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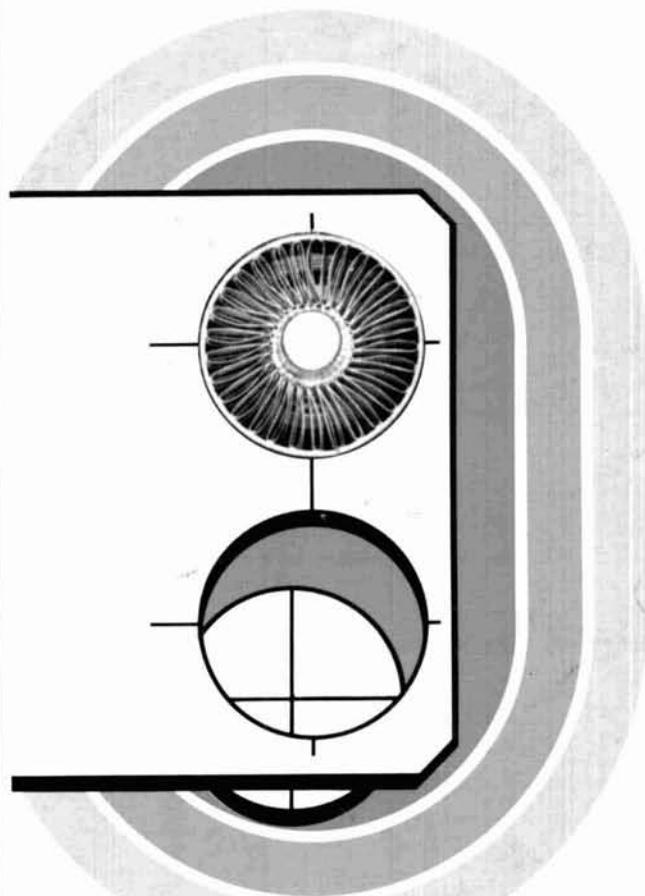
# ham radio

magazine

*hr* 

**OCTOBER 1977**

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- and much more . . .



**stripline  
kilowatt**  
for two meters

# TEMPO

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\*Not furnished.  
FCC Type accepted models available

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10W	80W	80A10	\$149
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FCC Type accepted models available.

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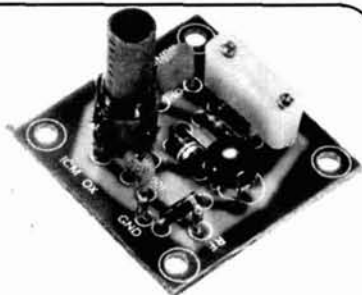
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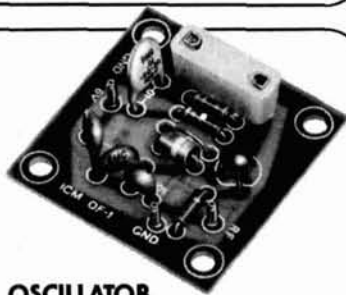
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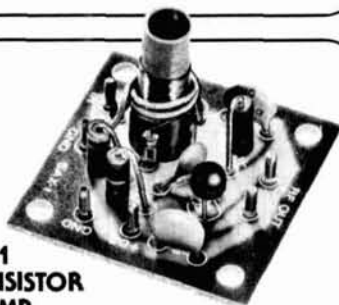
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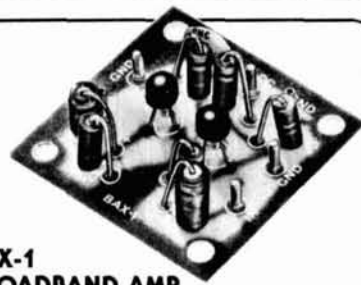
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**\$69<sup>95</sup>**

### MFJ-16010 ST Super Antenna Tuner

This NEW MFJ Super Antenna Tuner matches everything from 160 thru 10 Meters: dipoles, inverted vees, long wires, verticals, mobile whips, beams, balance lines, coax lines. Up to 200 watts RF OUTPUT. Built-in balun, too!

- Operate all bands with one antenna • Works with all solid state and tube rigs • Ultra compact: 5 x 2 x 6 inches • Uses toroid cores



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Now you can operate all bands — 160 thru 10 Meters — with a single random wire and run your full transceiver power output — up to 200 watts RF power OUTPUT.

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### CWF-2BX Super CW Filter

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**\$69<sup>95</sup>**

### MFJ-8043 IC Deluxe Electronic Keyer

This NEW MFJ Deluxe Keyer gives you more features per dollar than any other keyer available.

- Uses Curtis-8043 keyer chip • Sends iambic, automatic, semi-automatic, manual • Use squeeze, single lever, or straight key • Dot memory, self-completing dots and dashes, jam proof spacing, instant start • RF proof • Solid state keying  $\pm 300$  V max • Weight, tone, volume, speed controls • Uses 4 C-cells; external power jack • 6 x 6 x 2 inches • Sidetone and speaker • Optional squeeze key: \$29.95



**\$54<sup>95</sup>**

### CMOS-8043 Electronic Keyer

State of the art design uses CURTIS-8043 Keyer-on-a-chip.

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### LSP-520BX II Log Speech Processor

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**\$29<sup>95</sup>**

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**\$29<sup>95</sup>**

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Provides strong, precise markers every 100, 50, or 25 KHz well into VHF region.

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### MFJ-1030BX Receiver Preselector

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Work the world with 5 watts on 40 Meter CW.

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MFJ-12DC, IC Regulated Power Supply,  
1 amp, 12 VDC ..... \$29.95



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For the Newcomer to learn the Morse code.

For the Old Timer to polish his fist.

For the Code Instructor to teach his classes.

- Send crisp clear code with plenty of volume for classroom use • Self contained speaker, volume, tone controls, aluminum cabinet • 9 V battery • Top quality U.S. construction • Uses 555 IC timer • 2-3/16 x 3-1/4 x 4 inches

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**\$19<sup>95</sup>**

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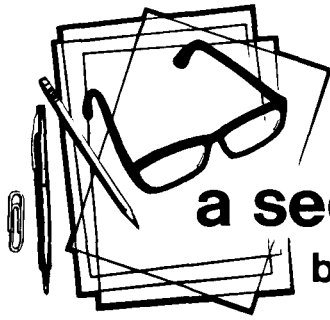
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## a second look

by Jim Fisk

**In the last few months there has been** an increase in the number of inquiries and complaints received by the FCC concerning state and local laws which deal with radio and television. Most of the calls and letters are related to CB, and ask whether a particular ordinance is constitutional, or complain about the enforcement of a state statute that is thought to be in conflict with the FCC regulations. To answer these questions, the FCC recently released Public Notice 87276 which provides information to amateurs, CBers, and other FCC licensees who feel they have run into improper local regulation of radio communications.

As the Public Notice points out, as early as 1912 the Congress recognized that radio communications was inherently interstate in nature, was a form of commerce, and was uniquely adaptable to uniform regulation by the federal government. The Radio Act of 1927 increased the federal government's authority to regulate this area, and the passage of the Communication Act of 1934 substantially completed the trend toward comprehensive federal regulation of interstate and foreign communications by wire and radio. To execute and enforce its provisions, the Act also provided for the establishment of the FCC.

It was the primary goal of the Communications Act to make available, "to all people of the United States a rapid, efficient, nation-wide, and world-wide wire and radio communication service . . ." The Act proposed to execute this policy by "centralizing authority" and by "granting additional authority with respect to interstate and foreign commerce in radio communication . . ." Furthermore, the Act claims complete jurisdiction over radio energy for the federal government, as stated in Section 301:

It is the purpose of this Act, among other things, to maintain the control of the United States over all the channels of interstate and foreign radio transmission; and to provide for the use of such channels . . . under licenses granted by Federal authority . . . No person shall use or operate any apparatus for the transmission of energy or communications or signals by radio . . . except under and in accordance with this Act and with a license in that behalf granted under the vision of this act, 47 U.S.C. §301.

In addition, Congress granted the Commission the authority to establish a pervasive system of regulation in the various radio services. Section 303 of the Act gives such numerous powers to the FCC as to leave no doubt as to the extent of this regulatory scheme. These and other sections of the Act indicate the clear intention of Congress that radio be regulated by the federal government.

Under the Supremacy Clause of the United States Constitution, state and local statutes may be pre-empted when (1) a local law conflicts with a law enacted by Congress, or (2) when Congress has adopted pervasive legislation in a particular field with the intent that regulation in the area will be conducted exclusively by the federal government. Furthermore, local ordinances which unreasonably burden interstate commerce may be invalidated under the authority granted to the federal government by the Commerce Clause of the United States Constitution.

Whether or not a particular local statute has been pre-empted by federal legislation is a question of law, and when a conflict between federal and state law arises, the courts, both state and federal, are usually called upon to make the final decision. For proper resolution the specific local law in question must be reviewed, and each case must be carefully judged on its own facts.

In general it may be said that in matters involving purely local concerns, the courts have found that reasonable local statutes are not in conflict with the Communications Act; such things as local zoning ordinances limiting antenna heights, and the right of local courts to adjudicate property rights involving licensee's facilities have all been upheld. On the other hand, where a local law conflicts with the FCC's regulatory scheme for radio services, the federal law will prevail; state laws involving the censorship of material carried on broadcast stations, for example, and those requiring FCC licensees to refrain from activities required by the Communications Act have been struck down.

The FCC does not have the resources to routinely monitor state and local laws which affect radio communications, nor can the FCC intervene in every local court proceeding in which the validity of various laws is tested. However, amateurs and other FCC licensees who feel victimized by improper local laws may raise federal pre-emption in their own behalf, and local legislative bodies should consider the issue when contemplating the enactment of ordinances in areas regulated by the Communications Act. Since many of the inquiries received by the FCC directly concern CB (and indirectly, amateur radio), local lawmakers should also be aware that the FCC has issued extensive regulations governing this area. Therefore, local ordinances designed specifically to regulate CB (or amateur) transmissions could be invalid according to the legal principles discussed above.

**Jim Fisk, W1HR**  
editor-in-chief



# That's all, Folks!

All you need for All Mode Mobile, that is.

All Mode Mobile is now yours in a superior ICOM radio that is a generation ahead of all others. The new, fully synthesized **IC-245/SSB** puts you into FM, SSB and CW operation with a very compact dash-mounted transceiver like none you've ever seen.

- **Variable offset:** Any offset from 10 KHz through 4 MHz in multiples of 10 KHz can be programmed with the LSI Synthesizer.
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\* a registered trademark of AT&T.

- **FM stability on SSB and CW:** The **IC-245/SSB** synthesis of 100 Hz steps make mobile SSB as stable as FM. This extended range of operation is attracting many FM'ers who have been operating on the direct channels and have discovered SSB.

The **IC-245/SSB** is the very best and most versatile mobile radio made: that's all. For more information and your own hands-on demonstration see your ICOM dealer. When you mount your **IC-245/SSB** you'll have all you need for All Mode Mobile.

#### SPECIFICATIONS

FREQUENCY COVERAGE  
MODES  
SUPPLY VOLTAGE  
SIZE (mm)  
WEIGHT  
TRANSMITTER  
TX OUTPUT  
CARRIER SUPPRESSION

144.00 to 148.00MHz  
FM, DTMF  
100W (A3), CW (A1)  
DC 13.8V ± 15%  
90x115x90x230mm  
2.7  
F3 10W  
100W (PEP), A1 10W  
40 dB OR BETTER

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MAXIMUM FREQUENCY  
DEVIATION  
MICROPHONE IMPEDANCE

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1.5KHz  
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F3 IS 4 MICROVOLTS OR LESS  
FOR 20 dB QUIETING  
S+N = 13N AT 1 MICROVOLT  
INPUT, 30 dB

SQUELCH THRESHOLD  
SPURIOUS RESPONSE

SYNTHESIZER  
FREQUENCY RANGE  
STEP SIZE

STABILITY

6 dB OR LESS (F3)  
60 dB OR BETTER

1.44 MHz to 148 MHz  
5 KHz for FM

100 Hz or 3 KHz for SSB  
PER C IN THE RANGE OF -10  
TO +40C ±0.00004%

\*VALID WITH SSB UNIT ONLY

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THE TYPE ACCEPTANCE and 10-meter amplifier ban dockets themselves — Dockets 20117 and 20116 — were not discussed at recent FCC meetings, only the ARRL's request for oral argument on those two propositions. After considerable discussion it was decided to reserve the decision on the League's request until later, concurrent with the Commission's actual discussion of the dockets. At this point it seems likely that formal consideration of those two proposals should occur in early October.

MARITIME MOBILES ABOARD U.S. VESSELS gained many new frequencies effective September 12. All U.S. licensed Amateurs operating on the high seas (not in the waters of a foreign power) will be permitted to operate on any frequency that Amateurs are authorized in that ITU Region. For example, in nearby waters (ITU Region 2) maritime mobiles may use all domestic U.S. Amateur frequencies, from 160 up. In the other ITU Regions Amateurs are more limited, of course — a U.S. maritime mobile off the coast of Europe or Africa would be restricted to 7000-7100 on 40 meters, 144-146 on two, and forbidden 6 and 220.

ARMA PRESIDENT DENNIS HAD tendered his resignation to the ARMA membership in a three-page letter. In the letter Denny cited the heavy burden the ARMA presidency had placed on him personally and on Dentron, a burden that — with a few notable exceptions — had not been shared by other ARMA members. Another factor in his resignation decision was criticism from a few of the ARMA members, criticism that reflected on his personal motives and integrity in his efforts to establish and maintain ARMA, while some of these same critical members were the ones whose catering to the illegal CB market had brought ARMA into being in the first place.

Rumors of a possible split in the organization have been in the air recently, with a vocal minority of ARMA members more and more openly critical of the majority's support of the "Amateur equipment for Amateurs" concept. The problem of those members whose "unethical conduct," Dennis said, "has brought on the legal and regulatory problems we now face..." is a prime reason that he decided to resign.

STATE LICENSING OF CBers and Novice and Technician Class Amateurs has been proposed in Michigan by State Senator Basil Brown. Licensing would apply only to radios used in cars, would require a \$2 yearly registration fee, a description of the rig along with details of where it was obtained, and a description of the car it is installed in.

The Proposal, Senate Bill 409, exempts General and higher class Amateurs as well as visitors from out of state. It has been referred to the Senate Judicial Committee, which is chaired by Senator Brown. Michigan Amateurs wishing to comment on it can write Senator Brown or their own state senators in care of the Michigan Senate, Lansing, Michigan 48902.

CENTRAL STATES VHF CONFERENCE in Kansas City presented the John Chambers award to W6PO for his outstanding contribution to rf power amplifier design and assistance to VHF and EME oriented people. The F9FT antennas captured honors on both 144 and 432 MHz with gains that measured upwards of 1.0 dB above its nearest competitor which included such notables as KLMS and Quagis. The best 144-MHz noise figure was registered by WAØRDX using a neutralized 2N5297. At 432 MHz, K2UYH's V244 GaAs fet measured 1.25 dB while WB5LUA's entry, an NE645 bipolar, was close behind at 1.35 dB. Next year's plans call for the conference to be held in Rochester, Minnesota starting on August 18.

KH6BZF EXCHANGED 599s with N4DT (WB4PAG) on OSCAR orbit 12634B, culminating a series of skeds which also include K1HTV, K2SWZ, W1JR, WA8UUY, VE3BNO, and W2KLN. Other east coasters wishing a sked with KH6BZF should write including an SASE.

AN ASCII OK and other benefits of the FCC's "bandwidth docket" (20777) may not be far off. Safety and Special Bureau Chief Charley Higginbotham told the audience at a session on regulatory matters at the APCO (Associated Public Service Communications Officers) Convention in Chicago that they could expect a report and order on 20777 to come out "this fall."

INTERFERENCE ON 160 and possibly the high end of 75 meters could result from the FCC's recent approval of wide-band swept anti-theft systems. The three bands authorized for such systems are 1.7-2.3, 4.05-4.95, and 7.4-9.0 MHz, with a maximum field strength of 100 microvolts per meter at 30 meters.

Anti-Theft Systems must not interfere with radio communications, so can be shut down if they bother Amateur operations.

CW SENDING TEST is being dropped by the FCC for all Commission administered Amateur examinations, shortening and simplifying (since examiners won't need CW qualifications) the exam.

Novice Exams Administered by volunteer examiners will still require a sending test, however, to weed out really bad fists.



# Now there are two MLA amplifiers. DenTron announces the NEW! MLA-1200

The MLA-1200 linear amplifier was designed to give you a choice. We know that not all amateurs want to run 2000 watts PEP, but we also feel the demand for a luxury styled amplifier. Hence the MLA-1200.

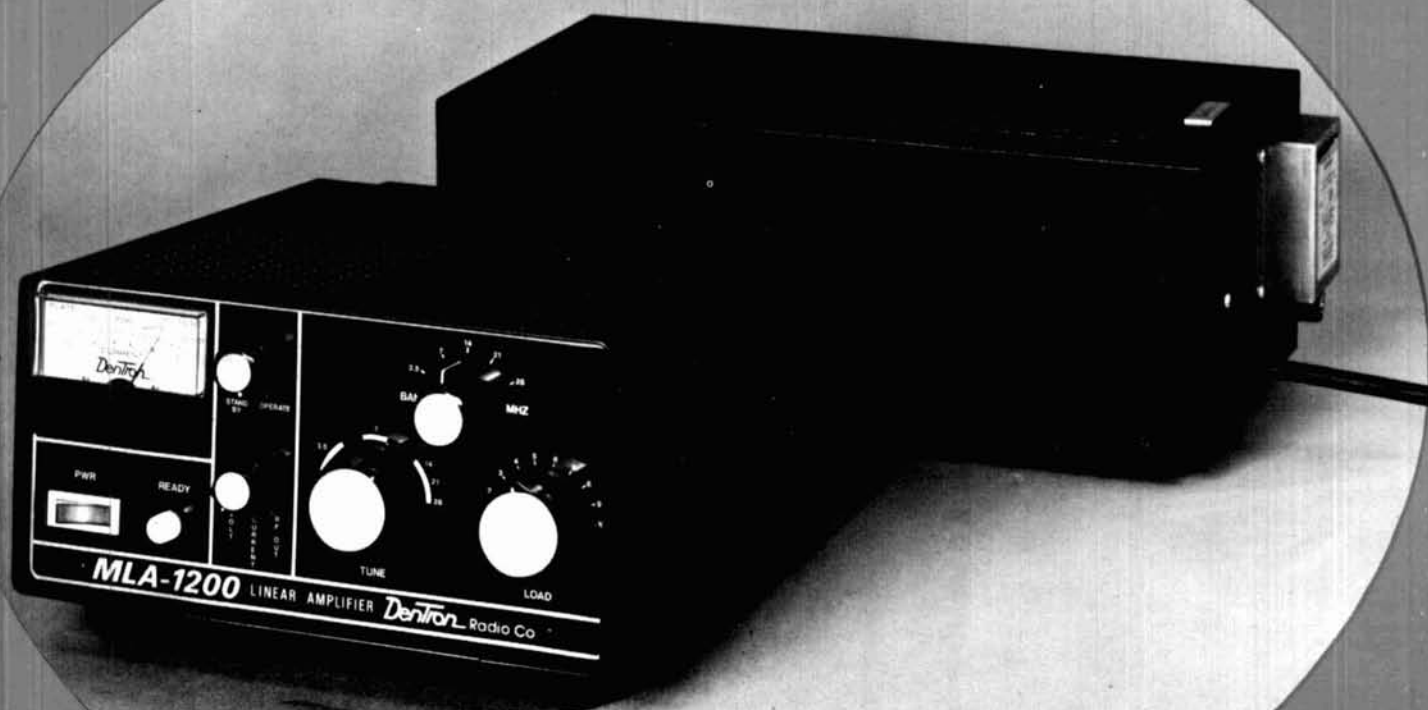
**Basically it's built on success.** The MLA-1200 incorporates the same sleek styling of the famous MLA-2500, but employs a single Eimac 8875 triode, yielding 1200 watts PEP SSB and 1000 watts DC CW with as little as 70 watts of drive.

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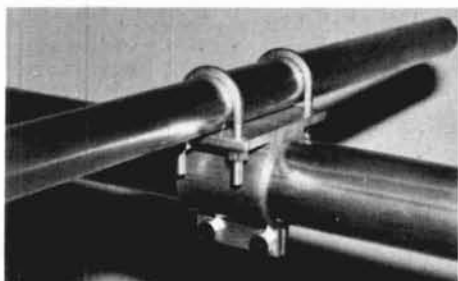
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Gain	10 dB	No. of Elements	5	Windload Area	146 lbs.
VSWR (at Resonance)	1.5 to 1	Longest Element	26' 7"	Shipping Weight	50 lbs.
Impedance	50 ohms	Turning Radius	18' 6"		



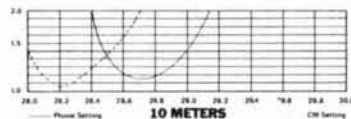
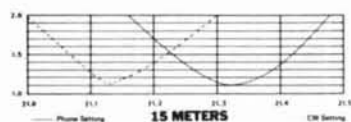
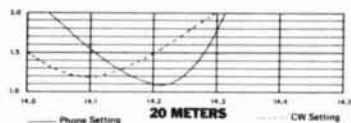
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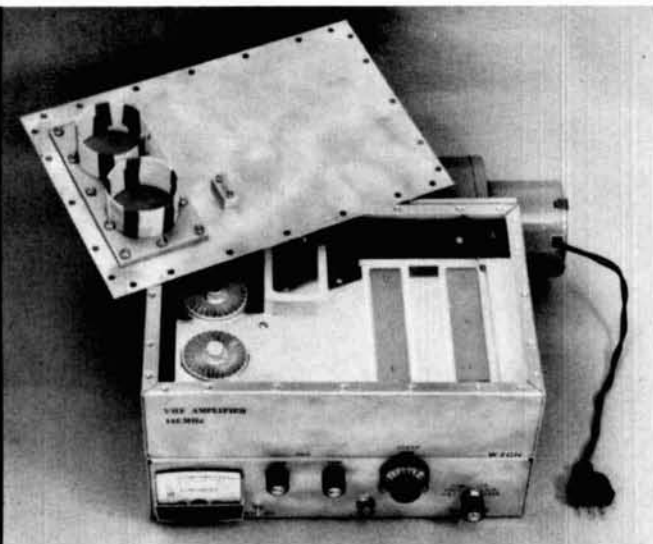
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# stripline kilowatt for two meters

Complete layout  
and construction details  
for a compact  
two-meter kilowatt  
based on the  
popular K2RIW design  
for 432 MHz

The stripline rf power amplifier designed by K2RIW for 432 MHz and described in *QST* several years ago has gained wide acceptance and use.<sup>1</sup> At the present time it's estimated that 300 to 400 of these amplifiers are in use around the world. The techniques outlined by K2RIW — using a pair of inexpensive ceramic tetrodes in a parallel stripline configuration — were used in a two-meter power amplifier designed by W9OJI.<sup>2</sup> A number of other single-tube stripline power amplifiers for two meters have also appeared in the amateur magazines. In this article I will try to put all this background and experience into construction information for a two-meter power amplifier packaged in the same com-

pact box as K2RIW's original design for 432 MHz. Such a unit could possibly become as popular on 144 MHz as the K2RIW amplifier has on 432.

Several stripline power amplifiers based on the layout described in this article have already been built and thoroughly tested on the air. When operated in the class AB1 linear mode, the amplifier provides 600 watts output with 6 to 8 watts drive. The all-mode two-meter transceivers now on the market have more than ample output to drive this amplifier to full output; the sharply tuned circuits in the amplifier help to attenuate any out-of-band products from the driver.

Any of the tubes from the 4CX250 series are suitable for the amplifier. However, the cooling problem is simplified by using 8930 tubes which are similar to 4CX250Rs except that they have a 2-inch (50mm) diameter anode. The dimensions for the plate line, chimneys, and top cover will be given for both tube types, but 8930s are the recommended choice.

Referring to the schematic, **fig. 1**, the plate line is a quarter wavelength long, with the plate blocking capacitor in the form of a Teflon sandwich at the cold end. Plate tuning is accomplished by a combination of fixed copper plate and beryllium copper flapper capacitor mounted below and near the plate end of the line, **fig. 2**. The capacitive loading to the output is adjusted by a flapper capacitor above the plate line which is also at the plate end of the line.

**By Fred Merry, W2GN, 35 Highland Drive, East Greenbush, New York 12061**



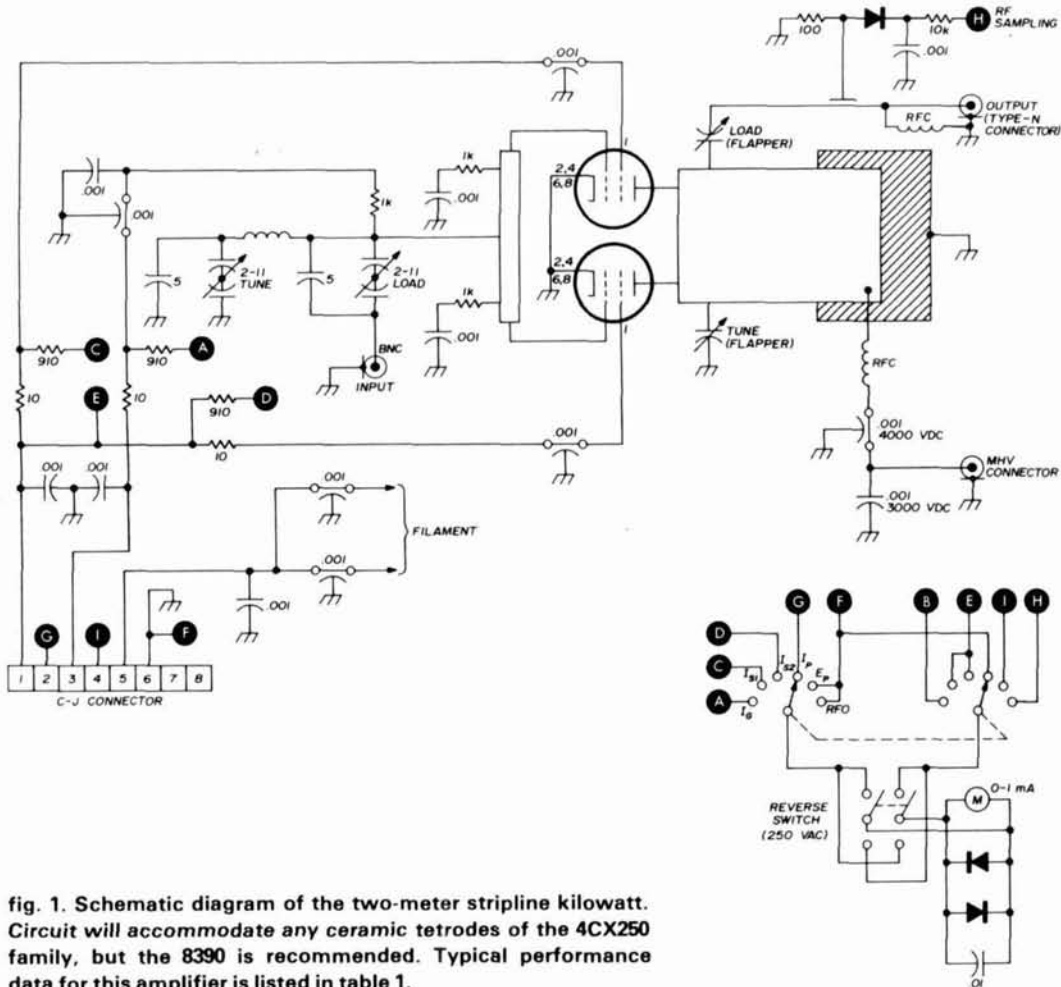
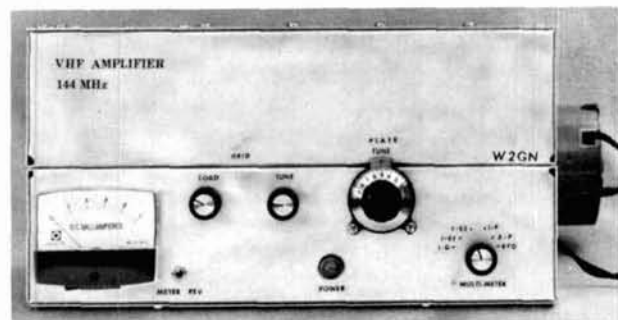


fig. 1. Schematic diagram of the two-meter stripline kilowatt. Circuit will accommodate any ceramic tetrodes of the 4CX250 family, but the 8390 is recommended. Typical performance data for this amplifier is listed in table 1.

The grid circuit consists of a 3-turn inductor tuned by a butterfly capacitor at the end away from the grids. Capacitive coupling is used for the input circuit. Eimac 620A or 630A sockets plus the construction and bypassing techniques used provide stability. Stability is further assured by loading the grid circuit down to approximately 300 ohms (derived from the grid bias resistor and two other 1000-ohm resistors mounted close to the grid socket connections of each tube, fig. 1).



Stripline kilowatt for two meters is compact, and measures only 6-inches (15cm) high, 12-inches (30.5cm) wide, and 8-inches (20cm) deep.

Chassis construction involves the use of three standard chassis: two 8 x 12 x 3 inches (20.3x30.5x7.6cm) and one 5 x 7 x 3 inches (12.7x17.8x7.6cm), plus a top plate and a bottom cover. The chassis preparation is covered by the illustrations accompanying this article which include complete drilling, punching, and cutting details. A good starting point is the top cover which is a piece of 3/32-inch (2.5mm) thick aluminum cut and drilled as shown in fig. 3. The large holes are made with a hole saw, 2-1/4 inches (5.7cm) for 8930 tubes, or 1-3/4 inches (4.5cm) for 4CX250s. The vent plate, which is 3/16-inches (4.5mm) thick can also be drilled and hole sawed at the same time. A piece of aluminum screening is cut to the size of the vent plate; the screen is fastened between the top plate and the vent plate with 1/2-inch (12.5mm) long screws, 6-32 (M3.5) lockwashers, and nuts.

The plate loading adjustment block is cut from a piece of 1/2-inch (12.5mm) square aluminum bar stock, drilled and tapped as shown in fig. 3. This block is fastened to the top plate with 3/4-inch (19mm) long 4-40 (M3) screws. The 8-32 (M4) nylon adjustment screw is cut to size and inserted in the block. This completes the top cover assembly.

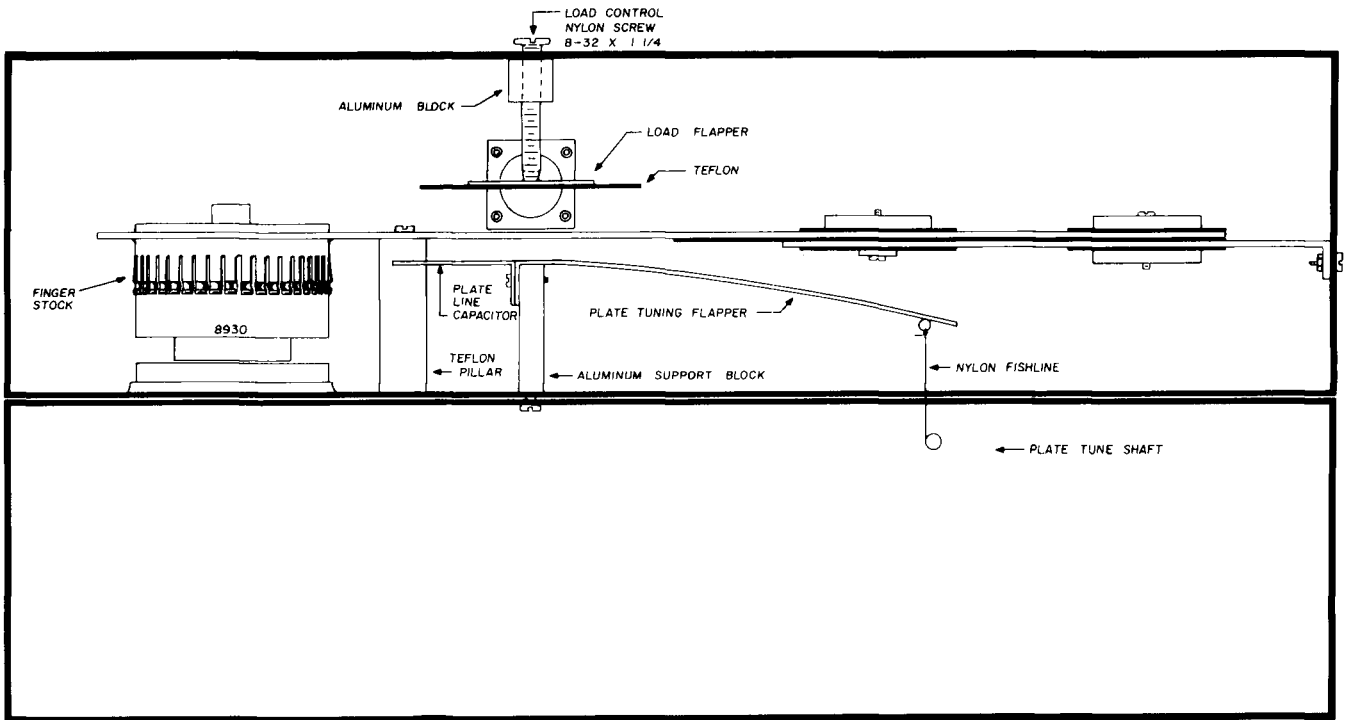


fig. 2. Cross-sectional view of the two-meter kilowatt showing the location of the plate circuit components.

The upper chassis is now prepared as shown in figs. 4, 5, and 6. Chassis punches 2-1/4 and 1-3/4 inch (5.7 and 4.5cm) in diameter are required for the socket holes and the air intake. Note also that the plate with a 1-3/4-inch (4.5cm) hole requires the use of a hole saw to get through the 3/16 inch (4.5mm) thickness. This screened air intake plate must be chosen for either a hose-connected blower, or a blower mounted directly on the chassis. The drawing

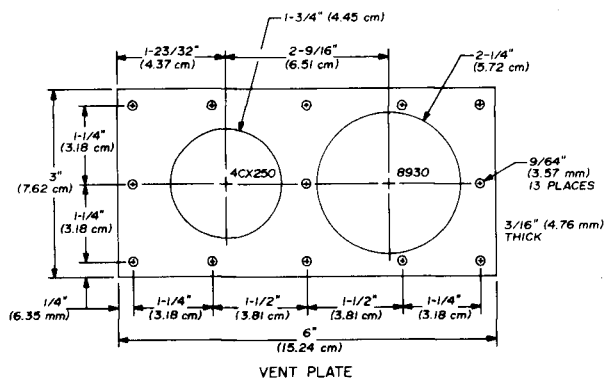
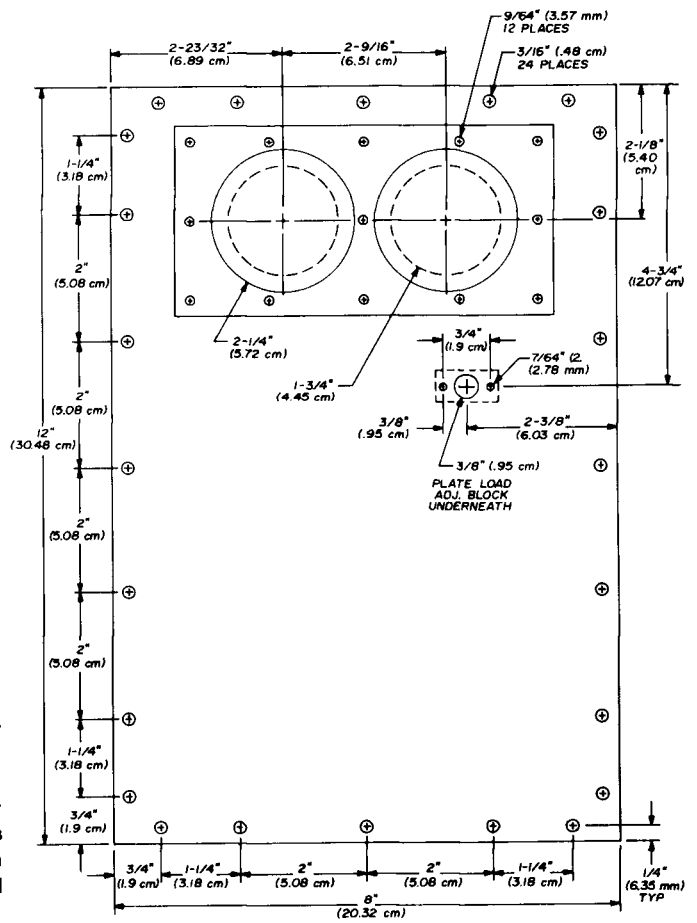


fig. 3. Bottom view of the top plate of the two-meter kilowatt. Top plate is made from 3/32-inch (2.5mm) aluminum sheet; vent plate is made from 3/16-inch (4.5mm) thick aluminum. The dashed 1-3/4-inch (4.5cm) circle is for 4CX250R and similar tubes; the 2-1/4-inch (5.7cm) circle is for the recommended 8930 tubes. A piece of aluminum screen is cut to the same dimensions as the vent plate and mounted between the top plate and the vent plate.



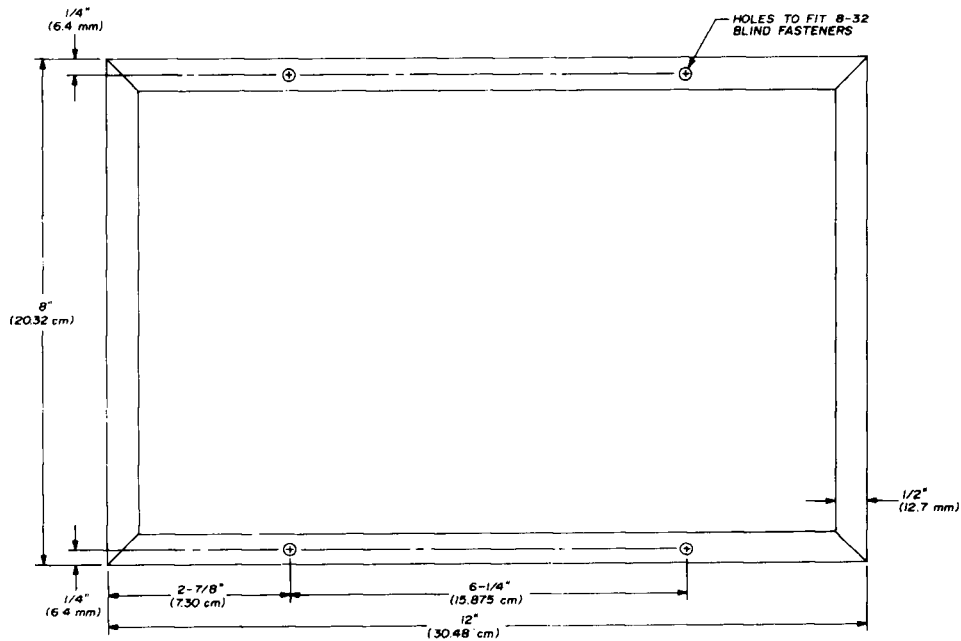


fig. 5. Top view of the upper chassis showing the top plate mounting holes. All holes are drilled to fit 8-32 (M4) blind fasteners.

for the chassis-mounted blower shows drilling and tapping for a Dayton 4CO1 blower.

Although chassis-mounted blowers have been used successfully, vibration can be a problem. The intake plate for hose-connected blowers is drilled for a Nutone plastic fitting type 366. This fitting will accept a hose with a 2-1/4-inch (5.7cm) inside diameter. For hose-connected blowers, use a blower

having 100 cfm free air rating into a 2-1/4-inch (5.7cm) aperture as a minimum. If 8930 tubes are used, the direct-mounted blower may be rated as low as 60 cfm into the same aperture.

Here are a couple of tricks to assure accurate drilling: lay the work out on masking tape which has been placed on the areas to be cut or drilled, and always use a 1/16-inch (1.5mm) pilot (starter) drill to

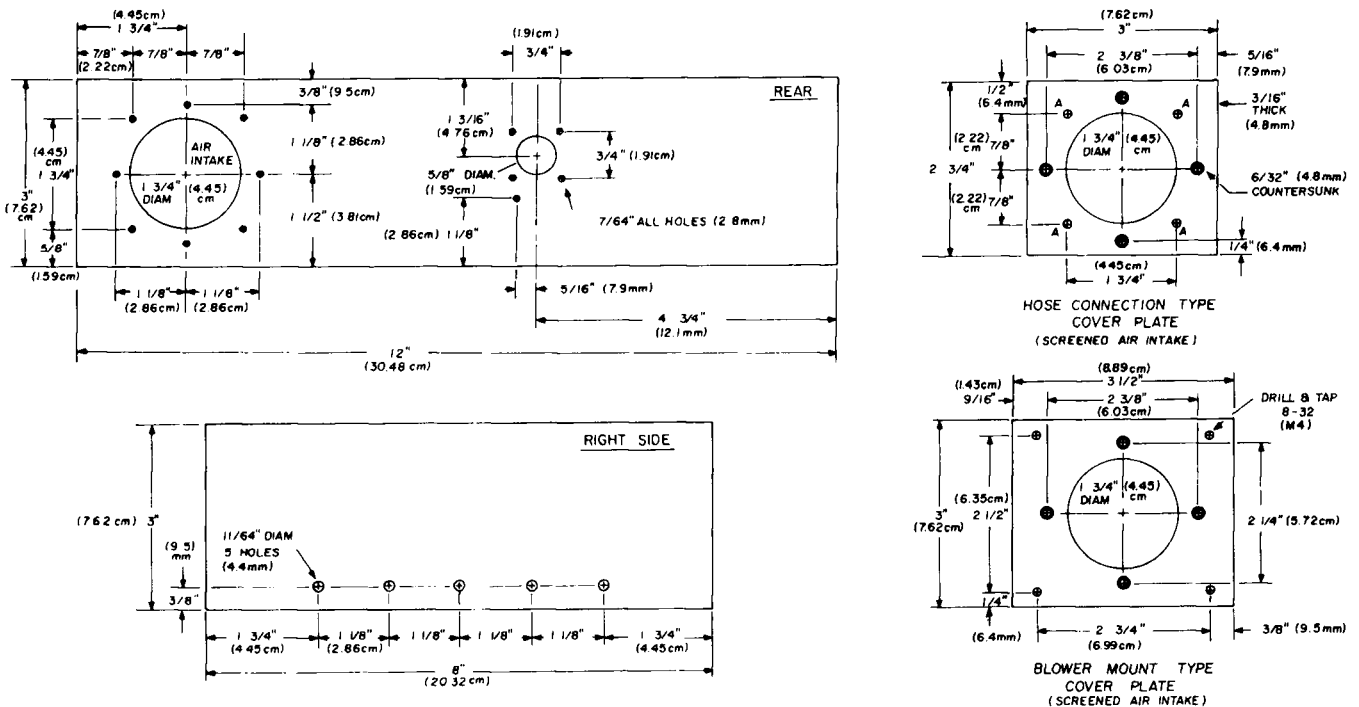


fig. 4. Top chassis for the two-meter kilowatt is made from 8 x 3 x 12-inch (20x7.6x30.5cm) aluminum chassis (Bud AC424 or equivalent). All holes not marked are 9/64 inch (3.5mm). Aluminum screening is mounted between vent cover plate and the air intake hole in the top chassis. Bottom view of the top chassis is shown in fig. 6.

center your holes. Although a drill press is convenient for all drilling operations, access to one is required only for the large holes through the 3/16-inch (4.5mm) thick material which requires the use of a hole saw.

