variable auto-transformer. Since the ac voltage output of all the secondary windings of T2 vary with the setting of T1, the 5- and 6.3-volt secondaries of transformer T2 are not used. The low-voltage transformer, T3, for the floating supply, operates directly from the constant ac line voltage.

The high-voltage rectifier uses four 1000-volt PIV silicon diodes in a full-wave, center-tapped circuit. Since the variable auto-transformer can push the primary ac voltage of T2 to 135 Vac, the ac output can go as high as 320 volts. Thus, the conservative thing to do is to use two 1000-volt PIV diodes in each leg of the rectifier. The standard 0.01 μ F disc capacitor and 470k resistor are connected across each rectifier diode to assure equal voltages across each. A 100- μ F capacitive input filter is used with a 10-ohm series resistor to limit input current to a safe level for the diodes (and for the capacitor). A 100k bleeder resistor was added across the 100- μ F filter capacitor to minimize surprises when doing initial circuit work.

The floating power supply is about as stark a supply as you will find anywhere. It is a simple half-wave type with a silicon diode, 10-ohm surge current limiting resistor and a 50- μ F filter capacitor. Since the worst-case current drain from this supply (by the MC1466L) is only 12 mA, not much of a supply is required. The two 0.33- μ F capacitors from the secondary leads of T3 are part of the transient protection for the IC.

The 100-ohm resistor, R1, and 1N5239 zener diode, CR1, in the regulator circuit are the primary recommended components to prevent IC breakdown during transients. The 0.33- μ F capacitors mentioned above represent *additional* transient protection.

There are some other added protec-

tive components that I felt would save the high-voltage transistors Q1 and Q2 in a particular failure mode. These are the 1/8-amp fuse in the unregulated high-voltage lead and a 200-volt zener between the emitter and collector of Q2. To explain this zener and fuse combination, suppose that the supply is set at +120 volts output and current limiting is set at 100 mA. Should the output be shorted, the *entire* unregulated high-supply is impressed across Q2; this would be about 180 volts at 100 mA or 18 watts. The transistor can handle this amount of wattage at least long enough for the operator to switch the supply off.

However, if the supply is set at, say, 280 volts output and 100 mA limiting, a short across the output will place about 330 volts across Q2. This, of course, exceeds its V_{ce} rating and will destroy the transistor. The 200-volt zener across Q2 limits the voltage during an output short condition to 200 volts, and the fuse opens at 125 mA to protect the *zener* from over-dissipation.

A high-current zener diode must be used (the zener must be able to handle at least several times the fuse current for a good part of a second). The 1N2846 is a 50-watt, 200-volt zener that is rated at 200 mA continuous current. The power supply will allow the output to go into current-limiting, providing the output voltage is below about 150 volts. At output voltages between about 150 volts and 300 volts the supply is still protected from a short circuit but a high-voltage fuse will have to be replaced after the short is removed.

construction

The supply is built into an LMB type W-1C box-chassis. This relatively small cabinet has more than enough room for everything; I can't even imagine trying to cram a 5T4, 6L6, 6SJ7 and 0A3 into such a box as we used to do. The voltage control pot (a Mallory UF55L,

made for coaxial use) is mounted on the front panel above the chassis plate. Directly behind this pot and aligned with it, mounted on an angle bracket, is the Superior Electric model 10B variable auto-transformer. The two are coupled together with a piece of 0.188-inch (5mm) drill rod which fits the ID of the hollow potentiometer shaft. The other end of the 0.188-inch rod is bushed back up to 5/16 inch (8mm) with an unused piece cut from the (long) pot shaft itself (this pot has a larger than 1/4-inch [6.5mm] shaft). The 5/16-inch diameter shafting means that the voltage-control knob and one side of the flex coupling (which is coupled to the auto-transformer) must be drilled out to 5/16 inch. A small hole is drilled in each of the two 5/16-inch hollow shaft pieces (one on the pot and the other on the bushing) so that the respective set screws will lock the 0.188-inch rod solidly to the hollow shafts.

The potentiometer should be set for minimum resistance and the auto-transformer for minimum ac output voltage from terminals 1 and 3 so that turning the output voltage control will increase pot resistance and simultaneously increase the ac output voltage. Then the set screws should be tightened.

The current limiting control, R2, is placed on the front panel, under the chassis plate near the circuit board with the IC and its associated components. The two transistors and CR2 are mounted on the chassis plate near the rear with mica washers and silicone grease for heat-sinking. CR2 and Q1 are mounted on top of the chassis plate with their pins protruding through this plate, and Q1 is mounted under the chassis. Although these mica heatsink washers are quite thin, they seem to be adequate to insulate the high voltages involved. At normal full-load operation these transistors do not even feel warm to the touch (when touching them,

however, remember that they have the full unregulated high-voltage on them — turn the supply off and wait until the bleeder reduces the voltage to a safe level).

A couple of other components in the circuit deserve mention. The 8.55k resistor between pins 2 and 12 of the IC is actually two 4.3k, 5%, 1/4-watt resistors in series. If you have an 8.55k, 1% resistor, use it by all means, but 4.3k resistors are easier to find. Also, the 2.5-ohm resistor between pins 9 and 11 of the IC can be a 1/2-watt, 2.4-ohm or four 10-ohm, 1/4-watt resistors in parallel.

There are numerous possible substitutions for the silicon rectifiers used in the supply; just make sure the PIV ratings match those called for. Similarly, the 9.1-volt zener can be most any 8.2- or 9.1-volt type with a 250-mW or larger rating. The high-voltage zener, 1N2846, may be replaced with a 1N3350. The high-voltage transistors Q1 and Q2 can also be replaced by other devices; Motorola has a number of such transistors, mostly in their MJ and MJE series. Other manufacturers (RCA for example) have lines of high-voltage npn transistors which might be suitable.

ham radio





dressing up the siamese paddle

Some
packaging ideas
for electronic
keyers

F. E. Hinkle, WA5KPG, Austin, Texas 78758

Electronic keyers have replaced the semi-automatic bug in many CW stations, and that's a sign of progress. However, a problem common to many home-built keyers is efficient operation of the paddle. This mechanical part of the keyer must provide two switch closures: one for dots and one for dashes. No matter how sophisticated the keyer electronics, the paddle plays an important part in how your CW sounds. An otherwise excellent keyer with a poor mechanical input will cause errors and poor operating habits.

Presented here are some ideas on improving paddle operation and providing a smart, professional appearance to any home-built electronic keyer. The "siamese paddle"¹ is used as an example of what can be done.

The siamese paddle is so-called because two surplus telegraph keys are used to provide the mechanical input to the keying circuit. The keys are mounted back-to-back on a heavy base.

Although this method works fine, the esthetic appearance of the key leaves much to be desired. Why build a good keyer only to have one of its most important features look 30 years behind the times? The refinements shown here will give an overall sharp appearance.

