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ham radio magazine

- 2716 EPROM programmer
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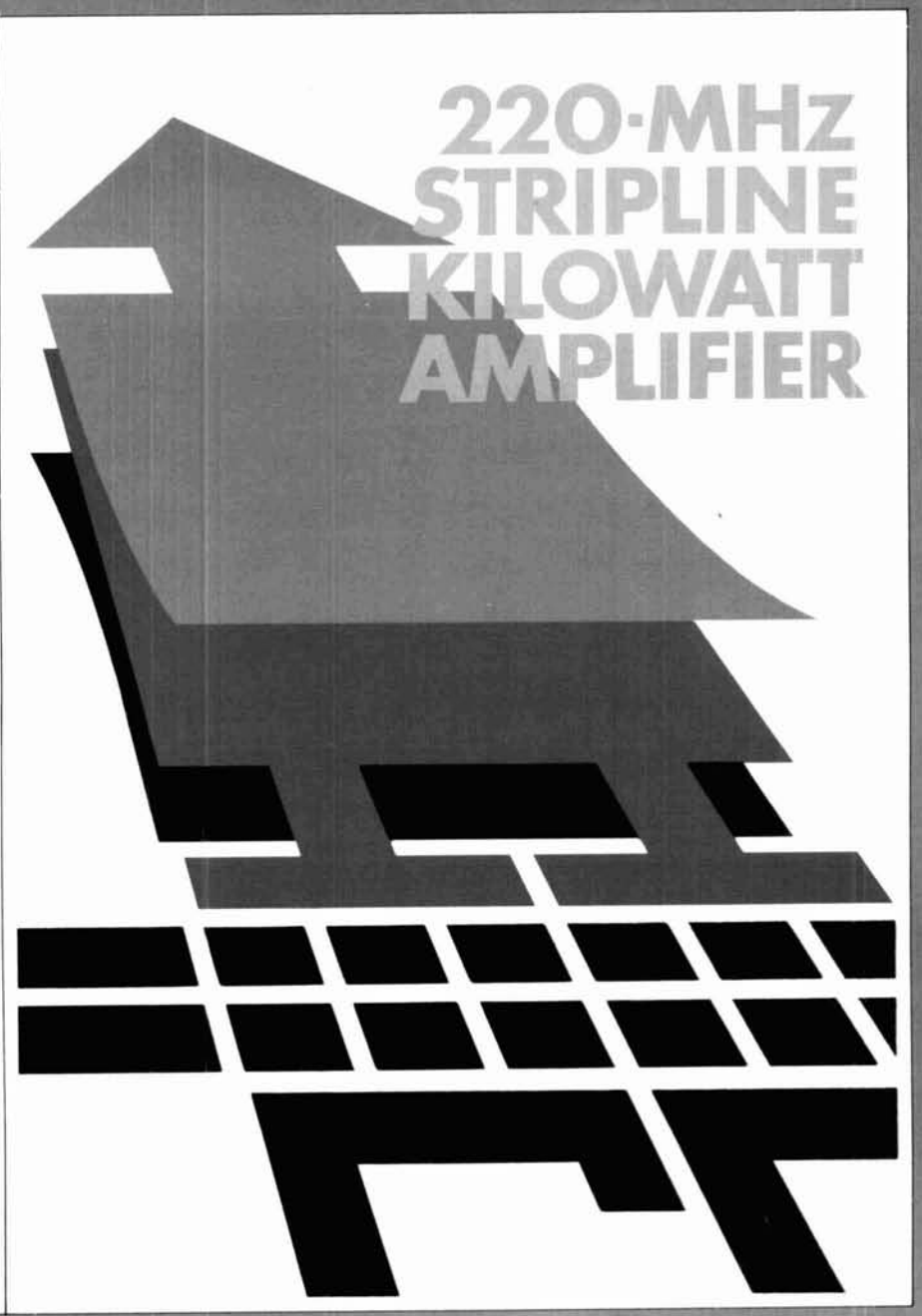

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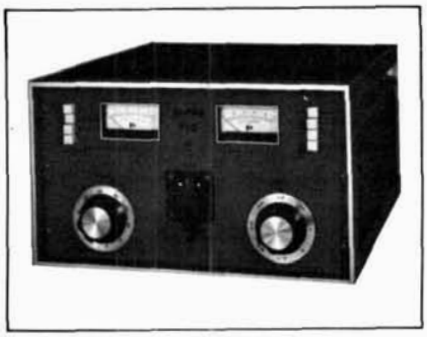
More Details? CHECK—OFF Page 92



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APRIL 1982

volume 15, number 4

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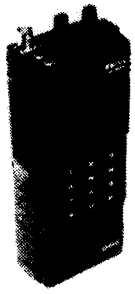

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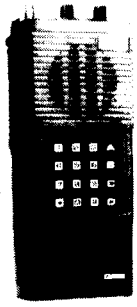

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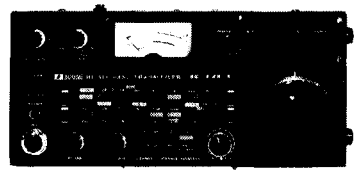

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'til next time, Don

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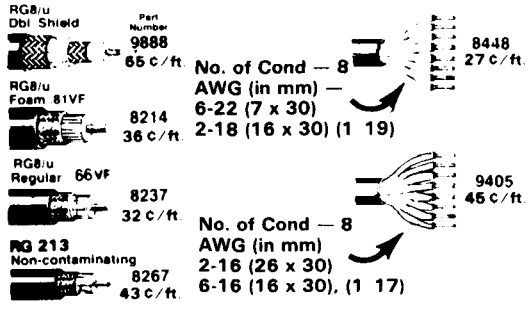

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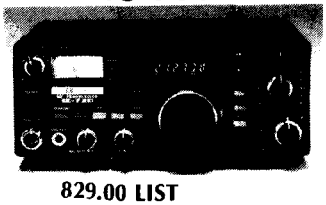

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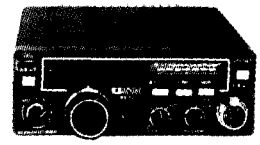

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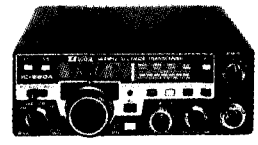

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2 meter multimode mobile, 12 VDC, 10 W. out, FM, SSB, CW, Priority channel, scanning, CW sidetone, squelch on SSB.

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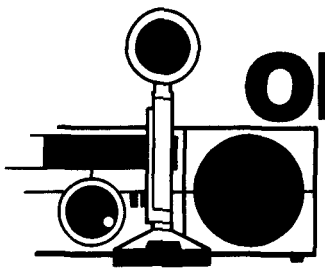

Observation & Opinion

During my ham career, I have always been an enthusiastic member of the DX fraternity. I've been through more sunspot cycles than I care to remember, always trying to increase my DXCC country total, and I have managed to accumulate a fairly respectable number of confirmed contacts. All this took place when I was in California. There I had all the trappings considered necessary to compete with the big guns in kilowatt alley and was able to hold my own pretty well in the pile-ups. However, things have changed — and for the better, I might add.

My move from California to New Hampshire required that I put all my ham gear, some 35 years' accumulation, in storage, where it still remains. But strangely enough, I don't really miss it. I've rediscovered a new and far more challenging pursuit, one that I followed only casually in California — the world of QRP, or low-power operation.

With the kind help of Skip Tenney, I was on the air with borrowed equipment and a longwire antenna shortly after I arrived in New Hampshire. The gear was nothing exotic — just a good high-frequency transceiver with adjustable power output and a few accessories. My experience with this borrowed rig, operating from a good location (for a change), has been most rewarding. It's altogether a different game chasing DX stations when you don't have a big antenna and a kilowatt amplifier.

The term QRP is from the international list of Q-code signals and means *reduce power*. QRP operation in the Amateur bands has several definitions, depending on whom you talk to. To some, anything below 100 watts is QRP. However, true QRP is generally recognized as an input power of 10 watts or less, and 1 watt or less is called QRP$_P$. With a good antenna and only a few milliwatts, tremendous distances can be covered in the high-frequency bands. But this kind of achievement is possible only with skillful operating and, above all, patience and perseverance.

A certain etiquette and some unwritten rules prevail among the QRP brethren. These have evolved over the years and are generally accepted by serious operators. For example, it's not considered good form to make contact with high power then ask the station to listen for your QRP signals. Another practice frowned upon is making prior arrangements with a station for a QRP contact. It is also considered unethical to have a friend ask the desired station to "stand by for W6BLANK using QRP." I tried a few of these tactics during my early days of QRP operating before I learned how to behave. True, I made some contacts, but they didn't seem as rewarding as those made according to the rules.

I've heard some operators say that it isn't very productive for a QRP station to call CQ. This may be true during the early evening hours when the bands are crowded; however, I've found that if I get on the air late at night, find a clear spot, and call "QRP" several times followed by my callsign, it is possible to obtain replies. Furthermore, many foreign stations enjoy working U.S. QRP stations, as I have discovered on 40 meters, especially near 7025 and 7060 kHz. Overseas operators also do a lot of listening, and I was surprised one evening to find that stations were actually calling me after I finished a QSO with a Belgian station. What an experience! I'd actually created a mini pile-up.

It doesn't take much equipment to get a QRP station on the air. A simple but stable VFO will serve as a transmitter. A selective receiver is important, and the antenna should be as efficient as you can possibly make it. Although a gain antenna is an asset, a simple, well-matched dipole will give good results in QRP work.

If you want to experience a real sense of achievement resulting from some rigid operating discipline, I highly recommend QRP work. Now, I wonder who will be the first U.S. ham to earn the Worked All Continents award with 500 milliwatts on the new WARC bands?

Alf Wilson, W6NIF
editor

comments

Pendergast's return

Dear HR:

The article on traps in the October issue is excellent stuff. Very seldom do I get so interested in the first article that I get stuck there to the temporary exclusion of the rest of the magazine. I normally scan the whole issue first and start with the one that interests me most. The return of the magazine to an emphasis on technical excellence is most encouraging. Congratulations on a good job.

A couple of small points. In the July issue, page 52, 0.707 of the power has somehow become half the power; 0.707 of the field strength *in volts* would be half the power.

In the August issue I couldn't help a feeling of foreboding that Pendergast had snuck back into Bill Orr's material, and sure enough when I arrived at work there was a note from a colleague saying, "If you are writing to *ham radio* for Pete's sake complain about Pendergast's return." I am hereby passing on that message, with a fervent plea from me that Pendergast stay dead. Bill Orr is often interesting, but the dialogue sometimes gets in the way. I know many readers that feel this way, and can honestly say that I don't know anyone who likes Pendergast. It was most encouraging to see no mention of P. in October!

To come back to the Gary O'Neil piece on traps, I think it would interest all readers if you could print a note from Gary on the kind of power his RG8/U traps can handle, and how far off frequency you can operate before the trap heats up because of circulating current. And here is a question. When feeding a trap dipole directly with coax (no balun), I find the trap in the side connected to the braid gets hot enough to melt the encapsulant, while the other one stays cool. Why? (Swapping them confirms that it is the position, not the trap, which causes the heating.)

Bob Eldridge, VE7BS
Pemberton, B. C.

lifeline SAR

Dear HR:

We are a volunteer, non-profit public service organization headquartered in Madison, Indiana, and we're looking for members from all over the world. Our prime objective is to form local chapter units for those areas that don't already have a qualified search and rescue (SAR) organization. There are, unfortunately, all too many such areas.

Our organization currently possesses members in 27 divisions (25 states plus Canada and the Republic of Singapore). We rely on Amateur Radio as a back-up communications network and for any long-range traffic we may have. Our primary means of communications is our own VHF-fm commercial radio system.

In addition to looking for members, we are also looking for donations of radio equipment (both VHF-fm commercial and Amateur) to help us build our organization and its chapters up to an operational level. All donations (cash and otherwise) are 100 percent deductible for federal income tax purposes.

Everyone is eligible to apply for membership. Those who inquire are asked to enclose an SASE to help with the rising costs of mailing. All inquiries will be answered promptly. For further information, please write Lifeline Search and Rescue, P.O. Box 237, Milton, Kentucky 40045.

Jeff E. Howell, CEMT (WB9PFZ)
Executive Director
Lifeline SAR

a card from Frenchy

Dear HR:

Bill Orr's article in the August issue brought back fond memories of DX for a then-young Amateur. After I got my ticket in mid 1938, it took me almost a year to scrounge up the parts for my homemade superhet and 6A6-PP6L6 transmitter.

By that time World War II had drawn the curtain over much of the DX, but nevertheless, my spare and weekend hours were spent listening for something "rare."

One early morning in December of 1939, there was the same KF6ROV mentioned in Bill's article, calling CQ; with trembling hand I called him, and "Frenchy" Paquette in Pago Pago came back to my call. This is one of my most prized QSLs.

Thanks again to Bill and to you for a fine magazine.

F.V. Sprick, W2LPV
Clifton, New Jersey

kilo foxtrot Charlie?

Dear HR:

In regard to the comments by Mr. H.B. Mouatt, W6BQD, in the January, 1982, issue, I am in full agreement. The use of Q signals on phone has long been a source of improper operation, insofar as they are intended for use on CW. If one is going to stop transmitting, simply say so, not QRT. I am sure there are others, but this is one I hear a lot. This practice seems to be common among newcomers and old-timers as well.

The use of one's own phonetics for one's own call, however, seems to be perfectly proper to me. I have heard both U.S. and foreign Amateurs use their own personal phonetics many times. In fact, one very good friend, Vic Clark, W4KFC (past ARRL VP and Roanoke Division Director), would probably be unrecognizable to me on the air if he were to say Whiskey Four Kilo Foxtrot Charlie instead of W4 Kentucky Fried Chicken.

Ed Redington, Jr., N4AGS
Ashland, Virginia

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You get text buffer, programmable and automatic message memories, error deletion, buffer preload, buffer hold, plus much more.

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The 256 character (50 for 494) **text buffer** makes sending perfect CW effortless even if you "hunt and peck."

You can preload a message into the buffer and transmit when ready. For break-in, you can stop the buffer, send comments on key paddles and then resume sending the buffer content.

Delete errors by backspacing.

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The ASCII mode includes all the features of Baudot. Transmission speed is 110 baud. Both upper and lower case are generated.

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More Details? CHECK—OFF Page 92

presstop

THE FCC HAS ACTED IN THE JAMMING cases involving the Maritime Mobile Services Net. In a release dated January 28, 1982, the Commission revoked the license of Leonard M. Boucher, K4MME, of Cantonment, Florida, and at the same time suspended for one year the license of Gerard Morin, W1GM, of Sanford, Maine. In their "Order of Revocation and Suspension" the Commission found that, between August, 1980, and June, 1981, Boucher and Morin operated in a split frequency scheme designed to deliberately and maliciously interfere with radio nets operating on the frequency of 14.313 MHz.

Boucher Received The Greatest Amount Of Attention and criticism from the FCC. They noted that on February 17, 1981, they monitored Boucher requesting a station to move down with him to the frequency on which net participants were operating, and on February 18th he was again heard to criticize the operator of a station for not moving directly on top of the frequency occupied by the net. Other instances were cited as well.

A5 MAGAZINE HAS PROPOSED SSTV operating frequencies based on the recent approval of FCC Docket 80-252 which expands SSTV/FAX operations in the General Class phone bands. A5 proposes the following frequencies: 3.990, 7.290, 14.340, and 21.440 MHz with all movement upward only utilizing the top 10 kHz of band edges. Any comments should go to Mike Stone, WBØQCD, A5 Magazine, P.O. Box H, Lowden, Iowa 52255. Mike will also be on hand at the 1982 Dayton Hamvention's ATV Forum at 2:00 PM on Saturday, April 24th.

ARNIE VERDOW, WØLIJ, a familiar sight at many hamfests as he manned the Collins booth, passed away February 1. His easy going, likable manner, along with his extensive first-hand knowledge of post-war Collins products, combined to make him a favorite in the Amateur community. He will be missed as a professional but even more as a good friend.

THE UNITED STATES WILL SOON HAVE A "WOODPECKER" operating in the 5 to 35 MHz spectrum. Like its Russian counterpart, it also will be an over-the-horizon radar system. It will be located near the city of Moscow, Maine. Built by General Electric Corporation under contract to the U.S. Air Force, it will have an ERP of 1.2 megawatts. The system is in its final testing stage, with full-time operation scheduled to begin sometime in 1982. What effect our woodpecker will have on Amateur Radio hf communications is unknown, but the military has promised to work with the Amateur community to reduce its impact.

DR. NORM CHALFIN, K6PGX, REPORTS that Wednesdays (UTC) are Experimental Days on the Soviet R/S Satellites. During that time, the birds are reserved for previously arranged uplink transmissions. Chalfin also informs us that all passbands on the R/S transponders are linear; that is, USB in on 2 meters produces USB out on 10.

SATELLITE TELECASTERS ARE GOING TO GREAT LENGTHS to try to end the pirating of their subscription services. Premier Communications Network of San Jose, California, placed an advertisement in a recent edition of the San Jose Mercury newspaper appealing to area residents to trade in their "illegal" pirate antennas on a "legal" installation from their company for Home Box Office service. The newspaper ad contains a reprint of findings regarding the secrecy of communications provisions of Section 605 of the Communications Act, and it then offers amnesty along with guaranteed service to anyone answering the ad and becoming a subscriber.

Swift Reaction Has Come From The Area's Local Amateurs. Writing in the Bay Area 220 Group newsletter, Pres. Jerry Lahtinen, W6TTU, stated that his organization considers HBO to be the real pirates since that service utilizes publicly owned spectrum, and he has called for the abolition of HBO entirely.

AN ON-SITE ALERT AT THE R.E. GINNA NUCLEAR PLANT January 25th saw hams from Rochester, Monroe County, and Wayne County (New York) put themselves on alert as well. Fortunately, the problem did not require evacuation of the area and the alert was downgraded just a few hours later. Ironically, this "real alert" followed only four days after a mock Nuclear Evacuation Drill had been held in the same area.

RE-BALLOTING IN TWO DISPUTED ARRL DIRECTOR'S ELECTIONS show that the incumbents, William Stevens, W6ZM, (Pacific Division), and Leonard Nathanson, W8RC, (Great Lakes Division), have been re-elected. According to League headquarters, in each case the winner's margin was almost 2:1 over his opponent.

ON JANUARY 4TH THE FCC BEGAN ISSUING the new General Radiotelephone license to replace the 1st and 2nd class phone licenses that were discontinued last year. The order initiating the change came last August but could not be implemented until new license forms had been printed. Current holders of 1st or 2nd class tickets should note that they are valid until expiration, but when renewed they will become General Radiotelephone licenses. All new licenses will be of that class as well.

Here's a Concept You Haven't Seen In Amateur Radio For A Long Time— Low Price.

The right design — for all the right reasons. In setting forth design parameters for ARGOSY, Ten-Tec engineers pursued the goal of giving amateurs a rig with the right features at a price that stops the amateur radio price spiral.

The result is a unique new transceiver with selectable power levels (convertible from 10 watts to 100 watts at the flick of a switch), a rig with the right bands (80 through 10 meters including the new 30 meter band), a rig with the right operational features plus the right options, and the right price for today's economy—just $549.

Low power or high power, ARGOSY has it. Now you can enjoy the sport and challenge of QRPp operating, and, when you need it, the power to stand up to the crowds in QRM and poor band conditions. Just flip a switch to move from true QRPp power with the correct bias voltages to a full 100 watt input.

New analog readout design. Fast, easy, reliable, and efficient. The modern new readout on the ARGOSY is a mechanical design that instantly gives you all significant figures of any frequency. Right down to five figures (± 2 kHz). The band switch indicates the first two figures (MHz), the linear scale with lighted red bar-pointer indicates the third figure (hundreds) and the tuning knob skirt gives you the fourth and fifth figures (tens and units). Easy. And efficient—so battery operation is easily achieved.

The right receiver features. ***Sensitivity*** of 0.3 μV for 10 dB S+N/N. ***Selectivity:*** the standard 4-pole crystal filter has 2.5 kHz bandwidth and a 2.7:1 shape factor at 6/50 dB. Other cw and ssb filters are available as options, see below. I-f frequency is 9 MHz, i-f rejection 60 dB. ***Offset tuning*** is ± 3 kHz with a detent zero position in the center. ***Built-in notch filter*** has a better than 50 dB rejection notch, tunable from 200 Hz to 3.5 kHz. An optional noise blanker of the i-f type has 50 dB blanking range. ***Built-in speaker*** is powered by low-distortion audio (less than 2% THD)

The right transmitter features. ***Frequency coverage*** from 80 through 10 meters, including the new 30 meter band, in nine 500 kHz segments (four segments for 10 meters), with approximately 40 kHz VFO overrun on each band edge. ***Convertible power:*** 100 or 10 watts input with 100% duty cycle for up to 20 minutes on all bands. ***3-function meter*** shows forward peak power on transmit, SWR, and received signal strength. ***PTT*** on ssb, ***full break-in*** on cw. PIN diode antenna switch. ***Built-in cw sidetone*** with variable pitch and volume. ***ALC control*** on "high" power only where needed, with LED indicator. ***Automatic*** normal sideband selection plus reverse. ***Normal 12-14V dc*** operation plus ac operation with optional power supply.

The right styling, the right size. Easy-to-use controls, fast-action push buttons, all located on raised front panel sections. New meter with lighted, easy-to-read scales. Rigid steel chassis, molded front panel with matching aluminum top, bottom and back. Stainless steel tilt-up bail. And it's only 4" high by 9½" wide by 12" deep (bail not extended) to go anywhere, fit anywhere at home, in the field, car, plane or boat.

The right accessories—all front-panel switchable. Model 220 2.4 kHz 8-pole ssb filter $55; Model 218 1.8 kHz 8 pole ssb filter $55; Model 217 500 Hz cw filter $55; Model 219 250 Hz cw filter $55; Model 224 Audio cw filter $34; Model 223 Noise blanker $34; Model 226 internal Calibrator $39; Model 1125 Dc circuit breaker $15; Model 225 117/230V ac power supply $129; Model 222 mobile mount, $25; Model 1126 linear switching kit, $15.

New TEN-TEC Argosy $549

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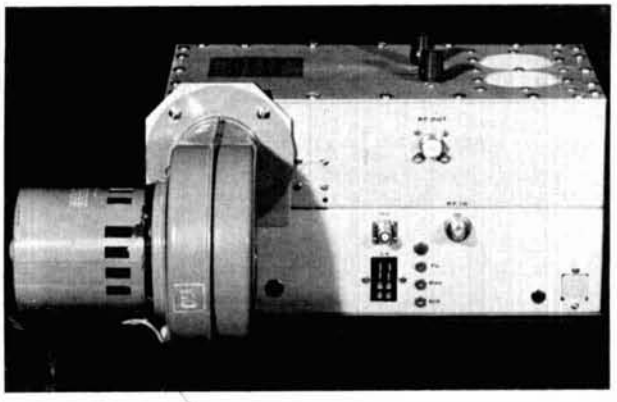
More Details? CHECK—OFF Page 92

stripline kilowatt amplifier
for 220 MHz

Updated version of a design published previously in *ham radio*

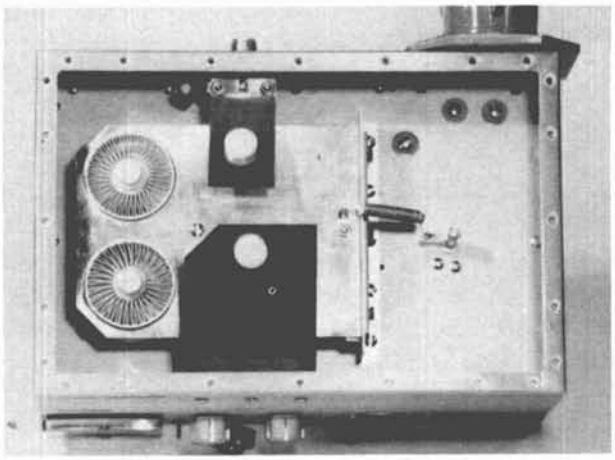
The 144-MHz stripline kilowatt amplifier described in the October, 1977, issue of *ham radio*[1] has been constructed and operated by a number of Amateurs, both from the information in the article and from parts kits available from ARCOS.* A 220-MHz version of this amplifier was built and tested during 1977 and has been reproduced several times. One of these models has been in service on a 220-MHz repeater for over two years. This same amplifier was borrowed from the repeater and used during VHF/UHF tests over the past two years by the W2SZ/1 (Mount

*ARCOS, Amateur Radio Component Service, Box 546, East Greenbush, New York 12061. All parts for the 220 amplifier and power supply are available.

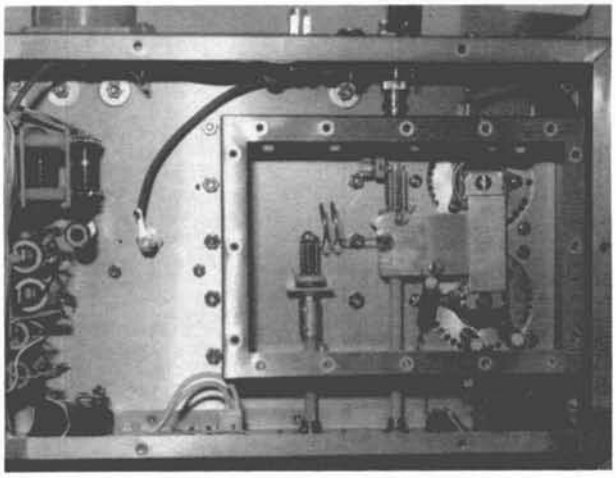


Front and rear views of the 220-MHz stripline kilowatt amplifier, which is enclosed in two mated chassis. Two optional designs are available, one for triode and one for tetrode tubes.

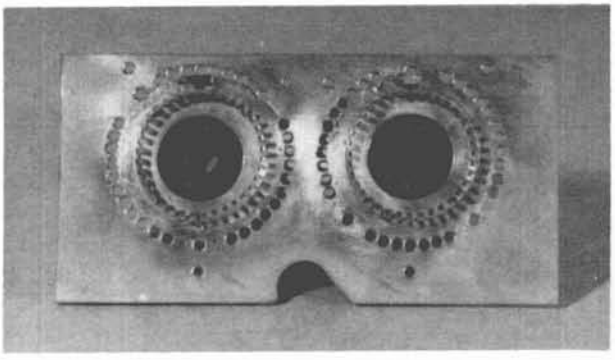
By F. J. Merry, W2GN, 35 Highland Drive, East Greenbush, New York 12061



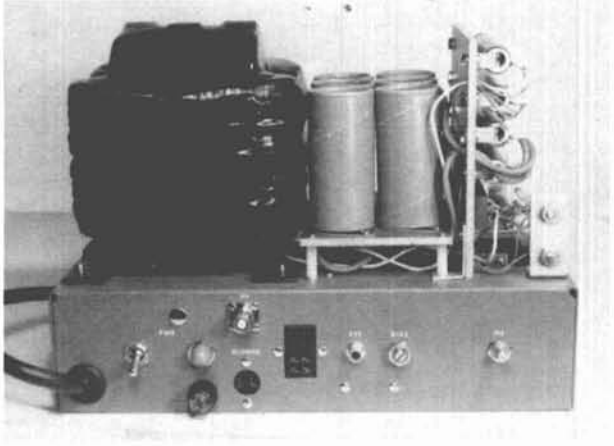
Top view of the stripline amplifier with cover removed showing the load and tuning flappers.



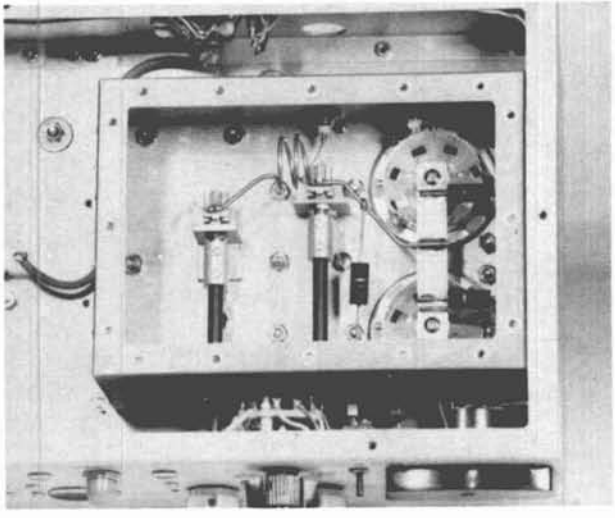
Bottom view of the triode amplifier with cover removed.



Socket assembly for the 8874 triodes, which may be installed onto the amplifier chassis in place of the tetrode sockets.



Front view of the power supply with cover removed.



Bottom view of the tetrode amplifier with cover removed.

Front view of the power supply for the stripline amplifier with cover installed.

Greylock) group. Experience has been favorable in all respects.

The experienced builder, especially if he has built the 144-MHz model, will find no difficulty in building and operating the 220-MHz version. With EME and tropo activity on 220 MHz on the increase, this amplifier is a good candidate where there is a need for reliable high-power operation.

Similar to the 144-MHz amplifier in chassis dimensions and other respects, the 220-MHz version uses a quarter-wave plate line and a coil-simulated half-wave grid line. Except for the plate-line mounting screws, the location of the high-voltage feedthrough capacitor and a hole for a bushing for the plate tuning flapper drive string, chassis punching is identical to the drawings for the 144-MHz amplifier as described in reference 1. Originally described by K2R1W (reference 2) for a 432-MHz stripline amplifier, this type of chassis construction has proven adaptable to not only 432, 220, and 144 MHz but also to an equally successful 50-MHz version using a pi-network output circuit with inductive tuning. The 50-MHz model will be described in a subsequent article.

The amplifiers mentioned above can use any of the ceramic tetrodes such as the 4CX250R, 4CX250B, or 8930, further illustrating the flexibility of this type of chassis construction. The 8874 triodes can also be used in a grounded-grid application by installing a mounting plate for the 8874 sockets in place of the individual EIMAC 630A sockets. The triode amplifiers have the advantage of not requiring the critical screen supply voltage and the disadvantages of higher tube cost and higher drive power requirement.

design

Referring to the schematic, (**fig. 1**), the quarter-wave plate line is tuned and loaded by flapper capacitors. The plate blocking capacitor is a Teflon sandwich at the cold (rf) end of the line. The grids are connected by a strap to which is connected the grid coil. A 1k, 2-watt resistor is used for a grid choke (class AB1 operation — no grid current). A 1k, 2-watt resistor in series with a 1000-pF capacitor is connected to ground from each grid. These two loading resistors increase the stability margin of the amplifier and desensitize it so that it can be driven to 500 watts output with about 10 watts of drive. Additional resistors may be added depending on the drive power available. If the grid load resistors are omitted, the amplifier is stable but it becomes extremely power sensitive.

A further examination of the schematic reveals an optional rf output indicator circuit and 660-MHz and

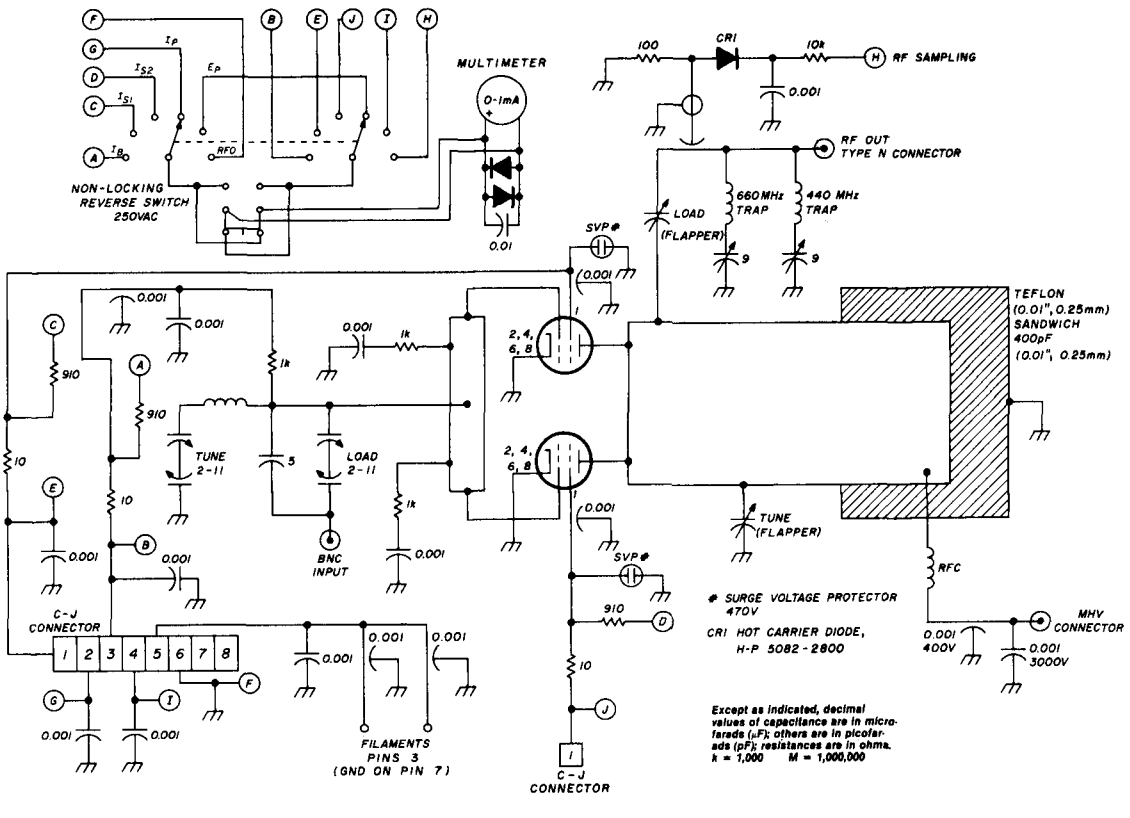


fig. 1. Schematic diagram of the tetrode stripline kilowatt amplifier.

440-MHz harmonic traps in the rf output, surge voltage protectors (SVPs) on the screen leads, and the usual lead filtering to keep the rf locked into the grid box and plate compartment. Metering is with a single 0-1 mA meter and a six-position switch with appropriate metering resistors for plate current, plate voltage, individual screen currents, grid current, and relative rf output. Thus, all important operating parameters are monitored.

A nonlocking reversing switch facilitates reading negative values of screen and grid currents, which are normally experienced with tetrode amplifiers. I recommend that an rf output wattmeter be used instead of the relative rf output indicator circuit. Proper adjustment of the plate tuning controls is difficult unless both plate current and the rf power output can be observed simultaneously. Other dc metering arrangements may, of course, be employed, including enclosing the meter circuit in a separate box at the operating position with the amplifier remotely located or by locating the metering circuit in the power-supply chassis.

The surge-voltage protectors in the screen circuit will ground the screens if the screen voltage rises above 470 volts. This protection is important and should be provided on all tetrode amplifiers. Emission effects in ceramic tetrodes will cause the screen to go negative under certain operating conditions. When this condition occurs, the screen voltage rises, causing higher plate current. The tubes can go into a runaway condition unless the amplifier is shut down. The surge voltage protectors prevent the runaway condition by automatically reducing the screen voltage to a very low value. Once one of the SVPs has fired, it's usually necessary to shut off the power. Power may be restored after a pause to let the capacitors discharge to a point below the sustaining voltage of the SVP that fired. A small saving can be realized by using only one SVP connected to the screen-supply lead.