To minimize alignment errors, one part with the 1/16-inch (1.5mm) pilot holes can be used as a drilling template for the matching parts. For example, use the top plate as a template for drilling the top of the upper chassis; use the vent plate as a template for the blower opening in the rear of the upper chassis.

Accuracy in drilling is essential, especially the socket holes, top plate vents, and plate line. These holes must line up nearly perfectly to assure alignment of the tubes, chimneys, and top vents.

It is best to use blind fasteners to secure the top plate to the upper chassis. Either 8-32 or 6-32 (M3.5 or M4) size is okay. The bottom plate may be fastened with self-tapping screws or blind fasteners with blind fasteners being the best choice. All other fastening is done with 6-32 or 4-40 (M3.5 or M3) screws, nuts, and lockwashers of suitable length.

The grid box is drilled and punched as shown in

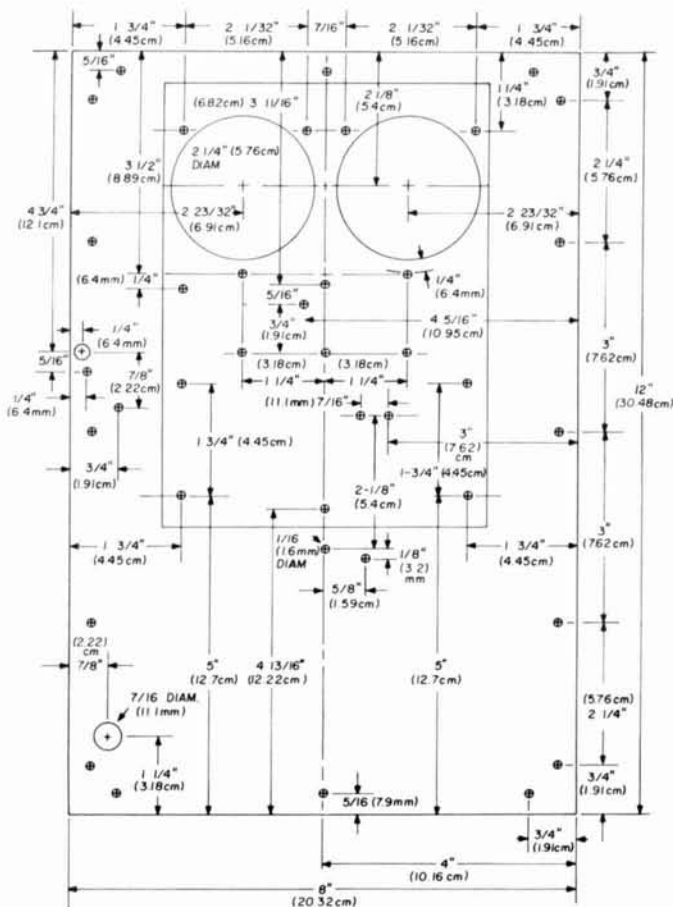
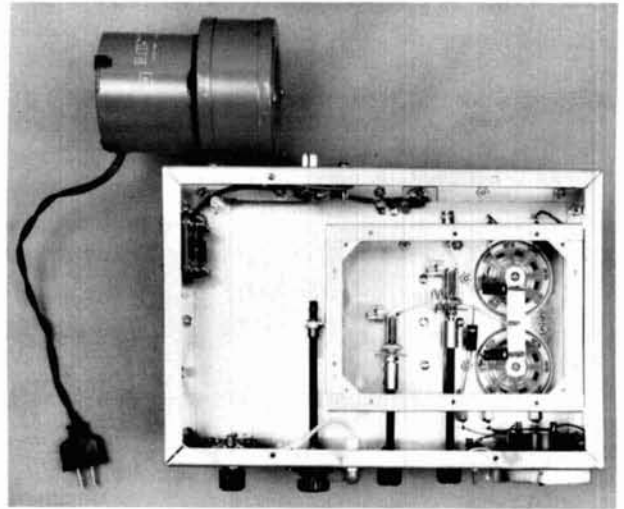


fig. 6. Bottom view of the upper chassis showing the layout of the tube cutouts and other mounting holes. All holes not marked are 9/64-inch (3.5mm) diameter.



Bottom view of the stripline two-meter kilowatt showing the wiring of the grid compartment.

figs. 7 and 8. To ensure alignment of the socket holes with those in the upper chassis, the grid box pilot holes, including the pilot holes for the sockets, are drilled using the upper chassis as a template.

The top of the lower chassis is cut out as shown in fig. 9. This can be done with a nibbling tool, a small hand saw, or if you are very careful, on a table saw. The meter hole in fig. 11 is for a Calectro D10912 — a 0-1 mA meter with 100 ohms resistance. Any 0-1 mA meter not more than 2-3/4-inches (7cm) high can be used; the clearance for the meter behind the front of the chassis is 1-1/4 inch (3cm).

The holes in the rear of the lower chassis may be changed to suit your choice of power connectors. The MHV high-voltage connector (Amphenol) is recommended for the B + lead.

The vent holes in both the grid box and the lower chassis can be covered with screening by using a 1-1/8 inch (2.9cm) punch to cut the center out of the pieces punched from the 2-1/4 inch (5.7cm) socket holes. This provides a ring-shaped clamp which is drilled to match the holes in the chassis.

The bottom plate shown in fig. 8 does double duty as it is fastened to both the lower chassis and the grid box. First drill the pilot holes in the bottom plate and then, using it as a template, drill the pilot holes in the bottom of the lower chassis and the grid box. This completes the chassis work operations.

## plate line

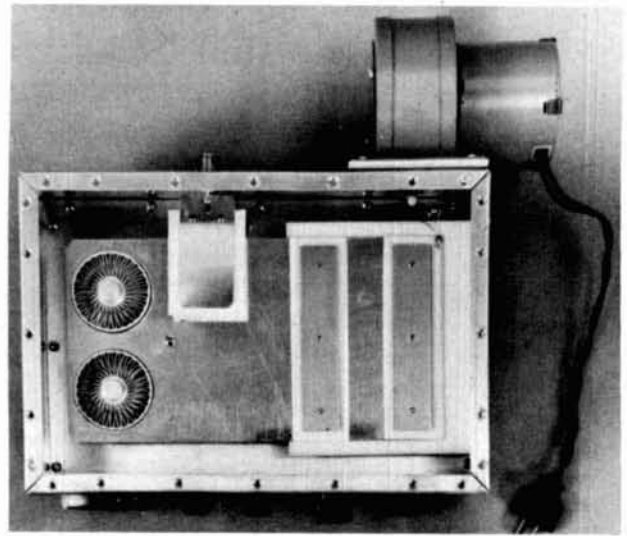
Before starting assembly and wiring, do the cutting and drilling for the plate line, the grid line, and the output flapper. The plate line consists of two pieces of copper clamped together in a Teflon sandwich by clamping bars (fig. 12). The cutting and drilling dimensions are shown in fig. 13. Note that only two of the clamping bars are drilled and tapped.



The third bar is drilled only 9/64 inch (3.5mm).

The finger stock is soldered on the under side of the plate line; this requires a soldering tool in the 200-watt range. The finger stock is held in place, flush with the upper side of the line, with a Pyrex beaker or some other cylinder of heat-resistant material about 2 inches (5cm) in diameter (1-5/8 inch or 4cm for 4CX250s) which is wrapped with Teflon tape to provide a squeeze fit which will hold the finger stock in place while soldering. Note that the smaller piece of the copper plate line is equipped with self clinching nuts; as an alternative, brass nuts may be soldered to the copper plate. The Teflon support for the plate line at the tube end is made from 1/2-inch (13mm) diameter Teflon rod, drilled and tapped 1/2-inch (13mm) deep on each end.

Fig. 14 shows the various components of the plate tuning and output flapper capacitors. The plate capacitor consists of two sections: the flapper and a piece of copper on the same mounting block which provides the additional capacitance needed to resonate the line. Semi-hard beryllium copper seems to make the best flapper material; it also has the advantage of taking silver plating which, while not



Top view of the two-meter kilowatt showing the plate stripline, the output coupling flapper (upper center), and Teflon sandwich at the cold end of the line (right).

essential, is desirable for all of the rf parts in both the plate and grid compartments of this amplifier.

Note the details for the aluminum support block in

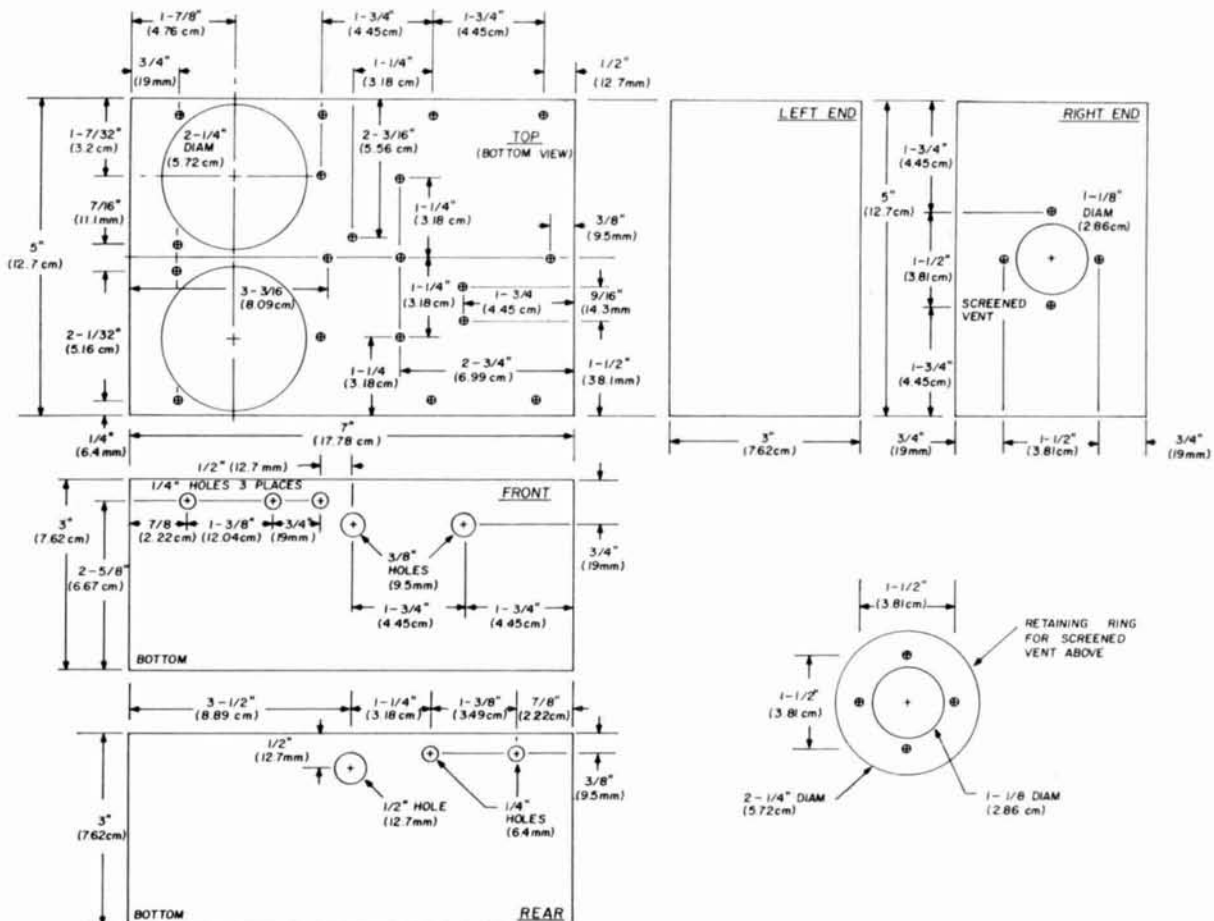


fig. 7. Construction of the grid box for the two-meter kilowatt. The aluminum chassis measures 5 x 7 x 3 inches (12.7x17.8x7.6cm) (Bud AC429 or equivalent). A piece of aluminum screen 2-1/4 inches (5.7cm) in diameter is clamped inside the box with the retaining ring. All holes not marked are 9/64 inch (3.5mm) in diameter.

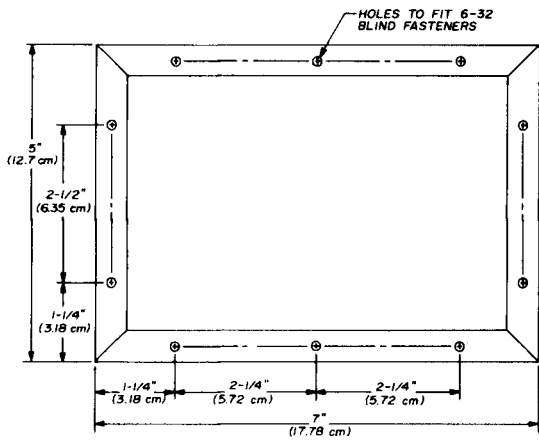


fig. 8. Bottom of the grid box and layout of the cover plate (Bud BPA 1519 or equivalent). The holes in the bottom of the grid box are drilled using the bottom plate as a template.

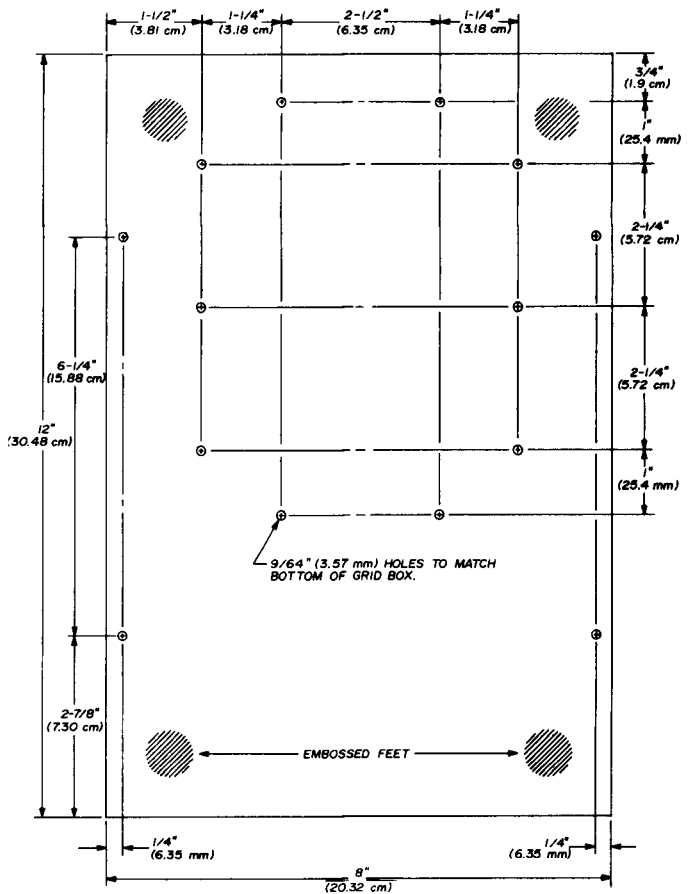


fig. 14; the flapper and fixed capacitor piece are mounted together with 8-32 (M4) hardware. The support itself is mounted to the chassis with 6-32

(M3.5) hardware. Dimensions for the bakelite shaft and bearing bracket for the plate flapper are also shown in fig. 14.

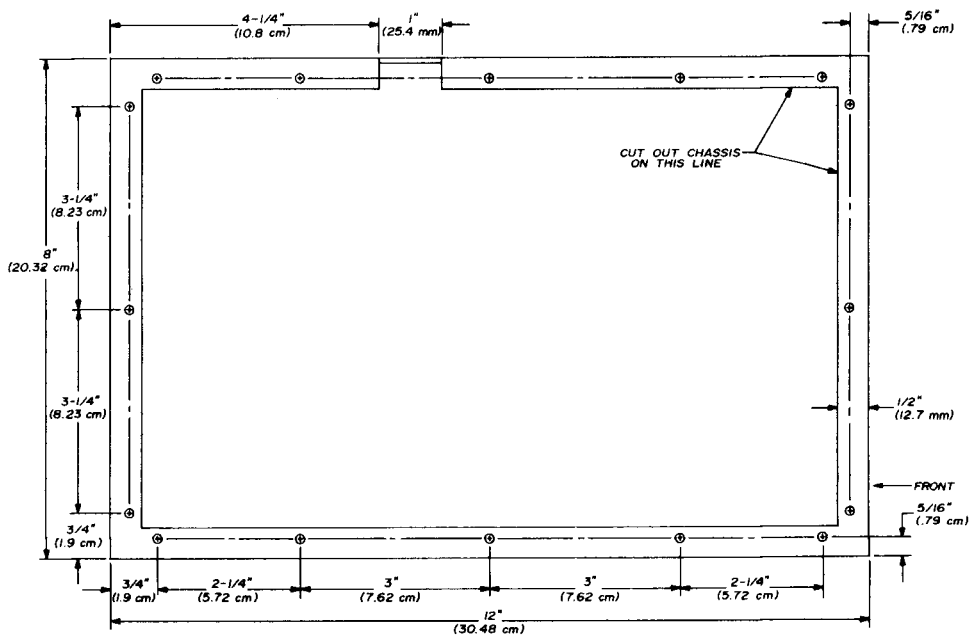


fig. 9. Top view of the lower chassis showing the large cutout made with a nibbling tool. Chassis is a Bud AC424 or equivalent. All holes are 9/64 inch (3.5mm).

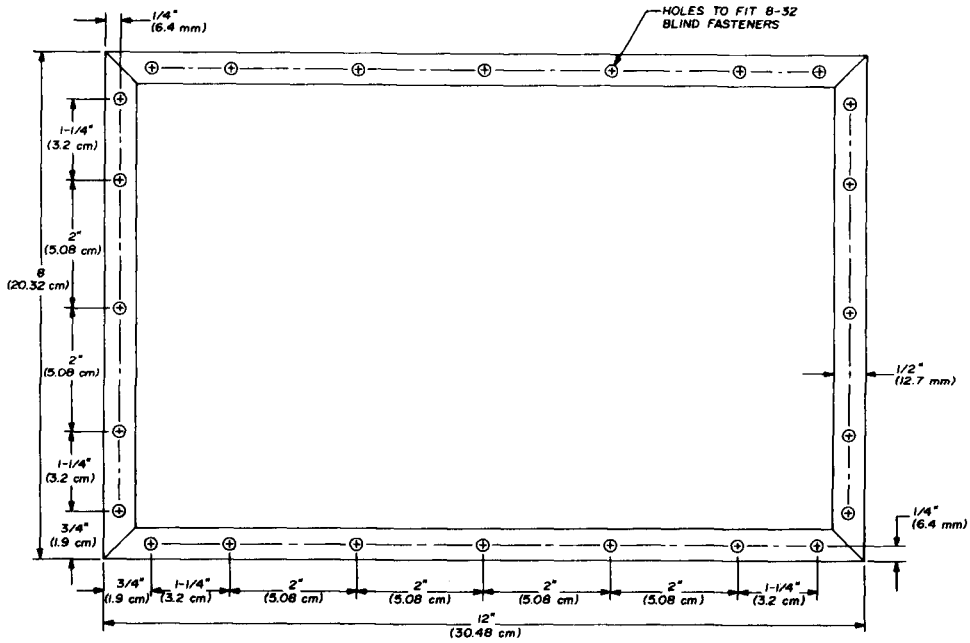


fig. 10. Bottom view of the lower chassis for the two-meter kilowatt.

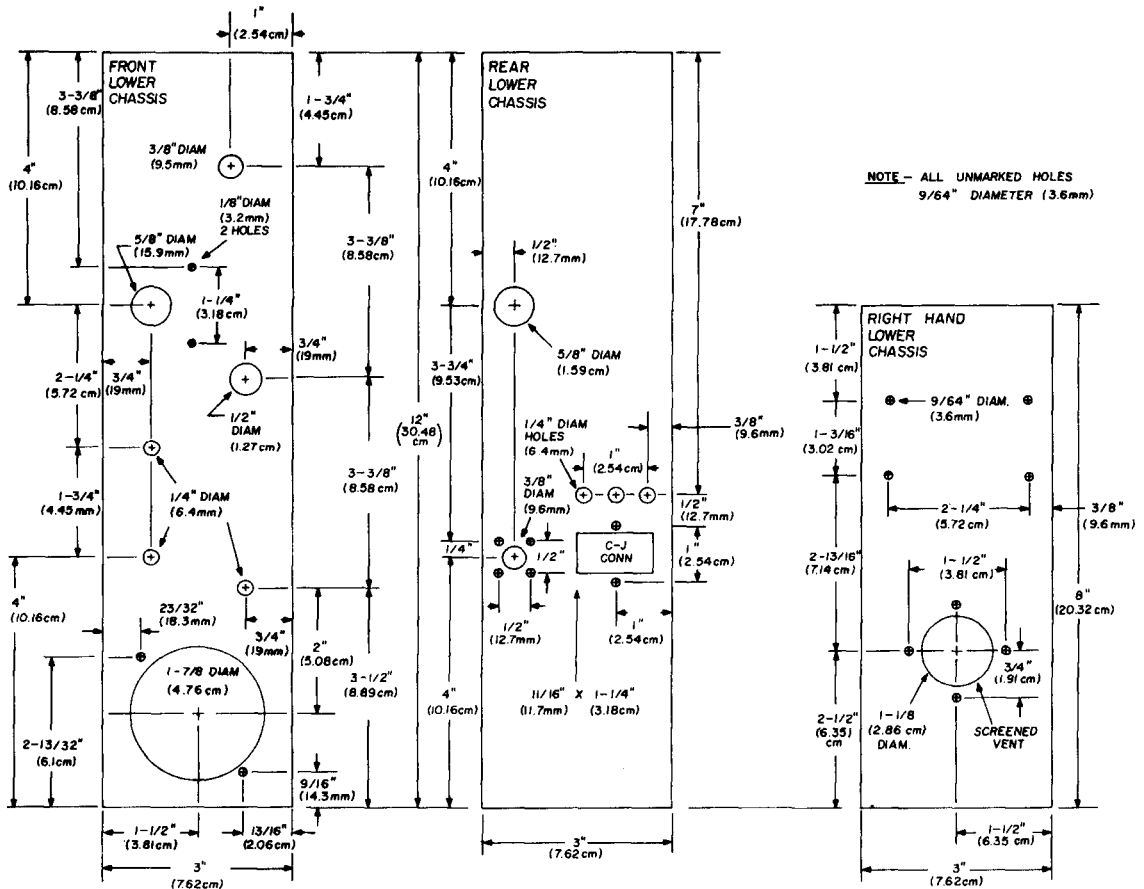


fig. 11. Layout of the front, rear, and right-hand side of the lower chassis (there are no holes in the left-hand side of the chassis). See fig. 7 for construction of the retaining ring for the screened vent. The meter hole in the front panel of the chassis is for a Calectro D109121 mA meter.

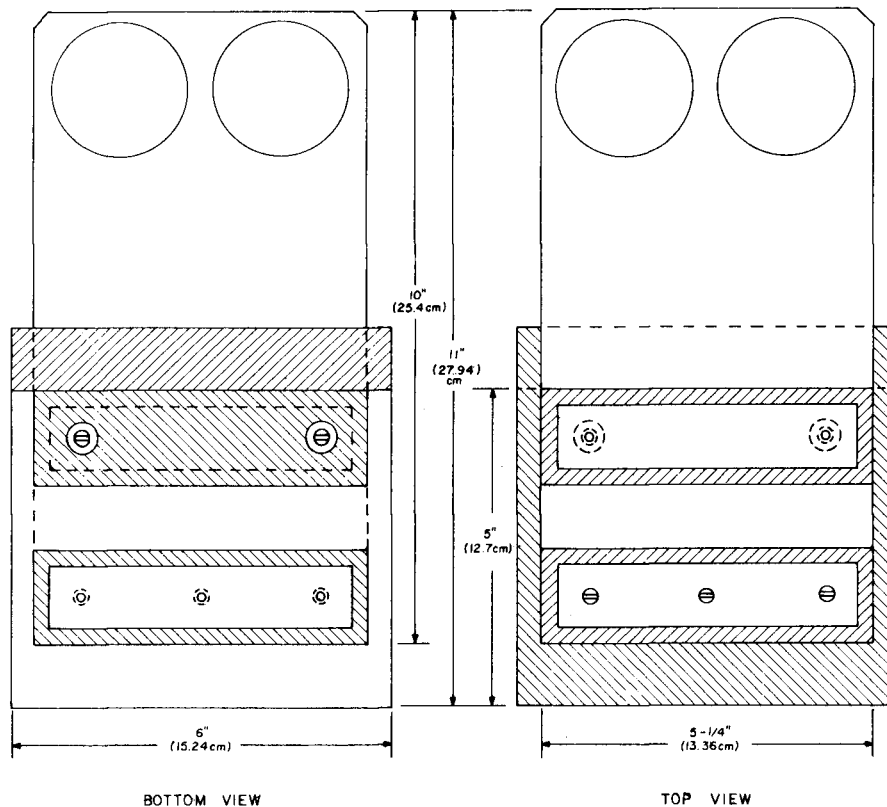
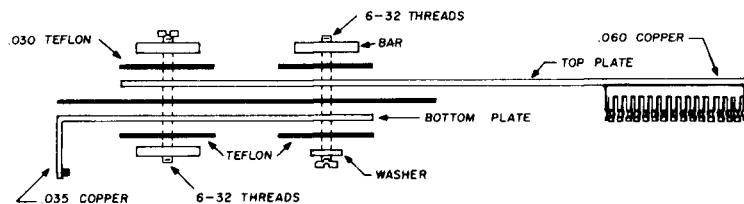


fig. 12. Construction of the plate line for the two-meter kilowatt. Material is .060 inch (1.5mm) copper (should be silver plated for best results). The shaded areas are 0.030-inch (0.8mm) Teflon sheet. Construction of the individual parts for the plate are shown in fig. 13.



A slot is sawed in the inner conductor of a type-N coaxial chassis connector to accept the output flapper (see fig. 2) which is soldered into the position shown. The two holes in the output flapper serve to mount a piece of Teflon underneath the flapper which prevents contact with the high voltage on the plate line. The dimensions of these items are shown in fig. 14.

Also prepare the short piece of 1/4-inch (6.5mm) diameter copper tubing for the rf sampling assembly and the piece of 1/4-inch (6.5mm) diameter Teflon

rod for the rf choke form (fig. 14). A copper strap for connecting the grid terminals together, and mounting details for the grid butterfly capacitors and their respective shafts are shown in fig. 15.\*

### assembly

Begin by mounting the parts and wiring the lower chassis. Connect all leads except the five leads from the grid box and the cable to the rf sampling assembly. Keep the wires formed into a bundle in the corner of the bottom of the chassis. Run in this manner, the wires will show only at the points of termination and can be laced into a cable with wire ties after they are all in place. Use a color scheme such as black for ground, green for filament, yellow for grid, and blue for screen.

\*Many parts and assemblies for this two-meter amplifier are available from ARCOS, Post Office Box 546, East Greenbush, New York 12061; telephone (518) 477-4990. A price list will be furnished upon receipt of a self-addressed, stamped envelope.



Turning now to the upper chassis, install the rf sampling assembly as shown in **fig. 17**. Also install the high-voltage feedthrough capacitor at this time. Fasten the upper and lower chassis together with 6-32 (M3.5) 1/4-inch (6.5mm) long screws.

Install the bulkhead BNC input connector and the five feedthrough capacitors on the grid box. Install the grid box and the sockets, making certain that

socket terminals 1 and 3 are opposite their respective feedthrough capacitors. Run the five wires from the grid box to the resistor assembly board and the RG-174/U coaxial cable to the rf sampling assembly. This completes the wiring of the lower chassis.

Mount the butterfly capacitors (see **fig. 15**). Note that there are two holes in the area where the grid tuning capacitor mounts. The capacitor assembly is

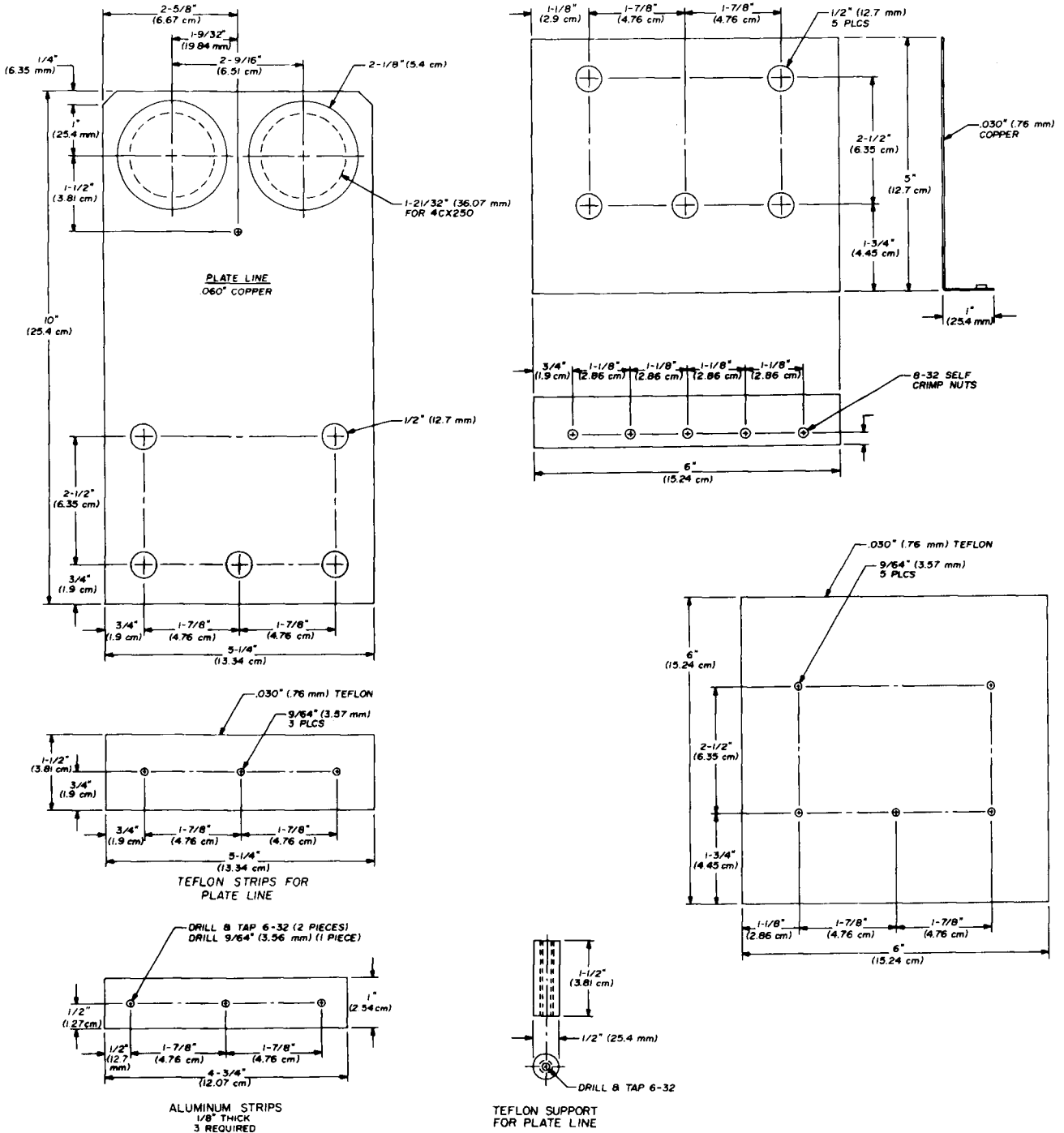


fig. 13. Plate line parts for the two-meter stripline kilowatt.

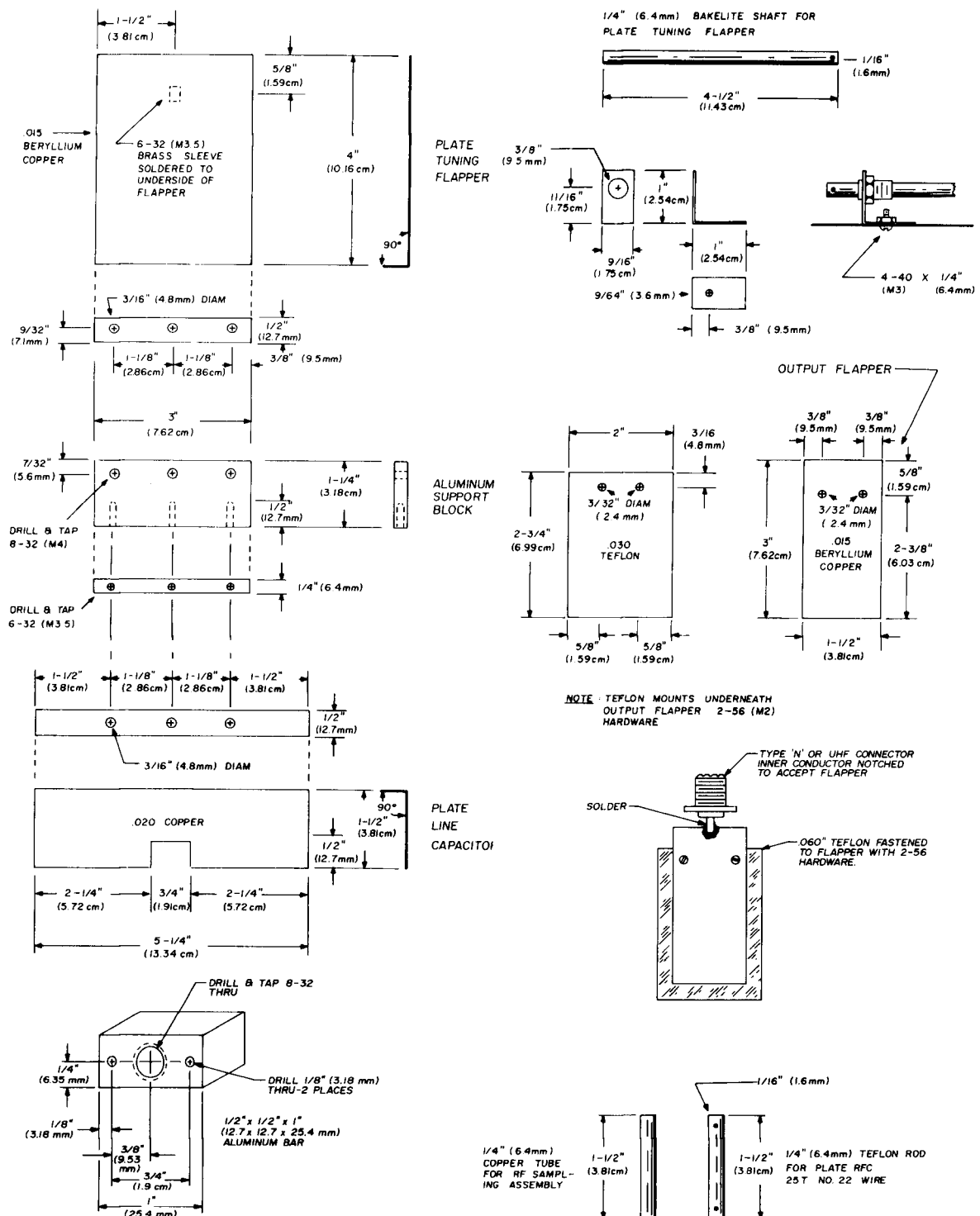


fig. 14. Construction of the plate line tuning and output flapper capacitors.

installed in the hole nearest the front of the chassis. Before mounting the tuning capacitor, put a spade bolt (with top cut off) in the rear hole. Tin the spade bolt. Now mount the capacitor assembly, adjusting the upper lug of the capacitor so it has some tension against the concave top of the spade bolt. Line up

the coupling shaft and tighten the nut on the spade bolt holding the capacitor. Make sure the capacitor turns smoothly.

Using a 200-watt iron, carefully solder the upper lug of the butterfly capacitor to the spade lug. This is a very important connection and becomes inacces-

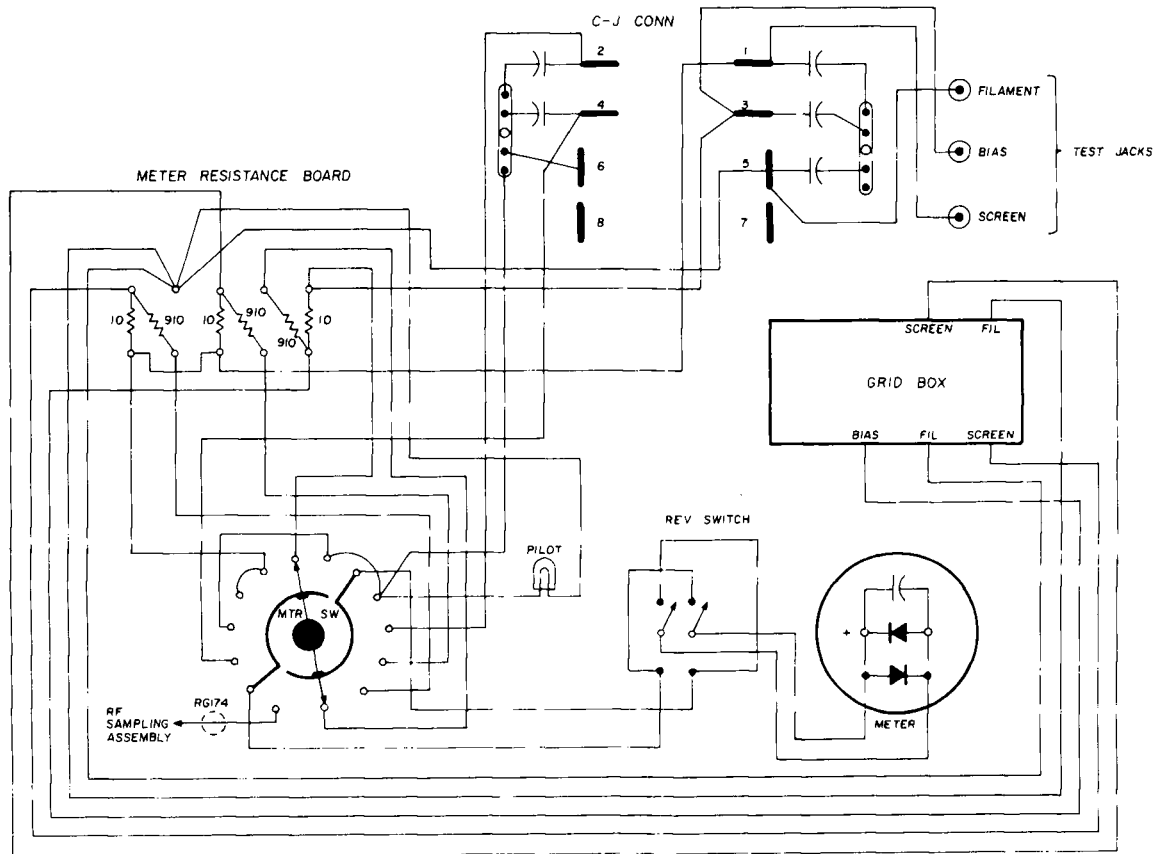


fig. 16. Wiring diagram for the two-meter kilowatt. Details of the rf sampling assembly are shown in fig. 17.

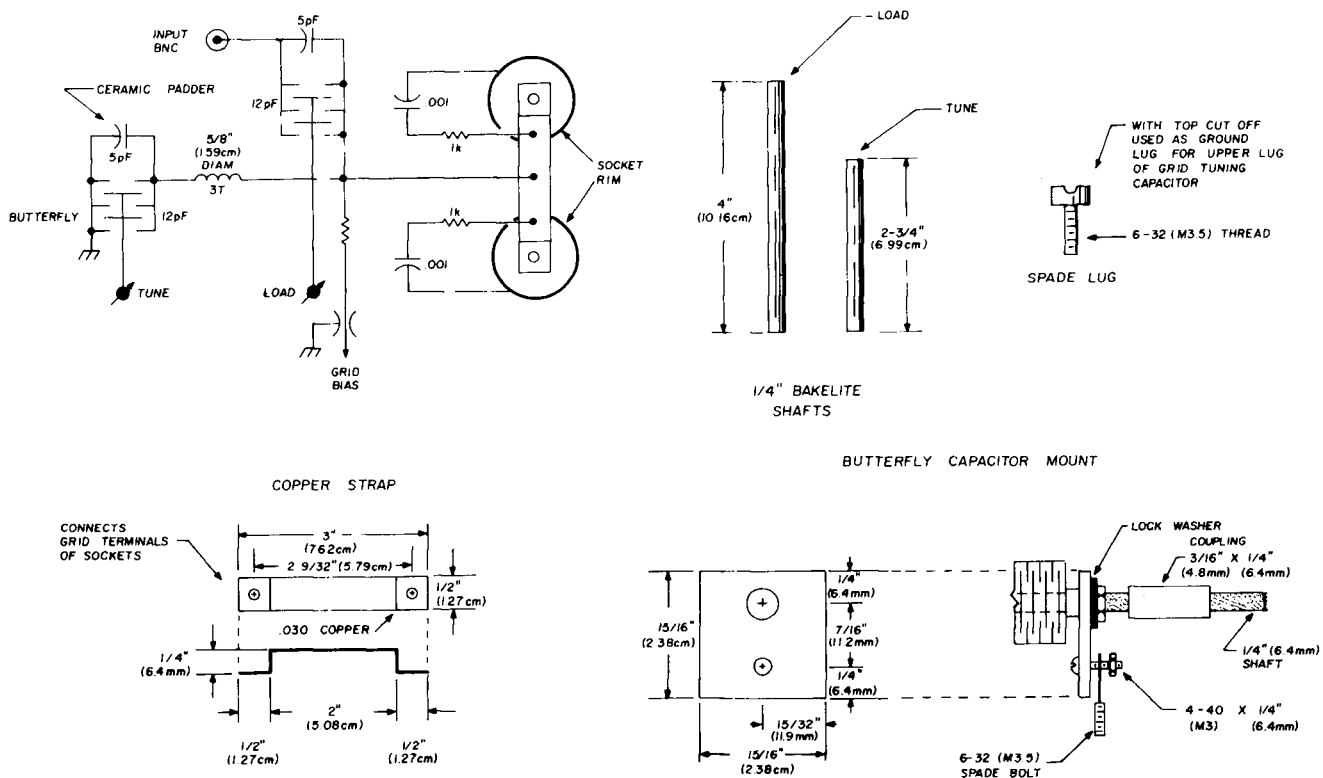


fig. 15. Grid circuit details for the two-meter stripline kilowatt.

sible later, so make sure it's a good solder joint. The other butterfly capacitor (loading) is not grounded so it is just a matter of making sure it operates freely. The balance of the grid circuit may now be installed.