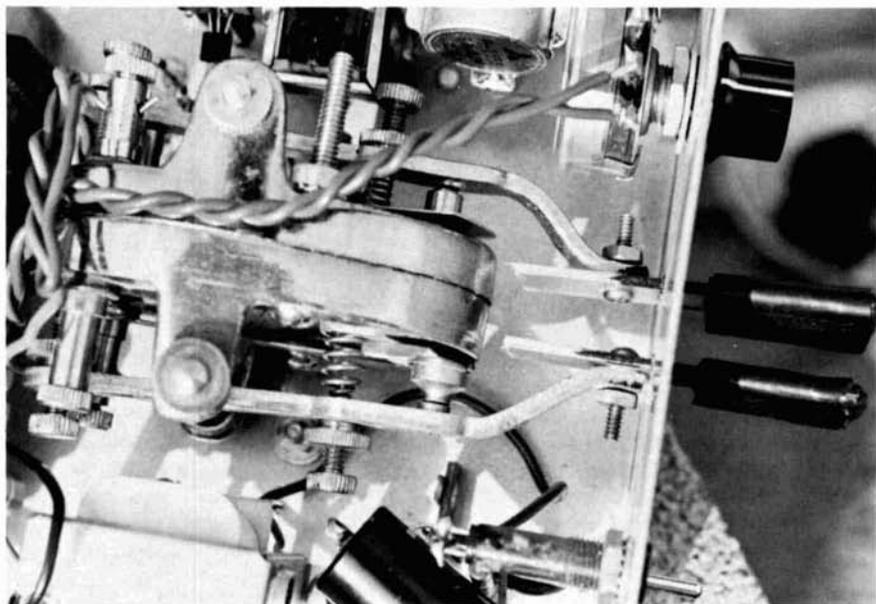
mechanical input

Three types of keys are available on the market today: the surplus telegraph keys (J-38), the ball-bearing pivot Japanese version of the J-38, and a plastic version of the J-38. The surplus and ball-bearing pivot types are better suited

extra mechanical considerations this type of key was not used.

packaging

If a siamese paddle could be constructed in an enclosure, the appearance would certainly be enhanced. After finding such a container, it became apparent that it had a lot of wasted volume. A suitable box size for the paddle is $5\frac{1}{4} \times 3 \times 5\text{-}7/8$ inches ($13.4 \times 7.6 \times 15$ cm).* With the extra space, keyer electronics and power supply fit easily into the container with the keys, making a very neat package.



Two telegraph keys are mounted back-to-back in the center of the cabinet. The ends of the keys are cut off, with fiberglass extension arms added. The handles are slipped over the arms.

to a keyer design because of friction reduction and the multiple adjustments possible. These keys are available for about \$3.00, depending on the source. It's important that the keys operate very smoothly and with little effort.

An alternative approach to a telegraph key is a microswitch for the mechanical input element. However, because of lack of adjustments and the

To install the two telegraph keys in the box, a method of mounting must be determined. The easiest approach is to use two bolts and two L-shaped brackets. A 2-inch (51-mm) bolt is used to fasten the keys back-to-back. The two L brackets are then attached to the re-

*A similar box is available from Radio Shack Stores for about \$3.40.

maining hole with another bolt of the same size.

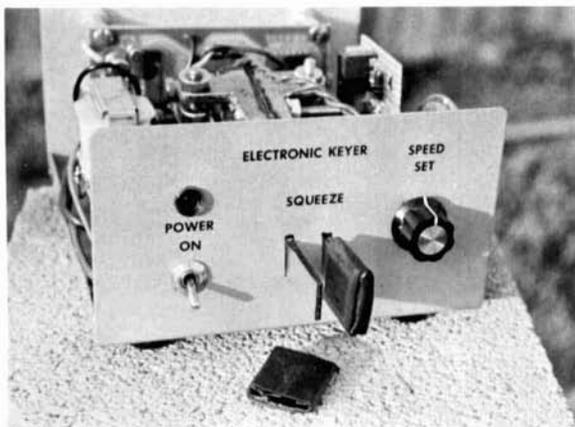
The keys may now be mounted at right angles to their normal positions, permitting lateral motion instead of an up-down motion. The keys are quite steady with just two mounting brackets. Since the arms of the keys are longer

allow the sidetone to be heard from the enclosure. Four rubber feet mounted on the bottom of the enclosure hold the keyer steadily during operation.

finishing touches

Decals were applied to give a final touch to the case. The dressing for the

Front of the paddle with one black handle removed. The handle slips over the protruding arm extension, and the fiberglass arms extend through two small file-slotted holes in the front panel.



than necessary, they should be cut off about 1½ inch (38 mm). Two small holes are then drilled into the arms to mount the paddles. Fiberglass printed-circuit boards work well for the paddles. The two arms on the keys should be bent to allow about 9/16-inch (14-mm) clearance between the paddles.

The photo of the keyer interior shows the twin paddle mounted in the middle of the box. Two 1/2 x 1-3/4-inch (13 x 19-mm) fiberglass paddles are brought out 1-1/4 inch (32 mm) from the front plate. The paddle emerges through two small file-slotted holes. Because of the irregular shape of the keys, the power supply is mounted on the left side of the box, while a sidetone circuit and speaker are mounted on the right side. An integrated-circuit Iambic keyer board is mounted with two stand-offs directly behind the keys. The back panel includes the output jack, a tune/operate switch, and a sidetone on/off switch. Ventilation holes in the cover

paddles is a plastic slip-on cover to give a better feel. Since the fiberglass paddle is about 1/2-inch (13-mm) wide, a convenient cover is a file cabinet plastic label holder. The label holder is cut to 1 x 1 inch (25 x 25 mm). The covers will then slip easily over the fiberglass paddle. To give a contrasting appearance, a black rubber alligator clip boot is cut and stretched over the clear plastic.

This type of key arrangement lends itself to a consolidated keyer design. Although an Iambic keyer board was used, the same mechanical arrangements should work with any type of keyer circuit. I hope this description will benefit those contemplating their own keyer design but haven't found a solution to the key packaging problem.

reference

1. Myron Hexter, "The Siamese Paddle," *ARRL Hints and Kinks*, Volume VI, Second Printing, 1959.

ham radio

With the HAL RVD-1005, what you see is what you get.



And you get more of what you expect from noiseless, trouble-free all solid-state TTY reception. The RVD-1005 converts the output of any TU into a clear, easy-to-read RTTY readout. The signal can be fed to a TV monitor* or, with slight modification, any standard TV receiver (Just imagine a 23-inch teleprinter!). It's the beginning of enjoyable TTY communications and the end of electromechanical devices with all of their maintenance headaches. The display above points out the many reasons why the RVD-1005 makes all other TTY systems seem obsolete—and it's just part of the HAL lineup of quality, state-of-the-art RTTY components for the serious amateur.

The HAL DKB-2010 dual mode keyboard is another example. It allows you to transmit TTY or Morse—TTY at all standard data rates, and CW

between 8 and 60 WPM. You also get complete alphanumeric and punctuation keys, plus 10 other function keys, a "DE—call letters" key and a "QUICK BROWN FOX..." diagnostic key. In both modes you have a three character buffer for bursting ahead (larger buffers optional); and in the CW mode you can adjust the dot-to-space ratio (weight) to your liking.

When we say what you see is what you get, you can count on getting all that and more, including quality construction throughout. So if you're into RTTY, join the ranks of amateurs the world over who are enjoying this hobby at its best—with professional gear at amateur prices from HAL—the leader in amateur RTTY equipment. Send today for the HAL products you want!

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In the RTTY mode, you can transmit at standard data rates of 60, 66, 75 or 100 WPM, as well as an optional 132 WPM, 100 baud. In addition to the complete alphanumeric keys, you get 17 punctuation marks, 3 carriage control keys, 2 shift keys, a break key, 2 three-character function keys, a "DE-call letters" key and a "Quick brown fox . . ." test key.

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2 three-character function keys. Output interfacing is compatible with cathode keying or grid-block keying. A side tone oscillator and built-in speaker allow you to monitor your signal — with adjustable volume and pitch controls.

