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magazine

JUNE 1980

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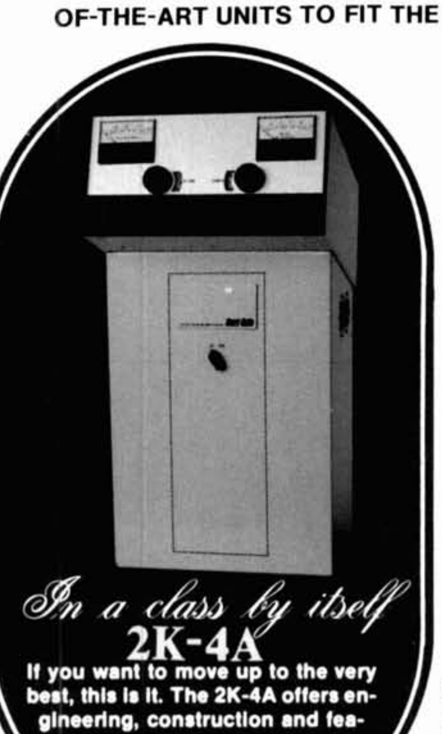

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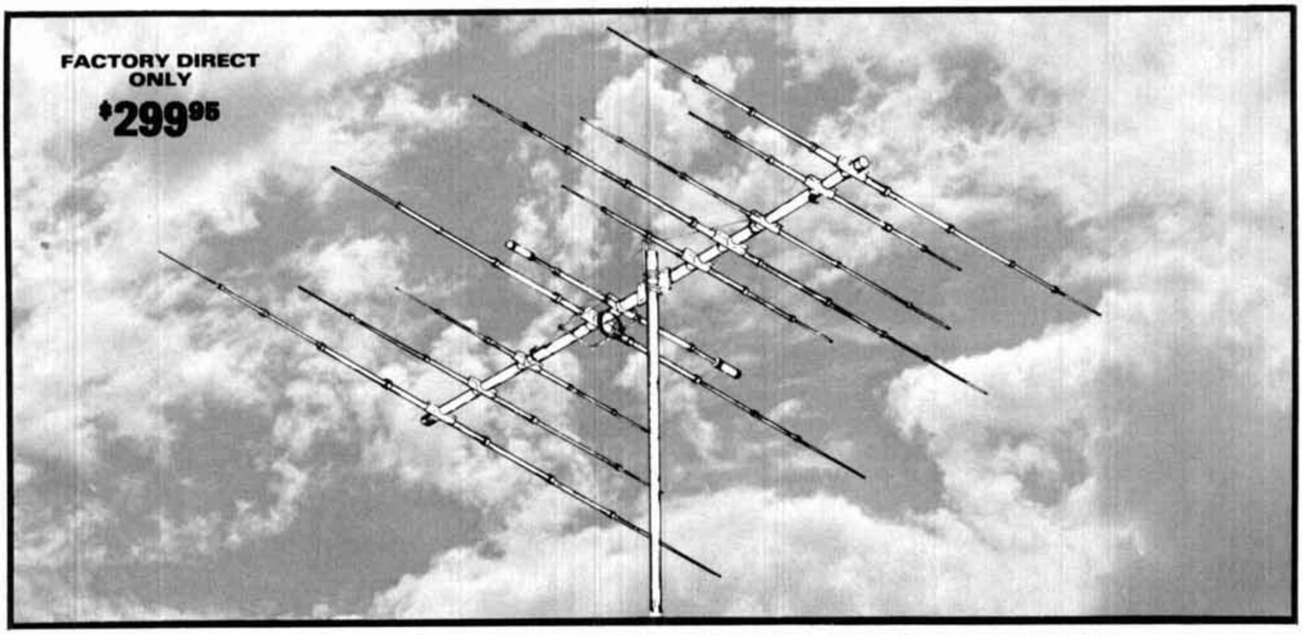

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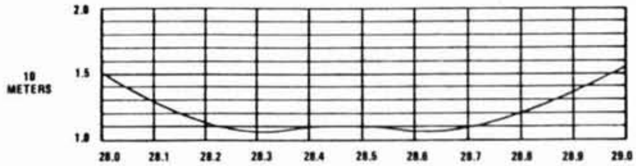

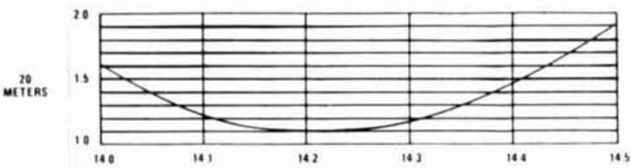

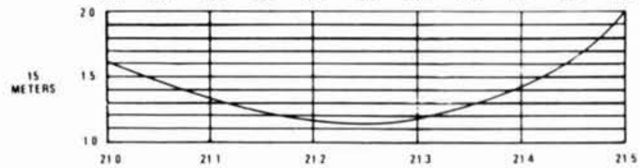

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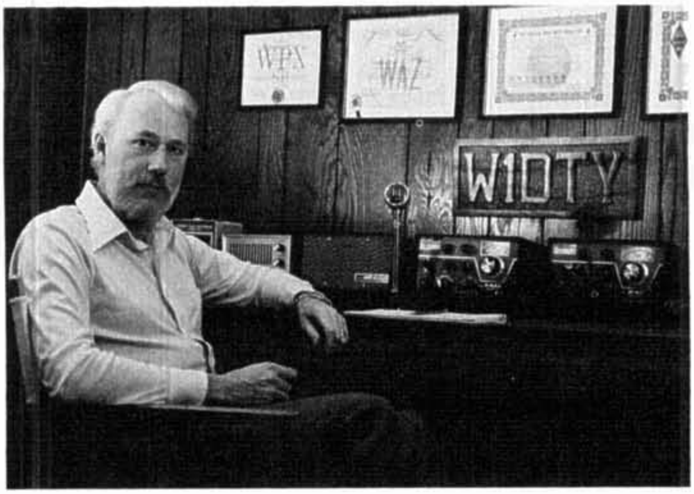
James R. Fisk

W1HR

December 12, 1934 - April 18, 1980



Ham Radio and ham radio meant much to Jim Fisk. His concerns involved pride of accomplishment and uncompromising effort, sensing the perfection that is possible, but seldom achieved, in either electronics or publishing.

The magazine was a part of Jim from the beginning, and its brain, body, and heart were Jim's. His layouts breathed life into the magazine's pages; his lean, clean prose became a model for other publications. The appearance of the magazine meant much to Jim as he strove for perfection.

Jim's concern with ham radio was a deep involvement. He wasn't a bystander or an onlooker, but a participant *par excellence*. And his participation often changed that in which he took part, to the benefit of all. Jim's last days with us typified this attitude of involvement, participation, and enjoyment. Above all, his first, second, and last looks were forward — to the future.

On Thursday morning, April 17, he came into the office with a lively step, a twinkle in his eyes, and moustache bristling; he was barely able to contain his excitement. "Did you get on 20 last night?" he asked. "The band was wide open; I've never heard better conditions, and — by God — I cracked some pileups! I worked Mount Athos, Tahiti, Mali, and Mayotte . . . even His Majesty, King Hussein, JY1. You know, I had never worked him before, and it was a thrill I'll never forget!"

He spoke with quiet pride of his Collins station, of his four-element Cushcraft monobander at 100 feet, and of his joy at beating some of the 'big guns' at their own game. He expressed this in a letter to the *DX Bulletin*:

> The DX stations available during the past 24-36 hours have really been hard to believe. At one point late last night SV1JG/A, TZ4AQS and FHØFLP were QRMing one another just below 14200! And it's been a long time since I worked three new ones in the space of a few hours . . . would have worked VKØKH, too, but he's supposed to come up again tonight.
>
> I have now worked the necessary contacts for 5B-DXCC, but am still short a few cards on 40 and 80 meters. As a matter of fact, my countries count on 80 is actually higher than on 15, but only because I haven't had time to get my beam up on the tower.
>
> So far as DX is concerned, April, 1980, has been a month to remember! But damn, I missed KP2A from 8Q7 . . .

Lunch that last day was a time to remember. Rush Drake, W7RM, had dropped by to visit, and the talk turned quickly to several large, high-performance high-frequency antenna systems that he had seen recently. Soon, the placemats at the local restaurant were covered with exotic sketches representing nifty ideas for multiple arrays with microprocessor controls; and Jim began to outline progress on his own exciting plans for a multi-operator super station that would be the envy of every contester. Several parts of his plan had already taken shape and some hardware was already in place. Jim hoped to have the rest finished soon. The sunspots were riding high and Jim was certainly intending to make the best of them in the months ahead.

We remember Jim's enthusiasm, his fire, his drive for perfection, his enjoyment of being who and where he was, and his long-lived love affair with *Ham Radio*, symbolized by his call: W1HR.

Yes, we remember . . .

W1XU

ham radio magazine

JUNE 1980

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contents

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More Details? CHECK—OFF Page 94

James R. Fisk, W1HR – Some Reflections

I first met Jim in May of 1967 when he was the editor of another Amateur Radio magazine. I had submitted an article for possible publication. It came in "over the transom," as they say in the publishing business. The article was accepted, and thus began a 13-year relationship with one of the most respected and competent individuals in one of the most highly specialized fields of publishing — a technical journal for Amateur Radio enthusiasts.

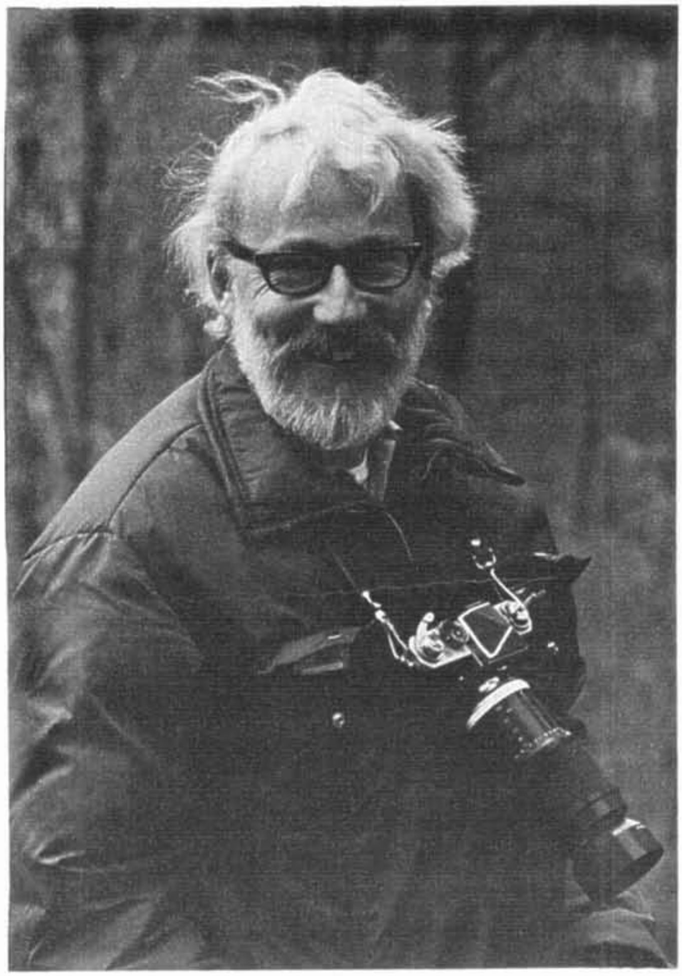
I talked to Jim on the air shortly after he and Skip Tenney established *ham radio* in a shoe-box office in New Hampshire. I offered my editorial services on a part-time basis, working from my home in California. Since then, my professional and personal relationship with Jim has grown and we've all enjoyed the benefits of hard work, a striving for excellence in the magazine, and respect from our peers.

Jim Fisk was *ham radio* magazine. Every page reflected Jim's influence and expertise. I have some stinging letters from Jim in which he criticized my editing — all in the interest of perfection. And that's good. Jim's footprints were all over the magazine. He was a dedicated professional and he will be difficult to replace.

So long, OM. We'll miss you.

W6NIF

W1HR
New Hampshire



Jim Fisk

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publisher's log

by Skip Tenney

There are certainly few business situations that can bring two people much closer than working as publisher and editor of a small magazine during its start-up years. It was my privilege to share with Jim Fisk, then W1DTY, just such an exciting, yet often highly frustrating, experience.

We had embarked on a project which many told us was pure folly: a fourth entry in the already well-filled Amateur Radio magazine field. Success was impossible, they said. But with Jim's expertise and ambition, plus my stubbornness and determination, we felt that we had something to offer that was really different — a completely new publication, dedicated to excellence and professionalism, which would make a very real contribution to the hobby we both loved so well.

Our success is history now, but it didn't come easily. Editorial problems, printing difficulties, mailing mixups, promotional disappointments; I guess we saw them all. But working 26 hours a day, seven days a week, we overcame them one by one and gradually *ham radio* magazine established itself as the technical leader we'd envisioned, and new standards were set for both technical and graphic excellence in our field. These standards were the work of Jim Fisk, certainly the most capable and professional editor in many years to touch the pages of a ham magazine. He has set a standard that Amateur Radio editors will strive to reach for a long time to come.

But Jim was much more to our hobby than merely an excellent editor. He was at the center of new ideas and technical advances. His office was virtually a central switchboard or meeting place for the top thinkers and leaders in our hobby to exchange their ideas and discoveries, and he introduced, through the magazine, many of the contributions to Amateur state-of-the-art which have been developed in recent years.

This was probably never better demonstrated than during the 1980 Dayton Hamvention, which took place just a week after Jim's death. As our staff met literally hundreds of people who had known and worked with Jim, we were constantly reminded just how important he had become not just to our own publishing efforts but also to the continuing progress of Amateur Radio itself.

Jim will be sorely missed both in the pages of *ham radio* magazine and in the Amateur Radio hobby at large. Fortunately, however, he has left behind much which will continue to make significant contributions for a long time to come. Thanks to his efforts, we now have a well-trained editorial staff who have learned how to do things to Jim's standards. The magazine itself will act as a living memorial to Jim, as it continues to be the rallying point for excellence in both Amateur theory and practice. Although we will now be operating without him, we will continue to work to his standards. The question, "How would Jim have done this?" will be asked many times, and the answer will provide our guidelines and keep us on our toes.

The question of just who is going to take his place on the masthead has already been asked many times. It is a difficult decision and one which we want to approach with a great deal of care and deliberation. For the time being, I personally will serve as acting editor, a position which I can fulfill only with the help and backing of Jim's top notch staff. They will be doing the work and I'll try primarily to provide the focal point between them and all of you.

In closing, I know I speak for all of us, both the *ham radio* family and Jim's personal family, when I express our thanks for all the many letters and calls we have received in recent days. They have been a great inspiration to all of us during this difficult period.

W1NLB

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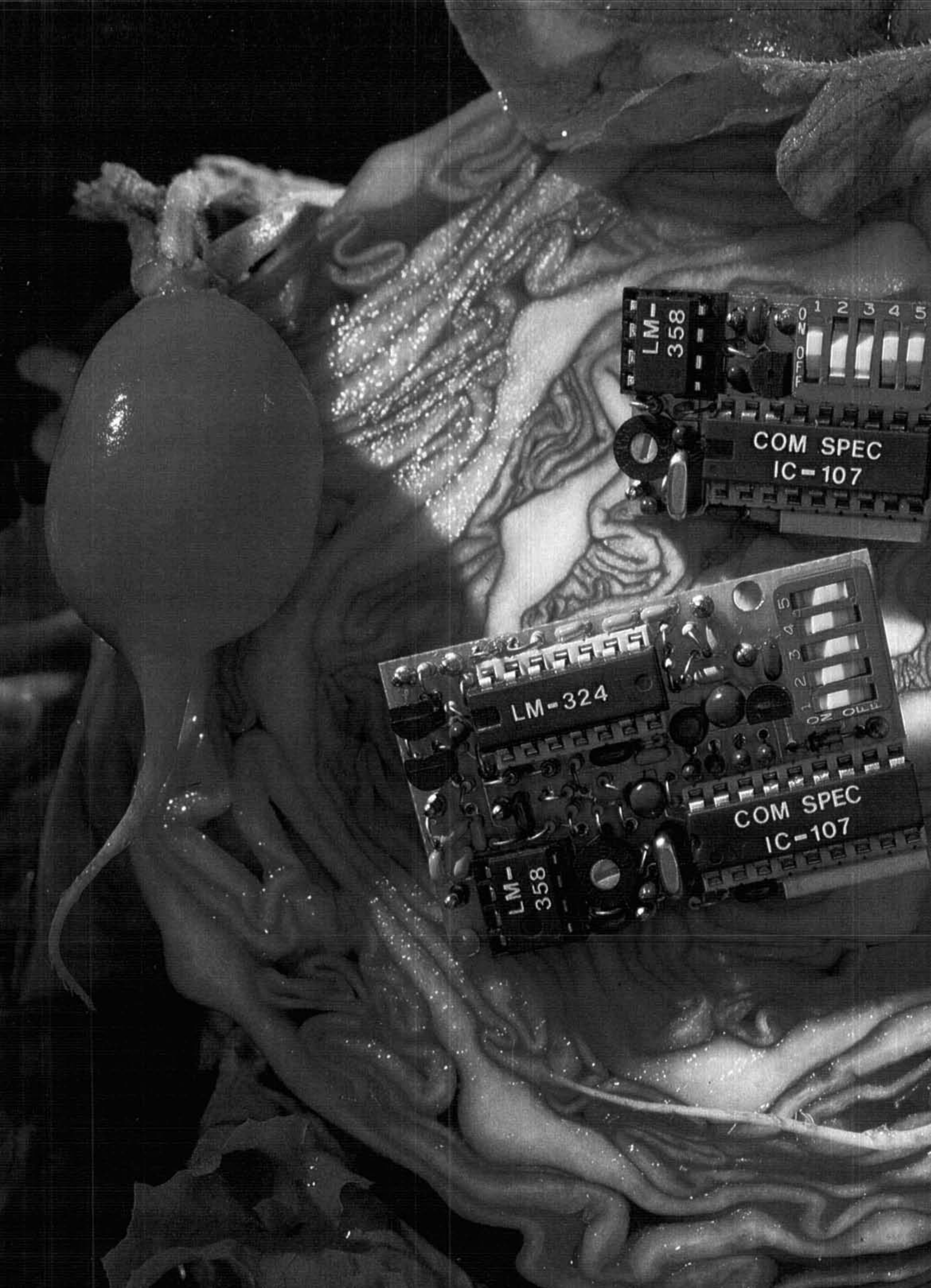

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77.0 XB	100.0 1Z	131.8 3B	173.8 6A
79.7 SP	103.5 1A	136.5 4Z	179.9 6B
82.5 YZ	107.2 1B	141.3 4A	186.2 7Z
85.4 YA	110.9 2Z	146.2 4B	192.8 7A
88.5 YB	114.8 2A	151.4 5Z	203.5 M1

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The Eimac 8877 is a high-mu ceramic-metal triode rated for use up to 250-MHz and several successful amplifier designs using this tube have been constructed for hf through vhf.[1,2,3] The 220-MHz amplifier described here has proven to operate very well during the last year, including several successful Earth-Moon-Earth (EME) contacts.

This 220-MHz 8877 linear amplifier is designed for the serious vhf DXer who demands reliable service combined with good linearity and efficiency. The amplifier requires no neutralization, is completely stable and free of parasitics, and is very easy to operate.

The amplifier is designed for continuous duty operation at the 1000-watt dc input level, and can develop 2000-watts PEP input for SSB operation with ample reserve. For operation at 2000-watts PEP the plate supply should be between 2500 and 3000 volts; under these conditions the amplifier will deliver 1230 watts output. With the higher plate-voltage supply, up to 14-dB gain can be obtained with an amplifier efficiency of 61 per cent; see **table 1**.

The 8877 triode has very good current division; that is, the grid current is quite low in comparison to the plate current. The grid current is typically about 15 per cent of the value of the plate current. the 8877 also has good gain and intermodulation distortion characteristics. The plate dissipation rating is 1500-watts. The cathode is indirectly heated; filament requirements are 5.0-volts at 10.5 amperes. The tube base mates with a standard septar socket.

the circuit

In the amplifier circuit shown in **fig. 1** the 8877 grid is operated at dc ground. The grid ring at the base of the tube provides a low-inductance path between the grid element and the chassis. The plate and grid currents are measured in the cathode return lead. A 12-volt, 50-watt zener diode in series with the negative return sets the desired value of idling current. Two additional diodes are shunted across the meter circuit to protect the instruments in case plate voltage arcs over to ground, or if there is an internal tube arc.

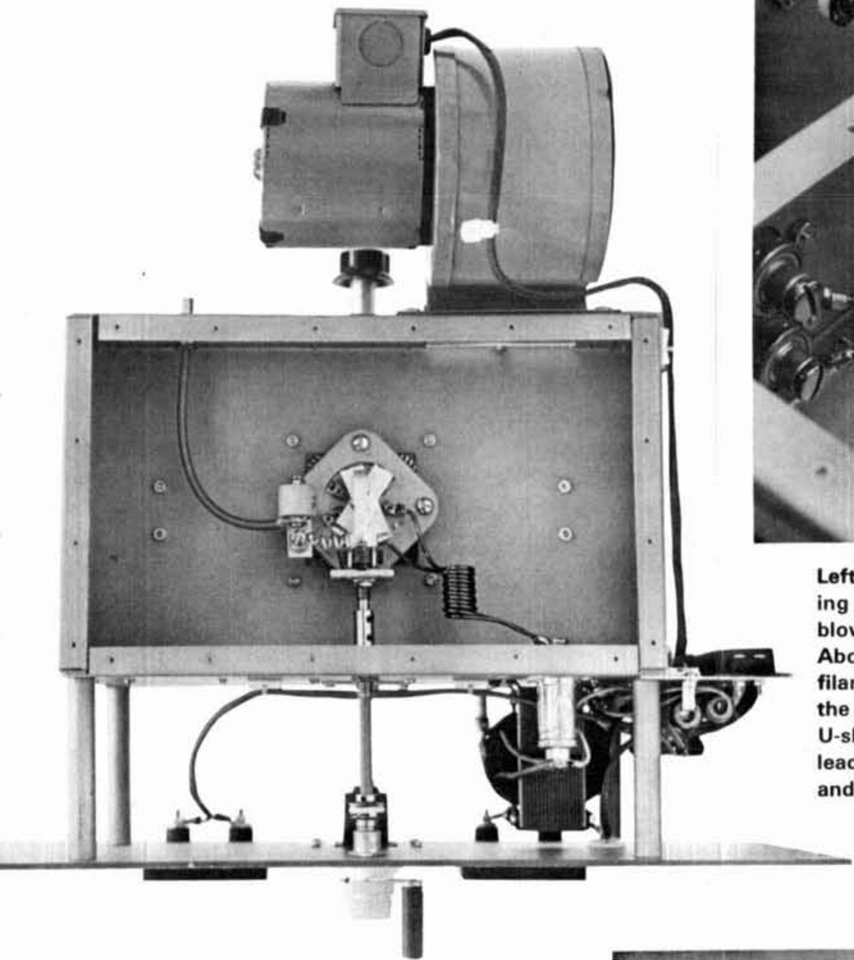
Standby plate current of the 8877 is reduced to a very low value by a 10,000-ohm cathode resistor. This resistor is shorted out in the transmit mode by the station control circuit. The resistor must be in the cathode circuit when receiving to eliminate the noise generated in the station receiver if electron flow is permitted within the 8877 tube.

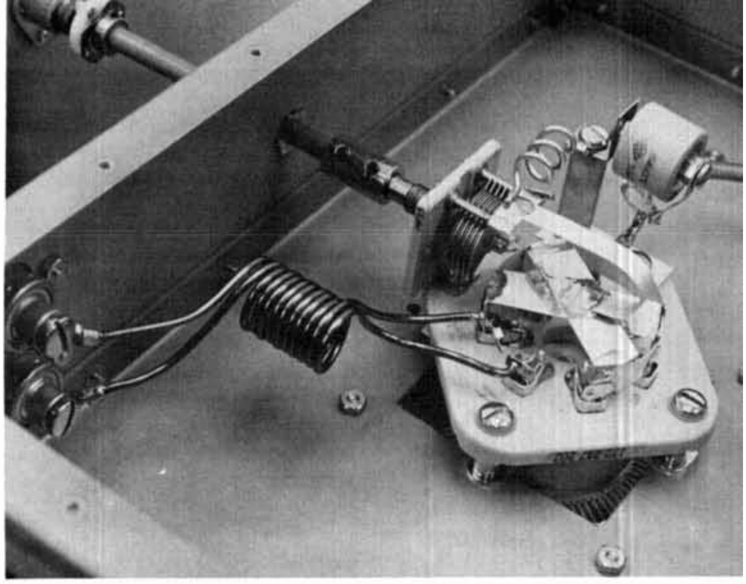
A 200-ohm safety resistor insures that the negative side of the power supply does not go below ground potential by an amount equal to the plate voltage if the positive side is accidentally grounded. A second safety resistor across the 1N3311 zener diode prevents the cathode potential from rising if the zener should accidentally burn open.

input circuit

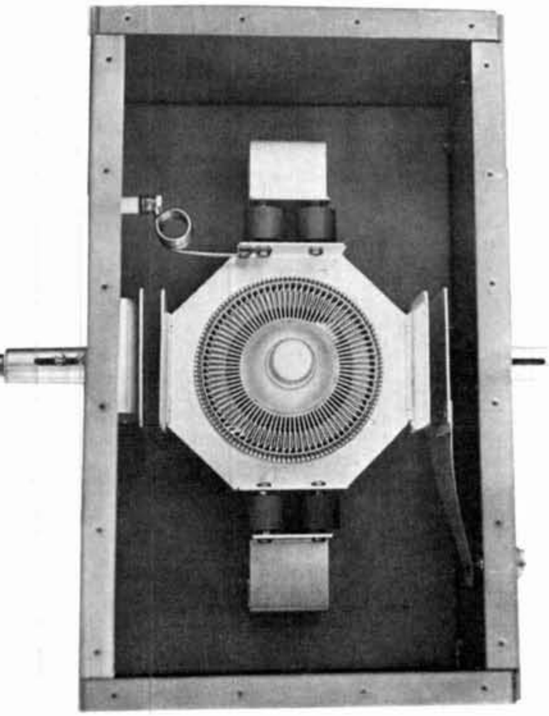
The cathode matching circuit is a T-network which transforms the input impedance of the tube (about 54 ohms in parallel with 40 pF) to 50 ohms at the coaxial input connector; the network consists of two series inductors and a shunt variable capacitor. The inductors are fixed and have a very low value of inductance; in fact, the rf return path through the chassis has about the same inductance value. To design the input circuit, many values of circuit Q were tried in the calculations. When the design equations yielded physically realizeable inductance values, then several combinations were tried in the actual amplifier. Since the stray inductances in the chassis and connecting leads in the socket were not included in the calculations, the final inductors were smaller in value than the calculated size. The actual inductors which resonated and provided a reasonable input match are specified in fig. 1 and are shown in some of the photographs. For those who build this amplifier I would expect that some minor variations in these coils might be required to attain an adequate input match.

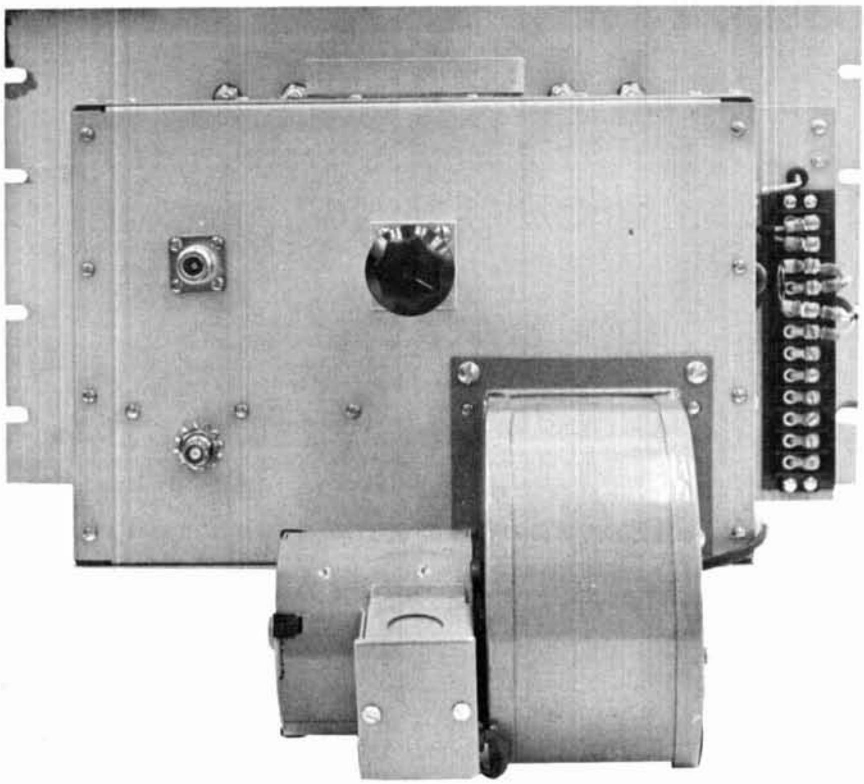
By Robert I. Sutherland, W6PO, EIMAC Division of Varian, 301 Industrial Way, San Carlos, California 94070





Left, underside view of the 220-MHz power amplifier showing the blower location as well as the input circuit. The blower is a Dayton 4C446.
Above, close-up view of the input circuit shows the bifilar filament choke L3 and L4 and the matching network. C2 is the 35-pF air variable mounted on the 8877 socket. L2 is the U-shaped strap connecting the capacitor to the cathode leads. L1 is the coil going between the variable capacitor and input line blocking capacitor C1.





Left, top view of the amplifier plate compartment. The 8877 tube is in the center with L5 and L6 to the left and right. The plate tuning capacitor C5 is at the bottom and the loading capacitor C6 is at the top.
Right, back view of the amplifier. The type-N connector is the rf power output; the BNC fitting is the connection for drive power. The knob is the loading adjustment. The terminal strip to the right is for the input voltage and control circuit connections. A Millen high-voltage connector is used for the plate voltage.

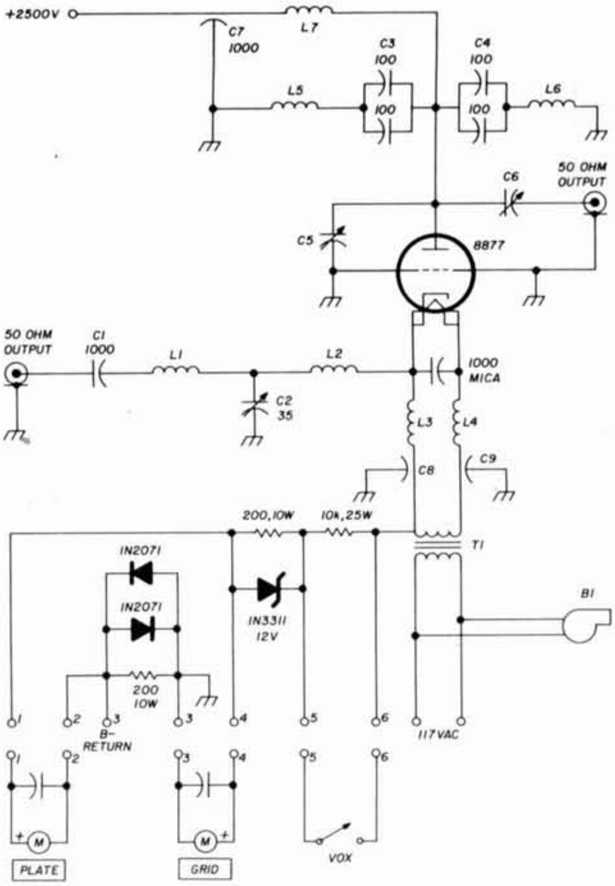


fig. 1. Schematic of the grounded-grid 220-MHz triode amplifier. Operating bias for the 8877 is supplied by a 12-volt zener diode in the cathode lead.

table 1. Performance of the 220-MHz grounded-grid 8877 rf power amplifier.

Plate voltage	3000 V	2500 V	2500 V
Plate current (single tone)	667 mA	800 mA	400 mA
Plate current (idling)	54 mA	44 mA	44 mA
Grid voltage	− 12 V	− 12 V	− 12 V
Grid current (single tone)	48 mA	50 mA	29 mA
Power input	2000 W	2000 W	1000 W
Power output	1230 W	1225 W	621 W
Efficiency (apparent)	61%	61%	62%
Drive power	48 W	69 W	20 W
Power gain	14 dB	12.4 dB	15 dB

C1	1000 pF ceramic transmitting type (Centralab 858S-1000)
C2	35 pF air variable (Hammarlund HF35 or Millen 22035)
C3, C4	Each consists of two parallel connected 100 pF, 5000 volt ceramic transmitting capacitors (Centralab 850S-100)
C5	Plate tuning capacitor (see **fig. 2**)
C6	Output loading capacitor (see **fig. 7**)
C7	1000 pF, 4000 volt feedthrough (Erie 2498)
C8, C9	0.1 uF, 600 volt feedthrough capacitor (Sprague 80P3)
L1	3 turns no. 14 (1.6 mm) wire, 1/4 inch (6.5 mm) inside diameter, 5/8 inch (16 mm) long
L2	Copper strap 1/4 inch (6.5 mm) wide, 2-1/2 inches (64 mm) long, bent into a U 5/8 inch (16 mm) wide
L3, L4	7 bifilar turns no. 12 (2 mm) enamelled wire, bifilar wound on 1/2 inch (12 mm) inside diameter
L5, L6	Plate resonators (see **fig. 5**)
L7	6 turns no. 14 (1.6 mm) wire, 1/2 inch (12 mm) diameter, 1 inch (25 mm) long
T1	Filament transforrmer rated at 5 volts, 10 amps (Stacor P-6433)

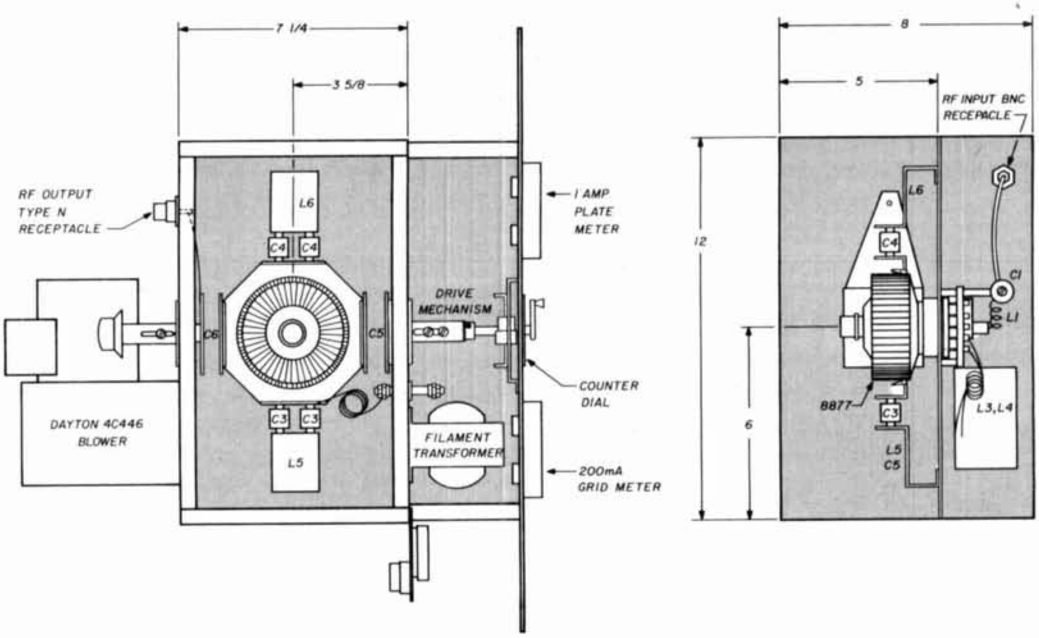


fig. 2. Structural details of the amplifier showing relative size and position of the various components. Assembly is made of aluminum panels.