Two other factors are involved in foolproof operation of the screen circuit:

1. The screen power supply must be provided with a current-limiting resistor so that the current doesn't exceed about 100 mA when one of the SVPs fires.

2. The power supply must have a resistor, from screens to negative, which is of a value low enough to provide a sink current of at least 40 mA. This feature provides a path for the negative screen current so that the screen voltage will hold at the regulated value.

With the above features provided in the screen circuit, the tetrode amplifier will perform as reliably and smoothly as a triode amplifier.

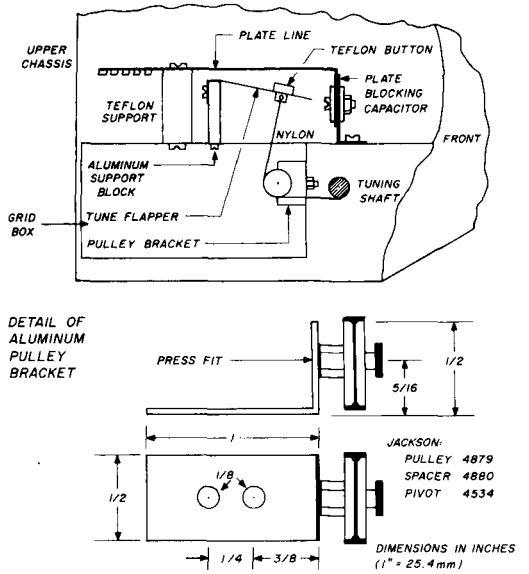


fig. 2. Cross-sectional diagram illustrating operation of plate-tuning flapper. The diagram is for front-panel control. Alternatively, the plate-tuning flapper may be located above the plate line and adjusted with a screw and knob (like the load flapper).

construction*

Chassis punching and drilling follows the same pattern shown by the drawings and as discussed in the 2-meter amplifier article.[1] Variations are listed below.

Plate-line mounting holes. The five holes in the right end (facing front) of the upper chassis (used to mount the 2-meter plate line) are not required. The 3/16 inch (5 mm) holes that fasten the 1-1/4 meter plate line to the chassis are located by setting the line in place with the tubes installed.

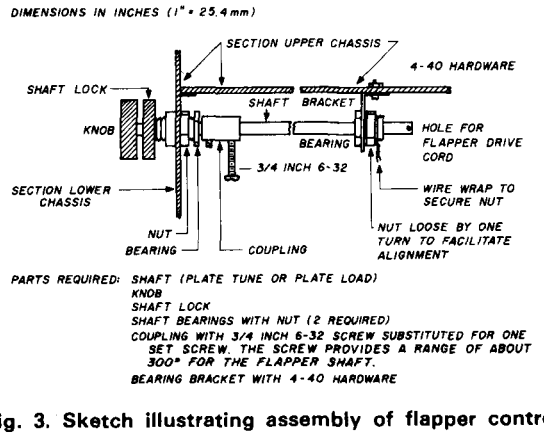


fig. 3. Sketch illustrating assembly of flapper control shaft with shaft lock. This assembly is used in place of planetary drives. It provides a greater range of adjustment and more positive operation.

*See the appendix before proceeding further.

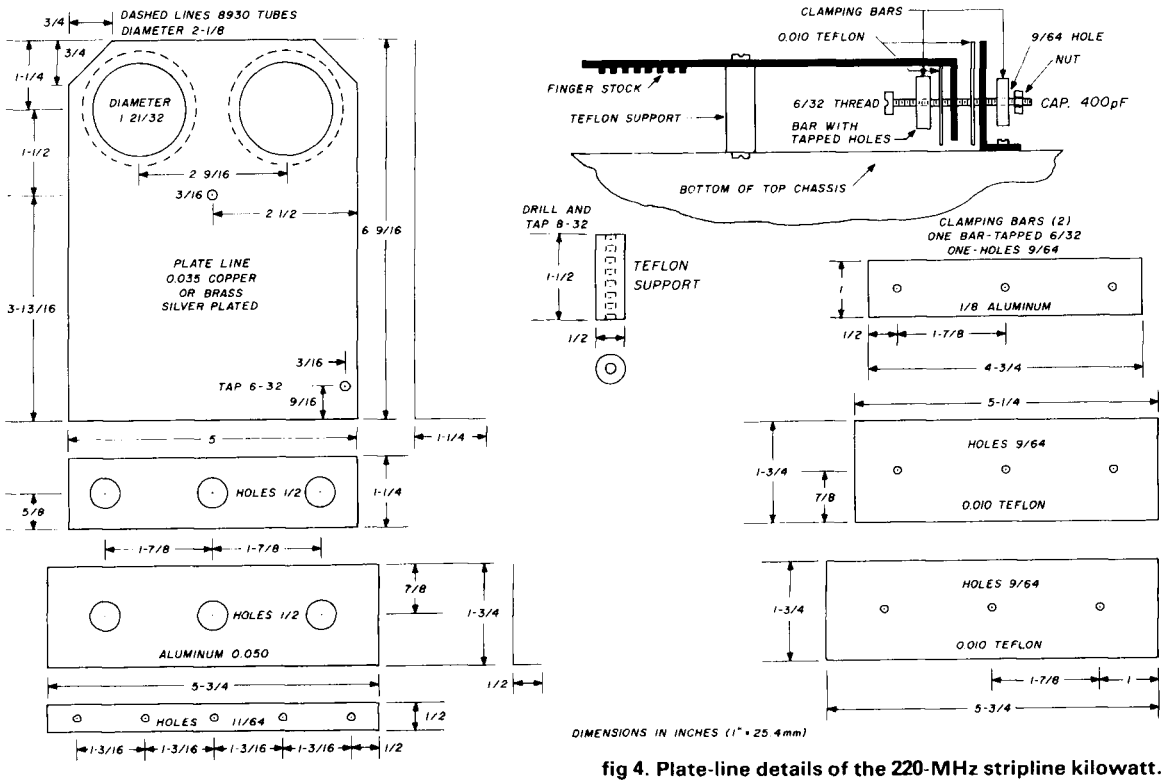


fig 4. Plate-line details of the 220-MHz stripline kilowatt.

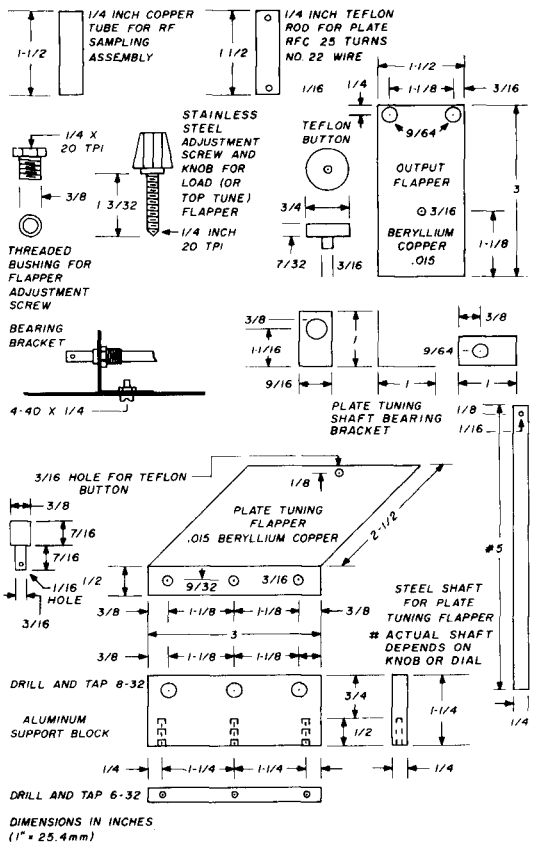


fig. 5. Plate-line tuning and output flappers.

Mounting the high-voltage feedthrough capacitor. The 7/16 inch (11 mm) hole for the high-voltage feedthrough capacitors is located 2 inches (5 cm) to the right (facing the front of the amplifier) of the cold end of the plate line and in line with the rear edge of the plate line. The rf choke is mounted between a lug on the plate line and another lug on the high-voltage feedthrough capacitor.

Plate-tuning flapper. The plate-tuning flapper is mounted on an aluminum block as in the 2-meter amplifier. It is shorter than the 2-meter flapper. The drive cord is connected to the tuning control through a pulley inside the grid box, **fig. 2.** A knob shaft lock and a steel shaft provide the plate tuning adjustment, **fig. 3.**

An alternative method of installing and controlling the plate tuning flapper is to secure it to the front of the upper chassis wall and adjust it with a 1/4 inch (6.4 mm) threaded rod from the top of the chassis — a simple and positive method of control, the same as that used to control the plate load flapper.

Plate line. The construction of the plate line is shown in **figs. 4** and **5.** The parts of the line must be free of burrs to avoid puncturing the Teflon insula-

tion. Assembly of the line must be accurate so that the screws holding the clamping bars are centered in the holes in the plate line and the underside of the plate line is 1-1/2 inches (38 mm) from the floor of the upper chassis.

Grid circuit. Details of the grid circuit are shown in **fig. 6**. Miniature capacitors (20-pF) may be substituted for the butterfly caps. The advantage of the costly butterfly cap is that no bearings are included in the rf path. The 2-11 pF butterfly caps will require a10-pF padder mounted across the two stators.

triode amplifier

If the 8874 triodes are the tube choice, the sockets can be mounted on a brass plate, which is then installed onto the amplifier chassis in place of the EIMAC 630A sockets used for the tetrodes, **fig. 7**. There's no need to change dimensions of the plate line provided it's for the 4CX250 tubes. The grid line becomes the cathode line, and an rf choke is substituted for the 1k, 2-watt grid resistor. The grid load resistors are also omitted. See the schematic of the triode version, **fig. 8**.

Note that the triode amplifier has two meters mounted on the chassis. The right-hand meter reads plate current; the left-hand meter reads grid current. By operating a nonlocking meter switch, plate voltage is read on the grid-current meter. (I assume that an rf wattmeter will be used to monitor power output.)

Metering and cathode resistors are mounted on the right-hand end of the lower chassis. The zener bias diode and the control connector are mounted on the rear of the lower chassis. An ungrounded contact closure on the control connector is required to establish operating bias.

harmonic traps and rf indicator pickup

The harmonic traps (440 MHz and 660 MHz) in the rf output are installed in a small box (Pomona 2428) mounted on the rear of the amplifier, **fig. 9**. Alternatively, these traps can be installed in a box with coaxial connectors on each end (Pomona 2411). This box can be inserted in the output line at the rf output connector or immediately following the output wattmeter. The adjustment of these traps is best done

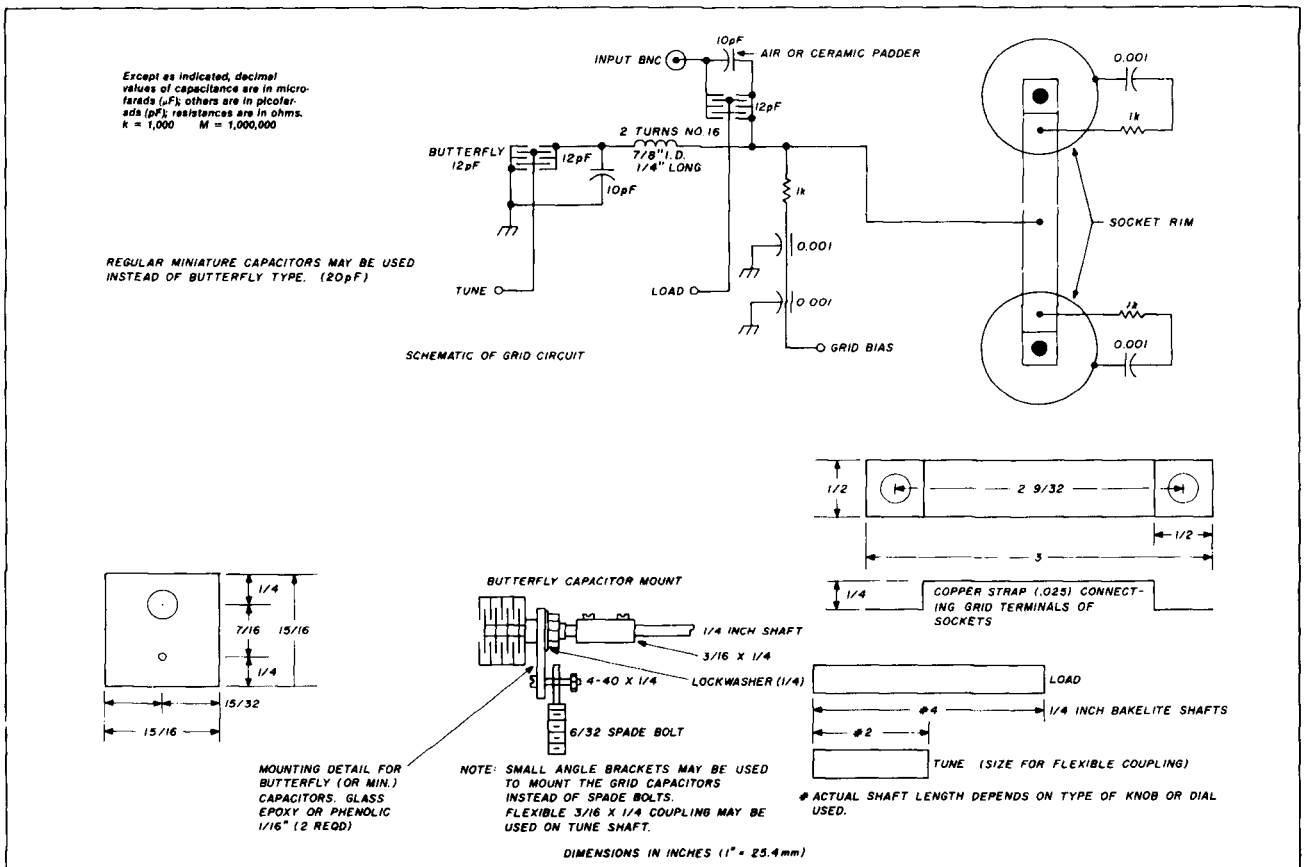


fig. 6. Grid-circuit details. The butterfly caps will require a 10-pF padder mounted across the two stators.

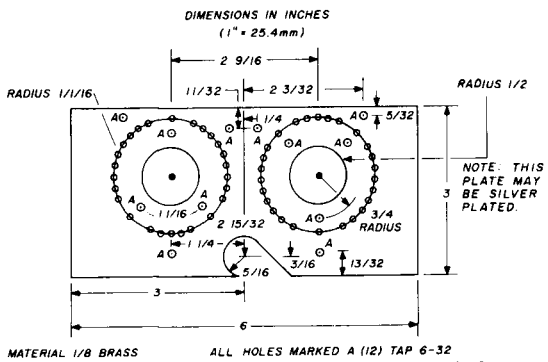


fig. 7. Socket plate for the 8874 amplifier.

while observing the level of the harmonic output on a spectrum analyzer.

The rf pickup assembly is also illustrated in **fig. 9.** The amount of rf pickup is obtained by adjusting the position of the lug, which is mounted on top of the output flapper, with respect to the lug on the stand-off insulator.

The rf pickup assembly may be omitted if you plan to have an rf wattmeter in the output circuit. As I mentioned previously, it's desirable to have an rf wattmeter to monitor output and to achieve the best adjustment of plate tune and load controls for maximum efficiency.

assembly

The following sequence is suggested for assembly:

1. Mount and wire all parts on the lower chassis.

2. Fasten the grid box to the upper chassis and install the sockets, feedthrough capacitors, SVPs and BNC input connector. For the tetrode amplifier, orient the sockets so that terminals 1 and 3 are opposite their respective feedthrough caps. The sockets for the triode amplifier are mounted so that the heater terminals are positioned between their respective feedthrough capacitors on the cathode box.

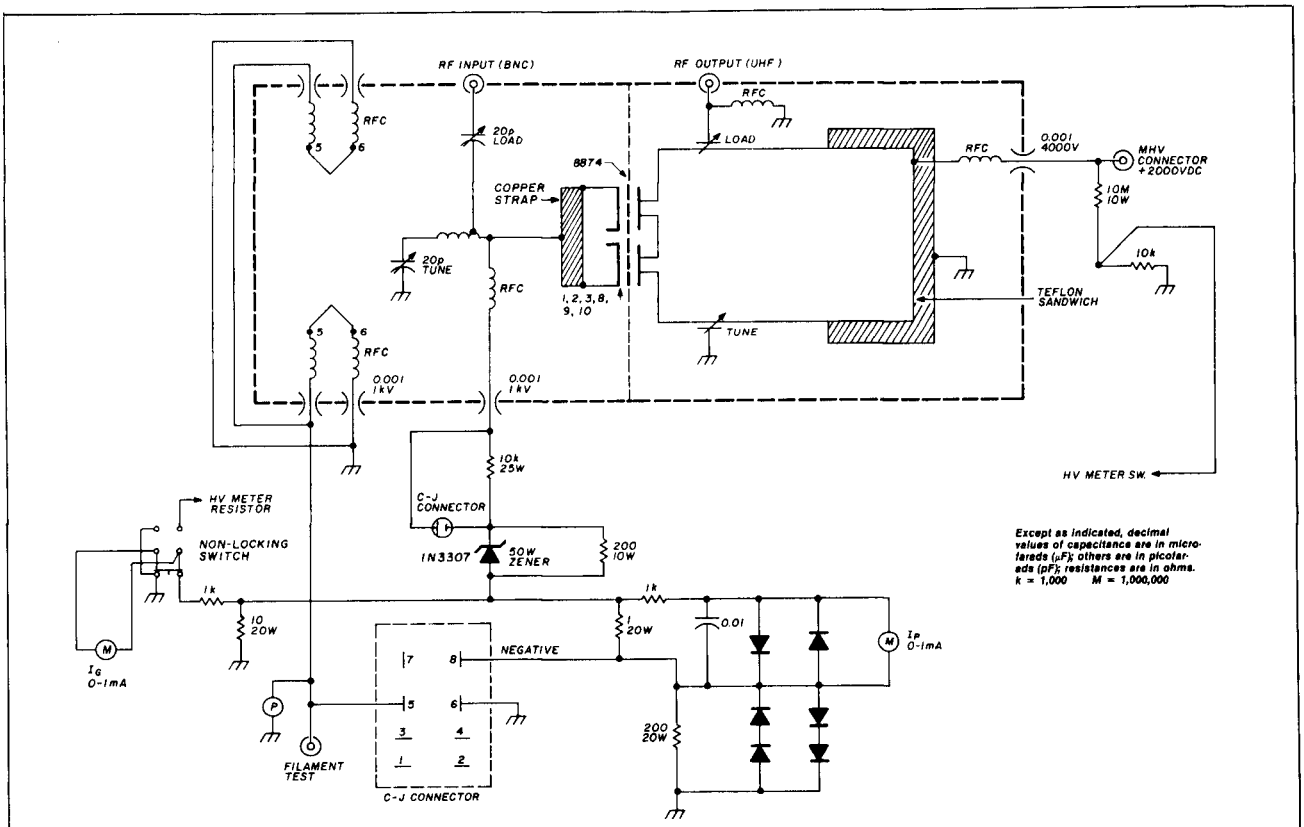


fig. 8. Schematic diagram of rf section, triode amplifier.

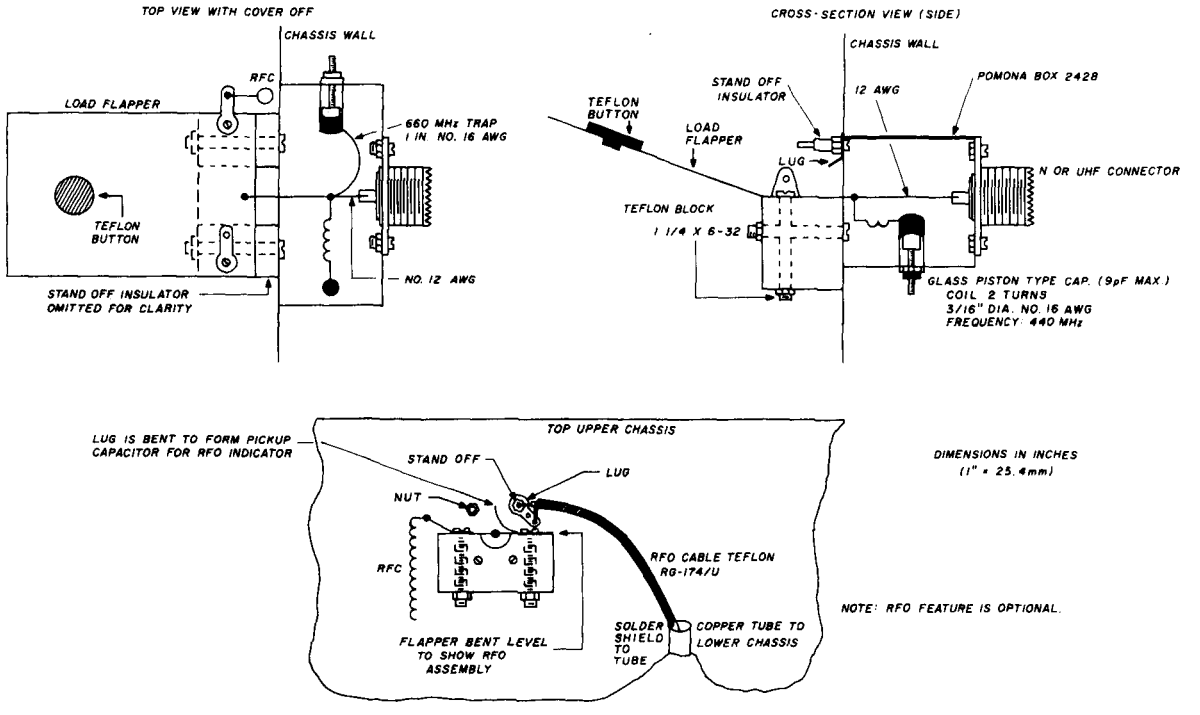


fig. 9. Harmonic traps and rf indicator pickup assembly.

3. Install the high-voltage feedthrough capacitor and the rf output pickup assembly.

4. Fasten the upper and lower chassis together and complete the wiring interconnections.

5. Mount the butterfly caps in the grid box (**fig. 6**) and install the tune and load controls.

6. Install the grid line, grid coil and resistors as in **fig. 6.**

7. Install the plate-tuning flapper, pulley, dial, shaft and bearing. Tie the nylon line to the flapper before mounting the flapper.

8. Install the tubes temporarily and put the plate line (previously assembled) in place. Work the finger stock over the tubes *very carefully*. Make sure everything lines up. Mark the mounting holes at the end of the plate line, then remove the plate line and tubes and drill the mounting holes for the plate line. Reinstall tubes and plate line.

9. Connect the plate rf choke.

10. Install the output flapper, rf grounding choke and RFO assembly.

11. Assemble the top plate screen and vent plate and the threaded bushing for flapper adjustment. Put the tubes in place and put the Teflon chimneys in position in the vent plate. Fasten the top plate in place.

12. Recheck wiring and fasten the bottom plate.

The amplifier is now ready for test.

blower

The blower may be mounted onto the air-intake plate on the rear of the amplifier or it may be hose connected. The Dayton model 4C012A specified in the 2-meter construction article[2] is satisfactory for normal operation. **Figs. 10** and **11** give the dimensions for air-intake plates for higher-power blowers;

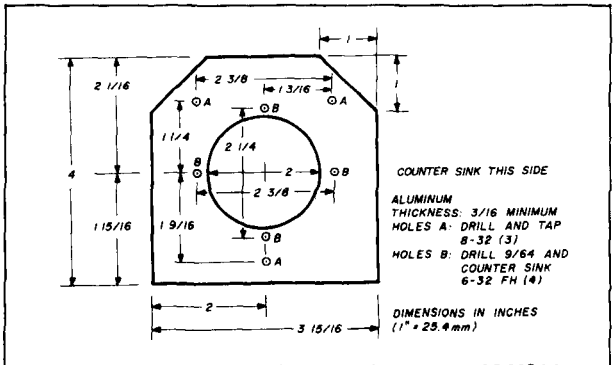


fig. 10. Air intake cover-plate details, Dayton 4C443 blower mount.

that is, the Dayton 4C443 (100 CFM) and the Rotron V537A2R4 (160 CFM). Generally speaking, the more air flow the better, so the choice of blowers is usually a compromise based on noise level and price. The noise can be reduced appreciably by control circuits that reduce blower speed during standby periods. To make the blower operation foolproof (the amplifier will fail in less than a minute without air), an air switch can be mounted in the output air stream of the blower, or a pressure switch can be mounted on the upper chassis. These switches can be connected to shut down the power supply or bias the amplifier to cutoff (see next section).

power supply

The power supply was given a rather brief treatment in the previous article.[1] There's a tendency to consider the power-supply design and construction as less significant than the amplifier. This can be a mistake, especially for the tetrode screen supply which, as discussed previously, has critical requirements for successful operation of tetrodes. This time, to provide background on its operation, the power supply is described in some detail (see the schematic, **fig. 12**).

Features of modern high-voltage power supply

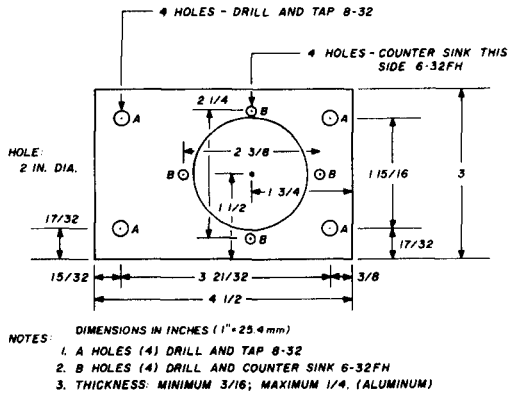


fig. 11. Air intake cover-plate (Rotron V537A2R4).

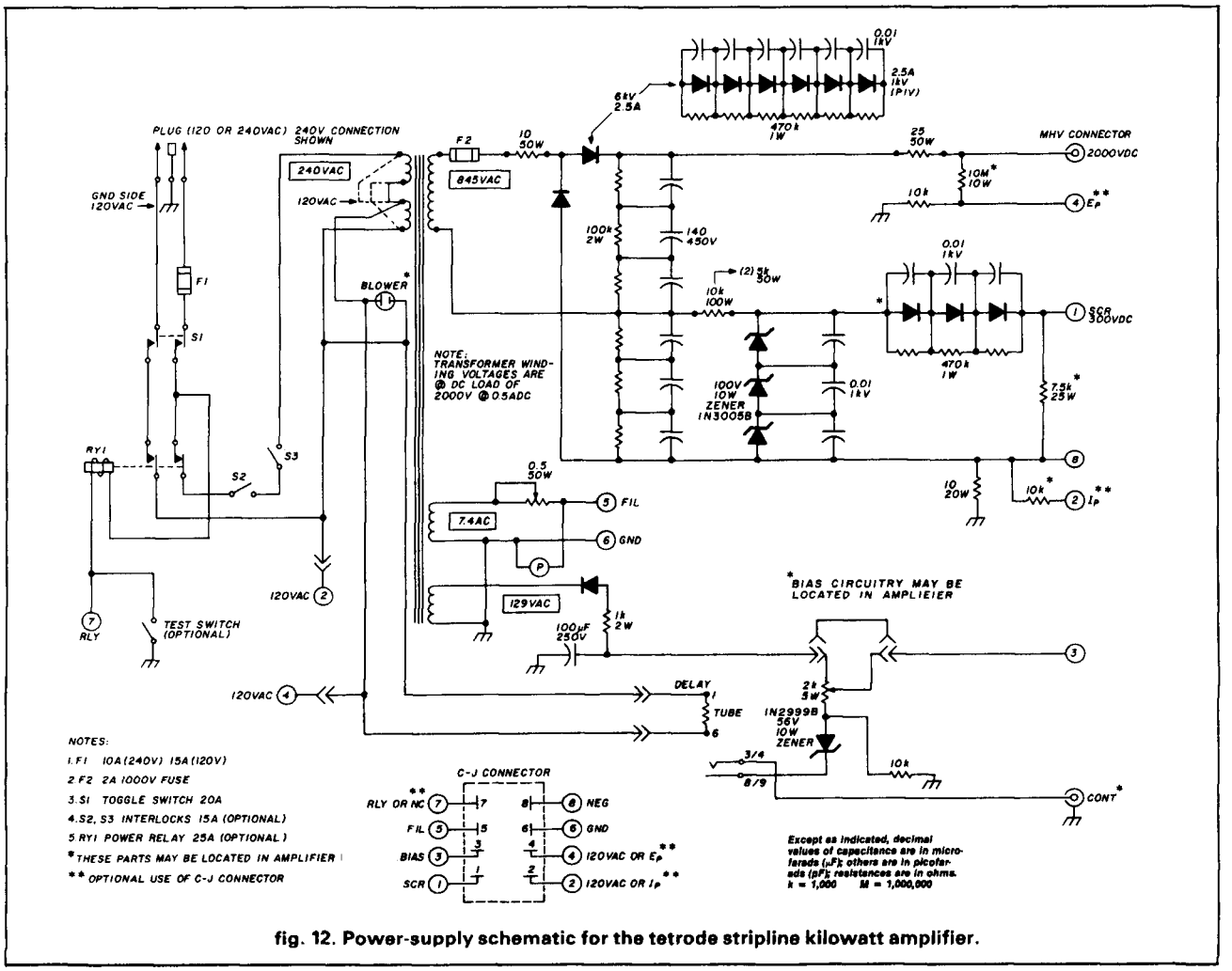


fig. 12. Power-supply schematic for the tetrode stripline kilowatt amplifier.

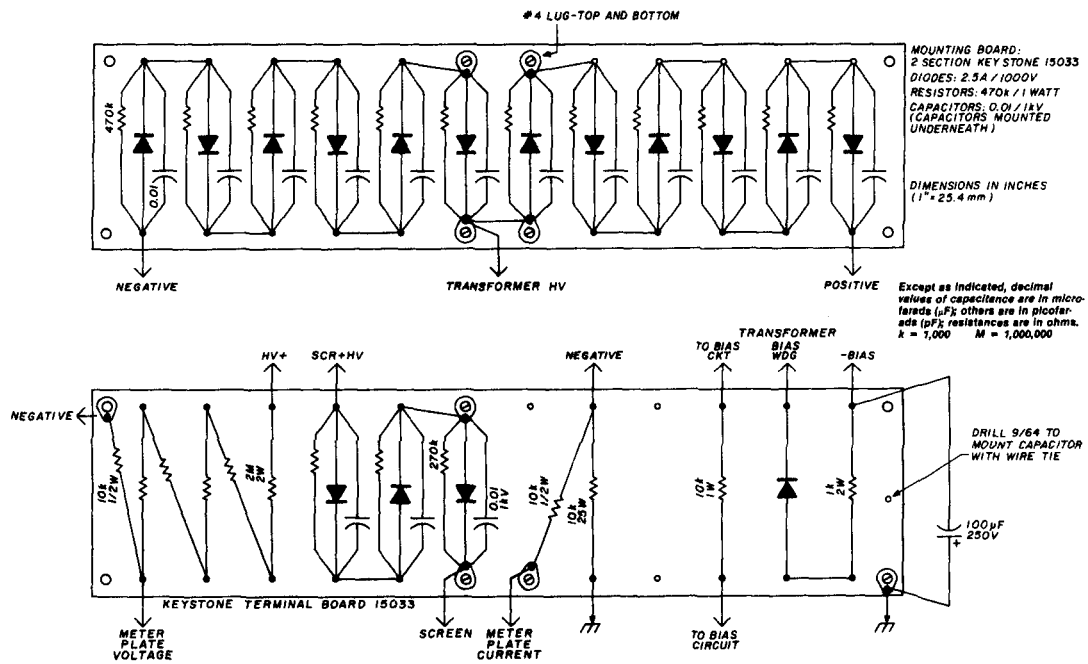


fig. 13. Details of the power-supply terminal strips. These two strips are mounted one over the other with 1-inch 6-32 spacers, with the high-voltage rectifier board toward the chassis.

design include compactness: 12 inches wide by 7 inches deep by 10 inches high (30.5 by 17.8 by 25.4 cm) and light weight (37 pounds, or 17 kg). All output voltages and other features to operate the amplifiers discussed above are provided. No-load output is 2300 volts dc. Outputs under loads of 1 ampere, 500 mA, and 100 mA are respectively 1850, 2000, and 2200 volts dc. Screen voltage is 300 volts dc regulated to 40 mA sink current. Cutoff and operating bias voltages are respectively −120 volts dc and −56 to −90 volts. (Operating bias is regulated at −56 volts dc.) Also provided are 7.6 volts ac, which is adjustable from 5.5 volts to 6 volts ac at 6 amperes. One-hundred-and-twenty volts ac are provided at the blower receptacle.

The transformer (custom manufactured by H. E. Johnson and Associates, Clearwater, Florida for ARCOS) has input provisions for either 120 Vac or 240 Vac, 50 to 400 Hz. Assembled around a 1540-watt hipersil core, the transformer is vacuum impregnated with insulating varnish then coated with a single-part thermosetting epoxy for mechanical protection. In ambient air of 25 degrees C with convection-radiation cooling only, continuous operation at 1000 watts dc results in a temperature rise of less than 30 degrees C.

The primary power circuit consists of a three-wire power cord, double-pole power switch, power relay (optional) and top and bottom cover interlock switches (optional). A test switch (also optional) simulates the ground for operating the power relay, which comes from the associated amplifier over pin 7 of the low-voltage connector. The power cord must be sensed correctly for this feature to work with the 120-Vac connection.

A blower receptacle is provided. The power cord from the power supply blower, which is mounted on top of the power supply, plugs into the blower receptacle. The blower cord has a bridged receptacle to which the amplifier blower can be connected. Alternatively, 120 Vac may be connected to pins 2 and 4 of the power supply's low-voltage connector for operating the amplifier from a receptacle on the amplifier chassis. If this option is chosen, metering resistors for plate current and plate voltage must be located in the amplifier instead of in the power supply.

A review of the schematic will show that a voltage-doubling circuit is used with over 30 μF of electrolytic capacitors in each leg of the rectifier circuit. Six 1000-volt PIV/2.5-amp diodes are used in series in each rectifier leg. The diodes are protected by a secondary fuse (2 amps/1000 Vdc) and a 10-ohm, 50-watt series resistor. The short-circuit current is limited in the high voltage lead by a 25-ohm, 50-watt resistor.

The voltage doubling circuit provides a 1000-Vdc output for developing regulated 300-Vdc screen

voltage (pin 1 of the low-voltage power connector) by using a series resistor and zener diodes. The zeners are protected from high-voltage transients on the screen leads from the amplifier by series diodes in the screen lead. The screen terminating resistor may be located either in the power supply or in the amplifier.

The screen series resistor and screen terminating resistor values were chosen to maintain regulation with a 40-mA sink current in the screen terminating resistor. Adequate sink current for the screen circuit is essential to the proper operation of tetrode amplifiers. The sink current path through the terminating resistor provides a bleed path for the reverse screen current, which is normal for tetrodes. As I mentioned previously, if an adequate bleed path is not provided, the screen voltage will attempt to rise to the plate voltage and the tube will go into a runaway condition unless protected by surge voltage protectors at the screen-socket terminals. The 40 mA sink current provided for the screen terminating resistor in this power supply meets the tube manufacturer's recommendation for at least 15 mA per tube.

The series diodes in the screen lead block any high-voltage transients, which can occur in the time interval it takes for the surge voltage protection to operate, from destroying the zeners used for regulation.