The DKB-2010 also has a three-character memory buffer which operates in either the RTTY or CW mode, allowing you to burst type ahead without losing characters. A 64-character memory buffer is also available as an option. Key function logic in either mode is governed by LSI/MOS circuitry. All key switches are computer grade.

The DKB-2010 is available assembled or in kit form. Should you choose the kit, you'll find construction easy — the unit consists of three assemblies: power supply board, logic PC board, keyswitch PC board, and pre-assembled wiring harness.

Any way you look at it — as an easy-to-build kit, a complete assembly, as a CW keyboard, or an RTTY keyboard, the HAL

DKB-2010 is a real breakthrough for every amateur. It adds a whole new dimension to the exciting world of amateur radio. Once you've used the DKB-2010, you'll wonder how you ever got along without it!

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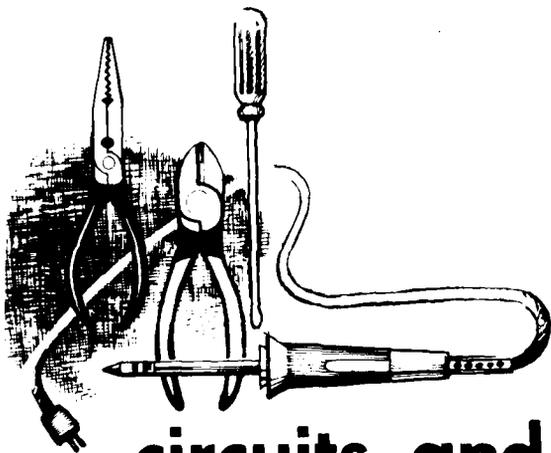
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circuits and techniques

ed noll, W3FQJ

winding up the wind

The sun blesses us with warmth and light, each a non-polluting form of abundant energy. By indirect means the sun begets the wind, a conveyer of tremendous energy, since it is the ever-shifting differential heating of the earth's surface by the sun that launches the wind. It blows over the wind-swept plain, races above the mountain tops and dances among the sea cliffs. It also howls and whistles across your backyard. The conversion of its energy to electricity can easily power your amateur radio station.

How much non-polluting energy is available from the wind? Estimates vary from 20 billion kilowatts capacity at choice sites to a maximum of at least 80 trillion kilowatts to be derived from the winds of the Northern Hemisphere. The peak summer power demand in 1973 was only 344 million kilowatts. In 1970 the peak world demand was 1 billion

kilowatts; approximately one-third of this peak capacity was made available in the United States. The world has to struggle to generate this quantity of electrical energy while the vast non-polluting energy sources continue to be ignored — light and heat from the sun, the wind, the tides and geothermal warmth.

Today it is possible to use solar energy to heat your home (with very little augmentation, even in the northern states). You could supply a goodly portion or all of your electrical needs by wind and light energy converters. Would you like to start out on your ham station?

I am doing just this at W3FQJ, struggling toward a hybrid combination that will permit me to use the wind to full-charge batteries while solar cells provide a trickle charge. I am aiming for a 1000-watt capability.

general plan

What are the major units of a wind-to-electrical-energy conversion system? The initial step is the conversion of wind energy to mechanical motion, **fig. 1**. This can be accomplished by a variety of wind blades and rotors such as multi-bladed metal or wooden propellers, sail blades made of light frames covered with material, Princeton and Chalk rotators, Savonius S-rotators, vertical axis rotators, etc. Each has its own particular characteristics and meets specific needs. Various blade types will be described in succeeding columns.

Electrical generators of various types can be used to convert mechanical rotation to electricity. Often an inter-

vening belt and/or gear system makes an appropriate conversion between the rotational speed of the wind-driven rotor and a favorable speed of rotation for the generator. Others are directly driven by wind-driven rotors. Either dc or ac generators can be employed with various voltage and power capabilities as required by the system application. Mechanical arrangements can also be set up to rotate more than one generator. Popular generator-voltage values are 12, 24, 36 and 110 volts. For amateur stations 12-volt systems are likely to be popular because of the availability of low-cost automobile generators and alternators.

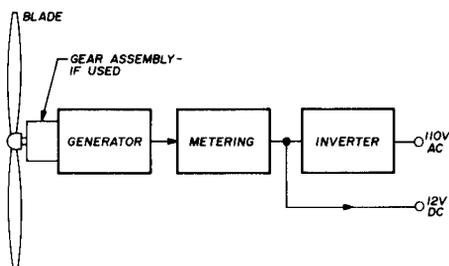


fig. 1. Basic wind generating system. Typical commercial wind generators are shown in the photographs of figs. 2 and 3.

storing electrical energy

There are periods of calm and low wind velocity when generators become inactive. Electrical energy must be stored by batteries for these time intervals. Presently the secondary battery serves as the reservoir of electrical energy. The system must be planned according to the average wind-velocity conditions of an area with an added safety factor that will accommodate a reasonable length wind-quiet period.

Lead-acid batteries are currently the most economical types for medium- or high-powered systems. Other types of secondary batteries are practical for low-power installations. Smaller and better battery systems are inevitable.

Despite the debilitating public relation outputs from the current energy empires, *continuous* service can be supplied by solar and wind electrical generating systems.

At the present time high-powered, continuous-service systems are expensive simply because they are not widespread. One can anticipate, therefore, that in the interest of economy, backup systems can incorporate means for using utility services or a fuel-driven generator. Furthermore, in many installations wind generators will be designed to provide only a percentage of the total need. A radio amateur may have as his first objective the self-sufficient powering of his amateur equipment. Later he may wish to incorporate additional electrical needs of his dwelling into the overall system.

electrical energy distribution

Ingenuity in meeting desired requirements is the key word. Presently, for most applications, the most expedient manner of operation is to use the wind generator to charge batteries. In suitable wind and with adequate capacity the output of a wind generator can be made to supply the load as well as to charge batteries. The most popular manner of distribution now is with dc voltages. You will find that for almost any ac motor application you will be able to find a dc replacement. Low-voltage bulbs are readily available for dc light distribution. For those devices and equipment that require 110-volt ac, you can use an inverter. Solid-state inverters with ratings from 50 to 75 watts to as high as five kilowatts are available.

Much modern amateur equipment is designed to operate on 12 volts dc. Fortunately, 12-volt wind generating systems for low and moderate power applications are currently the least expensive. They can also be home-brewed readily at low cost, particularly if you are willing to scrounge in auto junk yards and surplus stores for com-

ponents. Low-powered inverters of low cost can be purchased right out of the electronic parts catalogs. New and rebuilt auto generators and alternators are available from auto stores and catalogs.

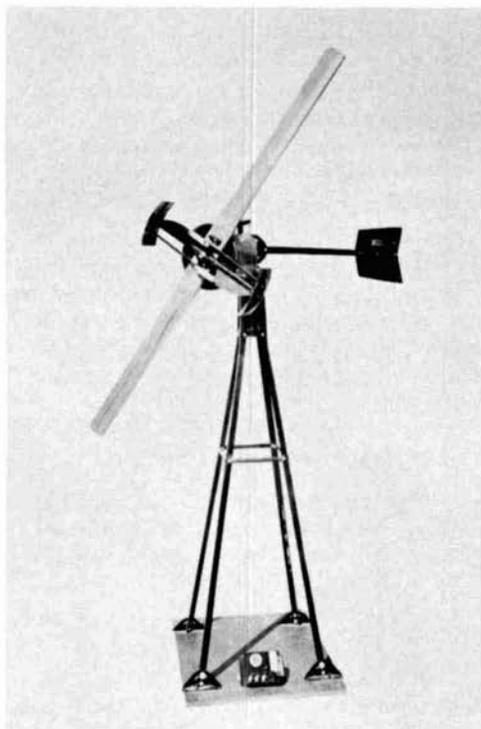


fig. 2. A 200-watt wind generator suitable for many amateur radio stations (photo courtesy Wincharger).

reading the wind

The conversion of wind energy to mechanical rotation has every indication of being a complex science. Windmills have been available for generations but have only been conceived and used in rather simple forms. Types of blades and rotors respond differentially to wind. One might be efficient at low velocity; another much more efficient at high velocity. There are now many arrangements under investigation.