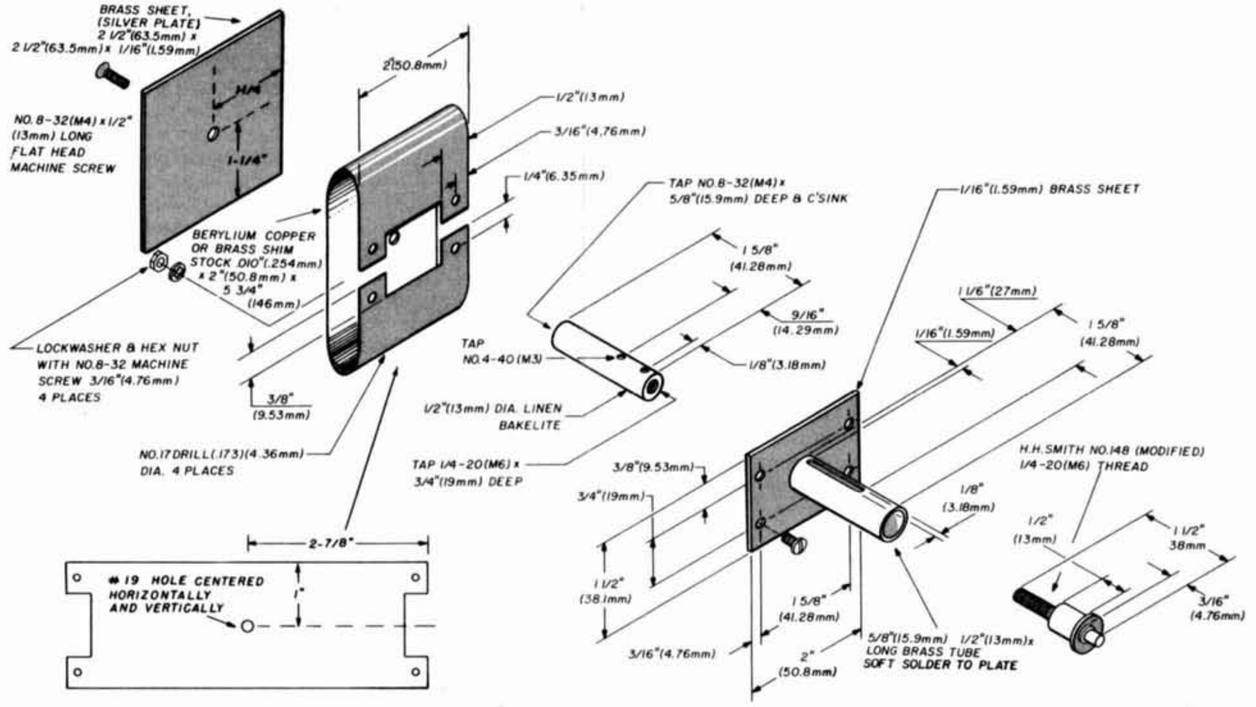


fig. 3. Variable plate portion of plate-tuning capacitor C5. Since there are no moving or sliding contacts which carry heavy rf current, this arrangement permits the capacitor to be adjusted under full power without erratic tuning.

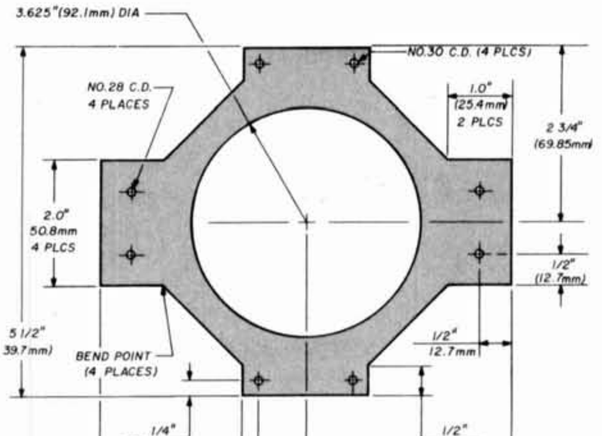
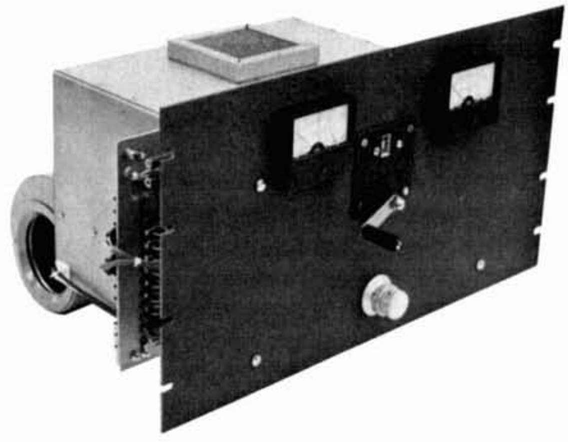


fig. 4. Anode collet and capacitor plate support pattern.

The underchassis layout of components is shown in the photographs. In the close-up view the bifilar wound coil in the foreground is the filament choke. The variable capacitor is C2, and L2 is the U-shaped strap connecting C2 with the cathode terminal. All the cathode leads and one filament lead are connected together with low inductance copper straps. Note that L2 is connected to the center point of all the cathode leads in an effort to equally balance rf drive to all sides of the cathode. At the frequency of 220-MHz, lead length and residual inductance are very important.

The inductor L1 connects capacitor C2 with the input blocking capacitor C1 at the top of an insulating piller. A section of RG-142B/U teflon-insulated coax connects the other side of C1 to the BNC coax input connector. It is difficult to see in the picture, but there is a 1000-pF chip ceramic capacitor connected from one heater pin to the other on the socket.

The socket for the 8877 is the Eimac SK-2210, the version with the grounded grid clips. The filament transformer is located between the aluminum enclosure and the panel. The filament voltage is fed



through the enclosure wall using 0.1 μF Sprague *Hy-Pass* feedthrough capacitors.

plate circuit

The plate circuit of the amplifier is a transmission-line type resonator. The line (L5 plus L6) is one half-wavelength long with the tube placed at the center. This type of circuit is actually two quarter-wavelength lines in parallel. One of the advantages is that each of the quarter-wavelength lines is physically longer than if only one is used. This is because only half of the tube output capacitance loads each quarter-wavelength section. Another advantage to this layout is a better distribution of rf currents around the tube seals.

The dc blocking capacitors are surplus Centralab 100-pF, 5000-volt ceramic capacitors. Two are used on each line to handle the rf current. The homemade variable capacitor C5 tunes the plate circuit. Note that this type of capacitor structure has no wiping contacts. All the rf currents flow through a fixed path which provides very smooth tuning with no jumping meter readings. The load capacitor C6 is constructed in a similar manner.

The plate choke L7 is visible in the photograph of the plate compartment. It is connected to the plate collet assembly with the Erie high voltage feed-through capacitor C7.

construction

The 220-MHz power amplifier is built in an enclosure measuring 8 × 12 × 7-1/4 inches (20 × 30 × 18 cm). The 8877 socket is centered on an aluminum deck 5 inches (12.7 cm) from the top of the enclosure. A centrifugal blower* forces cooling air into the under chassis area; the air escapes through the air-system socket, the teflon chimney (SK-2216), and then the tube. The warm air is exhausted through a "waveguide beyond cut-off" air outlet. This is an assembly which has expanded metal about 1/2 inch (12 mm) thick, mounted in a frame. A perforated aluminum cover may suffice in most cases, although restricts air flow slightly more and is not a very good rf shield at 220 MHz.

The plate tuning mechanism is shown in **fig. 3**. This simple apparatus will operate with any variable plate capacitor, providing a back-and-forth movement of about one-half inch. It is driven by a counter dial and provides a quick, inexpensive, and easy means of driving a vhf capacitor. The ground return path for the grounded capacitor plate is through a wide, low inductance beryllium-copper or brass shim stock which provides spring tension for the drive mechanism.

The variable output coupling capacitor is located at the side of the 8877 anode. The type-N coaxial

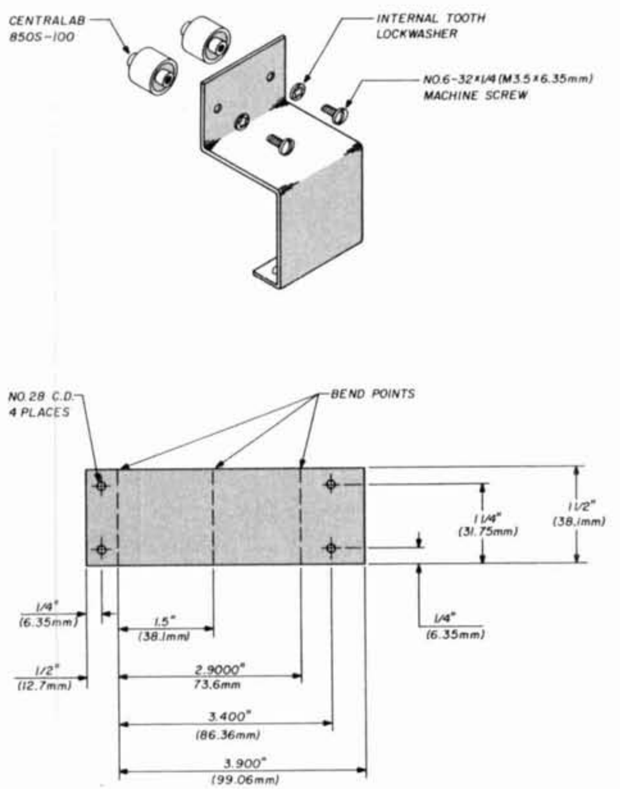


fig. 5. Plate line inductor pattern and bending layout for L5 and L6. Two assemblies are needed for the plate circuit.

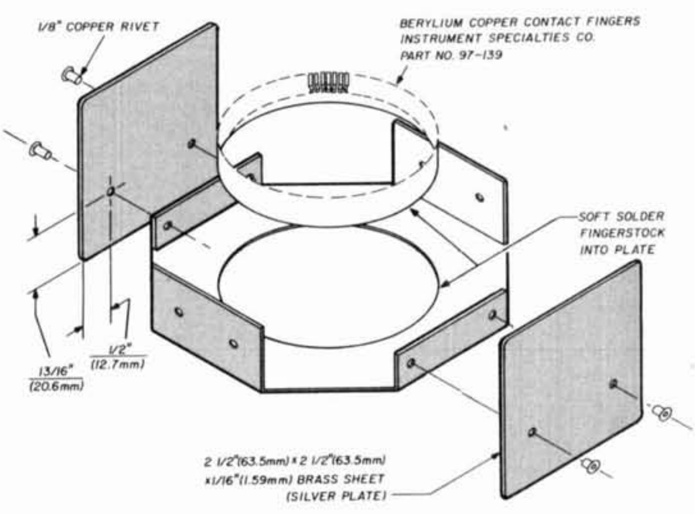


fig. 6. Anode collet and capacitor plate support assembly. The two fixed capacitor plates for C5 and C6 are mounted to the assembly using copper pop-rivets and then soldered. The two remaining bent-up edges are for mounting the blocking capacitors C3 and C4. The finger-stock is soft-soldered into the large hole in the center. A tight fitting aluminum disc helps to hold the finger stock in place while soft soldering with a hot plate.

*Recommended blower is the Dayton 4C446, a 115-Vac unit rated to deliver cooling air at 135 cubic feet per minute (3.8 cubic meters) with a static pressure equivalent to 0.2 inch (5 mm) of water.

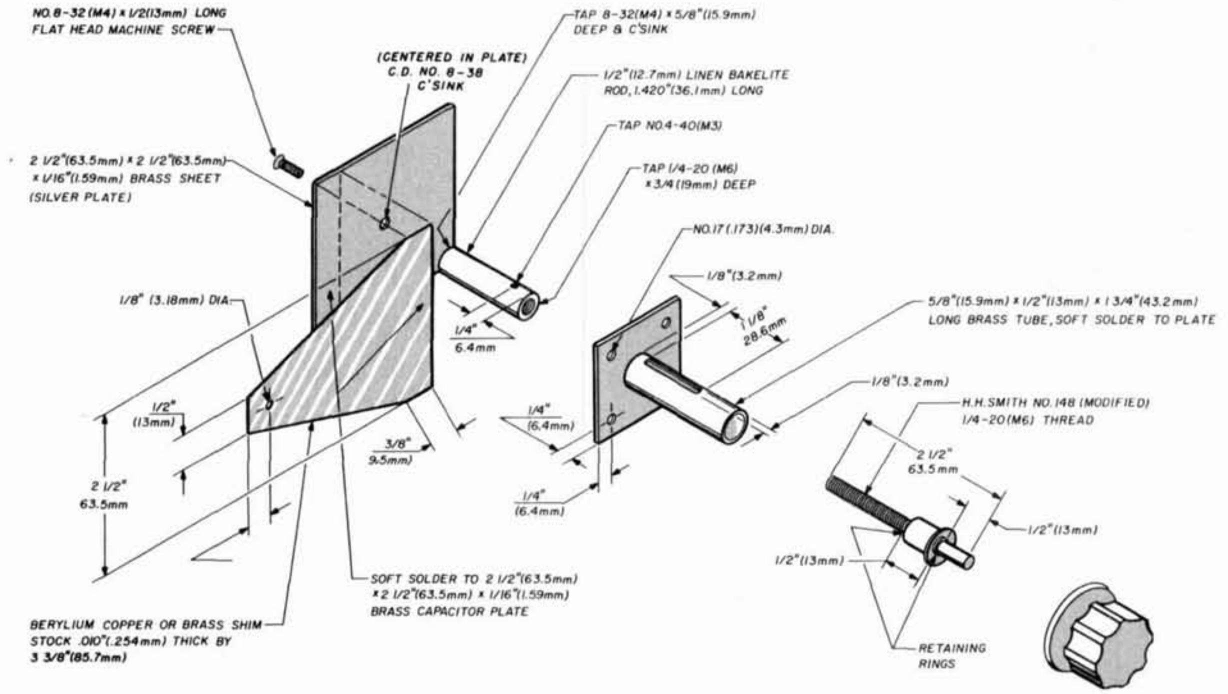


fig. 7. Variable plate portion of the loading capacitor C6. The beryllium-copper portion carries the rf current to the type-N coaxial connector as well as providing spring tension on the tuning mechanism. Because of the constant rf conducting path, the loading is very smooth with no jumpiness.

output connector is connected to the moveable capacitor plate by a wide beryllium-copper strap. The capacitor plate is driven in a manner similar to the tuning capacitor as shown in **fig. 7**.

The plate line is made up of two inductors L5 and L6 (see **fig. 5**) and the anode collet and capacitor assembly shown in **fig. 6**. With the inductor sizes given, the amplifier can be tuned from 220 to 222.5-MHz; no tests were run above 222.5-MHz.

The plate rf choke is mounted between the junction of the anode collet and a pair of the dual blocking capacitors. The high-voltage feedthrough capacitor is mounted on the front wall of the plate compartment. The blocking capacitors are rated for rf service, and inexpensive television-type capacitors are not recommended for this amplifier.

operation

Amplifier operation is completely stable with no parasitics. The unit tunes up exactly as if it were on the hf bands. As with all grounded-grip amplifiers, excitation should never be applied unless the plate voltage is on the amplifier.

The first step is to grid-dip the input and output circuits to near-resonance with the 8877 in the socket. An SWR meter should also be placed in series with the input line so the input network may be adjusted for lowest SWR.

Tuning and loading follows the same sequence as any standard grounded-grip amplifier. Connect an SWR indicator at the output and apply a small amount of rf drive. Quickly tune the plate circuit to resonance; the cathode circuit should now be resonated. The SWR between the exciter and the amplifier will not necessarily be optimum. Final adjustment of the cathode circuit for minimum SWR should be done at full power because the input impedance of a cathode-driven amplifier is a function of the plate current of the tube.

Increase the rf drive in small increments along with the output coupling until the desired power level is reached. By adjusting the drive and loading together it will be possible to attain the operating conditions given in the performance chart in **table 1**. Always tune for maximum plate efficiency: maximum output power combined with minimum input power. It is easy to load heavily and underdrive to get the desired power input but power output will be reduced if this is done.

references

1. R. Sutherland, W6UOV, "Two Kilowatt Linear Amplifier for Six Meters," *ham radio*, February, 1971, page 16.
2. R. Sutherland, W6UOV, "High Performance 144-MHz Power Amplifier," *ham radio*, August, 1971, page 22.
3. M. Partin, K6DC, "Custom Design and Construction Techniques for Linear Amplifiers," *QST*, September, 1971, page 24.

ham radio

Woodpecker noise blanker

The Russian over-the-horizon radar has been causing interference on the high-frequency bands — here's a noise blanker that helps

Anyone who operates regularly on the high-frequency Amateur bands has probably run into interference from the Russian over-the-horizon radar which operates between 10 and 30 MHz; because of its peculiar sound, it is popularly known as the "Russian Woodpecker." The noise-blanker circuit shown in **fig. 1** was designed especially by M. Martin of the Hahn-Meitner Institute in West Berlin to blank the Woodpecker noise pulses;[1] this unit is also suitable for blanking out the Loran pulses that plague long-distance communications on the Amateur 160-meter band.

Although the circuit of **fig. 1** was built for a 9-MHz i-f, it should be relatively easy to adapt the circuit to other i-f systems. The circuit requires only two integrated circuits and six transistors; it has a blanking range of about 80 dB and does not degrade the receiver's dynamic range.

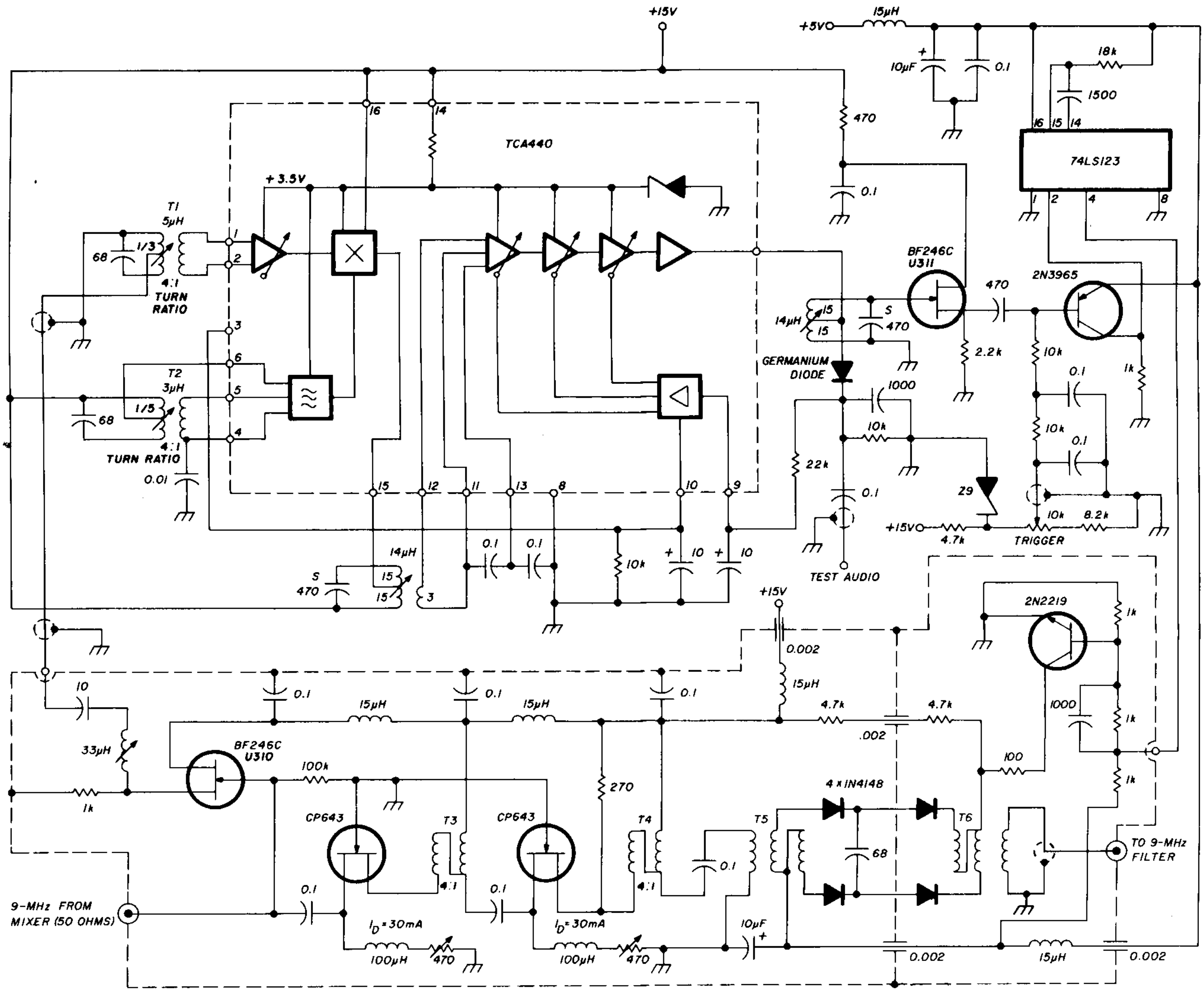
circuit description

The rf signal is picked up at the receiver's first mixer (9 MHz in this case), amplified by the CP643 fet amplifiers, and fed through the four diode gate, which is frequency compensated: the output is designed to drive a 9-MHz crystal filter. It should be possible to use this same basic circuit over the range from about 3 MHz to 70 MHz by changing the frequency tuned circuits.

A small fraction of the rf signal is coupled through the BF246C source follower and a tuned circuit to the Siemens TCA440 IC, which is actually a complete a-m receiver on a single chip;* this IC operates up to

*Circuit designers who are interested in developing the Woodpecker blanker for use in the Drake R4C, Collins 75S-3C, and other Amateur communications receivers please contact the editor.

By Ulrich L. Rohde, DJ2LR, 52 Hillcrest Drive, Upper Saddle River, New Jersey 07458



T1	Primary is 10 turns no. 28 (0.3 mm) on a FT37-61 ferrite core, tapped 3 turns from cold end; secondary is 2 turns no. 28 (0.3 mm)
T2	Primary is 7 turns no. 28 (0.3 mm) on a FT-37-61 ferrite core, tapped 2 turns from cold end; secondary is 1 turn
T3	Bifilar winding, 17 turns no. 28 (0.3 mm) wire on a FT50-61 ferrite toroid
T5,T6	Trifilar winding, 12 turns no. 30 (0.25 mm) wire on a FT37-61 ferrite toroid

fig. 1. Schematic of the noise blanker that can be added to most modern communications receivers for reducing Woodpecker interference between 10 and 30 MHz. This device is also suitable for blanking out Loran pulses on the Amateur 160-meter band.

40 MHz and is available in the United States. The TCA440 contains its own oscillator and converts the 9-MHz signal to a lower i-f (about 2 MHz) where it is amplified and detected. (The audio test output is for monitoring the AGC action of the TCA440 receiver section.) The BF246 source follower drives the 2N3965 amplifier which has an adjustable trigger threshold; this in turn drives the 74LS123 Schmitt trigger. The Schmitt trigger, through voltage-translator transistor 2N2219, activates the diode gate.

Designer Martin has shown that this arrangement has an intercept point of about 26 dBm and the switching gate has a depth of approximately 80 dB. In practice, with this noise blanker, the Woodpecker noise pulses are completely nulled out, allowing the weakest high-frequency signals to be received successfully.

This circuit is relatively simple, easy to build, and not critical. Some care is required when building the switching gate, however, to eliminate rf signal leakage; good balance is required.

reference

1. Michael Martin, DJ7VY, "Moderner Storaustaster mid hoher Intermodulationsfestigkeit gegen den 'Specht' und andere Pulse," *CQ DL* (West Germany), July, 1978, page 300.

ham radio

automation for synthesized 2-meter mobile stations

Meet the *Auto-mate* — a design for improving operation of 2-meter radios using synthesizers

You say you've joined the crowd and have stopped buying crystals for your 2-meter rig? Now that you're into synthesizers and can dial up everything from the area's most valuable and used machine to the three-man operation 50 miles (80 km) away, no doubt you wish you could keep track of all the action. It gets rather scary when you try to manipulate all those dials in the darkness of your automobile.

This article may not solve all your problems, but it goes a long way toward making your mobile operation safer and more fun. It allows you to eavesdrop on the metropolitan chaos while keeping both hands on the wheel. I'll show you how to automate your synthesizer so that it "knows" exactly what you want when you dial in only the desired receiver frequency. I'll show you how to add scanning push-to-talk/push-to-receive controls to relieve you from "mobile thumb" derived from holding down the PTT button, and more. In the end you'll have 1) a radio setup that has a synthesizer up front with you and a trunk-mounted radio if you desire (sorry thieves!), 2) short microphone wires to avoid trash pickup in mobile operation, and 3) a unit you can run in complete darkness. I call it the *Auto-mate*.

background

My project began with an article by Bob Fanning, K4VB, and Gary Grantland, WA4GJT.[1] This article showed how to build an 800-channel synthesizer from boards and parts supplied by the authors.

I had already fallen in love with the KLM 2700 synthesized radio I use for a base station on 2 meters, so synthesis had to be the way to go for mobile operation. I mounted a Heath HW-202 in the trunk of my Toyota. It became a case of running a huge wiring harness or settling for one channel (trunk chosen) and stopping every time I wanted to change channels. This doesn't make for the greatest operation when you travel around the country! In addition, I had alternator whine because I tried to run unshielded microphone lines to the trunk to simplify the wiring. Bob and Gary[1] gave me the solution to that one with their synthesizer, because you can modu-

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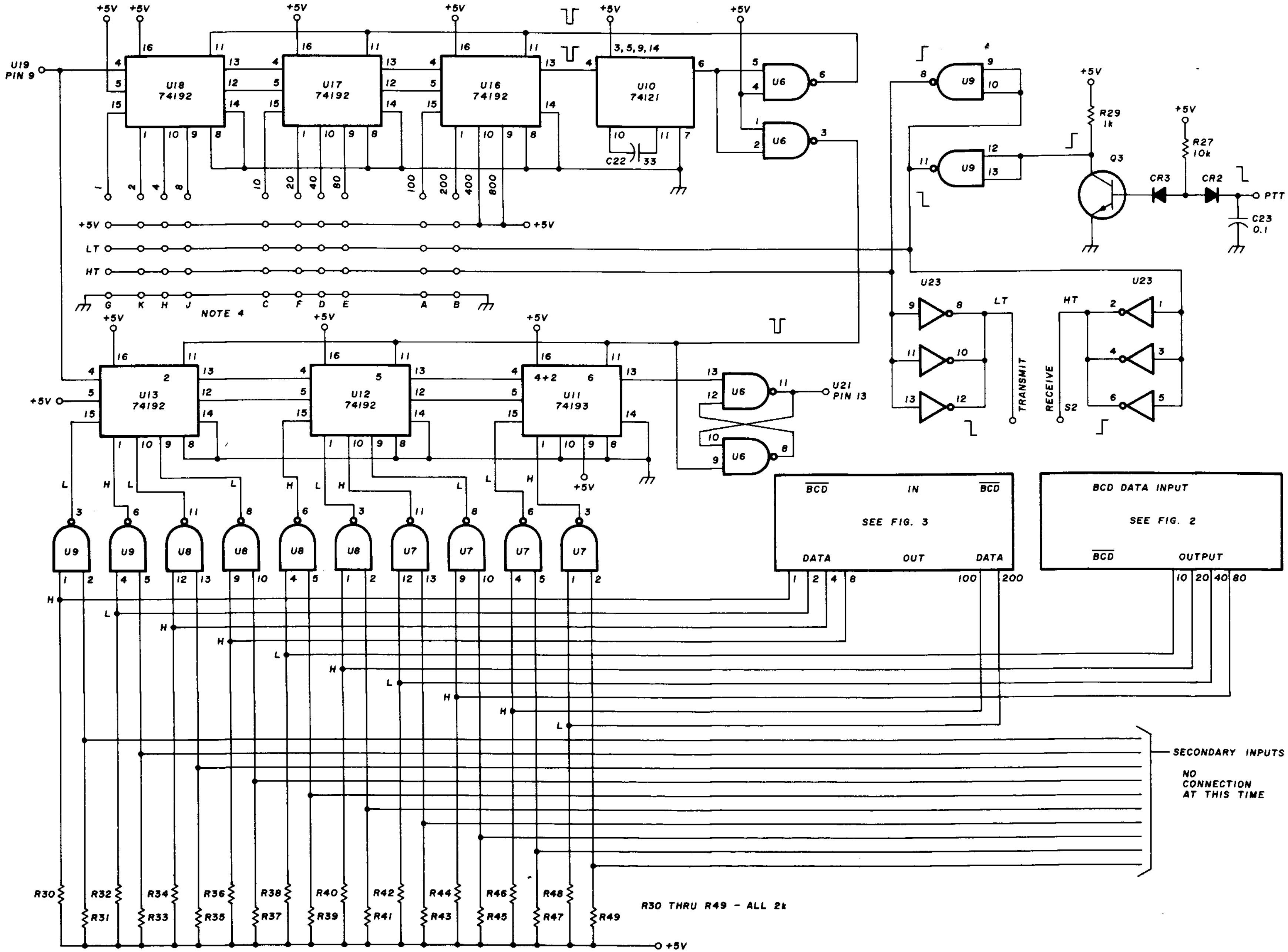


fig. 1. Counter portion of the synthesizer described by K4VB and WA4GJT shown in (reference 1). The thumbwheel switches are replaced by the circuits in this article.

late the sythesizer up front and run only two small rf coaxial cables to the trunk for full-channel control.

The synthesizer[1] used two BCD-encoded output switch sets to control channel selection and a separate switch to control transmit and receive modes. This can be quite confusing in a mobile, even in the daylight; at night it becomes a disaster! I can't give enough praise for the synthesizer, boards, parts, and most of all, the personal help by K4VB and WA4GJT. If you are about to go the synthesizer route on *any* rig, *do* read their article,[1] and look into this one further.

How would you like to dial up only the receive frequency on one BCD switch, set (three) switches and have a readout automatically tell you your switches are set correctly for both transmit and receive?

switching logic

If you're acquainted with BCD codes for the numbers 0-9 (you can learn them very quickly, I assure you), you can use inexpensive SPST switches for one BCD set and the second set can be eliminated altogether. If you arrange the BCD sets as two rows of four switches for the 100s and 10s of kHz, and a ninth switch to control the 146- or 147-MHz choice, you can do your setup in the dark.

The action is totally by feel. For example, you feel the front panel and locate the top row or switches. Flip up the right-hand three switches (A - B - C, from right to left — a decimal 7). Drop down to the second row. Flip the middle pair up (B - C, from right to left — a decimal 6). Make sure the MHz switch, placed by itself, is to the left (146 MHz, or lower segment), and you'll be on our local machine: 16/76. It's just that simple and you can do it blindfolded. If you're in Indiana, please, don't do this to prove a point while driving! It's really easier than the decimal-faced/BCD output switches and cheaper.

control circuit operation

Now you must be wondering what takes the place of the BCD set switches (at $10 per set), besides one set of SPST switches. Simple TTL gates! (And very few of them, thanks to our band plan setup.) Consult the tables included here and you'll see the very nice arrangement of our channels. Pay close attention to the numbers in bold type, as these are the only numbers on which my circuit operates. The 10s of kHz are fed in straight from the switches of that row (I suggest the bottom row). This is a 1 - 2 - 4 - 8 line combination in Bob and Gary's article.[1] The 146/147-MHz solution is by another single switch, rather than by a BCD deck. I simplified matters by wanting only the 2 MHz. The 100s of kHz (in bold face) are the only numbers processed on the gate board.

some examples

You feed the switch information into the gate board on A - B - C - D, and their respective outputs are marked 10 - 20 - 40 - 80, as in reference 1. The scheme will work on *any* synthesizer using the same encoding shown in **fig. 1**, which is from reference 1. The authors use TTL 7400 NAND gates at the switch inputs to allow for the dual switches. Some synthesizers require true BCD inputs directly to an up/down counter to set "jam" inputs. Just add inverters to the 10 - 20 - 40 - 80 lines for these models and wire the other switches for true data as well.

For my example frequency of 146.76 MHz, the 7 would be A - B - C low and D high, at the 10 - 20 - 40 - 80 lines that are my board outputs. If you must have true data, invert the 10 - 20 - 40 - 80 outputs — not the data from the switch feeding my gate board. My board has true data as inputs and it outputs inverted data as shown.

gating circuit

For the same example, the 7 is operated on my board (remember the A - B - C inputs are high and the D low). In receive, and in all simplex channels, the information is handled by gate U1 (**fig. 2**). The A - B - C high and D-low condition results in a low on U1 pins 3, 6, 8, and a high on pin 11. These are the outputs of my board and the inputs to the synthesizer 7400 gates. The gate on the synthesizer board[1] inverts the data and sets it for the jam inputs of the counters. Be sure to wire the 100s of kHz for true inputs to the gate board, and the 10s of kHz and MHz switches for the inverted data, as shown for the synthesizer board[1] since that's where they're connected. (See **fig. 3** for details.)

144-147 MHz coverage

There's a good design scheme in the synthesizer[1] that only allows the 4-MHz frequency spread from 144-148 MHz to be dialed in. A 4 is hardwired on the C jam line input (400). Only two wires come from the BCD deck switch that are used in the synthesizer for MHz. These two lines allow you to add a 0 - 1 - 2 - 3 to achieve *144* + 0 — *144* + 3 as a usable MHz figure. Thus, you get 144+ — 147+ MHz coverage, so I only have to enter a 2 or 3 on the two lines. The 2 (for 146 MHz) requires the A line to be low and the B line to be high. The 3 (for 147 MHz) requires the A and B lines to be 800-line high.