The blower, mounted on top of the power supply over the vent slots near the screen-series resistors, provides cooling for approximately 100 watts of heat dissipation from the screen circuit components.

The grid-bias voltage (pin 3 of the low voltage connector) is regulated by a zener and is adjustable by a potentiometer. A delay tube is used to delay operating bias on the amplifier during warm-up. The bias changes from cutoff (– 120 Vdc) to operate (– 56 to – 90 Vdc) when ground is placed on the control jack. Provision is made for metering plate voltage and plate current over pins 2 and 4 of the low-voltage connector (when these pins are not used, as described above, for 120 Vac to the amplifier chassis). Pin 5 of the low-voltage connector provides adjustable filament voltage to the amplifier. Pin 6 provides ground and pin 8 connects to the negative lead of the power supply. The high voltage is connected to the amplifier by RG-59/U coaxial cable using Amphenol MHV connectors.

The conductors between the amplifier and the power supply, other than the high voltage, are connected over an eight-conductor cable (Belden 8448) having one pair of No. 16 AWG conductors used for the filament voltage and ground. The other six conductors are No. 22 AWG.

Construction of the power supply is shown in the photos. The amplifier was assembled on a pre-punched foundation chassis available from ARCOS. Diagrams of the terminal strips used to mount the high-voltage diodes, screen and bias circuitry, and so forth, are shown in **fig. 13**. Other construction details are included in **fig. 14**. There's nothing critical about parts location, so any convenient chassis arrangement may be used. Be sure to provide adequate ventilation for the screen resistors and zeners.

For use with the triode amplifier, the screen regulation and grid bias components are omitted (**fig. 15**). Note that the metering resistors for the triode amplifier are located in the amplifier.

test and operation

Connect the amplifier to the power supply and make the usual checks of blower operation, filament voltage, bias voltage, screen voltage and plate voltage. Set the bias for an idling current of about 100 mA for initial tests. Apply a watt or so of excitation and adjust the grid controls for maximum plate

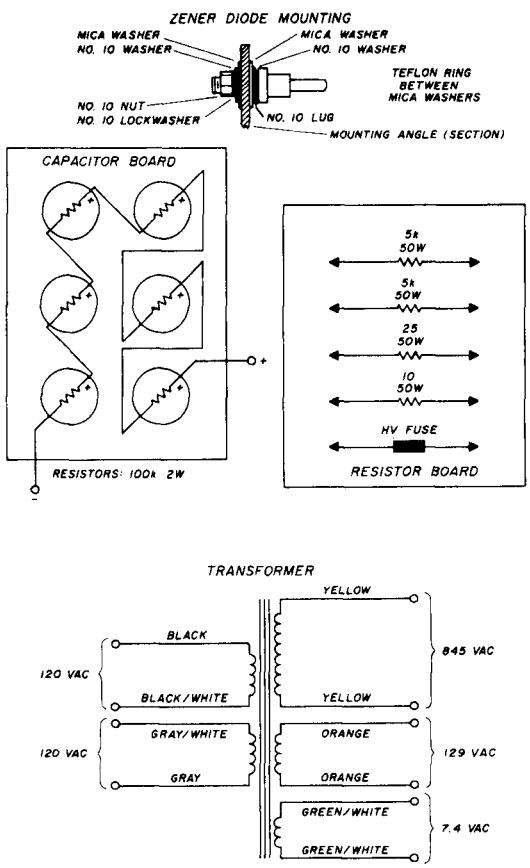


fig. 14. Construction details for the zener mounting, capacitor board, and resistor board in the power supply. The transformer is custom made for ARCOS by H.E. Johnson and Associates, Clearwater, Florida. Secondary ac voltages shown at a dc load of 2000 volts at 0.5 amp.

current. Then resonate the plate circuit by observing power output. If the plate circuit will not resonate, change the range of the plate-tuning flapper controls.

Increase drive until the output is at about 400 watts with the loading control about 1/8 inch (3 mm) above the top plate. Now set the grid controls for minimum SWR toward the driving source. Next, adjust the plate load and tune controls for a compromise between maximum output and minimum plate current at an output level of 500 to 600 watts. See **table 1** for a typical set of readings taken during the test of one of these amplifiers.

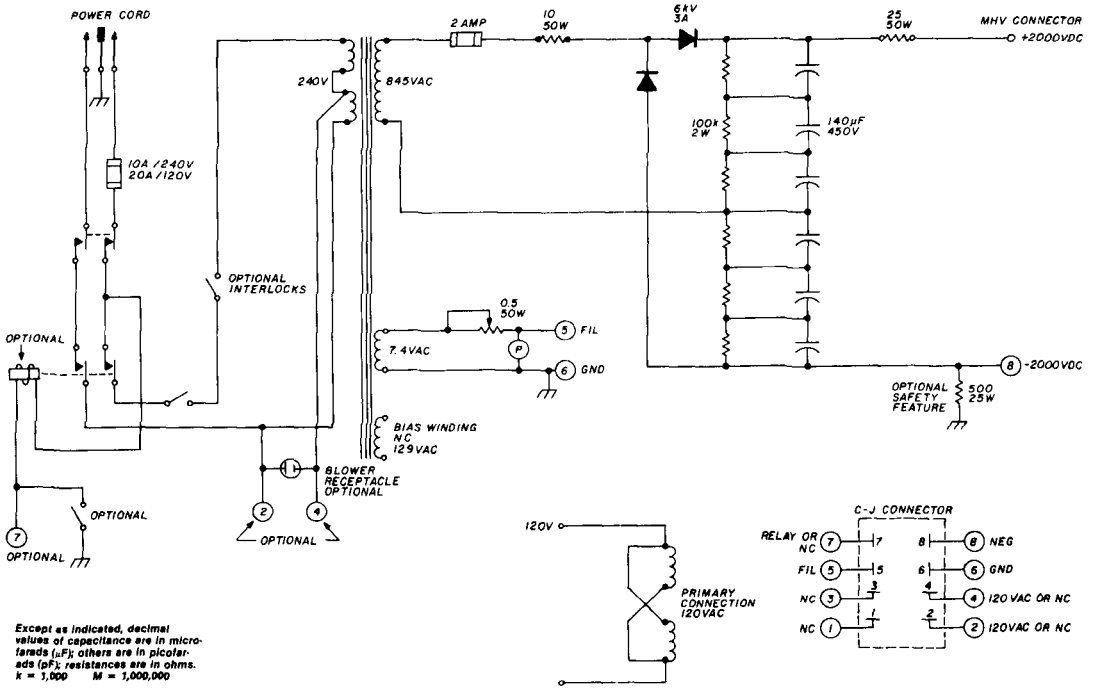


fig. 15. Schematic of the power supply for the triode stripline kilowatt amplifier.

table 1. Typical test results for the 220-MHz amplifier.

E_{fil} (volts)	E_{grid} (volts)	E_{scr} (volts)	E_{plate} (volts)	I_{grid} (mA)	$I_{scr\,1}$ (mA)	$I_{scr\,2}$ (mA)	I_{plate} (amp)	RFO	drive (watts)	output (watts)	input (watts)	temperature 1 (F)	temperature 2 (F)
5.9	−92	380	2350	—	—	—	.100	—	idling	—	235	128	128
5.9	−92	379	2200	0	−6	−2	.280	4	6	280	616	180	180
5.9	−87	378	2100	−1	−5	−1	.540	6	12	600	1134	170	170

tubes: 4CX250R
dummy load: 150 ft (46 meters) of RG-8/U terminated by a Heath Cantenna.™
operation: Class AB1

Notes:

1. Temperature 1 and temperature 2 refer to the temperatures at the two exhaust ports.
2. Efficiencies are 45 percent on line 2 and 53 percent on line 3.
3. RFO readings are the relative power output on the multimeter of the amplifier.
4. The negative grid and screen currents are normal for this type operation.
5. *Observe the excellent screen voltage regulation.*
6. Plate voltage regulation is 11 percent.
7. At 1-kW input the power output would be about 540 watts on CW for this operation condition.
8. SSB inputs can exceed the above figures somewhat if desired.
9. Key down on CW at 1 kW input, the tubes are within their dissipation rating (500 watts).
10. Power readings were taken with Bird 43 wattmeters in both drive and output.

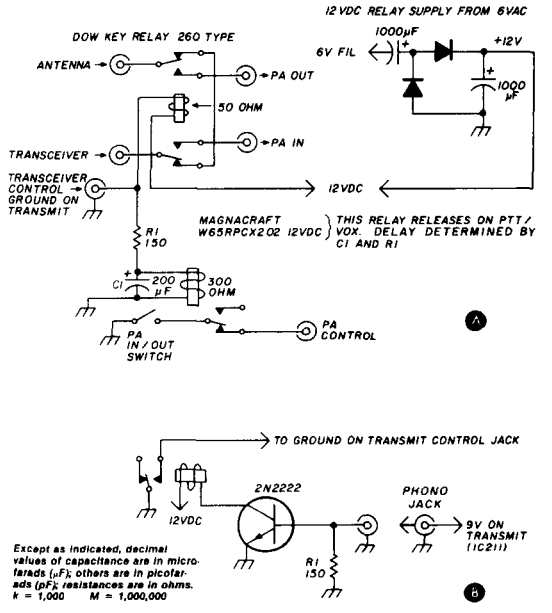


fig. 16. Antenna relay control schematic, A. Circuit prevents "hot" switching and also provides power-amplifier input-output control. Place a tab of cellophane tape on the pole piece of the Dow-Key 260 relay. B shows a circuit to adapt the ICOM or similar transceivers to furnish ground during transmit. The base circuit (R1) must be adapted to the application used.

A relative indication of the effectiveness of cooling, as well as the relative dissipation shared by the two tubes, can be obtained, as suggested by K2R1W[2] by mounting a candy thermometer over the air outlets. Temperatures read in this manner should not exceed 200 degrees F (93.5 C) under any condition. The thermometer is equipped with a pair of stiff wire legs, which faciliate setting it on top of the amplifier over the exhaust holes.

A failure of the air supply, if undetected, will result in a very rapid and disastrous temperature rise inside the plate compartment. Usually the solder on the plate line melts and the finger stock springs out to touch the chassis — grounding the high voltage and operating the high-voltage fuse. In cases observed so far, the tubes have survived. To prevent damage, an air switch in the blower or a pressure switch for the plate compartment may be used to shut down the power supply or bias the amplifier to cutoff when air pressure fails.

A suggested setup for switching the antenna when using a transceiver for drive power is shown in **fig. 16**. Some transceivers don't furnish ground on transmit, providing either 12 Vdc or some other voltage. There's not enough current available in some cases to operate a relay. A transistor and relay may be connected as shown in **fig. 16** to accept a voltage on transmit and produce a ground to operate the antenna-switching circuit. Note that a 12-Vdc supply is required for the above circuit. This may be obtained from the 6 Vac on the filament line as indicated.

references

1. Fred Merry, W2GN, "Stripline Kilowatt for 2 Meters," *ham radio*, October, 1977, page 10.
2. Richard T. Knadle, Jr., W2RIW, "A Stripline Kilowatt for 432 MHz," *QST*, April, 1972, page 48; May, 1972, page 59.

appendix

Errata in the October, 1977, article[1] on the two meter amplifier should be considered during construction.

Page 11 — fig. 1: "B" lead to meter switch is not shown. It is a direct lead from the opposite side of the 10-ohm metering resistor. (Opposite from the "A" lead.)

Page 12 — *Caption on* **fig. 3** *should read* 8930.

Page 13 — The caption of **fig. 5** is correct, but the drawing should be interchanged with that of **fig. 10.**

Page 13 — (fig. 4): The 3/8-inch dimension shown on the right side view should be 3/4 inches. The Dayton blower referred to in the text is model 4C012A. (The blower now recommended is Dayton 4C443. A different blower mounting plate is required.)

Page 15 — The dimension 1-7/8 inches (upper left) for the center line of the socket holes should read 1-5/8 inches.

Page 17 — (fig. 10): See note concerning page 13, **fig. 5** above.

Page 19 — (fig. 13): *(upper right) — the dimension not shown for* the self-crimping nuts on the lower piece of the plate line is 1/4 inch.

Page 20 — (fig. 14): Aluminum support block — the vertical holes in the block should be 1-1/4 inches apart (not 1-1/8). The width of the fixed plate-line capacitor plate is 1-1/8 inches, not 1-1/2 inches.

Page 21 — (fig. 15): The grid coil is three turns, 5/8 inches diameter, 3/4 inches long, No. 16 AWG.

Page 21 — (fig. 15): The butterfly capacitor mounts are made of G-10 glass epoxy laminate having a thickness of 0.06 inch.

Page 21 — The dimension between the holes in the copper strap is 2-9/16 inches not 2-9/32.

Improvements developed since the October, 1977, article was published:

1. Surge-voltage protectors were added to the screen terminals of each socket.

2. The output (load) flapper assembly has been strengthened by mounting it on a Teflon block. A large Teflon button is mounted in a hole in the load flapper on which the adjustment screw bears. The adjustment screw was changed to a 1/4-inch thread cap screw. With this arrangement, there is no strain on the center conductor of the output connector, and mechanical stability is achieved. The Teflon piece underneath the load flapper is not required.

3. In the original design, the plate-tuning flapper was quite close to the plate line at resonance, which resulted in a tendency for it to flash over when loading was too light. To provide additional clearance and smoother tuning control, a padder capacitor of the flapper type was added above the plate line opposite the plate loading capacitor.

4. The zener regulators in the power supply are protected from high-voltage transients on the screen lead by a string of diodes.

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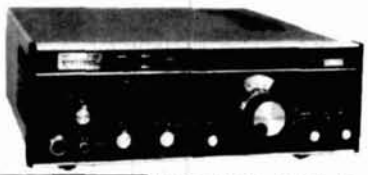

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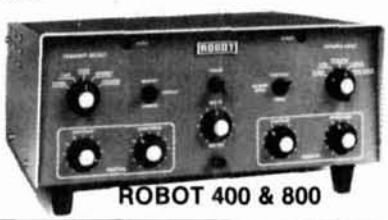

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More Details? CHECK—OFF Page 92

ham radio TECHNIQUES

Bill Orr W6SAI

I was young once and knew everything. One of my beliefs was in the honest-to-gosh reading of an SWR meter. You merely put it in the line to the antenna and this magical instrument would tell you just what was happening inside the coaxial line. It was all very simple. Fortunately, I learned rapidly, and in the process amassed six or seven SWR meters. It was always amusing to make SWR measurements on an antenna with one meter and then to repeat the measurements with another meter. It was almost possible to hand-pick the SWR curve I wanted by the correct choice of instrument, since they provided widely different readings.

I'm not the only Amateur who has been led down the daisy path by the SWR meter. The complications associated with this interesting device are more important today than ever before because of the advent of the solid-state, high-frequency transceiver.

the more you have the less you get

Most high-frequency transmitters that have a solid-state power amplifier incorporate a protective circuit that will gradually turn off the amplifier as the SWR on the antenna system rises. Since most antennas are single-frequency devices (that is, adjusted at one spot in a particular band), a low value of SWR is obtainable at only one frequency. Operating the antenna off frequency causes the SWR on the feed system to rise, even though the antenna may work in excellent fashion across the whole band (**fig. 1**).

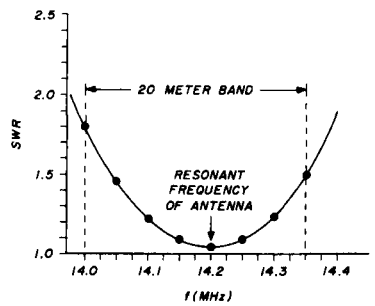


fig. 1. Idealized SWR curve of 20-meter antenna. Resonant frequency is 14.2 MHz. Antenna is matched at this frequency and the SWR is very nearly 1-to-1, rising rapidly as antenna is operated off frequency.

Tube-type amplifiers with their adjustable output controls (TUNE and LOAD) can adapt themselves to wide variations in the SWR of the antenna system. The solid-state wide-band amplifier, on the other hand, requires protection against SWR excesses. Hence the fail-safe shut-down design. When the SWR starts to rise, the amplifier transistors are electrically derated for protection.

All well and good, I say, but the user of such equipment must pay attention to the SWR across his band of operation, or he will find that he can get full power output from his rig only over a small portion of the band. This vexing problem is particularly true on 160, 80, and 10 meters, where the width of the band is large in proportion to the center frequency.

enter the SWR meter

To determine just what is going on with regard to a particular antenna, an SWR meter is commonly used to gain a picture of SWR vs frequency, as shown in **fig. 1**. But is this a true picture of what is happening? Possibly not. A knowledge of the workings of the SWR meter and its use are of utmost importance.

Most modern SWR meters are composed of two directional couplers built into one case. A single indicating meter is switched between the couplers and the meter is usually calibrated directly in terms of SWR (standing wave ratio).

A directional coupler is a device which samples power flowing in one direction in a transmission line but is insensitive to power flowing in the reverse direction.

If the antenna exactly matches the characteristic impedance of the transmission line and also matches the line

with respect to balance, it will absorb all power transmitted down the line. If a mismatch exists at the antenna, a certain portion of rf power will be reflected back down the line toward the transmitter.

The circuit in the directional coupler picks up energy from the line by means of both inductive and capacitive coupling. The inductive current in the line flows according to the direction of the traveling wave producing it. Thus there can be direct and reflected waves passing through the coupler. The capacitive pickup, however, is independent of the direction of the traveling waves, and the sum of coupled currents in the device produced from the waves of one direction will add in phase. Those produced from waves of the opposite direction will subtract in phase.

The electrical balance of a coupler is such that the current induced from the reverse-traveling wave will cancel the other completely, or nearly so, resulting in a directivity factor in the coupler. This means the coupler is highly insensitive (nulled) to a wave traveling in the reverse direction. Thus the device is sensitive to only one of the traveling waves which produces standing waves by interference. To determine SWR it is necessary to read forward and reverse (incident) power flowing in the line. Two couplers, reverse connected, can do the job (**fig. 2**). In order to obtain accurate readings, both couplers must be identical. And each coupler should be insensitive to power passing through it in the unwanted direction.

The important characteristic of a coupler is the ratio of the measurement in the forward direction to that in the reverse direction. If the coupler is sensitive to the unwanted reading, the accuracy of the coupler is seriously affected. When two couplers are used to make up an SWR meter, the problem is compounded.

A good laboratory-type coupler will have a directivity of better 25 dB, indicating that the coupler provides 25 dB of discrimination between opposite directions of power flow. An SWR meter made up of two such couplers provides an indicated value of SWR differing from the true value, as shown in **fig. 3**. As an example, a true value of SWR of 1.5-to-1 on a transmission line can provide an indicated value on the SWR meter which can vary between the extremes of 1.23-to-1 and 1.8-to-1. And most cheap CB-type SWR instruments are not this accurate.

Added to the directivity limitation, most inexpensive SWR meters have a built-in error because of the nonlinearity of the diode used to provide voltage for the indicating meter. At low voltage levels where the SWR reading is of the greatest importance, diode linearity is poorest.

Finally, all directional couplers are sensitive to second harmonic voltage that may exist in the antenna circuit. Since the antenna is mismatched at harmonics, it is possible for high SWR to exist at a harmonic frequency and if the coupler is accidentally placed at a point in the line having high harmonic current, pickup of this current will adversely affect the reverse reading of the coupler.

You may scoff at this notion, and say that the second harmonic level of your transmitter or exciter is "down 35 dB," or some such number. Well and good, but just remember that with a high value of antenna mismatch reflection at a harmonic, the harmonic voltage passing through the coupler may be many times higher than you suppose. And don't forget that when a coupler is measuring the reflected wave in a line, it may be measuring as high as 40 to 50 dB below the fundamental signal level. That is to say, the unwanted harmonic voltage can easily be of the same order of magnitude as the measured reflected wave.

For best results, therefore, I suggest you buy the best SWR meter you

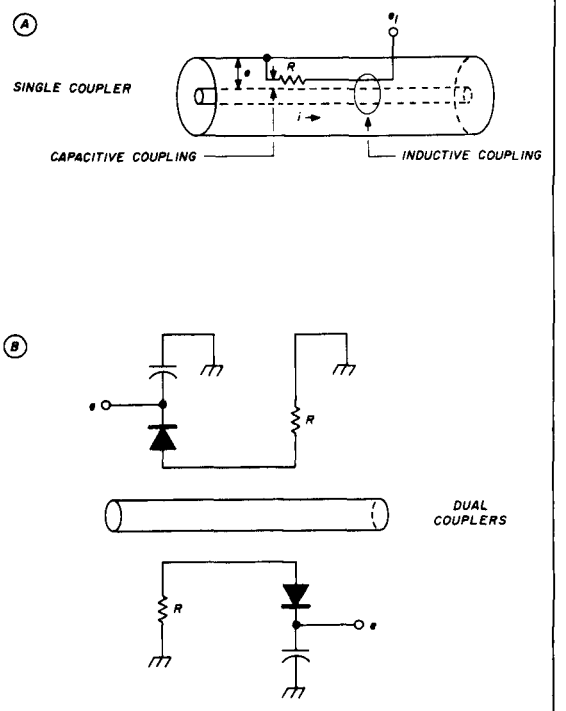


fig. 2. The directional coupler can sense either the forward or reflected wave components in a transmission line by taking advantage of the fact that the reflected components of voltage and current are 180 degrees out of phase, while the forward components of voltage and current are in phase. A short section of line coplanar with the inner conductor of the main transmission line (A) is formed into a loop through a series resistor. Voltage across the series-connected loop and resistor is measured, the combination constituting a short, terminated transmission line. The pickup device is sensitive to waves traveling in one direction by virtue of capacitive and magnetic coupling. The coupler may be rotated physically 180 degrees to pick up waves traveling in the reverse direction. An alternative is to employ two couplers built in one unit but oriented oppositely (B). Ideally, both couplers should be identical in coupling to the coaxial line and in directivity.

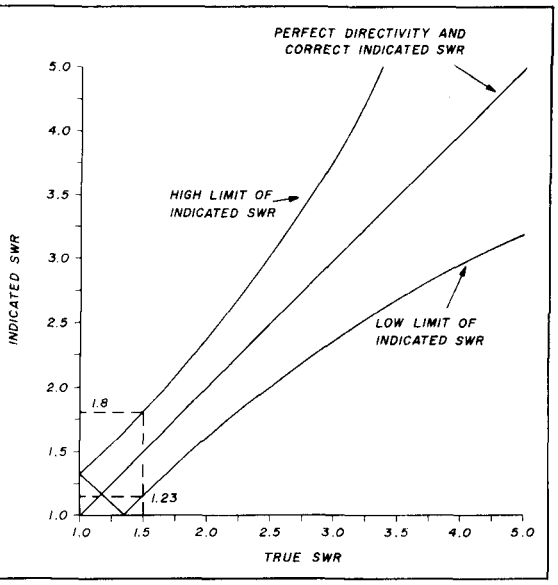


fig. 3. Extreme limits of indicated SWR versus actual SWR for a coupler having 25 dB of directivity. (Adapted from "Possible Errors in VSWR Measurement," Breetz, *QST*, November, 1959.)

can afford. Some SWR meters are made up of two directional couplers, back to back. Others have a single coupler with a reversible element. I prefer the latter type. One coupler made in the U. S. A. has plug-in heads for various frequencies and power levels. It is useful for both hf and VHF antenna measurements. While I don't believe in "plugging" name brands in this column, be assured this high-flying instrument is really a Bird!

pitfalls in making SWR measurements

So now you have a good SWR meter! Congratulations. If you use it properly, you'll get meaningful information. But you just can't jam it into a coaxial line and expect the instrument to do its job. It is up to you to make sure that the meter reads what you are looking for (true SWR of the antenna) and not a jumble of information resulting from unwanted coupling between the transmission line and the antenna. Let me explain.

Any conductor in the field of an antenna is coupled to it inductively. The degree of coupling depends upon the position of the conductor with respect to the antenna and the distance between antenna and conductor. A good example of such a conductor is a parasitic element in a beam antenna. It is closely coupled to the antenna and tuned closely to its frequency.

Other conductors coupled to your transmitting antenna are overhead power lines, telephone lines, and your transmission line.

Yes! The outer shield of a coaxial line can be inductively coupled to the antenna if it runs parallel, or nearly so, to the antenna and is elevated above ground level. An example of this is shown in **fig. 4**, a typical antenna installation.

Antenna current induced on the outer shield of a transmission line will influence the SWR reading of currents within the line, as the outer shield is no longer at ground potential, even though the SWR meter and transmitter are supposed to be near ground potential. The outside of the coax line has become part of the antenna system (due to inductive coupling to the antenna) and thus becomes part of the load on the line, in addition to the antenna load. The SWR on the line is now determined by the composite load of the antenna and the outside of the line.

This is one reason why changing the length of the transmission line changes the SWR reading. The portion of the load caused by unwanted line coupling is being changed!

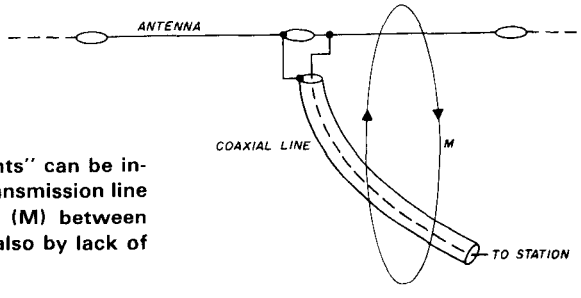
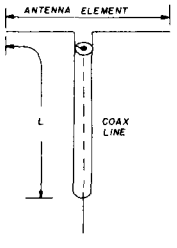


fig. 4. "Antenna currents" can be induced into shield of transmission line by inductive coupling (M) between line and antenna and also by lack of balun at the antenna.

how to reduce unwanted line currents

To achieve an accurate SWR reading on your transmission line it is necessary to detune and decouple the line from the antenna. Certain lengths of transmission line, as measured between one tip of the antenna and the SWR meter (L) are not resonant in the Amateur bands (**table 1**). Cutting the transmission line to rec-

table 1. Recommended non-resonant transmission line lengths (L) for the high-frequency Amateur bands. Lengths indicated include distance between one tip of driven element and feed point, plus coaxial line length.



23 - 30 ft.	158 ft.
35 - 44 ft.	164 ft.
46 - 47 ft.	
52 - 63 ft.	
71 - 81 ft.	
86 - 90 ft.	
93 - 97 ft.	
106 - 112 ft.	
141 - 147 ft.	

(Adapted from *The ARRL Antenna Book*)

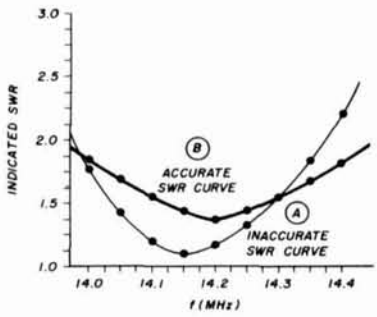


fig. 5. (A) Measured SWR curve with unwanted antenna currents flowing in outer conductor of coaxial line. Curve indicates antenna system resonance near 14.15 MHz with very low SWR. The more accurate curve run with antenna currents on line suppressed shows a flatter response, with higher value of minimum SWR at 14.225 MHz. Classic curve of measurement A may lull Amateur into thinking he has a perfect match, whereas the correct curve (B) shows match is not quite so good.

ommended lengths helps, but is not a total cure to the problem.

Of equal importance is the fact that the transmission line should not run parallel to the antenna elements. And it should be positioned close to the ground and not suspended above the ground. This is a large order when a rotary beam is used because at some beam heading the antenna elements will probably run parallel with the transmission line. The best solution is to run the coaxial line along the ground from the antenna tower to the station, or bury it beneath the ground in a section of water hose. The worst thing is to run the coaxial line a long distance above the ground from tower to station (along the roof top, for example). This places the coax line up in the air and closer to the active antenna.

But what do you do when it is impossible to cut line length to a recommended value and the line must run along the rooftop in the vicinity of the antenna? Obviously, induced antenna currents are going to flow in the outer conductor of the line. How can SWR measurements made under these conditions be trusted?

decoupling the transmission line

Let's assume that your situation is this: You have a tri-band beam for 20-15-10 meters atop a 40 foot tower. The coax feedline runs down the tower to the 10 foot level and then runs along your roof for about 20 feet to the station, then drops down to near ground level, entering a window near the transmitter. You make SWR measurements across each band and get a reassuring set of curves that bear a little resemblance to the "typical" curves supplied by the manufacturer. How can you determine your curves are valid?

The easiest and quickest check is to add four or five feet of coaxial line between the SWR meter and the antenna and rerun the SWR curves. If the shape or amplitude of the SWR curves change, it is a good bet that you have unwanted coupling between the antenna and transmission line. Of course, to make this experiment, it is understood that the unbalanced, coaxial line is properly terminated at the antenna in a balun or other device which provides a match between the unbalanced line and the balanced driven element of the beam. (Note: Such a test is valid *only* if you have a good SWR meter.)

If you find that interaction between line and antenna exists and it is impractical to move or otherwise change position of either the line or the antenna, what is to be done?

One helpful and easy thing to do is to coil the line into a simple rf choke at the foot of the tower. Four or five turns about a foot in diameter, taped together with electrical tape, will help to "cool off" the line at the tower.

At the station end of the line, a second, similar coil may help solve the problem. The coil can be made by splicing an extra length of line into the system with coaxial adapters. After the coils are in place new SWR runs are made, with and without the extra spliced-in line section. Now, do

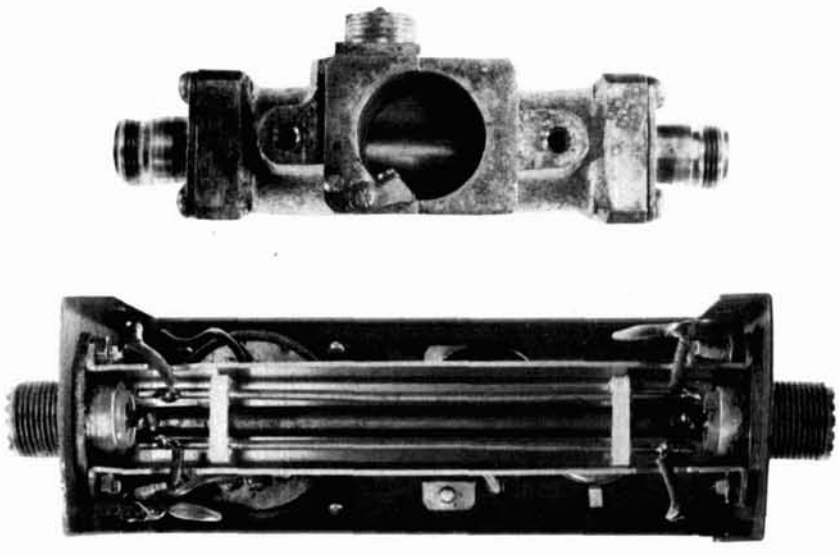


fig. 6. Bird coupler (top) is machined from solid brass casting. The coupling element is plugged into hole at center of the structure. Center conductor of coaxial line can be seen running through the center of the coupler. Voltage pickup is taken from fitting on side of the casting. Inexpensive "CB-type" SWR meter (bottom) has two directional couplers made up of wires placed parallel to center conductor of open coaxial line section. Open trough with one side exposed permits antenna currents flowing on outside of the coaxial line to enter the measuring section of the line where the coupling elements are located.

the two sets of measurements agree within reason? If they do, your transmission line is decoupled from the antenna (**fig. 5**). Don't expect the curves to match exactly; a degree of line coupling can still exist, particularly if the transmitter or exciter are enclosed in a "leaky" cabinet that permits rf to pass from the transmitter circuits to the outside of the cabinet (most of today's modern transmitters fall into this regrettable category).

a final word on SWR meters

The name of the game is to keep all the rf bottled up inside the transmission line up to the antenna and let none of it escape along the outside of the coaxial line. This will provide the most reliable SWR indication. But all your good efforts may go for naught if you choose a poor SWR meter! Look at **fig. 6**. This photo compares the directional element of a Bird coupler with an inexpensive, imported "CB-type" SWR meter. Note that the coupling element of the cheap device is an open trough, with one side exposed, providing excellent coupling between the wanted measurements and any induced waves traveling along the outside of the coaxial line. The break in the line shield inside the SWR meter provides a perfect place for transmission line currents and unwanted induced currents to join — right at the point the measurement is being taken.

Don't throw out your cheap SWR meter, but don't put too much trust in it. Borrow a good directional coupler and place it in series with your SWR meter. See how the two compare in readings across your antenna's span of operation. Decouple your transmission line by keeping it close to ground level and winding it up into rf chokes at the station and tower ends of the line. Make sure you use a good balun at the antenna, if one is required.

More in my next column.

ham radio

For more information on the use of the SWR meter, the reader is referred to the just-published 22nd edition of the *Radio Handbook*, available from Ham Radio's Bookstore. **Editor**

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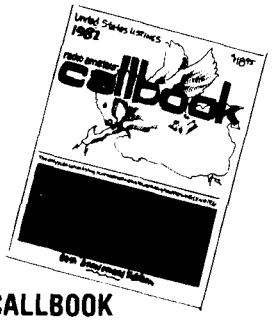

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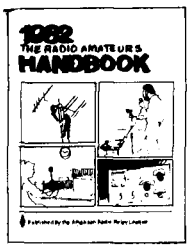

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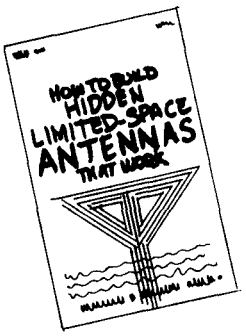

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More Details? CHECK—OFF Page 92

2716 EPROM programmer

Easy method for burning EPROMS with your microprocessor

Programming read-only memories (ROMs) is a virtual necessity if you're developing microprocessor-controlled ham gear. Many microprocessor systems, such as the KIM, SYM, and AIM, are capable of developing and debugging simple control programs, but none have ROM programming capability. As a first step to integrating microprocessor control into my projects, I found that I needed something to go with my KIM that would program and read erasable programmable read-only memories (EPROMs). The circuits presented here will work with the KIM, SYM, and AIM and are adaptable to other microprocessor systems.

what is an EPROM? why program one?

Solid-state memory for microprocessors comes in two forms, random-access memory (RAM) and read-only memory (ROM). The former is a general-purpose memory that can be used to store both program and data material. Information stored in it may be changed at will.

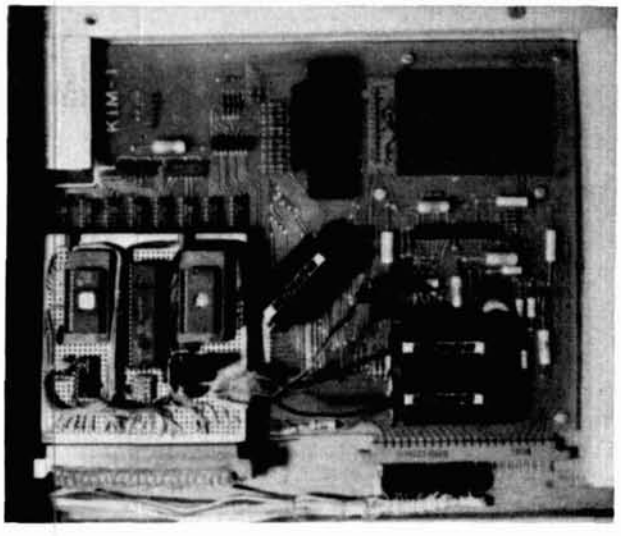
ROM is used for permanent programs and their constants. As the name implies, it can be read only. If scratch pad space beyond that contained in the microprocessor is required, it must be supplemented with RAM.