In planning a wind generator installation find out as much as you can about your local wind conditions. Such infor-

mation can be obtained from your local weather bureau or directly from the National Climatic Center, Federal Building, Ashville, North Carolina 28801. A particular interest should be the yearly mean wind speed (average wind velocity).

For most presently available wind generators the minimum average is about 8 mph (12.9 kmh) or more. Average rating of equipment is often based on a velocity of 10 mph (16.1 kmh). In practice, however, the real energy producing winds range between 15-25 mph (24-40 kmh). If these levels are maintained for an average two-day interval out of seven throughout the year you are in a practical situation for a wind-generating system when using a battery-storage plan. If you enjoy a site with wind values better than these, you will have a bonus in extra power.

A small, commercially available and practical 12-volt wind generator, fig. 2, provides approximately 20 kilowatt hours per month in an area of 10 mph (16 kmh) average wind velocity.* If your site averages 16 mph (26 kmh) instead of 10, the same generator has a capability of 35 kWh per month.

Usually the wattage rating of such a generator is based on the minimum wind velocity that will produce maximum output. For example, the unit of fig. 2 produces about 200 to 250 watts output with a wind velocity of 23 mph (37 kmh). Power output levels fall off above this wind speed. In fact, automatic braking systems are included to hold down rotational speed and prevent breakdown from excessive wear.

power calculations

What are your amateur station

*For more information on the Wincharger line of wind-driven electrical generators, write to Mr. Ed Hult, Winco-Dyna Technology Inc., Box 3263, Sioux City, Iowa 51102. For more information on Solar Wind equipment, write to Mr. Henry Clews, Solar Wind, Box 7, Bar Harbor Road, East Holden, Maine 04429.

needs? Go to your log and collect some figures. Here is an example: Assume on transmit that your power demand is 120 watts. This represents a current demand (with a 12-volt supply) of

$$I = \frac{P}{E} = \frac{120}{12} = 10 \text{ amperes}$$

Assume you operate four hours per day and have a transmitter on-time of about 40%. Remember that some current is also drawn on receive and standby but for solid-state equipment this is usually relatively low. Assume a 50% *on time* to compensate for this additional current. (This approximates a two-hour period of operation drawing 120 watts continuously.) Daily consumption then approximates 20 ampere-hours ($10 \times 0.5 \times 4$). Monthly consumption would be 600 ampere-hours (30×20).

A suitable heavy-duty 120- to 150-ampere-hour 12-volt battery would adequately supply these needs. A second battery would give plenty of backup power as it could be kept on charge while the first battery is in operating position. Furthermore, a solar panel to provide a trickle charge to the battery in use will give you an additional safety factor.

How would you fare under 24 hours of continuous operation? This would correspond to a time period of 12 hours of continuous 120-watt demand. A very maximum consumption would be 240 ampere-hours. You even have some power in reserve for a very extended period of operation. You would have no trouble operating a 180- to 200-watt PEP solid-state transceiver under the above circumstances. In fact, you would have power to spare.

What would be your monthly consumption of power based on the above average conditions? Your daily use of electricity would be 0.24 kilowatt-hour (120×2). This would be 7.2 kWh per month (30×0.24). Based on the rating of the wind generator of fig. 2 you again

would have extra power because its rating at an average wind speed of 10 mph (16 kmh) is approximately 20 kWh. Therefore, you have extra power to operate additional equipment in the

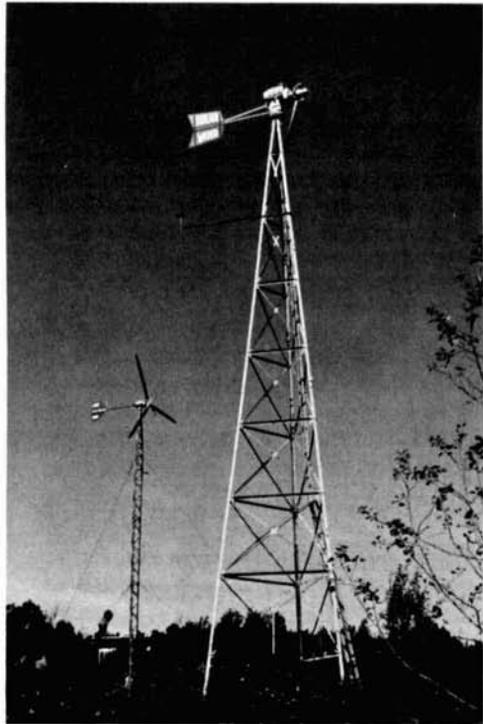


fig. 3. This 6-kW wind generator (foreground) and 2-kW unit (to the rear) supply power to a business (photo courtesy Solar Wind).

ham shack, operate more hours or use a bit more power.

These calculations have been very conservative and indicate how the smallest of wind-generating systems can make a modest ham station self-sufficient electrically. Knowing the ingenuity of radio hams, each, according to his operating habits, will find the most efficient use of the generated power. In fact, some of the power will probably be diverted to other services in the house. As the lament says, "... the answer is blowing in the wind."

ham radio



comments

5/8-wavelength antennas

Dear HR:

Having built and used both quarter- and 5/8-wavelength ground-plane and mobile antennas on two meters, I was surprised at the article in the May, 1974, issue of *ham radio*. I have had very good results using the 5/8-wavelength antenna, and KØDOK's article spurred me to do some of my own testing to see the difference for myself.

I decided that my Heathkit HW202 with a step attenuator between the antenna and transceiver would make a

good rf micro-voltmeter with which to make the measurements. The antenna is a portable ground plane consisting of three 5-foot sections of telescoping TV masting, guyed and set on a pin so the antenna could be lowered to change the driven elements and be put back in exactly the same position (I used nylon guy ropes which had enough stretch so it was unnecessary to change the guy ropes between antenna changes). The ground radials are mounted to a steel angle bracket with wing nuts for portability. The antenna is attached to a bracket with a PL-259 plug which connects to a SO-239 jack on the mounting plate.

The 5/8-wavelength element consists of a series matching inductor to the 5/8-wavelength radiator with a vswr of 1.7:1. The quarter-wavelength radiator has a vswr of 1.2:1. Both antennas were mounted on the same 15-foot mast.

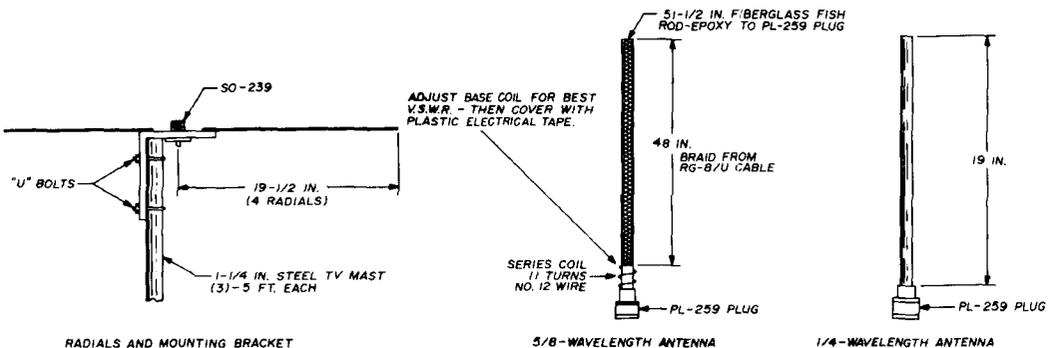


fig. 1. Details of the antennas, ground radials and mounting bracket used in gain comparisons.