Now mount the shaft bearing bracket and the bearing for the plate flapper tuning control. Install the plate tuning dial and the shaft. Make sure the shaft turns freely in the dial hub; this will facilitate placing the flapper tuning in the proper range. Install the Teflon support at the plate end of the plate line.

Assemble the two parts of the plate tuning capacitor to the aluminum support block and bolt the support block to the chassis. (The fishline control should be made fast to the plate tuning flapper before mounting the flapper assembly to the chassis, and the plate flapper positioned to about 1-3/4 inch (4.5cm) above the chassis.) Assemble the plate line (see fig. 12) and mount it to the chassis. Before tightening up the Teflon sandwich make sure that the large piece of Teflon between the plates is centered in the mounting holes.

Install the rf choke and the output flapper (which should be bent up to within 1/4 inch or 6.5mm of the top of the chassis). Position the rf sampling capacitor about 1/8 inch (3mm) away from the output flapper

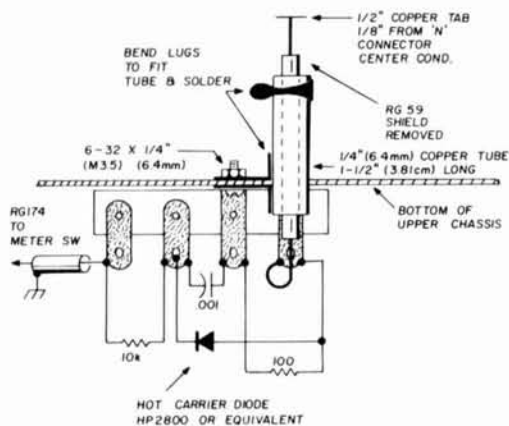
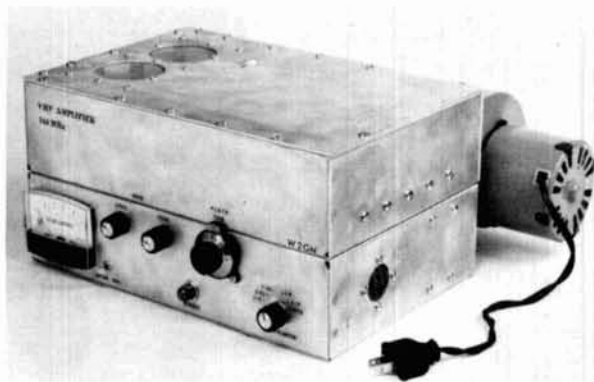


fig. 17. Side view of the rf sampling assembly. Adjust the position of the copper tab for approximately 0.6 mA on the meter at 600 watts output.

and type-N connector. Now assemble the top plate vent and the loading adjustment block. Fasten the top plate and bottom cover to complete the assembly of the amplifier.

### power supply

A power supply suitable for this amplifier is shown in fig. 21. The voltage-doubling circuit offers a 1000 volt source for the screen dropping resistor. Since no grid current will flow with linear operation, the bias supply can be the simple zener regulated type



The entire amplifier is assembled in two mated chassis.

shown. The protective features of this supply include a high voltage fuse and a diode protective resistor in the transformer secondary lead. A delay tube maintains cutoff bias until the tubes warm up. The filament voltage is 8 volts at the transformer winding and offers ample control of the voltage at the sockets with the adjustable 1/2-ohm series resistor.

This power supply will deliver 2000 volts at 500 mA with a no-load voltage of 2200 volts. At 1 ampere the output voltage drops to 1850 volts. With a transformer weight of 30 pounds (13kg) the total weight of the unit is only 45 pounds (20kg). This is quite a relief from the 80 to 100 pound (35-45kg) power supplies of the past.

### test and check out

An inexpensive dummy load for a high power vhf amplifier can be set up with 100 feet or 30 meters (or more) of RG-8/U with a Heath Antenna at the end. This will stand up on 144 MHz for about ten minutes or so at 600 watts output before the cooling oil in the dummy load starts to boil. The driver for this amplifier *must* have an adjustable output control unless it is capable of less than 5 watts maximum output because the amplifier is very power sensitive; it is not possible to adjust it properly if it is over-driven.

After connecting the amplifier to the power supply

table 1. Typical operation of the two-meter stripline kilowatt using 8930 ceramic power tetrodes (grid bias = -77 volts, screen supply = 409 volts, idling current = 100 mA).

drive power	grid current	screen 1 current	screen 2 current	power input	power output
2 W	0	-6 mA	-6 mA	800 W	200 W
4 W	0	-8 mA	-10 mA	1000 W	400 W
8 W	-1 mA	+1 mA	+2 mA	1360 W	830 W

Plate voltage during these tests ranged from 2100 volts at 200 mA idling current, to 1700 volts at 830 watts output.

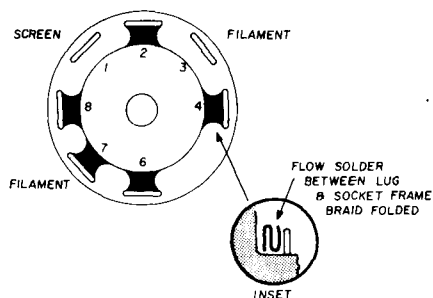


fig. 18. Grounding for the Eimac 620A socket. The 630A socket requires this modification only on terminal 7.

and making the usual checks of filament voltage, bias, screen voltage, and blower operation, establish an idling current of about 150 mA for initial tests. Applying a watt or so of excitation, adjust the grid circuit controls for a rise in plate 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 until the dial is mid-range for your chosen operating frequency.

The next step is to increase drive until the amplifier is at about 400 watts or so output with the loading screw about 1/8 inch (3mm) above the top plate. Now the grid circuit controls should be set for minimum swr toward the driving source. The reverse power will drop to an unreadable value. Once grid tuning is established, adjust the load control on the top of the amplifier for a compromise between maximum output and minimum plate current at an output level of 600 watts. Keep the loading on the heavy side.

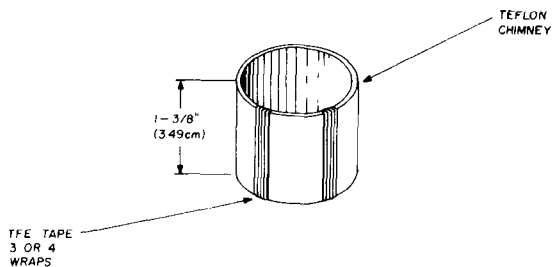


fig. 20. Tube chimneys for the two-meter kilowatt are made from 0.010-inch (0.25mm) Teflon, 1-3/8-inches (35mm) wide. Roll the Teflon for a tight fit in the top vent plate; secure with 1/4-inch (6.5mm) Teflon tape wrapped vertically around the roll. 12 inches (30cm) of Teflon is required for 4CX250s; 24 inches (60cm) is required for 8390s.

Once the proper setting for the load control is found, there should be no reason to change it unless you wish to operate the amplifier at a lower power level or with different voltages. Having set up the initial operating conditions, further tests and adjustments can be made for best linearity.

Check for blower operation each time the amplifier is turned on. If the air supply should fail, the solder on the plate line will melt and the finger stock usually springs out, grounding the plate supply and operating the breaker within about 30 seconds. The tubes survive but it is a messy job to repair the plate line.

## safety

Like any other piece of radio equipment operating at high voltages, this innocent looking aluminum box can be a killer — it is absolutely unforgiving of careless moves. Just to repeat the safety rules, disconnect the B+ line before taking covers off. Don't operate the amplifier with the covers off. If you must take a reading inside with the cover off, disconnect the power, connect the meter with well-insulated leads, stand back and take the reading *after* you have put the power plug back in. One hand in the pocket while you are testing is the time-tested rule

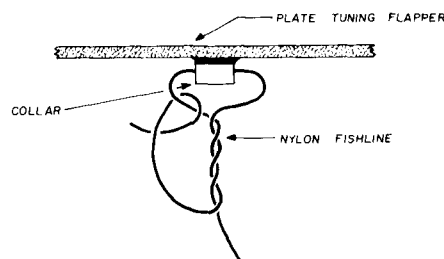


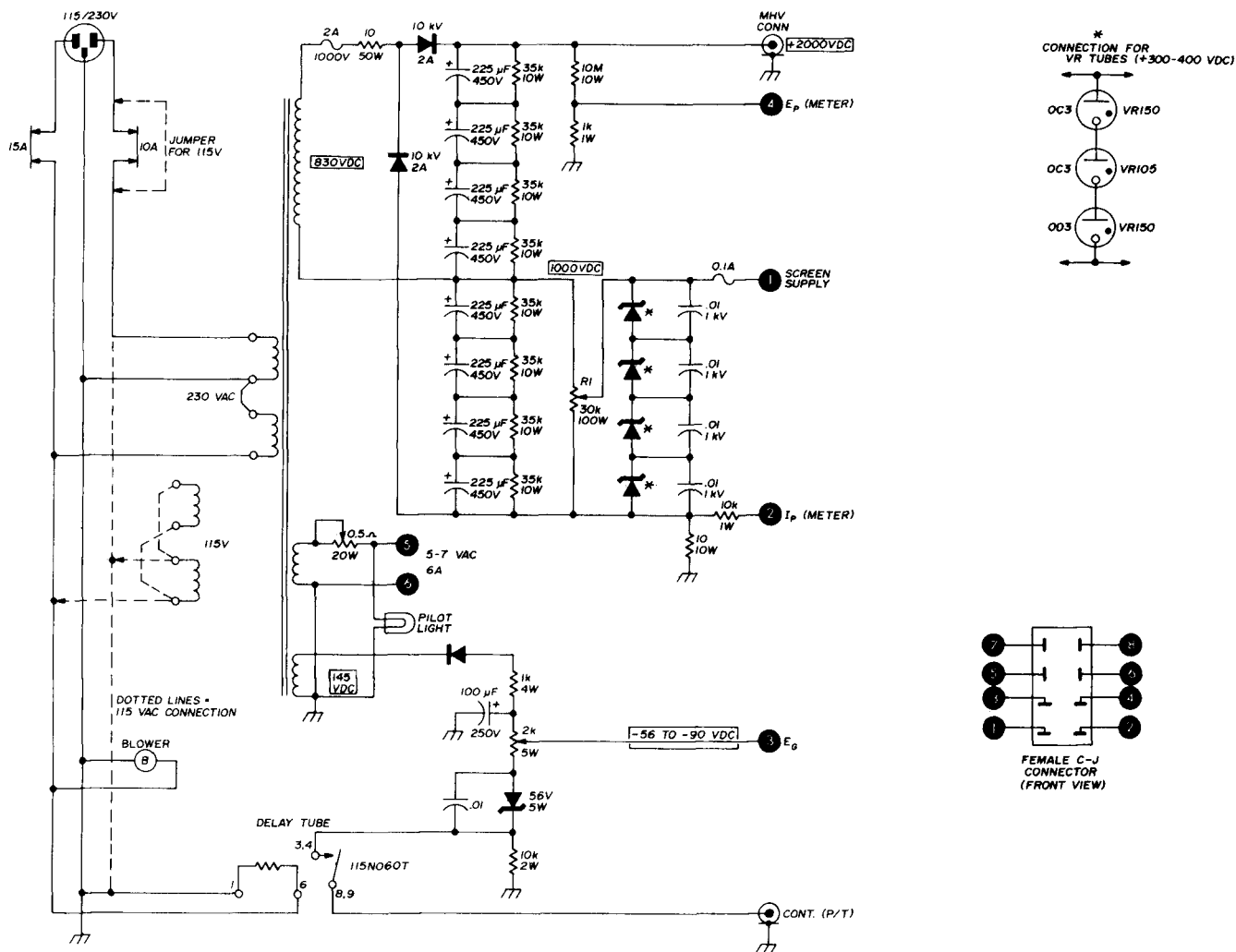
fig. 19. Knot for fastening nylon fishline to the collar on the plate tuning flapper, and to the tuning shaft. Pull the knot tight to prevent unraveling.

for staying alive. Another precaution in dealing with this level of rf power is to stay out of the path of the rf radiated from the antenna.

## operation

To adjust the amplifier for linear operation, perhaps the simplest setup is to use a directional wattmeter at both the input and the output. Set the idling current at 200 mA. Using the test values of 2, 4, and 8 watts drive, (see table 1) adjust the loading control and the plate tuning control for best linearity at the lowest value of peak plate current. When the proper adjustment is reached the power output will be approximately 200, 400, and 800 watts, respectively. These tests can be made at the bench and the adjustments will be valid for a 50-ohm antenna system with low swr.

For CW operation the bias can be set higher for an idling current of 100 mA or less, and the loading control and plate tuning optimized for best output at the least plate current. At 1 kilowatt input, 600 watts output is the objective. About 5 watts drive is required.



Voltage: no load, 2300 V; 500 mA, 2000 V; 1 A, 1900 V  
 Bias: -55 to -95 volts (no grid current)

Standby bias: -150 volts (P/T contacts open)  
 Weight: 45 pounds (20 kg)

fig. 21. Recommended power supply for the two-meter stripline kilowatt is rated at 1 kilowatt continuous duty, 2 kW PEP. Adjust R1 (30k, 100W) for 500 volts at the screen terminal with the zener diodes (or VR tubes) disconnected. Readings in boxes were taken at 1 kilowatt output.

The temperature of the exhaust ports can be checked by setting a candy thermometer on top of the amplifier in a nearly vertical position (put a pair of stiff wire legs on it). This does not give a reading of the temperatures at the tube seals, but is a relative indicator. Based on many hours of testing these amplifiers, a suggested limit for the exhaust air temperature read in this manner is 200°F (95°C). The tubes will not fail under continuous operation at this temperature limit. The 8930s will stay well within this level but the 4CX250s will tend to exceed it.

The filament voltage for the two-meter amplifier has been set at 6 volts on the assumption that the effects requiring 5.5 volts on the filaments at 432 MHz are not as significant at 144 MHz.

The grid current should be at zero or barely

negative for AB1 operation. Screen current will go negative (read with the meter reverse switch) to 10 mA more or less. It may become barely positive on modulation peaks. The screen voltage is regulated at 350 to 400 volts.

Once you have this amplifier on the air, properly adjusted, you will find that no further attention is required except perhaps an occasional tweaking of the plate tuning to match the antenna.

### references

1. Richard T. Knadle, Jr., K2RIW, "A Stripline Kilowatt for 432 MHz," *QST*, April, 1972, page 49; May, 1972, page 59.
2. Steve Gross, W9QJL, "A Parallel 4CX250B Amplifier for 144 MHz," *QST*, May, 1975, page 11.

ham radio



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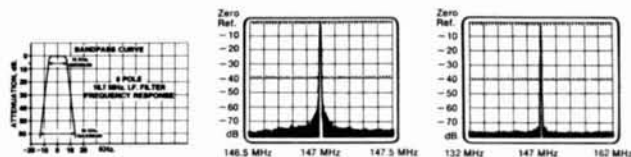
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# how to improve the accuracy of your frequency counter

Circuit details for  
a phased-lock time base  
and sensitive  
wideband probe  
that will improve  
the accuracy and usefulness  
of your frequency counter

**Most electronic equipment** requires a warmup period to allow them to stabilize and become ready for use, and the solid-state frequency counter is no exception; many instruction manuals caution that no critical frequency measurements should be made until the counter has warmed up for 30 minutes or more. If you have an accurate frequency standard, you can use the output of this standard to eliminate any warmup drift and to greatly improve the accuracy of your frequency measurements.

Some years ago, being interested in accurate frequency measurement, I built an oven mounted, tem-

perature controlled 100 kHz crystal oscillator, divided the frequency to 60 Hz, and used the amplified output to run a synchronous electric clock with a sweep second hand. I can set this clock to the exact time as broadcast by WWV and, with a little care, the crystal frequency can be adjusted so the clock keeps exact time. If the clock stays within one second of WWV time for a 12-day period, this means that the 100-kHz oscillator is accurate to one part in  $10^6$ ; if it can be held to one second in 4 months, this represents an accuracy of one part in  $10^7$ , or a little more than one cycle per second in 14 million. This accuracy can be easily translated to the time-base oscillator in your frequency counter.

The construction details of the 100-kHz standard

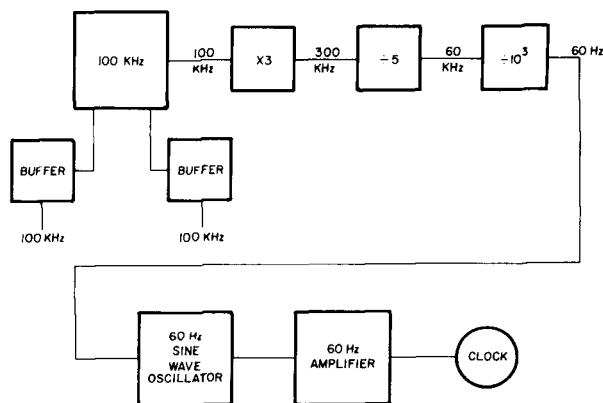


fig. 1. Block diagram of the 100-kHz frequency standard used by W1RF to drive a clock. This same basic circuit can be used to provide excellent time-base stability when used in a frequency counter.

By Clifford A. Harvey, W1RF, Box 88, Sturbridge, Massachusetts 01566

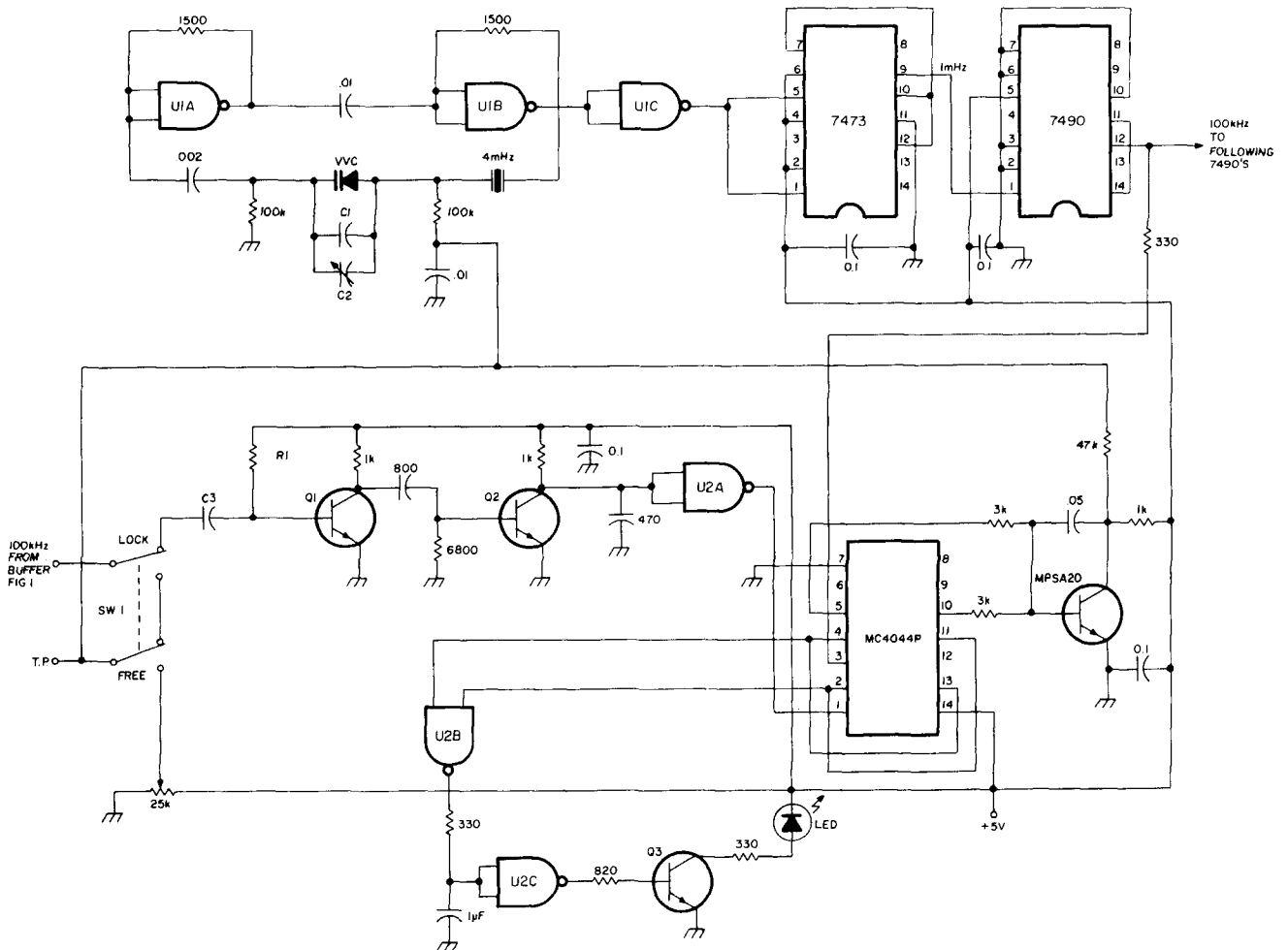
are beyond the scope of this article, but the block diagram of **fig. 1** shows the basic idea. The schematic of the crystal oscillator and associated count-down circuitry in my counter is shown in **fig. 2**. I used a 4-MHz crystal in the oscillator because I had a number of old 75-meter phoneband crystals on hand, and it was a simple matter, with a little careful grinding to move one up to 4 MHz. With a different division ratio, you can use a different frequency crystal.

The total capacitance in series with the crystal, necessary for setting it precisely to 4 MHz, consists of a fixed capacitor in parallel with a variable capacitor in parallel with a voltage variable capacitor, a varicap diode, or in my case, a silicon rectifier diode. The control voltage for this diode is developed by a Motorola MC4044P phase frequency detector and associated amplifier and filter. As shown, the 4-MHz signal is divided by four in a 7473 IC, and further divided by 10 in a 7490; the output is at 100 kHz. Part of this output is taken off through a 330-ohm resistor

and the main output being further divided by additional 7490s (down to 1 Hz in my counter).

The output from the 100-kHz buffer is less than 0.5 volt, so I had to provide additional gain with Q1 so U2A would saturate properly. There are hundreds of transistor types which can be used for Q1, Q2, and Q3; the ones I used came from surplus board assemblies so the type numbers are unknown.

A good way to select proper component values is to put an oscilloscope probe on pin 1 of the MC4044P and adjust C3 and R1 for a symmetrical square wave with clean leading and trailing edges. Capacitor C3 in my unit is 68 pF; R1 is 300k. These values will vary, depending on the types of NPN transistors you use. The 470-pF capacitor from the collector of Q2 to ground was required in my circuit to remove a high-frequency oscillation appearing on the leading edge of the square wave. Gates U2B, U2C, and transistor Q3 form a lock indicator circuit; when the 4-MHz crystal oscillator is locked to the 100-kHz standard,



**fig. 2.** Circuit diagram of the phase-locked frequency standard. The author used a 4-MHz crystal, but other frequencies are possible if the division ratio is changed accordingly. The oscillator circuit is phased locked to the output of a high-stability 100-kHz frequency standard (see fig. 1). U1 and U2 are SN7400s.

the LED will light. Don't forget that the LED is a diode and will light only when properly connected into the circuit.

Switch S1 is helpful in initially setting up the circuit, and allows the counter to be used for normal accuracy readout anytime it is not necessary or desirable to have it phased locked to the frequency standard. With S1 in the *free* position and a vtvm connected to test point TP, set the 25k pot so the meter reads about 3 volts. With C2 set at about the mid-capacitance position, select a value for C1 such

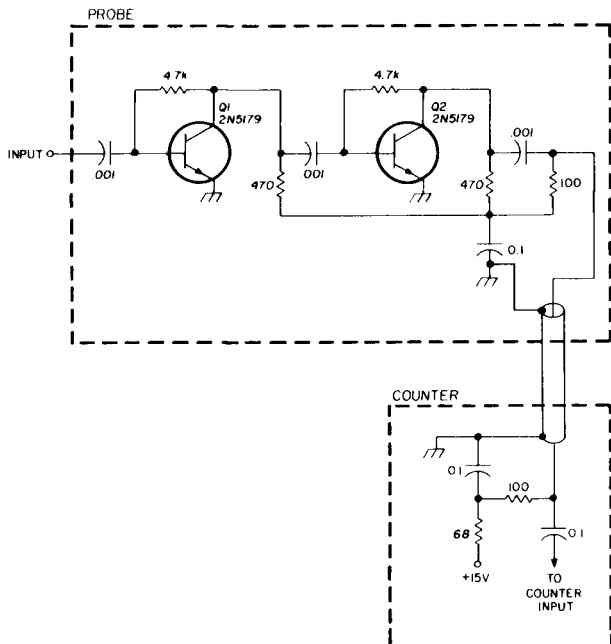


fig. 3. Rf probe for frequency counters which greatly increases sensitivity at the higher frequencies. Power for the probe is provided through the coaxial input cable.

that the crystal oscillator is very nearly on the correct frequency. In my circuit C2 is a 5-35 pF trimmer set for about 20 pF, and C1 is 20 pF.

With the 100-kHz standard connected and S1 in the *lock* position, the LED should light and the vtvm should read somewhere between 1 and 5 volts. C2 should now be readjusted for a vtvm reading of about 3 volts. If the counter is now connected to read out the frequency of a stable external oscillator, note that varying C2 will not change the readout but will only vary the control voltage. If the LED does not light and no lock is obtained regardless of the setting of C2, the vtvm will probably read 5 volts; this indicates that the crystal is too far off frequency to be brought in by the varicaps, or the varicaps do not have enough range.

In my counter, running free and measuring a 5-MHz external oscillator, varying the 25k pot from zero to 5 volts changes the readout from 4 999 980 to

5 000 184 Hz. Using a silicon power diode as a varicap is somewhat questionable as some diodes have much greater capacitance range than others of the same type. If you run into trouble, a Motorola MV-series varicap should be tried (such as MV2110).

With the time-base oscillator locked to a good frequency standard you can be sure that both the accuracy and the stability of your counter is greatly improved. Some years ago, after completing a similar phase-locked counter, I set up the counter to read out the frequency of my transmitter exciter. One evening I tuned in on the ARRL Frequency Measuring Test. Due to skip conditions I could hear only two of the transmitted frequencies, but it was a simple matter to zero beat W1AW with my exciter and read out the frequencies. When the actual transmitted frequencies were published a month or two later, I was pleased to note that of the two readings I submitted, one was precisely as published and the other was 1 Hz off! If you want to get to the top of the list in a Frequency Measuring Test, all you need is a phase-locked oscillator in your counter, and a little luck!

Another useful accessory to my counter is a probe based on the broadband amplifier described previously in *ham radio*.<sup>1</sup> One trouble you run into when measuring high frequency signal in low-power circuits is the difficulty of obtaining sufficient voltage to actuate the counter. If you connect the circuit under test to the counter with coaxial cable, capacitance of two or three feet (1 meter) of cable can produce a relatively low impedance, and an unwanted load. The broadband amplifier appeared to be a solution to the problem, but I disliked hooking up the amplifier and associated power supply every time I wanted to use it so I modified it slightly and built it into a probe. The simple modification shown in fig. 3 allows the amplifier to be powered over the same coax that carries the amplified input.

If you have 15 volts at about 20 mA available in your counter to power the amplifier, the probe is very convenient to use. If you are handy with a lathe the probe can be made to look quite professional; mine is 3/4 inch (1.9cm) in diameter and 5 inches (12.7cm) long. With the probe I need only 5 millivolts at 40 MHz, 2 millivolts at 2 MHz to operate my counter. Since the center conductor of the coax connector on the counter is carrying 15 volts, be sure to use an external isolating capacitor if a direct connection is made to the circuit under test.

## reference

1. Randall Rhea, WB4KSS, "General-Purpose Wideband RF Amplifier," *ham radio*, April, 1975, page 58.

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# syllabic vox system

## for the Collins S-Line

Full break-in capability  
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using an array  
of switching transistors

**Rapid, silent switching** of transmitter-receiver functions will always improve a station's "on-the-air" effectiveness. By eliminating the slow dynamic operation of mechanical relays, caused in part by conventional vox systems, the operator may then enjoy a higher quality of communications. There never will be a situation of *doubling* with another station because you can be interrupted at any time with the help of this high-speed switching network.

Recently Ray Hitchcock, W6RM,<sup>1</sup> updated my earlier vox system<sup>2</sup> by using logic circuitry which offered many advantages over the older style. This article concerns itself with the conversion of his syllabic vox for the Drake equipment to the Collins S-Line. When he and I are using ssb, the conversation is essentially the same as using the telephone. If a visiting operator were to use the station, he could use the equipment in a normal fashion and not be aware of any modifications except that he would be hearing between his transmitted syllables and code elements. There are no external devices which require adjustment nor is defacement of the equipment necessary. The 5 Vdc power supply (fig. 1), is housed in the speaker cabinet. The original vox controls (*vox gain* and *anti-vox*) perform the same basic functions as previously. The *vox delay* circuit is rendered inoperative by this modification.

Unless two separate antennas are used, the most critical portion of the syllabic vox system is at the antenna change-over location. W6RM has refined the diode antenna switch into a well designed, trouble-free device and suggests the appropriate name, "Diode-Biased Antenna Gate." The actual switching takes place 200  $\mu$ s before the rf appears and is accomplished by forward biasing the diode with a dc voltage. No rf rectification occurs as in former T/R switches.

Directions for initial setup and the logic theory of the system are given in W6RM's paper; you are urged to consult this excellent article. One serious problem arose with the 32S-3 conversion: an intolerable audio oscillation occurred with only a moderate degree of vox gain. The vox was thrown into activation making correction of this defect mandatory.

You will note differences around the LM3900 (U1A), see fig. 2, as compared to the schematic diagram in W6RM's article. The input to the LM3900 comprises a highpass filter, and the 74122 (U2) delays vox activation for 2.1 milliseconds.

The syllabic vox amounts to a very high speed vox without the use of relays. In the original relay circuitry each set of contacts opens and closes a single circuit. In the new vox, each set of contacts has been replaced by a switching transistor. The circuits are coordinated so that each syllable or code element controls the transmitter-receiver functions. All switching is done in the proper sequence.

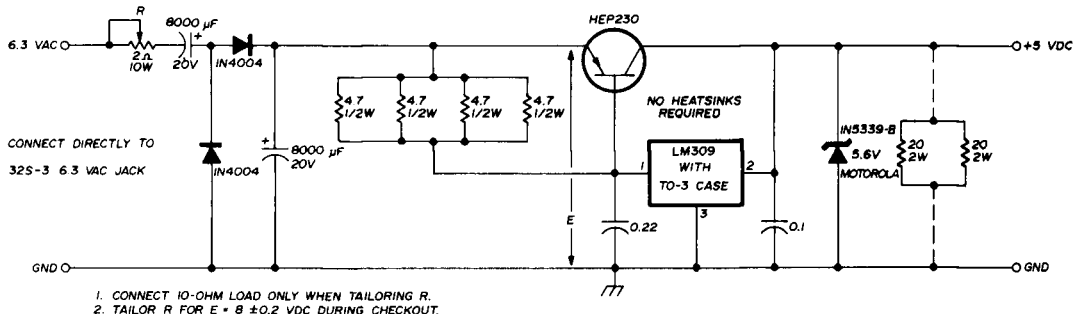
### construction

The technique that I followed was point-to-point hand wiring with number 22 AWG (0.6mm) tinned wire. Teflon sleeving is used to cover this wire where required. To facilitate the connections to the innumerable power and ground points, the periphery of the usable portion of the board is enclosed by two wire loops, each terminating at the rear of the board. A solder lug is bolted to the board at each termination point (see photograph). Solder lugs are bolted to

By H. Rommel Hildreth, MD, W0IP, 15022  
Claymoor Court, Chesterfield, Missouri 63017

each point where interconnecting cables are attached. The 6.3 Vac jack, at the left rear, supplies the power to the 5 Vdc source (the spare jack may be used for the 5 volt input).

For the most part, the general layout follows that of the schematic diagram. The 2-mH choke is fastened to the rear of the bfo using one of the already available screws.



1. CONNECT 10-ohm LOAD ONLY WHEN TAILORING R.  
2. TAILOR R FOR E = 8 ± 0.2 VDC DURING CHECKOUT.

fig. 1. Power supply for the integrated circuits. The 6.3 Vac is obtained from the connector on the rear panel of the transmitter.

A second circuit board was mounted at the opposite end of the chassis as shown in the photograph. It holds the high-voltage transistors and is convenient to the high-voltage chassis connections. The 100k resistor becomes so hot that it must be elevated above the board for ventilation. All other components are barely warm to the touch after a prolonged operating period.

### diode-biased antenna gate

A metal box measuring 1-1/2 x 2 x 2-3/4 inches (38x51x70mm) houses the gate. Two coax fittings are mounted at the ends and two phono jacks are on top of the box. The coax fittings are connected by RG-8/U coaxial cable cut 2 inches (51mm) longer than necessary. The vinyl is removed, leaving the center 1 inch (25mm) of the braid unexposed. The wire sheathing is skinned back over the center and the wire is cut to fit into the notches after removing a bit of the foam, center insulation. Solder the wire. At one end solder one terminal of the 50 pF capacitor after covering the wire with Teflon. Then cover both bare ends with tape so that when the shielding is brought forward it may be soldered to lugs in the screws holding the fittings and thus provide proper rf shielding. The remaining parts for the gate are easily placed within the box.

The Collins coax fitting did not lend itself well to rigid mounting, so the shortest possible length of coax was used. The entire length, including fittings, was only 4 inches (100mm).

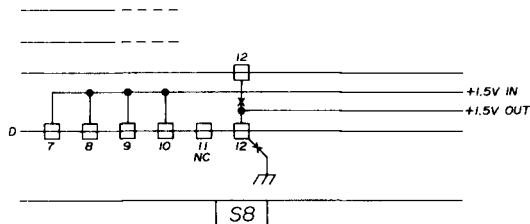
The two gates shown by W6RM are to be used when the linear amplifier is placed at a distance from the exciter. Note that the relay in each box

automatically places one or the other of the gates into the circuit. The relays play no part in the rf operation.

### 32S-3 modifications

Upon inspection of the chassis when placed upside down, the vox relay is at the left center. The drawing (fig. 3) will help identify the contacts of the

relay. Attached to the front panel, in front of this relay, is the *emission* switch (S8). Wafer D is the wafer closest to the front panel. At its top (when upside down) is terminal 12 of wafer D with a connection to terminal 12 of wafer C. Terminal 11 is unused. Terminals 10, 9, 8 and 7 continue to the left.



1. At section 2 of the vox relay disconnect the lead to the antenna relay from the normally open, non-movable contact.
2. At section 4 of the vox relay disconnect the lead to ground at the movable contact (later this lead will be used to ground the several cable shields which converge in this region). Next, connect the circuit board extension lead labelled "Mute Line" to the movable contact.
3. At section 3 of the vox relay connect the circuit board extension lead labelled "Mixer Hold" to the movable contact.
4. At section 1 of the vox relay connect the circuit board extension lead labelled "+ 270 V" (non-movable contact).
5. At the movable contact of section 1 of the relay connect the circuit board extension lead labelled "+ 275 V".



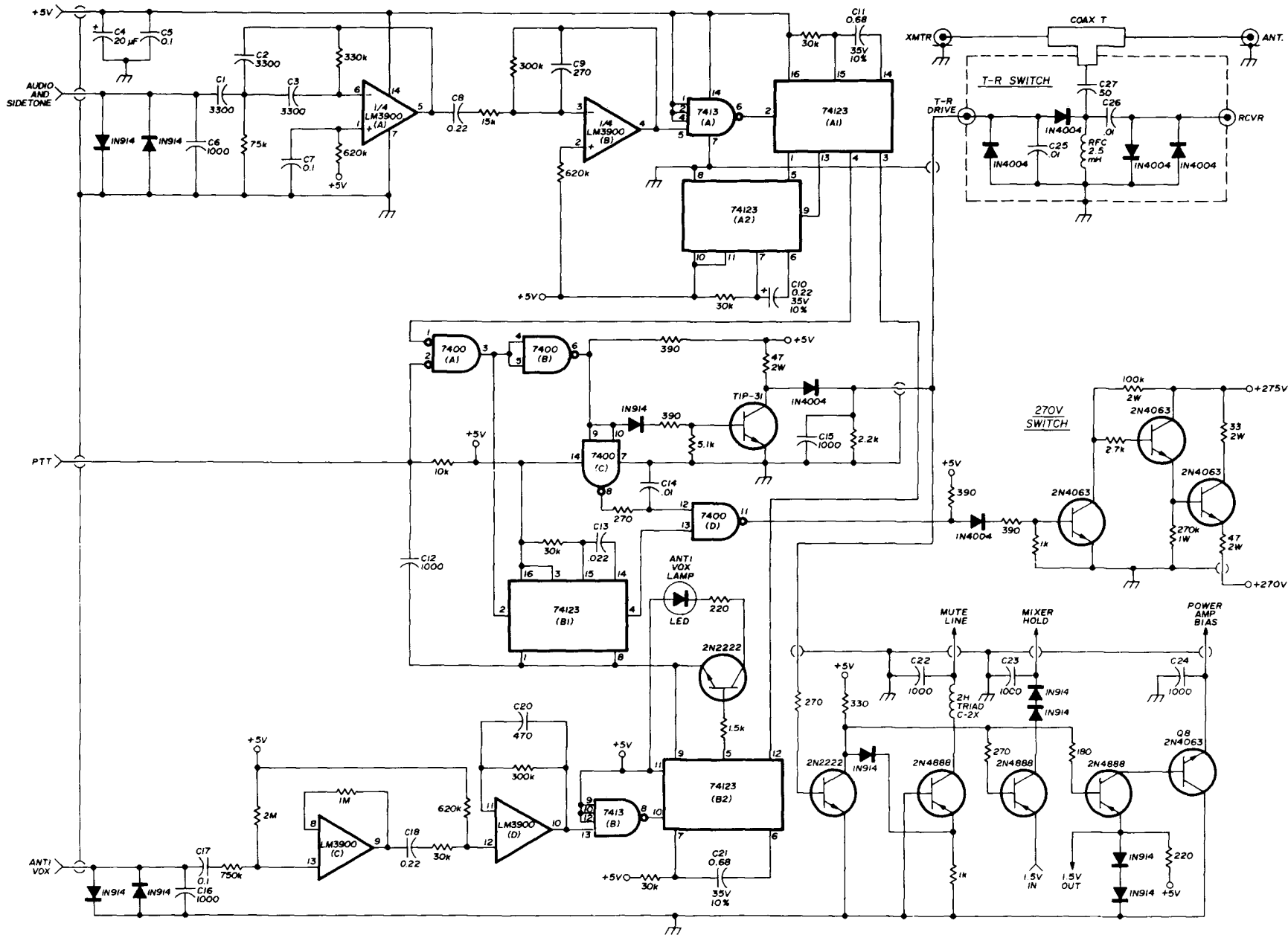


fig. 2. Schematic diagram of the control circuitry for the syllabic vox system. CR4-CR7, CR9, and CR10 are 1N4004 or equivalent diodes; all others are 1N914 or equivalent. The rf choke is a 2.5 mH, 200 mA transmitting type. All resistors are 1/2 watt, 10 per cent, unless otherwise specified.

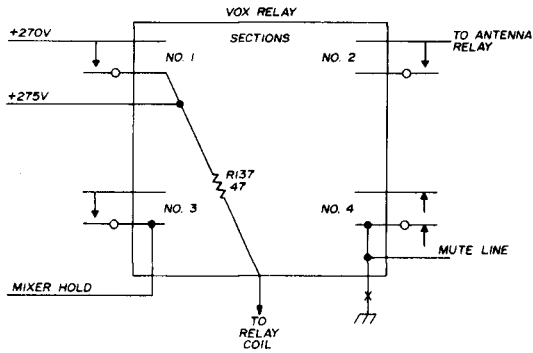


fig. 3. View of the vox relay in the transmitter with the chassis upside down.

6. One end of the 47-ohm, 2-watt resistor is connected to a relay coil terminal. The opposite end of the resistor is attached to the movable contact of section 1.

7. Remove the knobs from the vox and anti-vox controls. Also, remove the nuts so that the terminals of these potentiometers may be reached.

8. At the movable contact of the PTT switch (S10), connect the circuit board extension lead labelled "PTT", (fig. 4A).

9. At the wiper of vox gain control R74, connect the circuit board extension lead labelled "Audio and Sidetone".

10. At the wiper of anti-vox control, R85, connect the circuit board extension lead labelled "Anti-Vox".

11. Remove tubes V10, V14, and V12 since the high frequency oscillator of the receiver is ordinarily not used. This reduces the load on the power transformer.

12. Disconnect the plate lead to terminal 1 of V11.

13. Disconnect the lower end of R87 (470 ohms) from the PTT line. This resistor is near S8.

14. Disconnect the lead from the two parallel 2-watt resistors, R89 and R112. These two are also near S8, and alongside R87.

15. At S8, disconnect the lead between terminal 12 wafer D and ground. Also open the lead between terminals 12 of wafers D and C, (fig. 4B).

16. At terminal 12 of wafer D connect a circuit board extension lead labelled "+ 1.5 V Out".

17. At the bus wire connecting terminals 7, 8, 9 and 10, wafer D, connect a circuit board extension lead labelled "+ 1.5 V In".

18. Disconnect the lead to the antenna relay jack. Connect a circuit board extension lead labelled "Power Amplifier Bias" to the antenna relay jack.

19. At the vox relay, ground the several sheaths earlier mentioned. Use the ground lead already disconnected from the "Mute Contact".