The shortcoming of RAM is that it is volatile; that is, if the power is removed the RAM forgets. Many schemes for making RAM more permanent are available, such as battery or large-capacitor power supply backup, but in the long run permanent programs should be stored in some sort of nonvolatile ROM. This places them beyond the reach of power failure and programming errors, which would leave a RAM filled with garbage.

An additional advantage of ROM is that microprocessor chips, when powered up, awaken seeking the address of their first instruction at a particular location. If the program stored in the ROM has the correct addresses, pointing the way to the beginning of the program, the routine will be self-initiating when powered up. In other words, the operator doesn't even have to know that a microprocessor is there.

ROMs fall into different categories depending on their application and the volume of their manufacture. The particular chip considered here, a 2716, is selected based on its popularity and price. The 2716 is an erasable programmable read-only memory (EPROM) with 2K (2048 bytes) of memory. It may be programmed with simple circuitry and straightforward techniques.

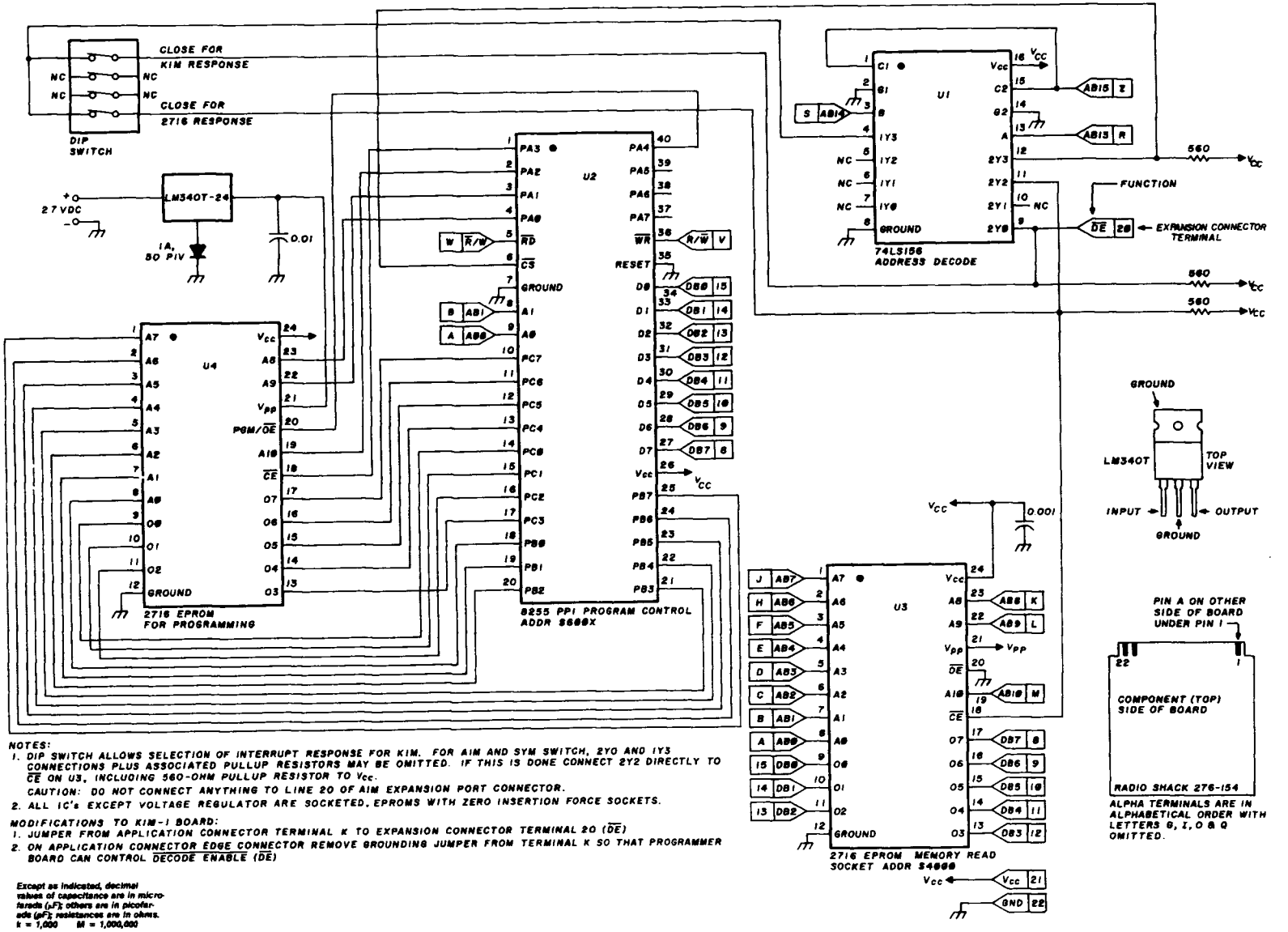
To correct mistakes, or when you wish to replace an old program with a new one, the chip can be erased by exposure to ultraviolet light.* Program-



The completed unit. The PPI is the large IC in the center of the board. The programming socket is to its right and the read socket to the left. The regulator with a heatsink is mounted vertically at the bottom right corner of the PPI. The regulator bypass capacitor is between it and the battery connectors.

*Commercial UV erasers are available from computer hobbyist supply houses for $65 to $75. A simple home-built eraser is described by Golter, "Build a Low-Cost EPROM Eraser,", *BYTE*, April, 1980.

By C.A. Eubanks, N3CA, P.O. Box 127, Valencia, Pennsylvania 16059



NOTES:
1. DIP SWITCH ALLOWS SELECTION OF INTERRUPT RESPONSE FOR KIM. FOR AIM AND SYM SWITCH, 2Y0 AND 1Y3 CONNECTIONS PLUS ASSOCIATED PULLUP RESISTORS MAY BE OMITTED. IF THIS IS DONE CONNECT 2Y2 DIRECTLY TO $\overline{CE}$ ON U3, INCLUDING 560-OHM PULLUP RESISTOR TO V_{CC}.
   CAUTION: DO NOT CONNECT ANYTHING TO LINE 20 OF AIM EXPANSION PORT CONNECTOR.
2. ALL IC's EXCEPT VOLTAGE REGULATOR ARE SOCKETED. EPROMS WITH ZERO INSERTION FORCE SOCKETS.

MODIFICATIONS TO KIM-1 BOARD:
1. JUMPER FROM APPLICATION CONNECTOR TERMINAL K TO EXPANSION CONNECTOR TERMINAL 20 ($\overline{DE}$)
2. ON APPLICATION CONNECTOR EDGE CONNECTOR REMOVE GROUNDING JUMPER FROM TERMINAL K SO THAT PROGRAMMER BOARD CAN CONTROL $\overline{DECODE\ ENABLE}$ ($\overline{DE}$)

Except as indicated, decimal values of capacitance are in microfarads (μF); others are in picofarads (pF); resistances are in ohms. k = 1,000 M = 1,000,000

fig. 1. Schematic diagram of the 2716 EPROM programmer-reader.

ming can be accomplished a byte at a time, or the entire EPROM may be programmed at once. Unfortunately, during erasure, everything gets erased together.

how it works

The basic programming circuit is built around an 8255 programmable peripheral interface chip (PPI). The 8255, designed for compatibility with the 80XX line of microprocessors, is easy to interface and has sold in sufficient quantity to be economical for Amateur use. It can be addressed by the controlling microprocessor bus and directed to either read from or write to its input/output lines, providing communication with the EPROM being programmed.

The microprocessor board supplies the byte address of the location in the EPROM being programmed, the data to be recorded and the enabling signal. Programming all of the 2048 EPROM locations at one time requires about 103 seconds, or 50 milliseconds per location.

Programming a 2716 EPROM requires a 25-volt positive signal. This voltage is derived from a 24-volt LM340T monolithic regulator chip, as shown in **fig. 1**. A diode in the regulator's reference leg increases the output to approximately 25 volts. The chip is powered by three 9-volt transistor radio batteries connected in series. Though not elegant, the technique is quite effective for small volume use.

The microprocessor chips used in the KIM, AIM and SYM circuits have a pull-down-to-reset signal, which is not directly compatible with the 8255 chip (pull-up to reset). Rather than add an additional IC to provide the extra gate needed for hardware reset, I decided to do it with software. This is accomplished by converting all of its ports to inputs with a control instruction before connecting the batteries to the 24-volt regulator.

The programming algorithm includes a testing operation before programming to ensure that the EPROM area to be used is clean (all bits set to logical ones — the erased condition). The algorithm also contains a second comparison routine after programming to ensure that data transcription is correct. **Fig. 2** is a flow chart showing the initial verification and programming. The final comparison uses similar technique.

I selected the addressing of the PPI and 2716 EPROM read socket to be compatible with the SYM, AIM, and KIM microprocessor boards. On the first two these addresses are mapped into the user expansion space. On the KIM they fall above the monitor.

Both the PPI and the EPROM read socket must be enabled; that is, told when to respond to address and data bus inputs. This is accomplished by applying a logical zero (low level) signal to the NOT chip enable

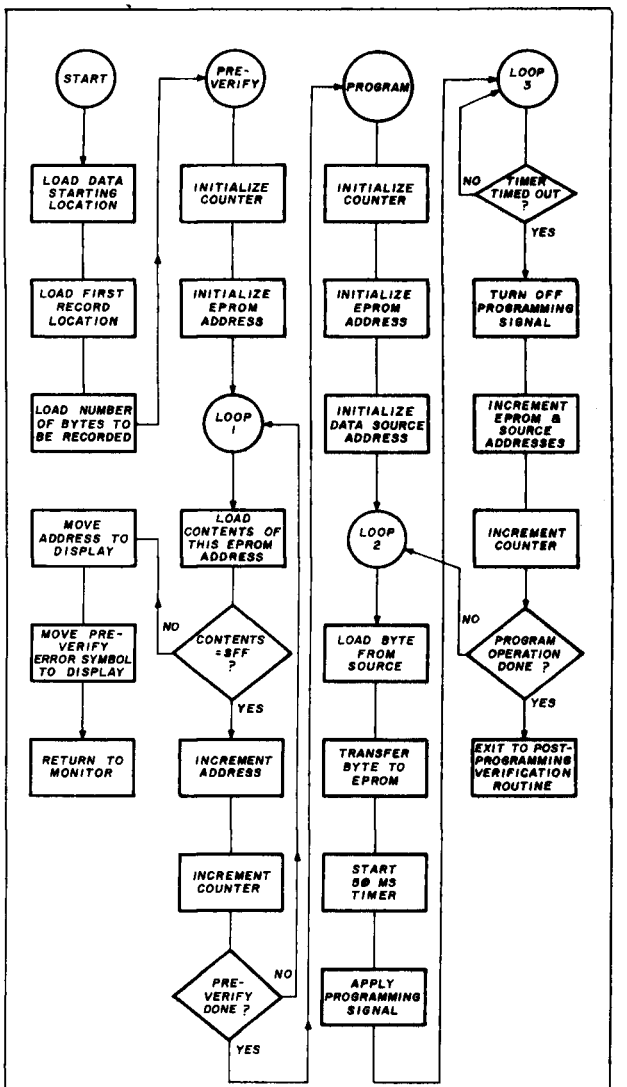


fig. 2. Flow chart of pre-verify and programming routines. Post-programming verification is similar to pre-verify except that the EPROM is checked against its source.

($\overline{CE}$) line of the selected chip. A 74LS156 three-to-eight line open collector decoder performs this selection by address decoding. It breaks the 64K addressing capability of the microprocessor into eight 8K segments as shown in **fig. 3**. The NOT 8K segment 3 line ($\overline{8K3}$) is assigned to the PPI and the $\overline{8K2}$ line is assigned to the EPROM read socket.

Beyond this point the KIM differs from the SYM and the AIM. The latter two fully decode the portions of memory that they use internally, whereas the KIM does not have this feature. Without outside help it can't tell one 8K segment from another. The KIM's NOT decode enable ($\overline{DE}$) must be brought low only when its on-board devices are to respond to an address on the address bus. To permit this action the $\overline{8K0}$ and the $\overline{8K7}$ lines from the 74LS156 decoder are

wire-OR tied (paralleled — see **fig. 3**) together. The first of these picks up on-board KIM devices during normal addressing, and the latter allows interrupt responses.

This occurrence gives rise to an interesting opportunity for the KIM user. If the $\overline{8K7}$ line is instead wire-OR tied to the EPROM read socket, the resident EPROM will respond to interrupts. To permit this, a DIP switch is included on the board to control which device gets the $\overline{8K7}$ enabling signal. As mentioned above, this applies only to the KIM.

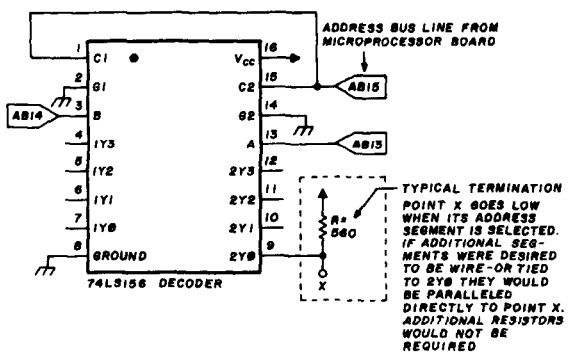
Note that if circuitry is set up for use with the KIM, it may be used on AIM and SYM systems with the following provisions:

1. The EPROM read socket must not be selected as the interrupt source. If it is, bus contention will result when both the host board and the EPROM try to respond to $\overline{8K7}$ addresses on read cycles.

2. Line 20 on the expansion connector must be left open with the AIM.

The AIM 65 uses this connection for other purposes. Alternatively, AIM and SYM users may omit the connections to the $\overline{8K0}$ and $\overline{8K7}$ lines, the associated resistors and the DIP switch.

You will notice that this is a fairly wasteful method of addressing. The PPI uses only four addresses out of the 8K available to it. The EPROM read socket uses only 2K of its 8K. I found no use for the additional possible PPI addresses, but the EPROM addresses are a different story. The price of 2732 EPROMs (4K byte EPROMs) are today about half of what 2716s cost two years ago. I expect that before long I'll modify the programming board to handle 2732s and possibly 2764s. They are virtually identical to the 2716 and require minimal circuit changes



SEGMENT	74LS156 PIN	HEXADECIMAL ADDRESS RANGE FROM	TO	COMMENTS
8K0	2Y0	0	1FFF	USED FOR KIM ON-BOARD DEVICES
8K1	2Y1	2000	3FFF	—
8K2	2Y2	4000	5FFF	EPROM READ SOCKET ENABLE
8K3	2Y3	6000	7FFF	PPI ENABLE
8K4	1Y0	8000	9FFF	—
8K5	1Y1	A000	BFFF	—
8K6	1Y2	C000	DFFF	—
8K7	1Y3	E000	FFFF	USED FOR KIM INTERRUPT RESPONSE

fig. 3. Address decoding arrangements used for chip enable of PPI and EPROM read sockets.

construction

The unit is assembled on a Radio Shack two-voltage edge-card board, part no. 276-154. I selected this board because it has an edge connector matching that found on the KIM, SYM, and AIM systems. Those with a different type of microprocessor system may choose alternative boards better suited to this application.

All ICs except the voltage regulator are socketed. The sockets make modifications easier and let you remove static-sensitive MOS chips when the board must be handled. For the EPROMs, zero insertion force (ZIF) sockets were selected to minimize wear and tear on the 2716 chips. The ZIF sockets are wide enough so that they overhang the outermost connections for each pin on the programmer board, which means that the wiring must be completed before installing the ZIF sockets. Advance planning in the wiring layout is necessary to keep it from obstructing ZIF socket installation.

A four-unit DIP switch was selected to control decoding for top-end-of-memory addressing. A conventional toggle switch could be substituted, but the DIP switch fits more neatly into the board layout. These switches are needed only if KIM compatibility is sought.

All wiring and components are located on the blank (non-foil) side of the board. Install short jumpers for V_{cc} and ground connections before wiring the longer runs.

Jumper cables with suitable connectors are available* to connect the boards together but they are considerably longer than my layout required and they're expensive. I obtained wire-wrap connectors at a hamfest and hand wired them together instead. I mounted the programmer board quite close to the microprocessor board to minimize reactance and crosstalk. The wiring between the connectors is 1-1/2 inches (4 cm) long. After wire wrapping the connectors I applied a liberal coat of silicone rubber sealer to keep repeated installations and removals from loosening the wraps.

The KIM expansion connector contains all the necessary lines except the $\overline{DE}$ line. Fortunately, there are unused lines on the expansion connector, termi-

*Available from the Computerist, Inc., Post Office Box 3, South Chelmsford, Massachusetts 01824. Program documentation and programmed EPROMs are available from the author. Send an SASE for information.

nals 18, 19 and 20. I wired the DE line from the application connector's terminal K to terminal 20 on the expansion connector with an on-board jumper. No board changes are needed on the SYM or AIM.

The regulator chip probably doesn't need a heatsink at the currents drawn during programming. If one is handy in the junk box, however, there's certainly nothing lost in installing it.

The batteries are connected using 9-volt battery connector leads. When not programming EPROMs the batteries should be disconnected and may be relegated to the refrigerator to prolong their life.

Both the jumper lead on the microprocessor board and the battery connector leads on the programmer board should be anchored with spots of silicone rubber sealant, which prevents placing mechanical stress on their solder joints.

notes on components

The basic cost of the parts for this board is about $34, which includes the two ZIF sockets but does not include connectors or 2716 EPROMs. Comparable EPROM programming systems available commercially start around $80. Many run in excess of $200 wired, although the higher end boards usually have multiple EPROM read sockets and may perform other functions such as handling memory expansion as well.

The more exotic chips used here (the 2716s and the 8255) were picked up from mail-order suppliers. Most of these accept phone orders for credit-card billing and feature 48-hour order turn-around via UPS. A sample of five suppliers of 8255s from the July, 1981, issue of *BYTE* magazine shows a unit price range from $5.40 to $9.95.

initial operation

Check the wiring to make sure its correct and that no shorts or solder bridges exist before applying power. My original wiring was all right, but apparently I'm losing my color vision: one resistor was the wrong value.

With both EPROM sockets empty, connect the board to the microprocessor system's expansion connector (with the system de-energized, please!). Fire up the microprocessor and direct the 8255 PPI to output logical ones to each of the programming socket's pins, one at a time. Check operation with a voltmeter. Note that KIM and similar systems can't write to the PPI manually because the monitor tries to treat the PPI as a read/write memory. Things get snarled up with the monitor when it tries to read back what it's just written. To write to the PPI, a store absolute instruction (or its equivalent) must be used.

I've encountered only one hardware problem since startup (my software is always full of bugs). During an EPROM read, one or more bit at one or more addresses would occasionally be wrong. To the best I've been able to determine, this was due to low power-supply voltage (about 4.75 volts on the EPROM board). I corrected this by installing a 0.001 μF bypass at the read socket's V_{cc} pin and by cranking the power supply up to 4.98 volts under load.

Table 1 lists the rules for using the PPI to talk to the programming socket as they apply to this circuit. Carefully step through your algorithm before applying programming voltages to an EPROM, and make sure that the 50-millisecond period falls somewhere between 45 and 55 milliseconds. Periods under 45 milliseconds may give incorrect programming, and over 55 milliseconds may leave you a dead EPROM!

An additional consideration on the EPROM programming side is that the manufacturer's data sheet requires application of V_{cc} (+5 volts) before applying V_{pp} (+25 volts) and removing V_{pp} first (concurrent application and removal are also permitted). To avoid getting into trouble, don't connect the batteries until you are ready to program, and disconnect them just as soon as you are finished.

table 1. Rules for PPI programming.

function	PGM/$\overline{CE}$ port line PA3 (2716 Pin 18)	$\overline{OE}$ port line PA4 (2716 Pin 20)	2716 response
program	⎍	1	program data in
program inhibit	0	1	high Z outputs
program verify	0	0	data out

8255 PPI control for this circuit

control addresses:
- $6000 = port A
- $6001 = port B
- $6002 = port C
- $6003 = control word register

control words:
- $80 = make all ports outputs (for programming)
- $9B = make all ports inputs (resets PPI and applies no signals to EPROM)
- $89 = *make ports A and B outputs; port C an input (for verify)*

port assignments:
- port A = EPROM address lines A10 through A8 correspond to port lines PA2 through PA0, EPROM $\overline{CE}$ to PA3, EPROM $\overline{OE}$ to PA4
- port B = least-significant address byte
- port C = data bus

Once everything checks out, you're ready to go. Remember in use that the 8255 PPI and the 2716 are static-sensitive devices and may be ruined by improper handling. Follow manufacturer's recommendations and use an insulated insertion/extraction tool to handle the devices.

ham radio

More Details? CHECK — OFF Page 92

performance capability of active mixers

Part two: practical circuits and testing

In the first part of this article, I introduced the basic characteristics that distinguish active double-balanced mixers. The equations that define the sigificant interfering effects during signal handling were also developed. Now we will look at some practical mixer circuits and examine some testing techniques.

practical circuits

Because we are interested in the problems of balancing harmonics and other unwanted products, we will not consider simple, single-stage mixers but instead will look at several active mixer circuits that pretty much represent the state of the art. Depending on the bias to cutoff ratio of the devices selected, fairly high intercept points (up to +30 dBm) can be obtained.

Fig. 9 is the schematic of an active mixer using two VHF transistors in push-pull. Because of the number of spurious frequencies generated, substantial filtering at the output is recommended, as can be seen from the highpass-lowpass filter section. The two rf chokes at the base of each transistor prevent unwanted oscillation at fairly high frequencies.

Fig. 10 shows a balanced mixer using the 3N200 field-effect transistor in push-pull. This is a multiplicative mixer in which the rf input signal is fed in parallel.

Ed Oxner of Siliconix has designed several mixers based on the U257 transistor. The schematic is shown in **fig. 11**. Siliconix also made a version with four field-effect transistors in one package. **Fig.12** shows the schematic of such a configuration using the U350.

VMOS transistors have become popular, and a push-pull version with the VMP4 power FET, as described by Doug DeMaw, was shown in *QST*.[4] (See **fig. 13**.)

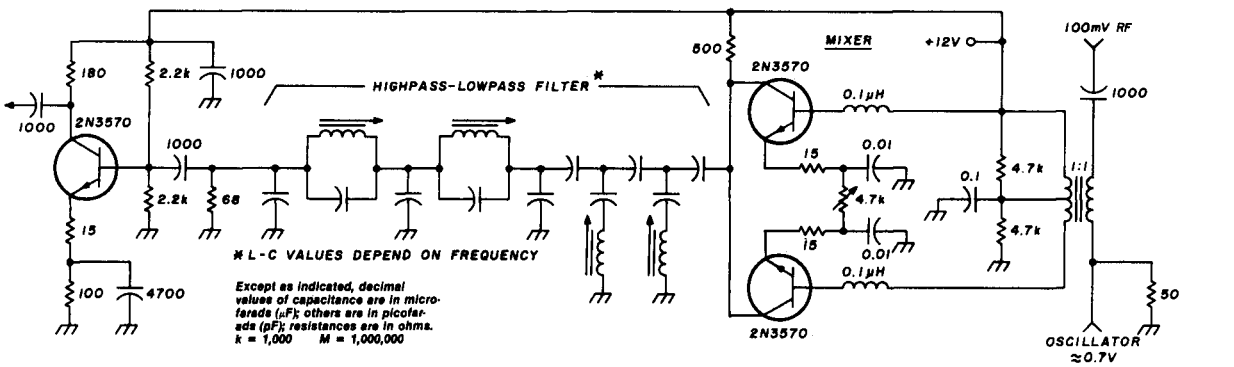


fig. 9. Active mixer with transistors and bandpass filter.

Most loads into which the mixers operate do not present precisely 50 ohms to the mixer output. Also, most designers of active mixers have carefully avoided indicating the effects that occur in active mixers as the termination changes from a purely resistive 50-ohm load into some other value. In general, any change in resistive load that does not introduce reactive components does not affect the mixer substantially. A VSWR of 1:2 from 50 ohms, or change of load from 25 to 100 ohms resistive, does not have too many adverse effects. If, however, the mixer is terminated by an LC filter or crystal filter, the impedance changes and becomes reactive, and the intercept point changes drastically. In some cases with active mixers, I have observed instabilities even to the point where the mixer turned into a low frequency oscillator.

Three basic circuits are known to prevent change of impedance. **Fig. 14** shows a recommended ar-

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

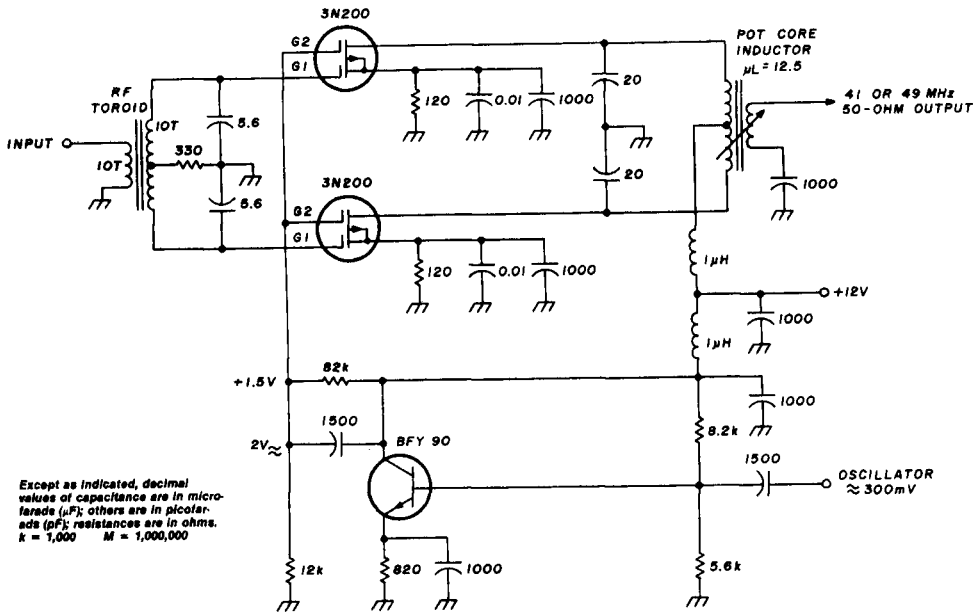


fig. 10. Push-pull mixer with 3N200 FETs.

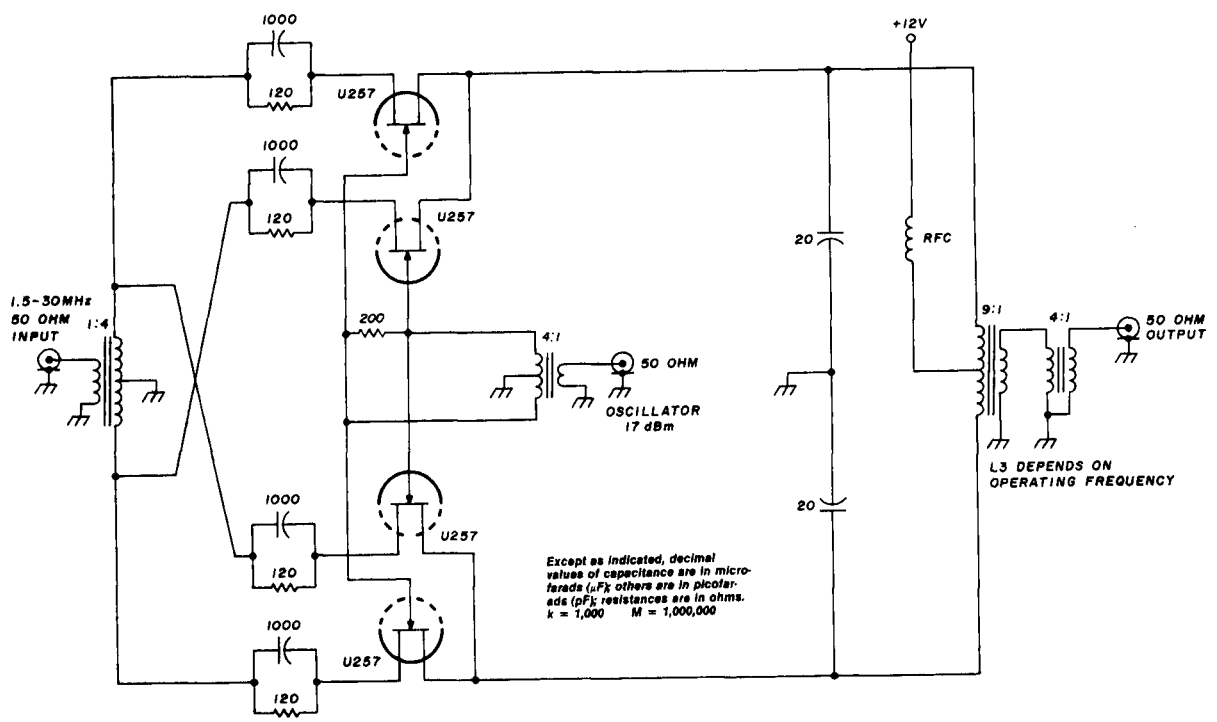


fig. 11. Double-balanced mixer with Siliconix U257.

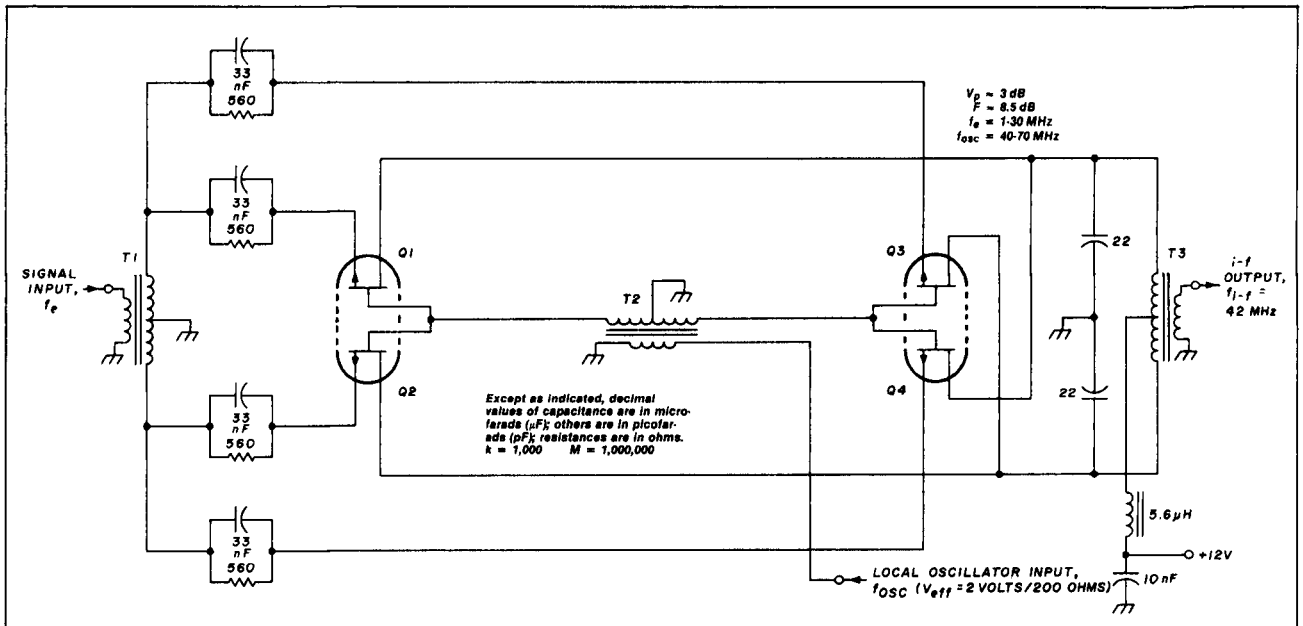


fig. 12. Double-balanced mixer using U350.

rangement whereby the mixer, in this case a passive double-balanced mixer, is terminated by the input impedance of a grounded-gate field-effect transistor. It must be remembered that grounded-gate field-effect transistors properly biased exhibit purely resistive input over an extremely wide frequency range.

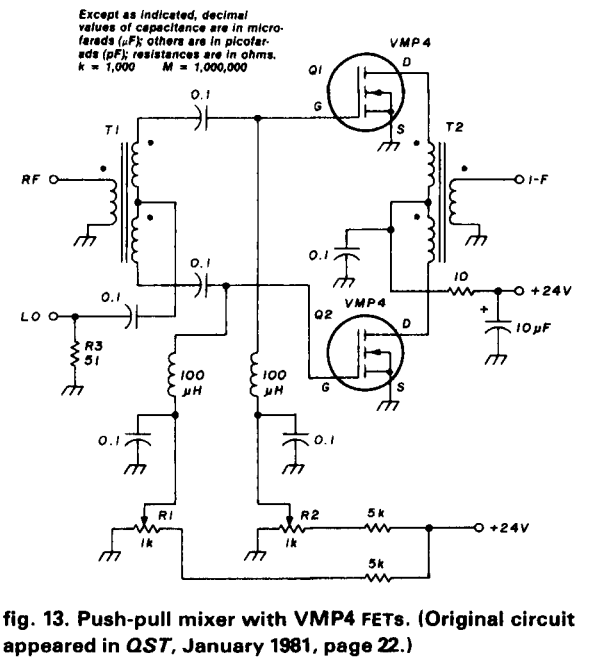


fig. 13. Push-pull mixer with VMP4 FETs. (Original circuit appeared in *QST*, January 1981, page 22.)

This holds true in most cases basically from dc to several hundred MHz. The CP643 or CP640 made by Teledyne Crystalonics is a good choice.

Another alternative is a feedback amplifier that uses noiseless feedback as described in the literature[5,6] based on patent 3891934 of 1975. The third alternative is the use of a diplexer whereby the image at the output of the mixer is terminated with a 50-ohm resistor.

Probably the best solution is a combination of two transistors with a diplexer as shown in **fig. 15**. Again, for convenience, the circuit is shown with a passive balanced mixer together with this particular termination circuit.

Let's now take a look at some systems calculations that will yield a surprising result.

Active mixer with perfect termination. Consider an active mixer such as the Plessey SL6440 in any of the previously shown schematics. The noise figure under large-signal operation is around 11 dB for the Plessey device and 8 dB for a U257 mixer. Relative to the typical loss of 6 dB in a passive mixer, the zero-dB gain of an active mixer already represents gain; to be specific, 6-dB gain over the passive device. Let us assume further that the amplifier following uses noiseless feedback and its noise figure is 2 dB. As the mixer has unity gain, the noise figure at the input is equal to the noise figure of the second stage plus the noise figure of the mixer, and in the case of the Plessey mixer the resulting noise is 11.2 dB.

If we use a U257 stage, we get a 10-dB noise figure if we allow the same amount of gain. The intercept point is determined by the mixer and the second amplifier, and because of the special rf feedback applied in the second amplifier, we will, for the moment, assume that the second amplifier does not contribute any intermodulation distortion products. The very moment we operate the mixer with gain, we must take distortion of the second stage into consideration.

Passive double-balanced mixer with termination stage. Let's use the same example with a high-performance double-balanced mixer. The double-balanced mixer has an insertion loss of 6 dB, and the noise figure also is 6 dB.