The measurement plan was to use received signals, attenuate the signal to a mark on the S-meter in the transceiver, note the attenuation, take the antenna down, change the driven element, put the antenna back in place and again attenuate the signal to the same meter mark, record the reading and note the results. The step attenuator used has a range of zero to 101 dB in 1-dB steps. The results are shown in table 1.

Stations of different distances were used to take into account the different

As I pointed out in my article, obtaining this performance from a monopole depends upon creating an image element, hopefully from a reflection in the ground plane. I suspect that what Mr. Pearson has actually managed to do is to excite sufficient currents along his 15-foot support mast to, in effect, create an image radiating element. There is at least one commercial antenna (the Ringo) which appears to depend on this as it does not even include ground-plane rods. From a de-

table 1. Gain comparison of 5/8- and 1/4-wavelength two-meter groundplane antennas with three different stations. Measurement technique is discussed in letter.

	distance	1/4-wave antenna	5/8-wave antenna	gain
Station 1, Base Station	11 miles	18 dB	21 dB	+3 dB
Station 2, Repeater	21 miles	31 dB	34 dB	+3 dB
Station 3, Repeater	41 miles	4 dB	7 dB	+3 dB

angle of radiations between the two antennas. Every effort was made to replace the antenna in exactly the same spot as before so that the tests were all based on a very minimum of variables.

In conclusion, the data in table 1 shows that the 5/8-wavelength antenna has 3-dB gain over the 1/4-wavelength antenna. The antennas used for making these tests are shown in fig. 1.

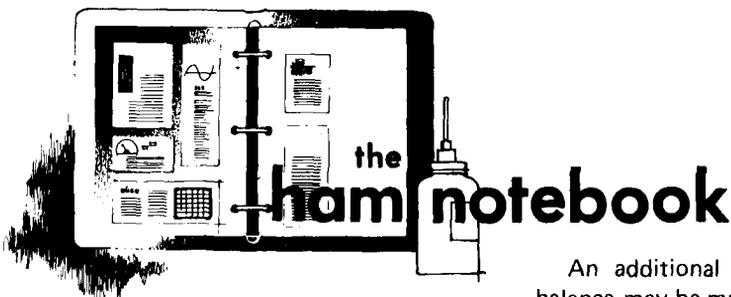
**John H. Pearson, K2GVP
Baldwinsville, New York**

I can find no obvious fault with Mr. Pearson's measurement technique although he has used a crude method at best. However, the averaging of a number of results of this type of measurement should yield a meaningful result. That is in effect what Mr. Pearson has done although his measurement resolution of one dB and the small number of samples (three) makes it hard to find the true average. I would conclude from the data however, that Mr. Pearson did indeed achieve gain from the 5/8-wavelength radiator.

signer's point of view this is a dangerous approach because the designer has no control over the antenna mounting structure and very few amateur installations will probably wind up having the antenna atop a long straight conducting pole. More likely the antenna will be set just above a 20-meter beam or even side-bracketed to a tower.

It would, of course, be very interesting if we could see a vertical plane radiation pattern of each of Mr. Pearson's antennas to see if a correspondence exists to fig. 8 and 9 of my article. Even given a well equipped antenna test range, that measurement would be a tricky one to make. On several occasions I have attempted range measurements at 150 MHz and have always been plagued by ground reflections, especially when tipping the antenna on its side so that it could be rotated for a pattern in the plane of the monopole. That is why the model work reported in my article was conducted at 1000 MHz where reflections are far easier to control.

Paul E. Meyer, K0DOK



better balancing of the Heath HM-2102 wattmeter

After wiring the Heath vhf wattmeter very carefully it may be rather disappointing to note that anything below a swr of 1.5:1 is apparently considered normal in balancing the bridge, and as designed the bridge very often cannot be nulled much below a 1.5:1 reading. Of course, it is assumed a good 50 ohm load is used at the nulling frequency, such as a Bird dummy load. However, if after following the nulling procedure per the Heath manual no good null can be obtained, the following change may be considered.

Exchange C3 (7.7 pF) and C16 (10 pF) so C16 becomes a capacitor of 7.7 pF. In parallel with C16 mount one of the 1/4-inch (6-mm) diameter miniature ceramic trimmer capacitors with a range of about 1.5 – 7 pF. If this is not available mount only a miniature trimmer with a range of about 5 – 15 pF. The intention here is to make C16 variable around 10 pF. By alternately adjusting C4 and C16 in the nulling procedure an excellent null can be obtained, much better than is possible with a fixed value of C16. Or C3 should have a greater value, in many cases it seems to, and this can be judged from the position of the rotor of C4 when this capacitor is adjusted for maximum null before modification. If C4 is fully closed C3 should be increased in value.

An additional check for sensitivity balance may be made as follows. Set the sensitivity control to maximum (minimum resistance) and with no load on the antenna side of the bridge feed just enough rf power into the bridge for a full-scale deflection on the meter in the forward position. Switching now to the reference position should give the same indication on the meter. If there is a difference of more than 10%, a correction can be made by adding additional resistance in series with the higher reading line at either point B or C on the PC board – start with about 470 ohms. This test can only be done with vhf rigs able to operate without a load (such as the Heath HW-202). If the rf output level of the rig cannot be reduced as needed, the bridge's sensitivity control may be used instead but this will reduce the accuracy of the test, of course.

Bob Fransen, VE6RF

retune weather monitor receiver to two-meter fm

A quick glance through any of several mail-order catalogs will reveal that there are inexpensive transistor receivers available for use as "weather monitors." These fixed-frequency receivers are designed to receive vhf-fm continuous weather information transmissions from National Oceanic and Atmospheric Administration (NOAA) stations on either 162.40 or 162.55 MHz. The broadcasts, a part of the National Weather Service, are intended to provide

local weather information in the public interest, especially where natural hazards are involved. This is a great idea, and many people have bought these units with thoughts of keeping track of hurricanes, receiving tornado warnings, and for assistance in planning weekend boat trips.



This particular model receiver already had a very small trimmer "Tuning" control to provide reception of either 162.40 MHz or 162.55 MHz.

However, quite a few would-be listeners have found that these units lack the sensitivity to detect the low power government transmitters at their homes and consequently the fixed-tuned receivers are useless to them. This is understandable when you compare the fine print of the receiver specs in the catalog and note a $7.5\text{-}\mu\text{V}$ sensitivity rating — and then remember the NOAA recommendation of a receiver with capabilities of $1.2\text{ }\mu\text{V}$ for 40 miles from the station; $0.9\text{ }\mu\text{V}$ for 50 miles and $0.6\text{ }\mu\text{V}$ for 60 miles.

Now, if you know of someone who has one of these little boxes and is about to throw it out, you might casually mumble that you, "could use the radio for parts" and, with luck, carry it back to your shack. Upon inspection, you will find that you possess a 9-transistor (typically) fm receiver which, with the addition of one capacitor, can be tuned to any frequency you want, such as the local repeater. Mine is set for 146.94 MHz.