20. Remove the cover of the rf section. The five screws are removed to reach the antenna relay contacts.

21. Short the antenna relay rf contacts with a short piece of wire (the rf side is near the pi network).

22. Disconnect the lead attached to the jack marked "Receive Antenna". This lead is now the rf output.

### 30L-1 modifications

The Collins 30L-1 linear amplifier requires a slight

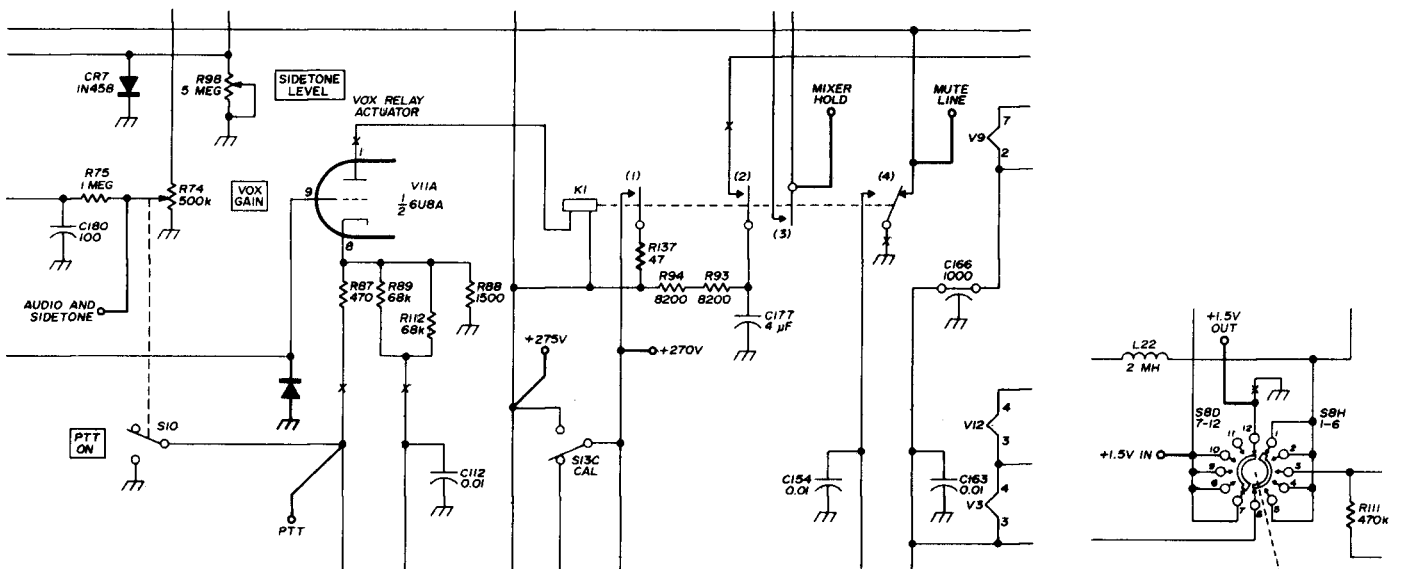


fig. 4. Circuit modifications for the 32S-3 transmitter which will permit instantaneous vox operation.

modification in the grid bias stage. Referring to fig. 5, the changes in the standard wiring diagram are indicated. The only components to be added to this area are as follows: 22k, 2-watt resistor; 1N4004 diode; and the 200  $\mu$ F, 200-volt electrolytic capacitor. Be sure to observe the polarity of the diode connections. The revised circuit now uses a switching transistor to control cut-off during receive. The bias line is grounded through Q8 (2N4063) in accordance with transmitted voice syllables or code elements. The relay in the 30L-1 (K1) is now wired to be continuous-

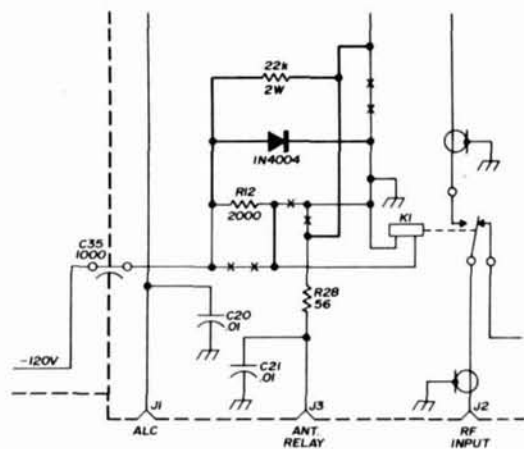


fig. 5. The bias circuit in the Collins 30L-1 amplifier requires changes to interface with the transistor in the control circuitry. The 200  $\mu$ F capacitor can be epoxied to the chassis.

ly energized; this relay is controlled with the main power switch. The large 200  $\mu$ F capacitor is held in place with epoxy cement in the power compartment.

Some of the newer amplifiers have their grid bias lines wired in a similar fashion. The purpose of the modification is to maintain the tubes at cut-off bias during reception. The duty cycle during CW or ssb is short so the tubes operate at a much cooler level.

## results

For the past nine years I have been operating with equipment using no relays, in both the CW and ssb modes. The many advantages of high-speed, silent switching are numerous and add greatly to the pleasure of operating. The Collins conversion has added to that pleasure and has been most gratifying. My sincerest thanks are extended to W6RM, for without his guidance, the conversion would never have been accomplished.

## references

1. R. W. Hitchcock, W6RM, "Syllabic Vox System for the Drake Equipment," *ham radio*, August, 1976, page 24.
2. H. R. Hildreth, W0IP, "An Experimental All-Electronic Vox System for SSB," *QST*, March, 1968, page 36; "Instantaneous Voice Interruption," *QST*, October, 1968, page 40; "More on Instant Voice Interruption," *QST*, June, 1972, page 19.

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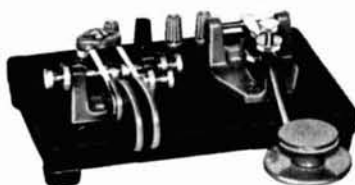
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# hybrid-tee mixer for 10 GHz

How to use  
a hybrid-T  
waveguide junction  
to build a  
balanced mixer  
for 10-GHz receivers

The majority of amateur microwave receivers use front-ends which consist of a local oscillator coupled to a mixer diode. Radio-frequency amplifiers are available for the microwave frequencies but they are usually too expensive for amateur use. Receiver performance is therefore limited by the noise figure of the mixer, and to some extent by the following i-f amplifier, so any method which can improve mixer performance is well worth it.

At present two mixer types are prevalent among amateurs working at 10 GHz. The first is the self-oscillating mixer<sup>1</sup> (usually a Gunn device) which has the advantage of simplicity; the second is the mixer

diode with a separate local oscillator. In the latter system optimum mixer performance can be obtained by adjusting local-oscillator injection and mixer impedance matching.

Some improvement in mixer performance can be achieved by using a balanced mixer. The design described in this article offers some improvement in mixer performance, and is simple to build.

## design

The hybrid-T waveguide junction shown in **fig. 1** has the following properties: power fed into port 3 will divide equally and in phase between ports 1 and 2; no power will appear at port 4. Power fed into port 4 will also divide equally between ports 1 and 2, but out of phase. Therefore, a balanced mixer may be constructed by placing mixer diodes at ports 1 and 2, injecting local oscillator power via port 3, and connecting the antenna to port 4. This arrangement has the advantage over the single-ended mixer in that the a-m noise sidebands associated with the local oscillator are cancelled out in the mixing process. In the single-ended mixer the local-oscillator noise sidebands are transferred to the i-f signal in the mixing process. System sensitivity is therefore limited by the quality of the local-oscillator signal. Further information on balanced mixers can be found in **references 2 and 3**.

The hybrid-T junction has useful properties as a power divider and isolator and may be constructed as a unit on its own. In commercial models it is usual

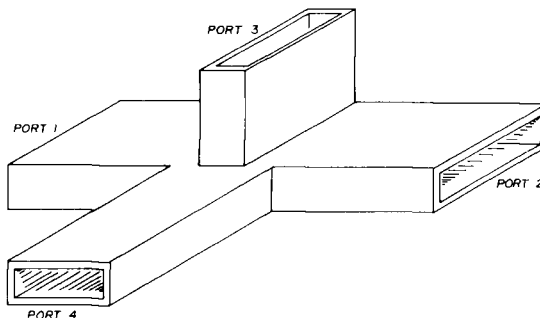
By **R. J. Harry, G3NRT**, Aldwickbury Crescent, Harpenden, Herts, AL5 5SE, England

to insert irises and matching stubs to compensate for the mismatch at the junction of the four ports. In the unit described here no attempt has been made to compensate for the inherent mismatch.

It is also necessary to match the mixer diodes to the waveguide. This is achieved by placing matching stubs (tuning screws) in front of the diode mounting. An improved match could be obtained by using a tapered diode mounting, however, the matching stub approach simplifies construction.

## construction

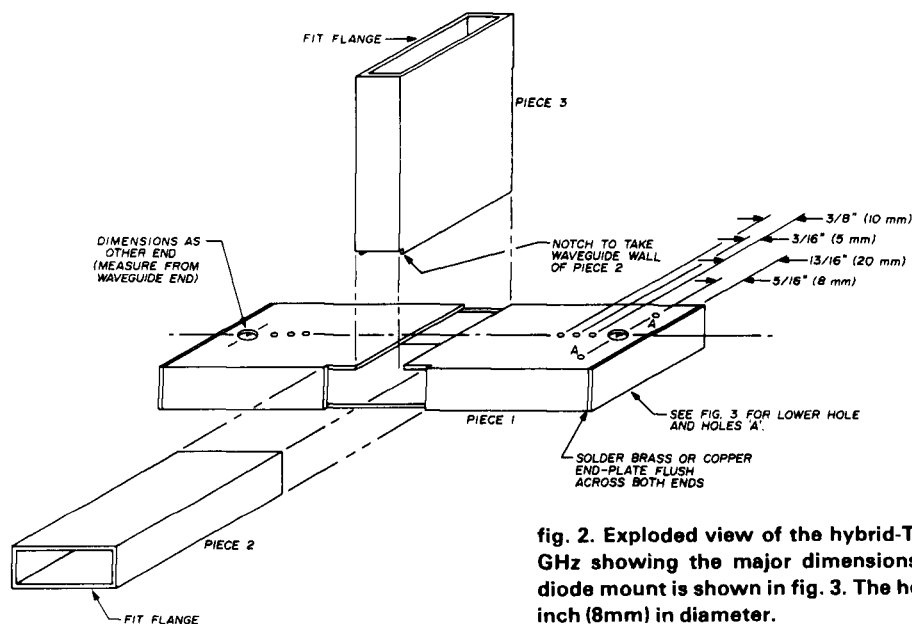
The mixer assembly is made from three pieces of waveguide (0.4 x 0.9 inch or 1 x 2.3cm internal dimensions) as shown in **fig. 2**.<sup>\*</sup> The exact lengths are not critical but piece 1 should be at least 3 1/4 inches (8.3cm) long. Start by cutting the waveguide to length and neatly finishing off the ends. The slots in piece 1 should be scribed using the external dimensions of the waveguide for reference. The best way to remove the slots is to insert into the waveguide a piece of wood trimmed to the internal dimensions of



**fig. 1. The hybrid-T waveguide junction. Power fed into port 3 will divide equally and in phase between ports 1 and 2; no power will appear at port 4. Power fed into port 4 will also divide equally between ports 1 and 2, but out of phase. This property can be used to build a balanced mixer: the mixer diodes are installed at ports 1 and 2, local-oscillator power is injected at port 3, and the antenna is connected to port 4.**

adjacent waveguide wall because this will introduce discontinuities into the guide and permit solder to flow into the interior.

The slots should be filed out for a snug fit. Check that pieces 2 and 3 do not protrude into the inside of



**fig. 2. Exploded view of the hybrid-T balanced mixer for 10 GHz showing the major dimensions. Construction of the diode mount is shown in fig. 3. The hole for the diode is 5/16 inch (8mm) in diameter.**

the guide. A neat cut will be obtained by using a small hacksaw and sawing on the inside of the scribed lines. It is important not to cut too deeply — the presence of sawdust in the metal cut will assist in judging the depth of the cut. Do not cut into the

<sup>\*</sup>Following is a list of some of the common classifications used for 10-GHz waveguide. If in doubt check the internal dimensions — they should measure 0.4 x 0.9 inch (1x2.3cm).

WG16	United Kingdom
WR90	United States (EIA)
RG-52/U	United States (JAN)
R100	IEC

the guide by looking into the open end of piece 1. When a good fit has been achieved, drill the matching screw holes and tap to suit the thread.<sup>\*</sup>

The diode holes should be made by first drilling the smaller hole through both broad faces in one operation, this will ensure good alignment. The hole for the body of the diode can be entered as shown or from the opposite broad wall — this is a matter of choice.

<sup>\*</sup>Any size screw thread of about 1/16" (1.5mm) diameter may be used.

The diode mounts are very simple in construction, but a word of caution: some diodes available on the surplus market are electrically sound but are out of specification mechanically. Therefore, use the dimensions given here only as a guide and check with your favorite diodes for a good fit. The diode should be a firm sliding fit into the collar (fig. 3). The collar height should be such that the diode, when fitted in the waveguide, has its shoulder at the pin end touching the lower interior guide wall.

The insulation between the diode mount and the waveguide is ordinary cellophane tape (e.g., Scotch tape). The nylon retaining screws should be cut so they are flush with the inside wall of the waveguide when secured. When all drilling has been completed and all internal burrs are removed, soldering can be started. Pieces 1, 2, and 3 should be soldered first, followed by the waveguide flanges. A damp rag should be wrapped around the T junction to prevent

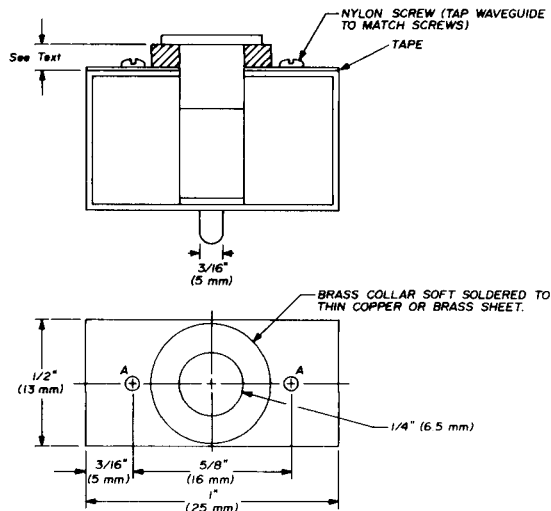


fig. 3. Construction of the diode mount for the 10-GHz balanced mixer. The i-f connection is made to the diode through a solder lug placed under the head of one of the nylon screws (see fig. 4 for i-f and metering connections).

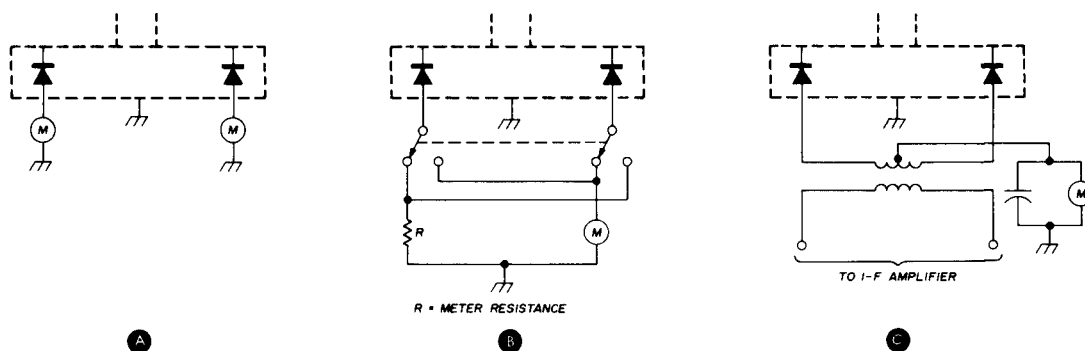


fig. 4. Metering and i-f connections to the hybrid-T waveguide balanced mixer. When initially setting LO injection, two identical meters should be used as shown at A, although the metering circuit at B is acceptable. Connections to the i-f transformer are shown at C.

the joint falling apart when soldering the flanges and end-pieces.

All soldering is best carried out with the work placed on a flat sheet of aluminum. This provides a firm base for the work, and avoids the possible embarrassment of soldering the waveguide to unwanted objects. A small gas jet should be used in preference to a soldering iron.

### adjustment

When connected to a local oscillator (5 -10 mW) the tuning screws should be adjusted for maximum mixer current. Ideally, this should be done with identical meters in series with each diode (fig. 4A), but if this is not possible the arrangement shown in fig. 4B can be used.

The tuning screws should be held in position with lock nuts. After the local-oscillator level has been adjusted for the recommended diode current, the metering circuit can be removed. A single meter for

monitoring purposes can be placed in series with the i-f transformer center-tap (fig. 4C).

### conclusion

Performance will depend on the diodes you use (preferably a matched pair). No performance figures are given because a meaningful set of measurements is beyond my present resources; the main object has been to describe the construction of a simple balanced mixer for 10 GHz which will encourage other amateurs to copy, experiment, and hopefully improve the design.

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2. F. E. Terman, *Electronic and Radio Engineering*, McGraw-Hill, New York, 1955, section 5-9.
3. *The Services Textbook of Radio*, volume 5 (England), Her Majesty's Stationery Office, 1958, chapter 7.

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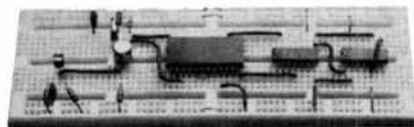
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A programmable calculator allows accurate analysis of a circuit before it is built. Analysis takes a little time but it can literally save days otherwise spent in fiddling with marginal or unusable circuits. An advantage is that you get to know your circuits rather than just putting components together. It works with your own design or with published circuits.

The HP-25 can be purchased for less than \$150 — about the average day's computer time charge — and the built-in functions are good for complex number handling. It is assumed you already know impedance and admittance, and rectangular and polar forms. All are needed to understand the methods. If these are unfamiliar, take time for a review before going on.

## basic ladder model

A *model* for circuit analysis is a block diagram made from *branches* connected by *nodes*. The branches are component combinations having two common connection points or nodes. A branch may have one or many components and its impedance or admittance value is described by a single expression. Any circuit may be modeled in this manner.

The *ladder* configuration is a shunt-series-shunt branch arrangement as shown in **fig. 1** for five branches. A ladder can be any odd-number branch arrangement. A model not in the ladder form can be transformed in subsections until the ladder is achieved. The simple ladder model allows only one signal source. This source is not considered a full branch.

**Fig. 1** shows all branches as impedances. Actual

**By Leonard H. Anderson, 10048 Lanark Street, Sun Valley, California 91352**

model values have shunt branches as admittances, series branches as impedances. This convention is used for the calculator solution program and the rationale may be seen by examining the model and identities plus the solution for output voltage.

Output voltage,  $e_o$ , will be a relative term and solely a function of branch values. Actual output voltage can be found by multiplying it by actual input current expressed in complex form. Most network responses are expressed in dB relative to a reference value so the current source can be unity without destroying validity.

There is one important fact about this model form: The admittance of the signal source *must* be a part of the input shunt branch. Excluding it will destroy the method of solving output voltage.\*

Compare the terms in the final  $e_o$  expression with the model diagram and identities. Each term represents the total admittance,  $Y$ , or impedance,  $Z$ , at a particular point in the model, looking towards the load. The progression of identities from  $Y_{12}$  to  $Z_{45}$  show this and the arrows of the diagram locate the total network impedance seen by the current source. Each successive  $Y$  and  $Z$  is both the sum of all preceding values and a term of the output voltage expression.

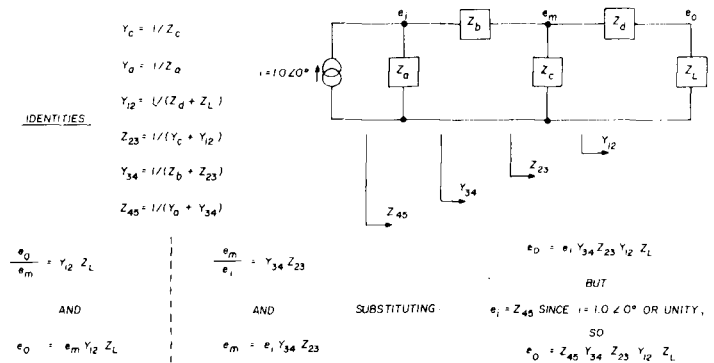
You can solve for both  $e_o$  and total  $Z_{in}$  by setting up the calculator to repeatedly request branch value entry, adding the entry to existing values, inverting the sum, multiply partial products by  $e_o$  by the sum (accumulating), then returning for next branch entry. This follows the identities of **fig. 1** and is the main loop (repeated operations) or **Program 1**.

A beginner in step-programming may be a little confused when confronted by only a program. The

flow chart in **fig. 2** represents the ladder network calculation of **Program 1**.

## ladder network flow chart

Flow charts are to programming what schematics are to circuits. Each chart symbol represents a component of the program. Lines with arrows indicate progression from one operation to the next. Rectangles with square sides are general operations, rounded-side boxes are program stops to display data, and slanted-side boxes are data entry stops. Diamonds represent decision points in the flow; program flow can change depending on what decision is made with particular data.



**fig. 1. Basic ladder network which can be quickly and easily analyzed with a hand-held, programmable calculator.**

The loop is at upper left. Branch value entry uses the rectangular form while inversion and multiplication is done in polar form. Partial products of  $e_o$  accumulate in memory while successive  $Y$  and  $Z$  remains in the stack.† The loop must stop after the last entry calculation so a counter is used for control.

The counter is just a memory register. Initialization at program start sets the counter to the number of branches in the model. After each loop is complete, the counter is decremented (reduced by one) and its value tested. A positive, non-zero value causes the program to jump back to loop start. Loop iteration stops when the counter is zero and program flow changes to the lower-right group.

The program is designed to give output voltage in dB relative to a reference,  $e_{ref}$ . Since the output voltage is unknown, reference to 0 dB is also unknown. The reference is automatically set if the first solution has the memory register for  $e_{ref}$  preset to zero. In this case,  $e_o$  is compared to  $e_i$  (input voltage = total

\*Exclusion of signal-source admittance does not affect input impedance.

†An algebraic-type calculator requires different storages so the program must be written from the original formulas of **fig. 1**.

Computer Aided Design, or CAD as it's known in industry, has been widely used by engineers and researchers to design and analyze electronic circuits. With the availability of low-cost, hand-held, programmable calculators, many of the benefits of this powerful analytical tool are now available to amateurs and experimenters.

In 1970 the author had to quickly find some time-delay equalizing networks for an avionics system's detector bank. Time was short and some components were in stock that *might* work. But would they? A fellow engineer told Anderson about the company's computer program and helped him check the circuit out on the terminal. The computer program had time-response capability and a half-hour of printout said the circuit would work fine. The circuit was built in the lab and checked out — the scope display was *identical* to the computer printout. The total elapsed time from assignment to results was less than five hours. The author has been a strong advocate of CAD ever since.

**Editor**

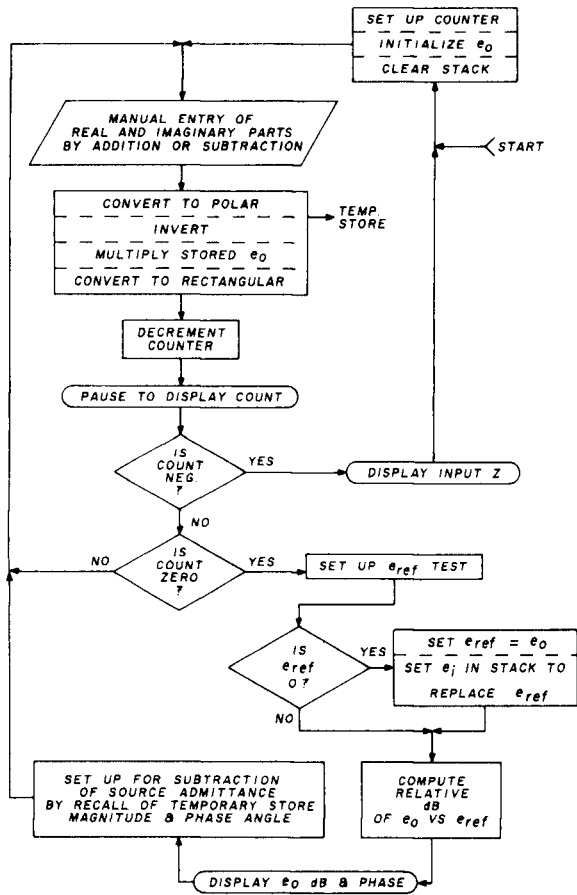


fig. 2. Flow chart for Program 1, ladder network analysis.

input impedance) and the first  $e_0$  display represents insertion loss/gain. All other  $e_0$  displays compare to  $e_{ref}$  unless the memory register is reset. An analysis usually requires one frequency at which relative output is 0 dB so this frequency should be solved first.

The lower-left block is a special operation. This sets up conditions for subtracting source impedance from total network admittance to find input impedance of only the network. This is very useful for filters and other circuits that require input impedance data. Each successive  $Y$  or  $Z$  calculated in the loop is also placed in temporary memory storage. In this part of the program the temporary storage contains total input admittance so this is recalled to the stack and flow jumps to loop start. At loop finish the counter will be  $-1$  so the flow is directed to input impedance display.

### program listing and details

The memory register block of Program 1 should be noted. Only three registers, R4, R5, and R6 must be preset before any run. Register R4 contains the constant 20 used in computing voltage gain in dB; holding constants in memory saves program steps. R5 is initially zero to establish the 0 dB reference

voltage for subsequent frequency solutions. R6 is set to the number of branches (do not count the current source as a branch).

Registers 0 and 1 accumulate the output voltage. Output phase angle is proportional to zero-degree input current. Input voltage phase angle is a function of total input impedance phase angle and must be calculated outside of this program. Successive  $Y$  and  $Z$  from the loop are stored in R2 and R3.

Steps 01 through 06 initialize the program run (upper right-hand corner of fig. 2). Register R0 is set to one so the partial products of  $e_0$  can be accumulated by register arithmetic. Register arithmetic allows any memory register to be added, subtracted, multiplied, or divided by the X register content without altering the X register.

The loop is contained in steps 07 - 21. Steps 07 and 08 do nothing on the first pass through the loop since both X and Y stack registers are zero. These steps are required on return jumps and will then contain the data indicated.

Branch value entry must be done manually by addition or subtraction, depending on sign. This is required to fit the limited number of program steps. Order of entry is always real part first, imaginary part second. Rectangular form is used here for both program and value-precalculation convenience.

Output voltage partial products are accumulated at steps 16 and 20 using register arithmetic. Polar form is more convenient here. Inversion of the polar form

STEP	KEY	X	Y	Z	T	REMARKS
01	RCL 8	NO				INITIALIZE
02	STO 7	NO				COUNTER
03	I	1	NB			
04	STO 0	1	NB			INIT, $e_0$ MAGN.
05	E STK	0	0	0	0	CLEAR STACK
06	STO 1	0	0	0		INIT, $e_0$ PHA
07	R $\downarrow$	(MAG)	(PHA)			LOOP START
08	E $\rightarrow$	REAL	IMAG			RECT. CONVERT
09	R/S	REAL	IMAG			INPUT REAL
10	X $\leftrightarrow$ Y	IMAG	REAL			
11	R/S	IMAG	REAL			INPUT IMAG
12	X $\leftrightarrow$ Y	REAL	IMAG			
13	g $\rightarrow$	MAG	PHA			POLAR CONVERT
14	g $\leftarrow$ X	1/MAG	PHA			RECIP INVERT
15	STO 2	1/MAG	PHA			TEMP. STORE
16	STO X	1/MAG	PHA			ACC. $e_0$ MAGN.
17	X $\leftrightarrow$ Y	PHA	1/MAG			
18	STO 3	PHA	1/MAG			TEMP. STORE
19	CHS	-PHA	1/MAG			FINISH INVERT
20	STO + 1	-PHA	1/MAG			ACC. $e_0$ PHA
21	X $\leftrightarrow$ Y	1/MAG	-PHA			
22	RCL 7	N	1/MAG	-PHA		
23	I	1	N	1/MAG	-PHA	DECREMENT
24	I	N-1	1/MAG	-PHA		COUNTER
25	STO 7	N-1	1/MAG	-PHA		
26	E PAUSE	N-1	1/MAG	-PHA		(OPTIONAL)
27	g $\leftarrow$ X	N-1	1/MAG	-PHA		
28	GTO 49	N-1	1/MAG	-PHA		JMP Z DISPLAY
29	g $\leftarrow$ X	N-1	1/MAG	-PHA		
30	GTO 07	N-1	1/MAG	-PHA		JMP LOOP START
31	RCL 0	N-1	1/MAG	-PHA		
32	RCL 5	C OF	0	1/MAG		
33	g $\leftarrow$ X	C OF	0	1/MAG		
34	GTO 38	C OF	0	1/MAG		JMP DB OUTPUT
35	R $\downarrow$	C OF				
36	STO 5	C OF				SET KEY REFER.
37	RCL 2	0	C OF			
38	R $\leftarrow$	RATIO	C OF			SETUP TO FIND
39	R $\leftarrow$	LOG	LOG			NETWORK INPUT
40	RCL 4	20	LOG			IMPEDANCE
41	X	DB				
42	R/S	DB				DISPLAY $e_0$ MAG
43	RCL 1	PHA	DB			
44	R/S	PHA	DB			DISPLAY $e_0$ PHA
45	RCL 3	Y PHA	DB			SETUP TO FIND
46	RCL X	Z OF	Y PHA			NETWORK INPUT
47	g $\leftarrow$ X	Y MAG	Y PHA			IMPEDANCE
48	GTO 08	Y MAG	Y PHA			JMP LOOP CONV.
49	R $\downarrow$	Z MAG	Z PHA			DISPLAY Z IN

MEMORY	REGISTER	INITIAL VALUE
R0	$e_0$	"MAGNITUDE"
R1	$e_0$	"PHASE ANGLE"
R2	MAGNITUDE	(TEMPORARY)
R3	PHASE ANGLE	(TEMPORARY)
R4	20	(CONSTANT)
R5	0	(REFERENCE)
R6	NUMBER OF BRANCHES	(CONSTANT)
R7	N	COUNTER

Program 1. Ladder Network Calculation.

is at **steps 14** and **19**. The intermix of steps may be confusing at first glance but is required to reduce the program size.

The pause at **step 26** is optional but useful when becoming acquainted with the program. The one-second display will show the branch number to be entered *next*. This assumes the first shunt branch is 1, the next series branch is 2, and so on. A zero display indicates that entries are complete and  $e_o$  display is next.

The first decision point is at **steps 27** and **28** on the new state of the counter contained in X. Program flow can be stated as, "If the contents of X is less than zero (negative), then go to **step 49**; otherwise continue with statement in **step 29**." The next decision point follows directly and is interpreted, "If the contents of X is *not* zero, then go to **step 07**; otherwise continue with **step 31**."

Many functions on the HP-25 require the *g* or *f* key prefix so make certain you use the correct one when entering the program steps. Strange results could happen from **steps 27** and **29** if the *f* key was mistakenly used.

**Steps 31** and **32** set up the  $e_{ref}$  test actually performed in **steps 33** and **34**. The 0 shown in Y and Z stack registers is the counter state; the program would not have reached **step 31** unless the counter was zero. Reference test is done on polar form magnitudes only. The content of R2 is now equal to total  $Z_{in}$  or equal to  $e_i$ . **Step 37** and the register roll-down of **step 35** are equivalent to replacing  $e_{ref}$  by  $e_i$ .

**Steps 38 - 41** compute voltage ratio in dB, displayed at **42** stop. Any register may now be examined manually since the following steps order the stack contents by recall. This is also true after the phase angle display stop at **step 44**.

**Steps 45 - 48** set up for source admittance subtraction. Phase angle in register R3 is in admittance form since the storage instruction of **step 18** came before the **step 19** sign change for inversion completion. R2 is an impedance since it was stored after inversion; this was a requirement of recall at **step 37** to reduce size. **Step 47** completes the magnitude inversion so the jump to **step 08** has X and Y in admittance form. Source admittance is subtracted within the loop and the resulting impedance magnitude is displayed at **step 49**. Exchanging X and Y manually will display impedance phase angle. Depressing the *R/S* key will return to **step 01** restarting for the next run.

Precalculation of all branch values is required before a solution is done. All frequency-sensitive branches must be precalculated at each solution frequency. If either real or imaginary part of the branch is zero, the particular entry may be skipped. It is im-

**table 1. Keyboard operations and displays using HP-25 Program 1 to analyze the R-C lowpass filter shown in fig. 3.**

keyboard	display	
	0.0000	(first stop after restart)
enter load G	1. -05	(EEX, CHS, 5)
add	1.000000-05	
R/S	0.0000	
enter 0.005 $\mu$ F B	0.000062832	
add	0.0001	
R/S	4.0000	(pause display for 1 second)
	2470.4410	
enter 10k res.	1. 04	(EEX, 4)
add	12470.4410	
R/S	-15522.2751	
(skip entry, X = 0)		
R/S	3.0000	(pause display for 1 second)
	3.1455036-05	
(skip entry, G = 0)		
R/S	3.9152883-05	
enter 0.05 $\mu$ F B	0.000628319	
add	0.0007	
R/S	2.0000	(pause display for 1 second)
	70.4467	
enter 1k res.	1. 03	(EEX, 3)
add	1070.4467	
R/S	-1494.8706	
(skip entry, X = 0)		
R/S	1.0000	(pause display for 1 second)
	0.0003	
enter source G	0.01	
add	0.0103	
R/S	0.0004	
(skip entry, B = 0)		
R/S	0.0000	(pause display for 1 second)
	-3.2067	$e_o$ magnitude in dB
R/S	-65.0970	$e_o$ phase angle in degrees
R/S	0.0103	total input conductance
enter source G	0.01	
subtract	0.0003	
R/S	0.0004	total input susceptance
(skip entry, B = 0)		
R/S	-1.0000	(pause display for 1 second)
	1838.6121	filter input Z magnitude
x $\leftrightarrow$ y	-54.3943	filter input Z phase angle
RCL 5	90.0090	$e_{ref}$

portant to keep entry order of real-part-first in mind; solution is invalid if these are mixed.

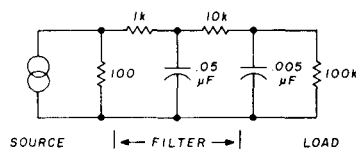
### example using program 1

The two-section R-C lowpass filter of **fig. 3** is a simple example. Capacitors are assumed lossless. There are only five branches in the model. The first branch has an admittance of  $0.01 + j0$  mho due to the source resistance of 100 ohms. Load admittance of 10 micromho is constant in branch 5 but the susceptance of the 0.005  $\mu$ F is in parallel. Branches 2 and 4 are purely resistive while branch 3 (0.05  $\mu$ F) is purely susceptive. To reiterate, all shunt branches are entered as admittances while series branches enter as impedances.

**Fig. 3** shows a tabulation of capacitor susceptance

as well as solved output voltage and filter input impedance. Susceptance is zero at dc, the reference frequency, so the reference solution required only resistive or conductive values entries. Insertion loss will display negative but some circuits have voltage gain; a voltage gain displays positive at the reference frequency.

Memory register 6 is set at 5 for the number of branches and R5 is set at zero for the reference run at dc. A tabulation of keyboard operations and resulting displays are shown in **table 1**. Display is set fixed at 4-decimals and the run is at 2 kHz.



frequency (kHz)	susceptance (mho)	
	0.05 $\mu$ F	0.005 $\mu$ F
1	0.000314159	0.000031416
2	0.000628319	0.000062832
3	0.000942478	0.000094248
4	0.001256637	0.000125664
5	0.001570796	0.000157080
10	0.003141593	0.000314159
20	0.006283186	0.000628319

frequency (kHz)	output voltage		input	filter impedance
	dB	phase angle		
0*	0.0	0.0000°	111000	0.0000°
1	-0.9499	-36.0202°	3162.84	-68.8897°
2	-3.2067	-65.0970°	1838.61	-54.3943°
3	-5.8972	-86.4955°	1456.26	-43.9354°
4	-8.5755	-102.1197°	1288.50	-36.5079°
5	-11.0862	-113.7452°	1198.50	-31.0653°
10	-20.7912	-143.2080°	1057.05	-17.3493°
20	-32.1027	-160.9919°	1014.94	-8.9974°

\*Reference frequency, insertion loss = 0.09065 dB

**fig. 3.** Susceptance, output voltage, and filter input impedance for an R-C lowpass filter, calculated with a programmable, hand-held calculator.

The tabulation looks formidable but operation takes less time than reading the listing. The RCL 5 at the end is not required; it was included only to show the internal  $e_{ref}$  value in memory.

For simple circuits such as this one, 5 significant

\*The question of accuracy sometimes comes up when calculator results are compared to computer printouts. Large computers don't automatically imply great accuracy — only when *long precision* (10 digits) or *double precision* (14 digits) are used does this happen. A recent computer run on an audio lowpass filter for an ssb rig indicated a *dc* insertion loss of 0.0002 dB with a  $-0.3723^\circ$  phase angle! Since inductor  $Q$  was not modeled in this program, insertion loss should be 0 dB. The computer program's phase angle can only be explained by the way the program was written and by the 7-digit precision.

digits of entry value should be sufficient. At least 6 digits should be used for larger models or those having reactance and susceptance in each branch. Most big computer analysis programs have only 7 significant digits for all calculation while the HP-25 uses ten — the program can actually be more accurate than computer results!\*

Analysis of L-C networks, especially filters, can be tiring when R or G is absent or a constant value. **Program 2** was designed for filter analysis when the source and load resistance is equal and the shunt branch conductance is always the same value. Top-coupled bandpass filters can be analyzed by this program. In this case the shunt conductance is calculated by  $B_L/Q$  at center frequency and  $Q$  is the mean value of parallel inductor and capacitor.

### modified ladder network program

**Program 2** is a rewritten version of **Program 1** and requires only the imaginary part of branch value be entered. Series branches are assumed nearly lossless; common shunt conductance is also added to the series branches by the program so solutions are valid only when series reactance is high compared to parallel reactance. It does serve to show how the basic program can be changed to achieve the same results.

Initialization, loop, and output voltage calculation in dB are the same as **Program 1** with a few exceptions. There is no temporary storage since this is occupied by constants  $1/R_L$  and  $G_s$ , the common shunt conductance. This leaves no room for finding  $Z_{in}$  by the program or automatically setting an  $e_{ref}$  value. Each of these can be set manually on the first run. The loop of **Program 1** starts and ends in polar form. **Program 2's** loop starts and ends in rectangular form so that shunt conductance and end conductance may be added by the program.

A notable exception is that the number of branches stored in R6 is one less than the model. This is a requirement of steering program flow at **steps 29** and **30** so that end conductance can also be added via **steps 32 - 34**. Load-end conductance is added by the GTO32 at **step 07** while source-end conductance addition results from decision steering.

A negative count at loop ending steers the program to output voltage calculation. The initial value of  $e_{ref}$  should be some number like one to prevent an error stop at **step 38** from division by zero. The first  $e_o$  display will be meaningless.

Total input impedance has been carried in the stack in rectangular form. This is converted to polar form after output voltage phase angle display. Manual register operations should be avoided until the stop at **step 48** since stack data could disappear.



STEP	KEY	X	Y	Z	T	REMARKS
01	RCL 6	NB				INITIALIZE COUNTER
02	STO 7	NB				
03	I	1	NB			
04	STO 0	1	NB			INIT. $e_0$ MAG.
05	F STK	0	0	0	0	CLEAR STACK
06	STO 1	0	0	0	0	INIT. $e_0$ PHA
07	GTO 32	0	0	0	0	JMP TO GL ADD
08	R↓	REAL	IMAG			LOOP START
09	RCL 3	GS	REAL	IMAG		
10	+	REAL	IMAG			ADD GS
11	X↔Y	IMAG	REAL			ENTER IMAGINARY PART BY MANUAL ADD OR SUBTRACT
12	R/S	IMAG	REAL			
13	X↔Y	REAL	IMAG			
14	g →P	MAG	PHA			POLAR CONVERT
15	g 1/X	1/MAG	PHA			BEGIN INVERT
16	STO X 0	1/MAG	PHA			ACC. $e_0$ MAGN.
17	X↔Y	PHA	1/MAG			
18	CHS	-PHA	1/MAG			FINISH INVERT
19	STO - 1	-PHA	1/MAG			ACC. $e_0$ PHA
20	X↔Y	1/MAG	-PHA			
21	I →R	REAL	IMAG			RECT. CONVERT
22	RCL 7	N	REAL	IMAG		DECREMENT COUNTER
23	I	N	REAL	IMAG		
24	-	N-1	REAL	IMAG		
25	STO 7	N-1	REAL	IMAG		(OPTIONAL)
26	I PAUSE	N-1	REAL	IMAG		
27	g X<0	N-1	REAL	IMAG		
28	GTO 35	N-1	REAL	IMAG		JMP OUTP. CALC.
29	g X=0	N-1	REAL	IMAG		
30	GTO 08	N-1	REAL	IMAG		JMP LOOP START
31	R↓	REAL	IMAG			
32	RCL 2	GL	REAL	IMAG		
33	+	REAL	IMAG			ADD END GL
34	GTO 09	REAL	IMAG			JMP TO GS ADD
35	R↓	REAL	IMAG			BEG. OUTP. CALC.
36	RCL 0	$e_0$	REAL	IMAG		
37	RCL 5	$e_{ref}$	REAL	IMAG		
38	I	RATIO	REAL	IMAG		(REFERENCE)
39	I LOG	LOG	REAL	IMAG		R6 NUMBER OF BRANCHES
40	RCL 4	Z0	LOG	REAL	IMAG	MINUS ONE
41	X	DB	REAL	IMAG		
42	R/S	DB	REAL	IMAG		DISPLAY $e_0$ MAG
43	R↓	REAL	IMAG			
44	RCL 1	PHA	REAL	IMAG		
45	R/S	PHA	REAL	IMAG		DISPLAY $e_0$ PHA
46	R↓	REAL	IMAG			
47	g →P	MAG	PHA			
48	R/S	MAG	PHA			DISPLAY Z MAG
49	X↔Y	PHA	MAG			DISPLAY Z PHA RESTART BY [R/S]

Program 2. Modified Ladder Network Calculation.

Network input Z must be calculated manually in this program.

Insertion loss at the reference frequency can be found as follows: Store total Z magnitude in register R7 by STO 7 after the stop at step 48. Continue to step 49 and record total Z phase. Depress RCL 0, STO 5 to set  $e_{ref}$  in memory, then RCL 7 and DIVIDE to find  $e_0/e_i$  ratio. Using R7 at this point will not disturb the program since a restart will initialize the counter, destroying any previous data there.

Program 2 is convenient for branch entry but inconvenient for reference and network input impedance. Tradeoffs must be made due to program size. The last steps of both programs can be altered to suit the reader's application.

### precalculation techniques

Branch values at each solution frequency must be known before applying either Program 1 or Program 2. This can be done by another calculator program and tabulation of values. Precalculation should begin at the last branch and work forward. Tabulation will then have the same order of entry as either solution program.

Fig. 4 shows a simple bandpass filter to be analyzed. The model will have only three branches. Source and load resistances are equal and capacitor Q is assumed much higher than inductor Q. Equivalent shunt conductance due to Q is calculated from inductive susceptance only.

Program 3 is an example of precalculation for fig. 4. Frequency is the only variable and all component values are stored in memory. This lets the calculator do all the work of sign and decimal-point placement for the least error.