The noise figure of the termination stage again is 2 dB, which results in a total systems noise figure of 8 dB, or 2 dB better than the previous example with the U257. Because of the 6-dB losses of the double-balanced mixer, the intermodulation distortion of the double-balanced mixer can be neglected, and the designer can concentrate on the mixer itself. This, I am sure, is a surprising result for most design engineers.

It is important to understand that the termination stage, when using the noiseless-feedback system, must also operate into a stable load. Any changes of the output load of such an rf feedback amplifier will be reflected into the input. A recommended way to reduce this change is to operate this stage at a higher than necessary gain; 3 or 4 dB is sufficient. A resistive pad with 3-dB attenuation will then prevent dramatic changes at the output.

In the case of the grounded-gate field-effect transistor as a termination, this circuit works reliably only if the drain-to-source feedback capacitor is kept extremely small and the capacitance is basically determined by the transistor itself.

If the output stage must operate into a crystal filter, we will find that most crystal filters outside the passband characteristic exhibit high impedance, which is either inductive or capacitive. This effect can be reduced by using a highpass filter at the output that incorporates the crystal filter. If the crystal filter's impedance increases, the highpass filter is mistuned, and the voltage at the drain or collector remains low. As a result, the third-order intermodulation distortion products remain low. In a convenional circuit, it is sometimes found that the sudden increase of impedance at the output of the transistor makes the intermodulation distortion deteriorate.

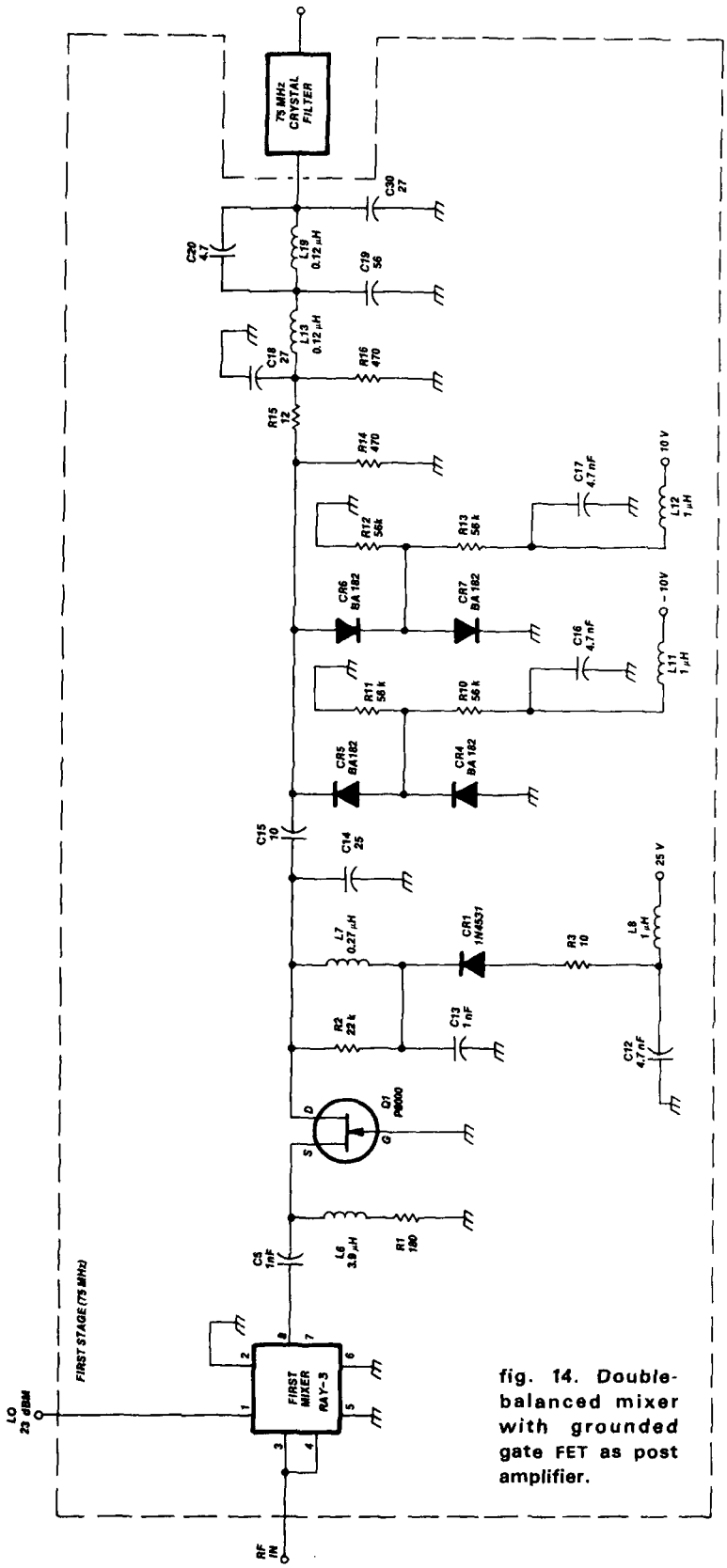


fig. 14. Double-balanced mixer with grounded gate FET as post amplifier.

passive mixer with active devices

Recent developmental work in the field of mixers

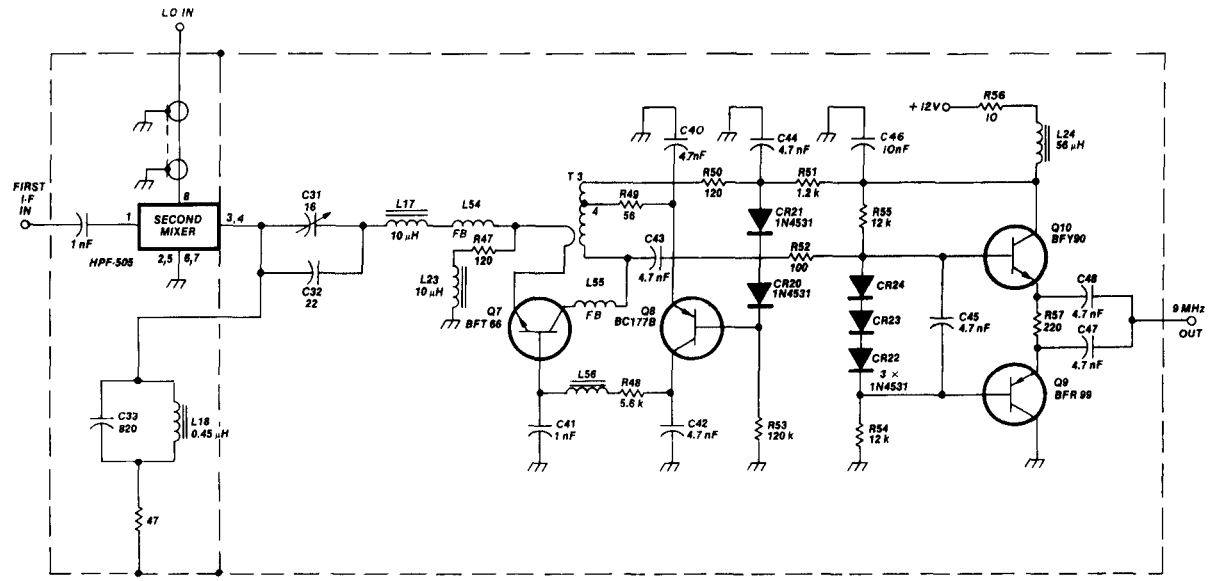


fig. 15. Double-balanced mixer with noiseless feedback amplifier as well as diplexer as termination.

indicates that the best way of achieving high intercept points in mixers is the use of:

1. Bipolar transistors as switches and with feedback.
2. Field-effect transistors as switches.

In ordinary applications, mixers using active devices operate on the nonlinear transfer characteristic, as explained earlier. Diode mixers are substantially better, because here the device is only switched on and off, and if the on-off resistance of the device has a high enough ratio, the device will be fast enough to follow the local-oscillator drive waveform. Enough local-oscillator drive power is available, theoretically, so that no harmonic distortion should occur. The losses would be 3 dB, as would the noise figure; thus we would not observe any intermodulation distortion products at all. Using active devices, we depend upon the nonlinearities of the input and output ports and, as with the field-effect transistor, possible distortion of the gate source diode and the potential nonlinearities of the channel resistance.

The state of the art for mixers using field-effect transistors without operating voltage and, therefore, only as switches, indicates approximately a +42 dBm input intercept point, 5.5 dB noise figure and insertion loss, and local-oscillator requirements of about +23 dBm. The local-oscillator drive requirement really results from the fact that a certain voltage has to be available at the gate electrode. In a quad configuration, this voltage can be as high as 50-volts PEP into the input capacitance of the transistor. The step-up transformer helps reduce the required power.

Fig. 16 shows the schematic of such a recomended mixer which, for test purposes, has a tuned input. This circuit is based on a patent issued to Mr. William Squires in 1968, number 3383601. It can be reported that for 1-volt input signal or +13 dBm, the third-order intermodulation distortion products are at −83 dBm, or 100 dBm down. This would increase to an intercept point of +70 dBm but can only be achieved in a narrowband circuit. In a wideband configuration, only 40 to 42 dBm is obtainable. The isolation between oscillator and signal port is about 60 dB and provides about 40-dB isolation to the i-f signal.

The area of using passive mixers with active devices is fairly new. The only company that seems to have a commercial product is Lorch in New Jersey, and the latest prices I have seen for their mixer were $600 or $700.

I had built an active mixer based on feedback and switching, which was published in *ham radio*.[7] This mixer with similar performance was used in the Rhode & Schwarz 400-watt transceiver in the Tornado warplane.

testing

To make proper tests on the mixers using signal generators, a hybrid coupler with at least 40 dB isolation between the two input ports and an attenuator are required. The test setup provided by DeMaw in *QST*[4] and shown in **fig. 17** is ideal for this. He used

two signal generators with outputs around 14 MHz and combined them. An attenuator drives the mixer under test (MUT), the local-oscillator signal is supplied by a VFO, and the output is then analyzed.

The 2N5109 amplifier shown may not be sufficient for extremely high intercept points, as this stage may no longer be transparent. For stability tests when using active mixers, it is recomended one have a reactive network at the output of the mixer for the sole purpose of checking mixer instability.

Rather than use expensive signal generators, two oscillators with extremely low harmonic content and

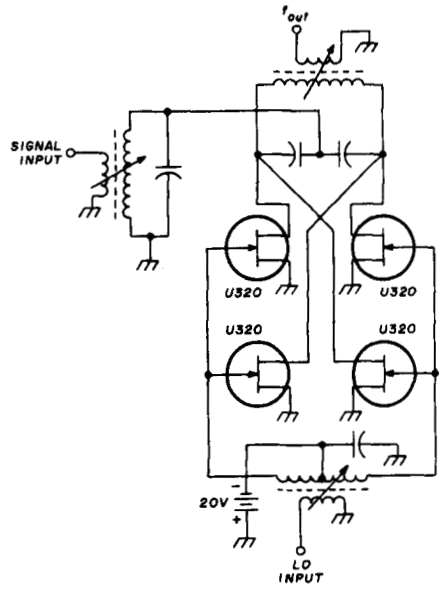


fig. 16. Schematic of a passive double-balanced mixer using FETs in a quad arrangement. This circuit represents the state-of-the-art that is possible today. While the narrowband version can have input intercept points of +70 dBm, a wideband version achieves about +42 dBm.

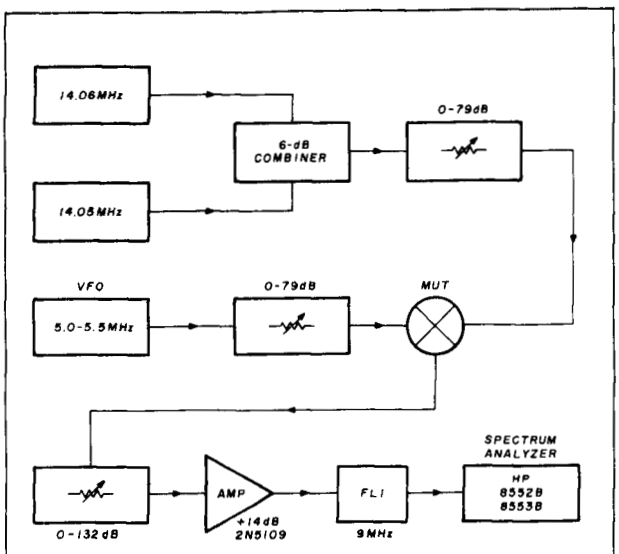


fig. 17. Recommended test setup for measuring mixer intermodulation distortion. (Original circuit appeared in *QST*, January, 1981, page 20.)

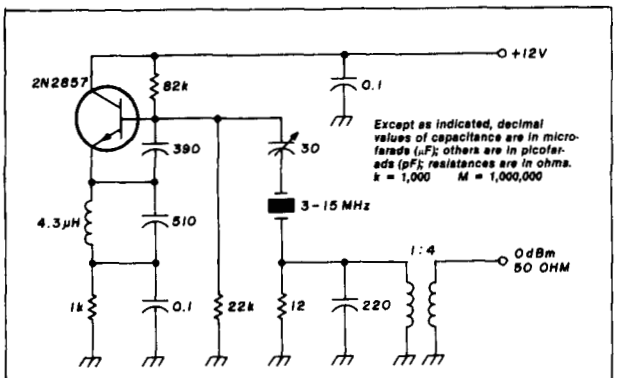


fig. 18. Low-noise crystal oscillator with 60-dB harmonic suppression.

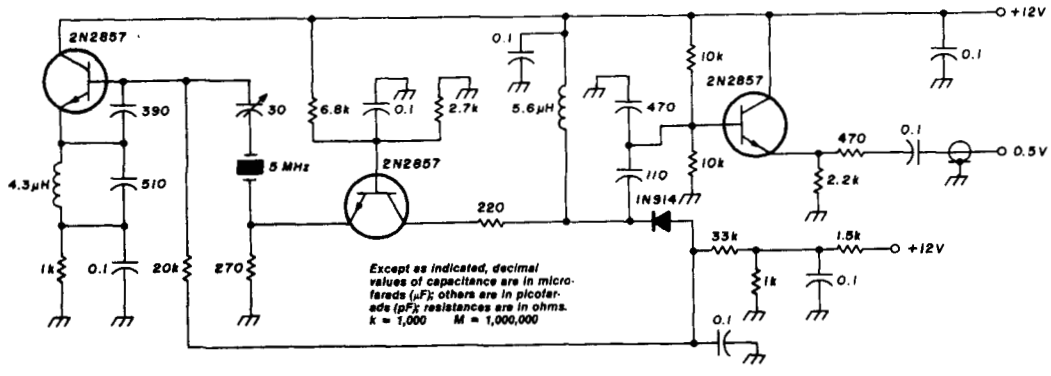


fig. 19. Ultra-low-noise crystal oscillator with ultimate noise floor of 168 dB/Hz.

very low noise sideband performance can be used. A convenient circuit to provide the required harmonic suppression and low noise is shown in **fig. 18**, based on an earlier paper of mine.[8] For those interested in obtaining an additional 20-dB improvement in noise sidebands and need a test oscillator with this performance, the circuit in **fig. 19** is recommended. This oscillator shows an ultimate noise floor of 168 dB/Hz at 1 kHz off the carrier. As can be seen, this oscillator is a derivative of the earlier one. The input impedance of the grounded-base stage is about 2 ohms and, therefore, does not really deteriorate the Q of the crystal.

summary

I have explained that ordinary active mixers based on the inherent nonlinearities of their transfer characteristic by definition will show a lower intercept point than is possible with passive devices. Passive devices are already used with great success, and the termination-insensitive mixers, although they are not yet offered below 1 MHz, are currently the state of the art in diode mixers. By using feedback techniques together with switching-type active stages and bipolar transistors (or better yet, using modern power junction field-effect transistors), I have measured third-order and higher input intercept points to 40 dBm. In selective cases and narrowband frequency operation, +70 dBm intercepts have been reported. It is not likely that these figures will be useful, as the termination stages of following crystal filters or other devices will become the limiting factor.

I have just learned that Mini-Circuit Laboratories has introduced a new mixer, type VAY1, that claims a 38-dB intercept point at the input, which results in a 32-dBm intercept point at the output. However, the drive requirements are much higher than for the passive FET mixer.

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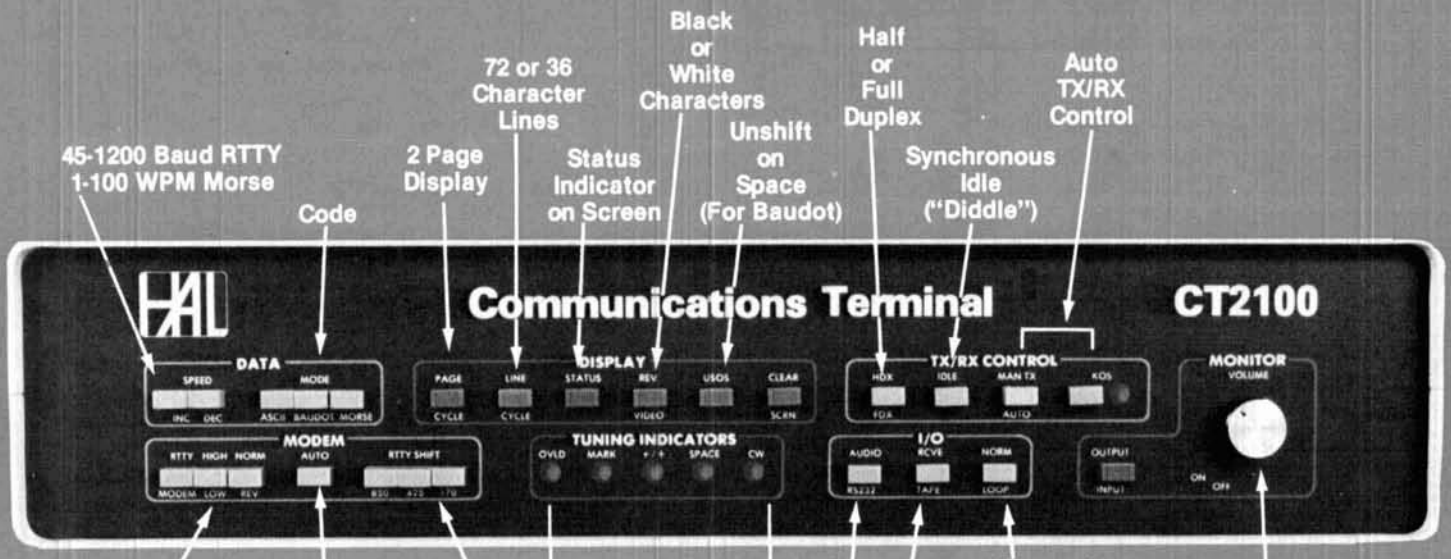

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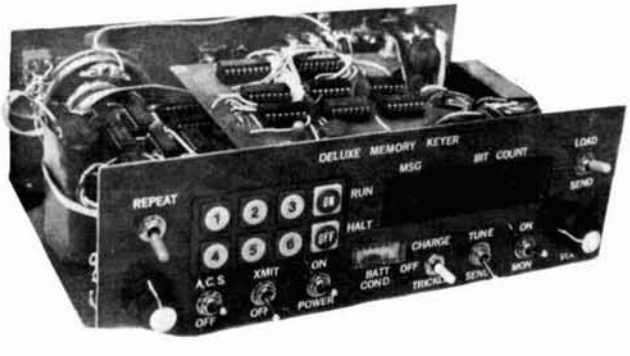
words per minute versus frequency

The handbook states that 24 WPM equals 10 dots per second times 2.4. To put it in another way, 24 WPM equals 24 dots per 2.4 seconds. It takes two clock pulses to equal one dot (1 dit and 1 space), so 24 WPM equals 48 clock bits per 2.4 seconds, or 24 clock bits in 1.2 seconds. All we have to do now is to let the counters tally the clock bits for 1.2 seconds, put in two 7475 latches to hold this count and display it on the readouts, and we have our WPM counter. On my first attempt at building a speed readout, I used a 3.58-MHz TV crystal and a 5369 oscillator chip for the 60-Hz time base and a multipole rotary switch to change modes. But then I decided a less expensive approach would be to use the 60 Hz from the secondary of the power transformer and two more 7400 chips to do the switching instead of the more expensive rotary switch. Thus evolved the circuit described here.

By Vernon W. Smith, WA1OEH, Box 75, E. Thompson Rd., Thompson, Connecticut 06277

theory of operation

Refer to **fig.1**. In the WPM mode, the DPDT switch



View of the speed adapter board mounted on top of the driver board. The existing keyer memory board is under the driver board. The bit count, WPM mode switch is mounted in the upper left corner, rear, next to the speaker. ***(Photo courtesy of Bill Mansfield, W1MLT.)***

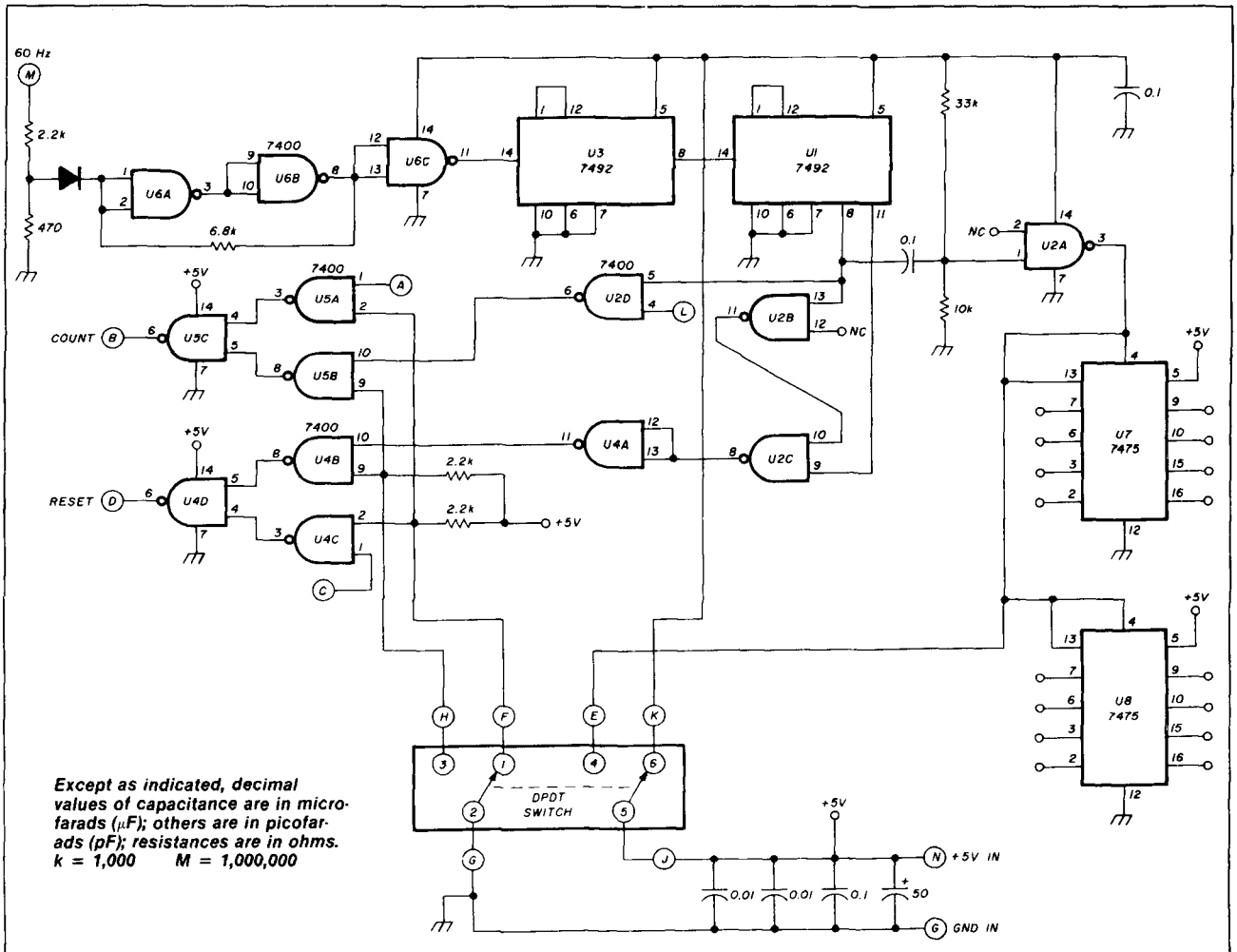


fig. 1. Schematic diagram of the WPM readout adapter. The circles indicate wire connections.

turns on the 5-volt supply for IC U1, U2, U3, and U6. The switch also grounds pin 2 of U4C and U5A, blocking out the count and reset pulses from the memory chip. Sixty Hz is fed into U6 from the power-transformer secondary. The 60-Hz waveform is shaped and conditioned by U6 and is fed into U3 (divide by 12). The output of U3, pin 8 (5 Hz) is fed into a second divide-by-12 IC, U1. The output of pin 8 of U1 is 2400 milliseconds, or 2.4 seconds long. This pulse is fed to pin 5 of the U2D NAND gate, which is high for 1.2 seconds and low for 1.2 seconds. During the high on U2D pin 5, the gate is held open, which allows the clock input pulse on pin 4 to pass through for a 1.2-second period. This count is in words per minute; that is WPM equals the number of clock pulses per 1.2 seconds. When pin 8, U1 goes low after the count time is concluded, pin 1 of U2A is pulsed, causing a high strobe pulse at its output and at pins 4 and 13 of U7 and U8. This action momentarily opens the 7475s, which latch onto the count and display it through the readouts. A pulse at pin 9, U2C resets the counters to zero and a new count begins.

In the **NORMAL** mode of operation, pins 9 of U4B and U5B are grounded, blocking the WPM counter and reset pulses, which allows the normal memory bit count and reset pulses to pass through to the counters. The other half of the DPDT switch removes the 5 volts from U1, U2, U3, and U6. This disables them and places 5 volts on the 7475 latches, holding them open to allow a steady bit count to be displayed.

construction

The speed adapter board uses eight inexpensive ICs, about $3 worth. The whole project shouldn't cost over $10 if all the parts have to be purchased

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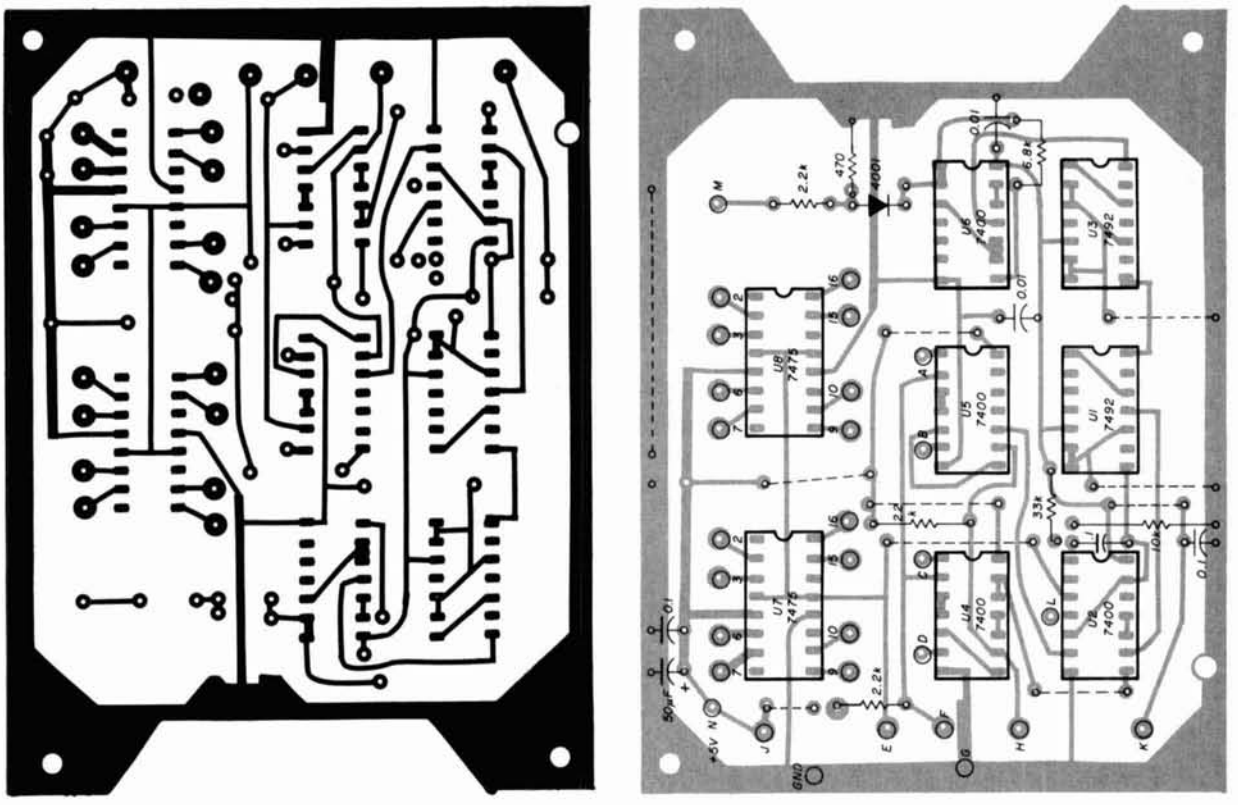


fig. 2. Foil side, *A*, and component side, *B*, of the speed adapter board. Dotted lines are wire jumpers.

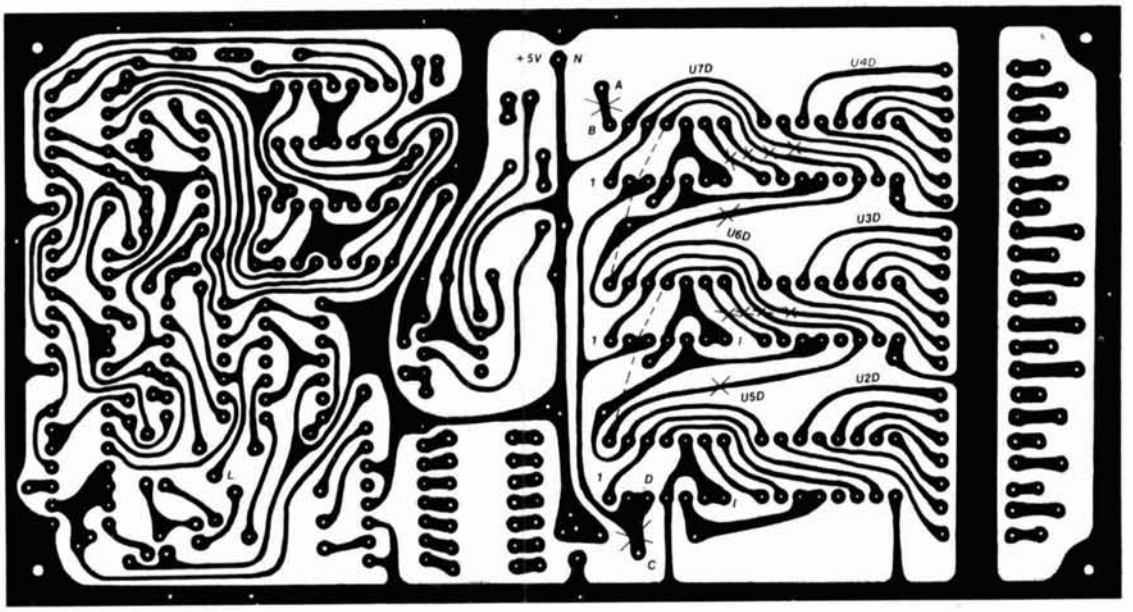


fig. 3. Foil side of Deluxe Memory Keyer driver board. Cut foil at 12 points marked with *X*. Connect wires from speed adapter board to identical letters on driver board. Add two jumper wires as indicated by dotted lines.

new. Components are mounted on the non-foil side of the board, as shown in **fig. 2**. All resistors can be ¼ watt. Capacitors are disc, except the 50 μF, which can be either electrolytic or tantalum at 10 volts. Dotted lines indicate jumper wires. Be sure the ICs are oriented correctly. I used sockets for the ICs, which makes them easier to change in case I zap one. Care must be taken when soldering in the sockets to prevent solder bridges across the pins. (I can supply a limited number of drilled and etched circuit boards for $6 each.)

The hookup requires 30 wires, so ribbon cable is the best route to follow. The jumper wire along the edge of the board in **fig. 2** is used to anchor the ribbon cable to the board. Mount the cable here first and leave about 5 inches (13 cm) for a hookup, then peel back each wire to the jumper anchor before routing to the designated letter. Measure and route each wire separately to its terminal. Cut, insert and solder each wire by number as shown in table 1 to avoid a mixup.

driver board

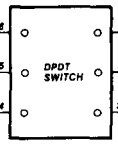
To prepare the driver board, the foil must be cut in twelve places as shown in **fig. 3**. Also add two jumper wires as shown by the dotted lines, from pin 11 of U7D to pin 14 of U6D, and from pin 11 of U6D to pin 14 of U5D.

wiring the driver board

The ribbon cable can now be installed on the driver board. Leave about 1½ inches (4 cm) of the cable between the boards for a hinge, and anchor the ribbon on the foil side of the driver board with a jumper wire across it. Leave about 7 inches (18 cm) of the ribbon on the free end. Peel back the first twenty-four wires to the anchor point. The last six wires may stay together. Run the last six wires to the DPDT switch and solder them on as indicated in **table 1**. All the connections to the driver board will be made on the foil side. Tack each of the first sixteen wires to the IC pin numbers as indicated in **table 1**. The next six wires go to the indicated letters. The twenty-third wire goes to either side of the secondary of the power transformer. The twenty-fourth wire is soldered to point **L**, in the keyer section of the driver board. The speed adapter board is mounted directly over the driver board with spacers in between.

table 1. Wire connections for 30 wire ribbon cable from speed adapter board to driver board and to DPDT mode switch.

	from driver board		to adapter board	
wire no.	device	pin no.	device	pin no.
1	U3D (7447)	7	U8 (7475)	9
2		6		15
3		2		16
4		1		10
5	U4D (7447)	7	U7 (7475)	9
6		6		15
7		2		16
8		1		10
9	U6D (7490)	8	U8 (7475)	2
10		9		6
11		11		3
12		12		7
13	U7D (7490)	8	U7 (7475)	2
14		9		6
15		11		3
16		12		7
17	reset C		reset C	
18	reset D		reset D	
19	bit count A		bit count	A
20	bit count B		bit count	B
21	ground		ground	G
22	+5 volts		+5 volts	N
23	ac secondary transformer		ac in	M
24	U4-7474 Cl pulse		Cl pulse	L
	pin no. on switch		**letter on adapter board**	
25	3		to	H
26	2		to	G
27	1		to	F
28	6		to	K
29	5		to	J
30	4		to	E



Two jumper wires on driver board

wire pin 14, U6D	to	pin 11, U7D
wire pin 14, U5D	to	pin 11, U6D

operation

With the switch in the WPM position, a string of dots about 3 seconds long will give an exact WPM count on the readout. Set the speed control to the speed at which you would like to send. The readout will receive a count update every 2.4 seconds. Any hesitations during sending will show a corresponding slower speed on the readout. With the switch in the normal position the keyer will operate as it did before the adapter board was installed. The bit count from or to the memories will be displayed on the readout.

references

1. *The Radio Amateur's Handbook*, Fifty-seventh edition, 1980, ARRL, Newington, Connecticut 06111

2. Robert C. Cheek. W3VT, "Deluxe Memory Keyer," *ham radio*, April, 1979.

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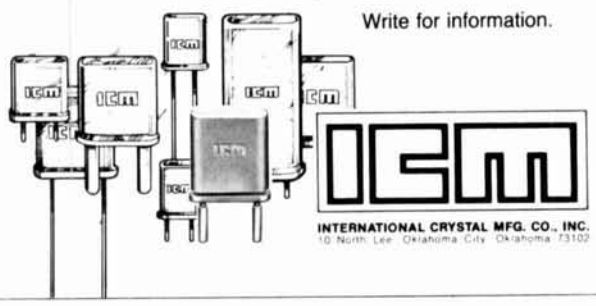

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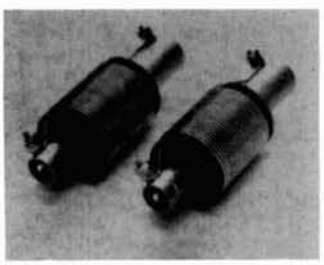

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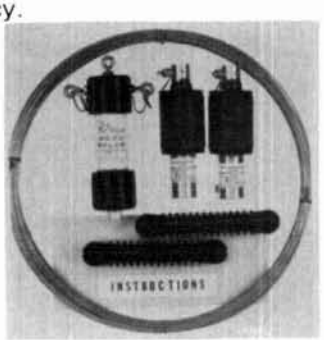

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More Details? CHECK—OFF Page 92

operation upgrade:
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This month we will examine the three basic forms in which active devices can be connected in amplifier circuits. Also, feedback and decibels will be outlined briefly.

classes of amplifiers

When active devices are used in amplifying circuits, the portion of the time that current flows in them determines the class of operation. The class of operation also helps to determine the efficiency of the amplifying stage. The three basic classes of operation are class A, class B, and class C. Most amplifiers are operated in class A, so we will discuss this class first.