I ran the 200 line as a hardwire to ground as in the circuit of reference 1, causing the B input after the gate to always be high. Then I tied the 100 line to +5 volts through a 2200-ohm resistor. When the MHz switch is to the right in the 147-MHz position, it grounds the 100 line through the 2200-ohm resistor

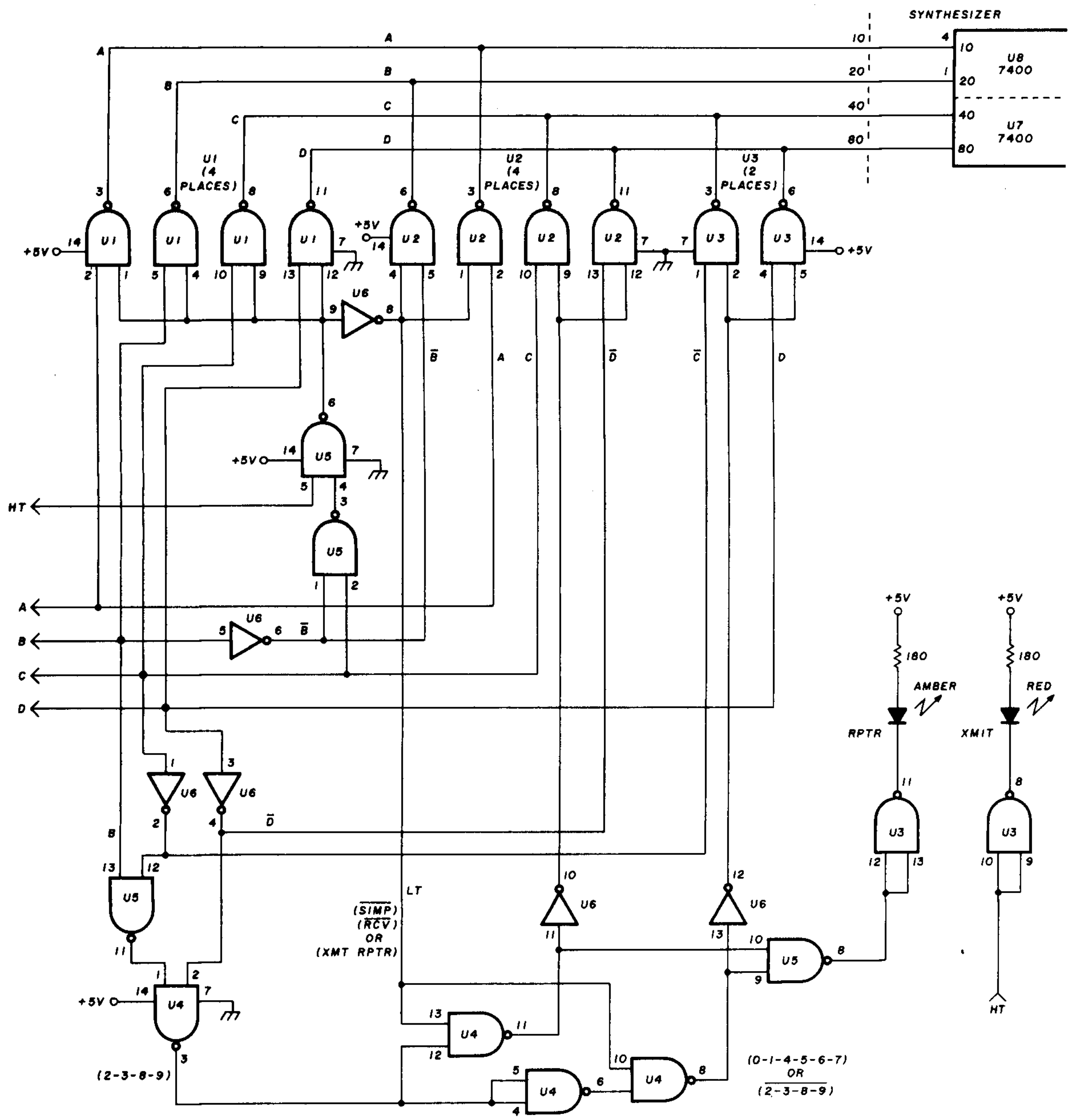


fig. 2. Schematic of the *Auto-mate* gate board. U1, U2, U3 are 7403s. U4 and U5 are 7400s. U6 is a 7404.

and causes the required high on the A line. For 146 MHz, the switch is merely an open circuit on the 100 line for a low on the A line.

The 10s-of-kHz-lines switches (1 - 2 - 4 - 8) are wired upside down from your normal true data switches (**fig. 4**). From my example 146.*76* MHz), you want the switches to provide a low on the B and C (or 2 and 4) lines. The inversion to true data is handled by the gates on the synthesizer board.

All this allows switching in the *receive* frequency at all times. In my area, a 16/76 machine is referred to as 76; to hear you dial up, switch in, or tune in 146.76 MHz.

bandplan considerations

My board takes care of the required 146.16 MHz when, and only when, you want to transmit. You really don't care about the transmit frequency as long as it's a) correct for the bandplan (same for simplex, and split for repeaters), and b) in the legal band. I solved the first requirement by my circuit, which automatically senses the receive frequency dialed in as being either simplex or repeater and processes it accordingly. Bob and Gary[1] solved the second problem by limiting operation to 144-148 MHz on their synthesizer board. As long as these requirements are met why bother with dialing in the transmit frequency? For those who want to go upside down (i.e., 76/16 if the repeater is down), it's as simple as dialing in the *transmit* frequency. My board will still shift things correctly for the actual transmit cycle. If you dial in 146.16 MHz to receive, you'll automatically transmit 146.76 MHz. This proper shift holds true for *all* repeater pairs anywhere in the 146-147 MHz region.

gating-circuit operation

The simple gates are easy to follow, line-by-line, in **fig. 2**. I'm sure you want to know how the circuit does its tricks. For this, see the tables. I'll cover only the 146-148 MHz region I use.

All my board does in the repeater function is add or subtract the proper 600 kHz from the receiver frequency that you've input to the switches. The tables show you how the bandplan allows this function. In the 146-MHz region, the receive-frequency numbers dialed in, such as 6 - 7 - 8 - 9 for the 100s of kHz column, result in 0 - 1 - 2 - 3 respectively (i.e., 76 receive/16 transmit) (**table 3**). For all these repeater pairs, my board gives a 600-kHz offset number no matter which one you dial in.

To set up a frequency (remember, choose the *receive* frequency), choose the MHz frequency by a switch totally independent of my board. Then choose the 100s of kHz going through my board by using the *receive* frequency. Then, choose the proper 10s of kHz and you're finished. When you press the PTT switch to transmit, my board will process the shift automatically whether you're in the 146- or 147-MHz region.

Gate U1 (**fig. 2**) handles all receive codes dialed in and all simplex transmit codes (the same as in the receive mode) and passes them to the synthesizer board. The left half of U2 operates on all repeater frequencies to pass line A (unaffected by the 600-kHz number shift), and an inverted line B (for all repeater shifts in transmit) to the synthesizer (lines 10 and 20). The right half of U2 and the adjoining half of U3 handle the C and D line inversions when required.

simplex operation

For all numbers 0-9, the B line is low and the C line high for only two numbers, 4 and 5, which detects the simplex frequencies you dial in. This is handled by U6 pins 5, 6 (inverting the B low to a high that can be gated in a TTL NAND gate), U5 and pins 1, 2 to gate the $\overline{B}$ and C together for a low at U5 pin 3, causing a high at U5 pin 6 and enabling all of U1 for simplex transmit. In receive, a high U5 pin 6 keeps U1 in use. This high is caused by a low at U5 pin 5 regardless of what occurs at U5 pin 4 and comes from the HT line (high on transmit; therefore low on

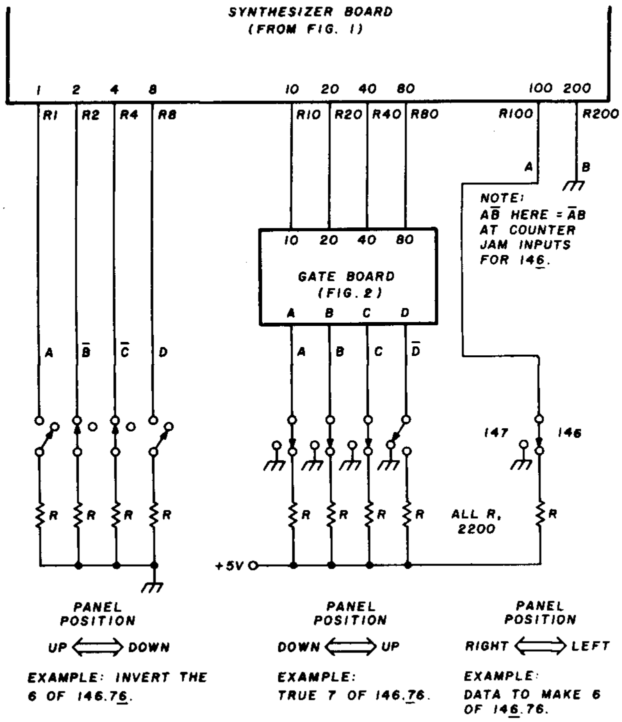


fig. 3. Panel-switch positions and relationship between the gate board and synthesizer board. The 100s of kHz should be wired for true inputs to the gate board. The 10s of kHz and MHz switches should be wired for inverted data (see text).

receive) of the synthesizer board connected to U5 pin 5.

Without going further into a line-by-line description, the other numbers of a repeater nature are detected by similar gating means and are used to control the function of the gates in the right half of U2 and left half of U3. All these outputs are paralleled so that only the correct one operates on the 10 - 20 - 40 - 80 output lines from the gate board. Control is maintained by lines such as the one line to all four gate inputs of U1 pins 1, 4, 9, 12. If this line goes low, regardless of the other inputs from A-B-C-D, all outputs will go high. In this case the gate is entirely out of the picture.

I'll be glad to answer any questions on the gate board upon receipt of a self-addressed stamped envelope. Questions on whether the synthesizer can be used on your radio should go to Bob and Gary.[1*] For questions on whether my scheme for automation will work between your switches and another synthesizer, send me a large copy of your schematic and I'll try to help you if I can. The Auto-mate should work on any synthesizer into which the count chain is fed as real frequency date, not as fancy codes!

Be sure to leave the leads a bit long between a) the

*G&F Electronics, P.O. Box 4151, Huntsville, Alabama 35802.

table 1. Amateur 2-meter bandplan for 146-MHz showing binary-coded decimal equivalents for input and output switching in the *Auto-mate*. Numbers in boldface type are those on which the circuit operates.

dial in receive frequency	type	desired transmit frequency	in code 146. × 1 D	C	B	A	outcode D	C	B	A	relationship (I = Invert) D	C	B	A
14 6 **0** 1	I R	14 6 **6** 1	0	0	0	0	0	1	1	0		I	I	
14 6 **0** 4	I R	14 6 **6** 4	0	0	0	0	0	1	1	0		I	I	
14 6 **0** 7	I R	14 6 **6** 7	0	0	0	0	0	1	1	0		I	I	
14 6 **1** 0	I R	14 6 **7** 0	0	0	0	1	0	1	1	1		I	I	
14 6 **1** 3	I R	14 6 **7** 3	0	0	0	1	0	1	1	1		I	I	
14 6 **1** 6	I R	14 6 **7** 6	0	0	0	1	0	1	1	1		I	I	
14 6 **1** 9	I R	14 6 **7** 9	0	0	0	1	0	1	1	1		I	I	
14 6 **2** 2	I R	14 6 **8** 2	0	0	1	0	1	0	0	0	I		I	
14 6 **2** 5	I R	14 6 **8** 5	0	0	1	0	1	0	0	0	I		I	
14 6 **2** 8	I R	14 6 **8** 8	0	0	1	0	1	0	0	0	I		I	
14 6 **3** 1	I R	14 6 **9** 1	0	0	1	1	1	0	0	1	I		I	
14 6 **3** 4	I R	14 6 **9** 4	0	0	1	1	1	0	0	1	I		I	
14 6 **3** 7	I R	14 6 **9** 7	0	0	1	1	1	0	0	1	I		I	
14 6 4 0	S	14 6 **4** 0	0	1	0	0	0	1	0	0				
14 6 4 3	S	14 6 4 3	0	1	0	0	0	1	0	0				
14 6 4 6	S	14 6 4 6	0	1	0	0	0	1	0	0				
14 6 4 9	S	14 6 4 9	0	1	0	0	0	1	0	0				
14 6 5 2	S	14 6 5 2	0	1	0	1	0	1	0	1				
14 6 5 5	S	14 6 5 5	0	1	0	1	0	1	0	1				
14 6 5 8	S	14 6 5 8	0	1	0	1	0	1	0	1				
14 6 **6** 1	R	14 6 **0** 1	0	1	1	0	0	0	0	0		I	I	
14 6 **6** 4	R	14 6 **0** 4	0	1	1	0	0	0	0	0		I	I	
14 6 **6** 7	R	14 6 **0** 7	0	1	1	0	0	0	0	0		I	I	
14 6 **7** 0	R	14 6 **1** 0	0	1	1	1	0	0	0	1		I	I	
14 6 **7** 6	R	14 6 **1** 6	0	1	1	1	0	0	0	1		I	I	
14 6 **7** 9	R	14 6 **1** 9	0	1	1	1	0	0	0	1		I	I	
14 6 **8** 2	R	14 6 **2** 2	1	0	0	0	0	0	1	0	I		I	
14 6 **8** 5	R	14 6 **2** 5	1	0	0	0	0	0	1	0	I		I	
14 6 **8** 8	R	14 6 **2** 8	1	0	0	0	0	0	1	0	I		I	
14 6 **9** 1	R	14 6 **3** 1	1	0	0	1	0	0	1	1	I		I	
14 6 **9** 4	R	14 6 **3** 4	1	0	0	1	0	0	1	1	I		I	
14 6 **9** 7	R	14 6 **3** 7	1	0	0	1	0	0	1	1	I		I	

switches and the gate board, b) the other switches and the synthesizer, and c) between the outputs of the gate board and the synthesizer. No high frequencies are on these leads so there'll be no radiation problem. Just don't dress the leads down around the VCO area. If you leave the leads a bit long you can add scanning, push-to-talk/push-to-receive circuits, and more.

further automation: scanning and PTT/PTR

In this part of the article I describe another simple board requiring nine or fewer ICs, of which three are simple "less-than-25-cents" gates. The total IC cost, from a recent ad, is $3.56. This circuit may be added between the synthesizer input switches and the synthesizer board to provide scanning of a full MHz (or part), push-to-talk/push-to-receive (PTT/PTR) control to ease the "mobile thumb" problem, and full scan control from the PTT switch on the microphone.

It's a nice package in itself. Note that this board is connected between the *receive* encoder switches and the synthesizer board. You'll still transmit on whatever command is dialed into the transmitter switches. The small expense of building both boards makes full automation the way to go. Should your synthesizer need true BCD codes at the synthesizer board inputs I've provided information for the IC and wiring changes.

This part of the article is arranged into the following parts: Scanning counter/jam inputs (**fig. 4**). PTT/PTR and scan/halt control circuits (**fig. 5**). Input and output processing (**fig. 6**), and what, where and why of the timing circuits (**fig. 7**).

scanning

Scanning is accomplished by feeding the binary outputs from a counter pair to the synthesizer gate inputs on the synthesizer board. These outputs change during scan and thus change the encoded input information choosing the channels. Which frequency band (MHz) that's to be scanned remains a table 2. Amateur 2-meter bandplan for 147-MHz showing binary-coded decimal equivalents for input and output switching in the *Auto-Mate*. Numbers in boldface type are those on which the circuit operates.

dial in receive frequency	type	desired transmit frequency	in code D C B A	out code D C B A	relationship (I = Invert) D C B A
14 7 **0** 0	R	14 7 **6** 0	0 0 0 0	0 1 1 0	· I I ·
14 7 **0** 3	R	14 7 **6** 3	0 0 0 0	0 1 1 0	· I I ·
14 7 **0** 6	R	14 7 **6** 6	0 0 0 0	0 1 1 0	· I I ·
14 7 **0** 9	R	14 7 **6** 9	0 0 0 0	0 1 1 0	· I I ·
14 7 **1** 2	R	14 7 **7** 2	0 0 0 1	0 1 1 1	· I I ·
14 7 **1** 5	R	14 7 **7** 5	0 0 0 1	0 1 1 1	· I I ·
14 7 **1** 8	R	14 7 **7** 8	0 0 0 1	0 1 1 1	· I I ·
14 7 **2** 1	R	14 7 **8** 1	0 0 1 0	1 0 0 0	I · I ·
14 7 **2** 4	R	14 7 **8** 4	0 0 1 0	1 0 0 0	I · I ·
14 7 **2** 7	R	14 7 **8** 7	0 0 1 0	1 0 0 0	I · I ·
14 7 **3** 0	R	14 7 **9** 0	0 0 1 1	1 0 0 1	I · I ·
14 7 **3** 3	R	14 7 **9** 3	0 0 1 1	1 0 0 1	I · I ·
14 7 **3** 6	R	14 7 **9** 6	0 0 1 1	1 0 0 1	I · I ·
14 7 **3** 9	R	14 7 **9** 9	0 0 1 1	1 0 0 1	I · I ·
14 7 4 2	S	14 7 4 2	0 1 0 0	0 1 0 0	
14 7 4 5	S	14 7 4 5	0 1 0 0	0 1 0 0	
14 7 4 8	S	14 7 4 8	0 1 0 0	0 1 0 0	
14 7 5 1	S	14 7 5 1	0 1 0 1	0 1 0 1	
14 7 5 4	S	14 7 5 4	0 1 0 1	0 1 0 1	
14 7 5 7	S	14 7 5 7	0 1 0 1	0 1 0 1	
14 7 **6** 0	I R	14 7 **0** 0	0 1 1 0	0 0 0 0	· I I ·
14 7 **6** 3	I R	14 7 **0** 3	0 1 1 0	0 0 0 0	· I I ·
14 7 **6** 6	I R	14 7 **0** 6	0 1 1 0	0 0 0 0	· I I ·
14 7 **6** 9	I R	14 7 **0** 9	0 1 1 0	0 0 0 0	· I I ·
14 7 **7** 2	I R	14 7 **1** 2	0 1 1 1	0 0 0 1	· I I ·
14 7 **7** 5	I R	14 7 **1** 5	0 1 1 1	0 0 0 1	· I I ·
14 7 **7** 8	I R	14 7 **1** 8	0 1 1 1	0 0 0 1	· I I ·
14 7 **8** 1	I R	14 7 **2** 1	0 0 0 0	0 0 1 0	I · I ·
14 7 **8** 4	I R	14 7 **2** 4	1 0 0 0	0 0 1 0	I · I ·
14 7 **8** 7	I R	14 7 **2** 7	1 0 0 0	0 0 1 0	I · I ·
14 7 **9** 0	I R	14 7 **3** 0	1 0 0 1	0 0 1 1	I · I ·
14 7 **9** 3	I R	14 7 **3** 3	1 0 0 1	0 0 1 1	I · I ·
14 7 **9** 6	I R	14 7 **3** 6	1 0 0 1	0 0 1 1	I · I ·
14 7 **9** 9	I R	14 7 **3** 9	1 0 0 1	0 0 1 1	I · I ·

function of the 146/147 MHz switch described previously and has no bearing whatever here. It's a manual, front-panel switch choice — no scanning involved.

Installation notes. To install the scanning circuitry, break the long leads described above and insert this in series. Trace the circuit from the switch line of 10s and kHz **A** line to the synthesizer gate input at R1 of **fig. 4**. You'll see two **X**s on the line that were one at the same point before you open the lead, as previously connected. Each other pair per lead is the same, i.e., B to R2 — Xs were the same point, C to R4 — Xs, etc. Where you open the leads will depend on where you place your new board. I'd mount the new board, make the break, and reconnect two points of each lead, one lead at a time.

Counters. The counters chosen for scanning are binary (not BCD or decade) for a very good reason, even though each one must count only ten positions to cover the 100 possible frequencies of each megahertz. (Because of the original synthesizer input scheme, you could dial in every 10-kHz increment, even though the channels are every 30 kHz). (See **table 4.**) Note that in my synthesizer, a $\overline{\text{BCD}}$ (inverted) code is required at the synthesizer gate inputs. The easiest way to accomplish this and still scan in an up (increasing frequency) direction without a lot of inverters is as follows.

From **table 4**, you'll see that to obtain a decimal 0 at the synthesizer counter jam inputs you must feed the inverse BCD (i.e., $\overline{\text{BCD}}$) to the synthesizer board input gates. This happens to be a decimal 15. Or, for a BCD 0 (0000) you need a gate input of 15 (1111). For the next step of 1, you need a 14, for 2, a 13, and so on. Thus, you require a binary counter that sets to 15, counts downward to 6 (10 counts), detects the next count of 5 without changing from the 6 outputs (reset or load takes precedence over count), and

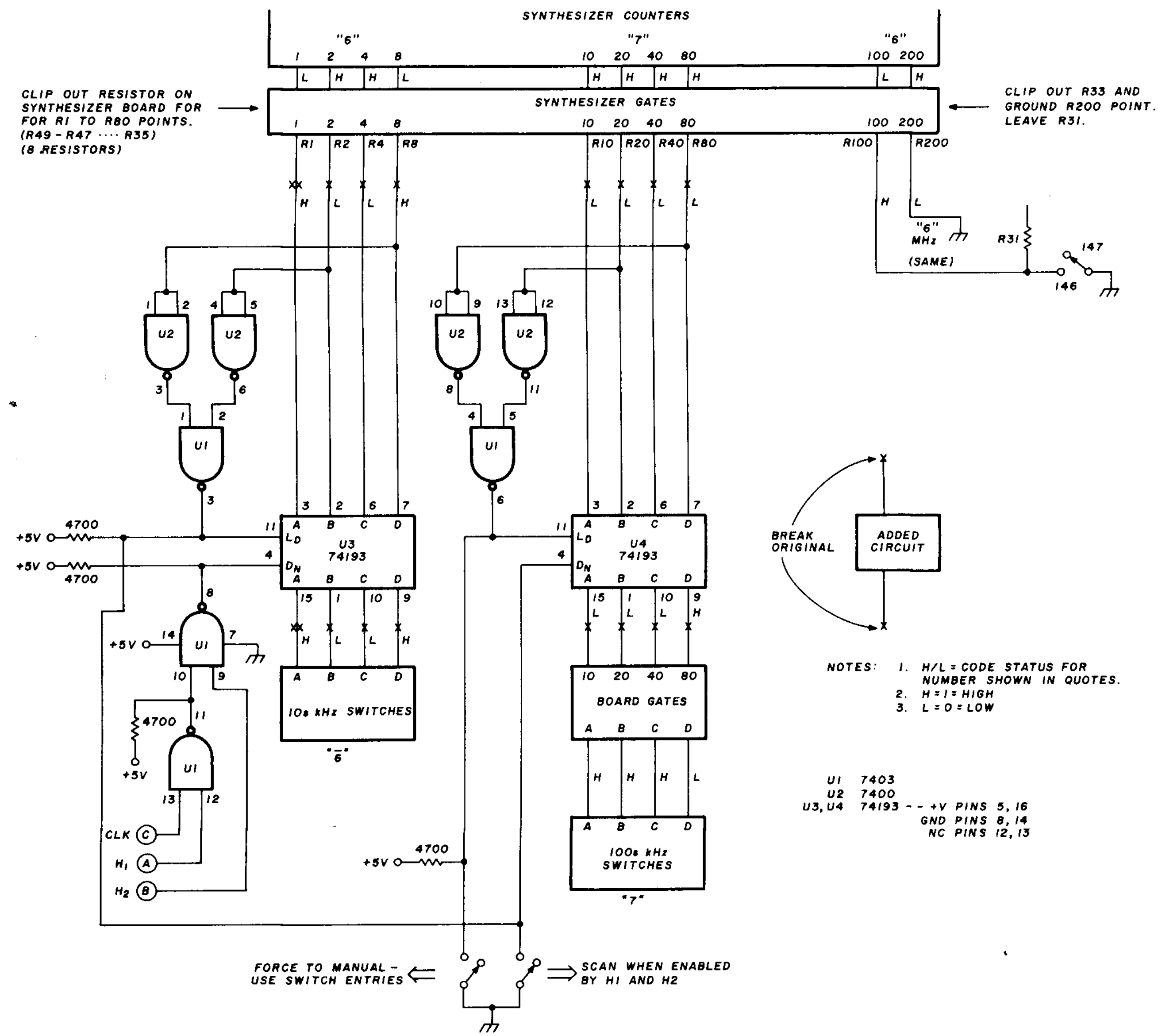


fig. 4. Scanning counter and jam inputs to the synthesizer counters. The 10s-of-kHz switch outputs and gate-board outputs are inverted BCD data, which can be fed directly into U3, U4, the counter ICs.

uses the detected 5 to set 15 again. This is the same as counting from 0 to 9 in inverted BCD — or from 15 to 6 in binary. It's the same if you want the same count sense (up) and inverted outputs.

The outputs of the 10s-of-kHz-switches and the gate board are inverted BCD outputs. They can be fed into the jam inputs of the new scanning counter set, U3, U4 (**fig. 4**). When the load line (U3, U4 pin 11) goes low, this information is passed directly to the outputs and to the synthesizer gate inputs — inverted and with the correct code ($\overline{\text{BCD}}$). This fact, (load line low to load the switch inputs) brings out some interesting sidelights and benefits.

First, for manual switch control and no scan, all you do is to force the load lines low with switch S1 (**fig. 4**). You're then in manual mode regardless of the states on H1 and H2 or whether the control (**fig. 5**) is in SCAN or HALT.

Second, the switches of 100s and 10s of kHz must be in their decimal zero position (all switches down) to feed the required 15 $\overline{\text{BCD}}$ to the counters (U3, U4, **fig. 4**) during reset, or load as it's called here. This is because, instead of clearing the counters (reset to 0 by a high on pin 14), you want to reset to 15. You do this by briefly pulsing the proper load line low with the outputs from U1 pin 6 or U1 pin 3 (**fig. 4**). If all switches are set to 00 (i.e., 146.000 MHz), the whole MHz segment will be scanned. Setting 00 puts the required 15-15 on $\overline{\text{BCD}}$ pulses on the synthesizer gate inputs.

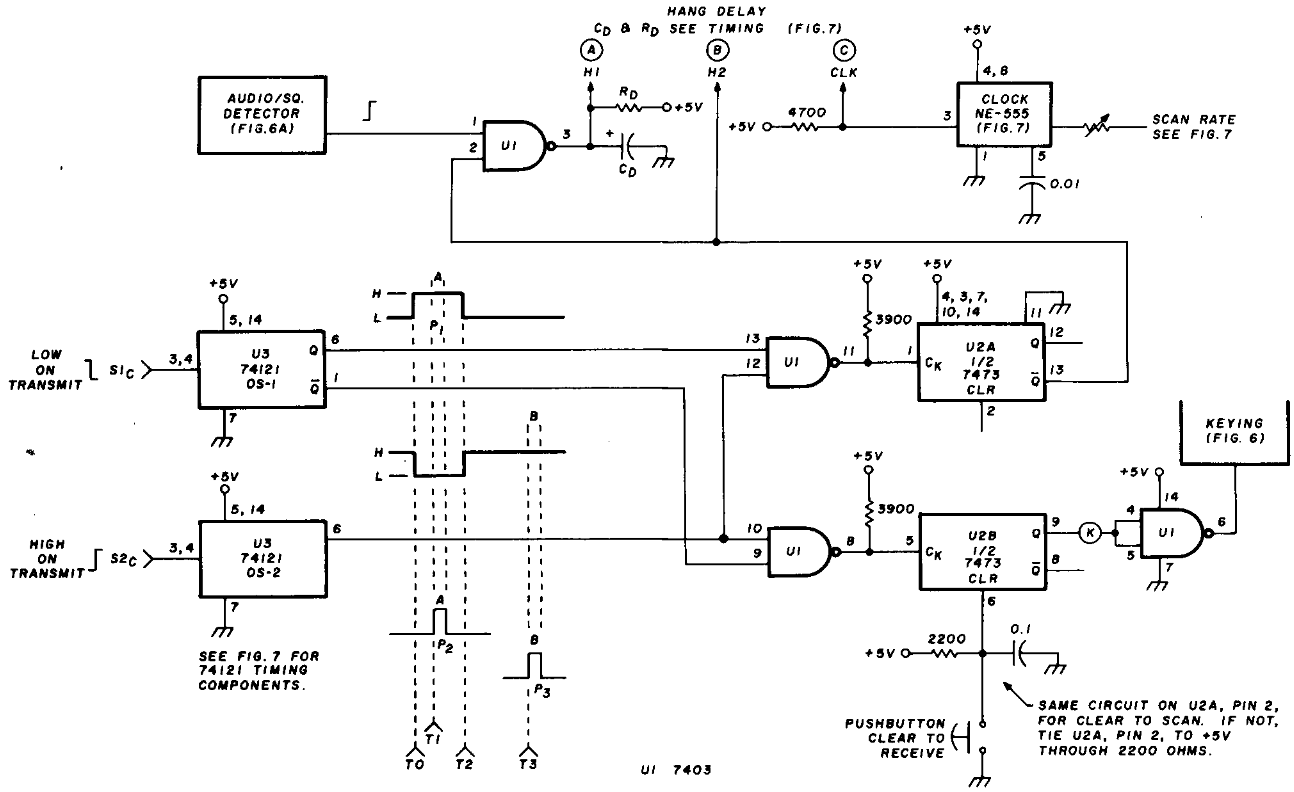


fig. 5. Push-to-talk and push-to-receive and scan/halt control circuits.

If you don't want the full MHz coverage, just set the 10s of kHz switch to 0 (all down — a must during all but manual mode), and the 100s of kHz switch to the *lowest* 100s of the kHz switch you wish to scan. Example: for the 146-MHz region, set the 100s of kHz switch to 6 (146.60) (B-C switches up), and you'll hear all repeater outputs. Set a 4 (146.40) (C switch up) and you'll get all simplex and repeater transmissions. This saves time by not scanning the repeater inputs.

If you like these ideas and have a synthesizer that requires BCD *true* data, you'll need a different counter scheme (**fig. 8**). Suggestion: build the gate board and the scan counter set (**fig. 4**) and add inverters at each of the upper Xs of **fig. 4**. If you then bring the outputs for true *and* inverted BCD to a plug, you can run the whole gadget on any synthesizer that requires direct frequency codes in BCD or $\overline{\text{BCD}}$, but not the models that require a special code.

PTT/PTR and scan/halt

Around my house there's just too much noise and unplanned interruptions to warrant VOX operations on any of the base station equipment. On the other hand, holding down a PTT microphone button for long periods during a 24-hour contest is no thrill either. Long ago I went to a push-to-talk/push-to-receive operation on all the base station radios; for mobile work it's even nicer. You can even go to a visor-mounted microphone and a steering-column or floor-mounted pushbutton for full hands-off control. No more hassles with a shift lever and the microphone cord!

how it works

As the PTT switch is closed, a pulse generated from OS-1, a 74121 one shot, (**fig. 7**), is directed to two gate inputs. You can vary the width of this pulse to suit yourself as in **fig. 7**, but I've found that 1 second is a nice average number with which to start. When the PTT switch is released, another much shorter pulse is generated by OS-2. If the switch is released within the 1-second timeframe of P_1 (**fig. 5**), the high of P_1 and P_2 triggers U1 pin 11 low for a P_2 wide pulse (i.e., a short blip on the PTT switch).

This short pulse is stored as a change of state in one-half of a 7473 that controls the H2 line. A low on H2 turns off gate U1 (**fig. 4**) and cuts off the clock pulses to the scan counter set — scanning stops. Another blip on the PTT and you're scanning again as the 7473 again changes state. This blip can be extremely brief. Unless you have a very quick transmitter, it won't be heard on the air. My circuit, used on a Heath HW202, is silent if I stab the PTT switch

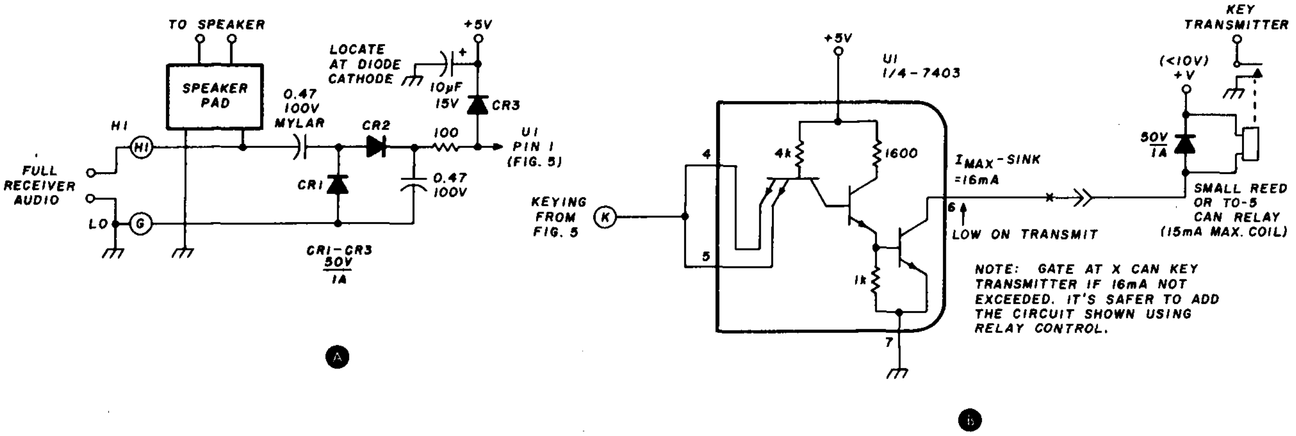
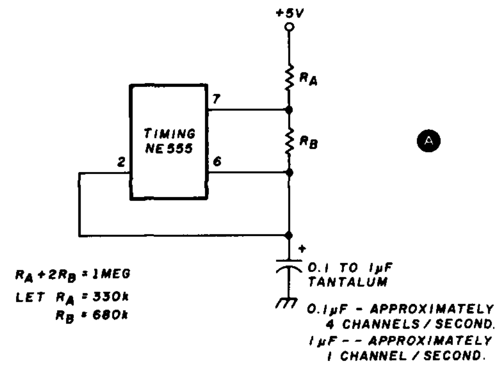
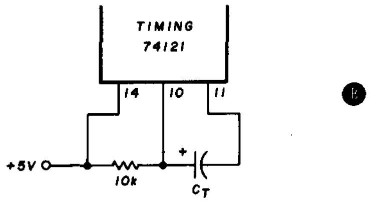


fig. 6. Input-output processing circuits. At (A) is a voltage doubler to handle the TTL gate input at U1 pin 5 (fig. 5). Component values have been chosen for maximum audio fidelity consistent with reliable halts during scanning. A keying system is shown in (B). U1, part of a 7403, will safely handle currents of 16 mA, but the relay circuit is recommended. CR4 is one of the 1N4000 family (approximately 50 volts at 1 ampere).





	C_T PULSE	PERIOD
OS-1	68 TO 100µF TANTALUM (≈1 SECOND)	T_0-TO-T_2
OS-2	6.8 TO 10µF TANTALUM (≈10mS)	P_2 OR P_3

NOTES:

1. HANG DELAY: R_D = 1k < R_D < 4700. C_D: ADJUST TO SUIT VOLUME OUTPUT OF RADIO. HANG MUST BE LONG ENOUGH TO HOLD DURING VOICE PAUSES AND DURING OPERATOR CHANGEOVER OR UNIT WILL RESUME SCAN.
2. THIS IS AUDIO-DERIVED HANG CONTROL AND WILL SKIP DEAD CARRIERS.
3. START WITH 4700 & 220µF/15V. REDUCE C TO SHORTEN HANG TIME.