Register arithmetic is used extensively and programming is linear (no loops or jumps). The memory block shows two values for registers R0 through R5, excluding R2. The first value is the preset constant while the second is frequency modified. Note that inductance and C2 is preset inverted, C2 is also signed negative. Since calculation will require this anyway, it saves program steps to store constants in this form.

Steps 02 through 08 change the memory by register arithmetic and also store the entered frequency. Steps 33-39 restore memory contents to original value. Register arithmetic is quite useful for repetitive operations like this and saves program steps. A little study will show how it is done.

Inductive susceptance is shown with a negative sign. A negative  $B_L$  is a positive quantity required for equivalent conductance due to Q. The subtraction at steps 17 and 31 properly sets the total susceptance sign. The negative  $B_L$  is a subtle reminder to remember the basics of admittance.

Computation is straightforward with display stops in order from load to generator, real part first, imaginary part second. Shunt branches are in admittance, series in impedance. Steps 19 and 20 are strictly

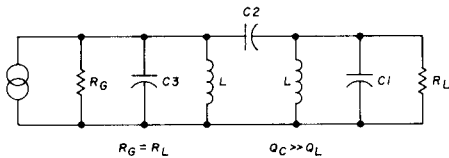
STEP	KEY	X	Y	Z	T	REMARKS
01	R/S	FREQ				ENTER
02	STO X 0	FREQ				RADIAN FREQ.
03	STO 7	FREQ				STORE TEMP.
04	RCL 0	$\omega$	FREQ			SET RAD. FREQ
05	STO + 1	$\omega$	FREQ			FIND -B(L)
06	STO X 3	$\omega$	FREQ			FIND B(C1)
07	STO + 4	$\omega$	FREQ			FIND X(C2)
08	STO X 5	$\omega$	FREQ			FIND B(C3)
09	RCL 1	-B(L)				BEGIN LOAD G
10	RCL 2	GL	-B(L)			
11	I	G(OL)				
12	RCL 4	G(LOAD)	G(OL)			
13	+	GL				END LOAD G
14	R/S	GL				
15	RCL 3	B(C1)				
16	RCL 1	-B(L)	B(C1)			
17	-	BL				LOAD B
18	R/S	BL				
19	RCL 0	0				SERIES R
20	R/S	0				
21	RCL 4	X(C2)				R0 2 PI
22	R/S	X(C2)				RPI F ( $\omega$ )
23	RCL 1	-B(L)				BEGIN GENR. G
24	RCL 2	GL	-B(L)			
25	+	G(OL)				
26	RCL 4	G(LOAD)	G(OL)			
27	+	G(GEN)				END GENR. G
28	R/S	G(GEN)				GEN G
29	RCL 5	B(C3)				
30	RCL 1	-B(L)				
31	-	B(GEN)				
32	R/S	B(GEN)				GEN B
33	RCL 0	$\omega$				
34	STO X 1	$\omega$				MEMORY RESET
35	STO + 3	$\omega$				MEMORY RESET
36	STO X 4	$\omega$				MEMORY RESET
37	STO + 5	$\omega$				MEMORY RESET
38	RCL 7	FREQ				2PI RESTORE
39	STO + 0					JMP TO START
40	GTO 01					
41						
42						
43						
44						
45						
46						
47						
48						
49						

Program 3. Precalculation Example.

reminders that the real part of the series branch is zero; these can be deleted.

**Steps 23-28** are duplicates of **09-14** since both inductors are the same value. The program can be written to hold end conductance in the stack after **step 14**, then bring it back for display. A better alternative is to let register R2 hold the constant  $1/(L Q_L)$  and add two register arithmetic steps. This would delete four steps from the program shown. It is always better to hold constants in memory so the program needs fewer steps to compute the desired value.

The original frequency entry will be displayed when the run is finished and jumps back to stop at **step 01**. This is a good reminder for tabulation. If you hit the **R/S** key at **step 01** without entering a new frequency, all displays will repeat the previous run.



**fig. 4.** Bandpass filter for the precalculation example discussed in the text.

Run through all displays when this occurs so that memory is restored. A mid-program change requires reloading memory.

Many variations of the precalculation program are possible. They are written to fit the particular circuit to be modeled. Adopting the style of **Program 3** has these advantages:

1. Only one entry for frequency, all other stops are displays.
2. Component storage in memory with inversions and signs as necessary will reduce program steps.
3. Register arithmetic forms reactance and susceptance directly in memory with the fewest steps.
4. Calculation is simple and direct.

More than one program may be required. It is suggested that the load-end values are all calculated first. This fits the back-to-front ordering of the solution programs.

Scaling to megahertz, microhenries, and microfarads is useful for rf work. Results will still be in ohms and mhos. Other scaling can be used but should only be done if you're very familiar with impedance and admittance.

**the branch jumping adjacent nodes problem**

This situation normally defeats the ladder configuration. The remedy is to use a transformation pro-

gram on precalculated values until the ladder is formed. **Fig. 5** illustrates the method using a delta-to-tee transformation on a subsection. Circled numbers are nodes above ground. Nodes 1 and 3 will carry over but the original node 2 is reformed.

**Program 4** follows the formulas given in **fig. 5** with rectangular form entry and polar form solutions. Available program size requires more manual steps. Both parts of each delta branch must be entered in the sequence: Input real part, press **ENTER**, input imaginary part, press **R/S** to continue. A manual conversion to rectangular is required at each tee branch solution.

The program accumulates the common denominator of the transformation using the rectangular form with storage in registers R6 and R7. Numerators require multiplication so the polar form is used to reduce program size. The memory register block may seem confusing but the memory contents change as the program progresses.

After  $Z_A$  is entered, a direct store is used to begin accumulation. Registers R0, R1 and R2, R3 both hold the polar form of  $Z_A$  while R6, and R7 holds the rectangular form. Entering  $Z_B$  will make R6, R7 equal to  $Z_A + Z_B$  and R0, R1 equal to  $Z_A \times Z_B$  via register arithmetic. A direct store places  $Z_B$  in R4, R5. The numerator of  $Z_I$  has been formed in memory. Entry of  $Z_C$  will complete accumulation of the denominator and remaining numerators by register arithmetic.

**Steps 31-40** recall the denominator, convert it to polar form and place the solutions in memory. Memory registers R0-R5 are then recalled in order

STEP	KEY	X	Y	Z	T	REMARKS
01	R/S					ENTER ZA
02	STO 7	IMAG A	REAL A			BEGIN DENOMIN.
03	X↔Y	REAL A	IMAG A			
04	STO 6	REAL A	IMAG A			ACCUM. DENOMIN.
05	g → P	MAG A	PHA A			POLAR CONVERT
06	STO 0	MAG A	PHA A			Z1 NUMERATOR
07	STO 2	MAG A	PHA A			Z2 NUMERATOR
08	X↔Y	PHA A	MAG A			
09	STO 1	PHA A	MAG A			Z1 NUMERATOR
10	STO 3	PHA A	MAG A			Z2 NUMERATOR
11	R/S	IMAG B	REAL B			ENTER ZB
12	STO + 7	IMAG B	REAL B			ACCUM. DENOMIN.
13	X↔Y	REAL B	IMAG B			
14	STO + 6	REAL B	IMAG B			ACCUM. DENOMIN.
15	g → P	MAG B	PHA B			POLAR CONVERT
16	STO 4	MAG B	PHA B			Z3 NUMERATOR
17	STO x 0	MAG B	PHA B			Z1 NUMERATOR
18	X↔Y	PHA B	MAG B			
19	STO 5	PHA B	MAG B			Z3 NUMERATOR
20	STO + 1	PHA B	MAG B			Z1 NUMERATOR
21	R/S	IMAG C	REAL C			ENTER ZC
22	STO + 7	IMAG C	REAL C			ACCUM. DENOMIN.
23	X↔Y	REAL C	IMAG C			
24	STO + 6	REAL C	IMAG C			DENOM. COMPLETE
25	g → P	MAG C	PHA C			POLAR CONVERT
26	STO x 2	MAG C	PHA C			Z2 NUMERATOR
27	STO x 4	MAG C	PHA C			Z3 NUMERATOR
28	X↔Y	PHA C	MAG C			
29	STO + 3	PHA C	MAG C			Z2 NUMERATOR
30	STO + 5	PHA C	MAG C			Z3 NUMERATOR
31	RCL 7	IMAG D				ZC ZC PHA
32	RCL 6	REAL D	IMAG D			Z2 NUMER. PHA
33	g → P	MAG D	PHA D			R4 ZB MAG
34	STO ÷ 0	MAG D	PHA D			Z1 SOLVE
35	STO ÷ 2	MAG D	PHA D			Z2 IMPEDANCE
36	STO ÷ 4	MAG D	PHA D			Z3 MAGNITUDES
37	X↔Y	PHA D	MAG D			
38	STO - 1	PHA D	MAG D			Z1 SOLVE
39	STO - 3	PHA D	MAG D			Z2 IMPEDANCE
40	STO - 5	PHA D	MAG D			Z3 ANGLES
41	RCL 1	Z1 PHA				
42	RCL 0	Z1 MAG	Z1 PHA			
43	R/S	Z1 MAG	Z1 PHA			Z1 DISPLAY
44	RCL 3	Z2 PHA				
45	RCL 2	Z2 MAG	Z2 PHA			
46	R/S	Z2 MAG	Z2 PHA			Z2 DISPLAY
47	RCL 5	Z3 PHA				
48	RCL 4	Z3 MAG	Z3 PHA			
49	GTO 01	Z3 MAG	Z3 PHA			JMP START DISH

MEMORY	
R0	ZA MAG
R1	ZB MAG
R2	Z1 NUMER. MAG
R3	Z1 PHA
R4	ZB PHA
R5	ZB PHA
R6	Z1 NUMER. PHA
R7	ZC MAG
R8	ZC MAG
R9	Z2 NUMER. MAG
R10	Z2 PHA
R11	Z2 NUMER. PHA
R12	Z3 PHA
R13	Z3 PHA
R14	Z3 MAG
R15	Z3 MAG
R16	Z3 PHA
R17	Z3 PHA
R18	Z3 PHA
R19	Z3 PHA
R20	Z3 PHA
R21	Z3 PHA
R22	Z3 PHA
R23	Z3 PHA
R24	Z3 PHA
R25	Z3 PHA
R26	Z3 PHA
R27	Z3 PHA
R28	Z3 PHA
R29	Z3 PHA
R30	Z3 PHA
R31	Z3 PHA
R32	Z3 PHA
R33	Z3 PHA
R34	Z3 PHA
R35	Z3 PHA
R36	Z3 PHA
R37	Z3 PHA
R38	Z3 PHA
R39	Z3 PHA
R40	Z3 PHA
R41	Z3 PHA
R42	Z3 PHA
R43	Z3 PHA
R44	Z3 PHA
R45	Z3 PHA
R46	Z3 PHA
R47	Z3 PHA
R48	Z3 PHA
R49	Z3 PHA
R50	Z3 PHA

**Program 4.** Delta-to-Tee Transformation.

and the stops display each tee branch magnitude. Tee branch phase angle is in the Y register at each stop. The stop for  $Z_3$  is at **step 01**. This not only reduces steps but permits an automatic return to start for transforming the next set of delta values.

**Program 4** will work with either impedance or admittance. The only change is from rectangular form to polar form. As an example, enter

$$Z_A = 3 - j4$$

$$Z_B = 4 + j5$$

$$Z_C = 5 + j3$$

The solutions (converted to rectangular) are

$$Z_1 = 2.375 - j0.875$$

$$Z_2 = 1.750 - j1.500$$

$$Z_3 = 1.300 + j2.650$$

Note the difference in signs for the imaginary part.

### transforming the other way

A prime example is the parallel-T circuit. To form the basic ladder a tee-to-delta transformation is required. This places each transformed delta branch in parallel with the other. Transformation formulas are as follows using the branch designations shown in **fig. 5**

$$Z_N = Z_1 Z_2 + Z_1 Z_3 + Z_2 Z_3$$

$$Z_A = Z_N / Z_3$$

$$Z_B = Z_N / Z_2$$

$$Z_C = Z_N / Z_1$$

**Program 5** performs conversion using the above relations.

A difficulty in programming is the common numerator expression. **Program 4** is needed only to form a sum of three quantities for the common denominator. **Program 5** must form the common numerator from the sum of three products. This eats up program steps so **Program 5** is a bit harder to work with.

All entries must be in polar form. This can be done by entering rectangular values and converting manually. Attention must be paid to the magnitude and angle location in the stack. This is especially true at  $Z_2$  entry since the Z and T stack registers cannot be disturbed from locations shown.

Registers R0 through R5 store only the individual impedances. The numerator product terms are formed in the stack, converted to rectangular, then accumulated in registers R6-R7. The  $Z_1 Z_2$  term is formed when **step 12** is reached.  $Z_1 Z_3$  is complete by **step 25**. **Program 5** requires stack register manipulation and more steps as a result of the common numerator expression.

Limitation of HP-25 program size results in solutions stored *inverted* in memory. Input impedance and the direct solution is in admittance but both are

STEP	KEY	X	Y	Z	T	REMARKS
01	R/S					ENTER Z1
02	STO 4	MAG Z1	PHA Z1			ZC DENOM. MAG
03	X↔Y					
04	STO 5	PHA Z1	MAG Z1			ZC DENOM. PHA
05	R/S					ENTER Z2
06	STO 2	MAG Z2	PHA Z2	PHA Z1	MAG Z1	ZB DENOM. MAG
07	R↔					
08	STO 3	PHA Z2	PHA Z1	MAG Z1	MAG Z2	ZB DENOM. PHA
09	+					
10	X↔Y	MAG Z1	PHA Z1			
11	RCL 2	MAG Z2	MAG Z1	PHA Z1		
12	X↔Y					Z1Z2 COMPLETE
13	E →R	RE 12	IM 12			RECT. CONVERT
14	STO 6	RE 12	IM 12			ACCUM. NUMERAT.
15	R↔					
16	STO 7	IM 12				ACCUM. NUMERAT.
17	R/S					ENTER Z3
18	STO 9	MAG Z3	PHA Z3			ZA DENOM. MAG
19	RCL 4	MAG Z1	MAG Z3	PHA Z3		
20	X↔Y					
21	X↔Y	PHA Z3	MAG Z3			
22	STO 1	PHA Z3	MAG Z3			ZA DENOM. PHA
23	RCL 5	PHA Z1	PHA Z3	MAG Z3		
24	+					
25	X↔Y	PHA Z1	MAG Z3			Z1Z3 COMPLETE
26	E →R	RE 13	IM 13			RECT. CONVERT
27	STO 8	RE 13	IM 13			ACCUM. NUMERAT.
28	R↔					
29	STO 7	IM 13				ACCUM. NUMERAT.
30	RCL 1	PHA Z3				
31	RCL 3	PHA Z2	PHA Z3			
32	+					
33	RCL 0	MAG Z3	PHA Z3			
34	RCL 2	MAG Z2	MAG Z3	PHA Z3		
35	X	MAG Z2	PHA Z3			Z2Z3 COMPLETE
36	E →R	RE 23	IM 23			RECT. CONVERT
37	STO 6	RE 23	IM 23			ACCUM. NUMERAT.
38	R↔					
39	STO 7	IM 23				ACCUM. NUMERAT.
40	RCL 7	IM N				
41	RCL 6	RE N	IM N			NUMERATOR
42	Q	MAG N	PHA N			POLAR CONVERT
43	STO 0	MAG N	PHA N			YA SOLVE
44	STO 2	MAG N	PHA N			YB ADMITTANCE
45	STO 4	MAG N	PHA N			YC MAGNITUDES
46	X↔Y	PHA N	MAG N			YA SOLVE
47	STO 1	PHA N	MAG N			YB ADMITTANCE
48	STO 3	PHA N	MAG N			YC ADMITTANCE
49	STO 5	PHA N	MAG N			YC ANGLES

ALL ENTRIES PLACED IN ORDER IN STACK AS SHOWN IN POLAR FORM

MEMORY

R0	Z3 MAG
	YA MAG
R1	Z3 PHA
	YA PHA
R2	Z2 MAG
	YB MAG
R3	Z2 PHA
	YB PHA
R4	Z1 MAG
	YC MAG
R5	Z1 PHA
	YC PHA
R6	REAL PART
	NUMERATOR
R7	IMAG PART
	NUMERATOR

RESTART BY [R/S]

**Program 5. Tee-to-Delta Transformation.**

in polar form — the input/output is opposite that of **Program 4**. Solutions are manually recalled after the forced stop at **step 49**

$Y_A$  magnitude in R0, angle in R1

$Y_B$  magnitude in R2, angle in R3

$Y_C$  magnitude in R4, angle in R5

The admittance form is not a disadvantage. Recalling the parallel-T, the transformations have all delta branches in parallel. Admittance addition is the easiest calculation of parallels.

### other transformations

Lattice networks and similar circuits can be programmed to tee or delta sections and the formulas are available in most textbooks. In most cases a circuit can be divided into relatively simple subsections represented by a single branch; a precalculation program can be used instead of transformation. The circuit to be analyzed should be carefully studied and divided into branches that minimize pre-solution work.

A key indicator of the necessity for transformation is the model's signal path or current flow. The parallel-T has two separate signal paths so transformation is unavoidable. Branch  $Z_B$  of **fig. 5** represents a second signal path vs flow from node 1 through node 2 to 3.

Schematics can sometimes be misleading. Often they are drawn to fit available space and parallel components may appear widely separated. Copying the schematic on scratch paper is useful; branches

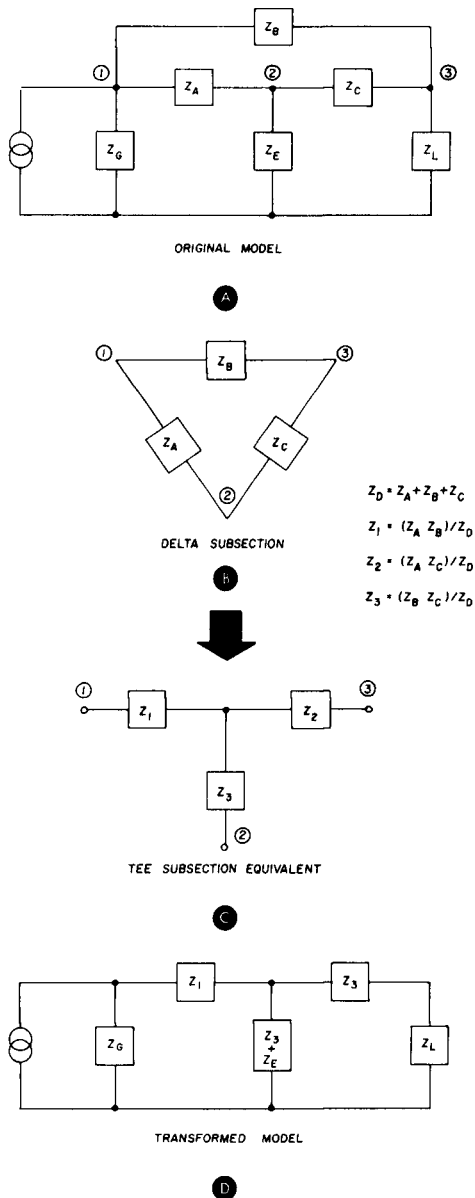


fig. 5. Model transformation. The delta subsection of the original model is first transformed to an equivalent tee network, then added to the original to form the transformed model.

can be marked or outlined without harming the original source.

### preparation

Practice with the calculator so you know what happens when you inadvertently key in a wrong instruction. Treat it like a piece of test equipment. In this application that is just what it is.

Use a separate pad of paper for branch value tabulation. When transformation is required, precalculate only the sub-sections and write down the solutions on the tabulation sheet first. The ordinary branches can be calculated later.

Remember to order branch values from back to front. It is probably easier to group values by frequency, making little blocks of values on the tabulation sheet. Calculate at more frequencies than you think you need. Network solutions will tell you which ones to skip over.

Five or six significant digits will give you good accuracy. A minimum is four digits, but only for simple circuits.

### group delay

Any circuit with inductance and/or capacitance has time delay and such delay is frequency sensitive. Group delay is the average time delay over a small increment or *group* of frequencies. It is a function of frequency increment and the differential phase angle within the increment. The formula is:

$$td = (\Delta \text{phase angle}) / (360 \cdot \Delta \text{Frequency})$$

where:  $\Delta \text{phase angle}$  = positive differential angle in degrees within the frequency increment

$\Delta \text{Frequency}$  = differential frequency over a small increment

Scaling can be seconds and Hz, milliseconds and kHz, or microseconds and MHz.

Frequency increments should be constant and small. For a bandpass filter, at least ten frequencies within the passband should give an accurate picture of group delay. Since the frequency increment is constant, the denominator of  $td$  is also constant.

Linear group delay in ssb filters will improve audio quality since all sideband components have the same amount of delay. Knowledge of rf to i-f to detector signal delay in receivers is useful when applying noise blankers of the Lamb or Collins type because the blanking signal must arrive before the noise reaches the blanking gate.

### is it worth the trouble?

Only if you do your own circuit designs or want to know what happens inside that collection of components. Programming is not difficult with the HP-25. Hewlett-Packard supplies a good applications manual free and the examples can give a quick insight to the various functions. The same is true for machines made by Texas Instruments.

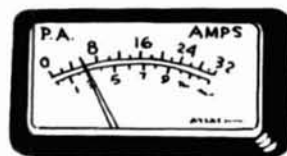
Computer aided design is used extensively in industry for design analysis. Calculator aided design should be equally useful to the amateur. A few extra hours of *testing on paper* will let you know how the circuit works before cutting metal or etching boards. You can spot errors that would otherwise cost money and time.

ham radio



## THE ALL SOLID STATE ATLAS 350-XL

*Its face has many interesting features:*

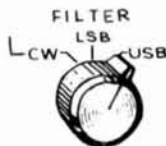


**350  
WATTS  
SOLID  
STATE  
POWER**

P.E.P. and CW input.

### SSB/CW TRANSCEIVER

SSB with PTT or VOX operation and full break-in CW operation.



### CW-LSB-USB FILTER

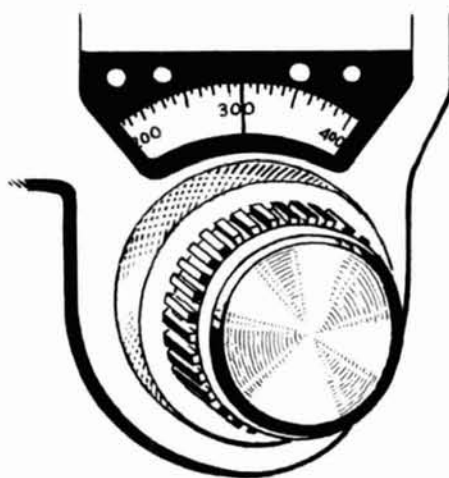
Selection of upper or lower side-band with 2700 Hz bandwidth, 1.6 to 1 shape factor, or 500 Hz CW bandwidth with 2.5 to 1 shape factor.

### A.F. NOTCH



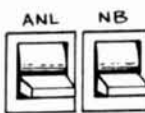
### AF NOTCH FILTER

Provides better than 40 dB rejection of an audio frequency, adjustable from 300 to 3000 Hz.



### ANALOG DIAL SCALE

0 to 500 kHz dial scale in 5 kHz increments. Velvet smooth dual speed tuning, with 18 kHz per revolution of fine tuning control.



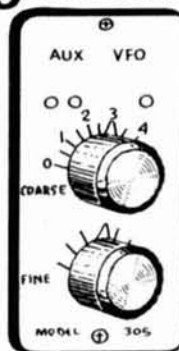
### ANL AND NOISE BLANKER

Automatic Noise Limiter reduces hash type noise interference which is not intermittent pulse type. Blanker effectively reduces or eliminates pulse type noises.



### RECEIVER INCREMENTAL TUNING

Permits receiving up to 5 kHz above or below your transmitting frequency. Especially useful for CW operation or in a net of SSB stations that are on different frequencies.



### PLUG-IN AUXILIARY VFO (Optional)

Can be either a tunable VFO with the same 500 kHz tuning range as primary VFO or a crystal controlled fixed channel oscillator with choice of up to 11 crystal controlled channels.

### 10-160 METERS COVERAGE

Provides a full coverage of all amateur bands in 500 kHz segments.



### AUXILIARY RANGES

Up to 10 additional 500 kHz ranges between 2 and 23 MHz can be added by plugging in auxiliary crystals. (Will not operate between 23 and 28 MHz.)

- ATLAS 350-XL (less options) . . . . . \$995.
- Model DD6-XL Digital Dial Readout . . . \$229.
- Model 305 Plug-in Auxiliary VFO . . . . \$155.
- Model 311 Plug-in Auxiliary  
Crystal Oscillator . . . . . \$135.
- Model 350-PS Matching Power Supply \$229.
- Plug-in Mobile Mounting Bracket . . . . \$ 65.



### DIGITAL DIAL READOUT (Optional)

Provides precise frequency readout within 50 Hz. All L.E.D. Dot Matrix 6 digit display.



**ATLAS  
RADIO INC.**

417 Via Del Monte, Oceanside, CA 92054  
Phone (714) 433-1983  
Special Customer Service Direct Line  
(714) 433-9591



# high-performance 20-meter receiver with digital frequency readout

Design and construction  
of a dual-conversion receiver  
featuring varactor tuning  
in the front end  
and digital display  
of the received  
signal frequency

**Described in this article** is an all-solid-state dual-conversion receiver for 20 meters. It features varactor tuning in the rf, mixer, and high-frequency oscillator and a digital display of the received-signal frequency.

Although the design is for the amateur 20-meter band, it may be easily adapted for a single-band

receiver operating in any amateur or shortwave band between 3 — 30 MHz.

Various LC networks and voltage combinations are used with the high-frequency oscillator, which allows limiting bandwidth to the CW or ssb portions of a band or expanding bandwidth to full amateur-band or shortwave-band segments in the order of 1 MHz.

The receiver portion uses a combination of dual-gate mosfets, fets, bipolar transistors, and ICs. The counter portion uses TTL, low-power TTL, and Schottky TTL logic devices. With suitable selection of HFO and LO frequencies within the capabilities of the Schottky logic upper-frequency limit, the counter may be used up to the 6-meter amateur band with no design changes.

## the receiver

**Fig. 1** is a block diagram of the receiver. It uses the straightforward dual-conversion design approach. Voltage-controlled varactor diodes are used for frequency selection in the HFO and tuning of the rf and mixer input stages. Local and BFO oscillator frequencies are established with crystal control for stability of the i-f. Intermediate frequency amplification and selectivity are obtained with a single integrated circuit in combination with a Collins narrow bandpass mechanical filter (2.1 kHz nominal).

**By M. A. Chapman, K6SDX, 935 Elmview Drive, Encinitas, California 92024**



A simple 5-digit, 7-segment LED display system provides  $\pm 1$  kHz accuracy for the receiver frequency display. It uses input signals from all receiver oscillator sections rather than just the HFO.

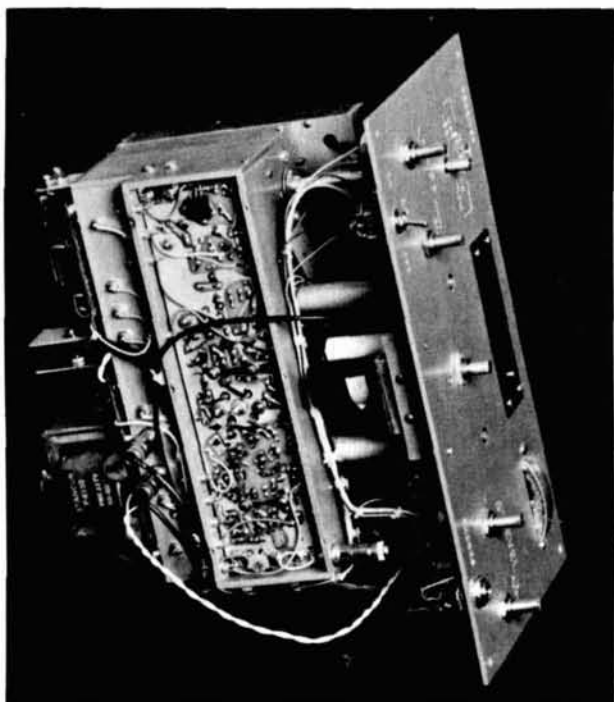
A nominal position is provided in the BFO selector switch to provide for interpolating the received signal resting carrier frequency. Incorporated into the audio system is an active lowpass filter, which minimizes spurious noise and i-f heterodyne signals, thus optimizing the receiver signal-to-noise ratio.

**Frontend.** Fig. 2 illustrates the frontend design. Moderately high Q coils are used in the rf and first mixer input. High Q coils in the rf section provide excellent signal-to-noise ratios, good selectivity, and high initial gain. Back-to-back varactor diodes are used for tuning the rf LC circuits by front-panel potentiometer control of the varactor diode bias voltage.

From fig. 2 we see that the first i-f is 1500 kHz, and the second conversion i-f is 455 kHz. As shown in fig. 2, the gates of the second mixer stage incorporate bias adjustment to optimize both device gain and signal-to-noise ratios. Gate biasing for rf and mixer may not be immediately apparent from fig. 2. Fig. 3 shows how the mosfets in the rf and mixer are biased and the method used to compensate for tolerances in the LC circuits to permit gang tuning of both stages.

The upper section of fig. 3 is a simplified ac model illustrating the tuned-circuit relationships. It's important to note that, from an rf standpoint, the cold end of the LC circuits is at ground potential as are the source and control gates of both devices. The lower section of fig. 3 includes the varactor diode and source-swamping-resistor relationship to the device. Here again, we see that the cold ends of the LC circuits are at ac ground and that the source swamping resistor is shunted to ground.

Since the rf amplifier and mixer are depletion mode devices, you can adjust the input voltage to the gates of Q1 and Q2 so that the gate-to-source bias is approximately  $-0.5$  volt. Tuning the varactor diode is accomplished by applying a positive voltage greater than that required for bias of the gate source



Bottom view of the receiver. A portion of the power supply board can be seen on the left.

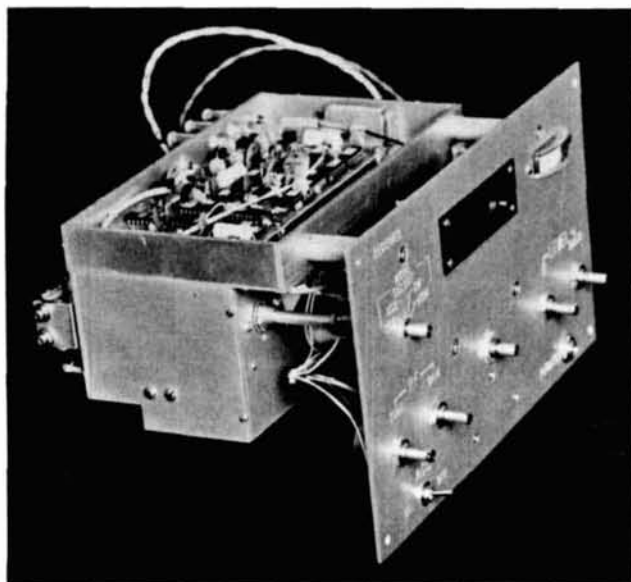
terminations. The varactor must be reverse-biased for it to operate in a nonconductive state and act as a variable capacitance across the inductors. For initial setting of the rf and mixer stages, bias voltage no. 1 should be adjusted for 0.5 volt differential bias to the source voltage point no. 3, with the control gate at maximum voltage (approximately 8 volts dc).

The initial bias and source-point voltages will be approximately  $+0.75$  volt. Examining the voltage divider network in the varactor diode tuning circuit, we see a minimum positive voltage of approximately 2.25 Vdc, providing a 1.50-volt reverse bias in the worst case and an 8 Vdc bias in the high case. You can optimize the voltage-divider circuit after assembly and test to increase or decrease the band-spread capabilities. Tuning the 20-meter band will require about 1.5 volts of differential. If you wish, optimizing can be implemented, so that the differential occurs on the major portion of the potentiometer adjustment range.

To minimize alignment difficulties, Q1 and Q2 should be matched for nominal  $I_{DSS}$  values, so that bias voltages 1 and 2 will require a minimum amount of adjustment to compensate for varactor diode and shunt-capacitance tolerance. Much variation exists between varactor nominal capacitance and capacitance change, with respect to voltage change when tuning the rf circuits. Compounding the problem is the nonlinearity that exists with the diode elements themselves. Since the Q of the rf input and mixer input circuits is quite high ( $\sim 75$ ), any differences be-

Author Chapman has provided much detail in his description of the design and construction of this receiver. The article is in two parts. Part one describes the basic rf and i-f circuits, and part two deals with the digital readout system. The digital readout system may be readily adapted to almost any receiver design. If you're interested in duplicating the receiver without the digital readout, you'll find the information you'll need in the following material. Part two, to be published in a subsequent issue of *ham radio*, wraps up the entire project and provides much useful information on calibration and alignment. Editor.





Side view of the receiver showing the rugged mechanical construction.

tween the diode-versus-voltage capacitance will result in circuit detuning.

Referring to **fig. 2**, the mixer gain control gate (G2) is at a fixed-voltage point and the rf stage uses a variable resistor to control the rf gain. One disadvantage of this scheme is that, as we vary the voltage

limited segments of a band (for example, the CW section), then very little rf **TUNE** adjustment is required. However, if a number of changes are made to the mixer gain, a corresponding adjustment to the **TUNE** control is necessary.

**I-f amplifier.** I-f amplifier gain and bandpass filtering is accomplished with an LM373H IC and a narrow bandpass Collins mechanical filter (**fig. 4**). The LM373H (U1), in addition to providing high i-f gain, also acts as the detector for both CW and ssb. Incorporated in its design is the ability to use agc or external manual i-f gain. An agc-level sensitivity control is included.

The voltage value indicated for initial adjustment of U1 represents an agc threshold setting of approximately 300 microvolts. To provide isolation of the detected audio output to the S meter and audio filter stages, a simple fet amplifier stage is incorporated (Q4). Almost any depletion-type device may be used in this stage by adjusting the source and drain resistors to obtain a voltage gain of approximately 5, as indicated. The minimum source bypass capacitance should be in the order of 10  $\mu$ F.

The Q4 output coupling capacitor should provide a low reactive impedance to the S meter and audio filter input to minimize signal loss at the low (150 Hz) signal levels. However, scaling of the S-meter input

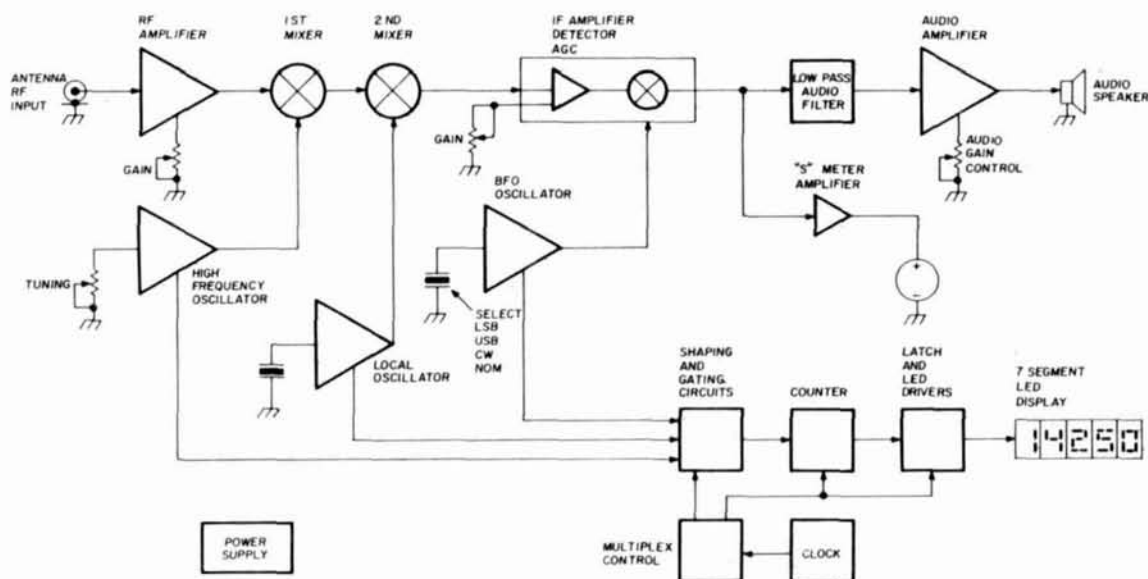


fig. 1. Block diagram of the 20-meter high-performance receiver.

of Q1 gate 2, causing a change in the varactor diode bias and its capacitance, a slight detuning occurs in the LC circuits.

When the gain level is adjusted to any appreciable extent, then the **TUNE** control must be repeaked to maintain overall-receiver gain. When operating over

is possible, since at this point we are only interested in the audio voltage level — very little current is drawn by this or the succeeding stage.

The S-meter amplifier is fully described in reference 1. The builder may elect to use either of the S-meter circuits described in the referenced article

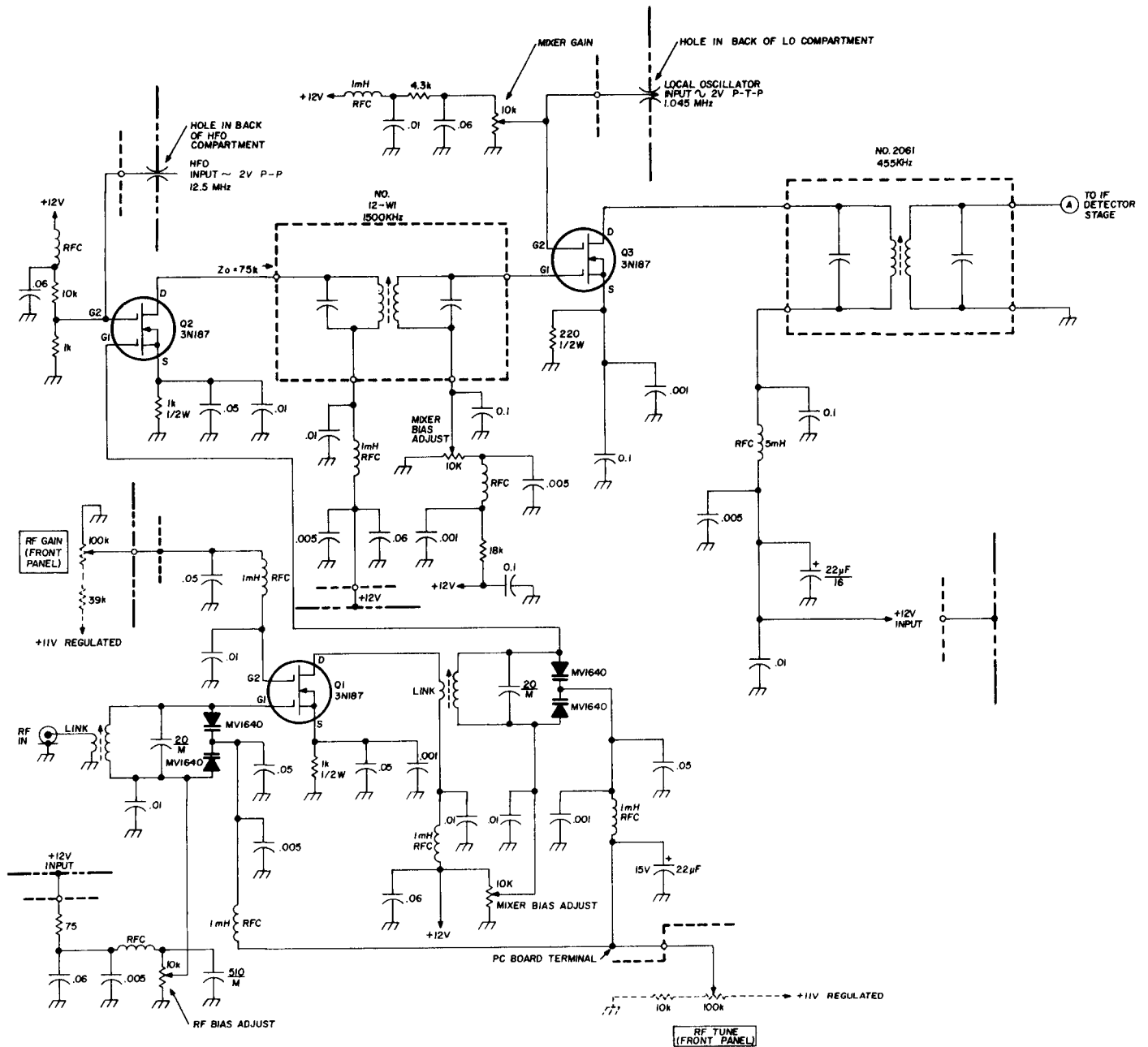


fig. 2. Rf and mixer schematic.

depending upon panel layout preference, and availability of meters.

**High-frequency oscillator.** An extremely high stability HFO is illustrated in fig. 5. This is an adaptation of the design discussed in reference 2 using a Goral buffering scheme. I've used this oscillator technique from 1 to 50 MHz with various LC combinations, changing only the source and emitter load inductors. An alternative device providing equal or better output voltages is the Motorola MPS-A09 bipolar transistor. Since the mixer-stage gate and counter input circuitry are high impedances, very lit-

tle signal loss occurs, and you should expect to see the output levels indicated on the diagram.

Substitution of alternative inductive loads can affect the output voltage levels. Use care to obtain the peak-to-peak values indicated in all oscillator stages.

Tuning of the varactor (VVC, MV1654) is accomplished using a positive voltage of approximately 6 to 7.5 Vdc. Since the first i-f is 1500 kHz, and down conversion is used, the HFO output, then, is between 12.5 MHz - 12.85 MHz to cover the 20-meter band (14 - 14.35 MHz). Considering that 1.5 volts of differential bias on the varactor is necessary, the fre-

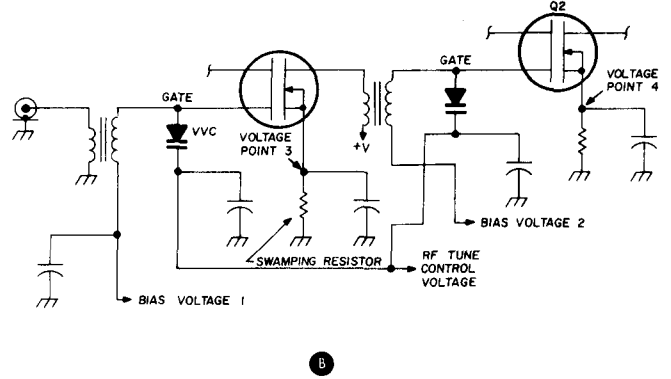
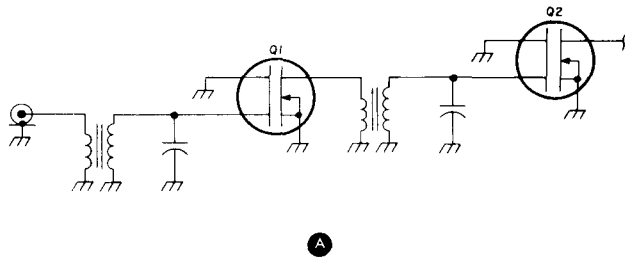


fig. 3. Rf amplifier tuning and bias schematics. Sketch A is a simplified ac model illustrating the tuned-circuit relationships. Sketch B includes the varactor diode and source-swamping-resistor relationships.

quency stability is more sensitive to power-supply ripple variations than the oscillator described in reference 3; therefore, a high-performance voltage reference supply is necessary to maintain a stable voltage on the varactor to minimize frequency drift. Presuming that the power-supply scheme illustrated later is used, and that good packaging and component selection is followed, you can expect a frequency drift of less than  $\pm 100$  Hz/hour after thermal equilibrium.