Simply remove the unit's cover, locate the local oscillator circuit, and place a padder capacitor across its tuned network. As shown in the photograph, I used a small variable trimmer and placed it outside the receiver. With this arrangement I was able to tune down into the commercial fm band (88 to 108 MHz), aircraft communications frequencies (108 to 136 MHz) and, of course, the entire amateur 2-meter band. When a variable capacitor has been found that allows coverage of the desired range of frequencies, it may be permanently installed within the receiver.

Kent Mitchell, W3WTO

cmos keying circuits

Shown in fig. 1 are two alternate keying circuits which may be used with the cmos electronic keyer which appeared in the June, 1974, issue of *ham radio*. The circuit in fig. 1A is designed for grid-block keying and will key up to -140 volts, maximum. The circuit in fig. 1B is designed for keying solid-state QRP transmitters.

Jim Pollock, WB2DFA

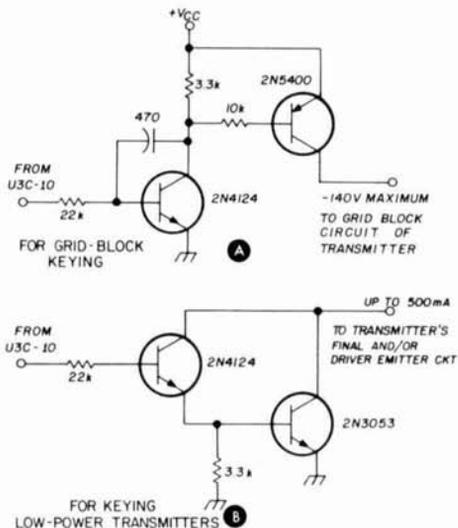


fig. 1. Alternate keying circuits for use with the cmos electronic keyer.

new products

monitoring scanner receivers



The Hy-Gain Electronics Corporation has introduced two new vhf scanner receivers, the Hy-Scan 10 for ten fm channels, and the pocket model Hy-Scan 4 for monitoring four channels. The Hy-Scan 4 is the second generation of Hy-Gain's popular Pocket Scanner, and includes several new features including individual channel lock-out, continuous volume and squelch controls, external antenna jack, earphone jack and an auto-manual scan switch. All of this is built into the small size of 5.5x2.5x1.2 inches (14.0x6.4x3.0 cm). The Hy-Scan 4 operates on four AA

batteries and uses standard 10.7-MHz i-f scanner crystals. Models are available for 30-50 MHz, 150-170 MHz and 450-470 MHz.

The Hy-Scan 10 is the big brother to the Hy-Scan 4 Pocket Scanner and features a rugged molded cyclac case with carrying handle with a flip-top which allows instant access for changing the plug-in rf modules in the single-band models (a three-band model is also available). The rf modules allow the choice of 30-50 MHz, 150-170 MHz or 450-470 MHz operation. Function controls include LED channel indicators, individual lockouts for each channel and automatic or manual scan select switch. The automatic battery charger and hide-away telescopic antenna are built in. Measuring 2.5x5.5x8 inches (6.4x14.0x20.3 cm), the Hy-Scan 10 has jacks for earphone and an external antenna, and uses standard 10.7-MHz i-f crystals.

For more information on either the ten-channel Hy-Scan 10 or the Hy-Scan 4 Pocket Scanner, write to Hy-Gain Electronics Corporation, 8601 North-east Highway 6, Lincoln, Nebraska 68505, or use *check-off* on page 94.

test equipment catalog

A six-page condensed catalog featuring Eico's broad line of electronic test and measuring instruments for laboratories, industry and amateurs is now available from Eico Electronic Instrument Company. The all new catalog features the most popular units in Eico's line of over 100 electronic kits and factory-assembled instruments, including oscilloscopes, VTVMs, VOMs, signal generators, tube/transistor testers,

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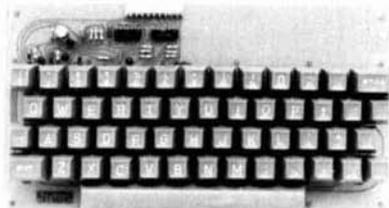
TTL cookbook

This new book by Donald Lancaster covers practically every aspect of TTL logic, shows you what TTL is, how it works, and how to use it in your own circuits and projects. In the first chapter the basics of TTL are given: what it is, how to interconnect it, how to power it, and so on. Chapter 2 is a catalog of TTL devices, giving physical and electrical specifications of all the devices mentioned in the book. Logic is covered in Chapter 3, starting with the usual basics, then going to more advanced logic designs. Particular attention is given to showing how TTL yields single-package solutions to traditionally difficult problems.

Gate and timer circuits are discussed in Chapter 4. Some practical applications are given including controlled oscillators, two-tone alarms, digital capacitance measurement, frequency meters, digital thermometers and others.

Succeeding chapters take up clocked logic, JK and D-type flip-flops and applications, counters and counting techniques, shift-register circuits, noise generators and rate multipliers. The final chapter discusses a number of practical applications, including digital counter and display systems, events counter, electronic stopwatch, digital voltmeter, digital tachometer, and other digital instruments. The author suggests several TTL projects that the reader may wish to try, relying on his own resources.

This book, by the same author of the very popular RTL *Cookbook*, is highly recommended to anyone who wants to

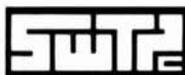


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know more about TTL ICs and how to use them. Published by Howard Sams & Company, 336 pages, soft-bound, \$8.95 from Ham Radio Books, Greenville, New Hampshire 03048.

swan ssb transceiver

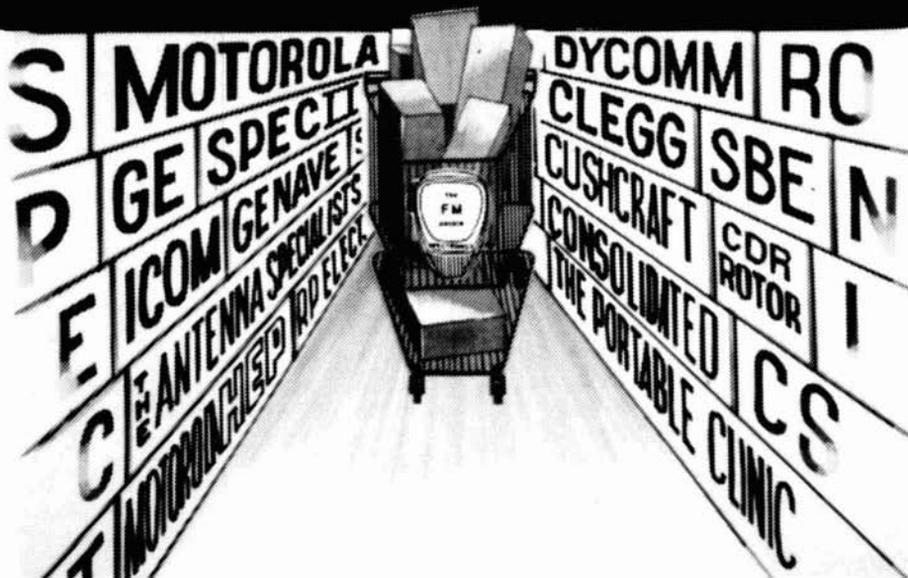


The new Swan 700CX Transceiver, priced under \$1 per watt, has a 700-watt PEP input rating on single-sideband, power enough to punch through QRM without need for an accessory linear amplifier. Frequency ranges span the 10-, 15-, 20-, 40- and 80-meter bands with extended frequency coverage of up to ten channels for MARS operation (available with use of an optional plug-in crystal-controlled oscillator).