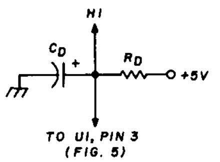


fig. 7. Timing circuitry; (A) shows the scanning clock, an NE-555 IC; (B) shows OS-1 and OS-2 timing-capacitor selection as a function of pulse length and period.

because the HW202 is relay-switched from receive to transmit.

Operation. To use the system, we'll start off in receive and unit scanning. Ah! There's Joe on the local machine. (How the scan stops to hear this in the first place is covered under **input/output processing**, but it does halt when it hears a station.) Then, to stay there and talk to Joe, blip the PTT microphone switch. Scan is now **Halt** through a H2 low. Joe finishes with Harry; now you want to talk to Joe. Firmly press the PTT for some period longer than you set up the P_1 pulse width. Release any time after that. Immediately when you *release* the PTT switch, you're on the air in transmit. As you near the end of your first go-around, again press the PTT switch firmly a few seconds before the end. When you *release* the PTT switch, you immediately return to receive — scanning is still unaffected and in **Halt**. Simple? Not much different, really, except the first release-to-transmit part!

For long-winded souls on quick-natured repeaters, you can even hook in an automatic timer to control the end of transmission. Several have appeared lately, so I won't go into any specifics here. Just wire the timer so that the act of going to transmit (U2A pin 13 low) triggers the timer on; the timer running out places a pulse low on U2B pin 6 (for a clear to receive command). See **fig. 5**. Wire so that a shorter conversation both resets to receive and resets the timer. Set the timer duration for about 10 seconds less than that of your local machines.

You don't even need a reset timer if the timer is of the 555 type. Just be sure to use the pulsed output to clear U2B and not toggle, as it does the PTT switch. If you've already returned to receive through the PTT

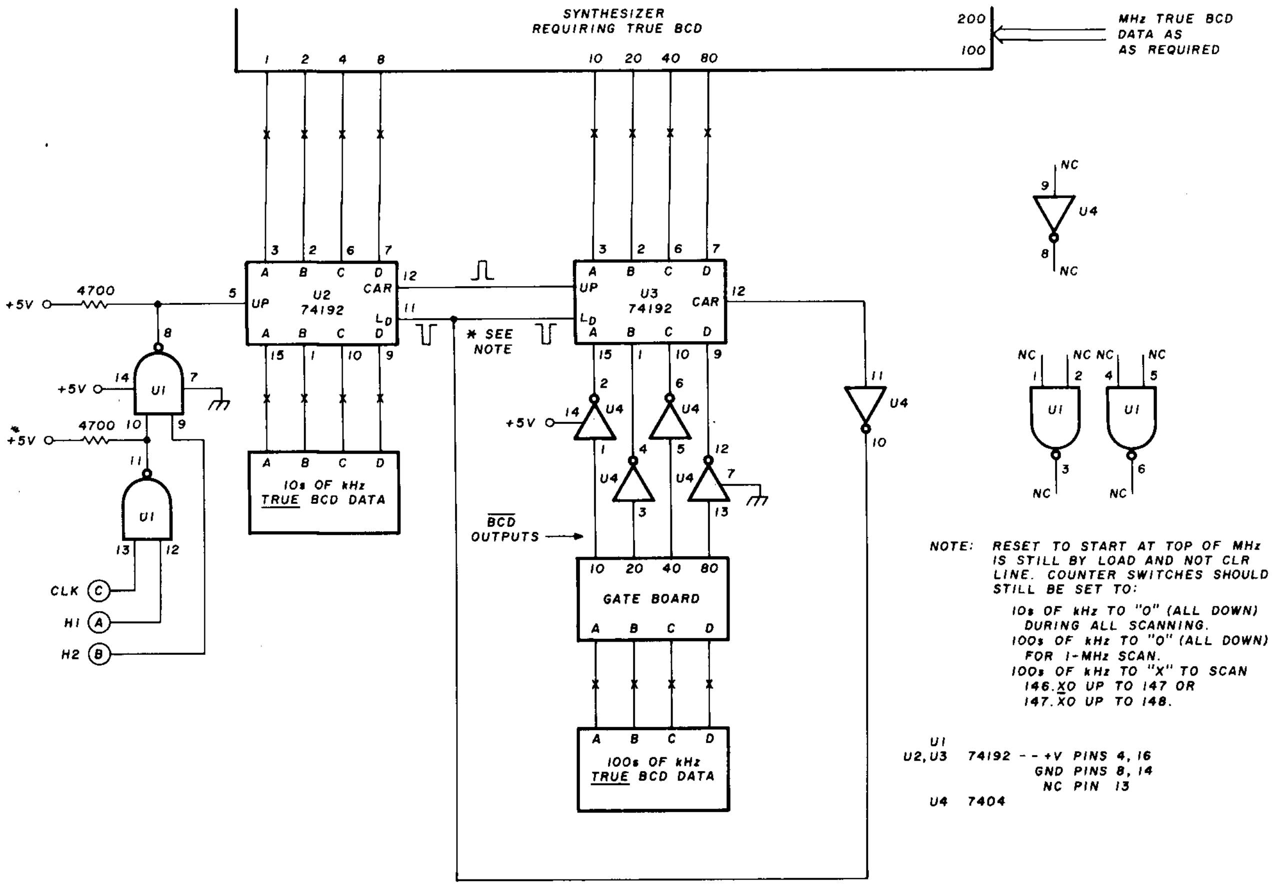


fig. 8. Schematic for synthesizers requiring true BCD input.

switch before the timer times out, this will pulse U2B to receive. If you return to receive *and* switch back to transmit before the first time period has run out (as often happens), the second return to transmit will again give you a full time period, as the 555 can be retriggered.

input/output processing

This is the easiest part of all. Output processing means whether or not to add the relay and/or additional transistor output stages to U1 pin 6 (**fig. 5**) to handle key-line currents of greater than 15 mA or voltages higher than about +12 volts. If in doubt, use the relay and send a nice, firm relay ground connection back to the radio to key the transmitter.

As for input processing, the control lines into the control section of **fig. 5** come from two points on the synthesizer I used. The control signals are TTL levels and a low is applied to OS-1 when the PTT switch is closed (keying the transmitter). A high is applied to OS-2 at that same time. If you don't have these controls, they should be easy to come up with. Just limit the high to about +5 volts. The low should be near ground to protect the inputs of OS-1 and OS-2.

I trunk-mounted my radio and wanted as few wires as possible back and forth, so I installed full volume audio to my synthesizer/control head and put a pad up front. This pad can be a low-impedance T pad if you have the room. With the radio volume control full clockwise or on, I put a resistor in series with the high-side speaker lead that reduced the volume to a comfortable level. The switch shorts out the resistor for the weak ones. I was cramped for space. With full volume coming forward the speaker is silent when full squelched and has plenty of audio available at the control head when a station comes on. Rectify this audio and you have a stop-scan signal, H1.

Looking at **fig. 6A**, a voltage doubler ensures that there's always enough voltage to handle the TTL gate input at U1 pin 1 (**fig. 5**). Diode CR3 (**fig. 6**) connected to +5 volts limits the input to U1 pin 1, **fig. 5**, to a TTL high level. The capacitor at the diode cathode ensures that no audio peaks over +5 volts will appear on the +5 volt line.

The 100-ohm resistor (**fig. 6A**) limits the gate input to +5 volts maximum without peak-limiting the audio peaks on the input side, which would distort the audio. You may have to decrease this value on some radios with low-volume output, but use a value as large as possible to still have reliable halts on all the stations that are on air (seen as lows on H1).

The RC network on H1 in **figs. 5** and **7B** puts a hang effect on the action of H1. Keep R_D within the limits shown and change C_D to keep the H1 line low between voice peaks or words. This is the alternative to *running a wire from the radio to show a no-squelch condition*. It also rejects any dead carriers with no modulation. If you use the wire, limit the voltage excursion to TTL levels and have a high for a station on frequency.

timing

Fig. 7 is self-explanatory as to the what and where, but here are a few of the whys. For OS-1 timing components, you're trying to create a pulse short enough that you don't have to hold the PTT down forever before releasing it to transmit. On the other hand, you don't want the pulse so short you could never use it for scan control. You can only blip your blipper so fast! I found the 1-second pulse a good compromise. Blip controls scan reliably, and Joe won't mind waiting one more second to hear from you.

The return to receive is no problem, as you know

table 3. Processing scheme for 100s of kHz as a function of switch inputs for the gate board. Examples are shown for 146.76 MHz (receive) and 146.16 MHz (transmit).

100s OF kHz PROCESSING

DIAL IN * RECEIVE FREQUENCY	OUTPUT FOR TRANSMIT FREQUENCY *	SWITCH INPUT D	C	B	A	PROCESS (D LINE)	PROCESS (C LINE)	PROCESS (B LINE)	PROCESS (A LINE)
0	6	L	L	L	L	PASS	INVERT	INVERT AND PASS THROUGH U_B	PASS THROUGH U_B
1	7	L	L	L	H	PASS	INVERT		
2	8	L	L	H	L	INVERT	PASS		
3	9	L	L	H	H	INVERT	PASS		
4	4	L	H	L	L	PASS ALL THROUGH U_A			
5	5	L	H	L	H				
6	0	L	H	H	L	PASS	INVERT	INVERT AND PASS THROUGH U_B	PASS THROUGH U_B
7	1	L	H	H	H	PASS	INVERT		
8	2	H	L	L	L	INVERT	PASS		
9	3	H	L	L	H	INVERT	PASS		

EXAMPLE:

	D	C	B	A	
146.76 RECEIVE	L	H	H	H	SWITCH INPUT
NEEDS	L	L	L	H	OUTPUT ON TRANSMIT

PASS ALL A
INVERT AND PASS ALL B
INVERT AND PASS C
PASS D

	D	C	B	A	*	
SWITCH	L	H	H	H	7	RECEIVE FREQUENCY 146.76
PROCESS	L	L	L	H	1	
GATE BOARD OUT	H	H	H	L	14	(OR $\overline{1}$)
THROUGH SYNTHESIZER BOARD GATES AND AT COUNT JAM INPUTS	L	L	L	H	1	TRANSMIT FREQUENCY 146.16

table 4. Conversion from decimal to BCD code for up-scan (increasing frequency) at the synthesizer counter jam inputs.

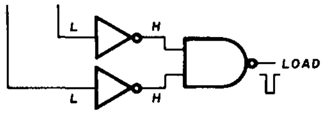
UP SCAN IN DECIMAL NUMBER	NUMBER IN BCD CODE D	C	B	A	$\overline{BCD}$ REQUIRED BY SYNTHESIZER INPUT GATES D	C	B	A	THAT $\overline{BCD}$ IS BINARY FOR DECIMAL NUMBER = DEC
0	0	0	0	0	1	1	1	1	= 15
1	0	0	0	1	1	1	1	0	= 14
2	0	0	1	0	1	1	0	1	= 13
3	0	0	1	1	1	1	0	0	= 12
4	0	1	0	0	1	0	1	1	= 11
5	0	1	0	1	1	0	1	0	= 10
6	0	1	1	0	1	0	0	1	= 9
7	0	1	1	1	1	0	0	0	= 8
8	1	0	0	0	0	1	1	1	= 7
9	1	0	0	1	0	1	1	0	= 6

SCAN

TO SCAN USING THE REQUIRED $\overline{BCD}$ CODE:

1. COUNTERS MUST DOWN COUNT.
2. RESET FOR FULL 1-MHz SCAN MUST BE TO THE NUMBER 15 (SWITCHES TO 14X.00).
3. RESET IS BY LOAD LINE AND OCCURS BY DETECTING THE NUMBER 5 ($\overline{10}$) AT OUTPUTS TO SYNTHESIZER BOARD.

10 N/A BUT $\overline{BCD}$ IS:
1 0 1 0 0 1 0 1 = 5



best when you're going to stop talking and turn it back over. Just press the PTT button a few seconds (over 1 second will do) before turning it over to receive. Return to receive is immediate upon PTT *release*. As for the P_2 or P_3 pulse (depending when you release the PTT), I wanted a pulse that was much shorter than P_1. You must take *some* time getting on and off the PTT for a scan blip, so that uses P_1 time. I figured a half second worst case, leaving half second if it's to be a P_2 scan-control pulse. Ten per cent of a half second (500 ms) is 50 ms, leaving a 90 per cent error margin, or P_1 safety zone. My capacitor happened to give me a 10-ms pulse that works just fine.

Just about any capacitor will give a pulse long enough. If your scan control PTT blips start putting you in transmit as well, the capacitor is too big, and P_2 is biting into the P_3 zone. Back off!

The C_D, R_D on H-1 depend on your radio. I've provided an R_D range and C_D starting point. Just use the advice under **input processing** to set things up.

scan clock

The scan counters (and even the switches) allow for increments of every 10 kHz, but there are stations only every 30 kHz. Therefore, the scan clock (**fig. 7A**) can run at a frequency three times per second as fast as you wish to scan the possible channels. With the components shown, you can make about 1.2-12 Hz, or less than one channel per second to four per second.

Start with a slow scan and another radio tuned to a channel with lots of activity if possible. Then start adjusting the scan clock capacitor, C, for faster rates (smaller C), after establishing R_D and C_D (**fig. 7B**) for the desired hang delay on channel. You could go up to the TTL counter limit of 32 MHz were it not for other limiting factors and the fact it's ridiculous anyway.

Some of the limits are found in a) the ability of the radio or, in my input circuit, to recognize a station and respond with a control stop only on H-1, b) the limit of the synthesizers to want data only so often (and settled data at that), and the fact that, as scan rates get high, trash is generated by switching that could cause havoc in the synthesizer itself.

Use the second radio to determine when your radio and scanner fail to stop on a station and remember, you're scanning only to remove the drudgery of always flipping switches.

stunt box fun

My scanner and synthesizer are such that I can still do a few cute tricks late at night when activity is low. Every time my synthesizer board wants new switch data input, the load line of the switch data input counters (pin 11 that controls the counters on the synthesizer board) goes low. The counter set (U3, U4, **fig. 4**) used for scanning happens to clock or advance on a low-to-high transition. With these two facts, I can cause some amusing things to happen! By making R_D and C_D provide a short pulse, like 10 ms, and using the synthesizer board load line as the clock input to the scan counter set, scan action really moves along! It only stops for 10 ms on each active channel and then moves on. By moving so fast, I can get 10-ms bursts of audio from each active channel — for a multiplex action. You wind up listening to more than one conversation at once. Scan control and PTT/PTR remain unaffected, but it would be a miracle if you could blip fast enough to stop on the channel you really wanted.

It's a novelty and demonstrates one of the upper limits of how fast is fast enough for scanning. All the commercial scanners are capable of scanning at many times the rates used, but you wouldn't be able to watch all the pretty LEDs go scanning along! The voices get pretty choppy in my speedy example above if you don't get the hang time just right. If several stations are on at once, it sounds like your local lodge meeting — everyone talking at once. It's just one of the cute things you can do with this miracle age of electronics. After all, now that you have a fully automatic station doing all the work, you must have something to do — it's called having fun!

reference

1. Bob Fanning, K4VB, and Gary Grantland, WA4GJT, "800-Channel 2-Meter Synthesizer," *ham radio*, January, 1979, pages 10-18.

ham radio

More Details? CHECK—OFF Page 94

Yagi antenna design:

more data on the performance of multi-element simplistic beams

Manipulating the boom length and element spacing of Yagi beams to maximize forward gain and front-to-back ratio

This is a continuation of last month's discussion[5] of simplistic Yagi antennas. To provide continuity to the complete subject I shall continue the sequential numbering of tables and illustrations. Last month I presented the performance characteristics of 2, 3, and 4-element simplistic Yagi antennas over a range of useful boom lengths. Systematic detailed computations have also been made for simplistic Yagi antennas for 3, 6, and 7 elements. To illustrate the behavior of these larger and more complex antennas the characteristics of 6-element Yagi simplistic beams are shown in **fig. 13** where free-space antenna gain in dBi is plotted against frequency, F, for a range of boom lengths up to $1.5\lambda_o$. Numbered curves correspond to element lengths given in table 3 of reference 5.

The total range of results shows a number of characteristics of interest. First, the bandwidth over which gain is high is determined primarily by the frequency spread between the reflector and the director(s). Second, the shape of the gain curve is generally not flat in the region of interest; indeed it may be sloped and/or humped or dished. Usually the slope favors the higher frequencies. Third, the shape of the gain curve is more complex where the number of elements is large, and the shape of the F/B ratio varies enormously — much more than the shape of the associated gain curve. It may show more than one peak; moreover, the peak structure shifts very rapidly with boom length. The height of the peak does not necessarily seem to vary monotonically with the frequency separation of reflector and director(s). Very high F/B values (greater than 30 dB) are quite rare and when present are invariably very narrow banded. In addition, the frequency bandwidth of the

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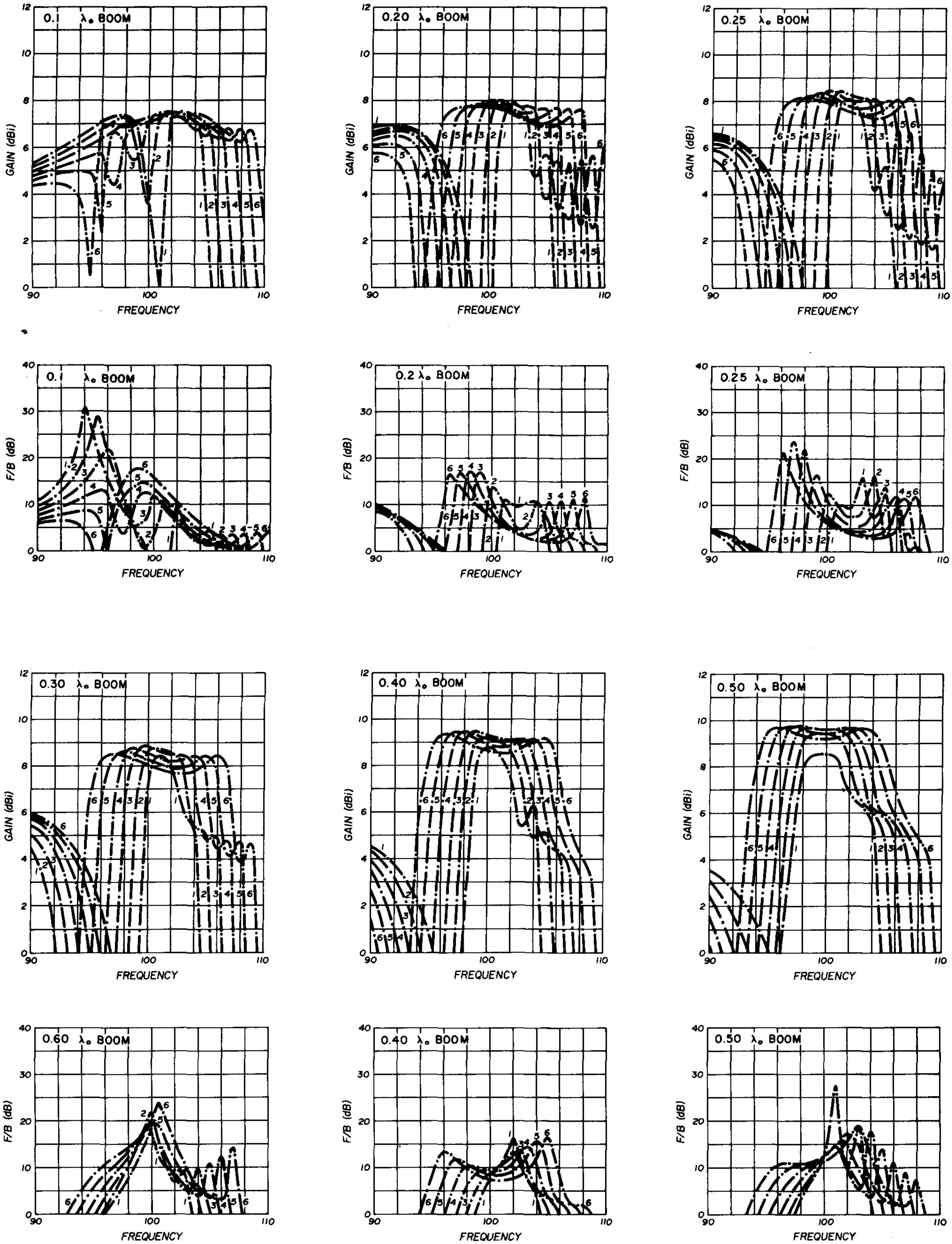
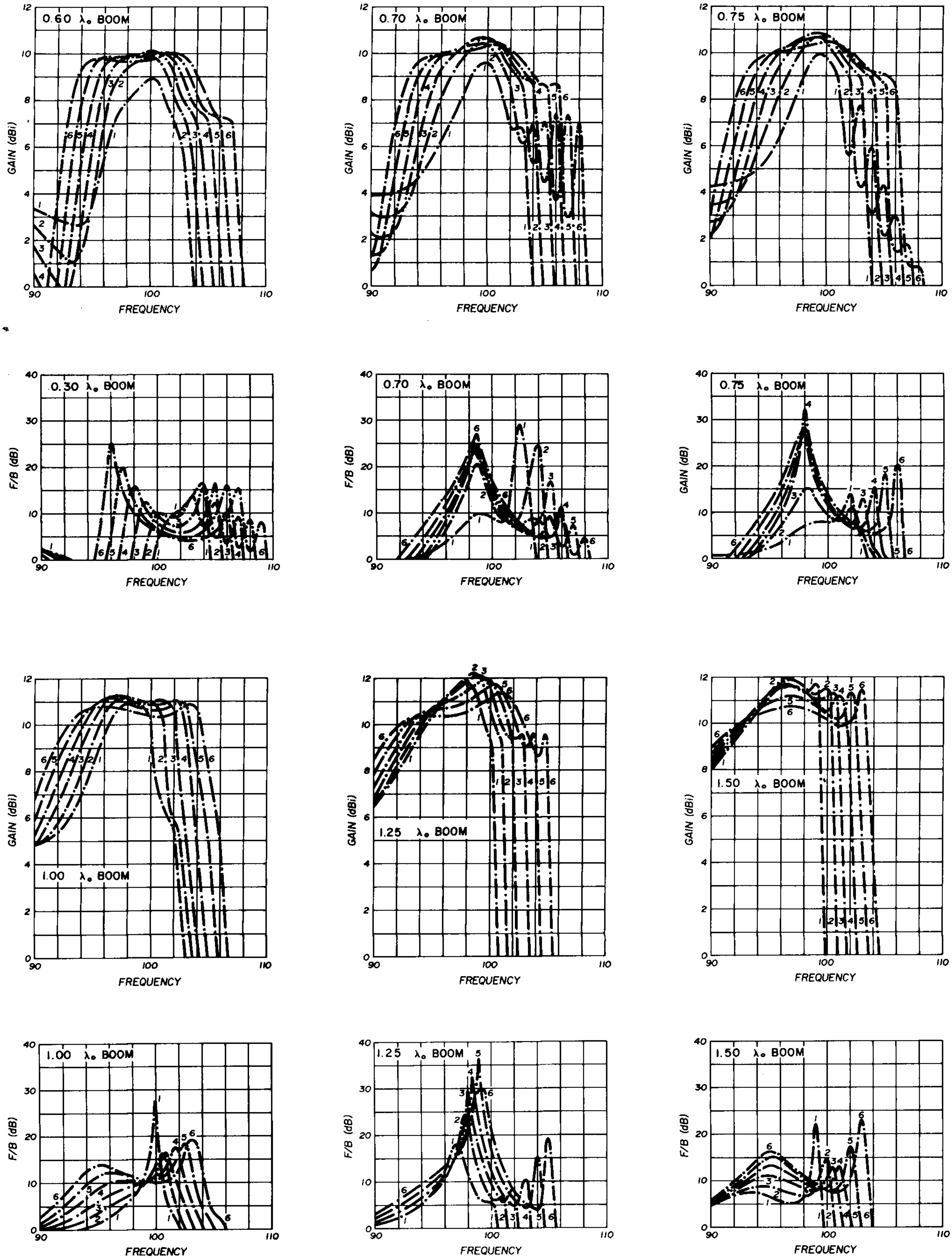


fig. 13. Gain and front-to-back (F/B) ratio in dB for six-element Yagi beams with boom lengths from $0.1\lambda_o$ to $0.5\lambda_o$, and changing reflector and director lengths (see table 3 reference 5 for complete data).



Gain and front-to-back (F/B) ratio in dB for six-element Yagi beams; boom lengths from $0.6\lambda_o$ to $1.5\lambda_o$.

table 4. Band-centered gain, dBi, and front-to-back (F/B) ratio, dB, vs boom length for various multi-element Yagi beams. Data for 3, 4 and 6 elements are plotted in figs. 11, 12, and 13.

boom length	3-elements		4-elements		5-elements		6-elements		7-elements	
(λ)	gain	F/B	gain	F/B	gain	F/B	gain	F/B	gain	F/B
0.10	6.980	12.21	7.216	12.14	7.481	8.36	7.493	7.12	7.486	6.65
0.20	7.960	14.10	7.901	5.49	7.877	7.90	7.759	5.56	7.590	4.34
0.25	8.233	19.88	8.466	8.06	8.262	10.06	8.260	7.83	7.923	5.12
0.30	9.072	12.32	8.797	7.66	8.640	9.47	8.600	8.00	8.353	6.62
0.35	9.254	11.37								
0.40	9.730	8.20	9.419	8.78	9.368	10.813	9.152	9.34	9.286	9.56
0.50	9.421	5.56	9.668	8.89	9.584	10.46	9.635	10.97	9.630	11.86
0.60	8.875	5.33	9.801	11.78	9.810	15.44	9.988	15.08	9.957	13.50
0.70	7.924	2.27	10.076	15.48	10.407	21.56	10.549	21.16	10.615	16.07
0.75			10.505	29.38	10.690	16.68	10.820	17.65	10.822	13.47
0.80			10.363	22.31	10.750	19.50	11.022	14.15	11.067	15.53
0.90			10.534	14.44	10.946	14.98	11.265	12.62	11.278	11.03
1.00			10.333	8.43	10.865	11.41	11.159	10.39	11.255	10.46
1.10			9.703	4.74	10.306	11.65	11.093	13.43	11.403	13.08
1.20					10.395	15.10	11.514	24.89	11.734	22.22
1.25					10.743	24.02	11.793	23.81	11.973	32.50
1.30					10.491	20.26	11.672	31.48	12.165	20.47
1.40					10.510	18.94	11.872	13.80	12.221	15.56
1.50					10.333	12.32	11.608	11.14	12.104	10.83

F/B parameter is undefinable because of the extreme variation in shape!

performance characteristics

If we look carefully at one of these plots, e.g., **fig. 11** (ref. 5) 3 elements, $boom = 0.25\lambda$, it becomes clear that it is quite difficult to simply characterize "the" gain and "the" F/B ratio. The *maximum* calculated gain at a single frequency is 8.9 dBi (curve 1) but a realistic gain at the center of a practical 4 per cent band (curve 3) is more like a 8.0 dBi! Even more difficult is the characterization of the F/B ratio. The *maximum* calculated F/B (curve 5) is a whopping 38 dB, but this occurs *only* at a very specific frequency ($F = 1.00$) and for the situation where maximum gain is comprised (reduced to 7.3 dBi). How then can we characterize the results by a single gain figure and a meaningful F/B ratio?

Since gain is perhaps the most important parameter of antenna performance, and since a practical antenna must work effectively over a reasonable band, I have elected to specify the gain at the center of a 4 per cent band. For each case, e.g., 3-elements, $boom = 0.25\lambda$, the band center is adjusted for each curve to give maximum gain performance over the entire 4 per cent band, and, finally, the specific curve is selected which yields best overall gain performance. I define "the" gain of this case as the gain at band center and "the" F/B ratio as the value at the *same* band center and the *same* selected curve! Note that the actual F/B may be significantly higher at some other frequency inside or outside the chosen band; we shall discuss this point shortly.

With this definition of band-center gain and band-center F/B, **table 4** has been constructed to show performance not only for 3-, 4-, and 6-element beams but also for 5- and 7-element beams; **fig. 14** shows a plot of the gain information; this graph is remarkable in four respects. First of all, it demonstrates a practical upper limit to the gain achievable from a given boom length! Second, it demonstrates that this gain is almost independent of the number of elements distributed along its length as long as there are enough! Third, the achievable practical gain shows a *slight* preference for *more* rather than less elements on a boom. Finally, the "boom gain" — achievable gain from a given boom length — is not

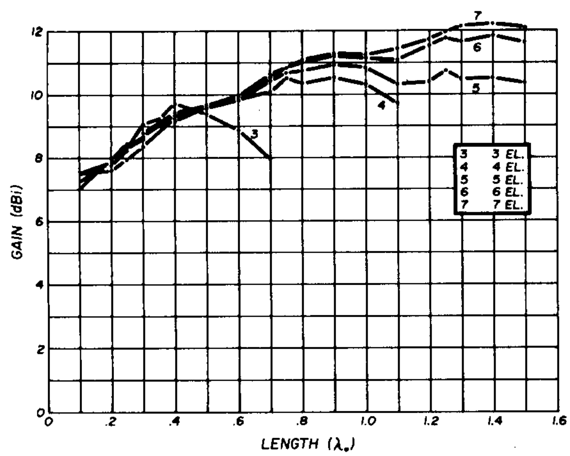


fig. 14. Yagi beam gain in dBi for 3, 4, 5, 6, and 7-element beams as a function of boom length in λ_o.

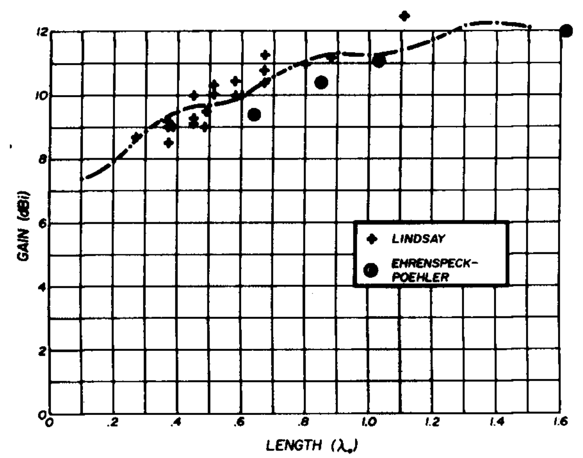


fig. 15. Theoretical Yagi beam gain envelope in dBi as a function of boom length in λ_o; comparison with experimental data of Lindsay (+) and Ehrenspeck-Poehler (o).

really a smooth function of boom length. Instead, it appears to exhibit "bumps" or oscillations with a fraction of a decibel amplitude and spacing at about a half wavelength!

This concept of boom gain, independent of the number of elements is not new; in fact, it was suggested by Ehrenspeck and Poehler[6] in a series of experiments using the automatic plotter built at the Air Force Cambridge Research Center. No claims by Ehrenspeck and Poehler were made as to the absolute accuracy of their results but they were able to demonstrate essential independence of gain on number of elements over rather wide limits for two long Yagi models (1.2λ and 6.0λ). If one accepts the idea of universal boom gain, it is instructive to compare the (upper envelope) curve of **fig. 14** with Ehrenspeck and Poehler's experimental points, as well as the experimental results of Lindsay.[7] Lindsay made a number of models of varying boom length (but unstated element dimension schedules) and measured directivity at a design frequency of 440 MHz. All of these results are shown in **fig. 15** where the solid curve is the theoretical maximum gain (from **fig. 14**) and the keyed points are from Ehrenspeck-Poehler and from Lindsay. The Lindsay experiments provide remarkable confirmation of the universal boom gain curve! The Ehrenspeck-Poehler points all appear to lie slightly below the theoretical curve (by a fraction of a decibel). It is not clear that the slight discrepancy in absolute value is a real disagreement; it may be within the expected accuracy of the gain calibration technique used on the automatic plotter. It may also be due to lack of optimization; Ehrenspeck and Poehler used a fixed reflector reactance and it is hard to guess how much more gain they would have found with an optimized configuration.

Fig. 16 taken from **table 4** shows a plot of the center-band F/B ratio as a function of overall length. It is notable that there are three empirical values of overall length which seem to produce high values of F/B *independent* of the number of elements! These apparently favorable overall lengths are 0.25, 0.75, and $1.25\lambda_o$ — all odd multiple of a quarter wave. For the $0.25\lambda_o$ position only the 3-element beam shows a high value, but this is primarily caused by the definition of *center-band* F/B ratio.

element illumination

This remarkable phenomenon suggests that there might be a basic physical explanation covering all cases; indeed, such a physical basis is not hard to find! Analogous to the physical optical illumination of an aperture by light, one can think of the Yagi boom length as illuminated by (electrical) excitation. Unlike the case of uniform illumination of an optical aperture, the Yagi illumination is *not* uniform but can be viewed as a series of discrete excitation points (elements) whose average envelope is quasi-uniform. Moreover, in the optical case the wave front is ordinarily plane (phase shift across the aperture is zero), whereas in the Yagi case the phase shift is purposely designed to cause the main diffracted "beam" to lie along the boom rather than broadside to the aperture as in the optical case.

The aperture produces a diffraction pattern (beam pattern) consisting of a "main beam" and several lobes; the *number* of lobes is determined basically by the size of the aperture in wavelengths; the *amplitude* of the lobes is determined by the way the aperture is illuminated (phase and amplitude).

An informative treatment of an end-fire array (aperture illuminated by a series of radiators having equal amplitudes) is given in Kraus[4] on pages 76-89. There are two interesting cases: the *ordinary* end-fire array in which the angular phase change between radiators is just equal to their spatial separation angle, and the *increased directivity* end-fire array first de-

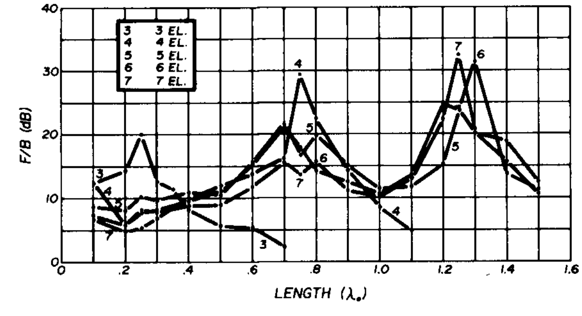


fig. 16. Band-centered front-to-back (F/B) ratio in dB for 3, 4, 5, 6, and 7-element Yagi beams as a function of boom length in λ_o.

table 5. Yagi null angles (fig. 17) as compared to ordinary end-fire arrays (OEF) and increased directivity end fire (IDEF).

boom length	freq	K = 1 null (degrees) Yagi	OEF	IDEF	K = 2 null (degrees) Yagi	OEF	IDEF	K = 3 null (degrees) Yagi	OEF	IDEF
0.25λ	0.972	—								
0.75λ	0.982	159								
0.25λ	0.992	120								
0.75λ	0.970	69	98.4	64.7	—	—	135.9			
0.75λ	0.980	66	97.7	64.3	171	—	134.5			
0.75λ	0.990	63	97.0	64.0	147	—	133.1			
1.25λ	0.976	51	71.5	48.8	102	111.5	91.4	—	—	135.0
1.25λ	0.986	51	71.1	48.6	99	110.6	90.8	171	—	133.7
1.25λ	0.996	48	70.7	48.3	93	109.8	90.2	150	—	132.3

rived by Hansen and Woodyard[8] where the radiator phase delay is larger than spatial separation by an angle π/n. The latter case is a good one with which to compare the Yagi antenna, because although the amplitude of the current(s) in the Yagi elements are not uniform, the phases are adjusted (by element reactance) to give highest directivity or gain. Kraus gives expected null angle directions for these two cases (null between lobes) as:

Ordinary end fire:

$$\theta_o = 2\sin^{-1} \pm [K\lambda/(2nS)]^{1/2} \quad (1)$$

Increased directivity end fire:

$$\theta_o = 2\sin^{-1} \pm [(2K-1)\lambda/(4nS)]^{1/2} \quad (2)$$

In our model the boom length ℓ_B is $(n-1)s$ so that we can rewrite these equations as:

Ordinary end fire (OEF):

$$\theta_o = 2\sin^{-1} \pm [K(n-1)/(2\ \ell_B n)]^{1/2} \quad (3)$$

Increased-directivity (IDEF):

$$\theta_o = 2\sin^{-1} \pm [(2K-1)(n-1)/(4\ \ell_B n)]^{1/2} \quad (4)$$

Note that where the number of elements, n, is large one would expect a high F/B ratio (a null at 180°) at particular values of boom length, ℓ_B, essentially independent of the number of elements!