**Local and beat-frequency oscillators.** The local and beat oscillators are described in figs. 6 and 7 respectively. Simple fet oscillators are used. Many fet substitutes will perform equally as well. The output voltages are as indicated on the schematic. Good-quality parallel-resonant crystals should be used, with only the nominal 455-kHz crystal requiring careful selection of the shunting capacitor, since this

will determine your transmit-frequency reference in the counter display.

Any errors introduced into the local-oscillator center frequency can be compensated by shifting the HFO frequency and tweaking the 1.5-MHz i-f transformer (fig. 2).

Caution note: the LM373H (U1) of the i-f detector stage is sensitive to excessive BFO injection voltages. The nominal input voltage to U1 for BFO detection is 60 millivolts rms. Slightly higher levels will increase the detected audio levels. A too-high injection level will result in audio motorboating and distortion; too low an injection level will result in poor or weak audio detection. To minimize generation of spurious and harmonic frequencies from feeding into other parts of the receiver, generous use is made of RC decoupling and bypass capacitors. Feel free to substitute capacitor values in these circuits with

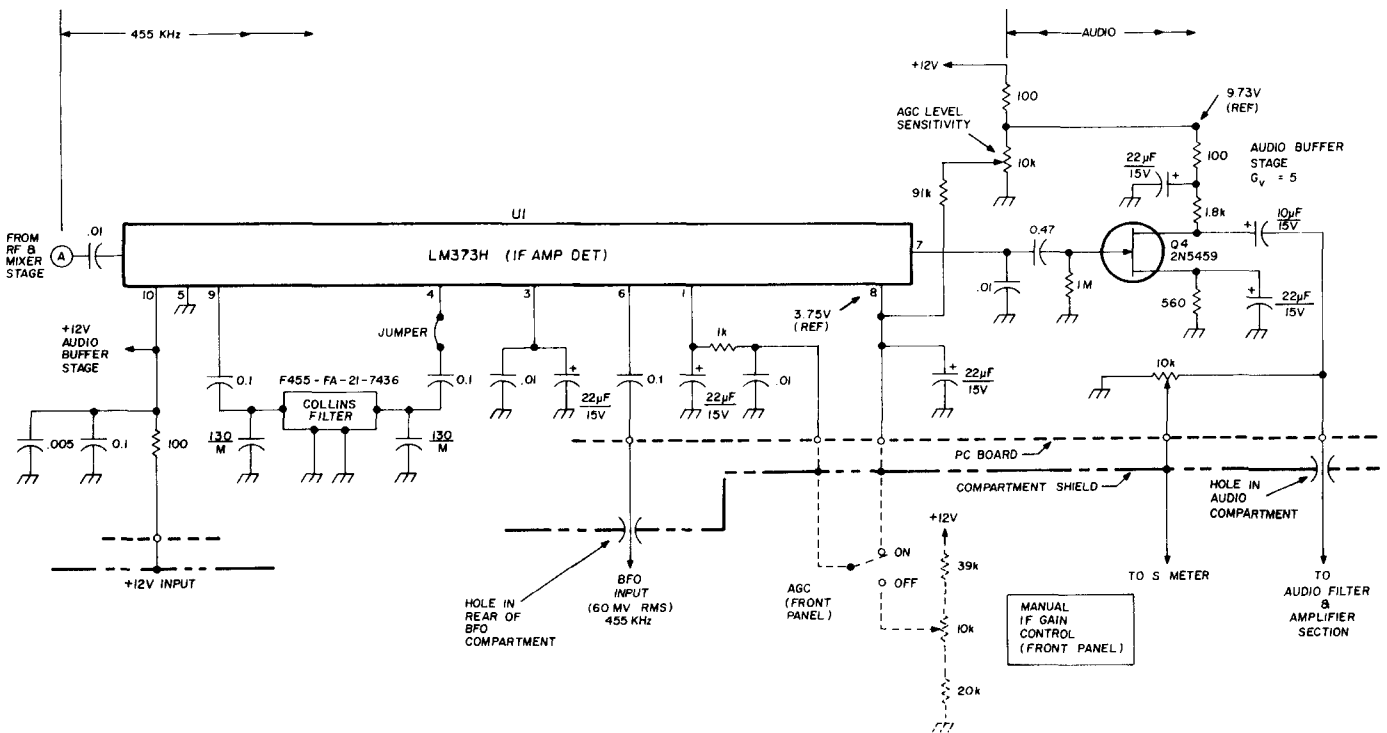


fig. 4. I-f amplifier, detector, and audio buffer schematic.

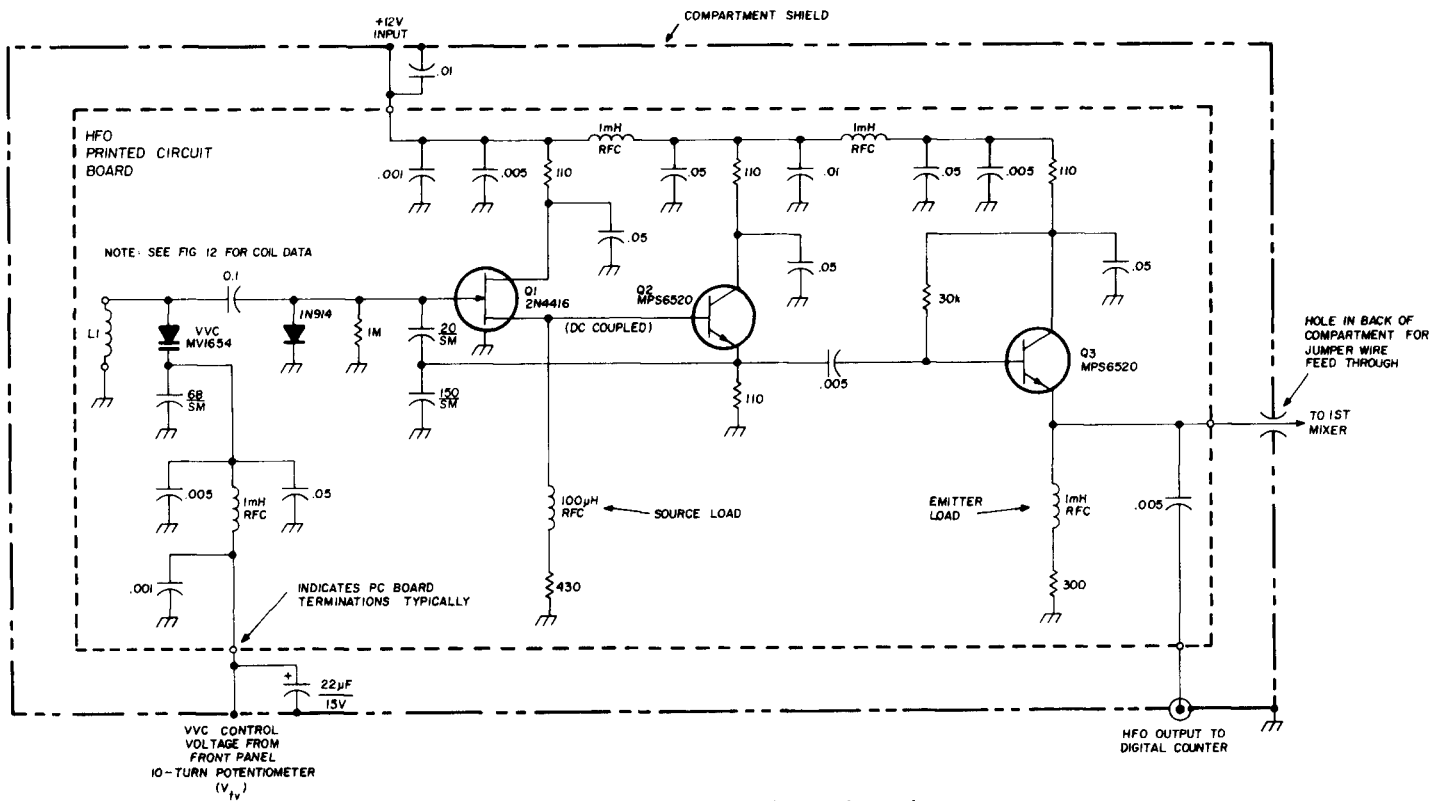


fig. 5. High-frequency oscillator schematic.

whatever is available, so long as the dc input is kept reasonably clean of the oscillator-frequency components.

The LSB and USB crystal frequencies may be determined by either measuring the Collins 455-kHz mechanical filter for the 20-dB passband points or by ordering a filter that has been measured by the manufacturer for the L20 and H20 dB points. An additional description is given in reference 4 and in the alignment and calibration sections of the article.

**Audio filter and amplifier.** The detected audio from Q4 is passed through an active lowpass filter-operational amplifier arrangement and further amplified in a one-stage 2-watt audio amplifier U3 (fig. 8). The U1 and U2 lowpass filter design is discussed in considerable detail in references 4 and 5. Normally, U1 and U2 operate from a plus and minus voltage source; however, a simple voltage-divider circuit on pin 3 of U2 establishes an artificial ground for both U1 and U2. The lowpass rolloff starts at 2500

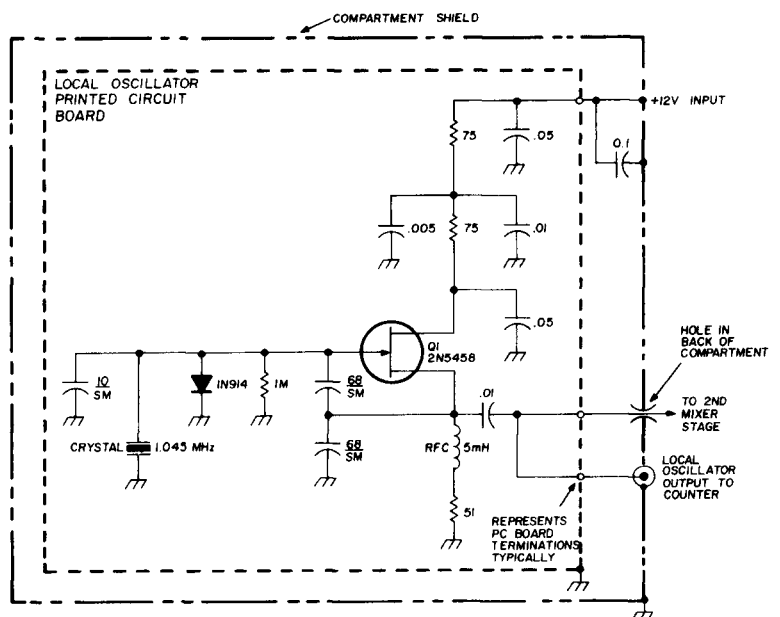


fig. 6. Local-oscillator schematic.

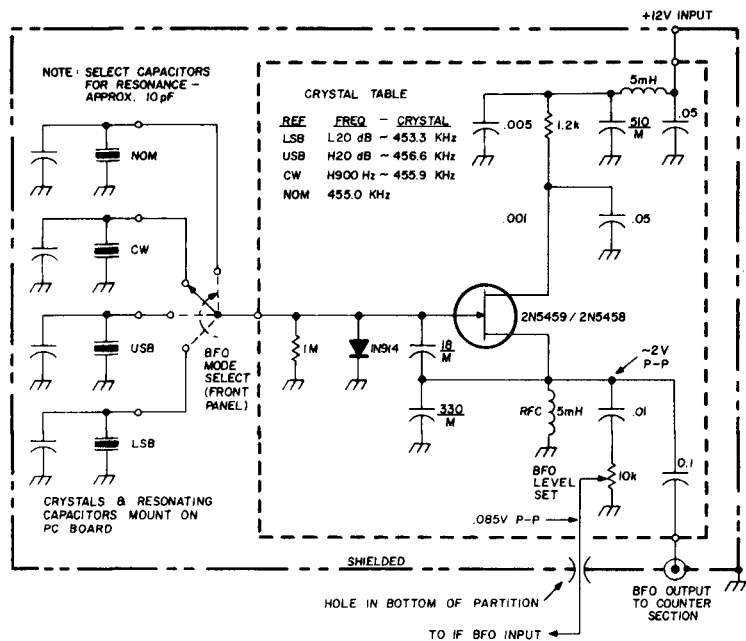


fig. 7. BFO schematic.

Hz, and a 15-20 dB attenuation of all higher audio frequencies is achieved. The normal i-f heterodyne hiss is greatly attenuated, and the receiver overall signal-to-noise ratio is enhanced. An additional high-frequency audio rolloff is achieved by the selection of the 680 pF mica feedback compensating capacitor of U3.

Audio and rf have many common grounding and feedback problems. To minimize circulating ground loops and achieve low-noise performance, a single-

point ground system should be used with the audio circuit. As an aid, those items of special significance are indicated as notes in fig. 8.

Notes 1 and 2 are self-explanatory; note 3 deserves some additional comment. A 1-meg level-set pot is shown between U2 pins 2 and 7. As the name implies, it establishes U1 and U2 output gain in combination. Ideally the gain is unity; however, since we're operating these devices  $\pm 6$  volts dc the overall gain will be in the order of 0.8-0.9. To obtain the best

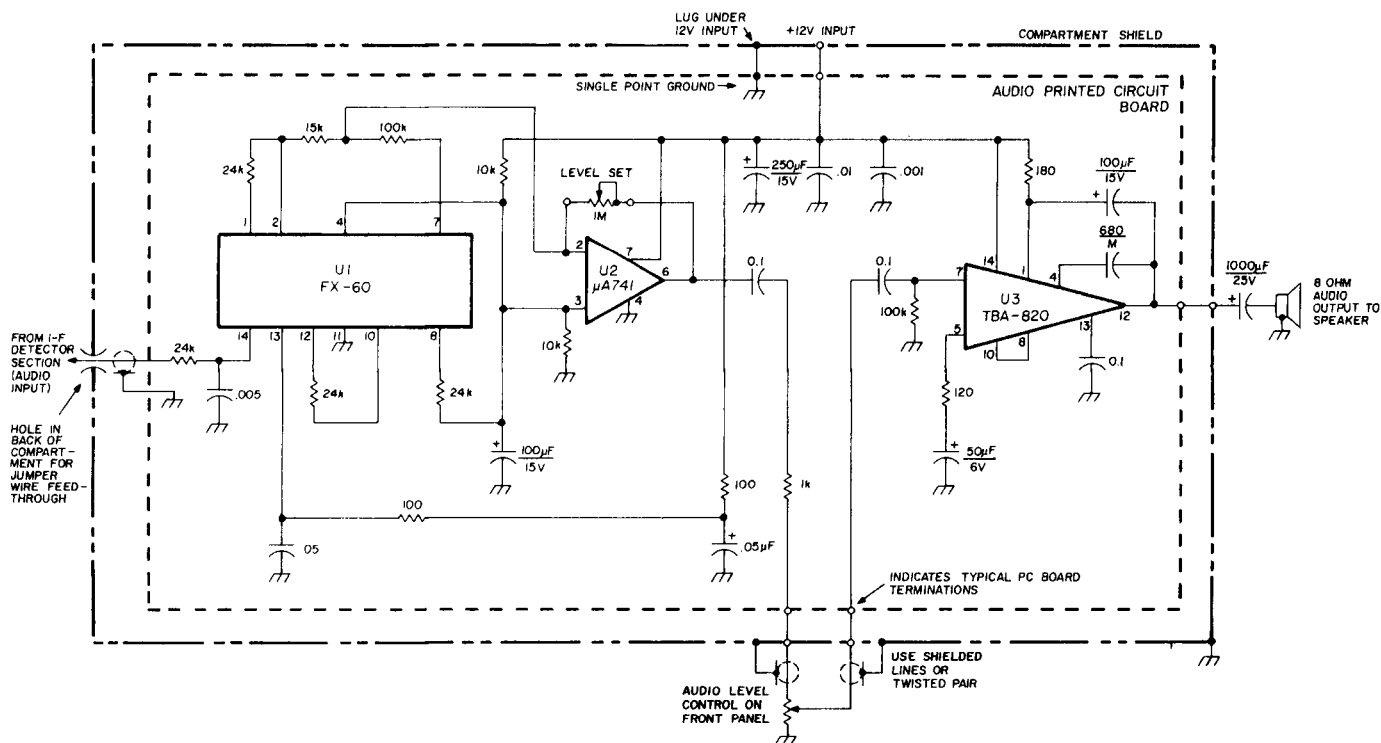


fig. 8. Audio filter and amplifier schematic.

setting for the level set, a low-level 50-100 millivolt audio signal should be coupled to U1 input through a 0.01  $\mu\text{F}$  capacitor while monitoring U2 and U3 output with a high-impedance scope. The level-set pot should be adjusted where the gain is about 90 per cent of maximum over the frequency range 150 Hz-2500 Hz. Then the pot may be removed and a fixed resistor installed with a value closest to that measured on the pot. The value of this resistor will be approximately 100k.

As in the other low-level audio-signal processing circuits, this is not the place to use an inexpensive, exposed wiper-type volume control. The added cost of a sealed, 2-watt type component with the case securely grounded to the chassis and panel will minimize wiper contact noise and ground problems. Use of 1/2-watt resistors in the low-level audio stages has been included in the PC design layout for additional noise control.

**Power supply.** The power supply and high-frequency oscillator varactor control system are illustrated in fig. 9. Three-terminal 7800-series voltage regulators are used for the +12 and +5 Vdc requirements. To minimize power dissipation and provide for a constantly changing current demand from the LED displays, a preregulator/derippler circuit is used ahead of the +5 Vdc regulator. A small amount

of series resistance isolates the display voltage from the +5 volt logic voltage.

To establish a stiff reference voltage for the HFO varactor diode ( $V_{FV}$ ), a precision voltage regulator is used (U2). Ripple rejection is in the order of 80 dB, and voltage stability is in the order of a few millivolts per degree F. Two small 10-turn trim pots allow fine tuning of the high and low end of the 10-turn  $V_{FV}$  voltage pot. A similar voltage control system is described in reference 3. Additional capacitive filtering will aid in the reduction of  $V_{FV}$  ripple content and may be added at your discretion.

Filtering across the  $V_{FV}$  10-turn pot should not be added, because such filtering will increase the HFO control-voltage time constant. Any added filtering should be used ahead of the trimpot or preferably U2.

### construction

Modular PC board construction is used, with each major function individually packaged on a separate board and isolated in an rf-tight housing. The photos clearly illustrate the relative board positions and techniques for interfacing the rf and audio circuits, as well as the method for isolating and developing the +12 source voltage between the receiver stages. Each functional section has its own +12-volt input

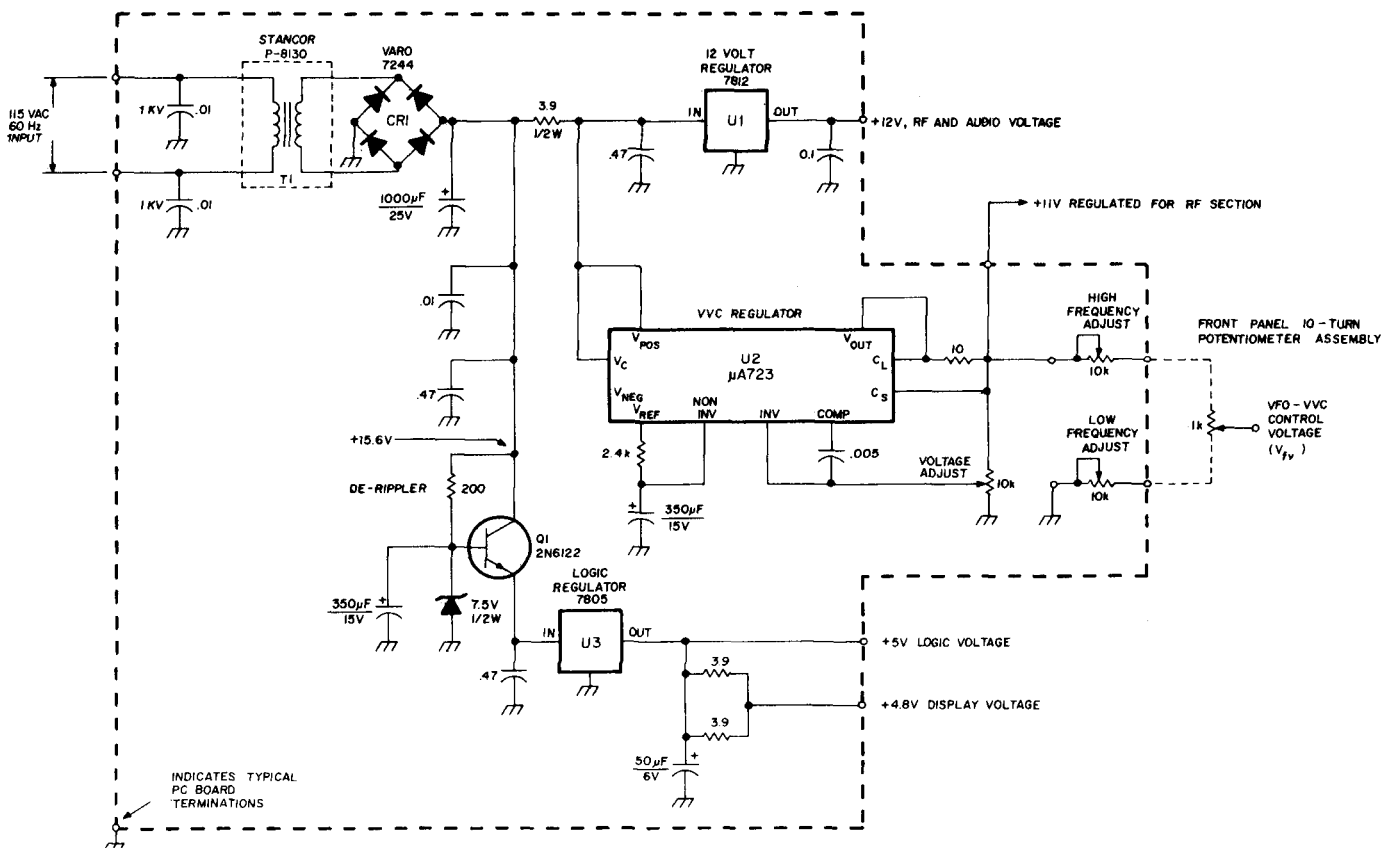


fig. 9. Power-supply schematic.

terminal, which is filtered at the board termination point.

**Front end and i-f amplifier/detector.** The rf, mixer, i-f and detector functions are located on one inline PC board (fig. 10). Heavy, well grounded shields are used between the rf, mixer, and i-f/detector sections, which also provide convenient mounts for the large coils of the rf circuits. Two standard, readily available i-f transformers are used in the drain circuits of Q2 and Q3, which are shielded with their own housings. Many 455-kHz i-f transformers having the same or similar geometry as the 2051 unit used here are available. If necessary, the board could be cut open and the alternative unit mounted in piggyback style.

If you'd like to operate the receiver at frequencies above 15 MHz, the 12-W1 transformer may be opened and the internal padding capacitors changed to allow for a higher first i-f more consistent with a good 10:1 rf mixer frequency ratio. If you elect to use an unprotected dual-gate mosfet device in the rf stage, provisions exist for the installation of back-to-back 1N914 gate-protection diodes; however, at higher frequencies this additional shunt capacitance could materially affect the signal level.

The Collins mechanical filter mounts directly to the board. However, several foreign-made filters of comparable performance are available, which will mount in this area of the board. Short jumper wires can be installed to interface with the input-output pins of the LM373H. Provisions are included on the board for an impedance-matching resistor to be installed in place of the jumper wire input to U1 and the i-f detector from the filter.

Inexpensive 0.1-inch (2.6mm) center trim pots

were used; however, after measuring the desired resistance values required for the S-meter, agc, and bias circuitry, fixed carbon composition resistors mounted vertically to the board could be used.

**High-frequency oscillator.** The high-frequency oscillator PC component layout is shown in fig. 11; fig. 12 shows the winding and coil data. As discussed in reference 3, a variety of LC, varactor-diode combinations are possible for this construction. Provisions exist for mounting two varacaps back-to-back on the board, and space is available for the addition of an extra shunt capacitor. The HFO output signal to the mixer should have the shield terminated on the HFO board and should be unterminated at the mixer input. Note that the board should be *well-grounded* to the chassis. Since the  $V_{FV}$  voltage is at a dc level, there should be no need to use shielded wiring unless an alternative packaging technique required different routing of this wire.

**Local oscillator.** The local oscillator is mounted on an independent PC board, as shown in fig. 13. Wiring and installation is straightforward. Many crystal sizes can be accommodated on this board. Provisions are included for an optional ceramic or air type trimmer capacitor. However, an error of 2 or 3 kHz is not harmful since this error can be compensated for in the final HFO trimming and adjustment. Crystals with low ESR (sluggish) will not operate well in this circuit and may have a slight tendency to drift, so purchase good-quality crystals or use an alternative circuit similar to the oscillator circuit described in reference 4.

**Beat-frequency oscillator.** The beat-frequency oscillator is also mounted on an independent PC

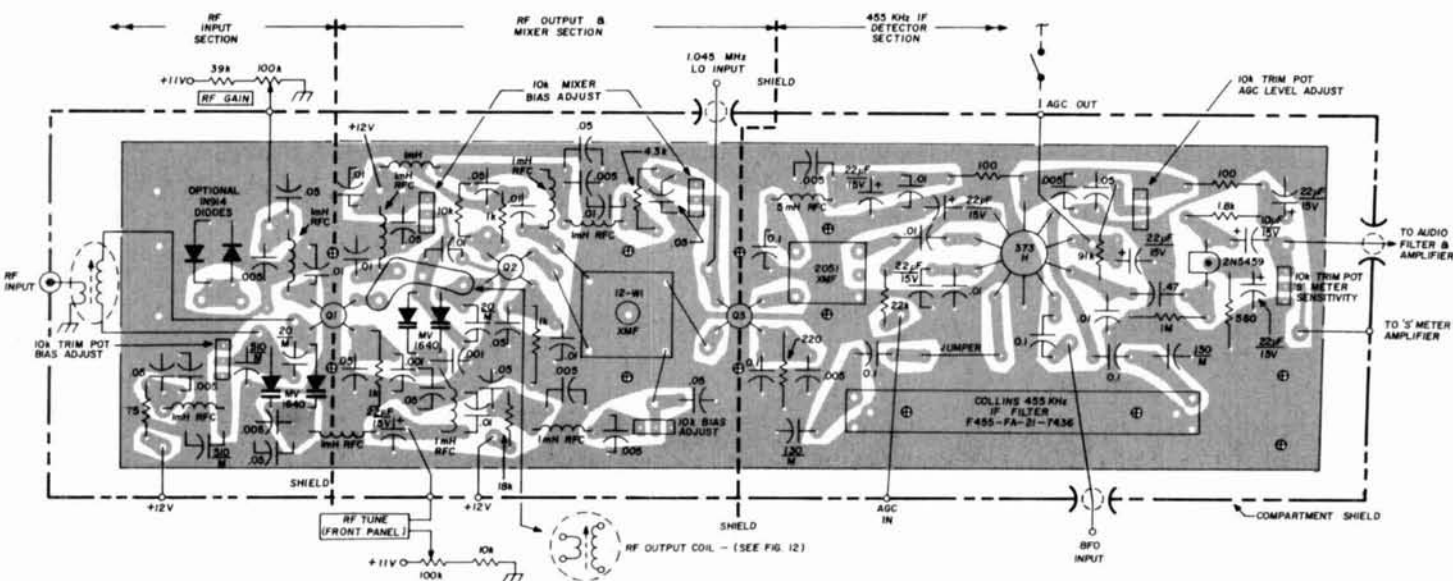


fig. 10. RF amplifier, mixer, and i-f/detector PC-board assembly. A complete set of circuit board layouts is available by sending a self-addressed, stamped envelope to *ham radio*, Greenville, New Hampshire 03048.



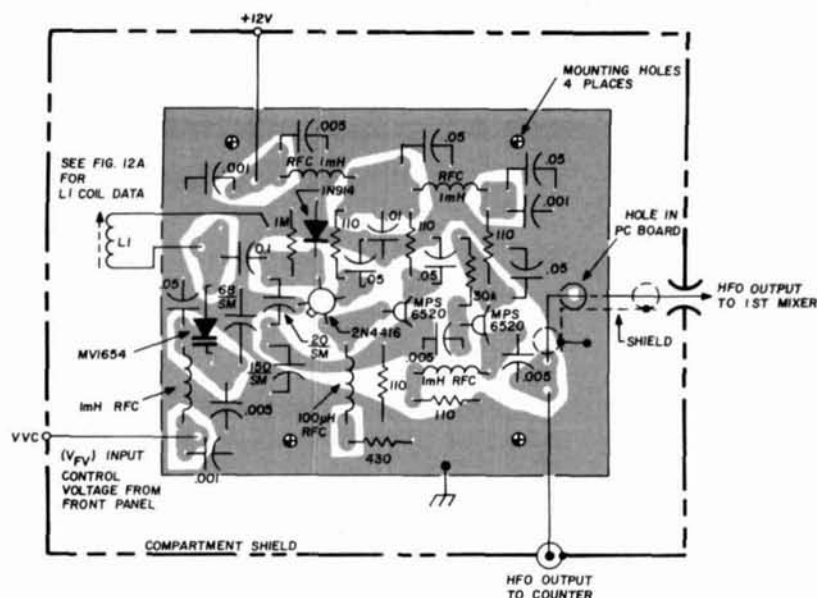


fig. 11. HFO PC board layout. Printed circuit boards for the rf portion of the receiver are available from the author for \$11.25, ppd.

board (fig. 14). The board assembly mounts directly to the switch mounting hardware behind the switch deck. The switch is a Centralab PA-3 with a PA-2 nonshorting 2-6-position deck. Wiring from the PC board to the switch terminals is illustrated in the figure.

As in the local-oscillator board, the crystals are soldered directly to the board; either standard or wire-type crystals may be used. I recommend that all crystals be of the same type to minimize any temperature variations and to provide equal output levels to the counter and mixer input circuits.

As previously mentioned, the USB and LSB crystals depend on the filter 20-dB passband points. With foreign mechanical filters, my experience has

been that the filter center frequency may not be at the nominal 455-kHz resting point, but may vary as much as  $\pm 5$  kHz from this point. If an alternative i-f filter is used, the center-frequency response and that at 20-dB points should be measured as accurately as possible for optimum receiver performance.

The CW crystal is normally  $\pm 800$ -1000 Hz from the center i-f filter frequency. It should be selected according to your preference. Use an audio oscillator to determine the preferred beat oscillator note, when ordering a corresponding BFO CW crystal.

A unique calibration scheme is described in part 2 of this article, which uses the CW and BFO frequency. During tests of the BFO, an accurate measurement of the CW BFO oscillator frequency should be

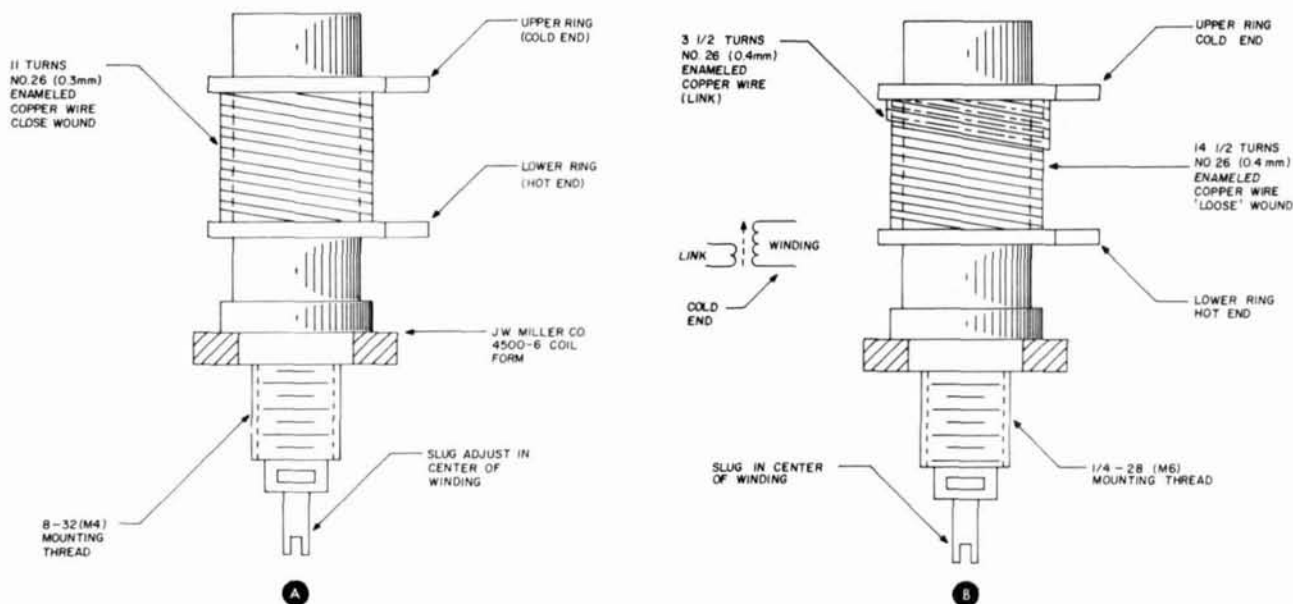


fig. 12. Construction details for the hf oscillator coil, A, and rf and mixer coils, B.

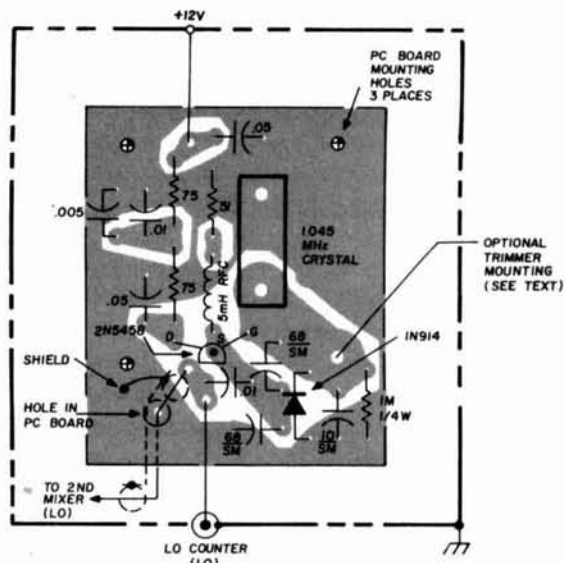


fig. 13. Local oscillator PC-board layout.

made if the crystal frequency is other than  $\pm 1000$  Hz from the filter center frequency. This will allow you to adjust the clock frequency accurately in the counter for the correct display. Both the local oscillator and BFO oscillator PC assemblies should be hard mounted to the chassis, using short aluminum standoffs for good grounding.

**Audio filter and amplifier.** The audio filter and amplifier are included on one PC board assembly, fig. 15. Terminals from U1 and U2 must be removed from the integrated circuits before installation. The FX-60 device may be mounted to a 14-pin DIP socket or soldered directly to the board. Grounding within the audio section is important, so a single-point

grounding scheme illustrated in the component layout of fig. 15 is recommended. The PC board should be isolated from the chassis using nylon hardware. The audio input shielded lead should be grounded at the PC board input and left floating at the detector output. Because of the large size of the audio output capacitor, I recommend that this component be located externally, near the speaker or speaker output terminal.

**Power supply.** The power supply component layout is shown in fig. 16. Heatsinking of Q1, U1 and U3 is mandatory because of the power dissipation of the regulator devices. The power supply photograph illustrates the technique I used, wherein a small piece of aluminum sheet was bent up, with holes drilled in the side and bottom. Since Q1 collector is not operating at ground potential, its case must be insulated from the heatsink. However, the common terminals of U1 and U3 are at ground potential, and their cases may be tied directly to the heatsink. A small amount of silicone grease under the mounting surfaces of these components will aid in thermal conduction. The peak power dissipation values are indicated on the schematic (fig. 9), as a reference for the builder to size the heatsink.

A small aluminum angle bracket is mounted on the end of the PC board assembly to support the HFO trimming resistors; however, these parts can be located at any convenient point on the chassis or next to the 10-turn HFO control on the front panel. The precision voltage regulator, U2, may be mounted to a standard 14-pin DIP socket or soldered directly to the board. Do not forget to add the short jumper wire shown on the back side of the PC board layout of fig. 16.

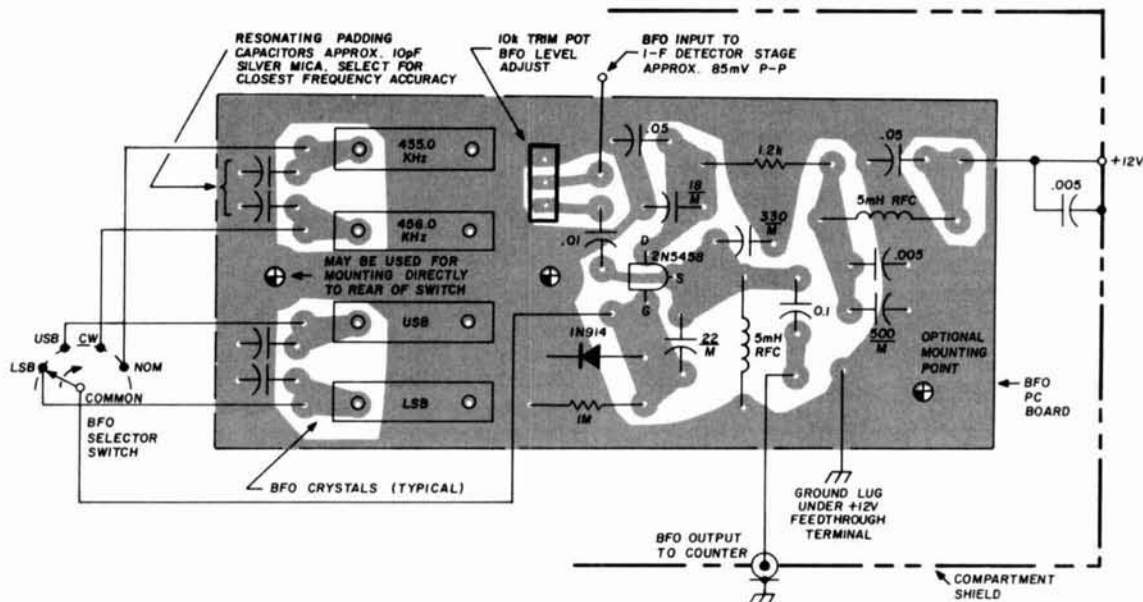


fig. 14. Beat-frequency oscillator PC-board component layout.



Remove the temporary 0.01- $\mu$ F capacitor from G2 of Q3.

2. Temporarily install a 0.01- $\mu$ F capacitor to Q2 gate 1 on the foil side of the board, as in **step 1**. With external controls set in the positions as previously indicated, apply a 1.5 MHz CW signal of 1 millivolt to the 0.01  $\mu$ F capacitor.

Adjust the mixer bias controls for Q2 and Q3 and the 1.5 MHz interstage transformer in the drain circuit of Q2, with power applied. Monitor the audio output as in **step 1**. With the signal level indicated, a minimum detected audio output of 6 volts peak-to-peak should be observed. Remove the 0.01- $\mu$ F capacitor from Q2 gate 2.

3. Temporarily install a 0.01- $\mu$ F capacitor to the drain terminal of Q1, foil side. With the front panel controls set as previously described, apply +12 V power and approximately +6.5 volts on the VVC  $V_{FV}$  voltage point of the HFO module. Apply a 1 millivolt signal of 14.125 MHz to the temporarily installed capacitor and adjust the rf gain and rf tune controls for maximum detected output. Adjust the rf bias pot on G1 of Q1 so that reverse biasing of the tuning diodes is ensured. With a CW signal applied as described, and all bias adjustments optimized, a 4.5-volt minimum peak-to-peak signal should be obtained at the audio monitoring point.

Remove the 0.01- $\mu$ F capacitor from the Q1 drain.

Note that some minor adjustment of the +6.5-volt  $V_{FV}$  voltage will be necessary to obtain conversion of the injected signal but should be somewhat less than 8.0 Vdc if the HFO oscillator slug is properly positioned.

4. Install a 0.01- $\mu$ F capacitor on the antenna input

link of the rf input tuned circuit. Position all controls as previously indicated, apply power and VVC  $V_{FV}$  control voltage. Inject a 30- $\mu$ V signal at 14.125 MHz, unmodulated, to the input capacitor. Adjust the  $V_{FV}$  voltage for obvious beat-detected audio output. Peak the rf tuning and bias adjustments along with the first and second i-f transformers. Repeaking of these controls should be done several times to optimize the detected audio signal.

With a 30- $\mu$ V signal applied as indicated, a clear detected audio output of approximately 7 volts peak-to-peak should be observed. Reduce the input signal to 0.5  $\mu$ V. A 1.0-p-p signal should be observed at the audio output.

Temporarily ground the input to the receiver and observe the audio output, which should be in the order of 0.25 volt peak-to-peak while varying the  $V_{FV}$  voltage from +4 to +12 volts. There should be no observable birdies or spurious audio output spikes over this frequency translation of the HFO. Using these values, the noise figure under test conditions is given by:

$$\frac{\text{signal} + \text{noise}}{\text{noise}} = 20 \log \frac{V_1}{V_2}$$

$$\frac{\text{signal} + \text{noise}}{\text{noise}} = 20 \log \frac{1.0}{0.25} \quad (1)$$

$$\text{signal} + \text{noise} \cong 12 \text{ dB}$$

Additional reduction of the input signal should indicate observable detected signals with input levels of 0.1  $\mu$ V or less.