Class A operation is the least efficient, but also distorts the amplified signal the least. Let's consider the solid-line curve of **fig. 1** first. Represented vertically, at the left, is the output circuit current (drain, collector, plate). Represented horizontally is negative, zero, and positive bias voltage for N-channel FETs or for VTs (vacuum tubes). You will note that the class A bias value is about halfway between output current cutoff and zero bias (or output current maximum). The shaded area illustrates the output-circuit current variations that occur with both a small input ac signal (e_i), and then a higher amplitude input signal. If the large input signal were made much greater it would drive the device into output current cutoff, or into the bent part of the curve at the top, or both.

Under the maximum undistorted output signal condition shown, the efficiency of the amplifier stage (its ac power output compared with its output circuit dc power input) would be about 45 percent (the theoretical maximum is 50 percent). With a small input signal, the dc power input to the output circuit averages the same but the ac power output will be much less because the output dc current varies less. In this case the efficiency of the stage might be only 5 or 10 percent. Normally, the efficiency of an operating class A audio amplifier averages about 25 percent. Class A operation has the advantage of requiring only a single active device to produce relatively undistorted amplification. This class of amplifier can be used for both audio and radio frequency amplification when distortion must be kept to a minimum.

Can you see that if the operating curve of the active device used happened to be curved or nonlinear (which it usually is), as is shown dashed, that even if

By Robert L. Shrader, W6BNB, 11911 Barnett Valley Road, Sebastopol, California 95472

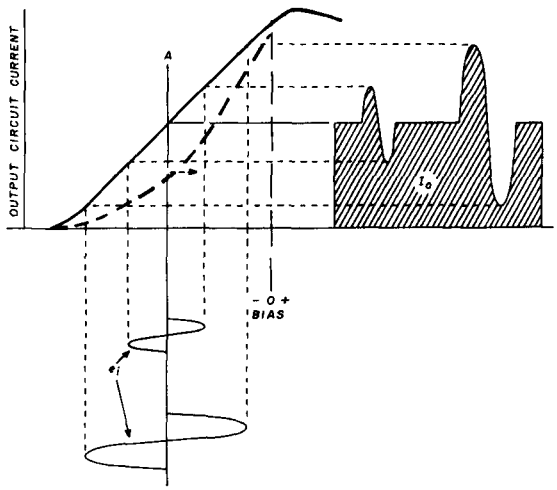

fig. 1. Operational curve to indicate how output circuit current I_o varies with input signal voltages e_i for a class A amplifier (simplified).

the input signal voltage had equal positive and negative peaks, the output circuit dc variations would be smaller for the negative half cycle of input ac, and larger for the positive half? This would produce a noticeably distorted output audio signal from such a stage. It would produce harmonics of all frequencies it amplified.

Class B operation is more efficient than class A but usually distorts more than class A; it requires two *push-pull* devices (first one operates and then the other) in a single stage for audio amplification. In the two-stage amplifier shown in **fig. 2a** the first stage is a JFET class A *single-ended* af amplifier (one device used and one end of its load grounded or bypassed to ground) which is transformer-coupled to a push-pull class A or B power amplifier second stage, transformer-coupled to a loudspeaker. Whether the output stage is biased to class A or B is determined by the values of bias developed by R_1 and R_2. The curve shown in **fig. 2b** indicates that with no bias at all on the BJT (R_1 = *zero ohms*) there is no collector current with no input signal. The bases of the two NPN transistors must be forward biased a little to produce class B operation (R_1 = ± 5 *ohms*). The BJT bases must be forward biased considerably more to put them in class A (dashed line). With class B bias, only the positive half of the input signal produces I_C in the transistor whose curve is shown.

Assume this curve is for the top BJT. Then during the next half cycle of the input signal, the top BJT will nave no I_C flowing, but the lower BJT is now being driven by the second half of the input ac signal. The voltages at the top and bottom of the center-tapped input transformer secondary will be 180° out of phase with each other. As the top BJT is being fed the signal as a negative (reverse) voltage, the lower BJT is being fed the same signal but as a positive (forward) voltage, and the lower BJT now has I_C flowing in it. In this way the output transformer primary has current flowing first in its top half and then in its bottom half. Both primary currents induce voltages into the secondary to feed power to the loudspeaker. Can you see that each BJT is working only about half of the time? For example, during much of the second half cycle of the input signal, the top BJT rests (cools). As a result, a pair of class B biased active devices will produce much more power output than two parallel-connected (B to B, E to E, and C to C) class A devices, both of which would have current flowing in them at all times. Practical class B stages can operate with maximum efficiencies in the range of 55 percent. If a single BJT in class A is capable of 1 watt output, two connected in parallel would be capable of 2 watts output, but two in push-pull could be driven to produce about 8 watts output if in class B, partly because of their ability to rest almost half of the time, plus the fact that a greater input signal could be accommodated with class B bias. When producing power output all active devices must have effective heatsinks attached to their collectors, drains, or plates.

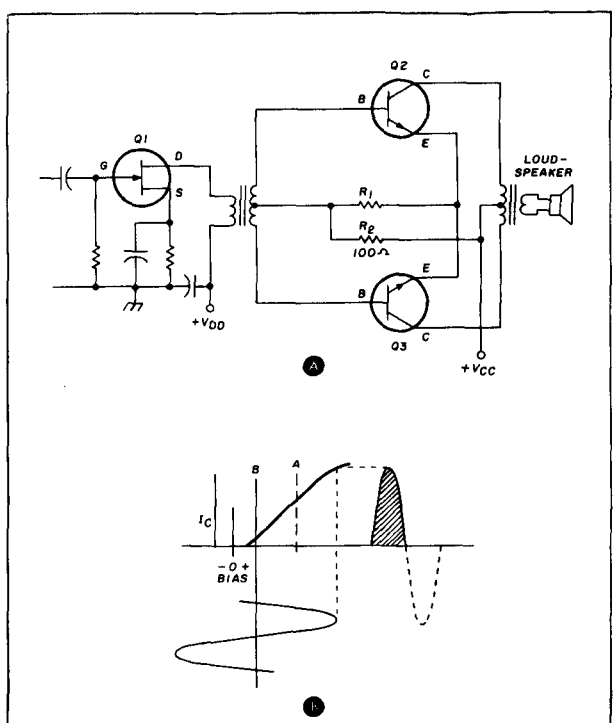

fig. 2. (A) Two-stage push-pull output af amplifier. (B) I_C versus input voltage (current) operation curve.

It should be mentioned that you will normally find BJT curves plotting emitter-collector voltage versus collector current with a series of more or less parallel horizontal lines indicating various base (input circuit) current values.

Class AB operation means biasing to some point between class A and class B. For audio amplifiers this also requires that two push-pull devices be used. As you might expect, class AB is in between classes A and B as far as power output and distortion are concerned. When using push-pull class A and class AB there is one other advantage. The two devices are operating 180° out of phase with each other so that any bend in the operating curves, which normally produces distortion in the output of a single ended stage, will be cancelled by the reversed curve (effectively) of the other device. This results in nearly distortion-free amplification in such push-pull stages. When using vacuum tubes (and N-channel FETs) class AB_1 indicates the input signal should never be

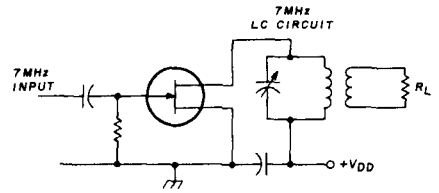

fig. 3. Basic class C rf amplifier (or frequency doubler if the input frequency is 3.5 MHz).

great enough to drive up into the positive bias area and produce grid (gate) current. Class AB_2 operation implies some grid current and that the input circuit resistance (impedance) is engineered low enough so that when the signal does drive into an input current condition, there will be no unwanted voltage drops developed across any resistance in the input circuits to produce distortion.

Class C operation is not used with audio amplification, but usually only in transmitter rf amplifiers or in oscillators. Class C stages are normally biased from 1.5 to perhaps four times the cutoff, or pinchoff, bias value. (Technically, a BJT with zero bias is in class C.) As a result, for a major proportion of the 360° of any input cycle (perhaps 240°) the device has no output circuit current; it's resting. It can produce maximum output power at perhaps 65 percent efficiency. This means that the output circuit current comes in relatively narrow (120°), high-amplitude pulses. If these powerful pulses are forced through an output LC circuit tuned to some radio frequency, such as 7 MHz (as in **fig. 3**), the pulses shock-excite the LC circuit into flywheel oscillation and produce nearly sinusoidal 7-MHz rf ac output from it. Of course, the input rf ac to such a class C amplifier should also be at 7 MHz, although if it is at 3.5 MHz the circuit will operate as an rf *frequency doubler*. Since class C amplifiers depend on the flywheel effect of relatively high-Q LC circuits to produce the output ac, the stages may use either single-ended one-device circuits, or may use push-pull circuits. Push-pull rf ac circuits produce less even-order (second, fourth, sixth, and so forth) harmonic ac output, and may be desirable to suppress such frequencies. If the coupling to a load on a single-ended class C rf amplifier (R_L in **fig. 3**) is too tight it will lower the Q of the LC circuit involved and drain the flywheel energy on the undriven half cycle too much. This will reduce the amplitude of the second flywheel half cycle and distort the sinewave shape of the ac wave. This develops harmonics and unwanted radiations. Push-pull stages do not have this difficulty as much as single-ended stages.

common-emitter type amplifiers

There are three basic methods of connecting and feeding three-element amplification devices such as FETs, BJTs, and VTs. Let's examine the basic theory as it applies to bipolar junction transistors. The most common amplifier circuit configuration is that of the common-emitter (common-source for FETs, common-cathode for VTs), also known as the grounded-emitter (-source, -cathode). The circuit shown in **fig. 4** illustrates a single-ended NPN BJT class A amplifier. R_1 and R_2 provide the forward bias for the transistor. R_3 produces the stabilizing bias to keep the transistor from thermal runaway in power stages. R_L is selected to produce a voltage-drop across itself with no signal input, of perhaps one third to a half of the V_{CC} value (depending on the R_3 value). R_L will probably be in the 1 to 5 kilohm range, depending on the beta of the transistor, the bias value, and the V_{CC} value. For af amplification the input and output coupling capaci-

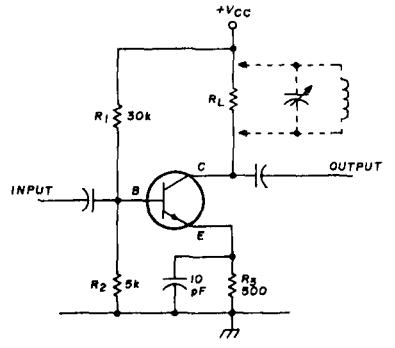

fig. 4. Common-emitter or grounded emitter form of BJT amplifier.

tances would be in the 5 to 15 μF range. The lower the lowest frequency to be amplified, the larger the capacitance values required. For high-frequency rf amplification the capacitors might be in the 0.01 to 0.1 μF range, but such an untuned rf amplifier is not often used. In rf amplifiers the R_L would usually be supplanted by a tuned LC circuit, shown dashed.

Generally, regardless of the V_{CC} value, the load resistor and bias values are selected so that with no signal input the voltage-drop across R_L will be equal to the EC voltage-drop for good class A operation.

Common-emitter-type circuits represent a relatively low impedance load for the stages ahead of them, perhaps 50 to 200 ohms, and look like a medium impedance to the stages that follow. With FETs, **fig. 5**, the common-source circuit usually uses a resistor between source and ground to provide bias. The input impedance of this stage in class A operation is essentially as high as the resistance of the gate-to-ground

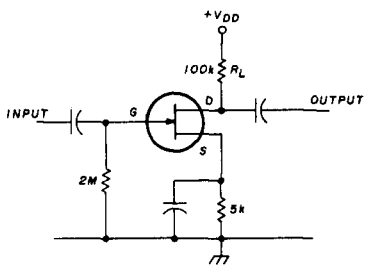

fig. 5. Common-source or grounded-source type amplifier.

resistor used in it. The output circuit impedance is perhaps one half of the resistance of the drain load resistor, R_L. If using tuned LC circuits for rf amplification, the output impedance may be several hundred to several thousand ohms. Vacuum tubes are similar to the FETs in impedance and component values. The phase shift of a signal amplified by all of these common-emitter type circuits is usually considered to be 180°.

common-base type amplifiers

A common-base, or grounded-base (-gate, -grid) amplifier is shown in **fig. 6**. R_1 and R_2 form a voltage divider across the power supply ($+V_{CC}$ to ground). Since the base is connected up the voltage divider from ground it is more positive than the emitter, which returns to ground through the input resistor. The amount of forward bias required to produce class A operation is that which will produce a static (no signal) I_C value somewhat less than half the maximum rated I_C value. C_1 is a filter capacitor whose

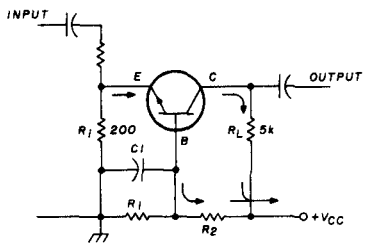

fig. 6. Common-base or grounded-base type amplifier.

function is to prevent any signal voltage variations from developing across R_1 as the input signal forces the I_B to change at the signal frequency and amplitude. Input-signal currents through the 200-ohm input resistor develop varying voltage-drops across it. Since these varying voltages are between base and emitter they force the collector current to vary, producing an amplified voltage-drop variation across the relatively high resistance load resistor. Can you see that the emitter current is the sum of both base and collector currents (arrows)? Therefore, the ratio of I_C to I_E will always have to be something less than 1, usually in the range of 0.95 to 0.98. This ratio or value is known as the *alpha* (α) of the transistor. The *alpha cutoff frequency* is the frequency where the gain of the transistor drops to 0.707 of its gain at 1 kHz.

Although a common-base circuit cannot have a current gain, it can have a voltage gain and therefore a power gain. If the signal voltage applied to the 200-ohm resistor is going positive, the base, being held constant by C_1, can be considered to be going relatively less positive than the emitter. We can say the base or control element is going relatively more negative. Such a reverse bias to the base reduces the I_C and the voltage drop across R_L decreases. This allows the top of R_L to become more nearly the $+V_{CC}$ value, or more positive. Therefore, as the input goes more positive so does the output, representing a phase shift of zero. With 0° phase shift there is little likelihood that this circuit will become regenerative and produce oscillations on its own. This is one of the advantages of such circuits. We say they are inherently stable, meaning that they are not likely to break into unwanted oscillations. When using vacuum tubes and an LC circuit in place of R_L, the equivalent circuit is known as a grounded-grid amplifier and is used in many of the present-day high-power Amateur rf linear amplifiers.

common-collector-type amplifiers

The third basic form of amplifier circuitry is the

common-collector, or grounded-collector (-drain, -plate) circuit, **fig. 7**. At first glance it may look like a common-emitter circuit, until you note that there is no load resistor in the collector circuit. Instead, the load resistor, R_L, is also the emitter resistor, R_E. Note that the collector is held at ac-ground potential by the relatively large value bypass capacitor, C_{bp}. An input signal applied base-to-ground causes I_C and I_E variations, which in turn produce variations of the voltage drop across R_E. The output voltage variation across R_E will always be a little less than the input voltage being fed to the base. However, this circuit has both current gain and power gain. Because a positive going signal to the gate produces an increase in I_C and therefore a more positive emitter, the common-base circuit produces zero phase shift of the amplified signal current. With 0° phase shift the circuit produces no regeneration and cannot break into oscillation, even at high frequencies. It is used mostly as an impedance-changing circuit. The input impedance is usually about half the value of R_i. With a high value of R_i the grounded-collector circuit acts as an impedance reducer, somewhat like a step-down transformer, except that a transformer cannot produce any power gain. This circuit is also known as an emitter-follower (source-follower, cathode-follower).

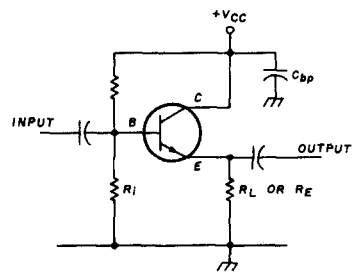

fig. 7. Common-collector or grounded-collector amplifier, also known as an emitter-follower circuit.

feedback

The term *feedback* deserves a little more explaining, since there is some of it in most circuits in which amplification occurs. The term itself indicates that a signal voltage (or current) being fed into an amplifier stage is amplified, and then part of the amplified output voltage (or current) is fed back into the input circuit. Assuming no time difference (phase shift) between the input signal voltage and the output, if the ac feedback voltage is out of phase 180°, or degenerative, the net result is a lessened effective input signal voltage, and therefore a lessened total gain of the stage. If there had been any distortion of the signal voltage (any change in the signal's waveshape) produced by the amplifying process of this particular stage (due to nonlinearity of its operating curve, for example) this distortion is also fed back 180° out of phase. This can almost completely cancel out any such distortion produced by the stage. Of course, if the input signal voltage were distorted to begin with, the degenerative feedback could not correct that. Degenerative, or *inverse*, feedback is used in many linear af amplifier systems, and may be developed as a degenerative loop feeding back distortion-cancelling voltages from a third stage back to a first stage, for instance.

The actual gain of a stage with inverse feedback can be determined by the formula

$$A_f = \frac{A}{1 + (-\beta)A}$$

where A_f is the amplification or voltage gain with feedback, A is the amplification without feedback, and $-\beta$ is a decimal fraction of output voltage (or current) fed back to the input. As an example, an amplifier without feedback has a gain of 20. What is its gain if the feedback factor is 5 percent (5 percent = 0.05)? Try working out this problem. Your answer should be an undistorted gain of only 10. With such inverse feedback, signal gain may be reduced, but when undistorted output is paramount this loss can be made up by merely adding another stage with inverse feedback. Furthermore, without feedback the gain of an amplifier stage might drop to a 50 percent output voltage at some lower frequency (due to the R and C values used in it). With the 5 percent feedback, at the original half-voltage frequency the output will now drop only about 10 percent. Thus, inverse feedback widens the bandwidth (spread of frequencies amplified almost equally) of an amplifier. In addition, instead of developing a 45° phase shift at the original half-voltage frequency, the resultant phase shift will be reduced to about 27°. So inverse feedback also reduces any undesirable phase shift (another form of distortion) in an amplifier.

If the feedback is close to 0° it has the tendency to make the stage around which it is introduced increase its gain (particularly at one frequency) if the feedback percentage is small. If such a forward or regenerative feedback is increased, it will usually cause the gain to rise so much at the frequency at which the greatest gain is being produced that the stage will break into oscillation at this frequency. As you may have deduced, both positive (regenerative) and negative (degenerative or inverse) feedback can be either an advantage or a disadvantage in electronic circuits.

decibels

You have probably noted that all of the amplifier

circuits have power gains, although the common-collector has no voltage gain, and the common-base has no current gain. We often talk about amplifier gain in terms of *bels* (after Alexander Graham Bell), or more commonly in tenths of bels (deci = 1/10), called *decibels*, or dB. Basically, a 3 dB gain means an approximately two-times output-over-input power gain. Another 3 dB, or a total of 6 dB gain represents an output of approximately twice plus twice more, or a four times gain. A gain of 10 dB is a power gain of exactly ten times. Thus, if an amplifier has 10 dB gain it amplifies the power fed to its input ten times. (We are speaking of power amplifiers here, not the usual class A FET or VT voltage amplifier which has essentially no power input but may have considerable power output.) If a power amplifier has 13 dB gain, it amplifies ten times (10 dB) plus 3 dB more, or twice ten, for a gain of twenty times the input power. What would be the power gain of an amplifier that has 16 dB gain? Can you see that the output would be ten times, plus being doubled again, then doubled again (10 dB + 3 dB + 3 dB), for a total gain of forty times the input power?

Since power is proportional to either the E^2 or the I^2 (from $P = E^2/R$, and $P = I^2R$), the voltage gain of an amplifier (assuming input and output impedances to be equal) in dB will be the square root of the power gain. A power gain of 6 dB is the equivalent of a four times power gain. The square root of 4 is 2. Therefore, 6 dB is the equivalent of a voltage (or current) gain of two times. If receivers have signal-strength-indicating meters (S-meters) and each S-unit is calibrated to be 6 dB greater than the one lower, one S-unit is equivalent to doubling (or halving) the signal voltage applied to the input of the receiver.

For accurate computations of decibels the formula to use is:

$$dB = 10 \log \frac{P_1}{P_2} \qquad \left(\text{from } B = \log \frac{P_1}{P_2}\right)$$

where P_1 is the larger power value being considered.

Variations of this formula to determine dB gain or loss using voltage or current values, again assuming input and output impedances to be equal, are:

$$dB = 20 \log \frac{E_1}{E_2}$$

$$dB = 20 \log \frac{I_1}{I_2}$$

If you use a table of logarithms you can solve dB problems using these formulas. For example, what is the dB gain if the input is 10 watts and the output is 20 watts? We have already given you the information to obtain an approximate answer of 3 dB. But let's try this problem using the first dB formula:

$$dB = 10 \log \frac{P_1}{P_2}$$

$$dB = 10 \log \frac{20}{10}$$

$$dB = 10 \log 2$$

From a log table, pocket calculator, or slide rule, if we can determine that the log of the number 2 is 0.301. So, ten times 0.301 means 3.01 dB is exactly twice the power. If the power input were 20 watts and the output 10 watts, the ratio is still equal to 2:1, or 3.01 dB, but now it is a loss of 3.01 dB, which may be expressed as −3.01 dB. You may not be given dB problems to work in an Amateur test, but you might! In any case you might want to memorize these ballpark dB values:

1 dB = 1.25 times the power (a 25 percent power increase)

3 dB = 2 times the power (a 100 percent increase)

6 dB = 4 times the power

9 dB = 8 times the power

10 dB = 10 times the power (exact)

20 dB = 100 times the power (exact)

30 dB = 1000 times the power (exact)

If you have a beam antenna with a 20 dB gain and you feed it 100 watts of rf ac, how much more power does it put out in its direction of maximum radiation? _____. Wow! Where can I get an antenna like that?

FCC test topics

The following Technician/General test topic is discussed in this article, but should be understood by Advanced applicants also:

- decibels

The following Advanced class test topics are discussed in this article:

- amplifiers, classes A, AB, B, C, characteristics
- common-emitter class A transistor amplifiers, bias network, signal gain, input and output impedances
- common-collector class A transistor amplifier, bias network, signal gain, input and output impedances.

For more information on these subjects it is recommended that you refer to a textbook such as *Electronic Communication*, by Robert L. Shrader, McGraw-Hill Book Company, available through Ham Radio's Bookstore, and to radio handbooks.

ham radio

HAM CALENDAR

April

SUNDAY	MON	TUES	WED	THUR	FRI	SATURDAY
W1AW Schedule October 25, 1981-April 24, 1982 MTWThFSSn = Days of Week Dy = Daily W1AW code practice and bulletin transmissions are sent on the following schedule: EST Slow Code Practice MWF: 9 A.M., 7 P.M.; TThSSn: 4 P.M., 10 P.M. Fast Code Practice MWF: 4 P.M., 10 P.M.; TTh: 9 A.M.; TThSSn: 7 P.M. CW Bulletins Dy: 5 P.M., 8 P.M., 11 P.M.; MTWThF: 10 A.M. RTTY Bulletins Dy: 6 P.M., 9 P.M., 12 P.M.; MTWThF: 11 A.M. Voice Bulletins Dy: 9:30 P.M., 12:30 A.M. CST Slow Code Practice MWF: 8 A.M., 6 P.M.; TThSSn: 3 P.M., 9 P.M. Fast Code Practice MWF: 3 P.M., 9 P.M.; TTh: 8 A.M.; TThSSn: 6 P.M. CW Bulletins Dy: 4 P.M., 7 P.M., 10 P.M.; MTWThF: 9 A.M. RTTY Bulletins Dy: 5 P.M., 8 P.M., 11 P.M.; MTWThF: 10 A.M. Voice Bulletins Dy: 8:30 P.M., 11:30 P.M. PST Slow Code Practice MWF: 6 A.M., 4 P.M.; TThSSn: 1 P.M., 7 P.M. Fast Code Practice MWF: 1 P.M., 7 P.M.; TTh: 6 A.M.; TThSSn: 4 P.M. CW Bulletins Dy: 2 P.M., 5 P.M., 8 P.M.; MTWThF: 7 A.M. RTTY Bulletins Dy: 3 P.M., 6 P.M., 9 P.M.; MTWThF: 8 A.M. Voice Bulletins Dy: 6:30 P.M., 9:30 P.M.				**SAROC CONVENTION**, Las Vegas, NV. Contact W7PBV – 1-4. **1**	**2**	**SP-DX** Contest, CW – 3-4. **ARRL** Open CD Party, Phone – 3-4. **ARRL** International EME Competition – 3-4. **LINCOLN TRAIL ARC Convention**, Elizabethtown, KY. Contact KA4BYA – 3. **MISSOURI STATE** Convention, Kansas City, MO. Contact WA0KUH – 3-4. **CENTRAL ARKANSAS REN**, Inc. Convention, Little Rock, AR. Contact W5RXU – 3. **MEMPHIS MINI-FEST**, Pipkin Bldg., Mid South Fairgrounds, Memphis, TN. For information contact K4FZJ – 3. **3**
4	**WEST COAST BULLETIN** – 9 PM PDT (8 PM PST - 0400 UTC) 3540 KCS A-1, 22 WPM – 5. **5**	**AMSAT** East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning) **6**	**DX-YL** to North American YL Contest, CW. For information contact WA6WZN – 7-8. **7**	**8**	**9**	**MISSOURI VALLEY AMATEUR RADIO CLUB** Pony Express Day. Contact W0NH – 10. **COMMONWEALTH CONTEST** sponsored by Canadian Amateur Radio Federation. Contact P.O. Box 2172, Station "D", Ottawa, Ontario, K1P 5W4, Canada – 10-11. **10**
11	**12**	**AMSAT** East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning) **13**	**DX-YL** to North American YL Contest, CW. Contact WA6WZN – 14-15. **14**	**W1AW QUALIFYING RUN** – 15. **15**	**16**	**SP-DX Contest**, phone – 17-18. **QRP ARCI QSO Party** – 17-18. **ARRL Open CD Party**, CW – 17-18. **WELLESLEY AMATEUR RADIO SOCIETY's Auction**, Wellesley, MA. Talk in on 63-03, 04-64 and 52. Contact WA1YHV 17. **ARRL STATE CONVENTION**, Jackson, MS. Contact KC5VD – 17-18. **TRENTON COMPUTER FESTIVAL**. Contact TCF-82, Trenton State College, Hillwood Lakes CN550, Trenton, NJ 08625 – 17-18. **GREAT BAY RADIO ASSOCATION** Annual Hamfest-Flea Market, Somersworth Armory, Somersworth, NH. Contact N1EX – 17. **SOUTHERN CALIFORNIA DX CLUB's** 1982 International DX Convention, Holiday Inn, Visalia, CA. Contact N6IC – 17-18. **NORTH TEXAS HIGH FREQUENCY ASSOCIATION** Novice Mini-Expedition. Contact KC5YN – 17-18. **17**
RALEIGH ARS CONVENTION, Raleigh, NC. KB4RV – 18. **MOULTRIE AMATEUR RADIO KLUB's** Annual Hamfest, Moultrie (IL) County 4-H Center Fairgrounds. Contact N9CDK – 18. **QUAD CITIES AMATEUR RADIO CLUB** special events station. For information contact N9BKY – 17-18. **18**	**WEST COAST BULLETIN** – 9 PM PDT (8 PM PST - 0400 UTC) 3540 KCS, A-1, 22 WPM – 19. **19**	**AMSAT** East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning) **20**	**21**	**22**	**DAYTON HAMVENTION**, Dayton, Ohio. Contact WA8KNM, General Chairman, P.O. Box 44, Dayton, OH 45401 – 23-25. **23**	**ARRL MORNING SPECIAL** – 24-25. **24**
W1AW QUALIFYING RUN – 25. **ROCK RIVER AMATEUR RADIO CLUB's** Annual Hamfest, Dixon, IL. Talk in on 146.25 simplex. Contact WD9CJB – 25. **25**	**26**	**AMSAT** East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning) **27**	**28**	**29**	**30**	***See Coming Events**

More Details? CHECK—OFF Page 92

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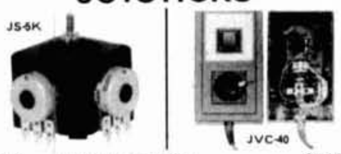

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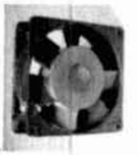

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MC6860	0-600bps Digital MODEM	10.95
MC6862	2400bps Modulator	12.95
MC6880A	Quad 3-State Bus. Trans. (MC8T26)	2.25

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COP1802	CPU	19.95
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AY-5-1013	30K BAUD UART	6.95

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1103	1024x1 Dynamic	.99
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2764Q	64K EPROM (Hitachi HN462764)	49.95
5203	2048 PROM	14.95
82S23(74S188)	32x8 PROM (Open Collector)	3.95
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2400-10

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2400-5C	6	C54321	14 pin	1.09 - 10/ 9.95
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GRAB BAG SPECIALS

GB180 (Pictured Above)

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Part No.	Description	Price
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GB101	60 each Mylar	4.00
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GB173	100 ea. 3/8" sq. single-turn (U Test & Sort)	5.00
GB174	25 ea. ¼ watt thumbwheel single-turn (500 ohm-5 Meg)	2.00

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GB164	200 each marked, unmarked rectifiers & zeners	2.00
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GB117	200 each 1/2 watt resistor assortment	2.00
GB118	30 ea. Wire Wound 5,10,20W (.1-100 ohm)	4.00
GB154	100 each 1 and 2 watt resistor assortment	2.00
GB178	600 each 1/4, 1/2, 1 watt (marked/unmarked) resistors	4.00

SWITCHES

GB120	25 each Miniature slide	$3.00
GB122	20 ea. Reed relays with coil and magnet — glass tube	5.00
GB168	40 asst. toggle, rocker, pushbutton	10.00
GB179	20 each Dip Switches (asst. positions)	8.95

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GB142	50 ea. Chassis mounting feet (rubber and plastic)	2.00
GB144	200 each Solder lugs (small)	2.00
GB145	100 each Lugs — crimp on (some insulated)	2.00
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GB128	30 each Toroid Cores — iron and tape	4.00
GB129	50 each Photo Transistors (LPT)	4.00
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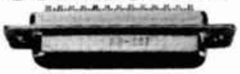
AC 500	117V/60Hz	12VAC 500mA	$4.95
AC1000	117V/60Hz	12VAC 1 amp	$5.95
AC1700	117V/60Hz	9VAC 1.7 amp	$3.95
DC 800	120V/60Hz	8VDC 400mA (batt. charger)	$2.49
DC6912 (above)	120V/60Hz	6,9,12VDC 300mA	$9.95
DV9200	117V/60Hz	9VDC 200mA	$3.25
DC900	120V/60Hz	9VDC 500mA	$3.95
DC1200	120V/60Hz	12VDC 300mA	$3.95

CONNECTORS



DB25P	D-Subminiature Plug	$2.95
DB25S	D-Subminiature Socket	$3.50
D20418-2	Screw Lock Hdwr. (2) DB25S/P	2/$.99
DB51226	Cover for DB25P/S	$1.75
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PL259	UHF Plug	$1.60
UG260/U	BNC Plug	$1.79
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Expand your 4K TRS-80 System to 16K
Kit comes complete with:

- 8 ea. MM5290 (UPD416/4116) 16K Dyn. Ram (*ns)
- Documentation for conversion

TRS-16K2 *150ns 19.95
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KEYBOARDS

Datanectics 74-Key Keyboard

Uses EA 20134 Chip (Electronic Arrays). Size: 16¾"L x 5½"W x 1-3/8"H. White, black, blue, grey key caps. (No Data Sheet) —

Part No. KB354 .... $29.95 ea.

Micro Switch 69-Key Keyboard

Uses AMI SW20350K Chip. Size: 16-3/8"L x 5¼"W x 1-5/8"H Metal Frame. Light & dark grey key caps (No Data Sheet)

Part No. KB69SD12-2 .... $19.95 ea.

Boschert Multi-Voltage Power Supply

5VDC, 12VDC and 24VDC

FEATURES: Voltages*: 5VDC @ 25amps, 12VDC @ 4amps, & 24VDC @ 4amps. Reg. Load: +5V out ±1%, +12 & 24V out ±5% (20-100% load). Overvolt. & overcurr. protection. 115 or 230VAC input. Wt. 4 lbs. Size: 4.95" x 2.50" x 15.00"
***Total average output shall not exceed 200 watts.**

General Description: The "Boschert" Power Supply was originally designed for application with ITT Advance Terminal Controller (ATC). This open frame switching power supply provides user with high current requirements common in use with computer systems. Its compact size provides versatility for mounting into electronic enclosures. Each supply has 6 threaded fasteners (pem nut type) for mounting. Specification requirements to be used with ATC enclosed.