Let's now examine the patterns of the cases where F/B is relatively high; I shall do this for the 6-element beam at three boom lengths: 0.25, 0.75, and 1.25 wavelengths long but will first find the precise frequency where the F/B ratio is maximum (presumably where the back radiation "null" occurs). It is instructive to also plot the pattern not only at this "best" frequency but also at frequencies just below (say −1 per cent and just above (say +1 per cent) of the best frequency. For all of these cases the reflector length was fixed at $0.50702\lambda_o$ $(FR = 0.95)$, and all director(s) length(s) were fixed at $0.45873\lambda_o$ $(FR = 1.05)$.

Fig. 17 shows the H and E plane patterns of all of these cases. The H-plane pattern shown "nulls" between lobes which can move with frequency (equivalent to boom length in actual wavelengths). We can compare the angle at which these nulls occur to those of the end-fire arrays (**eqs. 3** and **4**); **table 5** lists these comparisons.

Note that these comparisons show qualitative agreement; also note that the computed Yagi results are in better agreement with the IDEF model (Hansen and Woodyard) than the OEF model. The more rapid shift of null angle(s) with frequency for the Yagi(s) compared to either end-fire model is not to be taken too seriously because, as we shift frequency, not only does the effective boom length in terms of actual wavelength change, but the element reactance(s) change significantly, i.e., the Yagi really becomes a different Yagi!

The details of the Yagi pattern depend on the particular way in which the boom is illuminated, i.e., on the details of element positions(s), element current magnitude(s), and element phase(s). The depth of the nulls depends on the degree of vectorial cancellation of back radiation; since the vectors themselves vary significantly with all Yagi parameters it is no wonder that complete cancellation is accidental and ordinarily impossible. The *size* of the lobes is determined primarily by the shape and phase delay of the Yagi *illumination* function. For the *uniformly* illuminated case the reader is referred to the uniform end-fire arrays (see Kraus[4], pages 79-88).

It will be noted that for non-uniformly illuminated

table 6. Element currents for a six-element Yagi beam with a boom length of 0.75λ; frequency $F = 0.980$ (assumes rf current of 1 ampere at 0° in the driven element).

element	current (amps)	phase (degrees)
Reflector	0.476	154.5
Driven element	1.000	0.0
Director 1	0.379	−121.3
Director 2	0.467	−169.7
Director 3	0.258	115.3
Director 4	0.458	32.6

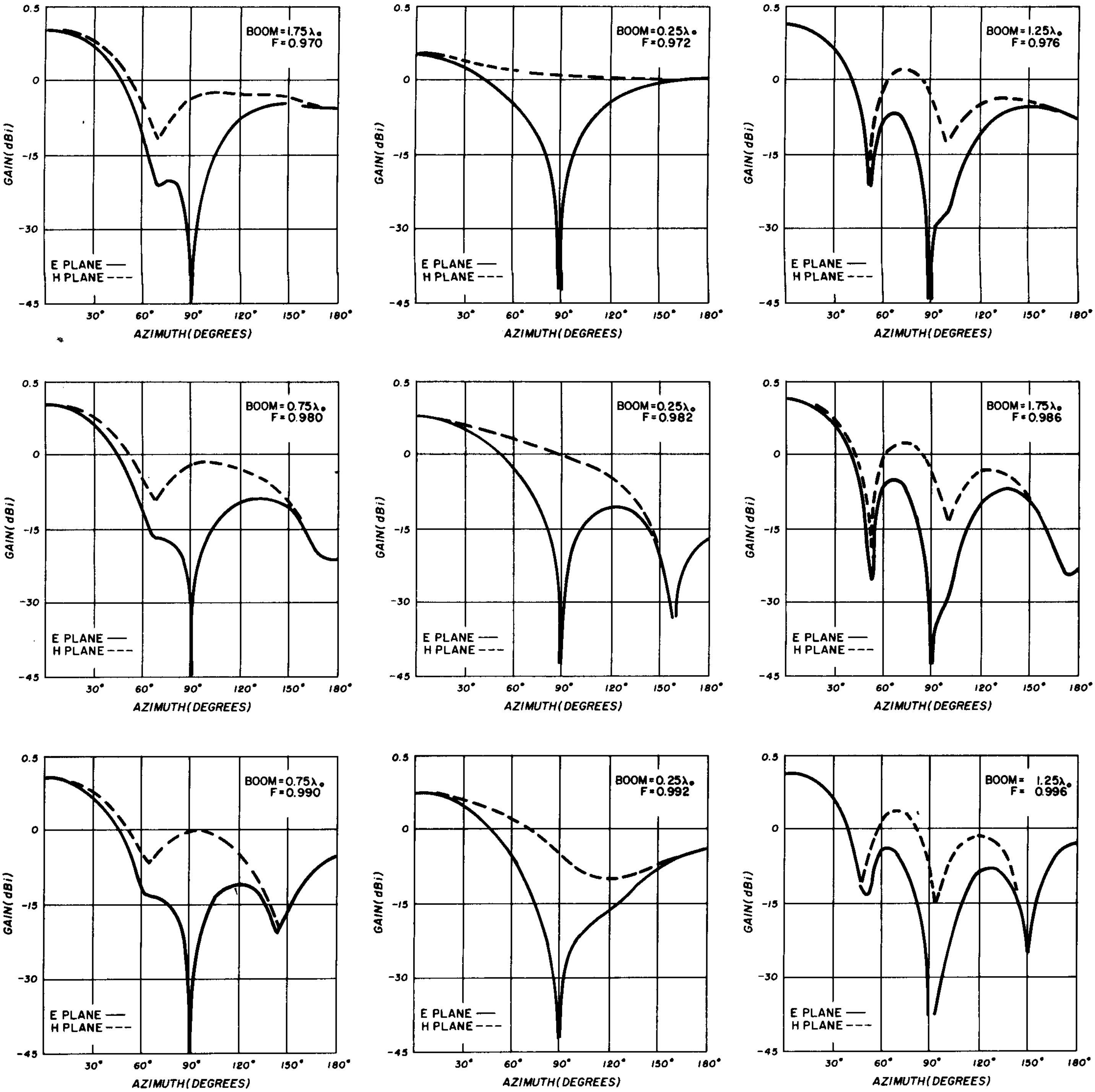


fig. 17. Yagi 6-element beam E and H-plane half patterns (0° to 180°) in dBi as a function of angle in degrees.

broadside structures (Kraus pages 93-121) the sidelobe level is highest for "edge" illumination, next for uniform illumination, and zero for illumination based on element amplitudes following the coefficients of a binomial series. One can expect the same kind of result for an end-fire array where edge illumination (2-element beam) produces high sidelobes, uniform illumination smaller sidelobes, and an illumination function falling at the extreme edges (reflector and end director currents smaller than in central elements) to produce still smaller sidelobes.

Unfortunately, for a given overall boom length the directivity or gain suffers somewhat as illumination is adjusted for smaller sidelobes. Moreover, in the case of a simplistic Yagi the illumination function is hard to adjust; the current amplitudes and phases are all

table 7. Computed F/B ratios for six-element Yagis with various boom lengths (see fig. 17).

length.	freq.	F/B (180°)	E-plane F/B minimum (90°-180°)	H-plane F/B minimum (90°-180°)
0.25λ	0.982	25.7 dB	18.75 dB	7.5 dB
0.75λ	0.980	32.5 dB	19.65 dB	12.6 dB
1.25λ	9.986	35.0 dB	18.8 dB	14.9 dB

determined by element reactance(s) and position(s) and it is necessary to simply accept the result! To get an idea of the current(s) and phase(s) to be expected **table 6** shows the current(s) and phase(s) of the elements for the case of the 6-element beam, *boom* = $0.75\lambda_o$, where the driver current is set at 1.0 ampere at 0° phase. Note that while the current amplitudes are not "uniform illumination," they seem to average out surprisingly alike! Incidentally, the current in the last director is always characteristically *higher* than that in the preceding director; this is due to the "end effect" (no mutual to an element ahead of it).

Thus we now have a consistent picture of the high F/B ratio Yagi design; the essence of correct design is to place the null between lobes exactly in the back direction! This will occur for simplistic Yagi antennas when the overall length is approximately an odd multiple of a quarter wavelength. The specific *best* design will involve optimizing the boom length and the boom *illumination function* (the particular element excitation currents and phases) to yield the best F/B ratio. Such optimization can be carried out around the best boom lengths; this will be the subject of a future article. For the present it is sufficient to note that really excellent F/B ratios are possible with these simplistic designs as long as one is willing to accept boom length(s) which are approximately odd multiples of a quarter wavelength.

As a final note on these simplistic *best* designs, not only is the back radiation low but the *minimum* (worst case) F/B ratio in the *entire* reverse direction (90° to 180°) is also surprisingly high! **Table 7** shows the result. These Yagi designs seem to be generally excellent!

With the exception of the 2-element beam case I have not yet commented on the driving point impedance of any of the Yagis shown. Remember that one can, by adjusting the length of the driver, always null out the driving point reactance at a designated frequency. The remaining resistance, however, just like that for the 2-element beam, varies enormously from case to case. It is very low for very short beams where there is very strong coupling between elements; moreover, in such cases it varies wildly with frequency as does the change in reactance with frequency. Thus to insure a reasonably reliable electrical feed system it is wise to keep element separation well above $0.05\lambda_o$; all such cases investigated have reasonably well behaved driving point impedances.

summary

Let me summarize the results for simplistic Yagi antennas:

1. 2 to 7-element beams with boom lengths to $1.5\lambda_o$ have been systematically explored.

2. Simplistic Yagis display a gain function where bandwidth is primarily a function of the resonant frequency separation between reflector and director(s). The bandwidth can easily be made several per cent of the central frequency.

3. The shape of the gain function is generally not flat in the region of interest. It is also more complex for beams which use a large number of elements.

4. Simplistic Yagis display a F/B ratio function with a shape that varies enormously from case to case. The shape may contain more than one peak and changes rapidly with boom length and/or frequency. It is so complicated that it is not possible to characterize its bandwidth.

5. High values of the F/B ratio (more than 30 dB) are quite rare; when they occur F/B is high only over a very narrow band of frequencies.

6. The spacing between elements should be generally greater than $0.05\lambda_o$ to realize a well-behaved feed.

7. The maximum practical gain of the simplistic Yagi is almost entirely determined by boom length. Maximum gain increases, but not steadily with boom length.

8. Best design for a high F/B ratio requires the approximate boom length to be an odd multiple of a quarter wavelength at the design frequency.

references

1. J.L. Lawson, "Design of Yagi Antennas," *ham radio,* January, 1980, page 22.
2. *The ARRL Antenna Book,* 13th edition, American Radio Relay League, Newington, Connecticut, 1974.
3. G.H. Brown, "Directional Antennas," *Proceedings of the IRE,* January, 1937, pages 78-145.
4. J.D. Kraus, *Antennas,* McGraw-Hill, New York, 1950.
5. J.L. Lawson, "Design of Yagi Antennas," *ham radio,* May, 1980 page 18.
6. H.W. Ehrenspeck and H. Poehler, "A New Method for Obtaining Maximum Gain from Yagi Antennas," *IRE Transactions on Antennas and Propagation,* October, 1959, pages 379-386.
7. J.E. Lindsay, "Quads and Yagis," *QST,* May, 1968, page 11.
8. W.W. Hansen and J.R. Woodyard, "A New Principle in Directional Antenna Design," *Proceedings of the IRE,* March, 1938, pages 333-345.

ham radio

More Details? CHECK—OFF Page 94

phased vertical antenna
for 21 MHz

An economical approach to beam antennas for the 15-meter band

By Ed Marriner, W6XM, 528 Colima Street, La Jolla, California 92037

Most of the Amateur antenna handbooks don't describe the phased vertical beam. For economy and performance they should be used more! I built a phased vertical beam using the references indicated.[1-4] I hope the explanation given here will motivate others to try this antenna. There's probably an easier way to construct the beam. W7EL describes another method of matching in reference 4. However, I chose to use the more classical Wilkenson match. Perhaps there should be more experimenting and discussion on feeding this beam. W7EL's method would do away with the problem of locating 100-ohm noninductive resistors for termination and balance.

phased vertical array

The phased vertical beam has some good features. **Fig. 1** shows horizontal radiation patterns for a two-element phased vertical array using three different phase angles for feeding the two elements. If both elements are fed in phase (zero-degree phase angle), the radiation pattern will be bidirectional at right angles to the plane of the two elements. This is known as broadside radiation. If the antenna elements are fed 180 degrees out of phase, an end-fire pattern results, producing bidirectional coverage in the plane of the elements (end fire). If one element is fed 90 degrees out of phase with respect to the other, a unidirectional pattern is obtained. Thus, with two vertical elements, properly phased with relay switching, you can cover all four quadrants of the compass.

I was interested in only one direction, and it just happened that my brick fence was in a line where I wanted the antenna pattern to go. The rest was easy, because only holes had to be drilled with a concrete drill and lead slugs driven in place to mount the element insulators.

construction

Fig. 2 shows construction details for my two-element phased vertical beam. I obtained two pieces of 1/2-inch (12.5-mm) diameter aluminum tubing 12 feet (3.7 meters) long. I cut each tube at 11 feet (3.4 meters) for the 1/4-wavelength antenna elements. The formula is:

$$L = \frac{468/f}{2} \qquad (1)$$

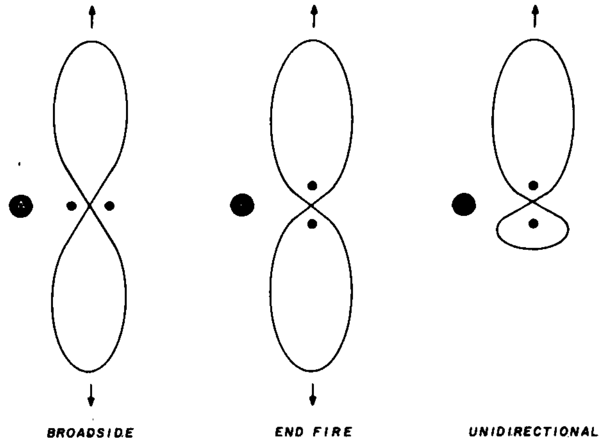


fig. 1. Radiation patterns for a two-element phased vertical array using three different phase angles for feeding the system. *A* shows the pattern when the elements are fed in phase. If the elements are fed 180 degrees out of phase, pattern *B* results. *C* shows the pattern when the elements are fed 90 degrees out of phase.

where L = length, feet

f = frequency, MHz

In metric terms **eq. 1** is:

$$L = \frac{145/f}{2}$$

Thus for my operating frequency (21.27 MHz) the element lengths were 11 feet or 3.4 meters. I mounted the two 1/4-wavelength elements on the fence, spaced 11 feet (3.4 meters) apart.

feed system

Any length of 52-ohm coax cable can be run to the antenna from the transmitter. The transmission line is connected to a coax T connector, as shown in **fig. 2.** I made two 1/4-wavelength sections of 72-ohm line (RG-11/U) and connected each line to the T connector. The other ends of the 1/4-wavelength lines were terminated with a 100-ohm noninductive resistor as shown.

The 1/4-wavelength coax line lengths are somewhat critical, as the slightest amount of variation at 21 MHz changed the frequency a great amount. These lengths were determined from:

$$L = \frac{246V}{f} \qquad \textbf{(2)}$$

where V = cable velocity factor

f = frequency, MHz

Thus:

$$L = \frac{246\,(0.66)}{21.27} = 7.6\,feet$$

$$L = \frac{74\,(0.66)}{21.27} = 2.3\,meters$$

I checked the coax length with a grid-dip oscillator. Any loop in the cable will give a false reading of the length. K6DS came up with the idea of using an inch-wide (25.5 mm) piece of PC board with two holes and soldered up short. The wide surface provided enough pickup for the grid dipper. Putting the plugs on the ends lowered the frequency.

Each piece of coax I checked had a different vel-

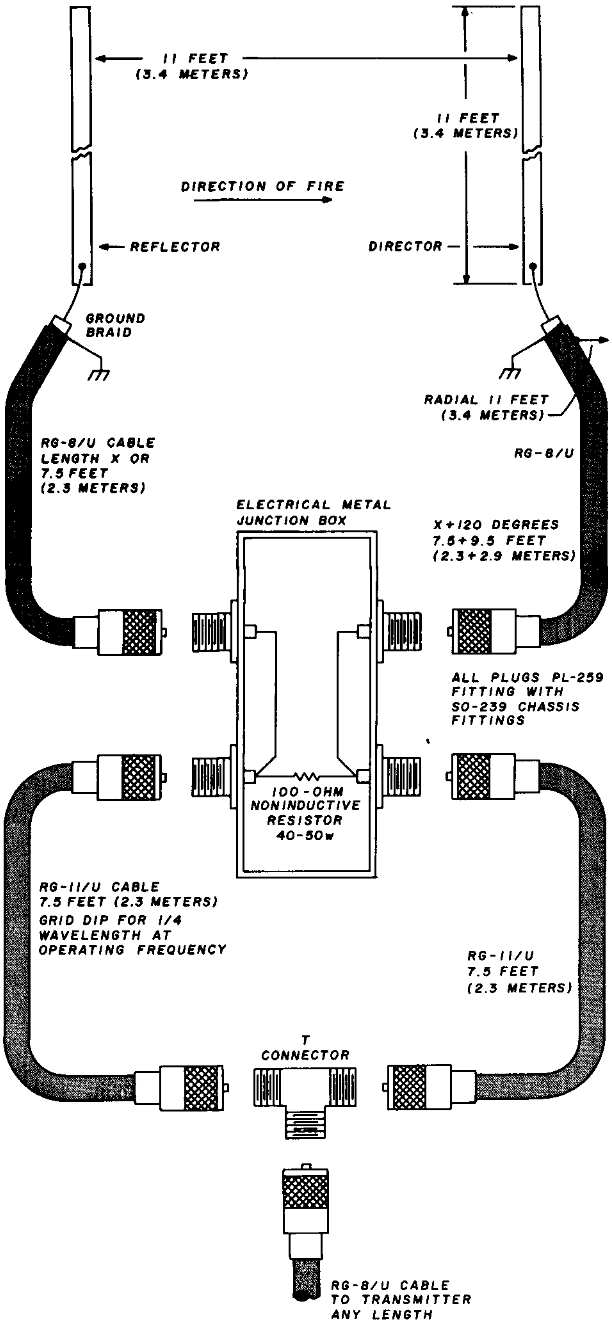


fig. 2. Construction details for the phased vertical beam for 21 MHz. Derivation of phasing-line lengths are discussed in the text.

ocity factor, V, varying from 0.6 to 0.68. You can check your coax by

$$V = \frac{fL}{246} \tag{3}$$

where V = velocity factor
L = length, feet

In metric terms **eq. 3** is

$$V = \frac{fL}{75}$$

where length, L, is in meters.

final assembly

Fig. 2 shows the details of my array. The junction box, containing the 100-ohm noninductive resistor and the SO-239 coax chassis receptacles, was mounted on the brick wall. I coiled the phasing lines and attached them to the wall. The radial wires are 11 feet (3.4 meters) long. **Fig. 2** shows the method of attachment. For best results run as many radials as possible.*

A quarter-wavelength of RG-8/U cable, 7-1/2 feet (2.3 meters) long was connected between the junction box and reflector element. Another coax line (RG-8/U) 7-1/2 feet (2.3 meters) plus 120 degrees was connected to the director. (See **fig. 3**). This length was 17 feet (5 meters). This line isn't too critical because it mostly affects the antenna back lobe.

results

When the antenna was finished I walked around it with a field-strength meter. The readings concurred with the pattern in reference 3. It was surprising to see the signal fall off at 90 degrees to nothing on the back. I made the first on-the-air checks locally using four stations about 10 miles (16 km) away. Two of the stations were in front of the antenna and two were off about 45 degrees to the side. Stations off to the side noticed the same signal strength as my two-element Yagi. However, those in front couldn't hear the signal from my Yagi but reported S9 signals from the phased vertical. This would indicate that the phased vertical antenna has a lower radiation angle than that of the two-element Yagi mounted at 20 feet (6 meters) above ground.

Reports from stations in South America were varied. With some there was a noticeable difference between antennas; with most I received the same signal report. (One fellow said the phased array was louder than horseradish, a scale I'm not familiar with.) When signals from one antenna fade out, signals from the other will be maximum. It's interesting to switch between antennas.

*In a similar design for twenty meters[5] the author used ground rods for each element as well as radial wires. As with any vertical antenna, the idea is to reduce ohmic losses in the system. **Editor**.

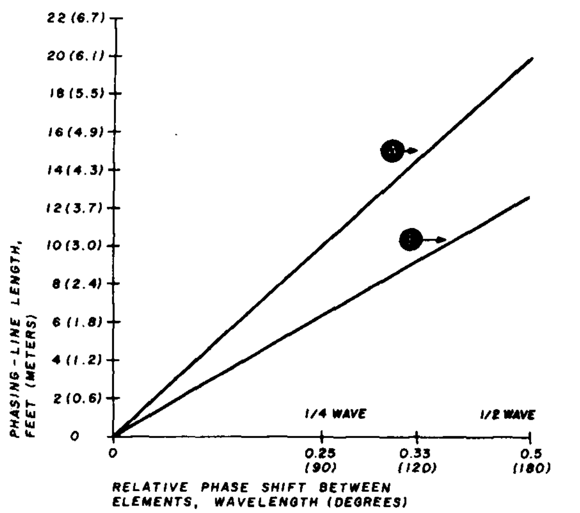


fig. 3. This curve may be used to determine the length of the 120-degree phasing line for the director element in fig. 2. *A* is the curve without velocity factor. *B* the length with velocity factor.

summary

To summarize my findings, I'd say that if I didn't have a two element Yagi beam, rotor and tower I wouldn't hesitate to use two of these phased vertical beams in place of it! The construction is far cheaper and I can find very little difference between the two. There's more of a null on the phased array off the back and sides, and the beam appears to be narrower than that of the two-element Yagi. The vertical antenna did not do what I had hoped: to get through a maze of power lines 100 feet (30 meters) away.

The most difficult part of the construction is locating 100 ohm noninductive resistors of 40-50 watts. The transmitter looks at low SWR and loads up very nicely.

The ideal of W7EL might be a solution to feeding the antenna without a termination resistor and just using RG-8/U coax from the T connection. It will be interesting to hear the experiences of others and get this simple beam into more use. It is strange that it hasn't found much use before, because the Wilkenson match is well known in uhf work. Many of the 160-meter stations have been using it for a long time, anyone who has heard them will realize the advantage for low-frequency work where a beam other than vertical is almost impossible to erect.

references

1. John Kraus, *Antennas*, McGraw-Hill, New York, 1950.
2. Henry Jasik, *Antenna Engineering Handbook*, McGraw-Hill, New York, 1961.
3. John Devoldere, *80-Meter DX Handbook*, Ham Radio Publishing, Greenville, New Hampshire, 1978.
4. Roy Lewallen, W7EL, "Notes on Phased Verticals," *QST*, August, 1979, page 42.
5. Walter D. Stead, VE3DZL, "Twins on Twenty," *QST*, May, 1961, page 24.

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antenna restrictions — another solution

How to install a full-size 40-meter dipole inside a mobile home

Antenna restrictions often make life difficult for hams who live in one of the new mobile-home parks. In fact, restrictions can make it almost impossible to get on the air without using a high degree of ingenuity. Articles have been written describing the use of fake (and not so fake) flagpoles as vertical antennas, but the problems of ground radials and low radiation angles limit the effectiveness of this kind of solution.

Lately many of the new double-wide modular homes are being built using conventional framing and roof construction with wood joists and rafters, wood sheathing and composition shingles. This leaves only the matter of space in the attic — how do you hide an 80-meter or even a 40-meter antenna inside if the long dimension is only 12-15 meters (40-50 feet)?

15-meter antenna

In my situation, our home is a 7.3-meter (24-foot) wide double unit in a park where restrictions prohibit outside antennas. As a retiree ham, off the air for about 40 years until 1978, I was able to solve my own antenna problem this way: For 15 meters I made up a simple dipole using four pieces of 1.8-meter (6-foot) long telescoping aluminum tubing, fed directly with 50-ohm coax and secured inside the attic close to the apex of the roof rafters. It works quite well, with low SWR and easy loading to one of the new "touchy"

By J. W. Bryant, N4AQD, 4736 Dauphine Boulevard, Tallahassee, Florida 32303

transceivers. As an afterthought, because I wanted to work primarily in one direction, I added a passive reflector mounted *outside* on the roof, down the slope far enough to provide the proper spacing. The reflector tubing was fastened to four small L brackets slipped under the shingle edges.

40-meter antenna

The 40-meter solution was a little more trouble. My mobile home is about 12 meters (40 feet) long, inside measure, so there was no way to insert a horizontal full-length halfwave dipole. I stretched the wire inside the limited attic space, then shoved the remaining lengths at each end (to make a total of 19.5 meters, or 64 feet) at 90 degree angles to the attic corners. This was done with 3.7-meter (12-foot) cane fishing poles, which I left in place to keep the wire extended.

To have some leeway to tune out any reactance, I improvised a tuner using series inductance and capacitance in each leg of the antenna at the feed point. I ended up with the arrangement shown in **fig. 1**. The center of the antenna and tuner were accessible through a hatch cut into the ceiling of the mobile home. Fortunately the location was right over the laundry alcove.

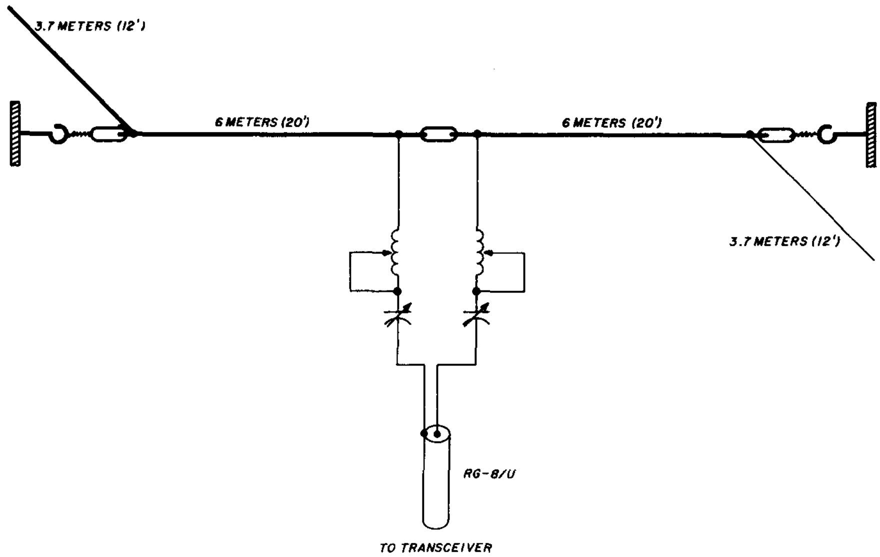

fig. 1. Author's inside 40-meter dipole. Horizontal sections occupy the length of the mobile-home attic. The end sections follow the corners of the attic to make a total radiator length of 19.5 meters (64 feet). The tuner provides near unity SWR in the phone portion of the band.

tune up

For final tuning I used a dip meter coupled to a one-turn loop at the line-to-tuner feed point to determine the approximate resonance adjustment of the series reactances. Then I inserted an SWR meter at the antenna end of the coax and adjusted each side of the tuner for lowest SWR, which came out to be very near unity at the phone end of the band. I've not tried to tune the antenna to 75 meters, but I'm sure it can be done with added inductance in each tuner leg.

Contacts on both 15 and 40 meters have given good reports, even before I told them of the indoor nature of the antenna arrangement.

further reading

The bibliography provides other interesting approaches to the problem of erecting Amateur antennas in locations that restrict outside structures. Allen Ward, KA5N, describes a modified ZL Special that can be mounted in an apartment room. Spence Collins, N6SC, installed a 7-MHz Hertz antenna in his first-floor apartment — stretched approximately 8 meters (26 feet), with the highest point 2 meters (7 feet) from the floor. And for vhf buffs, Warren Hodges, W6DHX, and Bill Wise, WB6QEZ, tell how to camouflage a 2-meter antenna using a weathervane atop the house, which is in a restricted area.

bibliography

Collins, Spence, N6SC, "Apartment Antenna for 7 MHz," *Ham Radio Horizons*, (*Benchmarks*), October, 1978, page 64.

Hodges, Warren, W6DHX, and Wise, Bill, WB6QEZ, "Camouflage Your 2-Meter Antenna," *Ham Radio Horizons*, December, 1979, page 33.

Ward, Allen C., KA5N, "10 Meter ZL Special Antenna for Indoor Use," *ham radio*, May, 1980, page 50.

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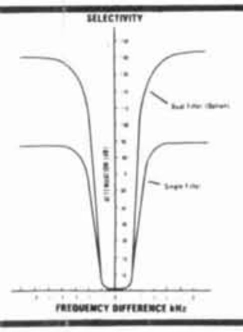

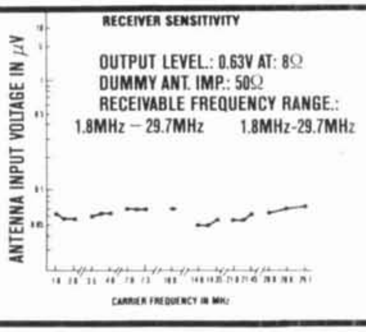

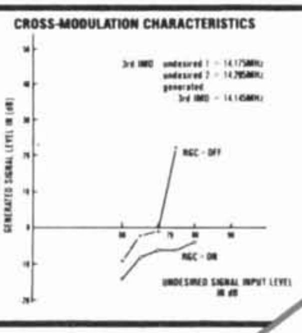

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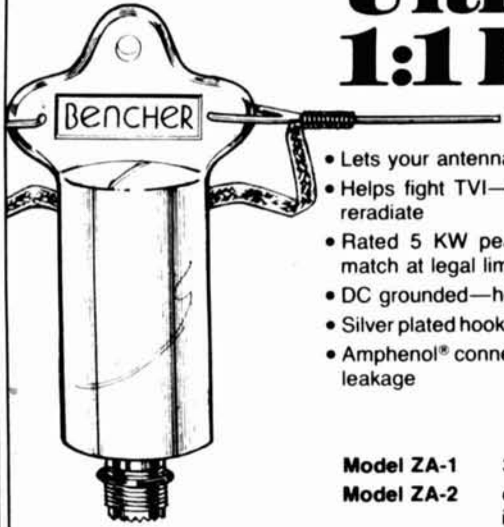

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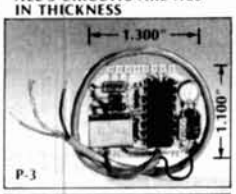

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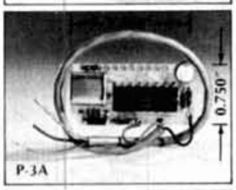

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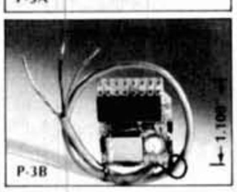

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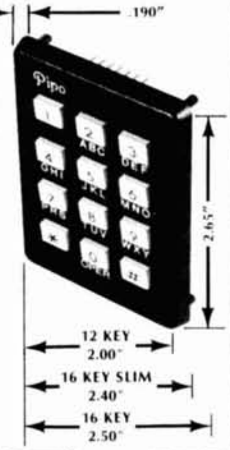

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tone-encoder for 2-meter autopatches

A design that produces clean sine waves tamed by AGC amplifiers for constant level — also featured is automatic PTT with delayed release

As the use of the Touch-Tone* system — both in telephones and in Amateur Radio — became widespread, a number of ICs were developed to generate the tones. Among the most popular are the Motorola MC14410 and the Mostek MK5087; there are several others on the market. These chips are generally superior to those in the original Western Electric *Touch Tone* (or DTMF) encoder, with its cup-core inductors. But they do have one disadvantage in common: they produce the tones by digital methods, so the outputs are not pure sine waves but are similar to the waveform shown in **fig. 1**. In telephone applications this doesn't matter, since the line itself acts as a lowpass filter, effectively restoring sine-wave purity. Also, being designed to work into such lines, the chips have greater output at higher frequencies to counteract the natural attenuation of the line.

When such a *Touch Tone* chip is used to activate a repeater autopatch through a 2-meter fm transmitter, these natural filter effects don't exist. Thus, in addition to harmonic distortion, the repeater autopatch must cope with deviation levels that vary according to the tones selected. This can cause problems in completing a call.

I designed a DTMF board that produces good, clean sine waves. In addition, it has agc amplifiers to keep the tones at constant levels. There's also provision for keying the transmitter automatically whenever any button of the *Touch Tone* pad is pressed and keeping it keyed until the dialing of the number is complete. The circuit will fit on a 3 × 5 inch (7.6 × 12.8 cm) board. After describing the circuit, I'll go in-

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

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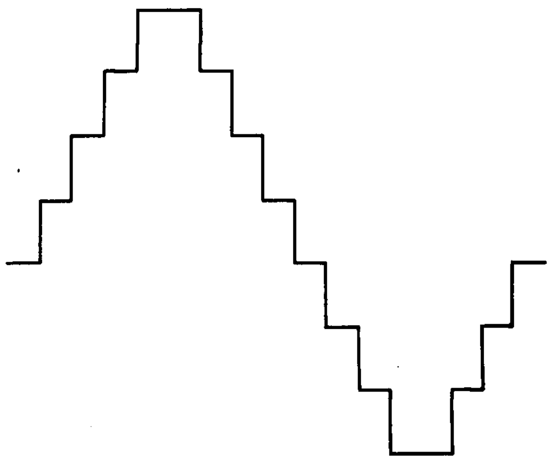


fig. 1. A sketch of the typical output of the MC14410 shows that it is not a true sine wave. This output is produced by a 16-stage walking-ring counter.

to the fine points of assembling and using the board — or of rolling your own, if that's your style.

circuit description

The tones are generated by a Motorola MC14410P. The advantage of this chip is that it has separate outputs for the low and high tone groups; this makes it easier to filter the tones. Since the MC14410 is widely used, there's no need to go too deeply into the circuit. The tone outputs are produced by walking-ring counters driving weighted-resistor networks. In addition to a dc level, each output waveform contains harmonics whose order is determined by the number of stages in the counter. A good source on this subject is reference 1.