5. Measure the  $V_{FV}$  voltage required by the HFO varactor diode to produce the differential frequency

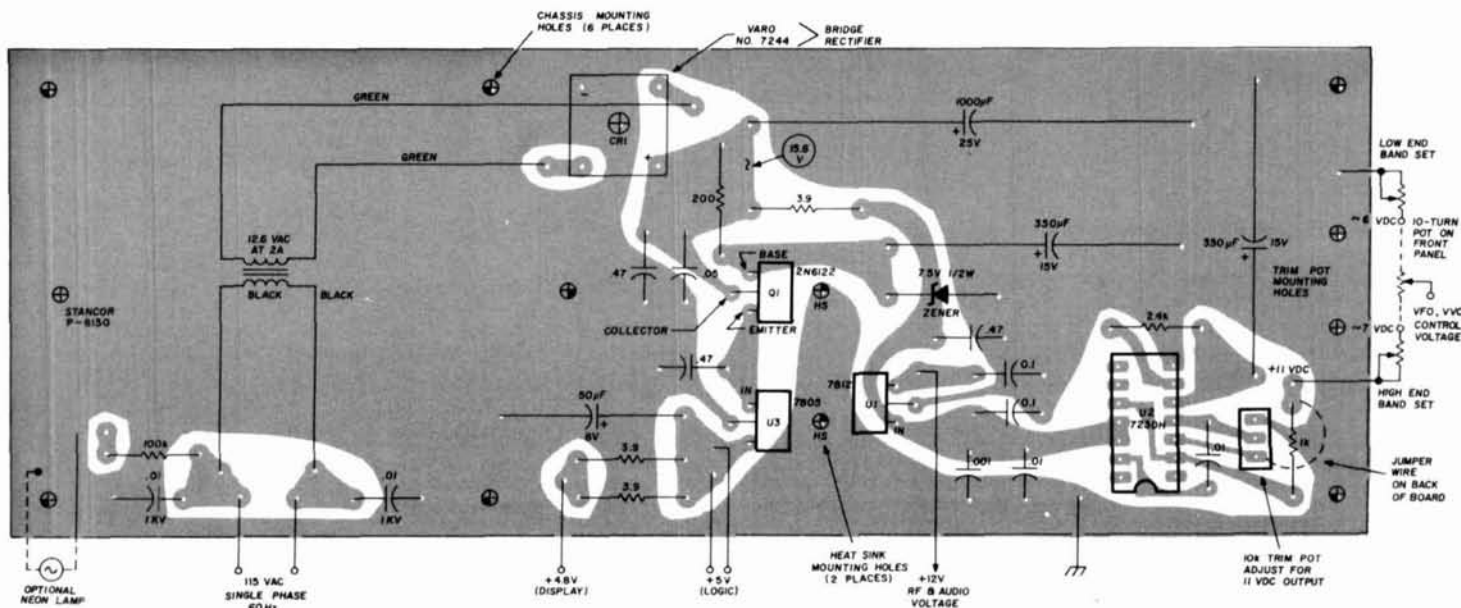


fig. 16. Power supply PC-board layout.



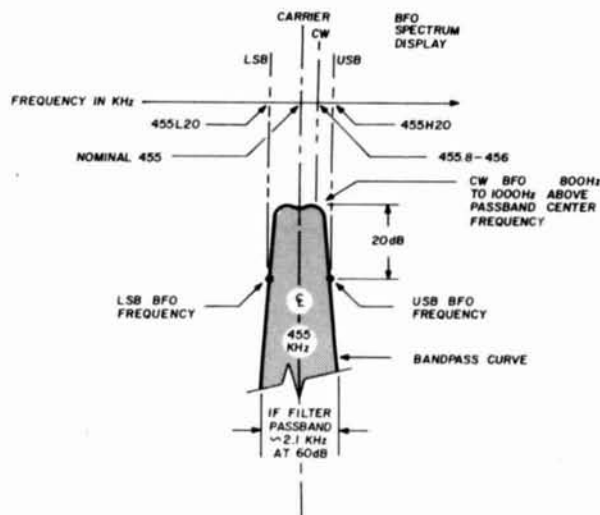


fig. 17. BFO versus i-f bandpass relationship (see text).

range desired; i.e., 12.5-12.85 MHz for standard 20-meter-band use. This voltage should be approximately 6-7.5 Vdc.

Apply ac line voltage to the power supply and adjust the trimpots for the  $V_{FV}$  voltage to correspond to the measured values determined above.

6. Mount the power supply and interconnect the wiring. Using an external signal generator, introduce a 10- $\mu$ V signal of 14.0 MHz and adjust the low end  $V_{FV}$  voltage for detected audio. Do the same at 14.35 MHz, while adjusting the high-end trimpot on the power supply. Repeat as necessary for full-band coverage.

In part two of this article, a simple voltage-divider circuit is discussed, which will allow you to extend the tuning resolution of the HFO. At this point you should be familiar enough with the receiver operation to incorporate any special features desired. In part two, I will present the companion digital display circuit, and offer some useful suggestions.

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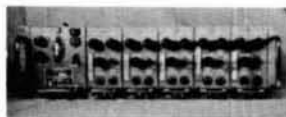
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The Kenwood DG-5 provides easy, accurate readout of your operating frequency while transmitting and receiving.

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The TS-520S incorporates a 3SK35 dual gate MOSFET for outstanding cross modulation and spurious response characteristics. The 3SK35 has a low noise figure (3.5 dB typ.) and high gain (18 dB typ.) for excellent sensitivity.

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ups and when the going gets rough.

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The TS-520S is completely solid state except for the driver (12B-Y7A) and the final tubes. Rather than substitute TV sweep tubes as final amplifier tubes in a state of the art amateur transceiver,

Kenwood has employed two husky S-2001A (equivalent to 6146B) tubes. These rugged, time-proven tubes are known for their long life and superb linearity.

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An effective noise blanking circuit developed by Kenwood that virtually eliminates ignition noise is built into the TS-520S.

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The TS-520S has a built-in 20 dB attenuator that can be activated by a push button switch conveniently located on the front panel.

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A special jack on the rear panel of the TS-520S provides receiver signals to an external receiver for increased station versatility. A switch on the rear panel determines the signal path... the receiver in the TS-820 or any external receiver.

#### VFO-520 — NEW REMOTE VFO

The VFO-520 remote VFO matches the styling of the TS-520S and provides maximum operating flexibility on the band selected on your TS-520S.

#### AC POWER SUPPLY

The TS-520S is completely self-contained with a rugged AC power supply built-in. The addition of the DS-1A DC-DC converter (optional) allows for mobile operation of the TS-520S.

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The TS-520S has 2 convenient RCA phono jacks on the rear panel for PHONE PATCH IN and PHONE PATCH OUT.

#### CW-520 — CW FILTER (OPTION)

The CW-520-500 Hz filter can be easily installed and will provide improved operation on CW.

#### AMPLIFIED TYPE AGC CIRCUIT

The AGC circuit has 3 positions (OFF, FAST, SLOW) to enable the TS-520S to be operated in the optimum condition at all times whether operating CW or SSB.

The TS-520S retains all of the features of the original TS-520 that made it tops in its class: RIT control • 8-pole crystal filter • Built-in 25 KHz calibrator • Front panel carrier level control • Semi-break-in CW with sidetone • VOX/PTT/MOX • TUNE position for low power tune up • Built-in speaker • Built-in Cooling Fan • Provisions for 4 fixed frequency channels • Heater switch.

## TS-520 Specifications

Amateur Bands: 160-10 meters plus WWV (receive only)  
 Modes: USB, LSB, CW  
 Antenna Impedance: 50-75 Ohms  
 Frequency Stability: Within  $\pm 1$  kHz during one hour after one minute of warm-up; and within 100 Hz during any 30 minute period thereafter  
 Tubes & Semiconductors:  
 Tubes ..... 3 (S2001A x 2, 12BY7A)  
 Transistors ..... 52  
 FETs ..... 19  
 Diodes ..... 101  
 Power Requirements: 120/220 V AC, 50/60 Hz, 13.8 V DC (with optional DS-1A)  
 Power Consumption: Transmit: 280 Watts Receive: 26 Watts (with heater off)  
 Dimension: 333(13 1/4) W x 153 (6-0) H x 335(13 (13-3/16) D mm(inch)  
 Weight: 16.0 kg(35.2 lbs)

#### TRANSMITTER

RF Input Power: SSB: 200 Watts PEP CW: 160 Watts DC  
 Carrier Suppression: Better than -40 dB  
 Sideband Suppression: Better than -50 dB  
 Spurious Radiation: Better than -40 dB  
 Microphone Impedance: 50k Ohms  
 AF Response: 400 to 2,600 Hz

#### RECEIVER

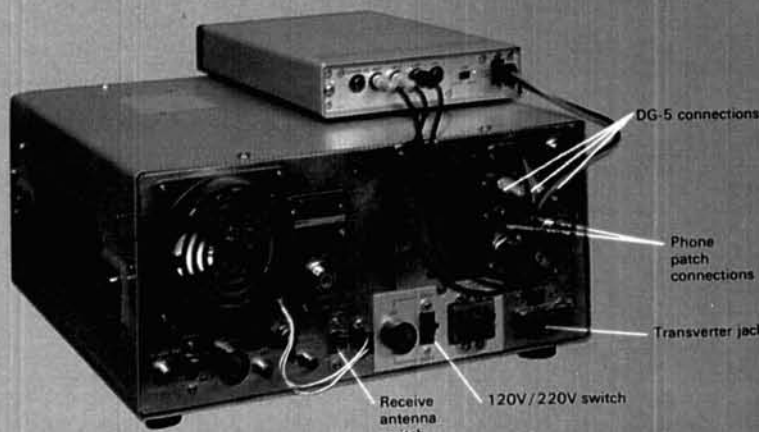
Sensitivity: 0.25  $\mu$ V for 10 dB (S+N)/N  
 Selectivity: SSB: 2.4 kHz/-6 dB, 4.4 kHz/-60 dB  
 Selectivity: CW: 0.5 kHz/-6 dB, 1.5 kHz/-60 dB (with optional CW-520 filter)  
 Image Ratio: Better than 50 dB  
 IF Rejection: Better than 50 dB  
 AF Output Power: 1.0 Watt (8 Ohm load, with less than 10% distortion)

AF Output Impedance: 4 to 16 Ohms

#### DG-5

##### SPECIFICATIONS

Measuring Range: 100 Hz to 40 MHz  
 Input Impedance: 5 k Ohms  
 Gate Time: 0.1 Sec.  
 Input Sensitivity: 100 Hz to 40 MHz... 200 mV rms or over, 10 kHz to 10 MHz... 50 mV or over  
 Measuring Accuracy: Internal time base accuracy  $\pm 0.1$  count  
 Time Base: 10 MHz  
 Operating Temperature: -10° to 50° C/14° to 122° F  
 Power Requirement: Supplied from TS-520S or 12 to 16 VDC (nominal 13.8 VDC)  
 Dimensions: 167(6-9/16) W x 43(1-11/16) H x 268(10-9/16) D mm(inch)  
 Weight: 1.3 kg(2.9 lbs)



## DG-5

The luxury of digital readout is available on the TS-520S by connecting the DG-5 readout (option). More than just the average readout circuit, the counter mixes the carrier, VFO, and heterodyne frequencies to give you your exact frequency. This handsomely styled accessory can be set almost anywhere in your shack for easy to read operation... or set it on the dash board during mobile operation for safety and convenience. Six bold digit display your operating frequency while you transmit and receive. Complete with DH (display hold) switch for frequency memory and 2 position intensity selector. The DG-5 can also be used as a normal frequency counter up to 40 MHz at the touch of a switch. (Input cable provided.)  
 NOTE: TS-520 owners can use the DG-5 with a BK-520 adapter kit.



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# TS-820S

## WITH DIGITAL FREQUENCY DISPLAY

We told you that the TS-820 would be best. In little more than a year our promise has become a fact. Now, in response to hundreds of requests from amateurs, Kenwood offers the TS-820S\*... the same superb transceiver, but with the digital readout factory installed. As an owner of this beautiful rig, you will have at your fingertips the combination of controls and features that even under the toughest operating conditions make the TS-820S the Pacesetter that it is.

Following are a few of the TS-820S' many exciting features.

**PLL** • The TS-820S employs the latest phase lock loop circuitry. The single conversion receiver section performance offers superb protection against unwanted cross-modulation. And now PLL allows the frequency to remain the same when switching sidebands (USB, LSB, CW) and eliminates having to recalibrate each time.

**DIGITAL READOUT** • The digital counter display is employed as an integral part of the VFO readout system. Counter mixes the carrier VFO, and first heterodyne frequencies to give *exact* frequency. Figures the frequency down to 10 Hz and digital display

reads out to 100 Hz. Both receive and transmit frequencies are displayed in easy to read, Kenwood Blue digits.

**SPEECH PROCESSOR** • An RF circuit provides quick time constant compression using a true RF compressor as opposed to an AF clipper. Amount of compression is adjustable to the desired level by a convenient front panel control.

**IF SHIFT** • The IF SHIFT control varies the IF passband without changing the receive frequency. Enables the operator to eliminate unwanted signals by moving them out of the passband of the receiver. This feature alone makes the TS-820S a pacesetter.

\*The TS-820 and DG-1 are still available separately.

# TS-600



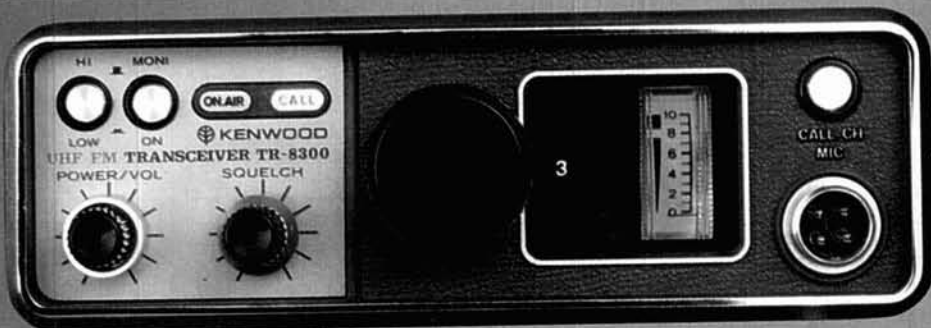
Experience the excitement of 6 meters. The TS-600 all mode transceiver lets you experience the fun of 6 meter band openings. This 10 watt, solid state rig covers 50.0-54.0 MHz. The VFO tunes the band in 1 MHz segments. It also

has provisions for fixed frequency operation on NETS or to listen for beacons. State of the art features such as an effective noise blanker and the RIT (Receiver Incremental Tuning) circuit make the TS-600 another Kenwood "Pacesetter".



# TV-506

An easy way to get on the 6 meter band with your TS-520/520S, TS-820/820S and most other transceivers. Simply plug it in and you're on... full band coverage with 10 watts output on SSB and CW.



# TR-8300

Experience the luxury of 450 MHz at an economical price. The TR-8300 offers high quality and superb performance as a result of many years of improving VHF/UHF design techniques. The trans-

ceiver is capable of F<sub>3</sub> emission on 23 crystal-controlled channels (3 supplied). The transmitter output is 10 watts. The TR-8300 incorporates a 5 section helical resonator and a

two-pole crystal filter in the IF section of the receiver for improved intermodulation characteristics. Receiver sensitivity, spurious response, and temperature characteristics are excellent.

**KENWOOD**  
...pacesetter in amateur radio

# TS-700S

WITH DIGITAL FREQUENCY DISPLAY



Check out the new "built-ins":  
digital readout, receiver pre-amp,  
VOX, semi-break in, and CW sidetone!  
Of course, it's still all mode, 144-148  
MHz and VFO controlled.

Features: Digital readout with "Kenwood Blue" digits • High gain receiver pre-amp • 1 watt lower power switch • Built in VOX • Semi-break in on CW • CW sidetone • Operates all modes: SSB (upper & lower), FM, AM and CW • Completely solid state circuitry provides stable, long lasting, trouble-free operation • AC and DC capability (operate from your car, boat, or as a base station through its built-in power supply) • 4 MHz band coverage (144 to 148 MHz) • Automatically switches transmit frequency 600 KHz for repeater operation. Simply dial in your receive frequency and the radio does the rest... simplex, repeater, reverse • Or accomplish the same by plugging a single crystal into one of the 11 crystal positions for your favorite channel • Transmit/Receive capability on 44 channels with 11 crystals.

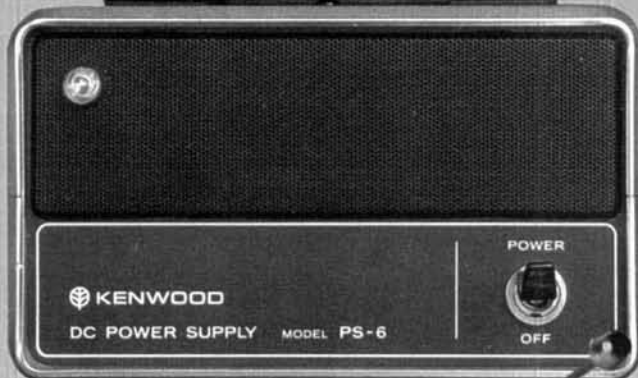
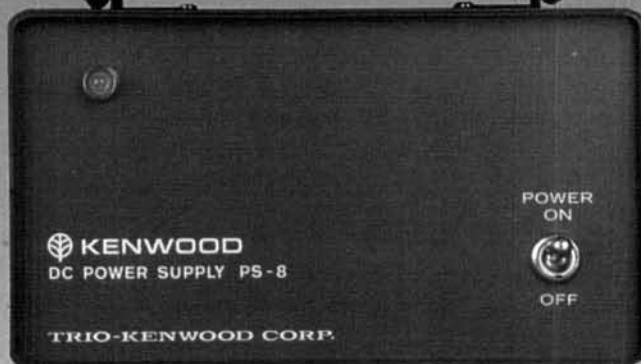


## VFO-700S

Handsomely styled and a perfect companion to the TS-700S. This unit provides you with the extra versatility and the luxury of having a second VFO in your shack. Great for split frequency operation and for tuning off frequency to check the band. The function switch

on the VFO-700S selects the VFO in use and the appropriate frequency is displayed on the digital readout in the TS-700S. In addition a momentary contact "frequency check" switch allows you to spot check the frequency of the VFO not in use.





# TR-7400A

Features Kenwood's unique Continuous Tone Coded Squelch system, 4 MHz band coverage, 25 watt output and fully synthesized 800 channel operation. This compact package gives you the kind of performance specifications you've always wanted in a 2-meter amateur rig.

Outstanding sensitivity, large-sized helical resonators with High Q to minimize undesirable out-of-band interference, and give a 2-pole 10.7 MHz monolithic crystal filter combine to give your TR-7400A outstanding receiver performance. Intermodulation characteristics (Better than 66dB), spurious (Better than -60dB), image rejection (Better than -70dB), and a versatile squelch system make the TR-7400A tops in its class.

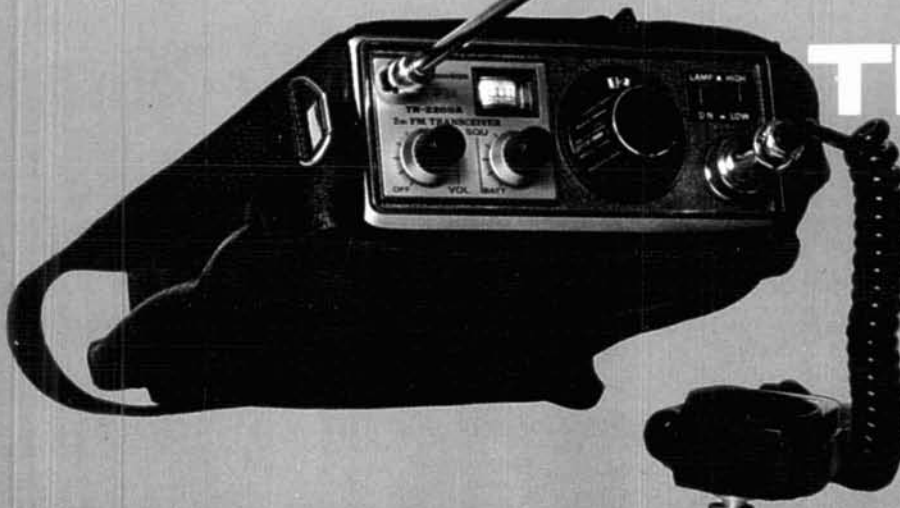
Shown with the PS-8 power supply  
(Active filters and Tone Burst Modules optional)

# TR-7500

This 100 channel PLL synthesized 146-148 MHz transceiver comes with 88 pre-programmed channels for use on all standard repeater frequencies (as per ARRL Band Plan) and most simplex channels. For added flexibility, there are 6 diode-programmable switch positions. The 15 KHz shift function makes these 6 positions into 12 channels. 10 watt output,  $\pm 600$  KHz offset and LED digital frequency display are just a few of the many fine features of the TR-7500. The PS-6 is the handsomely styled, matching power supply for the TR-7500. Its 3.5 amp current capacity and built-in speaker make it the perfect companion for home use of the TR-7500.

# TR-2200A

The high performance portable 2-meter FM transceiver. 146-148 MHz, 12 channels (6 supplied), 2 watts or 400 mW RF output. Everything you need is included: Ni-Cad battery pack, charger, carrying case and microphone.



# KENWOOD

...pacesetter in amateur radio

Kenwood developed the T-599D transmitter and R-599D receiver for the most discriminating amateur.

The R-599D is the most complete receiver ever offered. It is entirely solid-state, superbly reliable and compact. It covers the full amateur band, 10 through 160 meters, CW, LSB, USB, AM and FM.

The T-599D is solid-state with the exception of only three tubes, has built-in power supply and full metering. It operates CW, LSB, USB and AM and, of course, is a perfect match to the R-599D receiver.

If you have never considered the advantages of operating a receiver/transmitter combination... maybe you should. Because of the larger number of controls and dual VFOs the combination offers flexibility impossible to duplicate with a transceiver.

Compare the specs of the R-599D and the T-599D with any other brand. Remember, the R-599D is all solid state (and includes four filters). Your choice will obviously be the Kenwood.



## R-599D

## T-599D

# R-300

Dependable operation, superior specifications and excellent features make the R-300 an unexcelled value for the shortwave listener. It offers full band coverage with a frequency range of 170 KHz to 30.0 MHz • Receives AM, SSB and CW • Features large, easy to read drum dials with fast smooth dial action • Band spread is calibrated for the 10 foreign broadcast bands, easily tuned with the use of a built-in 500 KHz calibrator • Automatic noise limiter • 3-way power supply system (AC/Batteries/External DC) ... take it anyplace • Automatically switches to battery power in the event of AC power failure.





*Fine equipment that belongs in every well equipped station*

#### HF LINES

##### 820 Series

- TS-820S... TS-820 with Digital Installed
- TS-820... 10-160 M Deluxe Transceiver
- DG-1... Digital Frequency Display for TS-820
- VFO-820... Deluxe Remote VFO for TS-820/820S
- CW-820... 500 Hz CW Filter for TS-820/820S
- DS-1A... DC-DC Converter for 520/820 Series

##### 520 Series

- TS-520S... 160-10 M Transceiver
- DG-5... Digital Frequency Display for TS-520 Series
- VFO-520... Remote VFO for TS-520 and TS-520S
- SP-520... External Speaker for 520/820 Series
- CW-520... 500 Hz CW Filter for TS-520/520S
- DK-520... Digital Adaptor Kit for TS-520

##### 599D Series

- R-599D... 160-10 M Solid State Receiver
- T-599D... 80-10 M Matching Transmitter
- S-599... External Speaker for 599D Series

- CC-29A... 2 Meter Converter for R-599D
- CC-69... 6 Meter Converter for R-599D
- FM-599A... FM Filter for R-599D

#### SHORT WAVE LISTENING

- R-300 General Coverage SWL Receiver

#### VHF LINES

- TS-600... 6 M All Mode Transceiver
- TS-700S... 2 M All Mode Digital Transceiver
- VFO-700S... Remote VFO for TS-700S
- SP-70... Matching Speaker for TS-600/700 Series
- TR-2200A... 2 M Portable FM Transceiver
- TR-7400A... 2 M Synthesized Deluxe FM Transceiver

- TR-7500... 100 Channel Synthesized 2 M FM Transceiver
- TR-8300... 70 CM FM Transceiver (450 MHz)
- TV-506... 6 M Transverter for 520/820/599 Series

#### POPULAR STATION ACCESSORIES

- HS-4... Headphone Set
- MB-1A... Mounting Bracket for TR-2200A
- MC-50... Desk Microphone
- PS-5... Power Supply for TR-8300
- PS-6... Power Supply for TR-7500
- PS-8... Power Supply for TR-7400A
- VOX-3... VOX for TS-600/700A

Trio-Kenwood stocks a complete line of replacement parts, accessories, and manuals for all Kenwood models.

#### MORE ACCESSORIES:

Description	Model #	For use with
Rubber Helical Antenna	RA-1	TR-2200A
Telescoping Whip Antenna	T90-0082-05	TR-2200A
Ni-Cad Battery Pack (set)	PB-15	TR-2200A
4 Pin Mic. Connector	E07-0403-05	All Models
Active Filter Elements	See Service Manual	TR-7400A
Tone Burst Modules	See Service Manual	TS-700A; TR-7400A
AC Cables	Specify Model	All Models
DC Cables	Specify Model	All Models



The Kenwood HS-4 headphone set adds versatility to any Kenwood station. For extended periods of wear, the HS-4 is comfortably padded and is completely adjustable. The frequency response of the HS-4 is tailored specifically for amateur communication use. (300 to 3000 Hz, 8 ohms).



The MC-50 dynamic microphone has been designed expressly for amateur radio operation as a splendid addition to any Kenwood shack. Complete with PTT and LOCK switches, and a microphone plug for instant hook-up to any Kenwood rig. Easily converted to high or low impedance. (600 or 50k ohm).

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**KENWOOD**  
...pioneer in amateur radio

# repeater kerchunk eliminator for mobile rigs

The ubiquitous  
555 timer IC  
surfaces again —  
this time in a circuit  
that eliminates  
repeater noise  
in your receiver

Many repeaters, especially those on common channels, appear to be susceptible to endless testing and *kerchunking* by some mobile operators, usually to see if they are either getting into the machine, or if there is a repeater on a particular channel. Most of the time this is harmless, but quite often I've become irritated by so much noise and shut off the rig, thus missing an important call later.

The circuit shown here will eliminate most of these repeater squelch tails from just about any receiver employing its own squelch, but will allow normal communications to pass through. This is accom-

plished by placing the circuit between the receiver squelch gate and the point where the squelch acts on the audio amplifier. When a signal is received, and the receiver squelch gate is tripped, the kerchunk eliminator counts approximately 3 seconds before turning on the audio amplifier. If the received signal is gone before the 3 seconds is up, the radio remains silent, and the circuit resets itself. In this manner, the typical kerchunk will not be heard.

On the other hand, if the received signal lasts for longer than 3 seconds, which usually occurs if the repeater is interrogated, the receiver begins operating normally, squelch and all. Normal operation continues until the rig is turned off, then on again, which resets the kerchunk eliminator to give another 3-second squelch delay in the manner described.

The receiver also begins operating normally, without the 3-second squelch delay, if the operator uses the transmitter in the rig. In this way, a call may be made, and a reply received, without losing part of the message.

## circuit description

This circuit (fig. 1) is designed to work with receivers using a low voltage level to squelch the audio amplifier. If the input and output are inverted using switching stages similar to Q1, the circuit will then work with receivers using a high voltage level to squelch.

The NE-555 timer is wired for use as a monostable multivibrator (one-shot), and is triggered through inverting transistor Q1 and capacitor C1 each time the receiver squelch is tripped, provided that the scr is in the *off* mode. The output of the NE-555 goes

By Robert K. Morrow, Jr., WB6GTM, 9792  
Oma Place, Garden Grove, California 92641

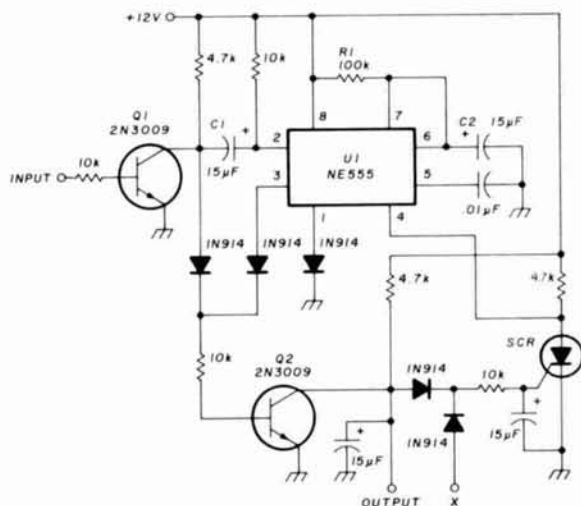


high for about 3 seconds, which is determined by the R1, C2 time constant, and is applied to Q2 base. Transistor Q2, which now acts as the squelch gate, also receives the output of inverting transistor Q1, and remains saturated as long as Q1 is cut off (no incoming received signal) and/or the output of the NE-555 is high (3-second timer delay is activated). When Q2 is in the *cutoff* state, the receiver audio amplifier is turned on, and incoming signals are heard. In addition, the scr is triggered, which eliminates the NE-555 from the circuit, so the squelch may now operate normally through Q1 and Q2. This same result is also accomplished whenever the transmit power bus is activated for any length of time. The entire system is reset when power is temporarily removed from the rig.

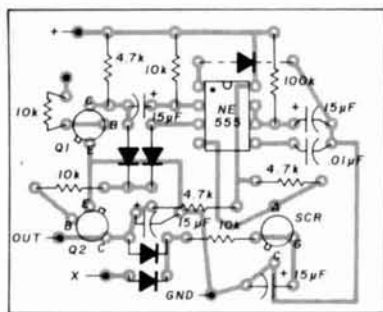
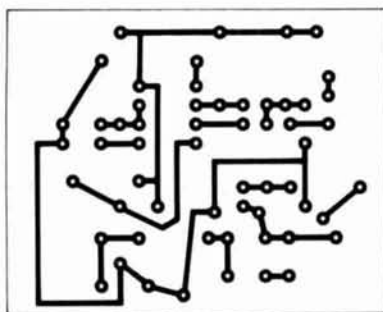
You may have noticed by now that the NE-555 is grounded through a diode. This is required because the forward voltage drop of the triggered scr is too high (about 0.7 volt) to reset the NE-555. By floating the ground of the NE-555 slightly above that of the scr cathode, this problem is eliminated.

## construction and installation

The printed circuit board diagram and parts placement are shown in **fig. 2**. Before beginning construction, make sure that your rig has a place to mount a circuit board of this size and shape. Parts placement is not critical, of course. Mount the PC board some-



**fig. 1.** Schematic of the repeater kerchunk eliminator. If the printed circuit shown in **fig. 2** is used, resistors should be 1/4 watt, and the 15  $\mu$ F capacitors either tantalums or vertical-mount electrolytics. Although a Radio Shack part number is given for the SCR, just about any type that will fit on the PC board will work. Likewise, any npn silicon switching transistor will work for Q1 and Q2. The input is routed from the squelch gate in the receiver, and the output connects to the squelch control point on the receiver audio amplifier.



**fig. 2.** Full-size printed circuit board (foil side) and parts-layout diagrams. The diode which grounds the NE-555 is mounted on the foil side of the PC board.

where in the rig, and connect wires from  $V_{CC}$ , ground, and the transmit power bus from the TR switch to their appropriate places on the circuit board.

Now find the place where the squelch gate controls the audio amplifier in the rig, break the connection here, and run wires from these two points to the circuit board.

## testing

The system may be tested without an incoming signal by turning the squelch control fully counter-clockwise. The characteristic background noise should become audible after about 3 seconds have elapsed. Turn the rig off, then on again, to reset the system with the squelch control set to eliminate background noise. Transmit briefly, and turn off the squelch again. Background noise should be audible with no delay encountered.

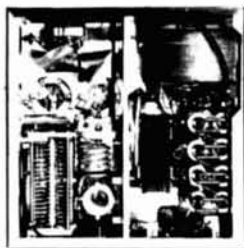
## results

After installing this kerchunk eliminator, I find that my rig is used much more often than before. An added advantage was discovered the next time I took a long trip: Distant repeaters that drifted noisily in and out of squelch did not activate the kerchunk eliminator until I was close enough to get a reasonably good signal. The kerchunk eliminator should prove to be a valuable addition to any mobile rig.

ham radio



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**SIGMA RF-2000 SWR & POWER METER**  
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Freq Range 3.5 - 150 MHz Please do not confuse the RF2000 with similar appearing lower priced units - RF2000 is an individually calibrated professional quality instrument - Unequaled at many times the price - Size 7" (w) x 2 1/2" (h) x 2 1/3" (d).



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## NEW! FMSC-2 SCANNER FOR KDK FM-144

14 CHANNEL PROGRAMMABLE  
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## NEW! 7400 SCANNER

FOR KENWOOD TR-7400A  
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**FMSC-1 - \$169**



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FMSC-1 Scanner for KDK FM 144 and 7400 Scanner II for Trio Kenwood TR 7400A.  
• Full scan 146 and 147 MHz consecutively or 1 MHz, or any MHz range • Scan rate: 1 MHz/2 seconds adjustable • Controls: Scan/Hold, Latch/Delay, 600 KHz offset (off, up, down), program 1 MHz • Simple installation.



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FMTD 1	Private Call Decoder for use with and Programmed by Any Touch Tone Pad	\$129
SC 12A	Audible Tone Encoder Decoder	\$119
FMSC 1	Scanner - Random Any Range	\$169
FMSC 2	Scanner - Programmable 14 Channels	\$109
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FMDF-1	Offset Option Kit - 2 Extra Positions. Crystals Required	\$19
FMDF 2	±1 MHz Offset Option Kit (No Crystals to Buy)	\$19
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Antenna Impedance Matching Network. Copper ribbon-wound, silver plated variable inductor. Heavy duty 7000 volt variable output capacitor. 10,000 volt fixed capacitors. Silver plated RF conductors. Large precision, easy-to-read dials. 360° readout. Overload protection for SWR meter.

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- **FREQUENCY RANGE:** Receive: 144.00 to 148.995 MHz, 5 KHz steps (1000 channels). Transmit 144.00 to 148.995 MHz, 5 KHz steps (1000 channels) + MARSCAP.\*
- **FULL DIGITAL READOUT:** Six easy to read LED digits provide direct frequency readout assuring accurate and simple selection of operating frequency.
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- **FULL AUTOMATIC TUNING OF RECEIVER FRONT END:** DC output of PLL fed to varactor diodes in all front end R-F tuned circuits provides full sensitivity and optimum intermodulation rejection over the entire band. **No other amateur unit at any price** has this feature which is found in only the most sophisticated and expensive aircraft and commercial transceivers.
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- **DUPLEX FREQUENCY OFFSET:** 600KHz plus or minus, 5KHz steps. Plus simplex, any frequency.
- **MODULAR COMMERCIAL GRADE CONSTRUCTION:** 6 unitized modules eliminate stray coupling and facilitate ease of maintenance.
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## NEW! 6 METER FM50-10SXRII

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Introductory Price \$389.00



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and other equipment  
using solid-state devices

It seems that vhf repeater activity is the only game in town nowadays. However, with the many transceivers in use, many of which were probably purchased for mobile work, many amateurs have opted to use the rig in the house powered by ac line voltage. Now comes the hitch: a *good* power supply at reasonable cost.

The power supply described here, which I call the "gutless wonder," surely answers this need. Take a

look at the schematic and you'll understand why I call it the gutless wonder: parts count is very low, but specifications are very high. Output is rock steady at  $13.7 \pm 0.7$  volts dc using line voltage between 98 and 128 Vac. Regulation is within tenths of a volt, from zero to 5 amperes. The design includes short-circuit, overcurrent, and overvoltage protection. Because of the small parts count, a PC board isn't needed. A couple of small 6-lug terminal strips do the job for mounting most components, and a 4-lug strip is used for ac-line wiring. Simple, but effective!

## regulator

The heart of the supply is one of the 3-terminal regulator ICs currently available. Not long ago, I spent many hours working out empirical formulas to determine a circuit that would most efficiently provide proper output voltage with protective circuitry. Invariably problems occurred with tolerances and temperatures, which made trimming controls mandatory. Today, all you have to do is choose a voltage and current and, lo and behold! You can buy a small piece of plastic containing three leads that will do the job — the overall size is about 1 inch by 0.4 inch (25 by 10mm) including leads.

Included in this little device are overcurrent and thermal-protection circuits as well as tight regulation characteristics. The family is known as the 7800 series IC, made by Motorola, Fairchild, Signetics, and others. Many variations are available based on fixed output voltage, maximum allowable current, and packaging. **Table 1** shows some of the devices

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table 1. Rundown of some regulator ICs presently available for use in the power supply.

regulator type	package	Maximum load (amperes)	load current regulation (percent)	P <sub>D</sub> (free air) watts
78XXC	TO3	1.5	2	3.0
78XXC	TO220	1.5	2	2.0
78MXXC	TO39	0.5	2	1.0
78MXXC	TO220	0.5	2	1.0
78LXXC	TO92	0.1	2	0.7
78LXXC	TO39	0.1	2	0.8
77XXC	TO220	0.75	2	2.0
77XXC	TO39	0.75	2	1.0
209	TO3	1.0	2	3.5 (Fixed 5V output)
309	TO3	1.0	2	3.0 (Fixed 5V output)
723C	TO100	0.15	0.6	0.85
723C	TO116	0.15	0.6	1.0

standard output voltages: 5, 6, 8, 12, 15, 20, 24. The 7700 series has an additional 20 volts.

presently available. In most cases, the chip must be mounted on a heat sink. The basic circuit using such a chip is shown in fig. 1. What could be simpler?

### the power supply

I wanted a minimum of 5 amperes at 13.6 volts for my power supply. No regulator chip is available that will handle this requirement, therefore it was necessary to add an external pass transistor to handle the required current. Also, no chips were available that provide exactly 13.6 volts (the resolution of this problem is discussed later).

The type 109-series regulators, familiar to most amateurs, uses a series-pass npn transistor to increase current-carrying capability. The circuit described here uses a pnp type MJ2955, which is the complement of the ubiquitous 2N3055. Any pnp transistor with a minimum  $h_{fe}$  of 20 or more at 4 or 5 amperes, and a rated dissipation of more than 150 watts, will be adequate for Q2. The limiting factor will be temperature rise of the transistor when mounted in your heat sink.

The gutless wonder schematic is shown in fig. 2. No chips were available for the required voltage, so the regulator IC was put on a voltage pedestal, which is the secret of success in this supply. I used an 8-volt regulator chip arbitrarily; alternative values of resistance for R3, R4 are given should you wish to

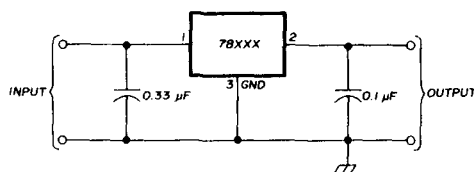


fig. 1. Basic circuit of the three-terminal voltage-regulator.

use a 12-volt regulator chip. Including all tolerances, the resulting output voltage was exactly as required.

The regulator chip specifications include a 5% tolerance. My output measured 7.8 volts, which is the average from the meter readings I used. If your supply output is off a couple millivolts, so be it.

### pedestal voltage

The pedestal voltage,  $E_p$ , is the voltage added to the rated chip voltage. It is approximately

$$E_p \approx I_p R4 + I_q R4$$

where

$$I_p \approx \left[ \frac{E_o}{R3 + R4} \right]$$

$$E_o \approx E_{chip} + E_p$$

$$I_q = \text{typical chip quiescent current (4.3 mA)}$$

Considering the interdependent parameters involved, it's best to use 40 mA for  $I_p$ . Operating the pedestal current at this value eliminated temperature and  $I_q$  variations prevalent among the various regulator chips.

### circuit protection

As mentioned above, the 7800-series regulators are overcurrent protected, but the external pass transistor is not, hence the reason for adding one more pnp transistor, Q1, a 2N6049. This transistor should have a current rating of 2 amperes because, when turned on, it must carry the "short-circuit" current of the regulator chip, which is about 250 mA. R2 turns on Q1 at a specified current. R2 consists of ten 1.2-ohm 1/2-watt resistors in parallel to provide 0.12 ohm. When the load current reaches 5.4 amperes, Q1 turns on and its collector removes drive to Q2, causing the output voltage to decrease to zero.

Another feature of building the supply overcurrent protection in this manner is that, by adding another 1-ohm resistor in parallel with R2, the current limit can be increased to 6 amperes. Adding two 1.5-ohm resistors instead will increase the limit to 6.25 amperes; adding two 1-ohm resistors to R2 increases the current limit to 6.7 amperes. If you must go above 8 amperes, however, change the regulator chip to a 7808.

### heat sink

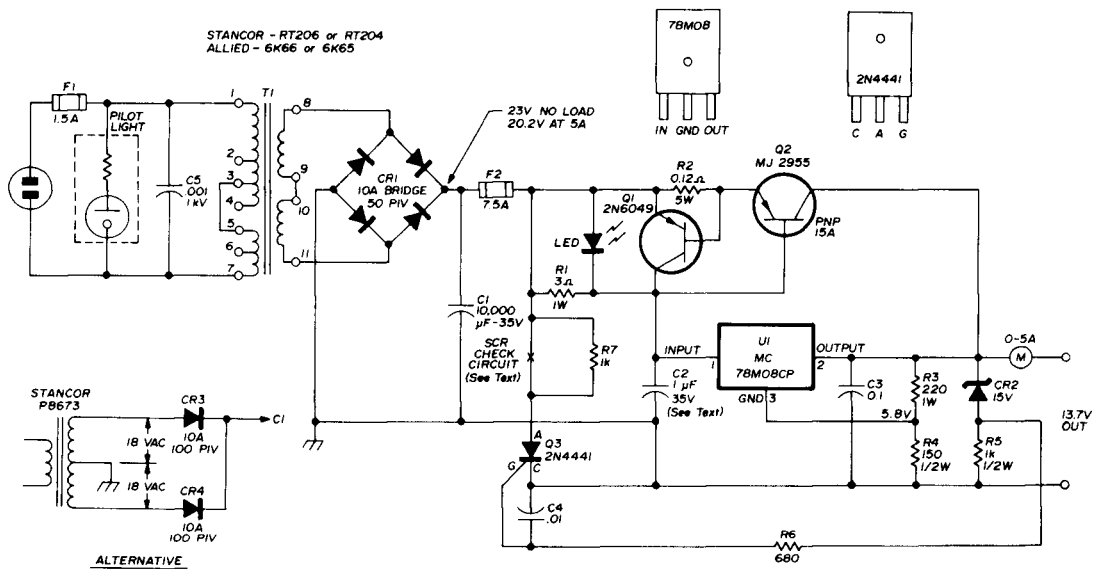
Transistor Q1 is a 40-watt device in a TO66 case, with an  $h_{fe}$  of 20 at 1.5 ampere. Transistors Q1 and Q2 are mounted on a heat sink. The heat sink specified is ideal for this application, because the mounting holes are predrilled for both transistors. The bad news is that the heat sink isn't anodized; therefore both devices *must* be insulated from the heat sink. Be sure to use oxide-filled silicone grease (type DC 340) on *both* sides of the mica insulator. Use shoulder washers to insulate the transistor-

mounting screws. Remember that the transistor cases are above ground, so avoid contact with external objects that may cause them to short circuit to ground.