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Other optional accessories include power supplies for dc or ac operation, a 2000-watt linear amplifier, external vfo, a super-selective i-f filter kit, plug-in vox, phone patch and mobile mounting kits. Price of the basic transceiver is \$599.95. For more information, write to Swan Electronics Corporation, a subsidiary of Cubic Corporation, 305 Airport Road, Oceanside, California 92054, or use *check-off* on page 94.

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SB-644 remote VFO

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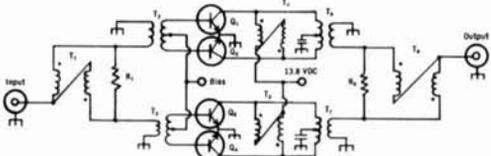


DESIGN NOTES

Mike Elliott
Sr. Design Engineer

Broadband solid-state power amplifier design

Designing a 100 watt output broadband power amplifier that will operate from a 12-volt source requires close attention to impedance matching. It is desirable to use as few devices as possible, to reduce overall complexity. However, high power devices display extremely low input and output impedances which are difficult to match over wide bandwidths. The SB-104's design uses only four transistors to develop 100 watts output across the 3 to 30 MHz range. A simplified schematic diagram is shown below with much of the bypassing and filtering deleted for clarity.



Transistors Q1 and Q2, with transformers T2 and T6 form a straightforward push-pull amplifier. Q3, Q4, T3, and T7 form a second push-pull amplifier. The push-pull configuration is desirable due to the even order harmonic rejection inherent in such an amplifier. In the SB-104, the push-pull amplifiers, combined with an effective low pass filter, reduce all harmonics to at least 45 dB below the 100 watt level.

Transformers T1 and T8 convert the nominal 50 ohm source and load impedances into two 100 ohm ports which are in phase. Any amplitude or phase imbalance causes power to be dumped in R1 or R2, thus assuring equal load sharing between the two push-pull amplifier sections. Similar hybrid transformers feed the supply voltage to the transistors at T4 and T5. Differences in phase or amplitude that would otherwise exist at the collectors are bypassed to ground, resulting in highly balanced output currents in T6 and T7. This technique helps insure excellent second harmonic rejection.

All transformers employ ferrite loading for broad response. In addition, T2, T3, T6 and T7 use brass tubing for the low impedance base and collector windings to minimize high frequency losses. The result is an amplifier which is flat within ± 2.5 dB across the 3 to 30 MHz frequency range.

Intermodulation distortion, which results in splatter, has been minimized in the SB-104, and is at least 30 dB below the output carrier level. This is accomplished by careful attention to the selection of device types and operating points. The bias voltage applied to the four power output transistors is fixed, and controlled by a diode mounted on the transistor heat sink. The proper operating point is automatically established in this manner, and thermal runaway is prevented since the bias diode characteristics change with heat sink temperature.

VSWR protection is afforded by a fast-acting ALC circuit. A directional coupler at the transmitter output provides both forward power and VSWR information. The resulting voltage controls the gain of the transmitter, thus controlling power output. In high VSWR environments, the power output is reduced to protect the power amplifier. Typically, a 2:1 VSWR results in a 10% power reduction, and a 3:1 VSWR reduces the output power to approximately 50 watts.

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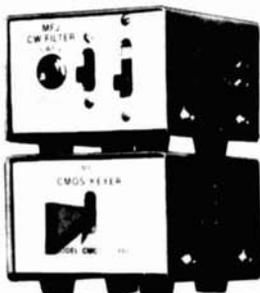
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RECEIVER: • **Sensitivity:** Typically .5 microvolt for 20 dB quieting • **IF Selectivity:** 20 kHz at 6 dB down; ±30 kHz channel rejection greater than 75 dB down. • **First IF:** 10.7 MHz with 2-pole monolithic crystal filter. • **Second IF:** 455 kHz with ceramic filter. • **Intermodulation Response:** At least 60 dB down. • **Modulation Acceptance:** ±7kHz. • **Audio Output:** At least 1 Watt at less than 10% distortion. • **Audio Output Impedance:** 8 Ohms

TRANSMITTER: • **RF Output Power:** 1 Watt minimum • **Frequency Deviation:** Adjustable to ±10 kHz maximum, factory set to 6.0 kHz. • **Multiplication:** 12 Times

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223.26	224.74	146.19	146.72	52.82	52.68
223.30	224.86	146.22	146.76	52.88	52.72
223.34	224.90	146.25	146.79	52.92	52.79
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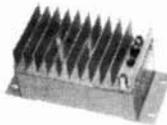
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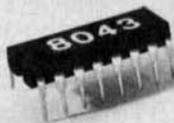
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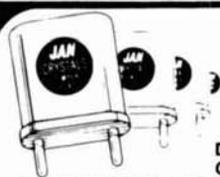
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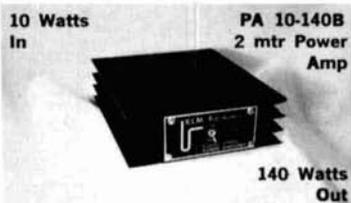
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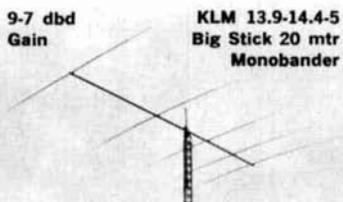
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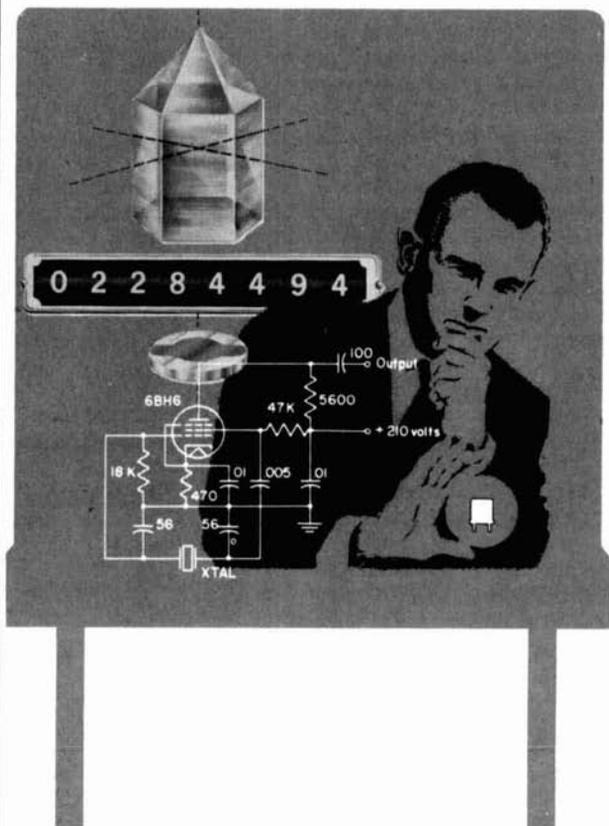
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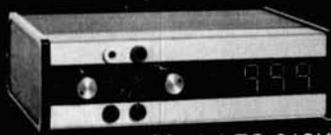
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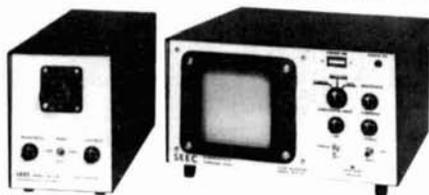
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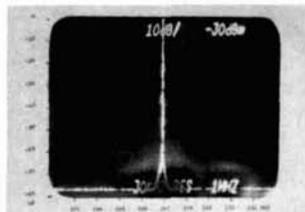
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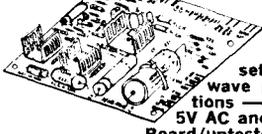