The main schematic of the DTMF board is shown in **fig. 2**. The wiring of U1 is standard except for two things: capacitors C1-C8 are for RFI protection, and the output of pin 7 — a square-wave test signal, not normally used — drives the automatic keyer circuit.

filter considerations

The filters don't have to be extremely sharp or well-centered on the nominal center frequency, since they don't have to separate the tones. Bandpass filters are required to block both the dc levels and the high-order harmonics in the outputs from U1. I used a multiple-feedback configuration because it permits a bandpass filter with a single op amp. One stage per filter gives sufficient selectivity; this allows both filters and the two agc amplifiers to be built using a single quad op amp IC.

In reference 2, Moberg described design equations for the multiple-feedback filter where the two capacitors are of unequal values (see appendix). These equations give great flexibility in choosing the filter parameters and are easily turned into a program for a handheld calculator.

The design procedure starts with the values of the two capacitors and the three filter parameters: Q, gain A_0, and center frequency, f_0. The values of the three resistors are calculated (for filter-component designations see **fig. 3**). U1 will produce roughly 2 or 3 volts p-p. To avoid overdriving the agc amplifiers, a

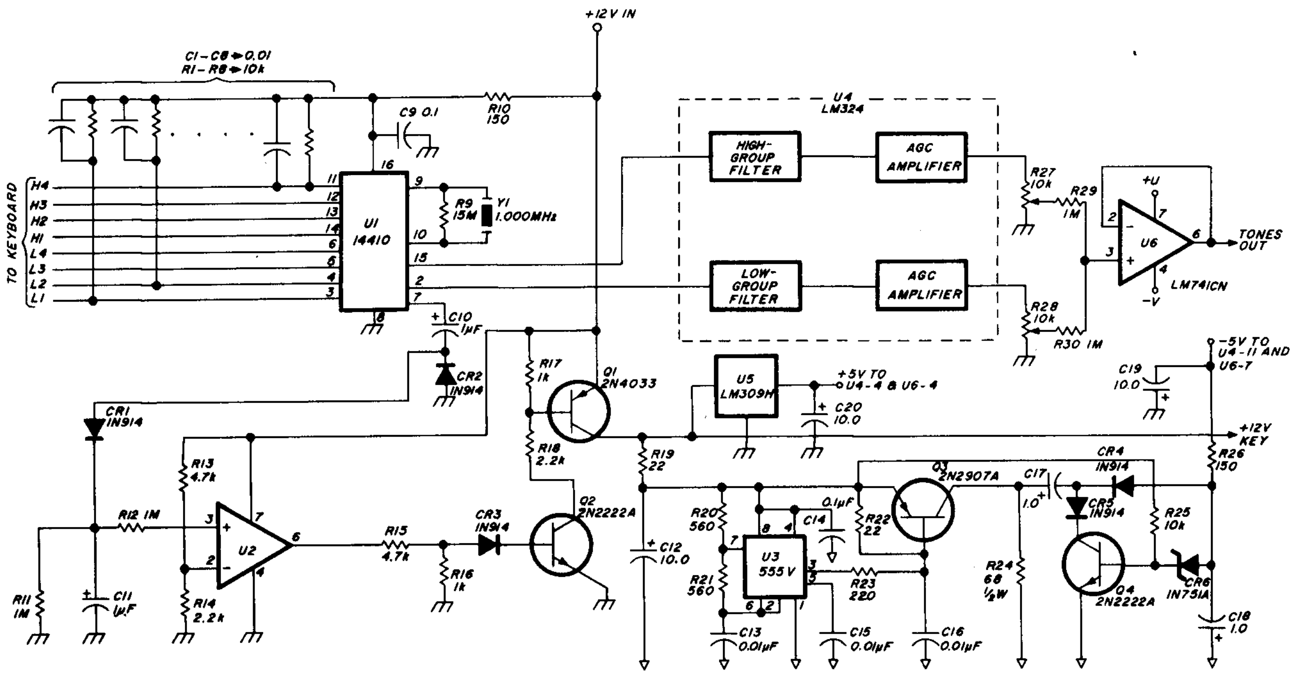


fig. 2. The main schematic of the DTMF board. Note the liberal use of bypassing and decoupling networks. To avoid duplication, filters and amplifiers are not shown in this illustration.

filter gain of unity or less should be used. **Table 1** summarizes the results for the parameters I used in my design.

The components used for the filters are standard non-precision types. The response curve of **fig. 4** shows that the results with such components are quite close to the ideal. There are two reasons that I "broke up" R1; it made the layout come out better and allowed easy matching of the calculated value of R1. The 100-pF capacitor is another rf bypass.

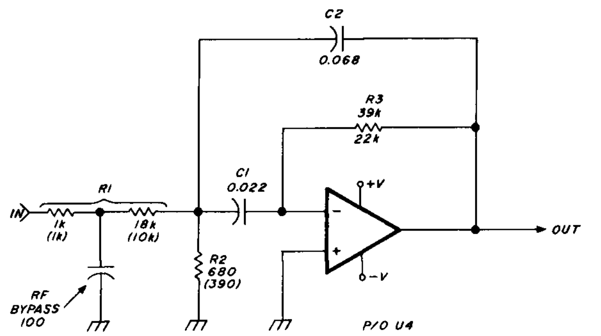


fig. 3. The two filter circuits differ only in resistor values. Those in parentheses are for the high-group filter.

keeping the outputs constant

The agc amplifier I use is based on one published in reference 3. It calls for a high-quality fet to give wide dynamic range and excellent linearity; here, there's no need for those characteristics, and substitutions can be made. My version of the circuit is identical to that of reference 3 except for the substitutions; it's shown in **fig. 5**. When the input level is below the threshold of compression (about 50 mV) Q1 gate is unbiased, and the full op amp gain of 70 is in effect. Larger amplitudes are rectified by Q2 and bias Q1 gate upward from its normal voltage of −5V. Q1's channel resistance drops, effectively pulling signal away from the op amp until equilibrium is reached. The attack time is a few milliseconds. R4 and C1 provide about one second of decay time. The compressed output is 1 volt p-p.

table 1. Summary of the design parameters used for the filters and the calculated resistor values.

	low group	high group
A_0	0.5	0.5
f_0	819.0	1,421.0
Q	3.357	3.351
C1(μF)	0.022	0.022
C2(μF)	0.068	0.068
R1(ohms)	19,195.0	11,040.0
R2(ohms)	665.6	384.2
R3(ohms)	39,241.0	22,582.0

The agc outputs amplifier go to a pair of pots so that the tone levels can be individually adjusted. Finally, U6, a voltage follower, combines the tones and provides a low-impedance output suitable for connection to the high-level audio input of any transmitter.

the split-supply problem

It would have been possible to power all the op amps from +12V and ground. Instead, to eliminate the need for coupling capacitors, I decided to run U4 and U6 from a split supply of ±5 volts. Then of course I was faced with the familiar problem of how to get a negative supply voltage in a vehicle.

I could have used a transistor radio battery, but it probably would have gone dead at a crucial moment. Luckily, I found an inverter circuit which suited my needs perfectly.[4] It consists of a high-frequency pulse source, a bootstrap inverter, and a shunt regulator. I changed the oscillator to a 555 timer IC, U3, running in astable mode at about 100 kHz. U3 drives Q3, which supplies solid 12-volt pulses to R24 and C17. As the voltage at the junction of R24 and C17 falls from 12 volts to zero, the other side of C17 is forced to go negative; this series of spikes is then smoothed by C18. With a 12-volt input, you can get up to −7 volts out. The shunt regulator (Q4, CR5, and CR6) holds the output constant within half a volt as the load varies from zero to 20 mA. In normal operation, the current drawn will be no more than 2 or 3 mA. With the zener rating shown, the inverter output should be close to −5 volts. More about this later.

automatic PTT

One drawback of the MC14410 is that, unlike many DTMF chips, it lacks an output that can serve as an "any-key-pressed" indicator. But, as I mentioned, it

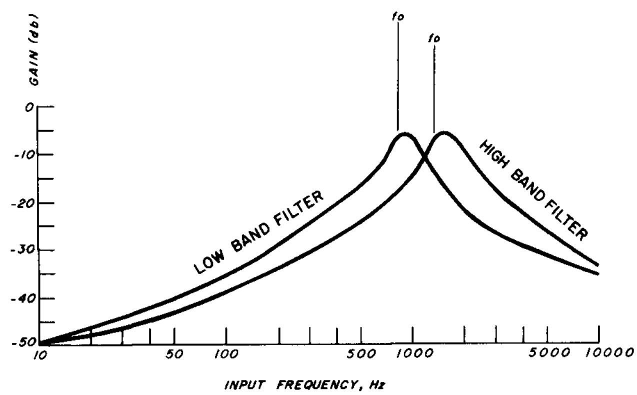


fig. 4. Filter response curves come close to the ideal; precision components are not required.

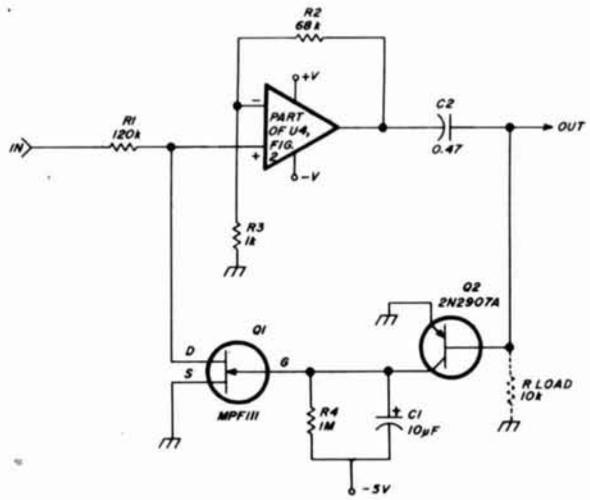


fig. 5. Simplicity and inexpensive components are the virtues of the amplifiers.

does produce a square wave on pin 7 when any key is pressed. This can be rectified and filtered, then used to key a transmitter.

In my circuit, U2 is wired as a comparator and drives Q1 and Q2. When any tone is activated, C11 will quickly charge to 8 volts. R13 and R14 set the threshold at 3.8 volts so that U2 output goes high (about 11 volts), and the full 12 volts appears on the keying line. This line can supply 300 mA with negligible drop in voltage. Because of the RC time constant at U2 noninverting input, the keying line will remain high for three seconds after the key is released; thus, keys can be pressed at a reasonably slow pace without losing the carrier.

assembly and use of the module

For those who desire to build this DTMF module, I have a PC board available for $8.50 postpaid. The board is double sided, with plate-through holes, and plugs into a 15-pin edge connector (pin spacing 0.156 inch, or 0.4 cm). Including the connector pattern, the board dimensions are 3 × 5 inches (7.6 × 12.7 cm). Even if you don't go this route, I recommend using a PC board of some kind. It's important to minimize the switching noise radiated by the inverter, and a PC board does this better than point-to-point wiring. Conducted noise can also cause trouble; note the extensive use of decoupling networks and bypassing in my circuit. The bypassing helps with RFI but is not a cure. For that you need a tight metal enclosure.

component tolerances

While we're on the subject of the inverter, be warned that it's very finicky. That is, it's easily rendered inoperative by component tolerances. R24 is the key to the puzzle; if its value is too high, the inverter will not supply any current. The first unit I built worked well with 390 ohms; the second required less than 100 ohms. The zener can be another source of trouble. You may have to try several before you find the rating that gives you the output voltage you want. This, too, depends on R24.

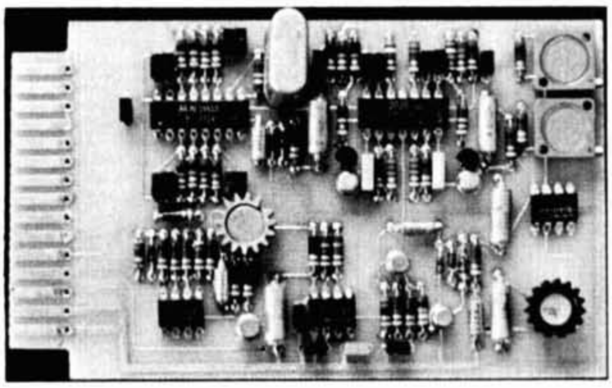
The following procedure works well: load the inverter output with a 1k resistor and select R24 by working down from 470 ohms. Go two steps lower still to give yourself a safety margin. Then make sure you have the right zener rating. Note, too, that for values between 50 and 100 ohms, R24 can get rather warm. You could probably get by with a quarter-watt resistor, but use a half-watt type and avoid the worry. It's a real hassle to test-select these components, but once it's done, the inverter will work reliably.

The components will tolerate normal supply voltage variations present in most vehicles, but it wouldn't hurt to limit the voltage to the 12-15 volt range. With a 12 volt supply and no external load on the keying line, the board will draw 25 mA in standby. When in use, the current will jump to 80 mA; the difference is due to the fact that only U1 and U2 are always powered up. The rest of the circuit is energized from the keying line.

interfacing

The DTMF module requires the following connections to the outside world: eight tone-select lines, the keying line, the tone output, and power and ground. All you should need in the way of off-board parts is a 12- or 16-button keyboard and something to interface the keying line to your rig's PTT line. This could be a relay or a power transistor.

If you want to modulate the rig through the mike input, you may need a fairly large series resistor to get



The completed prototype. The ICs, clockwise from the upper left are U1, 14410, and U4, LM324, both 14-pin DIP; U6, 741 op amp in an 8-pin DIP; U5, LM309H in a TO-5 package; and U3, 555 timer, and U2, 741 op amp, both in 8-pin DIPs.

the right signal and impedance levels. In other words, this board hooks up to the transceiver just like most *Touch Tone* pads. I intended it to be usable with a minimum of external parts but also to be part of a sophisticated access system. The system I have in mind includes an automatic dialer board and a third board that can automatically access one or several closed autopatches. These other two boards are currently under development and should soon be ready.

appendix

1. Filter design equations. Eqs. 1 through **3** are Moberg's (from reference 2). **Eqs. 4** through **6** show how to design filter parameters A_0, Q, and f_0 from component values.

$$R_3 = \frac{Q(C1 + C2)}{2\pi f_0 C1C2} \quad (1)$$

$$R_1 = R_3 \left[\frac{C1}{A_0 (C1 + C2)}\right] \quad (2)$$

$$R_2 = R_1 \left[\frac{A_0 C2}{Q^2 (C1 + C2) - A_0 C2}\right] \quad (3)$$

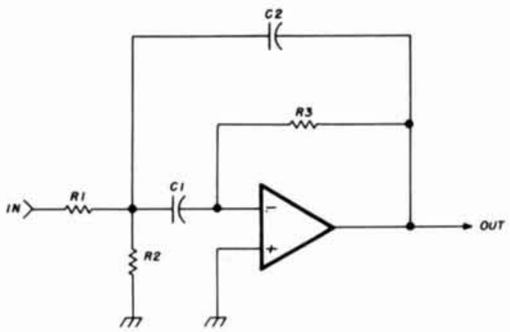
$$A_0 = \frac{R_3 C1}{R_1 (C1 + C2)} \quad (4)$$

$$Q = \sqrt{\frac{A_0 C2 (R_1 + R_2)}{R_2 (C1 + C2)}} \quad (5)$$

$$f_0 = \frac{Q(C1 + C2)}{2\pi R_3 C1 C2} \quad (5)$$

2. Calculator programs. The two programs following may be used with the HP-25C to calculate resistor values and the three filter parameters, A_0, Q, and f_0 for the multiple-feedback filter.

Program uses equations derived by Moberg.[2] To calculate resistor values for multiple-feedback filter:



Input values required are $C1$, $C2$, A_0, f_0, Q

$$R3 = \frac{Q(C1 + C2)}{2\pi f_0 C1 C2} \quad (1)$$

$$R1 = R3 \left[\frac{C1}{A_0 (C1 + C2)}\right] \quad (2)$$

$$R2 = R1 \left[\frac{A_0 C2}{Q^2 (C1 + C2) - A_0 C2}\right] \quad (3)$$

No warning needed. Simply store desired values in R1-R4, run program, and recall answers from R5-R7.

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	RCL 0	24 00	
	RCL 1	24 01	
	+	51	
	STO 3	23 03	
	RCL 7	24 07	
	RCL 5	24 05	
	÷	71	
	RCL 0	24 00	
	x	61	
010	RCL 3	24 03	
	÷	71	
	STO 2	23 02	Value of A_0
	RCL 5	24 05	
	RCL 6	24 06	
	+	51	
	RCL 1	24 01	
	RCL 2	24 02	
	x	61	
	x	61	
020	RCL 5	24 05	
	RCL 3	24 03	
	x	61	
	÷	71	
	f √x	14 02	
	STO 4	23 04	Value of Q
	RCL 3	24 03	
	x	61	
	2	02	
	gπ	15 73	
030	x	61	
	÷	71	
	RCL 7	24 07	
	÷	71	
	RCL 0	24 00	
	RCL 1	24 01	
	x	61	
	÷	71	
	STO 3	23 03	Value of f_0
	GTO 00	13 00	

REGISTERS

0	1	2	3	4	5	6	7	8	9
C1	C2	A_0	f_0	Q	R1	R2	R3		

User Instructions

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
	Store the following values:	C1, F	STO	0	
		C2, F	STO	1	
		GAIN, A_0	STO	2	
		f_0, Hz	STO	3	
		Q	STO	4	
				R/S	
	Run program		RCL	5	R1, Ω
	Recall resistor values				
			RCL	6	R2, Ω
			RCL	7	R3, Ω

Program calculates the three filter paramaters A_0, f_0, and Q from resistor and capacitor values. Equations involved are:

$$A_0 = \frac{R3\,C1}{R1\,(C1 + C2)} \quad (1)$$

$$Q = \sqrt{\frac{A_0 C2 (R1 + R2)}{R1 (C1 + C2)}} \quad (2)$$

$$f_0 = \frac{Q(C1 + C2)}{2\pi R3\,C1\,C2} \quad (3)$$

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	RCL 4	24 04	
	RCL 0	24 00	
	RCL 1	24 01	
	+	51	
	×	61	
	RCL 3	24 03	
	2	02	
	×	61	
	√x	15 73	
010	×	61	
	÷	71	
	RCL 0	24 00	
	RCL 1	24 01	
	×	61	
	÷	71	
	STO 7	23 07	Value of R3
	RCL 0	24 00	
	RCL 1	24 01	
	×	61	
020	RCL 2	24 02	
	×	61	
	÷	71	
	RCL 0	24 00	
	×	61	
	STO 5	23 05	Value of R1
	RCL 1	24 01	
	RCL 2	24 02	
	×	61	
	×	61	
030	RCL 4	24 04	
	gx²	15 02	
	RCL 0	24 00	
	RCL 1	24 01	
	+	51	
	×	61	
	RCL 1	24 01	
	RCL 2	24 02	
	×	61	
	−	41	
040	÷	71	
	STO 6	23 06	Value of R2
	GTO 00	13 00	

REGISTERS

0	1	2	3	4	5	6	7	8	9
C1	C2	A_0	f_0	Q	R1	R2	R3		
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E

User Instructions

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
	STORE COMPONENT VALUES IN R0, R1, R3, R6, R7			
	RUN PROGRAM			
	RECALL ANSWERS FROM R2 - R6			

references

1. Don Lancaster, **CMOS Cookbook**, Howard W. Sams & Co., Inc., Indianapolis, Indiana, 1977, pages 325-330.
2. Gregory O. Moberg, "Multiple-Feedback Filter has Low Q and High Gain," *Electronics*, December 9, 1976, page 97.
3. Neil Heckt, "Automatic Gain Control has 60-Decibel Range," *Electronics*, March 31, 1977, page 107.
4. Craig Scott and R.M. Stitt, "Inverting DC-to-DC Converters Require No Inductors," *Electronics*, January 22, 1976, pages 96-97.

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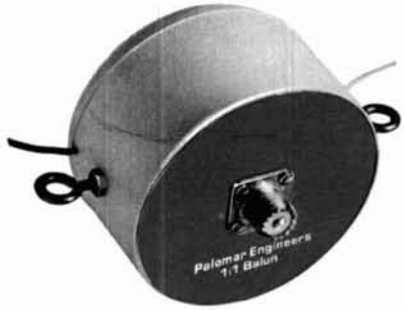

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solid-state T-R switch for tube transmitters

Combine the advantages of full break-in CW operation with the cost savings of older equipment

A recent article in *QST* by Dave Shafer, W4AX, explained the advantages of full break-in QSK CW operation,[1] advantages that can't be provided in today's high-priced transceivers. The article brought to mind another by Stu Goodman, K2RPZ, which appeared a year earlier.[2] He was concerned with the economics of getting on the air and pointed out the possibilities of using older equipment. To quote Stu, "All that is needed is a T-R switch and an antenna . . ." The T-R switch described here uses solid-state components and provides the capability of full break-in operation with low-cost used transmitters with vacuum tubes.

T-R switches

The origin of the T-R switch stems from early radar days. An automatic device was required in the radar to prevent transmitted energy from reaching the receiver, but allowing the received energy to do so without appreciable loss. For fast, reliable break-in CW operation, using a single antenna for transmitting and receiving, the T-R switch is used today. However, with transceivers now dominating the Amateur-equipment market, T-R switches have all but faded from sight.

I checked several references in this regard with no results. Either they were too new and didn't mention T-R switches, or were so old that only vacuum-tube circuits were shown.

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Reference 3 provided some good design concepts. However, these designs were more applicable to solid-state transmitters. Between the extremes of too old and too new, I found a design by W4ETO that was described by W1ICP in the April, 1971, edition of *QST* (it later appeared in several editions of *The Radio Amateurs Handbook*.[4]) I modified the design slightly to improve some operating parameters. It should work well with any moderate-power, class-C vacuum-tube amplifier (such as a pair of 6146s with a plate supply of 750 Vdc).

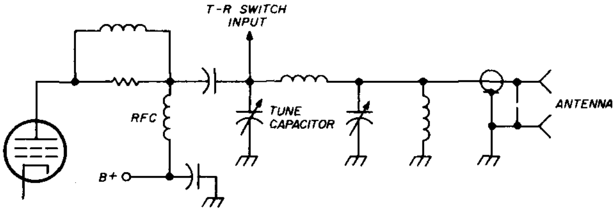


fig. 1. Typical vacuum-tube transmitter output circuit showing the pi network and connection point for the T-R switch.

theory of operation

A short explanation of how the T-R switch operates should be helpful. The principal purpose of the T-R switch is to allow both the receiver and transmitter to be directly connected to the antenna. When the transmitter is keyed, the switch should reduce the amount of signal reaching the receiver to a safe level, but otherwise provide a near unity gain path between antenna and receiver. The noise figure of the device should also be low enough to prevent loss of receiver sensitivity on the upper high-frequency Amateur bands. Some of the older T-R switches were designed to be placed at the transmitter output, but in some cases they caused RFI problems. While these circuits did protect the receiver, harmonics were generated in the T-R switch when the transmitter was keyed. To eliminate the harmonics associated with the circuit, the T-R switch is connected to the tube side of the transmitter pi-network; not to the antenna side. Any harmonics generated in the switch will be attenuated by the lowpass characteristic of the pi-network. The pi-network will also act as a preselector, attenuating out-of-band signals.

Most transmitters use shunt-fed, class-C, final amplifier stages and pi-network impedance-matching networks, as shown in **fig. 1**. The input to the T-R switch is taken from the TUNE capacitor in the pi-network, rather than from the plate rf choke, so that high plate voltage (B+) won't have to be blocked in the switch. When the transmitter is keyed, the vacuum tube sends current pulses into the pi-network that are filtered before reaching the antenna. When the key is up, the final amplifier tube is cut off and has no effect on the received signal. Note that a T-R switch can be used only with class-C final amplifier stages. With linear class A or AB amplifiers, current flows in the final device even when no signal is being

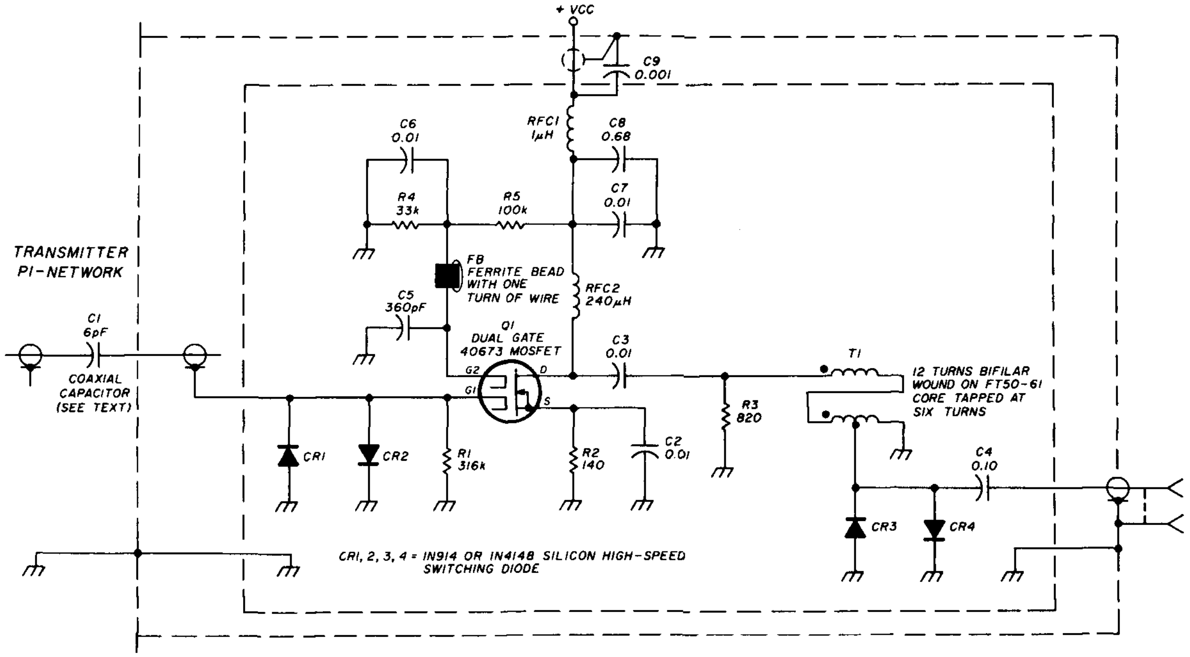


fig. 2. Schematic of a solid-state T-R switch that is suitable for use with moderate-power, vacuum-tube transmitters.

amplified. This action allows amplifier noise to pass directly into the receiver.

circuit details

The T-R switch circuit is shown in **fig. 2** and differs from W4ETO's original design in several ways. One is that a common-drain amplifier is used so that the overall gain can be set at unity. The pi-network transformation steps up the input voltage by the square root of the transformation ratio.

The switch input capacitor C1, and the parasitic capacitances of the two dioides and the mosfet form a voltage divider that reduces the signal level very close to the value it originally had at the antenna input to the pi-network. From the mosfet input at gate 1 to the output, the amplifier is designed for a nominal gain of unity. The mosfet g_m is typically 10 millisiemens, so that the 800-ohm load resistor sets the no-load gain at eight. The voltage stepdown in transformer T1 reduces the gain by a factor of four; adding a 50-ohm load reduces it by another factor of two. If the receiver input impedance is substantially higher than 50 ohms, the overall gain will be closer to two. A second set of limiting diodes, CR3 and CR4, is placed at the output to protect the receiver in the event of a T-R switch failure.

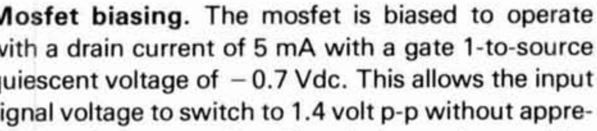


fig. 3. Construction details of the coaxial cable input capacitor (C1 in fig. 2).

Mosfet biasing. The mosfet is biased to operate with a drain current of 5 mA with a gate 1-to-source quiescent voltage of −0.7 Vdc. This allows the input signal voltage to switch to 1.4 volt p-p without appreciable gain compression. The diodes at the amplifier input will limit the signal to this same range so that they won't reduce the T-R switch dynamic range.

The voltage on gate 2 is set by a resistor divider at approximately 4 Vdc, setting the gate 2-to-source voltage to at least 3 volts. With these quiescent voltages and currents, the mosfet will have a transconductance of 10 millisiemens and a drain current swing of at least 10 mA p-p.

Bypass considerations. The mosfet is shunt fed to allow the drain-to-source voltage to remain above the minimum recommended by the manufacturer with the gate-2 voltage used. The value of the rf choke isn't critical. Values between 150 μH - 360 μH could be substituted. The decoupling of the mosfet drain supply is very conservative, using two capaci-

fig. 4. Printed-circuit board layout for the T-R switch. Component layout is shown in fig. 5.

tors in parallel (C7 and C8) to obtain several decades of effective bypassing. Gate 2 of the device is also decoupled with two capacitors and a ferrite bead to ensure the mosfet will remain stable through the uhf range. Again, the values of the decoupling capacitors aren't critical.

Supply voltage. The supply voltage, $V_{cc}+$, for the T-R switch can range from +12 Vdc to +18 Vdc without much effect on performance. Additional decoupling of the input supply voltage is obtained with RFC1 and C9.

Input coupling. The only unusual component is C1, the input-coupling capacitor. Because the rf voltage levels are quite high and the required capacitance so low, a suitable commercial component would be difficult to find. An inexpensive substitute is a piece of coaxial cable. A typical piece of 50-ohm coax will have a capacitance of 1 pF/cm (30 pF/ft), so that a 6.3-cm (2.5-inch) center conductor-shield overlap will provide 6 picofarads of capacitance. A sketch of the coaxial capacitor is shown in **fig. 3**. The length of

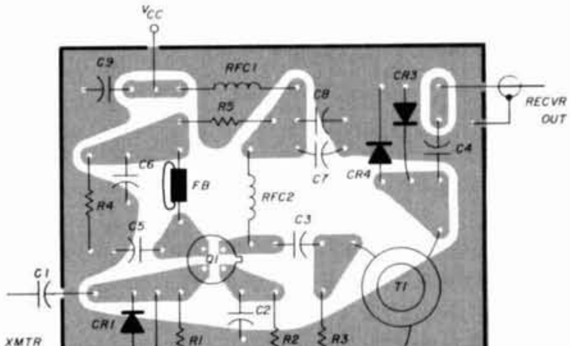


fig. 5. Component layout for the T-R switch.

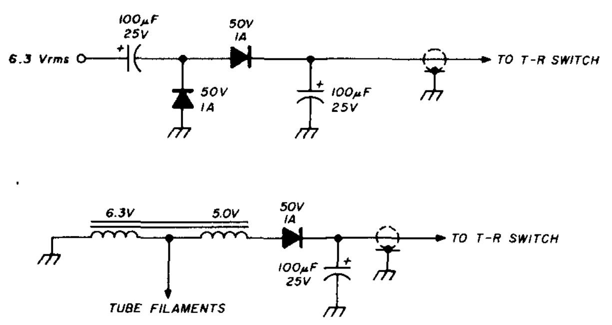


fig. 6. Two power supply options for the solid-state T-R switch. Supply voltage is not critical and may vary from +12 to +18 Vdc.

the un-overlapped portion can be as long as necesary to go from the pi-network to the T-R switch input. A piece of bare wire can be wrapped around the shield and soldered to complete the capacitor. For plate voltages less than +500 Vdc, RG-58/U can be used, with RG-59/U suitable for voltages up to +900 Vdc. With 70-ohm coaxial cable, the capacitance will be approximately 0.7 pF/cm (21 pF/ft), so an overlap length of 8.7 cm (3.4 inches) should be used.

construction

Circuit layout is shown in **fig. 4**. A 5.7 × 5 cm (2½ × 3¾ inch) single-sided copper-clad printed wiring board was used, and mounted in a 10 × 7.6 × 5 cm (4 × 3 × 2 inch) aluminum minibox. The board is mounted to the minibox using 2-cm (¾-inch) aluminum angle stock. The whole assembly was mounted on the rear of the transmitter shielded pi-network cage. The only critical aspects of the mechanical assembly are to provide good rf returns between the pi-network ground and the T-R switch board ground, and between the output connector return and the board ground.

Only one board was constructed, so photo etching wasn't used to make the board. Copper tape was used on the back of the board to provide the component interconnections. For those who wish to use an etched board, a suggested layout is shown in **fig. 4**;* the component placement is shown in **fig. 5**.

If the transmitter doesn't have the necessary supply voltage available, **fig. 6** shows two possible solutions. Both use the power-transformer filament windings in the transmitter. If the 5-volt rms winding is used, be sure it isn't connected to the high-voltage supply through the rectifier tube. This winding also must be properly phased with the other filament winding to prevent the two voltages from bucking. The power supply can be mounted in any convenient location in the transmitter and connected to the T-R switch with a shielded wire. At the switch end, the shield should be connected to the minibox, with C9 between the supply voltage and the shield-box connection.

conclusion

The T-R switch has been in use for over a year and has worked well under various operating conditions. Remember that the T-R switch protects the receiver only; it will not prevent the receiver from overloading if its dynamic range or agc characteristics are not up to standard. In most cases, muting the receiver when the key is depressed is the best solution to this problem. Take the advice of W4AX and K2RPZ: Turn that bargain transmitter into an effective CW rig with the addition of a good T-R switch.

editor's note

The bibliography at the end of this article has been culled from *ham radio* for the benefit of CW enthusiasts interested in break-in control circuits.

The article by Al Brogdon, K3KMO, combines the advantages of electronic switching using a Johnson model 250-39 T-R switch and an antenna change-over relay.

Cal Sondergoth, W9ZTK, describes a solid-state system for use with separate receive and transmit antennas using low-power transmitters (under 100 watts). The article emphasizes receiver overload during transmit.

W.M. Mitchell, W8SYK, presents a single-transistor CW break-in circuit for stations with separate transmit and receive antennas. The design is for grid-block keying.

J.K. Boomer, W9KHC, shows a low-power, solid-state T-R switch using a PIN diode. The circuit handles power to 100 watts at any desired keying speed.

references

1. David P. Shafer, W4AX, "Why QSK?" *QST*, February, 1979, page 53.
2. Stu Goodman, K2RPZ, "A Bonanza Awaits You in the Ham-Ads," *QST*, December, 1977, page 11.
3. Wes Hayward and Doug DeMaw, *Solid-State Design for the Radio Amateur*, ARRL, Newington, Connecticut, 1977, pages 179-180.
4. "A Solid-State T-R Switch," *The Radio Amateur's Handbook*, 49th edition ARRL, Newington, Connecticut, 1972, page 360.

bibliography

Boomer, J.K., W9KHC, "PIN Diode Transmit-Receive Switch," *ham radio*, May, 1976, page 10.