Part No. 200-3010 .... $69.95 each

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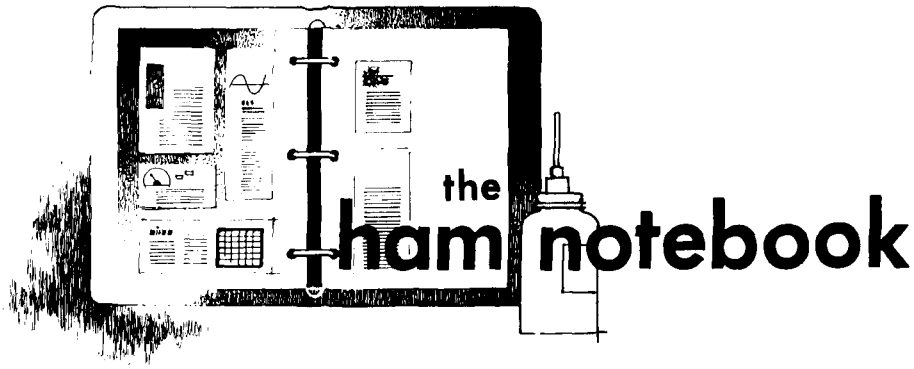
FULL 8-BIT LATCHED OUTPUT 19-KEY KEYBOARD

The JE600 Encoder Keyboard Kit provides two separate hexadecimal digits produced from sequential key entries to allow direct programming for 8-bit microprocessor or 8-bit memory circuits. Three additional keys are provided for user operations with one having a bistable output available. The outputs are latched and monitored with 9 LED readouts. Also included is a key entry strobe. Features: Full 8-bit latched output for microprocessor use. Three user-define keys with one being bistable operation. Debounce circuit provided for all 19 keys. 9 LED readouts to verify entries. Easy interfacing with standard 16-pin IC connector. Only +5VDC required for operation. Size: 3½"H x 8¾"W x 8¾"D

JE600/DTE-HK (After assembled as pictured above) $99.95
JE600 Kit 19-Key Hexadec. Keyboard, PC Board & Cmpnts. (no case) .. $59.95
K19 19-Key Keyboard (Keyboard only) $14.95
DTE-HK (case only — 3½"Hx8¾"Wx8¾"D) $44.95



binary coded decimal addition

In the course of typical Amateur Radio do-it-yourself projects, you may seldom encounter a requirement for a binary adder. But if you should, the CD4008 is a logical choice if you prefer CMOS. However, the 4008 operates in pure binary format and is not intended to be used for BCD arithmetic.

I recently encountered the need to add one binary coded decimal number to another. The requirement resulted from the desire to drive a seven-segment LED display from a BCD thumbwheel and also a divide-by-*n* IC in a frequency synthesizer. Sure enough, in true Murphy's Law fashion, these two requirements were not compatible — that is, unless a fixed BCD number was first added to the thumbwheel number for the divide-by-*n* circuit.

A search through all available handbooks failed to identify an integrated circuit dedicated to adding in BCD. Rather than resorting to use of more exotic means to resolve this *dilemma*, such as by the use of a PROM for example, a combination of five readily available and inexpensive integrated circuits was assembled. What emerged is shown schematically in **fig. 1.** Despite the fact that the circuit shown is a hybrid combination of CMOS and TTL (they were available in the "goodie" box), from the first time power was applied, performance was flawless.

The operation of the BCD "adder" is as follows:

Assume that initially the *Q* outputs of the 4029 counter agree bit-for-bit with the thumbwheel output bits at the comparator input terminals. This sets the 74LS85 $A = B$ output high, which in turn prevents clock pulses from reaching the 4029 counter. This is a static situation that will persist

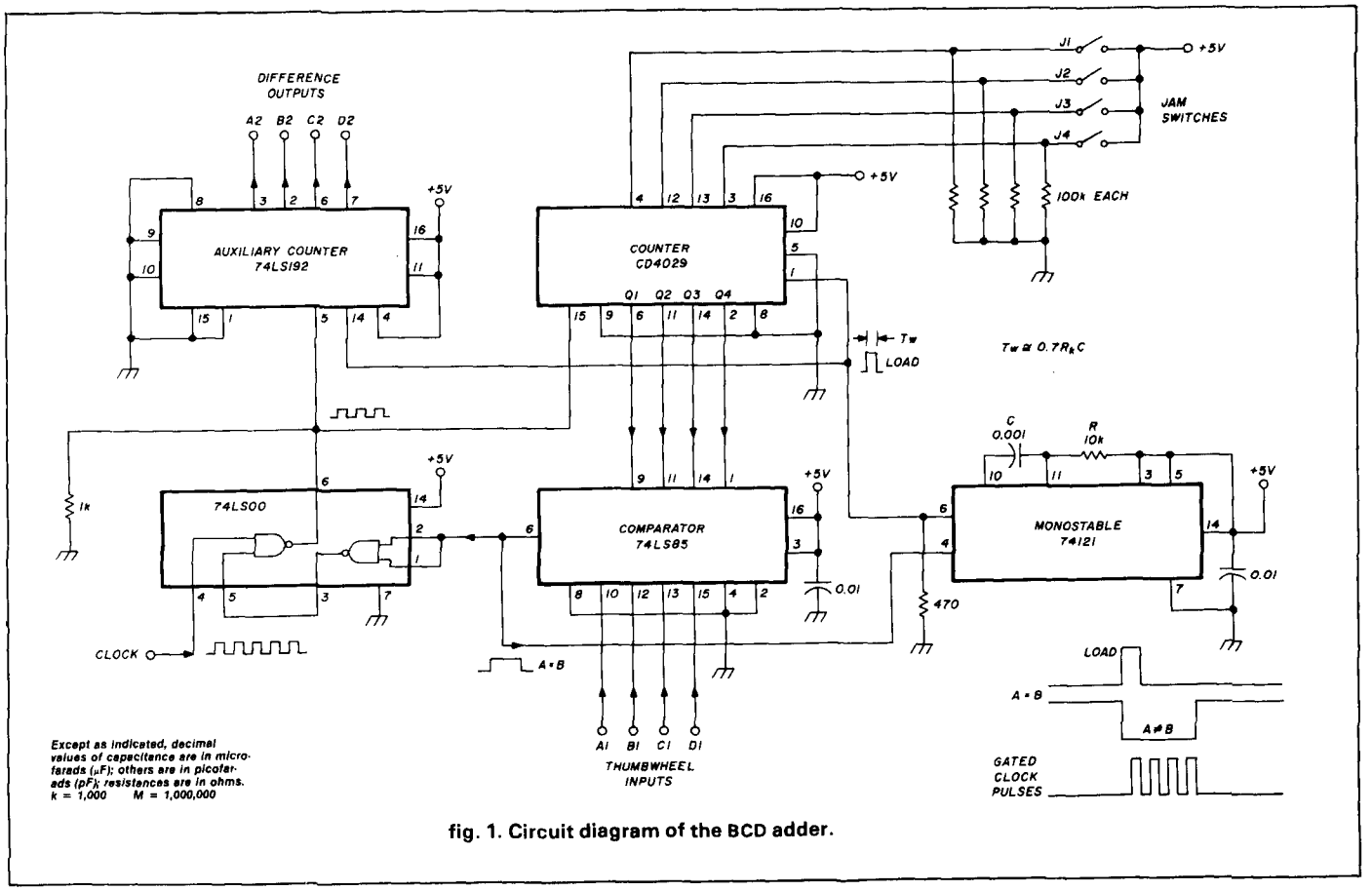


fig. 1. Circuit diagram of the BCD adder.

until such time as the thumbwheel switch setting is changed.

When the thumbwheel setting is changed, the falling edge of $A = B$ activates the 74121 monostable, which in turn generates a single LOAD or PRESET-ENABLE pulse. This pulse presets the 4029 counter so that its Q outputs agree with the JAM inputs. In other words, instead of being reset to zero, the counter is preset to some binary number equal to or greater than zero, according to the settings of the JAM switches.

At the same time, the comparator $A = B$ output is LOW, and the NAND gate is open, allowing clock pulses to reach the 4029 input terminal. Thereafter, the 4029 Q outputs change, starting from their preset values, until they again agree with the thumbwheel bits. At this time, the comparator's $A = B$ output goes high, thus interrupting the train of clock pulses and freezing the contents of the counter.

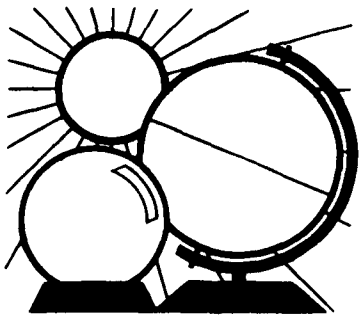
The number of clock pulses necessary to re-establish this static $A = B$ state depends upon the *difference* between the thumbwheel number and the JAM number. If, for example, the number nine (1001) is dialed, and the JAM number selected is three (0011), the number of clock pulses gated to the 4029 counter will be $1001 - 0011 = 0110 (9 - 3 = 6)$.

The gated pulses are also fed to an auxiliary counter, a 74LS192, which has its DATA inputs hard-wired to zero. Each time it receives a LOAD pulse from the monostable, it will reset to zero and accumulate a count numerically equal to the number of the clock pulses in the train. In the example above, the 74LS192 Q outputs will read 0110, or six, after being reset to zero, which is exactly the desired result.

The 74LS192 provides a *difference* output equal to the thumbwheel number minus the JAM number. Would it not therefore be more appropriate to call this circuit a SUBTRACTOR? After all, it's the difference that counts.

Norman J. Foot, WA9HUV

More Details? CHECK—OFF Page 92



DX FORECASTER

Garth Stonehocker, KØRYW

last-minute forecast

April brings a continuation of equinoctial propagation conditions and so could be a ball — remember last year's March and April? One cannot expect a duplication of last year, but be prepared to take advantage of the situation because there is good probability that something will happen. The sun/earth alignment makes for maximum ionospheric effect from solar wind particles released from the sun. The periods in April that look good for geomagnetic disturbances and erratic ionospheric movements are around the 10th, 19th, and 29th. These last two are associated with periods of solar flares and a 27-day solar activity maximum.

For the first week and a half of the forecast period the lower bands will probably be the best for DX. The higher bands are expected to improve the last weeks of the month both for trans-equatorial paths and north/south paths. North/south paths are enhanced the day or two before a disturbance; then the trans-equatorial paths are enhanced during the disturbance. The former is hard to recognize except by the presence of very low A and K geomagnetic indexes and by the use of beacons (see last month's DX Forecaster).

Other geophysical phenomena which may be of interest to DXers this month are the moon and meteor showers. The perigee of the moon's orbit (for moon-bounce DX) is on the 25th at 2100 hours; the moon will be at full phase on the 8th at 1018 hours. There will be short meteor shower, the Lyrid, on April 20-22. The rate is five per hour, hardly a real help for meteor-scatter DX. But a bigger shower, the Aquarid, starts before the end of the month, peaks on May 5, and ends by mid May. Its rate is 10 to 30 per hour.

Let's take a look at last year's spring equinox DX season. Using 6-meter contacts reported to *HR Report* as an indicator of good DX conditions, let's check on the openings and accompanying solar and geomagnetic conditions. With the solar flux above 240 and a mild geomagnetic disturbance in progress on February 28, a dip in the flux increased the disturbance so that a southern Africa to northern Europe trans-equatorial path opened up. At the same time, Liberia to the southwestern U.S.A. in a low-latitude east/west path was also good. On March 1st and 2nd other trans-equatorial paths from southern Africa to Europe and South America to the U.S. were open. After a quiet 3rd and 4th, a large disturbance with aurora arrived on the 5th and 6th with Columbia/Caribbean stations working into the U.S. On March 7th, the South America to Japan path was a big trans-equatorial opening.

The next disturbance, on March 13-15, found Ascension Island making over one hundred Japanese contacts; the flux was still above 200. Argentina and Chile had trans-equatorial openings all three days. There were good DX openings between Australia/New Zealand and the U.S. on the 14th and 16th. By the 21st and 22nd, the mid-latitude ionosphere was enhanced just before the commencement of the March 24-26 disturbance at low solar flux; east/west paths from the U.S. to Liberia, from Southern Africa to Hawaii, and from Canada/the Caribbean/French Guiana to Japan were open. The disturbance was very effective on the 26th between Southern Africa and Europe and between Australia/New Zealand and the Caribbean as the flux came back up above 200 again. LU3EX worked 550 JAs during the first half of March.

On the 6th of April the southern Africa/Hawaii path came alive again as the solar flux peaked on up to 276. From April 11 to 14 there was such a big storm most DX was wiped out, but a lesser disturbance on April 19-21 had French Guiana working Australia and southern Africa at the same time. Mexico worked Australia and New Zealand. The solar flux was about 200 during this disturbance. You can see how our solar-ionosphere connection really gives our DX hobby its interesting openings. Some geophysical rules of thumb, WWV flux and geomagnetic values, and beacons to use as tools can enhance the fun. Good DXing this month.

band-by-band forecast

Six meters should provide frequent band openings with a peak during the early afternoon hours on many days.

(Continued on page 72)

APRIL

WESTERN USA

GMT	0000	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300
PST	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00
N — ASIA FAR EAST	10	10	10	10	15	15	20	20	20	20	20	20	20	20	20	20	15	15	15	15	15	—	—	10
NE — EUROPE	15	20	20	20	20	20*	20	20*	20	—	—	—	20	20	15	15	15	15	15	15	15	15	15	15
E — S. AFRICA	10	10	15	15	15	15	15	20	20	20	20	—	—	—	—	—	—	—	15*	15	15	15	15	15
SE — S. AMERICA	10	10	10	10	20	20	20	20	20	20	20	20	20	20	15	15	10	10	10	10	10	10	10	10
S — ANTARCTICA	10	10	10	15	15	15	20	20	20	20	40*	40	40	40	—	—	—	—	—	15	10	10	10	10
SW — NEW ZEALAND	10	10	10	10	15	15	15	15	20	20	20	40	40	40	20	20	20	20	20	15	15	10	10	10
W — OCEANIA AUSTRALIA	10	10	10	10	10	15*	15	15	20	20	20	20	20	20	20	20	40*	—	—	—	—	15	10	10
NW — JAPAN	15	15*	15	15	15	15	20*	20*	20	20	20	—	—	—	—	—	20	20	20	15	15	15	15	15

MID USA

GMT	0000	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300
MST	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00
N — ASIA FAR EAST	15	15	15	15	15	20	20	20	—	—	—	—	—	20	20	20	20	15	15	—	—	—	—	15
NE — EUROPE	20*	20	20	20	20	20	20	20	20	20	20	20	20	20	20*	20*	20*	15	15	15	15	15	15	15
E — S. AFRICA	10	15	—	—	—	—	—	20	20	20	20	—	—	—	—	15	15	15	15*	15*	10	10	10	10
SE — S. AMERICA	10	10	10	10	10	15	15	15	20	20	20	20	20	—	—	15	15	10	10	10	10	10	10	10
S — ANTARCTICA	10	15	15	15	15	20	20	40*	40*	40	40	20	20	20	—	—	—	—	15	10	10	10	10	10
SW — NEW ZEALAND	10	15*	15	15	15	15	20	20	20	20	40	40	40	20	20*	20	20	20	15	15	10	10	10	10
W — OCEANIA AUSTRALIA	10	15	15	15	15	15	15	15	20	20	20	20	20	20	20	40	40	40	—	—	15	10	10	10
NW — JAPAN	15	10	10	15	15	15	20*	20	—	—	—	—	20	20	20	20	20	—	—	—	15	15	15	15
CST	6:00	7:00	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	5:00

EASTERN USA

GMT	0000	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300
EST	7:00	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	5:00	6:00
N — ASIA FAR EAST	15	—	—	—	—	20	20	—	—	—	—	—	20	20	20	20*	15	—	—	—	—	—	15	15
NE — EUROPE	15	15	20	20	20	20	20	20	20	20	20	—	—	15	15	15	15	15	15	15*	15	15	15	15
E — S. AFRICA	10	15	—	—	—	15	15	20	20	20	—	—	—	20	15	10	10	10	10	10	10	10	10	10
SE — CARIBBEAN S. AMERICA	10	10	15	15	15	15	20	20	40*	40*	20	20	20*	15	15	10	10	10	10	10	10	10	10	10
S — ANTARCTICA	15	15	15	15	20	20	20	20	20	20	20	—	—	—	—	—	—	—	—	15	10	10	10	15
SW — NEW ZEALAND	—	15	15	20*	20	20	20	20	20	40	40	40	40	20	20	15	10	10	15*	15	—	—	—	—
W — OCEANIA AUSTRALIA	10	10	10	10	15	15	15	15	20	20	20	20	20	20	—	—	—	—	—	20	15	10	15	15
NW — JAPAN	10	15	15	10	15	15	20	20	—	—	—	—	—	20	20	15	—	—	—	—	15	15	15	10

*Look at next **higher** band for possible openings.

Trans-equatorial north/south paths will be the best. Your guide to possible openings will be strong openings on 10 meters and high values of solar flux.

Ten and fifteen meters will be loaded with good DX signals from morning until early evening hours almost every day. Times of geomagnetic disturbance will limit the number of signals heard, but listen carefully — they can be from very unusual places. Fifteen meters should be open later in the day than 10 meters. So hit 10 first and finish off with 15. The lengthening of the daylight will be noticed as these bands open up a little sooner and stay open longer in the day.

Twenty meters will be the main daytime DX band, as it is almost always open to some part of the world. It opens to the east as the sun rises and extends into the late evening hours to the west. Geomagnetic disturbances do not affect this band as much as the higher ones, but still look for unusual trans-equatorial DX locations to be coming through once in a while. One-hop trans-equatorial DX of 5,000 to 7,000 miles (8,000 to 11,200 km) may be possible in the late evening hours during some of these unusual conditions.

Forty and eighty meters will have short skip during daylight hours and turn to DX after dark. The bands will open to the east soon after sundown, swing more to the south to Latin America about midnight, and end up to the Pacific areas during the hour or so before dawn. On some nights these bands will be as good as during the winter DX season. The coastal regions usually have the edge for working rare DX on these bands.

One-sixty meters will probably have many nights that will remind you of last summer's noise. However many good nights are left for working DX before this summer's noise comes to stay. Many stateside stations are fair game as DX on this band during this season.

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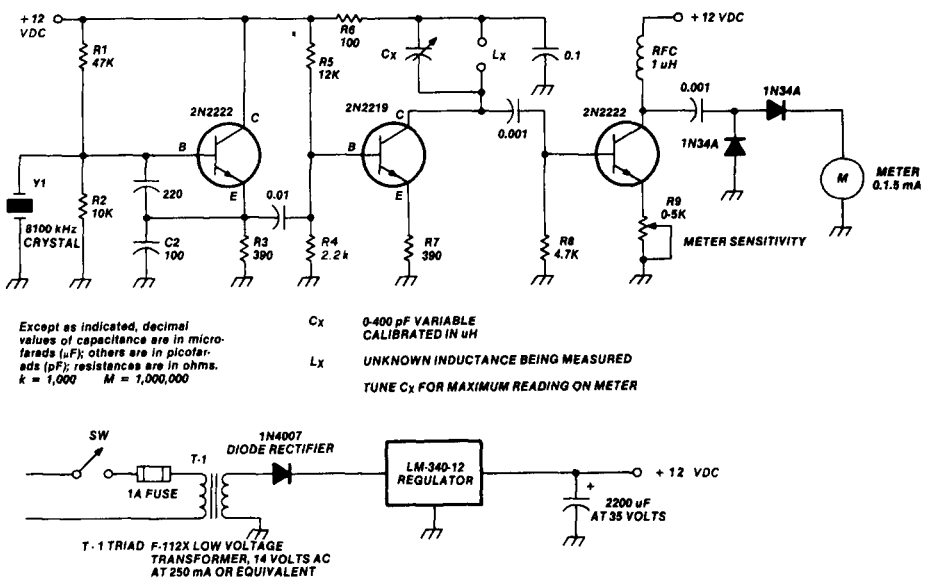


fig. 1. Schematic of the inductance meter, which uses a crystal oscillator on 8100 kHz.

This handy instrument will permit you to measure inductance from 0.5 μH to about 10 μH by reading a capacitor dial. I came up with this idea for my own work bench after searching for a good circuit for measuring inductance. This device does the job for the ham bands, and I hope you will like it as much as I do.

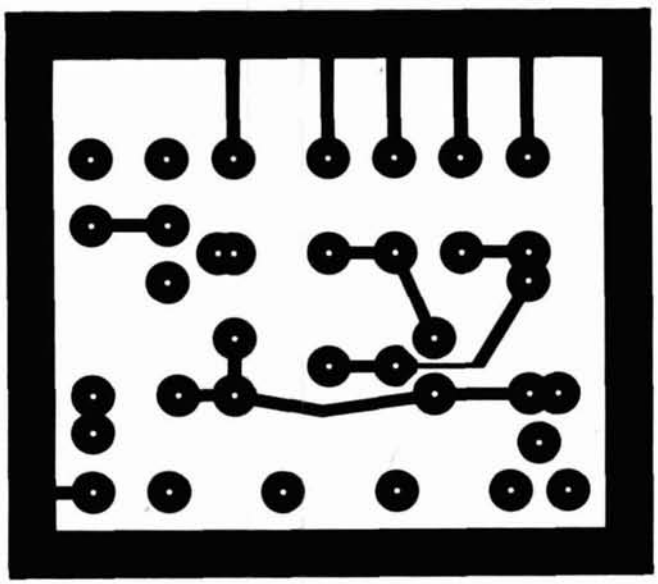
description

This inductance meter uses a crystal oscillator on a frequency of 8100 kHz (see **fig. 1**). The oscillator drives an amplifier. The unknown inductance is placed in the collector lead, and a capacitor across it is tuned for resonance. The dial is calibrated in μH so that the inductance can be read directly.

Another amplifier is used to build up the r-f voltage to operate the 0 to 1.5 mA meter used for tuning to a peak for resonance. A more sensitive meter (such as a 0-50 μA) could be used by shunting a 120-ohm resistor across it, if that is what you happen to have in the junk box.

I suppose the first question that will be asked is, "Why use 8100 kHz for the crystal oscillator?" Well, a surplus 8100-kHz crystal is cheaper to buy than one

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



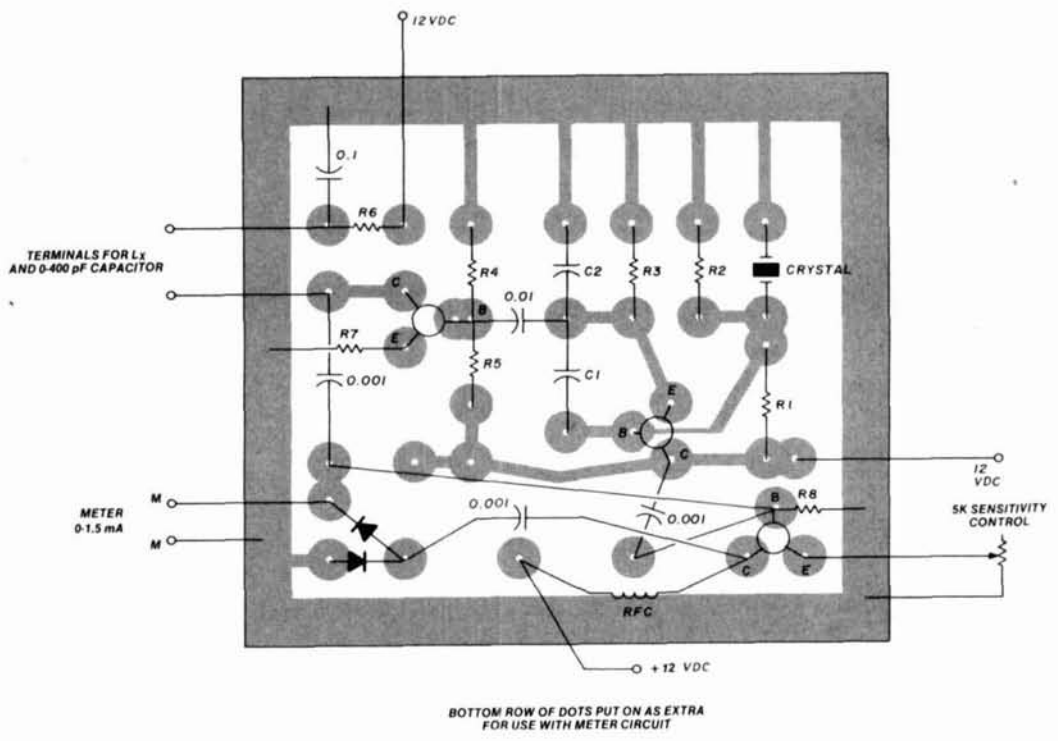


fig. 2. Printed-circuit board and parts placement for the inductance meter.

table 1. Capacitor calibration setting in μH.

pF	3500 kHz μH	7000 kHz μH	8100 kHz μH
10	200	51.6	38.5
20	165	25.7	19.2
30	70	17.2	12.8
40	52	12.9	9.6
50	42	10.3	7.7
60	34	8.5	6.4
70	30	7.3	5.5
80	26	6.4	4.8
90	23	5.7	4.2
100	21	5.17	3.8
125	17	4.5	3.0
150	14	3.4	2.5
175	12	2.9	2.2
200	16.5	2.5	1.92
225	8.6	2.3	1.6
250	8.4	2.0	1.5
300	7.6	1.7	1.2
325	6.0	1.5	1.1
350	6.5	1.4	1.1
375	5.7	1.3	1.0
400	5.5	1.2	0.9

Note: The 8100-kHz crystal was used because of its range and availability. Calibrate variable capacitor for whichever crystal you have from this formula:

f = Hertz
L = Henrys
C = Farads
$4\pi^2$ = 39.5

$$L = \frac{1}{4\pi^2 \times f^2 \times C} = \frac{1}{39.5 \times f^2 \times C} = \frac{1}{(39.5)(7 \times 10^6)^2 (10 \times 10^{-12})}$$

Example: $7000\ kHz = \frac{1}{39.5 \times 49 \times 10} = 0.0000516$, or $51.6\ \mu H$

for the ham bands. Also, if you examine the chart in **table 1**, you will see that the choice of a 10-400 pF capacitor covers a good range of inductances to be measured. Of course, it's your choice which span you want to cover. If another crystal frequency is used, calibrate the variable capacitor by using the formula in **table 1**. I was surprised to learn that this formula is not shown in most handbooks.

The accuracy of the dial reading in μH will only be as good as the accuracy with which you can measure the variable capacitor. A better way would be to check or calibrate the dial against known inductance values. Some suggestions on where to obtain inductances of known value are shown under the subheading calibration. (I found that Air-Dux coils did not correspond to the values shown in their listing, and I wouldn't use them for calibrating the meter unless they were measured first.)

construction

There is nothing difficult about building this tester once you've located the parts. Some sources for parts are listed at the end of the article. The printed-circuit layout I used is shown in **fig. 2**. I cut the board by gripping it between two pieces of angle iron and using a hack saw. Then I filed the edges, sanded the copper with steel wool, and used paper drafting tape for the masking. The dots were Avery self-adhesive color-coding labels that I bought at a stationery store. The wider tape I used for the border is Bishop precision-type 201-250-11, 1/4 inch × 20 yards (6.35 mm × 18.2 m). It's expensive, and yellow shelf-paper with stickum on the back can be used, if you prefer, by cutting it on a paper cutter.

The board was etched with ferric chloride, which takes about an hour, but the process can be speeded up by placing a lamp over the solution and juggling it around once in a while. Once the board has been etched and cleaned, by again scrubbing it with steel wool, it should be tinned with a hot soldering iron. Be careful not to apply to much heat, or the copper will come off! (There are other ways of tinning, using a solution.)

The holes can be drilled out using a No. 60 (1-mm) drill. The crystal socket was mounted using a spacer and a long 4-40 (M3) machine screw.

Before putting a unit in a box, test it out by determining if the crystal oscillator is working. Using FT-243 crystals, I found my values of C-1 and C-2 to be correct as shown. Handbooks call for other values, but they did not make the oscillator work for me. You can listen for the oscillator at 8100 kHz with a receiver or put an rf probe at the emitter output. You should have 1.5 volts of rf, enough to drive the following amplifier. The amplifier can also be checked by placing a coil in the collector, resonating it, and measuring with the probe at the collector. A coil with a value of 3-10 μH should be sufficient for this test.

I used germanium diode rectifiers to operate the meter because they provide more dc voltage than the silicon type. The 1N34A, 1N38, or 1N64 work well.

I used a Radio Shack cabinet, 5-1/4 × 3 × 5-5/8 inches (13.3 × 7.6 × 14.3 cm), to house all the parts including the power supply. Before installing the parts mount the capacitor on a piece of plastic to insulate it from the cabinet; use an insulated coupler and plastic shaft through a panel bushing for the dial knob. I used GR terminals with long shanks that went right up to the capacitor terminals. Make the leads as short as possible, because they become part of the inductance.

Once the amplifier has been finished it can be checked by advancing the sensitivity control and resonating a coil placed on the terminals. I put a 100-

table 2. Some values of Air-Dux coils which might be used to calibrate or check the dial. Values must be checked first.

Air Dux number	total inductance of coil (μH)
404	0.18
406	0.39
408	0.71
410	1.10
416	2.87
432	11.30
504	0.27
506	0.61
508	1.10
510	1.60
516	4.30
532	17.30
604	0.38
606	0.86
608	1.52
610	2.38
616	6.08
632	24.20
804	1.02
806	2.33
810	6.47
816	16.30
832	66.30

Other values of coils can be obtained by writing Illumitronic Engineering Corporation, 680 East Taylor Avenue, Sunnyvale, California.

ohm resistor in series with the control to limit the current reading and not ground the emitter. Most meters have the positive terminal on the left looking at the back. If your meter does not read, or reverse readings are obtained, turn the meter leads around. The meter dial plate is shown in **fig. 3**.

calibration

Several suggestions on calibrating the dial are given. I used a 0-400 pF capacitor, a BDC type out of Swan equipment, that I found at a flea market. The 0-365 pF units are more common and are available from J.W. Miller and Radio Shack.

One of the best ways of calibrating or checking your dial readings is to use the rf chokes listed below. They seem to be very accurate:

Miller rfc 420	0.22 μH
Miller rfc 220	0.82 μH
Miller rfc 144	1.72 μH
Miller rfc 50	8.20 μH
Ohmite Z-50	10.00 μH

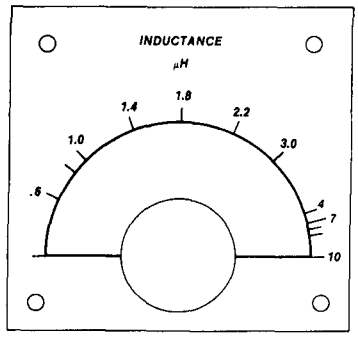


fig. 3. Inductance meter dial plate.

Other values of the type 4500 and 70F106AI chokes can be obtained from the J.W. Miller catalog (J.W. Miller, 19070 Royes Avenue, Compton, California 70224). If you know someone who can measure inductance, the Air-Dux line in the 400, 500, 600 and 800 series are also good to use. Some of the approximate values of Air-Dux are given in **table 2**.

table 3. Reference chart for other J.W. Miller coils that could be used for calibration.

J.W. Miller stock No.	inductance μH	Q
4580	0.10	70
4582	0.15	80
4584	0.22	95
4586	0.33	100
4588	0.47	105
4590	0.68	113
4592	0.75	115
4594	0.82	112
4602	1.00	58
4604	1.50	62
4606	2.40	63
4608	3.90	70
4609	5.50	70
4610	6.20	67
4611	8.20	67
4612	10.0	67
4622	10.0	70
4624	15.0	58
4628	39.0	93
70F106AI	2.0	
70F226AI	2.2	
70F336AI	3.3	
70F396AI	3.9	
70F476AI	4.7	
70F686AI	6.8	
70F826AI	8.2	
70F105AI	10.0	

See the catalog for a complete list of values in between. Contact J.W. Miller Co., Sales, Mr. Bill Courtney, 19070 Reyes Avenue, Compton, California 90224.

Table 3 gives values for some J.W. Miller coils, and **table 4** shows some typical toroid values. All these components are available from many sources throughout the country.

table 4. Some typical toroid values collected from magazine articles.

band	core	inductance (μH)	no. turns	enamel wire size AWG	(mm)
40 meters	T-50-2	13	50	28	(0.3)
20 meters	T-50-2	8	44	28	(0.3)
15 meters	T-50-2	4	25	28	(0.3)
10 meters	T-50-2	0.6	12	24	(0.5)

Note the red core is type 2, and the yellow core type 6.

core	inductance (μH)	no. turns	enamel wire size AWG	(mm)
T-68-1	0.5	10	22	(0.6)
T-68-6	0.5	8	20	(0.8)
T-68-6	0.7	12	22	(0.6)
T-68-6	0.8	13	26	(0.4)
T-68-6	1.0	14	20	(0.8)
T-68-2	1.2	13	20	(0.8)
T-68-2	1.8	19	22	(0.6)
T-68-2	2.0	20	22	(0.6)
T-68-2	2.1	22	22	(0.6)
T-68-2	6.0	32	24	(0.5)
T-68-2	7.0	32	24	(0.5)
T-68-2	21.0	56	24	(0.5)
T-68-2	24.0	60	28	(0.3)
T-50-2	0.57	7	26	(0.4)
T-50-6	0.60	12	24	(0.5)
T-50-2	1.70	17	26	(0.4)
T-50-2	0.9	11	20	(0.8)
T-50-6	2.4	25	26	(0.4)
T-32-2	0.28	8	22	(0.6)
T-32-2	0.37	9	22	(0.6)
T-32-2	0.8	14	22	(0.6)
T-32-2	1.0	22	22	(0.6)
T-32-2	2.6	25	26	(0.4)
T-32-2	3.0	27	26	(0.4)
T-32-2	6.0	37	28	(0.3)

Note: T-94 coil is 0.94 inch dia. (24 mm)
T-80 core is 0.79 inch dia. (20 mm)
T-68 core is 0.69 inch dia. (17.5 mm)
T-50 core is 0.50 inch dia. (12.7 mm)

Perhaps this little gadget is not the best way to measure inductance, but I find it does the job for most of my construction projects, especially for ham-band inductances.

Another reference for a final check of your dial: ARRL L/C/F Calculator Type A.

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CADILLAC OF QSL CARDS, 3 to 4 colors, send $1 for samples (Refundable). Mac's Shack, P.O. Box 43175, Seven Points, TX 75143.

MOBILE OPERATORS: Anteck's Mobile Antennas cover 3.2 to 30 MHz inclusive, with no coil changing. 50 Ohms input. Two models, the MT-1 MANUAL, MT-1RT REMOTE-TUNED from the operators position. Uses two Hyd. Pumps and Motors. MT-1 $129.95, MT-1RT $240.00 plus UPS postage. Check your local dealer or write for Dealer List and Brochure. ANTECK, INC., Route One, Box 415, Hansen, ID 83334. 208-423-4100.

WANTED: Micor and Mstr II Base Stations 406-420 and 450-470 MHz. Also 2 and 6 GHz solid state microwave equipment. AK7B, 4 Ajax Place, Berkeley, CA 94708.

AMP-LETTER: Devoted to designing, building, and operating Amateur Radio Amplifiers. Sample $2.00. AMP-LETTER, RR2 Box 39A, Thompsonville, IL 62890.

TUBES, TUBES wanted for cash or trade. 304TL, 4CX1000A, 4PR60C, 7F7, 7N7, 53, 6L6M. Any high power or special purpose tubes of Eimac/Varian. DCO, 10 Schuyler Avenue, No. Arlington, NJ 07032. (800) 526-1270.

HAM RADIO FANATICS! You need the W5YI Report — Twice monthly award-winning insider newsletter. 24 issues — $18.00. Sample issue SASE (2 stamps). W5YI, Box #10101-H, Dallas, Texas 75207.

KENWOOD TS-820S, two years old. Excellent condition. Call after 6:00 PM. (203) 348-3983.

ATLAS DD6-C Digital Dial $120.00 plus $4.00 UPS. NEW, while they last. Mical Devices, P.O. Box 343, Vista, CA 92083.