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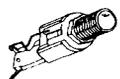
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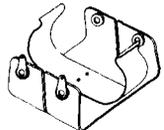
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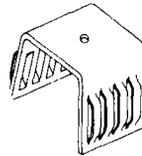


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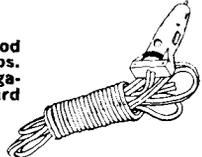
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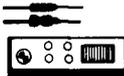
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MAN-64 *35 LED matrix

THREE QUARTER INCH DIGITS BY OPCA \$4.95

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 - 7 Segments
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50	\$.69	\$.88	\$ 1.49
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400	1.19	1.50	2.09
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SN7411	.27	SN7455	.37	SN74109	.89	SN74174	1.49
SN7413	.73	SN7455	.37	SN74112	.91	SN74175	1.81
SN7414	2.25	SN7462	.37	SN74113	.91	SN74176	1.55
SN7415	.37	SN7465	.37	SN74114	.89	SN74177	1.55
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SN7420	.18	SN7473	.41	SN74123	.91	SN74182	.79
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DAYTON HAMVENTION at HARA Arena, April 25, 26, 27, 1975. Program brochures mailed March 10th. Write for information if you have not attended the last two years to HAMVENTION, P. O. Box 44, Dayton, Ohio 45401.

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

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

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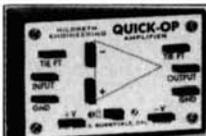
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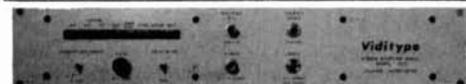
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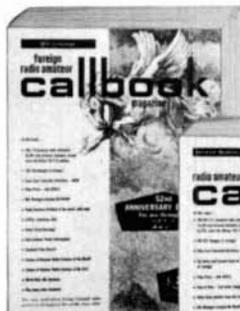
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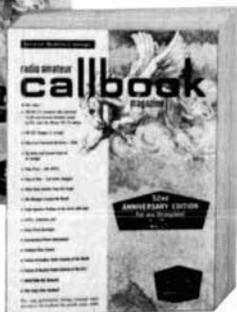
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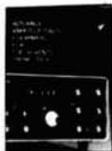
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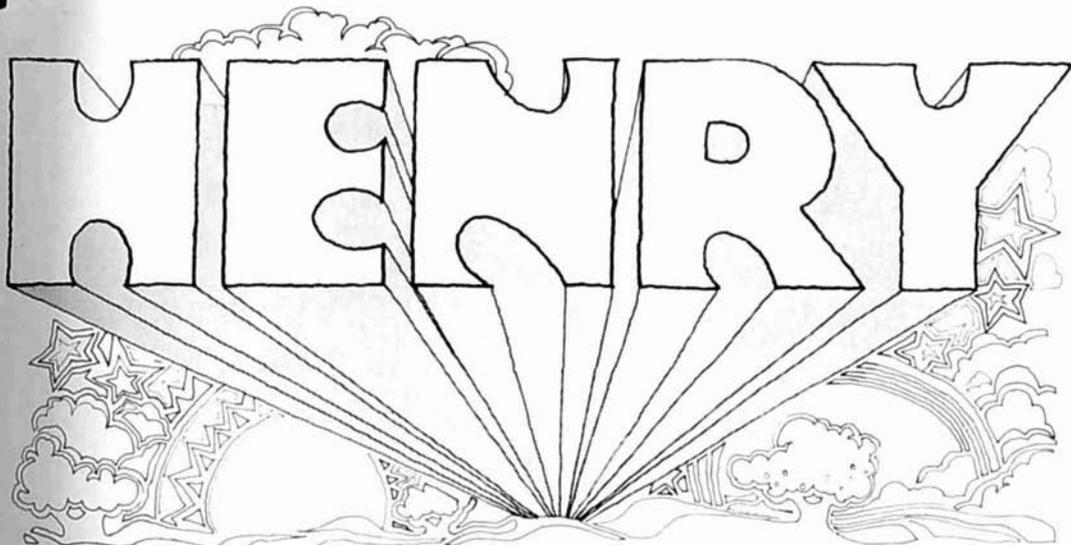
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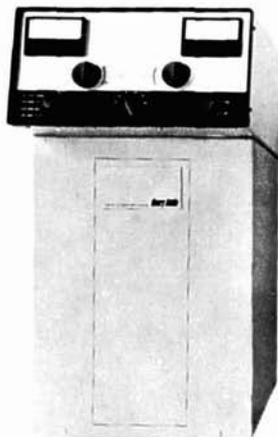
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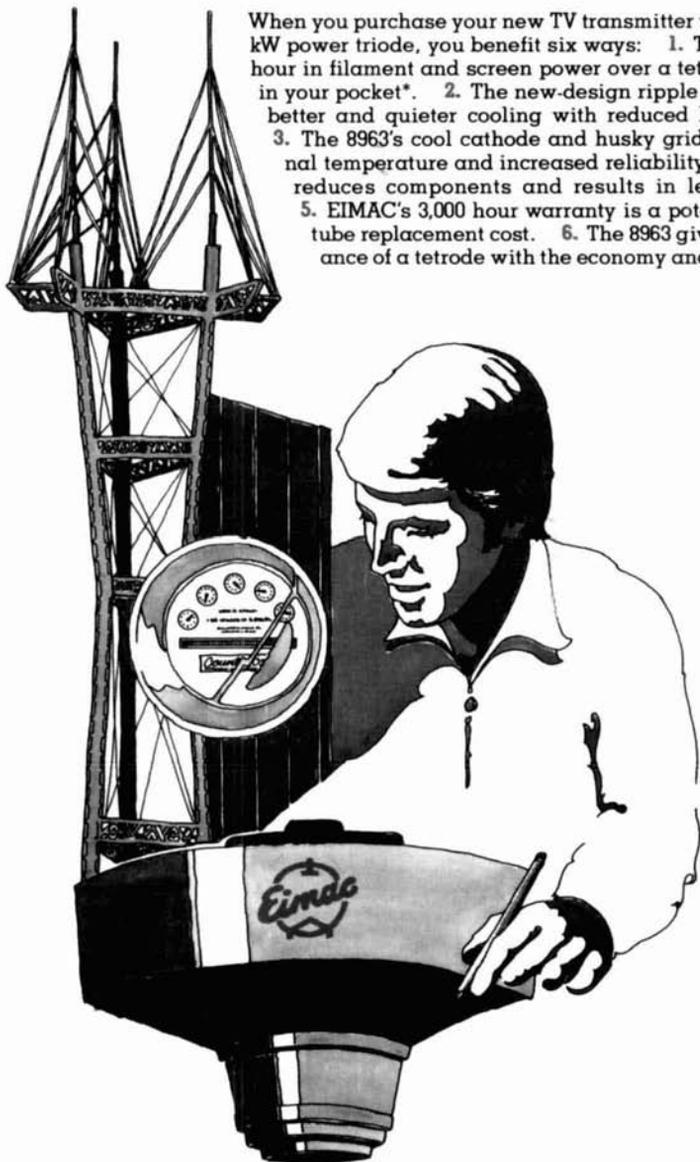
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