Brogdon, Al, K3KMO, "The Ideal T-R Switch," *ham radio*, April, 1979, page 61.

Mitchell, W.M., W8SYK, "CW Break-In Circuit," *ham radio*, January, 1972, page 40.

Sondergoth, Cal, W9ZTK, "Break-In Control System," *ham radio*, September, 1970, page 68.

ham radio

*A printed-circuit board and parts kit is available from Radiokit, Box 429, Hollis, New Hampshire 03049.

understacking high-frequency Yagi antennas

A novel system for stacking beams on a tower to minimize mast damage in heavy weather

Installation of a single Yagi antenna on a tower, whether the tower is guyed or not, provides a clean looking system that will no doubt perform as predicted. If a commercially manufactured antenna is used, and there is no desire to make adjustments for optimum performance, mounting it in the clear away from all surrounding objects is the only way to do it. That, however, is not very cost effective. A second beam means a second tower, a third beam requires a third tower, and so on. I quit with three towers — but I want beams for 40 through 10 meters.

Stacking distances of 10 feet (3 meters) or more aren't generally suited to high-frequency beam installations because it's difficult to prevent the mast from bending in severe weather. Ultra-strong steel masts are expensive, heavy, and do not provide easy access to the top antenna. By understacking antennas, rather than overstacking them, a number of features develop which overcome these problems.

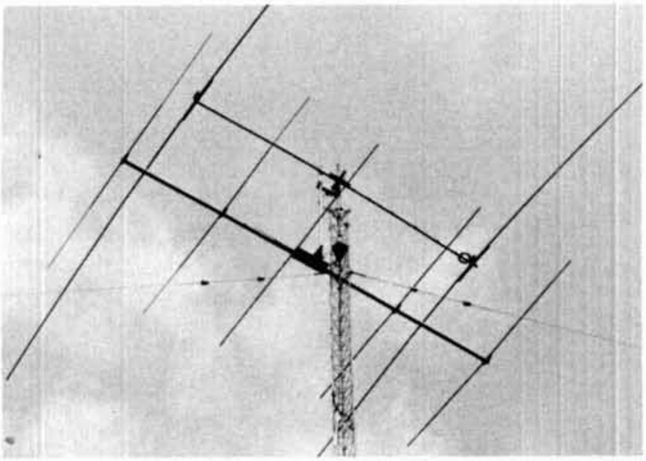
Understacking takes advantage of a unique relationship between the system weight and the effect of gravity. With conventional stacking arrangements, the weight of the top antenna *adds* to the bending moment at the base of the mast. Understacking *subtracts* the antenna weight from the bending moment because gravity aids in keeping the mast in a vertical position.

A number of other feature benefits come into play. First, installing, tuning, or repairing the stacked antenna is relatively easy because it is mounted within reach of the person climbing the tower. Properly designed tilting hardware makes it easy to reach any point on the boom of either antenna. Element repair or matching-network adjustments are relatively simple. Building the system shown in the photographs was a one-man project — no help was needed.

A primary objective for any antenna system is to have it remain intact during foul weather. One disasterous event which can destroy an antenna, especially one that is stacked above another, is a hurricane — or hurricane-force winds. Even with two days of notice (hurricanes are somewhat predictable!), an antenna stacked high on a mast offers little opportunity to take damage avoidance steps to weather the storm. With understacking, however, you can climb the tower and tie in the stacked antenna with heavy rope. When the boom of the stacked antenna is fastened securely to the tower face, the chance of mast damage is eliminated. Furthermore, the mast and boom of the stacked antenna are fastened at a point where the top set of guy wires have the greatest strength — right at the guy point. The tie-in procedure reduces the load above the top set of guy wires to one antenna surface instead of two.

Further security is built into the system by installing a torsion bar assembly at the very top of the tower; see the photographs. The benefit is obvious: during hurricane season (June through November), a ready-made set of guy wires is kept on hand. If they are needed, it is a simple task to install them (it can be done in less than an hour). With the extra guy wires in place, there is little chance of tower damage from high winds. Whether or not the antenna survives extremely high winds is a different matter. Keep in mind, though, it is far easier to repair a bent

By Robert M. Myers, W1XT, 221 Long Swamp Road, Wolcott, Connecticut 06716



The antenna installation at W1XT. Shown are a two-element, 40-meter Yagi and an understacked five-element, 10-meter Yagi.

antenna than it is to fix a bent tower!

There are a few minor benefits to understacking as well. The auxiliary mast is a torsion tube which reduces stress on both the tower legs and the rotor. The empty span between Yagis is ideally suited to the installation of a small vhf antenna.

mechanical components

Fabrication of the hardware is simple and can be done easily in the home workshop. There are three different pieces to the system: an 11-foot (3.3-meter) long galvanized steel mast, two boom-tilt assemblies, and two angle brackets to support the auxiliary mast at the top of the main mast. Standard discount store automotive muffler clamps are used to hold everything in place. Plated clamps are usually found in the hardware department rather than in the automotive section.

The mast sections are made from 1 ½-inch galvanized waterpipe. Because waterpipe is specified by inside diameter (ID), not outside dimension (OD), the outer dimension for the 1½-inch pipe is slightly under 2 inches (50 mm). This size is ideally suited to 1-7/8 inch (48 mm) clamps although 2-inch (50 mm) clamps are satisfactory. Galvanized waterpipe is available from most plumbing supply dealers but be prepared for a stiff price. The material used here cost nearly $20!

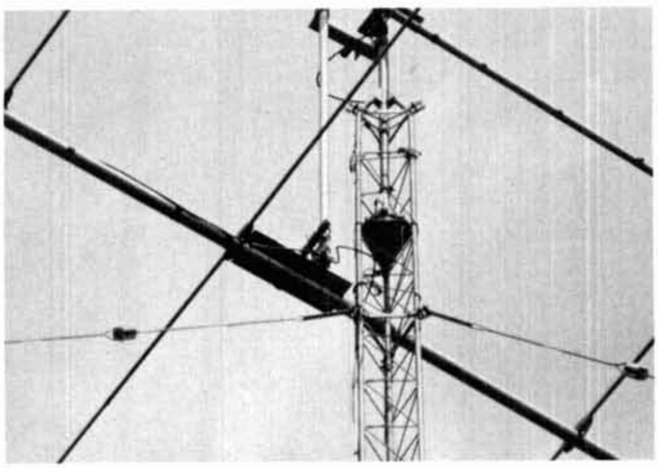
The two top mounted angle brackets are 12 inches (30 cm) long and provide adequate tower clearance for the auxiliary mast. The aluminum stock is 3 inches (8 cm) on a side and ¼-inch (6 mm) thick. The upper angle piece is equipped with six muffler clamps, three on each end; the lower one has two at each mast connection point.

Both boom-tilting assemblies are shown in the photographs. The ½-inch (25 mm) thick plate (aluminum) has a horizontal pipe section held in place by a group of muffler clamps. Each Yagi has its boom-to-mast plate turned horizontal so that it may sit on the tilt assembly plate. Loose clamp hardware allows relatively free tilting of the boom to any position for the installation of the elements. The top boom-tilt assembly is fastened to the main mast and not the auxiliary one. This helps offset the leaning action caused by the lower antenna.

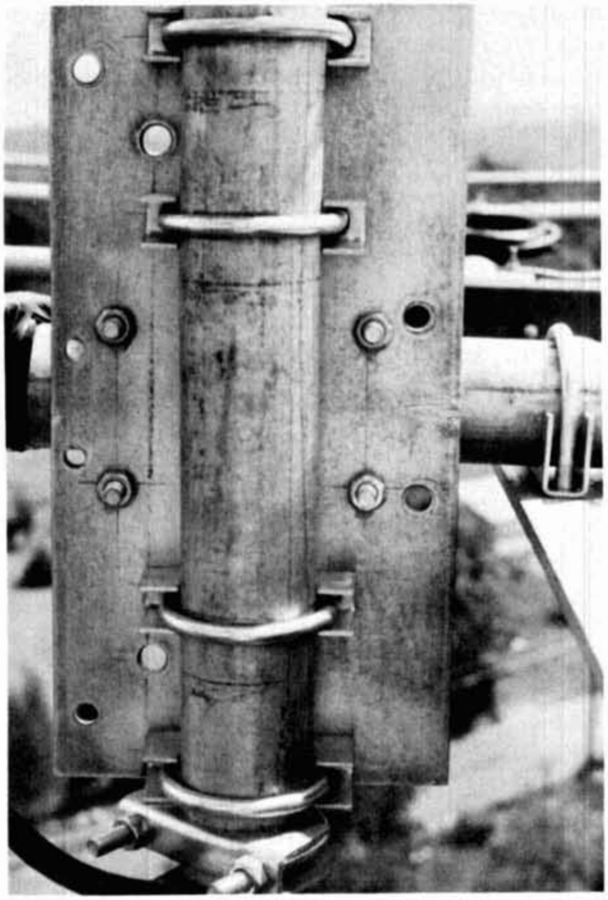
system description

A five-element, 24-foot (7.2 meter) boom 10-meter Yagi is stacked under a two-element electrically shortened 40-meter beam (Mosley S-402) which has 46-foot (13.8-meter) long elements. The Mosley antenna was selected because of its low wind surface profile as compared to a full sized array. The high Q of a loaded antenna makes it necessary to assure no detuning occurs as a result of other hardware being in close proximity to it.

A number of other factors were involved in selecting these antenna designs. The 10-meter beam has a boom length slightly longer than double the spacing between antennas which means that the top antenna interferes with rotating the lower boom vertical. Since the longest 10-meter element is shorter than the boom length for the 40-meter antenna (20 feet or 6 meters), it is a simple matter to turn one boom 90 degrees (horizontally) and tilt the 10-meter boom end and element up between the two 40-meter elements. The 24-foot (7.2 meter) boom length on the 10-meter beam was selected to provide element positions which would not be directly under the elements



The guy-wire torsion bracket is mounted just above the bottom rung of the tower top section. The 10-meter antenna rotates just above the top set of guys. An empty torsion assembly at the top of the tower is available for an additional set of guy cables if they should be necessary.



The 10-meter tilt assembly attaches to the auxiliary mast with four muffler clamps. Note the clamp at the very bottom of the mast. It is needed to keep the tilt assembly from slipping off the auxiliary mast and is an absolute requirement.

above. For one thing, this gives slightly more separation between elements than the vertical dimension indicates. More importantly, however, during a bad ice storm, the top elements won't droop and make contact with the lower antenna. Also, melting ice from the top elements will drop between the lower 10-meter ones. Falling ice can play havoc with the antennas beneath!

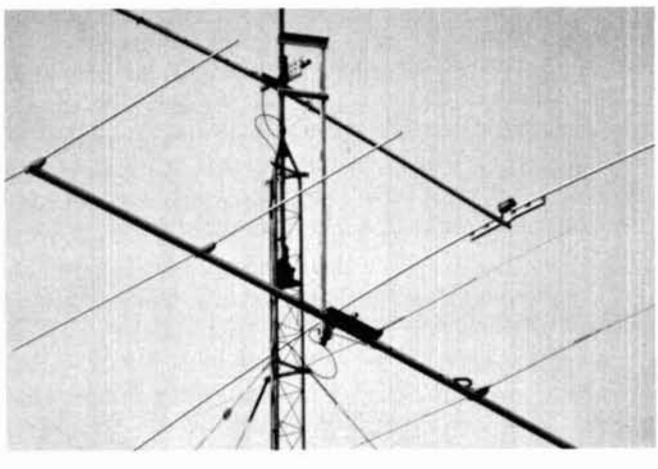
Interaction tests were required to assure no interaction between antennas. The Mosley antenna was installed first. An SWR curve was plotted, front-to-back measurements were taken, and the relative signal strength of a local broadcasting station were made (W1AW is 25 miles away and visible on a clear day). Next, the 10-meter Yagi was installed and similar measurements were performed. Rechecking the 40-meter tests showed no difference in the figures. Rotating the top antenna 90 degrees with respect to the lower one had no influence on the test results of either antenna. The conclusion is that stacking these two antennas 10 feet (3 meters) apart is sufficient to avoid detuning either one.

Mechanically, the system is stable and strong. The slightly off-center mounting of the auxiliary mast causes the main mast to lean to one side. This is counteracted to some extent by the top tilt assembly being mounted to the main mast with the horizontal pipe extending in the other direction. There is no binding in the tower top sleeve. The relatively long main mast to the rotor makes the misalignment insignificant. You should not attempt this type of understacking, however, if the rotor is mounted directly beneath the tower sleeve — or worse yet, if the rotor is mounted above the sleeve. Under these conditions, the lateral forces would destroy the rotor in short order.

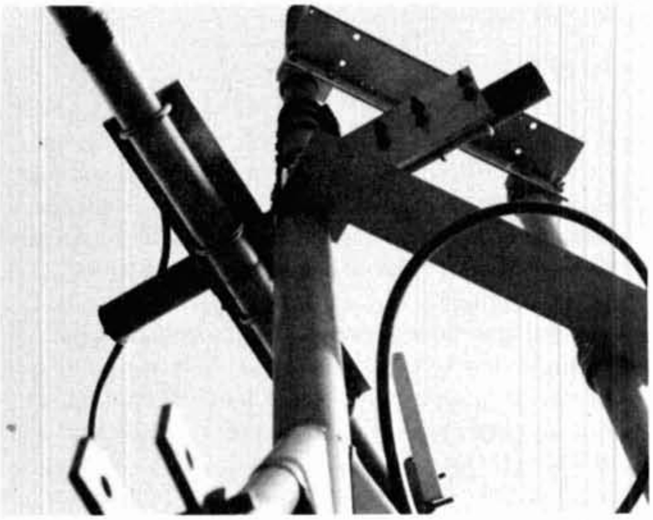
There have been two tests of the mechanical strength and reliability of the stacking procedure. In August, 1979, a severe storm whipped through central Connecticut, tearing roofs off buildings and uprooting trees. The local weather service measured wind velocities of 70 mph (110 km/h) for more than an hour. After the storm, the system inspection showed only a 40-meter element to be rotated around the boom; everything else was intact. During early September, Tropical Storm David generated wind gusts up to 70 mph (110 km/h); this time there was no damage. In neither case was the top set of guy wires installed (the extra set) or the lower boom tied into the tower face. A good deal of confidence was developed by these two events. After the first storm, it was a simple matter to tilt down the 40-meter boom and straighten the twisted reflector.

hardware installation

There are numerous ways an Amateur can approach this kind of a project. The testing requirements, however, dictated the order in which compo-



The top angle brackets have been offset to give a greater spacing between the tower legs and the 10-meter boom.



Two angle brackets are used to hold the auxiliary mast in place. One is attached above the 40-meter tilt assembly; the other is connected below.

nents were installed. It would be wise for anyone duplicating this system to perform tests similar to those mentioned earlier. If two antennas are put up and one doesn't operate correctly, it could be very difficult to determine the source of the problem.

First, install the tilt hardware to the main mast. Next, position the 40-meter boom on the horizontal tilt assembly pipe. With the appropriate boom end tilted down along side the tower, attach one element. It is necessary to tie a rope to the opposite boom end from where the first element is connected. It should be done before the boom leaves the ground. The rope is needed to pull the non-element end down after the first one is attached. With both elements connected, the antenna weight is balanced and vertical rotation around the tilt assembly is easy. Exercise extreme care when turning the boom up or down. Be sure the clamps can't slide off the horizontal pipe. The pulling rope must be strong and tied securely in place. If the rope breaks or slips half way through the tilting process, the heavy end will swing down with a vengeance.

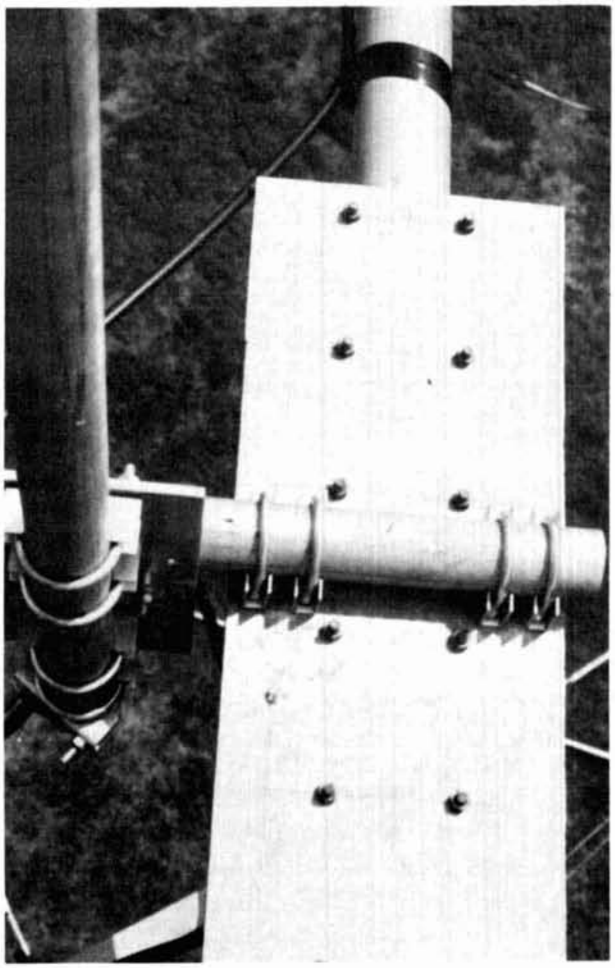
Once the 40-meter beam is installed and tested, the two auxiliary mast supports are clamped in place; one gooes above the 40-meter tilt assembly and the other mounts beneath it. Muffler clamps should be attached to the far end of the angle stock, ready to accept the auxiliary mast. Slip the mast pipe up through the clamps and secure all of the hardware. The 10-meter boom-tilt assembly can be attached to the auxiliary mast before it leaves the ground or after the mast is in place.

As with any antenna installation, safety is an absolute requirement. I have found the best procedure is to plan every step of the process in advance. Abbreviated notes are used to avoid mistakes.

boom-to-tower spacing adjustment

The auxiliary mast aligns on center with the tower when the support angle brackets are parallel to the 40-meter boom. The lower tilt assembly offsets the 10-meter beam sufficiently to clear the tower during rotation. Sway in the auxiliary mast caused by wind may allow the 10-meter boom to occasionally bump into the tower leg at some headings. Twenty turns of polypropylene rope are wrapped around the 10-meter boom where it comes close to the tower. The rope acts as a bumper pad during very high winds.

To increase the spacing between the boom and the tower legs, change the position of the angle supports toward perpendicular with the 40-meter boom. The lower beam will need to be repositioned slightly for a corrected heading; an 8-inch (20 cm) clearance



The homemade 10-meter beam mounts to the tilt assembly with four muffler clamps. The coaxial cable loop must be positioned so that rotation of the system doesn't crimp or cut it.

is adequate. Note the offset of the angle brackets in some photographs.

pitfalls

It is possible to forget some of the basics of good engineering practice. For instance, the auxiliary mast is indeed a 10-foot (3-meter) long lever arm and will flex the main mast pipe. An antenna of much larger dimensions than described here would likely cause one of the masts to bend if extremely severe weather were encountered. For use with bigger systems, hard steel tubing is recommended in place of waterpipe.

Another important consideration is tower loading. The tower shown here is 100 feet (30 meters) of Rohn 25 guyed at 33, 66, and 91 feet (10, 20, and 27 meters). The unsupported top section has a torsion guy assembly mounted just below the bottom rung which keeps lateral forces off the tower leg bolts. The load rating for Rohn 25 tower is 6 square feet (0.55 meter^2) of antenna; many Amateurs exceed that with large six-element Tribander. The surface area rating for the Mosley S-402 is about 3.8 square feet (0.35 meter^2). The lower five-element Yagi adds another 2.5 square feet (0.23 meter^2) of surface area. This tower is sufficiently loaded for maximum safe operation (note that tower load ratings assume a rotor, mast, and cables and should not be included in the calculations).

other combinations

Interaction between antennas is always a possibility when more than one antenna is placed on a tower. Many Amateurs have experienced difficulty in operation when 15- and 40-meter antennas are mounted together on the same tower. The end result is usually poor front-to-back ratio with the 15-meter system. The high Q of a Tribander accentuates the problem. For this reason, you should be cautious about installing a Tribander and a loaded 40-meter beam on the same support. If interaction does result, the simple solution is to turn one of the antennas 90 degrees with respect to the other. Double dial calibration would then be required.

A combination of antennas ideally suited to understacking is a small "Christmas Tree" of monobanders for 20, 15, and 10 meters. The largest antenna should go at the top and the smallest in the middle of the auxiliary mast. In this manner, the heaviest Yagi is mounted just above the top tower sleeve, and the next largest antenna will have its weight at the bottom of the auxiliary mast to counteract the bending moment.

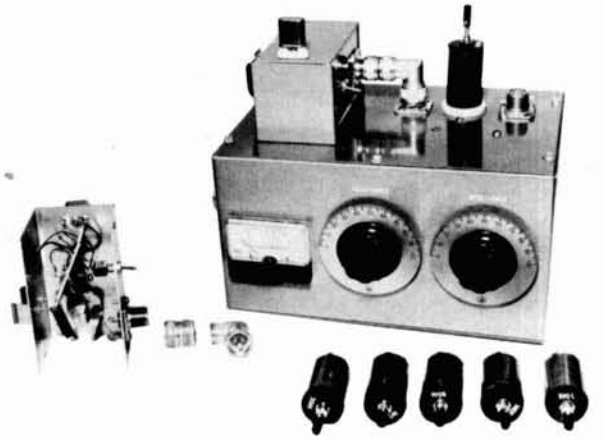
No matter what combination of antennas is selected, be sure not to overload the tower. Hardware falling from the sky is hazardous to your neighbors!

ham radio

More Details? CHECK—OFF Page 94

the Macromatcher:

increasing versatility



Several years ago I built the Macromatcher and the pickup coils[1] and used it with a grid-dip meter for antenna matching. This combination is rather cumbersome if used at the antenna terminals when the antenna is at the top of the tower. An alternative method is to use the above setup on the ground with one-half wavelength of coax to give the same characteristics as at the antenna.

I built a crystal-controlled transistorized signal source (powered by a 9-volt battery and mounted on the Macromatcher) for 20 meters (**fig. 1**) and 40 and 75 meters (**fig. 2**). The photo shows the complete unit. The 20-meter oscillator is on the left, and the 40- or 75-meter oscillator is mounted on the Macromatcher. A Bud minibox CU-2103-B, 102 × 58 × 58 mm (4 × 2-1/4 × 2-1/4 inches), was used. The part of the minibox with the lips is fastened to the Macromatcher as shown.

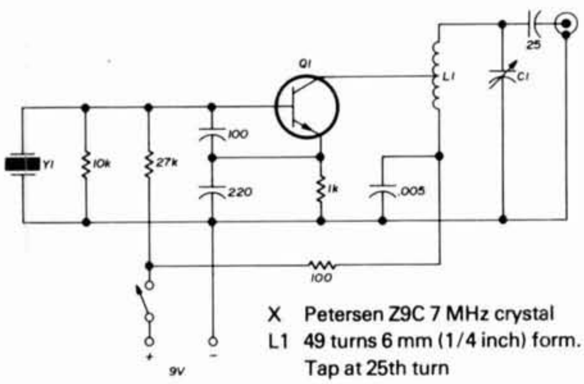


fig. 1. Twenty-meter oscillator.

Some thought and planning must be done to ensure proper positioning so that the oscillator output (coax receptacle) mates with the Macromatcher input receptacle.

Connections between the Amphenol fittings are as follows: an 83-877 (double male) from the 83-1R (SO-239) on the oscillator to a 83-1AP (angle) to the 83-1R (SO-239) on the Macromatcher (see photo). The oscillator was built in the other portion of the minibox, the part without the lips.

When the unit is to be used on a different band, all that's necessary is to remove the four screws holding the minibox together, unscrew the coax connector on the Macromatcher, change the battery, secure the other oscillator to the Macromatcher, and the unit is ready to use.

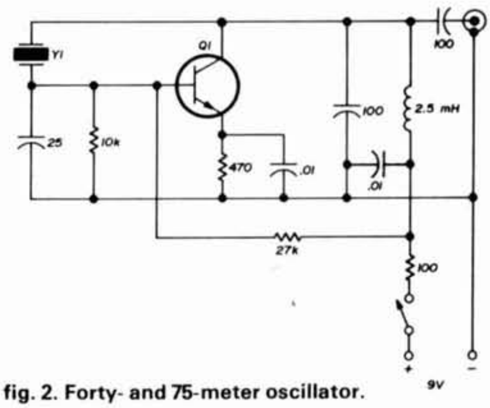


fig. 2. Forty- and 75-meter oscillator.

With a slightly larger minibox a VFO with a bandswitching arrangement could be built, which would have more versatility. You'll note that the dial skirts of my unit haven't been reversed and remarked for resistance and reactance values.

acknowledgment

A special thanks to Bob Henry of Satterfield Electronics for the photographs.

reference

1. The *Radio Amateur's Handbook*, 1979 edition, chapter 16, page 25.

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By Arnie Bachmann, K9DCJ, Route 1, Blue Mounds, Wisconsin 53517

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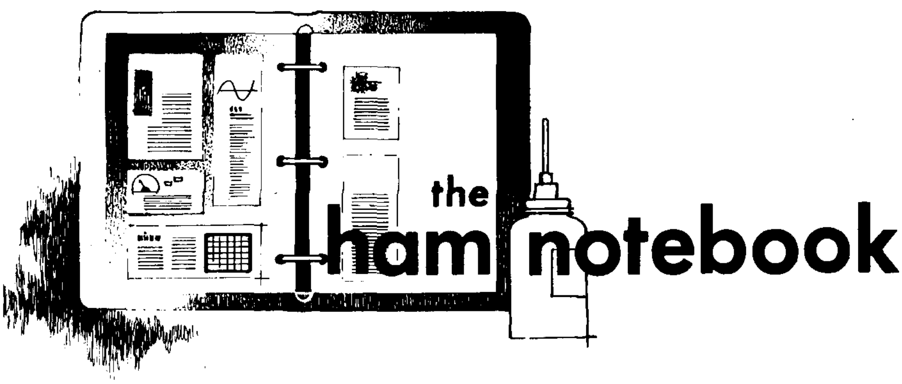


two for one

If the title sounds like poor odds on a tout sheet at Pimlico and not applicable to ham radio, have patience and read on. There have been a number of times in more than thirty-three years as an Amateur when I wished to use more than one receiver on a single antenna system at the same time. Whether corrected directly or through decoupling amplifiers, sensitivity was lost or undesired interaction in the form of rf oscillations resulted.

For use on 2-meter fm I built a quarter-wave ground plane antenna for base-station use. Some months later I obtained a tube-type aeronautical monitor receiver (I'm involved with flying and wanted to listen to the aeronautical service). In the aeronautical communications with which I work, a maximum of three vhf receivers are connected so that the primary side of all the antenna transformers are series connected; the bottom end of the antenna coil in the last receiver is grounded. These are double-conversion, fixed-frequency receivers with a minimum of 1-MHz frequency separation between the three series-connected receivers.

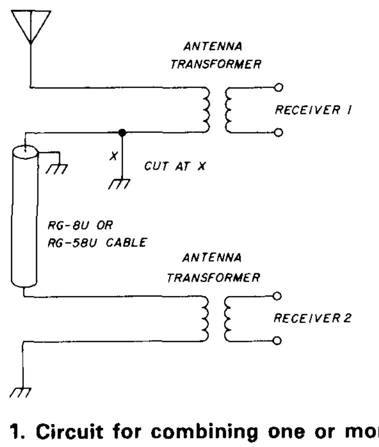


fig. 1. Circuit for combining one or more receivers to a single antenna.

Without a relative signal-strength meter in either the ham or the aeronautical receivers, I not only maintain my Amateur operation but also copy aeronautical ground station transmitters that I know are putting 10 watts into over 46 meters (150 feet) of RG-8/17, combined. Thus, with about 3 dB power loss in the coaxial cables, I operate both receivers simultaneously. I have more than 20 MHz frequency separation between the receivers. I'm about 32 km (20 miles) airline from the airport.

The only modification to any receiver with a grounded end on the antenna transformer is the addition of a chassis-mounted rf connector such as an SO-239 or a BNC, or N type connector (**fig. 1**). The ground connection is lifted and wired to the connector. Then, for single-receiver operation, this point is again restored to ground by a jumper plug of the appropriate type. For dual- or triple-receiver operation, these former ground points are series connected with suitable lengths of 50-ohm coaxial cable. The ungrounded end of the last receiver is grounded once again to re-establish the antenna-circuit continuity. The length of the coax jumpers is somewhat critical for the uhf and vhf ranges for optimum operation but will be less so in the hf range.

Jack Struthers, W2OZY

TS-820 filter switching modification

The addition of the YG-88C 500-Hz crystal filter to the TS-820 is a worthwhile operating aid. When this filter is installed according to the instructions furnished, the filter will be automatically selected when the TS-820 MODE switch is in either the CW or TUN position. It's convenient to be able to select the wider 2400-Hz standard filter during tune up or while scanning the CW portion of the band in use. Here's a scheme for selectable filter switching using no new hardware or new holes.

Fig. 2 shows the back of the TS-820 METER switch. It's a double-pole, five-throw (DP5T) switch with only one-half being used; i.e., single-pole five-throw, or SP5T. Thus half

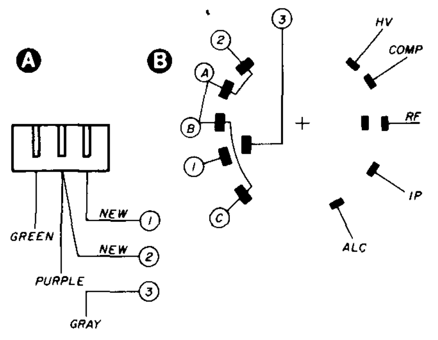


fig. 2. Modifications for selectable filter switching for the TS-820. The meter switch (S-1) is shown at (A) viewed from rear of panel. New connections to connector IF2 are shown in (B).

of this switch is available for other uses.

The speech processor is inoperative during CW and TUN modes, so the COMP position of the METER switch is ideal for activating and selecting the 500-Hz filter. During tune up, as the METER switch is switched through ALC, IP, and RF, the 2400-Hz filter is activated, allowing higher meter readings and finer adjustments.

For CW you can choose filters by switching to COMP to activate the 500-Hz filter or use any of the other METER switch positions for 2400-Hz filter operation.

Modification of the TS-820 is straightforward and should take less than an hour:

1. Remove cabinet top and bottom covers.

2. Locate and remove connector IF2 from the bottom of IF Board X48-1150-00.

3. Refer to the color-coded wiring of connector IF2 as shown in Figure 25, page 34, of the TS-820 Operating Manual.

4. Remove gray wire from IF2. Place the blade of a small screwdriver into the slot above the wire and gently pull on the gray lead.

5. Unsolder the gray wire from the connector tip. Solder a new wire approximately 46 cm (18 inches) long to the connector tip and reinsert the tip into the connector IF2.

6. Route the new wire along the large wire bundle and up through the chassis to the back of the METER switch. Cut to length, strip, tin, and solder to the switch at terminal 1 as shown in **fig. 2.**

7. Splice a second new wire approximately 46 cm (18 inches) long to the free end of the gray wire, route it to the switch, and solder at 3.

8. Remove the purple wire from IF2 using the blade of a small screwdriver as in step **4** above.

9. Solder one end of a third new wire approximately 46 cm (18 inches) long to the connector tip along with the purple wire. (There will now be two wires soldered to the single connector tip.) Reinsert the connector tip back into connector IF2.

10. Route this last new wire to the switch and solder at 2.

11. Connect and solder a short piece of uninsulated, tinned wire between terminals 2, A, B, and C. Be sure that the uninsulated wire does not touch terminal 1.

12. Neatly dress all leads (tie to existing wire bundles if desired) and replace the top and bottom cabinet covers.

This completes the modification. During tune up, as the meter is cycled through ALC, IP, and RF the 2400-Hz filter will be operative, as it will be during SSB. Additionally, the COMP position of the METER switch will activate the 500-Hz filter only while in the CW or TUN mode. Thus, the ability to read compression level during SSB operation with the speech processor is retained.

Don Jacobson, K7OAK

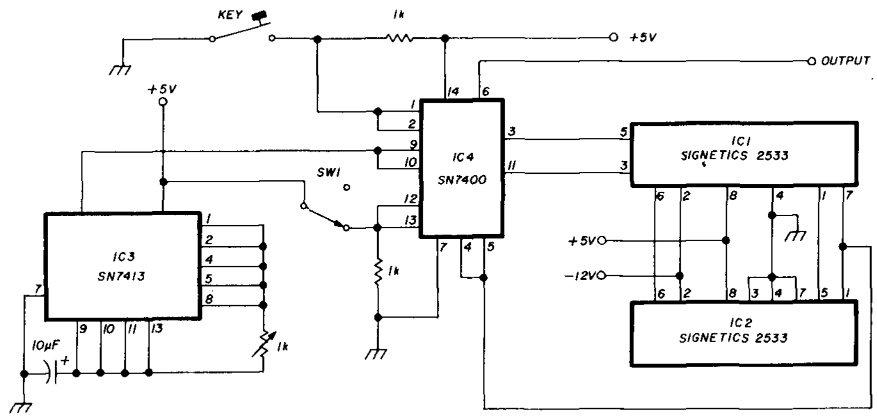
2048-bit memory keyer

I do quite a lot of moonbounce operating on 144 MHz and this can sometimes result in an hour or so of continuously sending callsigns. I designed the keyer in **fig. 3** to make operating easier. All I have to do is program the callsigns, and the keyer does the rest.

The circuit is simple. The key is an ordinary Morse hand key. SW1 is the information in-out switch. The 1-k variable resistor is adjusted so that information going into the keyer just fills the memory. Decoupling capacitors are left out for the sake of clarity, but at least 200 μF should be used from -12 volts to ground and at least 500 μF from $+5$ volts to ground.

The output will drive a solid-state keying switch or sensitive reed relay directly. The keyer is indispensable for contest work; other uses include beacon and repeater identification. Memory capacity is 2048 bits.

Dave Price, GW4CQT



IC1, IC2	Signetics 2533
IC3	SN7413
IC4	SN7400

fig. 3. Schematic of the memory keyer by GW4CQT, which takes the drudgery out of contest work for sending ID, CQ, and callsigns. Memory capacity is 2048 bits.

More Details? CHECK—OFF Page 94

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NEW products

new Heath remote coax switch

Heath Company, the world's largest manufacturer of electronic kits, announces a new remote coax switch, the SA-1480 which allows the Amateur Radio operator to select any of five antennas by simply turning a knob at his bench. One feedline from the inside control box to the outside switching box replaces five separate antenna cables, saving coaxial cable. A special grounding position grounds all antennas for lightning protection.

A specially shielded switching box protects the switching circuitry from the elements. Silver-plated switch contacts help lower SWR. The SA-1480 operates on frequencies up to 150 MHz, and will handle full legal power.

Heath engineers say the new remote coax switch can be easily assembled in six to eight hours. A U-bolt assembly is included to facilitate mounting the outside switching box on an antenna mast or tower leg.