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CONNECTICUT'S Ham Store — Rogus Electronics, 250 Meriden-Waterbury Turnpike, (Rt. 66) Southington. (203) 621-2252.

IMPROVE MORSE INTERPRETATION — automatically. Fully integrated microelectronics hardware, software. Unusual features. $169. Telecraft Laboratories, Box 1185, E. Dennis, Mass. 02641.

RTTY JOURNAL-EXCLUSIVELY AMATEUR RADIOTELETYPE, one year subscription $7.00. Beginners RTTY Handbook $5.00, RTTY Index $1.50. P.O. Box RY, Cardiff, CA 92007.

CW FILTER, 250 Hz, for all Yaesu FT-101A through FT-101E. Excellent condition $10. Also SSB filter, $10.00. John Skubick, K8JS, 791 - 106 Avenue, Naples, FL 33940.

CUSTOM EMBROIDERED EMBLEMS — Your design, low minimum. Informational booklet. Emblems, Dept 65, Littleton, New Hampshire 03561. (603) 444-3423.

OUR KEYERS turn difficult DX into logged contacts. SASE for information. Webco, Box 740211, Houston, Texas 77274.

WANTED: Pre-1950 TV sets and old TV Guides. Jeff Kadet, W3CRH, Box 90-HR, Rockville, MD 20850. (301) 654-1876.

RTTY FOR SALE: Several machines remaining. Model 15, Model 19, 28RO w/gearshift, p.s. for ROBOT 800, deluxe 34ASR, 28KSR, 28 keyboard typing reperf, 28TD's, 33KSR, 33ASR, 35KSR, several demodulators, video RTTY. Model 28 gearshifts, parts and supplies. Send SASE for complete list and prices. Lawrence R. Pfleger, K9WJB, 2600 S. 14th Street, St. Cloud, MN 56301. Phone (612) 255-9794.

MANUALS for most ham gear made 1937/1970. Send $1.00 for 18 page "Manual List", postpaid. HI-MANUALS, Box H802, Council Bluffs, Iowa 51502.

DON'T GET STRANDED! Battery Watchdog's alarm informs you of excess power drain. $19.95. J.F. Ratcliff, 3600 Meadow N., Renton, WA 98056. SASE brochure.

SB-102, SB-600, PS, CW filter. MINT honest. Original owner. K5PA, 12412 Mossybark, Austin, TX 78750. (512) 258-4959. $390.

WANTED: April '68 issue of HAM RADIO will buy or trade other issues. J. Smith, 700 S.W. 16th Place, Gainesville, FL 32601.

ELECTRONIC BARGAINS, CLOSEOUTS, SURPLUS! Parts, equipment, stereo, industrial, educational. Amazing values! Fascinating items unavailable in stores or catalogs anywhere. Unusual FREE catalog. ETCO-012, Box 762, Plattsburgh, NY 12901. SURPLUS WANTED.

OSCILLOSCOPE — Heath Model IO-4510, dual-trace, DC-10 MHz, delay line, sweep expansion, X-Y display, calibrator, like new, $300.00. W2BLL, RD 2, Box 72, Boonton, NJ 07005.

More Details? CHECK — OFF Page 92

HAM RADIO REPAIR, experienced, reasonable, commercial licensed. Robert Hall Electronics, P.O. Box 8363, San Francisco, CA 94128. W6BSH, (408) 292-6000.

OLD TIMERS — I need Vibroplex, McElroy, Logan and Johnson speed keys for my collection. Also need junkers for spare parts. K5RW, B.N. McEwen, 1128 Midway, Richardson, Texas 75081.

RUBBER STAMPS: 3 lines $3.25 PPD. Send check or MO to G.L. Pierce, 5521 Birkdale Way, San Diego, CA 92117. SASE brings information.

BNC MALE CONNECTORS, silver plated, military surplus. Specify RG-58, RG-59, or 8X. 6/$5, postage paid. Colonel Russell, 9410 Walhampton, Louisville, KY 40222.

MOBILE IGNITION SHIELDING provides more range with no noise. Available most engines. Many other suppression accessories. Literature, Estes Engineering, 930 Marine Dr., Port Angeles, WA 98362.

I WOULD LIKE TO GET a copy of the manual, circuit diagram, crystal information for the Standard SR-C146, 2 meter handheld transceiver. I am willing to pay any reasonable compensation. Any information on where this documentation can be obtained, i.e. club, library, etc., will be appreciated. Dennis Sladen, VE1BZJ.

QSL ECONOMY: 1000 for $13. SASE for samples. W4TG, Box F, Gray, GA 31032.

TEKTRONIX 661 SCOPE: 4S1 d.t. sampling, 5T1 time base plug-ins; dc - 1 GHz $250. C-12 scope camera $175. aL60 spectrum analyzer p-i with manual "as is". $125. A.P. Towbin, 436 Orange St., New Haven, CT 06511.

SEND 9½" SASE for surplus parts and equipment catalog. Bill Williams, P.O. #7057, Norfolk, VA 23509.

MEISSNER SIGNAL SHIFTER, manual, coils, best offer or trade for good receiver. KA4TCV, 105 E. King Arthur Drive, Port Richey, FL 33568.

OVERPRINTED — 1981 Fox-Tango Club Newsletters. Sixty loose-leaf pages packed with modifications and information on Yaesu rigs. Only $6 while they last. Also a few 1980 sets at $5. (Overseas add $3 each, airmail.) N4ML, Box 15944, W. Palm Beach, FL 33406.

SALE — HW-16 $125 (w/crystals $150). 2 Johnson matchbox tuners, best $50, other (needs repair) $25. Heath 2 meter mobile amp $30. 10-40 vertical $25. You pay shipping. KA4EBW, Jim Howell, 18 Dan Street, Salisbury, NC 28144.

SATELLITE TELEVISION: Information on building or buying your earth station. Six pages of what's needed, where to get it, etc. $4.00 to Satellite Television, RD #3, Oxford, NY 13830. Parabolic antenna construction book also available. Send SASE for details.

WANTED: New or used MS and coaxial connectors, synchros, tubes, components, military surplus equipment. Bill Willams, PO #7057, Norfolk, VA 23509.

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MAKE HAM RADIO FUN! Supplement your learning programs with a motivational hypnosis cassette. Tape #3, Learning the Code; Tape #4, Breaking the Speed Barrier; Tape #7, Electronic Theory. Free catalog. For tapes, $10.95 each to Gem Publishing, 3306 North 6th St., Coeur d-Alene, ID 83814.

CORDLESS TELEPHONES — Low prices, all major brands. Inquiries or Visa/MasterCard orders call (206) 743-3977 or Write Trinetics, Box 6005, Lynnwood, WA 98036.

VERY in-ter-est-ing! Next 5 issues $2. Ham Trader "Yellow Sheets", POB356, Wheaton, IL 60187.

MICROWAVE CONVERTERS, decoders. Catalog 20¢. G.W. Electronics, P.O. Box 688, Greenwood, Indiana 46142.

CB TO 10 METER PROFESSIONALS: Your rig or buy ours — AM/SSB/CW. Certified Communications, 4138 So. Ferris, Fremont, Michigan 49412; (616) 924-4561.

AFC SEMI-KITS! Stop VFO drift. See June 1979 HR. $55.00 plus $3.00 UPS. Mical Devices, P.O. Box 343, Vista, CA 92083.

HAMS FOR CHRIST — Reach other Hams with a Gospel Tract sure to please. Clyde Stanfield, WA6HEG, 1570 N. Albright, Upland, CA 91786.

SATELLITE TELEVISION...HOWARD/COLEMAN boards to build your own receiver. For more information write: Robert Coleman, Rt. 3, Box 58-AHR, Travelers Rest, SC 29690.

WANTED: Early Hallicrafter "Skyriders" and "Super Skyriders" with silver panels, also "Skyrider Commercial", early transmitters such as HT-1, HT-3, HT-19, and other Hallicrafter gear, parts, accessories, manuals. Chuck Dachis, WD5EOG, The Hallicrafter Collector, 4500 Russell Drive, Austin, Texas 78745.

WANTED: Surplus 1-3 KW HF transmitter type FRT-15, Collins TDH or equivalent. P.J. Plishner, 2 Lake Ave. Ext., Danbury, CT 06810. WA1LDU.

YAESU OWNERS: Join your International Fox-Tango Club, now in its eleventh year. Calendar year dues still only $8 US, $9 Canada, $12 airmail elsewhere. Don't miss out, get 1982 top-rated FT Newsletters packed with modifications monthly, catalog of past modifications, free advertisements, technical consultation, FT net (Saturdays, 1700Z, 14.325 MHz), more. Go Fox-Tango! To join, send dues to FT Club, Box 15944, W. Palm Beach, FL 33406.

GET OFF YOUR EARPHONES and start laughing. "Slices of Ham" is a light-hearted look at Amateur Radio. N1ADX has collected more than a dozen short stories to brighten your shack. For witty, technical humor send $5 (mailed anywhere). Add $1 for airmail overseas. Massachusetts residents add sales tax. Parsley Press (H), Box 94 Turnpike Station, Shrewsbury, MA 01545 USA.

Coming Events

ACTIVITIES

"Places to go..."

CALIFORNIA: The Southern California DX Club's 1982 International DX Convention, Saturday, April 17 and Sunday, April 18, Holiday Inn, Visalia. Pre-registration $35.50 and for first 500 may include a surprise gift. Pre-registrations received by April 9 are eligible for pre-registration prize. Door registration $37.00. Registration includes admittance to all events, Saturday banquet, Sunday champagne brunch and a chance for many prizes. Extra chances may be purchased. Make all checks payable to: Southern California DX Club. For information: Don Bostrom, N6IC, 4447 Atoll Avenue, Sherman Oaks, CA 91423.

CONNECTICUT: The fifth annual P.V.R.A. Flea Market, Sunday, May 2, George Penny High School, East Hartford, exit 91 off I-86. Tables $8.50; admission donation $1.00. 10 AM to 4 PM. For information or advance tables: Arnie, K1NFE, PO Drawer M, Plainville, CT 06062.

ILLINOIS: The Centralia Wireless Association's annual Hamfest, Kaskaskia College Gym, 3 miles N.W. of Centralia, Sunday, May 2. Talk in on 147.27/.87 and 146.52. Doors open 7 AM. No charge for flea market/exhibit space. Free admission; free parking. Refreshments available. Prizes throughout the day. Prize tickets $1.00 each; 6/$5.00. SASE for ticket orders to Centralia Wireless Association, Hamfest Tickets, PO Box 1166, Centralia, IL 62801. For information: Bud King, WB9QEG, (618) 532-6606. Lou Hodges, W9IL (618) 533-4724 or write CWA, Inc. at above address.

ILLINOIS: The Lake County Radio Control Club's Radio Control Expo V; static model airplane contest, Saturday, May 1 and Sunday, May 2, Lakehurst Shopping Center, Rt 120 and 41, Waukegan. Saturday 10 AM to 5:30 PM; Sunday 12 noon to 5:00 PM. Over 100 model airplanes competing for ribbons and trophies. All contestants eligible for door prizes. RC car and tank demonstrations. The Palos Air Show Team will give a 1-1/2 hour outside show. For entry information call John Russell (312) 249-3060 or Ed Fuerst (312) 336-7505.

ILLINOIS: The Moultrie Amateur Radio Klub's 21st annual Hamfest, April 18, Moultrie County 4-H Center Fairgrounds, 5 miles east of Sullivan on Cadwell Rd. Indoor and covered outdoor flea market, no charge to vendors. Talk in on 146.94 and 146.655/.055. For information: Ralph Zancha, N9CDK, PO Box 55, Lovington, IL 61937. (217) 873-5287.

ILLINOIS: The Rock River Amateur Radio Club's 16th annual Hamfest, Sunday, April 25, Lee County 4-H Club Center, one mile east of junction of Rts 52 and 30, South of Dixon. Advance tickets: $2.00 donation; $2.50 gate. Grand prize $500 cash; second prize $200 cash (need not be present to win). Hourly door prizes (must be present to win). Talk in on 146.52 simplex. For advance tickets: Ed Webb, WD9CJB, 618 Orchard, Dixon, IL 61021.

MASSACHUSETTS: Quannapowitt Radio Association (QRA) will hold an indoor/outdoor Hamfest, Saturday, May 1, 9 AM to 4 PM, South Hall Fire Station, corner of Salem and Summer Sts, Lynnfield. Admission: $1.00 door. Tables $7.00 door; advance $5.00. Food available. Talk in on 146.19/79 or 52. For details: Dave Meldrum, KA1MI, 28 Cedar Ln., No. Andover, MA 01845.

Tell 'em you saw it in HAM RADIO!

MASSACHUSETTS: A general Amateur Radio outdoor Flea Market, May 2, sponsored by the New England Amateur TV Group, Freeport Hall, Dorchester, just off S.E. expressway. Rain or shine. Admission: $1.00. Sellers $4 pre-registration by April 25 to NEAT, PO Box 406, Boston, MA 02102. $7 at gate. Talk in on 145.29 Repeater or 52 direct.

MASSACHUSETTS: The Wellesley Amateur Radio Society's annual auction, Saturday, April 17, Wellesley High School Cafeteria, Rice Street, Wellesley. Talk in on 63-03, 04-64 and 52. Doors open 10 AM. Contact: Kevin P. Kelly, WA1YHV, 7 Lawnwood Place, Charlestown, MA 02129.

MASSACHUSETTS: The Fall River Amateur Radio Club's Flea Market, Sunday, May 23, American Legion Hall, Freetown, 10 AM to 4 PM. Flea market spaces $7.00 advance, $9.00 door (price includes 2 admissions). Free coffee. Talk in on 147.63/03 and .52 direct. Check or money order to Fall River Amateur Radio Club c/o Ann M. Carro KA1DNB, 652 Old Colony Terrace, Tiverton, RI 02878.

MINNESOTA: The Arrowhead Radio Amateur Club's annual swapfest, Saturday, May 8, First United Methodist Church, 230 East Skyline Parkway, Duluth. Admission: $2.00 advance; $2.50 door. Door prizes include an Icom 2AT. Raffle prizes include a Regency D100 programmable scanner and portable B/W TV. Raffle ticket donation $1.00; 6/$5.00. Reserved 4-foot tables $3.00 advance, $3.50 door. Doors open 10 AM to 3 PM. Food, free parking, hourly prize drawings. Talk in on 34/94. For information, advance reservations, raffle tickets: SASE to Jerry Frederick, NØBNG, 1127 — 104th Avenue West, Duluth, MN 55808.

MISSISSIPPI: The Jackson Amateur Radio Club will host the ARRL State Convention, Saturday, April 17, noon to 5 PM and Sunday, April 18, 8 AM to 2 PM, Raymond Road National Guard Armory, Jackson. Forums, net and special activity group meetings, exhibits, prizes and flea market. Food available. Free admission. Swap tables $5.00 each day. Talk in on 146.16/76, 146.52 and 3987.5. For information/table reservations: Don Elder, KC5VD, 2806 N. Mill St., Jackson, MS 39216. (601) 362-0336.

NEW HAMPSHIRE: The Great Bay Radio Association's 2nd annual Hamfest-Flea Market, Saturday, April 17, Somersworth Armory, Somersworth, 9 AM to 3 PM. Antique radios and computers displayed. Hourly door prizes. Grand raffle for Radio Shack color computer and other prizes. Refreshments available. Free parking. Entrance fee $1.00 per person (ticket counts for door prizes). For information/registration: Dick Sedgewick, N1EX, (603) 742-3703 or write Great Bay Radio Association, Rt. 16, Dover, NH 03820.

NEW JERSEY: The Tri-County Radio Association's annual Indoor Hamfest/Flea Market, May 2, 9 AM to 4 PM, Passaic Township Youth Center, Valley Road, Stirling. Donation $2.50. Tables $6.00. Hot food and refreshments available. An ICOM IC-2AT will be one of many door prizes. Talk in on 247.855/.255 and 146.52. For information/table reservations: Jack Sammarco, 2062 Emerson Ave., Union, NJ 07083 or call Herb Klawunn, W2CHA (201) 647-3461.

NEW JERSEY: The 7th Trenton Computer Festival, Saturday and Sunday, April 17/18, 10 AM to 5 PM, Trenton State College, Trenton. Exhibits, flea market, technical sessions, free short courses on Sunday. Admission: $5.00 ($3.00 students). For information: TCF-82 Trenton State College, Hillwood Lakes CN550, Trenton, NJ 08625. (609) 771-2487.

NEW YORK: The Southern Tier Amateur Radio Club's 23rd annual Hamfest, Saturday, May 1, Owego Treadway, Owego. 9 AM to 5 PM. Outside flea market, dealer displays, door prizes and refreshments. Talk in on 146.22/82 and 146.16/76. For information: Craig England, KF2X, RD #1, Box 144, Vestal, NY 13850.

OHIO: The 13th annual B*A*S*H will be held on the Friday night of the Dayton Hamvention, April 23, at the Convention Center, Main and Fifth Streets. Parking in adjacent City Garage. Admission is free to all. Sandwiches, snacks and C.O.D. bar available. Live entertainment provided for a super social evening. Don't miss it . . . Awards include a new synthesized HT and a synthesized pocket scanner. For further information contact the Miami Valley FM Assn., PO Box 263, Dayton, OH 45401.

SOUTH CAROLINA: The Greenville Hamfest sponsored by the Blue Ridge Amateur Radio Society will be held at the American Legion Fairgrounds, White Horse Road, 1/2 mile north of I-85 in Greenville, May 1 and 2. Admission $3.00 at the gate, no advance sales. Talk-in on 146.01/61 and 223.46/224.06. For further information write Hamfest Chairman, Gary D. Whidy, Rt. 6, Box 268, Travelers Rest, South Carolina 29690.

TENNESSEE: The Memphis Mini-Fest, Saturday only, April 3, 8 AM to 5 PM, Pipkin Bldg, Mid South Fairgrounds. Admission $1.00. Flea Market space $5.00 or 2 spaces $8.00. Bring own tables/chairs. Hospitality party

More Details? CHECK—OFF Page 92

Saturday night. For further details: Mid South Amateur Radio Assn. President Clayton Elam, K4FZJ, 28 N. Cooper St., Memphis, TN. 274-4418 (days) and 743-6714 (nights).

TENNESSEE/VIRGINIA: The Bristol, Johnson City and Kingsport Amateur Radio Clubs' 2nd Tri-Cities Hamfest, May 1 and 2, Appalachian Fairgrounds, Gray. Forums, dealers, flea market. Only two hours away from the 1982 World's Fair that starts May 1. For further information: Tri-Cities Hamfest, PO Box 3682 CRS, Johnson City, TN 37601.

VIRGINIA: The Lynchburg Amateur Radio Club's annual Swapfest, May 2, Brookville High School, route 460 west of Lynchburg. Large covered tailgating area and plenty of food. Talk in on 146.01/146.61. Details via: PO Box 4242, Lynchburg, VA 24501.

WASHINGTON: The Yakima Amateur Radio Club's annual Hamfest, May 1 and 2, Ahtanum Youth Activities Park, Yakima. Doors open 9 AM Saturday. Dealers, a super prizes raffle, free swap and shop. Lunch available both days. Breakfast 6 AM Sunday. For information: David Pankey, N7BRB, 512 So. 7th Street, Yakima, WA 98901.

WISCONSIN: The Ozaukee Radio Club's 4th annual Swapfest, Saturday, May 8, Circle B Recreation Center, Highway 60, Cedarburg (20 miles north of Milwaukee), 8 AM to 1 PM. Admission $2.00 advance; $3.00 door. 8 foot tables $3.00. Door prizes, food, refreshments. For information or tickets: SASE to Ozaukee Radio Club, PO Box 13, Port Washington, WI 53074.

WISCONSIN: The 3F Amateur Radio Club's Swapfest, Saturday, May 8, 8 AM to 3 PM, Neenah Labor Temple. Admission $1.50 advance, $2.00 door. Tables $1.50 advance, $2.00 door. Prizes, food, beverages. Auction at end of day. Talk in on 146.16/146.76 and 146.52. A semi-formal banquet available Saturday evening, $8.00 per person to advance ticket holders only. For information or tickets: Mark Michel, W9OP, 339 Naymut Street, Menasha, WI 54952. (414) 722-4034 (after 0000Z).

KNOXVILLE TENNESSEE: See World's Fair while attending 1982 Knoxville Hamfest and ARRL Delta Division Convention, Memorial Day Weekend (May 22-23). DX, computer, and technical forums; air-conditioned exhibit area; and large indoor/outdoor flea market make this Tennessee's largest Hamfest. More information? (dealers, tickets, reservations) N4BAQ, 5833 Clinton Hwy., Suite 203, Knoxville, Tenn. 37912.

OPERATING EVENTS

"Things to do..."

APRIL 10: The Missouri Valley Amateur Radio Club's third annual Pony Express Day, from 1000 CST to 1900 CST commemorating the original running of the Pony Express from St. Joseph, Missouri to Sacramento, California. In addition, the Club is also offering a "wanted" poster of outlaw Jesse James as this will be the 100th anniversary of his death. Anyone contacting club station WØNH is eligible to receive both certificates. Phone frequencies: 10 Kc's from bottom of general phone bands on 15, 20, 40 and 75 meters. 10 meters - 28.575. CW: 28.150 on 10, 21.150 on 15 and 7.125 on 40. To receive certificates send two first-class stamps and a QSL card to Missouri Valley Amateur Radio Club, WØNH, 401 N. 12th Street, St. Joseph, Missouri 64501.

APRIL 17 & 18: A Novice Mini-Expedition. The North Texas High Frequency Association will be operating the Novice bands from Novice, Texas, from 1800Z Saturday to 1800Z Sunday. Call sign KC5YN will operate near center of the Novice bands at your calling speed. For a commemorative QSL send legal-sized SASE to North Texas High Frequency Association, Denton, Texas 76201.

APRIL 17 & 18: W9YCR, The Quad Cities Amateur Radio Club, Rock Island, Illinois, will operate a special events station commemorating the first bridge across the Mississippi River. W9YCR will be on the air from 1800 UCT Saturday through 1800 UCT Sunday. 80 - 10 meters. Frequencies: middle of CW portion of each Novice class band, as low as possible in the General CW portion of each band and 30 kHz up from lower edge of the General SSB portion of each band. For a commemorative certificate send QSL and business SASE to: Denny Spurgeon, N9BKY, 413 - 23rd Avenue, Moline, IL 61265.

MAY 7 & 8: The Indian River Amateur Radio Club in conjunction with the Florida Solar Energy Center at Cape Canaveral will participate in a "Sun-Day" exercise using club call, W4NLX/4 and, at that time, will be operating completely on solar power. 1300-1400 GMT, 40 meters, 7,250 to 7,275 kHz, SSB. 1400-2000 GMT, 15 meters, 21,350 to 21,375 kHz, SSB. For a certificate confirming contact or reception (free to each station or short wave listener sending a QSL) SASE (Foreign 1 IRC) to: Florida Solar Energy Center, "Sun-Day", 300 State Route 401, Cape Canaveral, FL 32920.

MAY 8: The Greater Fairfield Amateur Radio Association's special Dogwood Festival QSO Party. Members of the club (WB1COO) will be on six Amateur bands to explain significance of the festival. 1300-2200 UTC or 9 AM to 6 PM EDST. SSB frequencies: 3.975, 7.235, 14.330, 21.420 and 28.710 MHz. FM: 146.55 simplex. For a special, commemorative QSL card send SASE or IRCs to QSL manager, Grace von Stein, KA1JT, 248 Euclid Avenue, Fairfield, CT 06432.

MAY 15: In observance of Armed Forces Day, an Amateur Radio station will be operating from the United States Air Force Museum at Wright-Patterson Air Force Base near Dayton, Ohio using the call sign, K8DMZ, from 1400Z to 2200Z on Saturday. Operators will work primarily in the General Class phone segments of 75, 40, 15 and 10 meters with periodic CW excursions to the Novice subbands. FM and SSB operation on 2 meters is planned. This will be the first time an Amateur Radio station has operated from the Museum in conjunction with a special event and to commemorate this, the Museum will issue a special certificate for each two-way contact.

MAY THROUGH OCTOBER: The 1982 World's Fair in Knoxville will feature a special events Amateur Radio station sponsored by The Tennessee Wireless Association. The station will operate all bands 160-2m, all modes and will be on display to the public. Guest operators are welcome subject to rules laid down by the chief operator. For details: Jerry Goodchild, K4DZR, 3701 Warner Dr., Apt. 213, Knoxville, TN 37912.

PLAYBOY RESORT at Great Gorge, McAfee, NJ — the place to relax and enjoy — see all the manufacturers' and dealers' exhibits — attend the vital and informative forums — renew old acquaintances and make new ones — all at the ARRL Hudson Division Convention, October 30-31. Send SASE now for complete details to HARC, Box 528, Englewood, NJ 07631.

SCHOLARSHIPS: The Foundation for Amateur Radio, Inc., a non-profit organization with headquarters in Washington, DC plans to award nine scholarships for the academic year 1982-1983. The Foundation, composed of fifty local-area Amateur Radio clubs, fully funds two of these scholarships from the proceeds of the Gaithersburg (MD) Hamfest and administers, without cost to donors, two scholarships for the Quarter Century Wireless Association and one each for the Richard G. Chichester Memorial, The Radio Club of America, the Young Ladies' Radio League, the Edmund B. Redington Memorial and the Amateur Radio News Service. Radio Amateurs holding at least an FCC General Class license or equivalent may compete for one or more of these awards if they plan to pursue a full-time course of studies beyond high school and are enrolled or have been accepted by an accredited university, college or technical school. Awards range from $300 to $900. For additional information and application form, send letter or QSL/postcard prior to May 31, 1982 to: Hugh A. Turnbull, W3ABC, 6903 Rhode Island Avenue, College Park, MD 20740.

NEW products

Transi-Trap lightning protection

The conventional air-gap lightning protector design affords virtually no protection to solid-state components, since its breakdown voltage and response time are unpredictable because of the arc-forming characteristics of the molecules of air between electrodes in an air-gap protector.

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The Transi-Trap protector design allows devices to be set to fire at the lowest possible lightning pulse level for maximum protection of solid-state receivers and transceivers (Model R-T protector), or at a higher voltage level for protection of amplifiers, both tube-type and solid-state (Model HV protector). By using special constant-impedance brass tubing design for the in-line circuitry, excellent performance through 500 MHz is realized (typically 0.1 dB loss at 500 MHz).

For more information, contact Alpha Delta Communications, 116A North Main Street, Centerville, Ohio 45459.

Big Ben mike stand

Mobile radio operators who use their equipment in the base station will find their job made easier by the new Big Ben Mike Stand by Valor Enterprises, Inc. The new mike stand allows the operator to convert his mobile microphone to a base station microphone.

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Commsoft Codem

The Commsoft Codem, a universal CW interface for personal computers, is now available for Radio Amateurs. The Codem provides an easy way to get your Morse code software on the air. Converting received CW audio to RS232 or TTL signal levels and RS232 or TTL signal levels to transmitter keying, the Codem doubles as a code practice oscillator and CW regenerator.

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The price of the Codem is $124.95. The 9-Vdc supply is $9.95. Add $5.00 for shipping and handling. California residents add applicable sales tax. VISA and MasterCard orders accepted.

For more information, contact Commsoft, 665 Maybell Avenue, Palo Alto, California 94306; telephone 415-493-2184.

Hy-Gain tribander

Hy-Gain introduces the TH7DX, a broadband tribander based on the excellent front-to-back characteristics of the older TH6DXX plus the superior VSWR characteristics of a dual-driven element system. The combination produces an amazingly efficient broadband tribander without compromises.

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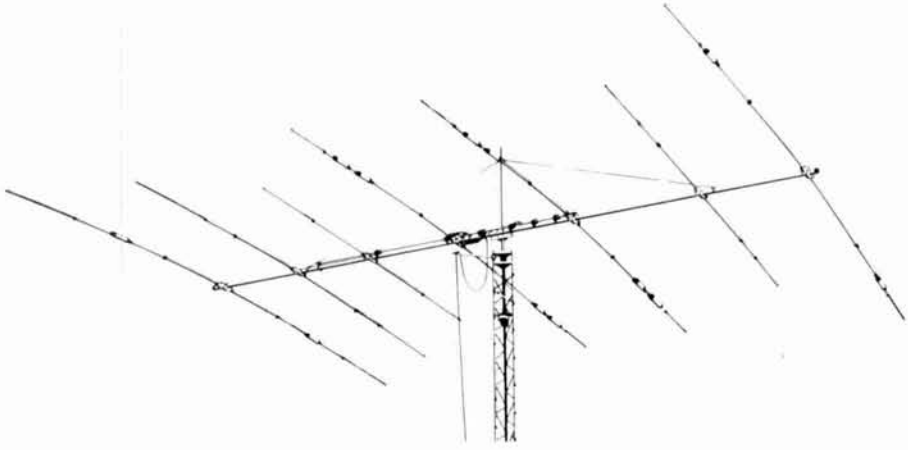

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tuning meter, and splash-proof housing. Attractive styling makes the ESR24 suitable for commercial or private installations. Price is under $1,000.

R.L. Drake is recognized for high technology Amateur Radio, commercial, and maritime communications equipment. For more information, contact R.L. Drake Company, 540 Richard Street, Miamisburg, Ohio 45342; telephone 513-866-2421.

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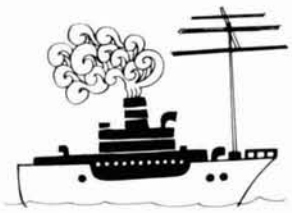

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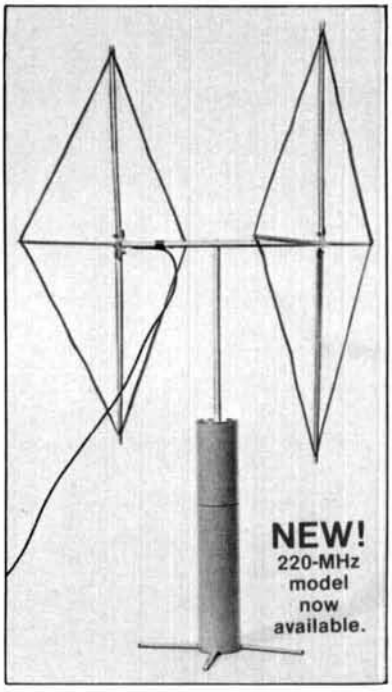

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More Details? CHECK—OFF Page 92

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- Output level flat to within 1.5db over entire range selected.
- Separate level adjust pots and output connections for each tone Group.
- Immune to RF
- Powered by 6-30vdc, unregulated at 8 ma.
- Low impedance, low distortion, adjustable sinewave output, 5v peak-to-peak
- Instant start-up.
- Off position for no tone output.
- Reverse polarity protection built-in.

Group A

67.0 XZ	91.5 ZZ	118.8 2B	156.7 5A
71.9 XA	94.8 ZA	123.0 3Z	162.2 5B
74.4 WA	97.4 ZB	127.3 3A	167.9 6Z
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

- Frequency accuracy, ± .1 Hz maximum - 40°C to + 85°C
- Frequencies to 250 Hz available on special order
- Continuous tone

Group B

TEST-TONES:	TOUCH-TONES:	BURST TONES:
600	697 1209	1600 1850 2150 2400
1000	770 1336	1650 1900 2200 2450
1500	852 1477	1700 1950 2250 2500
2175	941 1633	1750 2000 2300 2550
2805		1800 2100 2350

- Frequency accuracy, ± 1 Hz maximum - 40°C to + 85°C
- Tone length approximately 300 ms. May be lengthened, shortened or eliminated by changing value of resistor

Model TE-64 **$79.95**

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FT-230R: QUITE A SIGHT! (AND EASY TO SEE, TOO!!)

Sporting an all-new Liquid Crystal Display, the FT-230R is Yaesu's high-performance answer to your call for a very affordable 2 meter mobile rig with an easy-to-read frequency display! The FT-230R combines microprocessor convenience, a sensitive receiver, a powerful yet clean transmitter strip, and the new dimension of LCD frequency readout. See your Authorized Yaesu Dealer today — and go home with your new FT-230R!

SALE SUBJECT
FCC CERTIFICATION

- LCD five-digit frequency readout with night light for high visibility day or night.
- Two VFOs for quick QSY across the band.
- Ten memory slots for storage and recall of favorite channels.
- Selectable synthesizer steps (5 kHz or 10 kHz) in dial or scanning mode.
- Priority channel for checking a favorite frequency for activity while monitoring another.
- Unique VFO/Memory Split mode for covering unusual repeater splits.
- Up/Down band scan plus memory scan for busy or clear channel. Scanning microphone included in purchase price.
- Full 25 watts of RF power output from extremely compact package.
- Built-in automatic or manual tone burst.
- Optional synthesized CTCSS Encode and Encode/Decode boards available.
- Lithium memory backup battery with estimated lifetime of five years.
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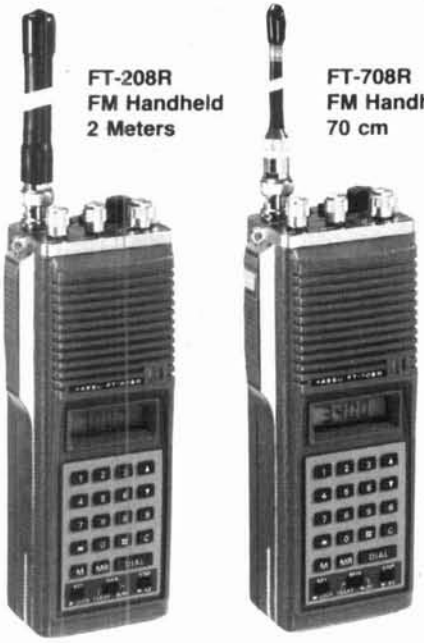

FT-208R
FM Handheld
2 Meters

FT-708R
FM Handheld
70 cm

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FT-290R - 2 Meters
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The radio.

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EIMAC's 4CW300,000G Power Tetrode. A new generation of high-performance power tubes.

EIMAC's 4CW300,000G combines all the desired features transmitter designers look for: high peak plate current, low grid emission, low internal capacitances and low internal inductance. This is the first of a new generation of high performance power tubes for LF, HF, VHF and pulse service.

Laserfab pyrolytic graphite grids

The control grid and screen structures of the 4CW300,000G are precision-cut by a laser beam. Each element is monolithic and combines extremely low coefficient of expansion with low structural inductance. These features permit the 4CW300,000G to have a very high transconductance—10^6 micromhos—and allow efficient, high-frequency operation.

Rugged mesh filament

The EIMAC mesh filament provides exceptionally high peak plate current and permits low plate voltage operation. This leads to power supply economy, making the 4CW300,000G the economic choice for 300 KW AM broadcast service or long-pulse switch service, each of which demands a reserve of peak emission.

Improved anode structure

EIMAC's multi-phase cooling technique provides high plate dissipation to extract heat evenly and quickly from the anode, contributing to long tube life and operating economy.

EIMAC expertise

EIMAC's expertise in electron ballistics pyrolytic grid production, thermodynamics and circuit techniques combine to bring tomorrow's tubes for today's transmitter designs. More information is available from Varian EIMAC. Or the nearest Varian Electron Device Group sales office.

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Varian EIMAC
Application Engineering
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San Carlos, CA 94070
Telephone: 415•592-1221, ext. 218

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Steinhauserstrasse
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Telephone: (042) 23 25 75
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