The Heathkit SA-1480 remote coax switch is mail order priced at $84.95 F.O.B. Benton Harbor, Michigan. Write for a free catalog to Heath Company, Dept. 350-220, Benton Harbor, Michigan 49022, or pick up a copy at the nearest Heathkit Electronic Center (Units of Veritechnology Electronics Corporation), listed in the telephone directory white pages.

Based in Benton Harbor, Michigan, Heath Company is a subsidiary of Zenith Radio Corporation.

pocket shortwave receiver

Measuring only 45 × 73 × 25 mm, the Model EP-8 is believed to be the smallest a-m/SW, two-band receiver available in the U.S. In addition to the standard "broadcast" band (a-m), the EP-8 receives shortwave frequencies from 3.9 to 12 MHz (ideal for receiving WWV time signals on 5 and 10 MHz). Controls include a band-select switch, tunable dial for a-m and SW, and volume control coupled with an ON-OFF switch. Audio output is via the supplied earphone only, and the receiver is powered by two hearing-aid type batteries (included).

The Model EP-8 has built-in ferrite rod antennas for both bands. While shortwave reception is satisfactory for powerful stations such as the BBC, Radio Canada International, Radio Nederland, Deutsche Welle, and others, better SW sensitivity can be obtained by placing the receiver near a telephone or ac-line outlet. No direct antenna connections are necessary.

Priced at $24.95 postpaid in U.S.A., the Model EP-8 is available from: Radios International, P.O. Box 6053, Richardson, Texas 75080; phone (214) 784-0862.

CMOS-safe IC extractor

O.K. Machine and Tool Corporation's model EX-2 extracts all 28-40 pin DIP IC's having standard 0.600 inch body widths, including MOS and CMOS devices. The mechanism is self-adjusting and gently lifts IC from socket or board using uniform pressure applied simultaneously at both ends of the IC. Designed for easy one-hand operation, the EX-2 features heavy chrome plating for reliable static dissipation, as well as a terminal lug for attaching a ground strip (strap not included). The EX-2 is priced at $7.95 and is available through local electronics retailers or directly from O.K. Machine and Tool Corporation, 3455 Conner Street, Bronx, New York 10475.

low-cost computerized Morse keyer from AEA

A new, microprocessor-based Morse keyer — the MK-1 — has been introduced by Advanced Electronic Applications of Lynnwood, Washington.

The MK-1, which incorporates more than twenty special features, will be offered to the CW operator and Amateur market at a special introductory price of $79.95.

"We're delighted with this new keyer," AEA President Lamb explained. "It represents a major breakthrough in Morse keyers because it offers the advantages of microprocessor digital control at an affordable price."

The MK-1 can easily be programmed to send code at any rate between 2 and 99 wpm with precise full weighting control. The operator can adjust the dot to element space ratio from 0.5:1 to 1.5:1 and the dash to element space ratio from 2.0:1 to 4.0:1.

"The most exciting feature that users comment on is how easy it is to adjust the MK-1 for precise 3:1:1 (dash:dot:space) ratio" Lamb added. "This full weighting feature is not available on other keyers."

Other features incorporated in the MK-1 include: Selectable semi-automatic "bug" mode (also useful for transmitter tuning), automatic stepped sidetone frequency selection, iambic keying with squeeze paddle (paddle not supplied), operates on 9 to 16 volts dc at 200 mA (power supply available for $9.95 retail), and output for grid-block or transistor circuits.

All control of the computer is performed with a modern keypad mounted on a sloping top surface for no-skid response. All mating connectors are supplied. The MK-1 can be used as code-practice oscillator with a straight key in the semi-automatic mode. The keyer has outstanding rf immunity.

For more information on the MK-1 and other AEA products including the MorseMatic* Memory Keyer, Iso-Pole* vertical gain antennas, or Magicom speech processors, contact AEA, P.O. Box 2160, Lynnwood, Washington 98036; phone (206) 775-7373.

Larsen Electronics expands Kūlduckie line

Larsen Electronics, Inc., has added another Kūlduckie antenna series to its rapidly growing line. The new Larsen KD-4 antenna series fits all radios using a BNC connector for antenna attachment, and is available in ranges of 136-174 and 406-512 MHz.

Larsen now has a Kūlduckie antenna to fit all of the most commonly used hand-held radios. These antennas are ruggedly built to withstand the rough use common to this type of antenna. Vhf and uhf models are spring wound for flexibility, and plated with high-conductivity material for maximum radiation efficiency.

They are protected from the elements by a tough, heavy duty coating which prevents detuning from shorting and adds flexibility. They handle a full 25 watts, and are flexible enough to bend 180 degrees in all directions.

For more information write Larsen Electronics, Inc., P.O. Box 1686, Vancouver, Washington 98668.

*Trademarks of AEA

hand-held DVOM

Hickok Electrical Instrument Co. has introduced the LX304, the latest model in their LX series of hand-held DVOM's. Like the LX303, the LX304 features an easy-to-read, ½-inch high, 3½ digit LCD display; automatic polarity, zero and over-range indica-

More Details? CHECK—OFF Page 94

A Note from the Ad Department

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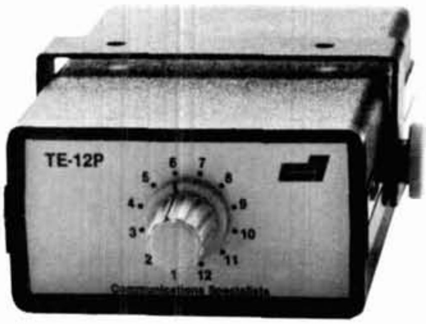
tion; ½-year battery life in typical use; simplified one-hand operation and ultra-rugged construction with excellent overload characteristics for long-term reliability.

Other features of the LX304 include an automatic decimal point, a built-in low battery indicator, diode and transistor testing capability and 0.5 per cent accuracy on dc volt ranges.

Designed for convenient and economical bench and field use, Hickok LX Series multimeters are self-contained, with test leads that store in the removable, protective thermoplastic cover. They will withstand a four-foot drop without loss of accuracy. A complete line of inexpensive accessories extends their use into high voltage applications and temperature measurements.

Price of the LX304 is $89.95. For more information, contact Hickok Electrical Instrument Co., 10514 DuPont Avenue, Cleveland, Ohio 44108.

programmable encoder



Communications Specialists has introduced a programmable 12-tone encoder, model TE-12P, available in either sub-audible or burst-tone configuration.

In the sub-audible range, this encoder allows the programming of 12 standard frequencies from 67.0 Hz to 203.5 Hz. In the audible range, burst tones may be selected in the range of 1600 Hz to 2550 Hz in 50-Hz increments. Additionally, there are thirteen other frequencies available which may be used for either burst or test purposes.

This encoder is housed in a durable plastic case measuring 5.25 × 3.3 × 1.7 inches and is complete with mounting bracket and hardware. It may be powered by 6 to 30 Vdc, unregulated at 8 mA and provides a low-impedance, low-distortion, adjustable sine-wave output of 5 V p-p. Reverse polarity protection is built-in.

Programming each channel can be done in seconds. A five position DIP switch is furnished for each of the twelve channels and it is merely a matter of setting each switch to the proper ON and OFF positions to achieve a binary-coded frequency.

The output level is flat to within 1.5 dB over the entire range of frequencies selected. In the low-frequency range, the frequency accuracy is ±0.1 Hz and in the high-frequency range, the accuracy is within ±1.0 Hz. Sub-audible tones are designated as Group A tones and audible frequencies are Group B tones. No counter or other frequency measuring device is needed to set frequencies.

The TE-12P is priced at $89.95, wired and tested, complete with instructions. For more information write Communications Specialists, 426 West Taft Avenue, Orange, California 92667.

transistor replacement guide

A 1980 edition of the RCA Solid-State Replacement Guide offering 1080 solid-state replacement devices which replace more than 161,000 domestic and foreign types is now available from RCA SK Device Distributors.

Published in January, the 1980 RCA SK Replacement Guide contains easy to read information on RCA's full line of replacement transistors, rectifiers, thyristors, integrated circuits, and high-voltage triplers including many MRO (maintenance and repair operations) replacements. The guide also includes an index and a comprehensive data section with listings grouped according to type of de-

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vice. Dealers can ask for the 368-page 1980 SK Guide at their local RCA distributor or they may send check or money order for $1.50 to RCA Distributor and Special Products, Post Office Box 597, Woodbury, New Jersey 08096.

overvoltage transient suppressors

Motorola has announced that it now supplies the recently introduced JEDEC-registered 1N6267 through 1N6303 series of zener overvoltage transient suppressors. The axial-lead, plastic packaged zener series is supplied over the standard zener diode voltage range of 6.8 to 200 volts, in both 5 and 10 per cent tolerances. These devices are rated for 1500 watts peak power dissipation for a 1 ms pulse, and 5 watts dissipation under steady-state conditions. Forward surge is rated at 200 amps for an 8 ms pulse. Maximum clamping voltage is also specified at rated reverse surge current.

The 1N6267 series is specifically designed to protect voltage-sensitive components such as TTL, CMOS, PMOS, NMOS, memories, power transistors, and other devices from destructive high-voltage transients caused by lightning, static discharge, and inductive switching. They are used in various applications such as power supplies, telecommunications equipment, industrial controls, instruments, medical electronics, communications equipment, and automotive electronics. Available now from your local Motorola Semiconductor distributor.

four-output, 5-MHz pulse generator

A new digital pulse generator has been introduced by the B&K-Precision Product Group of Dynascan Corporation. The generator, Model 3300, offers a frequency range of 5 MHz to 1 Hz and a pulse width of 100 ns to 1 s.

Four separate outputs are available. The first output is matched for 600 ohms and is intended for general purpose applications. This output offers adjustable dc offset and a maximum 30-volt p-p open-circuit output. A second output is matched for 50-ohm termination and permits pulse generation with a 15 ns rise or fall time. A TTL output is also provided for signal substitution in TTL circuitry. A full-width delay pulse output is also TTL compatible.

For analysis of digital circuitry, the 3300 outputs can be single pulsed. For interfacing two breadboarded circuits of different logic families, the 3300 can be used to shift pulse levels for compatibility. In this same way, distorted pulses can be reconstructed for operational tests. A pulse-burst capability allows the 3300 to be used as a signal source for testing counters and shift registers. The generator also can be used to frequency shift-key a function generator, such as the B&K-Precision Model 3010 or 3020.

Nine operating modes are offered on the 3300, including a pulse-delay mode, which allows the generator to be used with a conventional triggered scope to provide delayed-sweep operation. This allows the user to increase the usefulness of an existing scope without purchasing a delayed-sweep model. A fixed-delay mode is also provided for a quick set-up of scope delay.

For pulse generator operation, control over pulse period, delay, and width is fully independent. The controls for each have seven discrete steps, plus a continuous vernier adjustment. An LED warning indicator alerts the operator of any incorrect settings that might cause the generated pulses to overlap, thereby creating a dc level.

The 3300 comes in a compact case with a combination tilt stand/carrying handle. A 48-page operation and applications manual is included. Price is $325. For additional information, contact B&K-Precision, 6460 West Cortland Street, Chicago, Illinois 60635.

variable test load for rf power amplifier

A new, variable test load for rf power amplifiers and radio transmitters is available from Design Automation, Inc.

The Design Automation Model L10-5 is a 10.5 MHz variable test load that lets you determine if an rf power amplifier or radio transmitter can withstand arbitrary mismatched output loads without damage or spurious oscillation. Other standard test loads from 10 to 100 MHz are also available.

With a 50-ohm nominal transmission-line impedance, the L10-5 provides ten switch-selected values of SWR from unity to infinity (greater than 40), and continuously variable coverage of all 360° of reflection coefficient. Depending on SWR value, the test load can dissipate 5 to 20 watts.

The L10-5 is priced at $285. For more information contact Nathan Sokal at Design Automation, Inc., 809 Massachusetts Avenue, Lexington, Massachusetts 02173, or call (617) 862-8998.

Zulu II clock kit

The new six-digit Mobile/Fixed-Station Zulu clock kit is now available from Bullet Electronics. The kit features quality G-10 plated and drilled PC boards, detailed step-by-step instructions with illustrations and schematics and all the required parts.

The kit is called the Zulu II, and has as standard features large 1/2-inch character LED readouts, quartz crystal and brightness control, noise-rejection circuitry, and a calendar on demand.

The Zulu II will be sold without a case for $16.95, or with an attractive injection-molded case in either blue or beige for $22.95. The addition of a small 12 Vac transformer allows standard ac operation. The kit is the result of numerous customer requests for a clock of this design.

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new edition Of Kester Solder brochure

A new edition of Kester Solder's 12-page brochure covering its broad line of solders and fluxes has been published by the Litton Industries division.

The publication covers acid- and resin-cored solders, flux-cored silver-bearing solders, and radiator solder. Also included are Kester's half-pound spools of acid-core, solid wire, and "44" resin-core solders. Kester's handy package-goods solders, and other carded merchandise are featured too — metal mender, TV-radio solder, aluminum-repair solder, solder-paste flux, and related chemical products.

"Soldering Simplified" and "Questions and Answers about Soldering" are included in the brochure.

Copies are available on request to Mack Haraburd, Vice President, Marketing, Kester Solder, 4201 Wrightwood Ave., Chicago, Illinois 60639.

A Chicago company for 81 years, Kester Solder is a leading manufacturer of quality solders and soldering chemicals and cleaners.

Fault Finder locates shorts and opens

The Fault Finder is a solid-state electronic device which, when used in conjunction with a standard clamp-on ammeter, aids in locating shorts or opens in automotive, marine, and aircraft electrical systems, or any other type of electrical system which operates in the range of 5 to 30 volts dc.

Operation is extremely simple. In an automotive electrical system for example, the Fault Finder is clipped into the circuit at the fuse block or at the battery and the clamp-on ammeter gives a direct indication of a short. Any ammeter deflection means a short exists in the circuit. No deflection, no short. Exact location of the short is accomplished by taking readings with the ammeter at various points in the circuit away from the

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battery or fuseholder. When no current is indicated, the short is known to be between that point and the last point at which current was indicated.

Location of open circuits is accomplished without the use of the ammeter. A puncture clip is provided for this purpose, and a red LED indicator lamp on the Fault Finder gives direct indication of voltage.

The Fault Finder requires no internal battery and comes with a one-year limited warranty at a suggested retail price of $79.95. A variety of clamp-on ac ammeter models are available at the manufacturer's suggested retail price less 15 per cent. Dealer inquiries welcome.

Contact Paul Brinegar, Trinity Electronics, Inc., 6001 North Michigan Drive, Kansas City, Missouri 64118; phone (816) 452-1045.

CW station identifier

Spectrum Communications' model ID1000 automatic morse CW station identifier is a 1-2 channel, stored-program unit designed to connect with any solid-state or tube-type base station or repeater transmitter. This new IDer features automatic identification of the station, either at completion of activity or at 15-30 minute intervals, built-in AC power supply, optional provision for 12-Vdc battery input with automatic switchover to special "Emergency Power ID." CW tone pitch, speed, level, and time are adjustable.

The transmitted code signal is a pleasant sinusoidal note, and the unit has an output capacity of up to 6 volts p-p into a 600-ohm or greater load. A plug-in PMOM chip is used to store the memory. The unit is housed in a standard 19-inch rack mount.

The unit ensures full and automatic compliance with the FCC requirements of parts 89, 91, 93, and 95, as well as other applications. For further information, contact Spectrum Communications Corp., 1055 W. Germantown Pike, Norristown, Pennsylvania 19401, (215) 631-1710.

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flea market

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DX, YOU BET! THE DX BULLETIN — Best weekly DX info in the world. For FREE sample copy, send business-size SASE to: The DX Bulletin, 306 Vernon Avenue, Vernon, Connecticut 06066.

OSCILLOSCOPE: Tektronix model 541 30 MHz scope, without plug-in, $200. G. Hamlin, 118 Grand Canyon Dr., Los Alamos, N.M. 87544. (505) 672-9396 after 6 pm.

STOP LOOKING for a good deal on amateur radio equipment — you've found it here — at your amateur radio headquarters in the heart of the Midwest. Now more than ever where you buy is as important as what you buy. We are factory-authorized dealers for Kenwood, Drake, Yaesu, Collins, Wilson, Ten-Tec, ICOM, DenTron, MFJ, Tempo, Regency, Hy-Gain, Mosley, Alpha, CushCraft, Swan and many more. Write or call us today for our low quote and try our personal and friendly Hoosier Service. HOOSIER ELECTRONICS, P.O. Box 2001, Terre Haute, Indiana 47802. (812) 238-1456.

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Greenside, Johannesburg
Republic of South Africa

YAESU — FT 101E. $450. Kenwood 820S with AC and DC power supplies, $750. E. Kravat, WA4BBH, 103 C. Wellington CV, West Palm Beach, FL 33409.

ROHN TOWER: Buy wholesale from worldwide distributor; 20G, $28.44 each; 25G, $37.62 each; 45G, $83.60 each; 48-foot foldover tower, $660, freight paid; BX freestanding tower, $224.02. Hill Radio, 2503 G.E. Road, Box 1405, Bloomington, Illinois 61701. (309) 663-2141.

WANTED: GE 4EG27A10, 4EG28A10, 4EG28A11, GE General elements. Jim Arndt, N5TA, 1122 E. Austin St., Giddings, TX 78942.

SPECIAL SALE: Alliance HD-73 Heavy Duty Rotor $99.99 plus $3.00 shipping Continental USA. MC and Visa accepted. Scanner World, USA., 10-H New Scotland Ave., Albany, NY 12208. 518-436-9606.

RADIO BROADCAST TECHNICIANS — Voice of America has opportunities in Washington, D.C. for qualified Radio Broadcast Technicians. These positions require a comprehensive background in the recording, maintenance, studio and field areas. Salary range: $10.59-$14.87 per hour depending on qualifications. U.S. citizenship required. Submit standard Federal application form, SF-171, to International Communication Agency, MGT/PDE (1-78), Washington, D.C. 20547. An Equal Opportunity Employer.

MOBILE HF ANTENNA 3.2-30 MHz inclusive, 750 watts PEP, center loaded, tuned from the base, eliminating coil changing or removing from mount. Less than 1.5 to 1 VSWR thru entire coverage. $129.95 ea. plus shipping. Contact your local dealer, if none in your area order direct. Anteck, Inc., Route One, Hansen, Idaho 83334. (208) 423-4100. Master Chg., and VISA accepted. Dealer and factory rep. inquiries invited.

TRANSMITTER TECHNICIANS — Voice of America has opportunities for qualified technicians at VOA stations near Delano, California, and Greenville, North Carolina. Duties include operations/maintenance of high power shortwave transmitters and related facilities on shift basis. Minimum qualifications: 3-years chief broadcast engineer 5 to 50 KW, or 3-years supervisor of operations/maintenance high power military transmitting plant, or equivalent. U.S. citizenship required. Starting salary $18,760. Submit standard Federal application form, SF-171, to International Communication Agency, MGT/PDE (1-78) Washington, D.C. 20547. An Equal Opportunity Employer.

VERY in-ter-est-ing! Next 3 issues $1. "The Ham Trader", Wheaton, IL 60187.

SATELLITE T.V. . . . Build your own satellite receiving station. Quick and easy to construct. For more information write . . . Robert Colemen, Rt. 3, Box 58-A, Travelers Rest, S.C. 29690.

CW/SSB FILTERS: IC audio install in any radio, sharp CW, stagger tuned SSB — $15, $32. SASE info: W8CBR, 80 W. Mennonite, Aurora, OH 44202.

SOLAR PANELS: 500 MA. 17v open circuit. 32 · 2.2" cells on 1/8" fiberglass plate, potted in silicon. Slight mechanical imperfections, electrically perfect. 4 panels, $125 each. Send check or money order to James R. Zubrecky, 11609½ Friar St., N. Hollywood, CA 91606. Telephone: (213) 766-6831.

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

SELL CLASSIC RADIO EQUIPMENT. Viking I and VF-1, Meissner EX Shifter, VHF-152A, ST-203A, Command Xmtrs, tubes, parts. Reasonable. Write for list. Charlie Bremigan, W9WJL, 18650 Gottschalk, Homewood, IL 60430. (312) 798-6120.

WANTED — Instructor Ham Radio, N.Y.S. Co-ed Children's Sleep-away Camp. Write: Camp Kinder Ring, 45 East 33rd St., New York, NY 10016.

YAESU FT-207R OWNERS: We have an automatic scan module for your rig. 15 minutes to install; scan restarts when carrier drops off; busy switch controls automatic scan on-off; includes module and instructions. Model AS-1. Send $25 to Engineering Consulting Services, P.O. Box 94355, Richmond, B.C., V6Y2A8 Canada.

THE MOR-GAIN HD DIPOLES are most advanced, highest performance multi-band HF dipole antennas available. Patented design provides length one-half of conventional dipoles. 50 ohm feed on all bands, no tuner or balun required. Can be installed as inverted VEE. Thousands in use world wide. 22 models available including two models engineered for optimum performance for the novice bands. The Mor-Gain HD dipoles N/T series are the only commercial antennas specifically designed to meet the operational requirements of the novice license. Our 1-year warranty is backed by nearly 20 years of HD dipole production experience. Write or call today for our 5-page brochure. (913) 682-3142. Mor-Gain, P.O. Box 329H, Leavenworth, KS 66048.

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COLLINS: 75S3B — $550; 30LI — $595; 312B5 — $425; KWM2 — $495. All mint. Schaaf, Box 301, DePere, WI 54115. (414) 532-6643.

HAM RADIO REPAIR, alignment. Prompt, expert, reasonable. "Grid" Gridley, W4GJO, Route 2, Box 138B, Rising Fawn, GA 30738.

WE-800 — sell for $325. Just reconditioned by Wilson. Purchased late 1979. Dan Shamanski, 1202 Inchon, Norfolk, VA 23511. (804) 489-4460.

ATLAS OWNERS DD6-C and 350XL Digital Dial/Frequency Counters. $175.00 + Shipping (Calif. add tax). Mical Devices, Box 343, Vista, CA 92083.

WANTED: Older tube radio for grandson. Ham band or general coverage. Working or not. J.D. Grigas, 1449 W. Ash Ave., Fullerton, CA 92633.

REPLACE RUSTED ANTENNA BOLTS with stainless steel. Small quantities, free catalog. Elwick, Dept. 376, 230 Woods Lane, Somerdale, N.J. 08083.

MULTIBAND ANTENNAS! Completely assembled, tuned; half the length of a conventional dipole! Includes 90' RG58U, postpaid, guaranteed one full year. 80-10M, $59.95; 80-40M, $55.95; 40-10M, $49.95! Compare our prices! MPV Electronics, Box 1133, Cumberland, MD 21502.

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SATELLITE TV RECEPTION: 36-page "How-To" book. Complete reprint of Bob Cooper's 7-article series from *Radio Electronics* magazine. $6 postpaid, U.S. and Canada. All others add $3 postage. N.Y.S. residents add 48¢ sales tax. Satellite TV Reception, Box C, Radio Electronics, 45 E. 17th Street, New York, N.Y. 10003.

CALLETTER/NAME-BADGE — 1" × 3" Engraved in wood-grain appearing surface. $1.25 per line. Send check to Engraving Specialists, Box 77, Ypsilanti, Michigan 48197.

NEW & USED HAM AND COMPUTER EQUIPMENT. Monthly publication. Subscription $5.00. Write Nuts & Volts, P.O. Box 1111, Placentia, CA 92670.

FOR SALE: Kenwood TS-820S transceiver. Used 10 hrs and in mint condition. $700.00 and will ship UPS.

WANTED: EICO #720 or #723 xmtr, Hallicrafters HT40 xmtr and HA5 vfo. J. Titus, Box 242, Blacksburg, VA 24060. (703) 951-2684.

MANUALS for most ham gear 1937/1970. Send 25¢ for "Manual Catalog." H.I., Inc., Box H864, Council Bluffs, Iowa 51502.

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BUY-SELL-TRADE. Send $1.00 for catalog. Give name address and call letters. Complete stock of major brands new and reconditioned amateur radio equipment. Call for best deals. We buy Collins, Drake, Swan, etc. Associated Radio, 8012 Conser, Overland Park, KS 66204. (913) 381-5900.

FOR SALE: Collins Mechanical Filters — F 500Y; F 500 F 94; F455 D 60; F455 Z 5 — all $20 each. F 250 A 20; F 200 L 10; F112 Z 4; F 88 M 03; F 76 Z 2; F 76 Z 7 — all $10 each. Hank Olson, P.O. Box 339, Menlo Park, CA 94025.

Coming Events

ONTARIO: Lake Simcoe Hamfest, June 13th, 14th and 15th, at Molson's Park, Barrie, Ontario, Canada. Registration: $4 by mail, $5 at gate. Children under 18 admitted free. Doors open at 12:00 noon on Friday the 13th, with talk-in on VE3LSR 146.25/.85 and 146.52 simplex, or 3780 kHz SSB. For information, reservations, or tickets, write to Lake Simcoe Hamfest, P.O. Box 2283, Orillia, Ontario L3V 6S1, Canada.

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MAINE: Yankee Hamfest '80 sponsored by the Yankee Radio Club will be held on Saturday, June 28th at the Oxford County Fairgrounds, Oxford. Ladies and youth programs, swap tables, buffet dinner. Tickets: $8 with dinner, $7 in advance; for admission only $2.50. Camper hook-ups available at $2/night. Talk-in on 146.28/88, 146.52 simplex. For tickets and information send SASE to: Lynda Mount, 198 Cony Extension, August, ME 04330.

RADIO EXPO "80" Lake County fair grounds, Rt. 45 & 120. Sept. 6 & 7 — advanced tickets $2.00, $3.00 at gate. Write: Radio Expo Tickets, P.O. Box 1532, Evanston, IL 60204. Exhibitor information call (312) BST-EXPO.

CALIFORNIA: 1980 Santa Maria Swapfest and BBQ, Sunday, June 15th. Best steak and biggest hamfest in the west. Prizes include the Yaesu FT-707. Swap tables available. QLF and QBK contests. Tickets $7 adults, $3.50 children 6-12. Write Santa Maria Swapfest, P.O. Box 1615, Vandeberg AFB, CA 93437 or call KA6AKC (805) 734-1380.

ILLINOIS: The Jacksonville Area Amateur Radio Club will hold its annual Hamfest and Flea Market on June 15th, at the Morgan County Fairgrounds, Jacksonville. Indoor facilities, food available. Talk in on 52/52. Tickets $1.50 each or 4 for $5.00. Contact: Ken Gotsch, 213 Brookside, Jacksonville, IL 62650.

MICHIGAN: Central Michigan Amateur Repeater Association's Swap & Shop, Midland, June 21st, at the Midland County Fairgrounds. Computer demonstrations, door prizes. Talk-in on: 146.73 WR8ARB and 146.52 simplex. Tickets and info SASE to: R.L. Wert, W8QOI, 309 E. Gordonville Rd., R#12, Midland, MI 48640.

MICHIGAN: The annual Monroe County Radio Communications Hamfest is June 8th, from 8 a.m. to 4 p.m., Monroe Community College, Monroe. Tickets $1.50 — Xyl's and children free. Free parking. Plenty of table space — contest, auction, displays. Talk in on: 146.13/73 and 52. Contact: Fred Lux, WD8ITZ, P.O. Box 982, Monroe, MI 48161 or call (313) 243-1088.

OHIO: The annual Wood County Ham-A-Rama will be held Sunday, June 29th at the Wood County Fairgrounds, Bowling Green. Gates open at 10 a.m. with free admission and parking. There will be drawings for prizes; tickets $1.50 in advance, $2.00 at door. Tables and trunk sales space available — advance table rentals to dealers only. K8TIH talk-in on .52. For more info write: Wood County A.R.C., c/o C. Falls, 201 Martendale, Walbridge, OH 43465.

NEW JERSEY: The Raritan Valley Radio Club's annual Hamfest and Electronic Flea Market, June 21st from 8 a.m. to 4 p.m. at Columbia Park, Dunellen. Club calls W2QW and WR2ACS. For details write: RVRC, RD 3, Box 317, Somerset, NJ 08873, or call (201) 356-8435. Talk-in: 146.025/.625, 146.52. Tickets $2; sellers $3.

OHIO: The Champaign-Logan Amateur Radio Club's annual Hamfest, Sunday, June 29, at the Memorial Hall, Belle Center. Tickets $1.50 advance, $2 at door; trunk and table space is $3.00 Talk-in on 146.52 simplex. For more information write: C.L.A.R.C., P.O. Box 637, Bellefontaine, OH 43311.

VIRGINIA: The Ole Virginia Hams A.R.C. of Manassas announces its "Quality Hamfest" for June 1st, Prince William County Fairgrounds — 1/2 mile south of Manassas. Admission $3 — children under 12 free; tailgater $2 additional per vehicle. Indoor and outdoor exhibits, clinics, programs, breakfast and lunch available. Talk in on: 37/97 and 52 simplex. For more information write: Dick Fredrickson — W7MPZ/4, 9511 Sudley Manor Drive, Manassas, VA 22110.

ILLINOIS: The annual ABC Hamfest sponsored by the Six Meter Club of Chicago, will be held on Sunday, June 8th at Santa Fe Park, Willow Springs. Picnic grounds, displays, swapper's row, refreshments available — tickets in advance $1.50, at gate $2. Talk in on 146.94 FM or WR9ABC 37-97 (PL2A). For tickets write: Val Hellwig, K9ZWV, 3420 South 60th Court, Cicero, IL 60650.

VIRGINIA: Workshop: TRS-80 Interfacing and Programming for Instrumentation and Control, June 23-27. A hands-on workshop with participants working with and designing interfaces for TRS-80 Microcomputer. For more information write: Dr. Linda Leffel, CEC, Virginia Tech, Blacksburg, VA 24061 — (703) 961-5241.

WEST VIRGINIA: The Tri-State Amateur Radio Association's Hamfest will be held on June 7th and 8th at the Huntington Civic Center, Huntington. Commercial and flea market space still available. Many activities planned for both amateurs and non-amateurs including banquet on Saturday night. Admission $3 for both days. Talk-in on 146.04/146.64. For further details write: The Tri-State Amateur Radio Association, c/o Phil Jones, WD8OTJ, 309 22nd Street West, Huntington, WV 25704.

NEW YORK: WA2JHD will be taking calls on June 14th from 10 a.m. to 12 midnight EDT for special QSL cards commemorating the sesqui-centennial of the town of Amity. Call CQ centennial on 3915 ± QRM.

NEW HAMPSHIRE: The Mount Moriah Repeater Society will hold a DXpedition at Mystery Hill, North Salem on June 7 & 8 from 1800Z Saturday until 1800Z Sunday. Mystery Hill is a 4000 year old astronomical observatory and pre-historic temple. Frequencies: Phone — 3980, 7280, 14280, 21380, 28580, 146.52; CW — 3550, 3710, 7050, 7110, 14050, 21050, 21110, 28150 — call sign: K1MDX. For certificates send legal size SASE to K1RCT, P.O. Box 123, North Salem, NH 03073.

TEXAS: Ham-Com is hosting the West Gulf Division ARRL Convention at the North Park Inn, Dallas, on June 6, 7 & 8. For reservations write Ham-Com, Inc., Box 29340, Dallas, TX 75229 or call Tom Gentry at (214) 620-2784 and he will sign you up.

PENNSYLVANIA: The Milton Amateur Radio Club's Hamfest will be held June 8 at the Allenwood Firemen's Fairgrounds on U.S. Rte. 15, Allenwood, from 8 a.m. to 5 p.m. Sellers' tickets in advance: $2.50 - $3 at gate. XYL's and children free. Prizes, contests, indoor area available, food and beverages. Talk-in on 37/97 and 52 simplex; club calls: K3FLT, WR3ADL. For further details call or write: Kenneth E. Hering, WA3IJU, R.D. #1, Box 381, Allenwood, PA 17810, (717) 538-9168.

MARYLAND: Frederick A.R.C. Hamfest, June 15th, at the Frederick Fairgrounds, East Patrick Street. Grounds open 6 a.m. for commercial and tailgating; breakfast available. Hamfest opens 8 a.m. for general admission; donation $3 and $2 extra for tailgating; YLs and children free. Plenty food, drink, parking. Talk-in K3ERM 146.52 simplex. For more information, write Mike Staley, WB3LJK, New Market, MD 21774; or Hamfest Committee, P.O. Box 1260, Frederick, MD 21701.

WEST VIRGINIA: QSO party, from 1600Z 21 June to 1600Z 22 June, with no operating time limits. One contact for each station per band. Exchange QSO number, report, county (W.Va only), state or country. Only one unassisted operator per station for award. Multiplier for QRP. Send logs to West Virginia QSO Party, Route 1-A, Box 6-A, Moorefield, West Virginia 26836.

PENNSYLVANIA: The Broadcasters' Amateur Radio Club will conduct its Hamfest on July 13th from 9 a.m. to 4 p.m. at the Pocono Downs Race Track, Rt. 315, Wilkes-Barre. Unlimited outdoor and indoor space, refreshments, prizes; admission $2.50 — XYL's and children free. No additional charge for sellers. Gates open at 8 a.m. for set-up. Talk in 147.66/.06 and 146.52. Contact: Charles Baltimore, WA3NUT (717) 823-3101; B.A.R.C. 62 S. Franklin St., Wilkes-Barre, PA. 18773.

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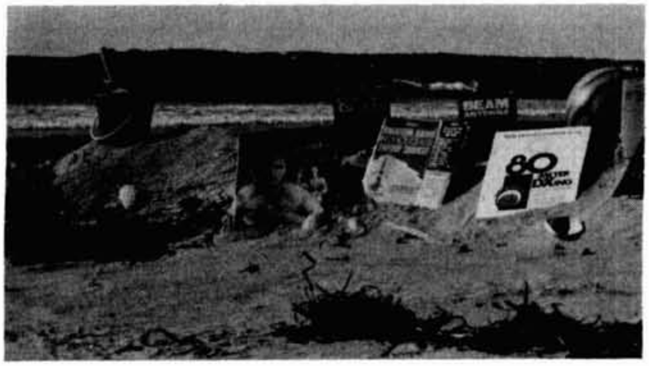

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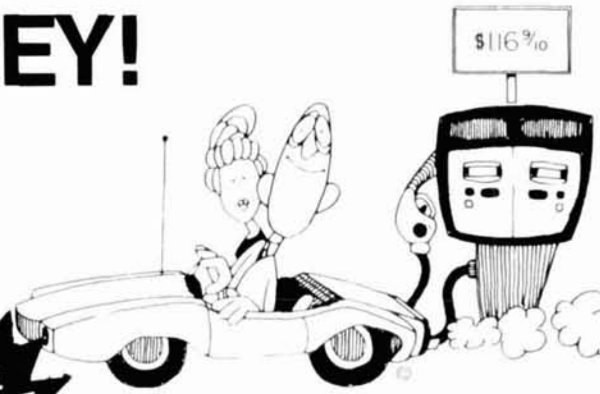

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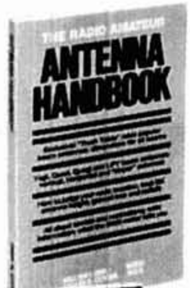

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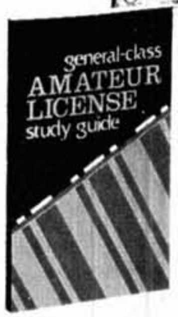

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