### operating mode

This power supply operates in the so-called constant-voltage, current-limited mode. Let's be sure we understand what these fancy words mean.

The current through the pass transistor is limited by the value of R2; however, when the load is a low value of resistance or dead short circuit, a path to ground through the transistor causes the current to continue to flow, although it is limited. A voltage across Q2 exists, depending on the transformer secondary voltage, the electrolytic capacitor value, the transformer secondary resistance, and the impedance of the diodes in the bridge. In my supply this voltage turned out to be 16 volts. Multiply this voltage by the current, which is 5.4 amperes, and you'll find that the transistor is dissipating close to 90



- |          |   |               |  |
|----------|---|---------------|--|
| C1       | 10k μF, 35V electrolytic                                      | R7            | 1k, 1/2 watt   |
| C2       | 1 μF, 35V tantalum  | T1            | multitap transformer. (For 6 amperes, Allied 6K66 or Stancor RT206; for 4 amperes, Allied 6K65 or Stancor RT204)   |
| C3       | 0.1 μF discap   | U1            | MC78M08CP (8V); 78M12 (12V)  |
| C4       | 0.01 μF discap  |               |  |
| C5       | 0.001 μF, 2kV discap  |               |  |
| CR1      | bridge rectifier, 10A at 50 PIV                               | <b>Notes:</b> |  |
| CR2      | 15V, 5% Zener   | 1.            | Q1, Q2 are mounted on Radio Shack part no. 276-1361 heat sink. Mounting hardware: Radio Shack 276-1370, 276-1371.  |
| CR3, CR4 | 10A, 100 PIV  | 2.            | U1, Q3 must be insulated from chassis.   |
| R1       | 3 ohms, 1 watt  | 3.            | Open jumper across R7 for checking crowbar circuit (see text).   |
| R2       | 0.12 ohm, 5 watt (ten 1.2-ohm 1/2 watt resistors in parallel) | 4.            | LED short-circuit indicator must be a gallium-arsenide phosphide (GAsP) device; Vf approximately 1.8 volts.  |
| R3       | 220 ohms, 1 watt (alternative for 12V chip, 300 ohms)         | 5.            | T1 can be 18 Vac at 4 amperes for full-wave bridge rectifier. For a full-wave center-tapped circuit use Stancor P8673 or equivalent (see alternative circuit). |
| R4       | 150 ohms, 1/2 watt (alternative for 12V chip, 39 ohms)        |               |  |
| R5       | 1k, 1/2 watt  |               |  |
| R6       | 680 ohms, 1/2 watt  |               |  |

fig. 2. Power-supply schematic. The voltage-pedestal method is used to obtain desired output voltage.



watts! You'd better believe that the transistor gets *damn hot*, so the addition of the LED overcurrent indicator (described below) becomes more meaningful. If you need a higher capacity, at the very least mount the power devices on a *larger* heat sink!

### transient response

C2, C3 improve chip transient response. I've also found that C2 is a must to prevent oscillation under certain conditions. C2 can be anything from 0.33  $\mu\text{F}$  and higher. Tantalum capacitors are recommended for their high-frequency bypass characteristics. If you can't find a tantalum capacitor, use a minimum of a 10- $\mu\text{F}$  electrolytic with a 0.01- $\mu\text{F}$  discap in parallel.

### overvoltage protection

A means of cutting off the power supply if an overvoltage condition occurs is the most important protective device I could add. Some transceivers have this protection built in — others don't. The thought of zapping a string of hard-to-find transistors in the transceiver for lack of a simple protective circuit is scary. The overvoltage-protection circuit shown is simple but effective — I know, because I tried it under dynamic operating conditions, and both primary and secondary fuses blew when 18 volts was applied to the meter end of zener CR2. The scr, Q3, is an 8-ampere rms device and I saw it do a job on the fuses! The scr turn-on time is 1 microsecond.

Capacitor C1 should be 10k  $\mu\text{F}$  at 35 volts. It can be made up of several caps in parallel if necessary. I've used capacitance as low as 3k  $\mu\text{F}$ , but the ripple voltage increased to a value higher than I cared to under high-current load conditions.

Transformer T1 was obtained from Allied Radio. A transformer with a secondary voltage of about 18 V at rated current is ideal but hard to come by. We must pay dearly for the multiple taps on the transformer, but I have the utmost confidence in the scrounging abilities of my fellow hams. Because of the intermittent nature of transmitter operation, a 3- or 4-ampere current rating should suffice for T1.

### construction

Photographs show the method of construction. Most of the wiring is no. 18 (1mm) wire to eliminate voltage drops. A separate terminal strip is used to mount the ten 1/2-watt resistors. As mentioned earlier, only two 6-lug terminal strips are required for mounting all the other components. A separate 4-lug strip is used for the 117-V wiring.

Both the regulator chip and the crowbar circuit scr are mounted on the bottom of the cabinet. Both must be insulated from the chassis using the mica washer supplied with the device. Use silicone grease

here also. The regulator chip will handle up to 500 mA; however, above 200 mA the MJ2955 handles the output current. The MJ2955 and 2N6049 are both mounted on, but isolated from the heat sink with the wiring between the two made at the heat sink. Only four wires are needed from the terminal strip on the back cover through a hole in the cover to the power transistors. If you'd like to add a luxurious touch to your supply, install a 25 Vdc volt-meter and a 5-10 amp ammeter.

### checkout

Testing is done before connecting the supply to your rig. Turn on the supply and check the output voltage. If it doesn't come out right, note the voltages indicated in fig. 2. With so few parts involved, problems are usually caused by defective transistors. If you have power resistors, hook them up and check regulation. The output voltage shouldn't drop until you draw somewhat higher than 5 amperes, depending on the value of R1.

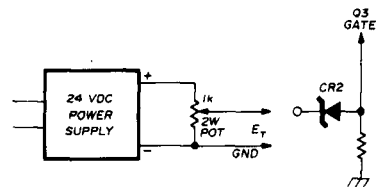


fig. 3. Test setup to determine exact trip point of the SCR crowbar circuit in fig. 2.

If you wish to check out the crowbar-circuit operation for the exact trip point, set up an external supply as shown in fig. 3. Disconnect CR2 from the output bus and remove the jumper from across R7. Connect a voltmeter between the scr anode and cathode. Turn on the supplies and rotate the arm of the pot toward the high-voltage end of the pot. Watch the voltage across the scr. When the test voltage fires the scr, the voltage across the scr will drop to about 1 volt. Measure the voltage between the pot arm and ground ( $E_T$ ); this is the trip voltage. Remember to reconnect the zener and reinstall the jumper across R7.

The LED overcurrent indicator is turned on by the voltage across R1. It serves as a warning that something is wrong. If it lights up, turn off the supply and check the equipment connected as a load. Be sure you are using a GAsP LED — not a GaP; the voltage drops across the two are different. Fairchild, Monsanto, Litronix, and Hewlett-Packard devices are GAsP; Opcoa LEDs are GaP.

So now you have it. An excellent piece of equipment that will perform flawlessly under all conditions without jeopardizing your expensive transceiver.

ham radio



# The DRAKE TR-33C



\$229.95

## Amateur VHF FM Transceiver

### DRAKE TR-33C SPECIFICATIONS

**GENERAL:** • **Frequency Coverage:** 146-148 MHz, 12 channels (2 supplied: 146.52 and 146.94). Crystal determines receive frequency. • **Transmit frequency offset** for repeater operation determined by 5-position switch: Simplex, +600 kHz, and -600 kHz supplied; any two additional offsets available with accessory crystals. • **Power requirements:** 13.0 volts dc  $\pm$  15% external supply OR internal battery supply. • **Current Drain (Batteries):** Squelched receive: 30 mA; transmit: 400 mA. External supply: above plus 45 mA for channel switch indicator lamp. • **Antenna:** 50 ohm external antenna through SO-239 connector OR screw-on telescoping whip antenna supplied, may be replaced with rubber helix antenna. • **Dimensions:** 5.5" x 2.8" x 8.5" (13.8 x 5.8 x 21.6 cm). • **Weight:** 4.4 lbs (2 kg).

**RECEIVER:** • **Sensitivity:** less than .5  $\mu$ V for 20 dB noise quieting. • **Selectivity:** +30 kHz adjacent channel rejection greater than 75 dB. • **Modulation acceptance:** at least  $\pm$  7 kHz. • **Intermodulation Rejection:** 70 dB referenced to sensitivity level. • **First IF:** 10.7 MHz with monolithic crystal filter. • **Second IF:** 455 kHz with ceramic filter. • **Audio Output:** nominal 1 watt at less than 10% distortion into 8 ohm built-in speaker or external speaker.

**TRANSMITTER:** • **Rf Output Power:** 1.5 watts minimum with 13.0 volts dc supply. • **Frequency Deviation:** Direct frequency modulation adjustable to at least  $\pm$  7 kHz deviation, factory set at  $\pm$  5 kHz. • **Separate microphone gain and deviation adjustments** • Drake 1525EM Push Button Encoding Mike can be used direct with no modification.

- **Hand Held Convenience, 12 Channel Capability**
- **SCPC (Single Crystal Per Channel) Frequency Control**
- **Lower Receiver Battery Drain**
- **Expanded Portable Antenna Choice**

• 12 Channels—only one crystal per channel provides simplex OR repeater operation on ANY channel, 2 channels supplied. 5 transmit offset positions, 3 supplied. • All FET front-end crystal filter for superb receiver intermod rejection. • Small convenient microphone included. • New lower power drain circuit on squelched receive. • Nicad rechargeable batteries supplied. • Built-in battery charger. • Ac and dc power cords supplied. • Telescoping screw-on antenna supplied, rubber helix optional. • Channel indicator light when using external dc supply. • Carry strap supplied. • Meter Indicates receive strength, xmit output, or battery voltage. • External speaker jack on rear panel. • Auxiliary jack on rear panel—may be used for tone-pad connections, etc. • Traditional R.L. Drake service backup.

### DRAKE TR-33C ACCESSORIES

#### Drake AA-10 Power Amplifier

10 dB power increase greatly adds to the transmitting distance covered by any 2-meter fm transceiver running up to 1.8 watts output

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**Drake 1525EM, microphone with tone encoder — \$49.95**  
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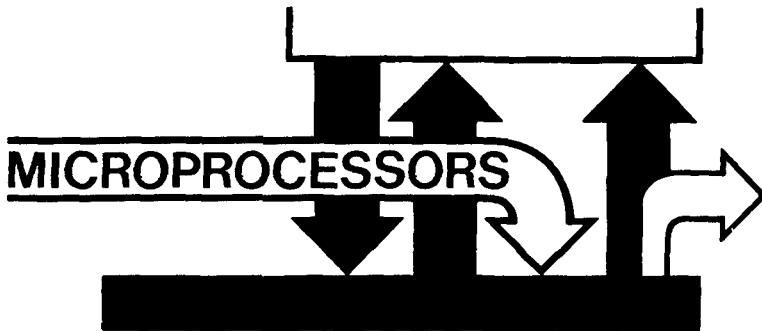
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## data converters: the microprocessor and the amateur

In the future, the microprocessor will be faced with many new and unique amateur radio applications. Unfortunately, though, a large problem exists when trying to interface the digital world of the microprocessor to the analog world of amateur radio. Of the numerous articles written on the microprocessor, many assume interfacing a foregone conclusion, being contained within the microprocessor. Nothing could be further from the truth! This article will provide the necessary guidance to fill this void by demonstrating how data converters perform this valuable interface.

Two types of data converters will be discussed; one changes voltage to a digital code and the other performs the opposite function, transforming a digital code to an analog voltage or current. The former is an analog-to-digital converter (ADC), while the latter is a digital-to-analog (DAC). The digital code is in the format necessary for processing by the microprocessor. In effect, the two devices provide a means by which the microprocessor can acquire analog information, massage it, and deliver an output, in analog form, to an external source or terminal capable of controlling or displaying a function of the original analog input.

It may appear that a number of circuits or black

boxes other than a microprocessor can do this. Certainly, but remember, this type of circuit is a fixed design, its cost is high, and extremely costly if hardware changes are required to change functions. The microprocessor/data converter combination is superior due to its low initial cost (by comparison) and the flexibility of being able to handle a multitude of assignments with no change in hardware. The microprocessor/data converter system is used in industry to control such variables as temperature, flow, pH, viscosity, and weight of a liquified processed chemical. Furthermore, if the process formula is ever changed the hardware is left intact while the program is altered. It is this feature that makes the microprocessor/data converter system attractive.

Choosing the correct ADC or DAC is based to a great extent on the type of analog input and output to be associated with the respective data converters. There are many types of data converters that provide an assortment of functions, but those most applicable to amateur radio are the integrating and successive approximation ADC, and the voltage/current and multiplying DAC. A description of the functional peculiarities of each type is necessary to fully understand their application.

### digital-to-analog converter

Fig. 1 illustrates a simple  $n$ -bit binary DAC. The digital input is applied to the terminals labeled LSB to MSB. Each digital input drives a fet switch that connects the binary weighted summing resistors to the reference or to ground depending on the individual state of each of the digital inputs. Note that by virtue of the R-2R resistor configuration, binary weighting is achieved as the current flowing through each resistor is divided by a factor of two at each junction. With this scheme, the impedance as seen by the op

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amp is constant and only two resistor values are required.

The output voltage ( $E_o$ ) is directly related to the number of switches which are connected to the reference by the 1 applied to the digital input. On the other hand, a zero applied to the digital input grounds the R-2R resistors, resulting in zero voltage at the output of the DAC. Thus, all 1s would give a maximum voltage at the  $E_o$  and all 0s, of course, is a binary code which produces an output voltage directly proportional to the digital code. This type of DAC delivers output voltage by virtue of the op amp inserted at the summing point and will, in most cases, fill the need of most amateurs. A current DAC does not contain an output op amp and delivers a current to its load.

The current DAC, due to its fast settling time and small glitches, is ideal when the interface is with a CRT display. The glitches are voltage spikes on the output that are caused by the switching transients. They are particularly large at the major transitions, i.e., going from all 1s to all 0s and vice versa. One method of reducing the spikes is to insert a lowpass filter before the display; another is to use a deglitcher after a current DAC. This is essentially a sample-and-hold type circuit, usually built from discrete components.

There may be times when it's necessary to multiply a digital word by a range of analog voltages to pro-

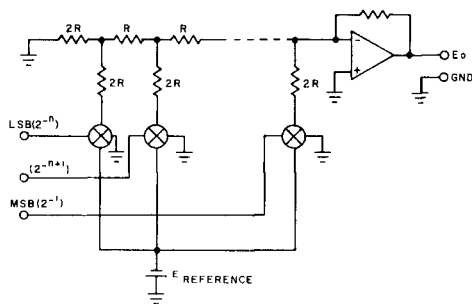


fig. 1. Schematic diagram of a basic digital-to-analog converter. The fet switches connect the 2R resistors to either ground or the reference voltage.

duce an output voltage or current representing their product. This is accomplished through the use of a multiplying DAC (MDAC) in which the internal reference is supplemented by an analog input. Of course, it's possible to use the MDAC as a conventional voltage or current DAC by applying an external reference voltage to the analog input terminals. This becomes particularly advantageous when more than one DAC is used in a system. A number of MDACs can share the same reference source, thus saving money on the cost of a conventional DAC and at the same time

making the stability characteristic of each MDAC identical to one another by virtue of the common reference voltage.

## analog-to-digital converter

The successive approximation ADC is shown in fig. 2 and functions as follows. First, the most significant bit (MSB) of the DAC is turned on by the control logic, and the output is compared to the ana-

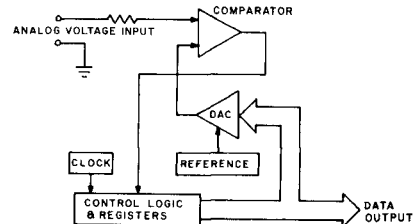


fig. 2. Block diagram of a successive approximation type analog-to-digital converter. The analog voltage is compared to an internally generated voltage. The control circuitry that operates the internal DAC also generates the final digital output.

log input voltage. If the comparator determines that the input is less than the DAC output, the bit (MSB) is turned off. If it is greater than the DAC output, it is left on.

The next MSB is then turned on and the same sequence of events repeated adding to the previous bits whether left on or turned off. This process is continued until a digital code (binary, 2's complement, offset binary, etc.) is formed, producing a voltage output from the DAC that in turn produces zero output from the comparator. In short, the output voltage from the DAC equals the analog input voltage to the ADC.

The state of the code present at the output registers is now a digital representation of the input analog voltage. Actually, this digital output does not cover each finite voltage applied to the input but a quantized incremental voltage step, the number of which is determined by the resolution of the ADC. An ADC with a resolution of 12 bits, for example, would have 4096 discrete quantized voltage levels or digital states. A 10-bit unit would have 1024, an 8-bit, 256.

The integrating ADC has a much slower conversion speed than the successive approximation type, but is a less complicated device and therefore, less expensive. It is used primarily with a slowly changing analog input as from a thermistor, thermocouple, or strain gauge input. An additional advantage of most integrating ADCs is their ability to convert in 16.67 microseconds, giving them exceedingly high common mode rejection to 60 Hz.

This type ADC, as shown in fig. 3, integrates the

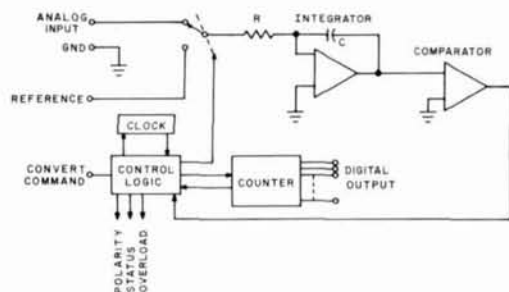


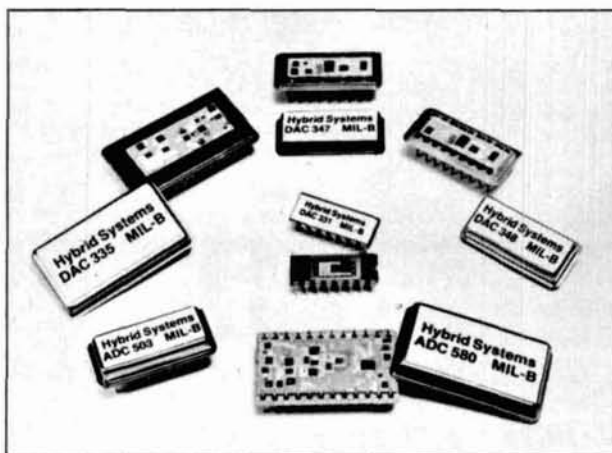
fig. 3. An integrator type ADC is used for slowly varying analog inputs.

analog input signal for a fixed period of time determined by a counter. The resulting integrated voltage is returned to zero by integrating a reference voltage of the opposite polarity. The resultant time of the integrator to return to zero as measured by the counter is proportional to the average value of the analog input over the integration period. Pulses from the counter are loaded into a register and deliver a specific output code to the microprocessor. ADCs of this type frequently have other options such as polarity indication, over-range output, ratiometric measurement capability, and auto zero. They are the basic ingredients of a digital panel meter and the digital voltmeter.

### choosing the right converter

Speed is a major consideration; this is known as settling time for DACs and conversion time for ADCs. In the former case, the time it takes a DAC to reach its rated output voltage/current after strobing is of prime concern when considering the response of the circuit it feeds.

The DAC, of course, does not respond coincidentally with its command to convert. It takes time for the fet switches to close and the op amp to reach its proper output magnitude. ADC conversion time is



selected as a function of how rapidly the input analog voltage varies. A general rule of thumb requires the conversion time to be at least twice that of the input frequency in order to digitally reproduce the input analog voltage.

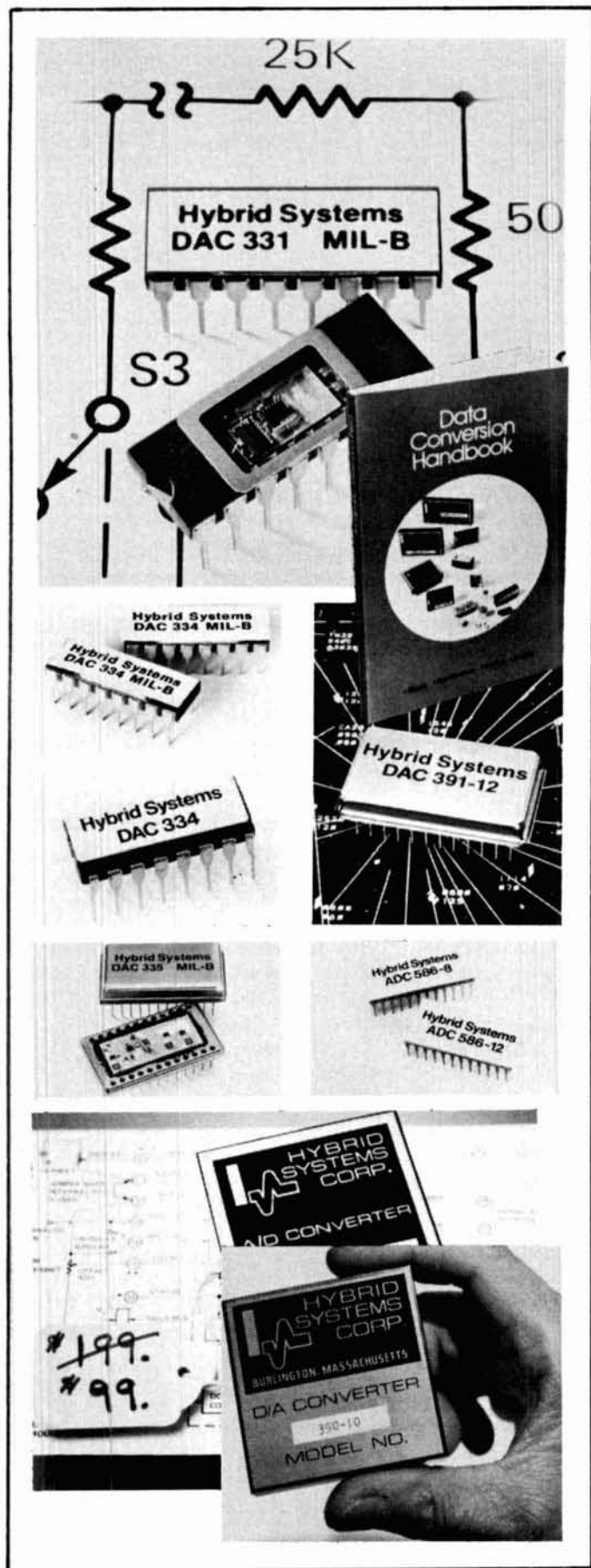
If a thermal input representing rf power were applied to an ADC, for example, its slowly varying nature would dictate the use of an integrating ADC. On the other hand, digitizing voice frequencies would

table 1. Manufacturers of data converters.

Analog Devices, Inc. P.O. Box 280 Norwood, Massachusetts 02062 (617) 329-4700	Hybrid Systems Corp. Crosby Drive Bedford, Massachusetts 01730 (617) 275-1570
Analogic Corp. Audubon Road Wakefield, Massachusetts 01880 (617) 246-0300	ILC Data Devices Corp. Airport Int'l Plaza Bohemia, New York 11716 (516) 567-5600
Beckman Instruments, Inc. Helipot Division 2500 Harbor Blvd. Fullerton, California 92634 (714) 871-4848	Intech Function Modules 282 Brokaw Road Santa Clara, California 95050 (408) 244-0500
Burr Brown Int'l Airport Industrial Park P.O. Box 11400 Tucson, Arizona 85734 (602) 294-1431	Micronetworks Corp. 324 Clark Street Worcester, Massachusetts 01606 (617) 852-5400
Cycon, Inc. 1240 Elko Drive Sunnyvale, California 94086 (408) 734-1535	Motorola Semiconductor Products Box 20912 Phoenix, Arizona 85036 Contact Distributors
Datel Systems, Inc. 1020 Turnpike Street Canton, Massachusetts 02021 (617) 828-6395	National Semiconductor Corp. 2900 Semiconductor Drive Santa Clara, California 95051 Contact Distributors
Dynamic Measurements Corp. 6 Lowell Street Winchester, Massachusetts 01890 (617) 729-7870	Phoenix Data, Inc. 3384 West Osborn Road Phoenix, Arizona 85017 (602) 278-8528
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require the use of successive approximation type. Assuming the maximum voice frequency to be digitized is 5 kHz, a conversion time of no more than 100 microseconds would be required to produce an accurate digital representation of the input (a faster conversion speed would more precisely duplicate the input voltage).

When the rate of the signal being digitized also



varies at a rapid rate, it becomes necessary to retain the original signal for a period of time sufficient to perform the digital conversion. Simply feeding this signal to the ADC will not guarantee an accurate conversion. However, this can readily be achieved by inserting a sample-and-hold circuit between the analog input and the input to the ADC. The sample-and-hold will track the input signal, acquire it on command, and hold it while the ADC performs the conversion. At the completion of conversion the ADC generates a reset pulse and puts the sample-and-hold back into the sample or track mode. This sequence is repeated successively as determined by the nature of the measurement or control function desired.

Resolution, or the number of bits, of either the DAC or ADC determines the incremental accuracy and the linearity. In effect, it determines the number of increments the analog input or output has been divided into. A high resolution converter naturally yields a more accurate representation of its input over the complete range of its input than would a lower resolution device.

There are many specifications that are related to the converter's temperature environment. Close examination of each manufacturer's specification is necessary to understand a converter's parameters when subject to changes in temperature. Reference is made to the bibliography at the end of this article for those readers who wish more detailed knowledge on data converters. Many of the manufacturers listed in **table 1** have applications notes and technical papers available which discuss the various details of data converter products.

## interfacing

The ADC and the DAC in **fig. 4** represent memory locations for the microprocessor similar to those occupied by RAMs and ROMs that are normally associated with microprocessor/microcomputer systems. Access to the converters is gained by the assignment of an address code similar to those allotted to conventional peripherals such as displays, Teletype machines, and printers. This arrangement provides direct access to the converters without the necessity of using the microprocessor memory.

Although **fig. 4** does not show it, a *programmable* or *peripheral* interface element can be inserted between the ADC and the microprocessor. This IC handles addressing and decoding generation of instructions, interrupt, and bus access signals.

Controlling a DAC is a simple process and is accomplished by performing a store operation; that is, transferring data from the microprocessor to the latches or registers associated with the DAC. The DAC now only requires an instruction to deliver its output to its load. The ADC is accessed by fetching



data from its memory location or by having the programmable or peripheral interface element perform this function under instructions from the microprocessor. Of course, if the total system involves a multichannel arrangement of DACs or multiplexed ADCs, each individual channel must be separately addressed and fetched. Systems this complex depend entirely on the programmable and peripheral interface element to perform the addressing.

This has been an overview of how the amateur can utilize the microprocessor to automatically control his equipment or perform measurements in a

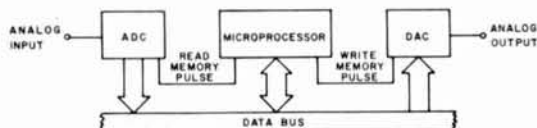


fig. 4. Block diagram of the interface between a microprocessor and data converters. Either data converter can be eliminated, depending upon the analog voltage requirements.

systematic fashion. It shows the necessity of the data converters as a means of connecting the microprocessor to a vco, a voltage-controlled attenuator, an rf power meter, or other device that performs equipment adjustments or measurements. It will hopefully provide many amateur radio enthusiasts with a tool that will provide many interesting hours of thought and experimentation.

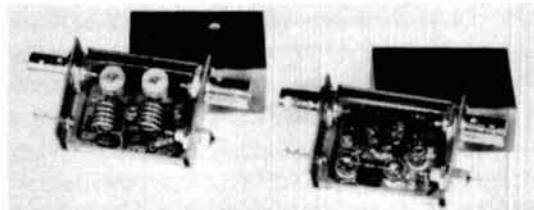
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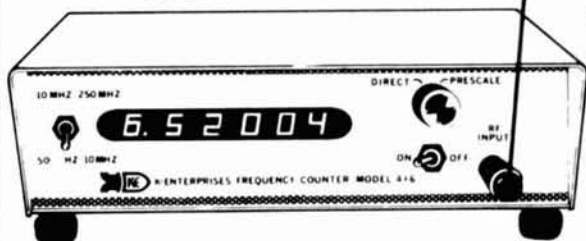
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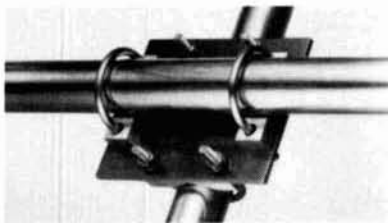
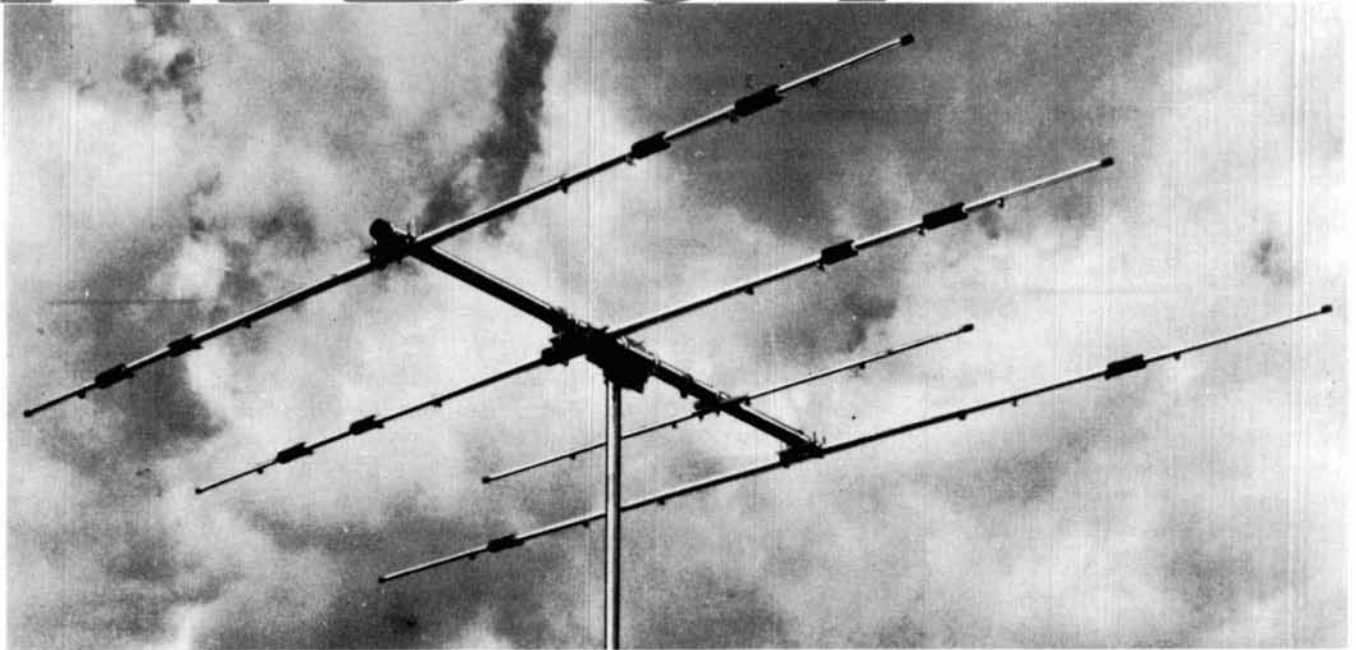


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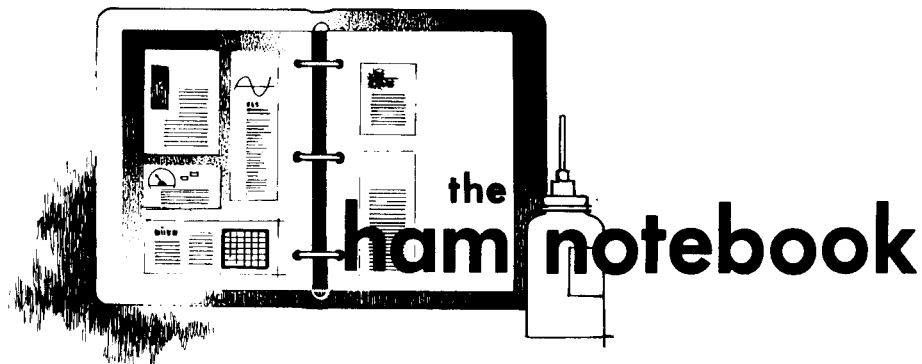
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## increasing the capacity of the RAM RTTY message generator

I was very interested in K4EEU's 146-character message generator

(*ham radio*, January, 1975, page 8) and immediately built it. I am particularly impressed with its performance in conjunction with my ST-6. I recently changed the clock because the Motorola MC724P is now reserved for maintenance, and I used

the double monostable 74123 which is more readily available.

From time-to-time the number of available characters was not sufficient, so after I discovered INTEL's 2102 (1024-bit RAM), I decided to multiply the original capacity of 146 characters by four. Now I can store 585 seven-bit RTTY words. The cell array of the 2102 is organized is 32 rows and 32 columns; that is to say, it's necessary to have two five-bit counters instead of the two four-bit counters (7493) for correctly decoding the 1024 positions.

It is possible to add one bit to each of the four-bit counters with the state of the fifth bit changing each time output D of the 7493 falls from logic 1 to logic 0. A dual JK master-slave

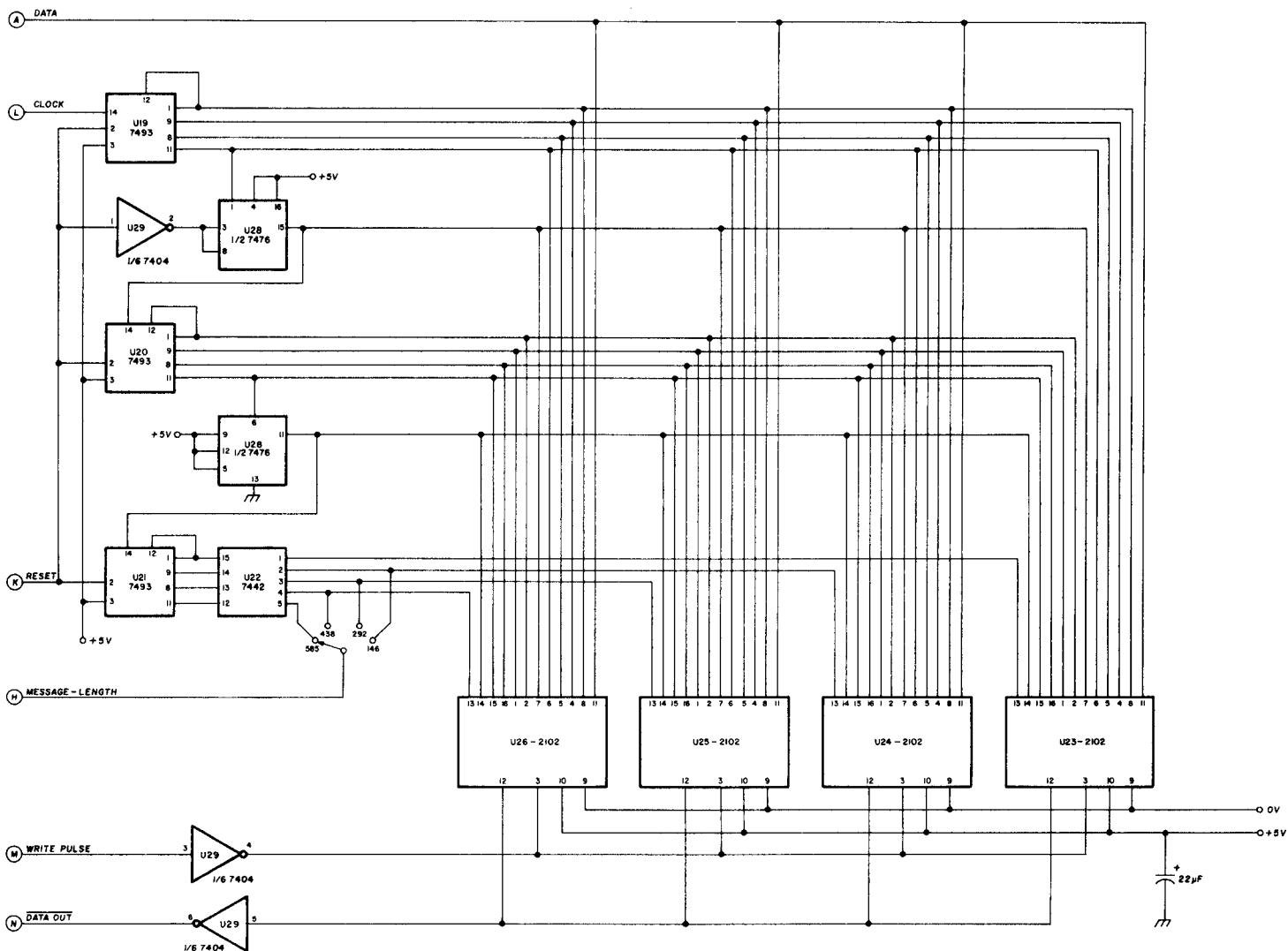


fig. 1. Schematic diagram of the improved RTTY message generator.

flip-flop (7476) does the job nicely by connecting one flip-flop to the D output of U19 and the other to the D output of U20.

To be sure that the Q output is set to zero when beginning a message, it is necessary to apply a zero to the clear input at the same time U19, U20 and U21 are reset. In these circuits the reset level is logic 1, so it is inverted by one-sixth of a 7404. With this arrangement, the 1024 positions of each 2102 memory can be decoded correctly, the chip-select circuit being the same.

In addition to the different pin configurations of the 1101 and 2102, two other points are changed. First, the read-write levels are inverted, so I used another part of the 7404 to correctly set the levels. Second, the 2102 offers only a DATA OUT and we must have a DATA OUT, so I inverted the output of the memories with an inverter (part of the 7404). Everything is now set to enter 585 RTTY characters and recall them at will.

The new integrated circuits were mounted on wire-wrap sockets installed in a 0.1 by 0.1 inch (2.5 by 2.5 mm) grid-drilled epoxy board. The connections between these circuits have been wrapped, the 1101s removed from their sockets, and the connections between the original circuit and the additional circuit are hard-wired with 10-inch (25cm) wires.

The first test was okay and the entire system worked well with the new, added circuit. It is possible to install the new circuit on spacers in the former box, but it would be better to design a printed-circuit board that could be connected directly to the 1101 sockets. In the latter case, only seven connections would have to be made with single-contact connectors.

Jean-Claude Piat, F2ES

## Heath SB-102 headphone operation

The phones jack on the SB-102 is fed from a high-impedance source

and should be used with headsets of high impedance. If low-impedance headphones are used, the *phone volume* control must be wide open to achieve a good balance between speaker and headsets. To provide a

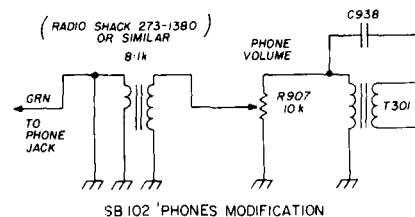


fig. 2. Shows addition of a small output transformer to the headphone circuit of a Heathkit SB-102 to permit use of low-impedance headphones.

better impedance match and control over the volume, a small imported output transformer was used as shown in fig. 2. Rather than add the circuitry externally, the transformer was mounted on the *bias* pot by soldering the frame to the pot body with the primary high-impedance winding facing the rear of the chassis and the *phone volume* pot. A two-terminal lug was attached to the chassis with one of the circuit-board mounting screws opposite the *bias* pot. The leads were transferred from the *phone volume* pot to the terminal strip, the secondary of the transformer wired to the terminal strip and the primary to the *phone volume* pot. Now, balance between speaker and headphones is more easily achieved and no distortion is noted.

Paul K. Pagel, K1KXA

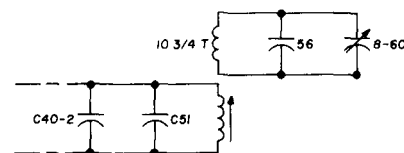
## NCX-500 modification for 15 meters

If the NCX-500 transceiver is not carefully aligned, the fourth harmonic of its 5.2-MHz carrier oscillator, which appears at 20.8 MHz, creates a strong spurious signal in the receiver. A simple trap installed on the 15-meter mixer coil minimizes this spurious response.

The trap consists of a coil and parallel capacitor, prepared in the following manner.

Close wind 10-3/4 turns of no. 18

AWG (1.0mm) enameled wire on a 3/8-inch (9.5mm) diameter, 1-inch long (25mm) coil form. Place a 56 pF fixed capacitor in parallel with an 8-60 pF compression trimmer-type variable capacitor and place the parallel combination across the coil. Wrap approximately two turns of electrical tape around the top of L14 to obtain a tight fit and fit the trap to the top of L14 of the NCX-500. Adjust the coils so that the spacing between the two windings is about 5/8-inch (16mm).



## adjustment instructions

1. Remove crystal Y3 (25.1 MHz) from the transmitter.
2. Tune the transmitter to the 20.8 MHz spurious frequency.
3. Adjust the variable capacitor on the trap for **minimum** transmitter output or plate current reading. (Use whichever gives the most sensitive indication).
4. Re-adjust the distance between the windings by moving the trap a little closer or further away from coil L14 and retune the trap as per **step 3**.
5. Replace the 25.1 MHz crystal, retune the transmitter to 21.1 MHz and re-adjust the slug in L14 for **maximum** transmitter power output. Note that the core in L14 should be sitting at the top end of the coil, farthest from the chassis.
6. Repeat **steps 1** thru **5**, because adjustment of either the trap or coil L14 will influence the other.

The trap will effect the performance of the NCX-500 receiver section at 21 MHz, hence coupling between L14 and the trap should be as loose as possible to minimize this effect. Finally, fix the trap to coil L14, using a little adhesive such as *Duco* cement.

Conrad J. Espinola WA1KY0

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## The French Atlantic Affair

In the midst of so much mistaken publicity about amateur radio, wherein problems caused by CB stations are blamed on the ham by an uninformed press, it is refreshing to see a book that has amateur radio woven into the plot as one of the "good guys." Moreover, the book is not one that would normally rate just a casual glance and then be placed back on the shelf.

The *French Atlantic Affair*, by Ernest Lehman, is a novel of such length that it will keep the average reader at it for several evenings, if he can force himself to put it down, or all night if he cannot. There is almost continuous action throughout the story, and the way author Lehman has brought amateur radio into focus early in the converging lives of the characters portrayed almost guarantees that it will play a significant part in the unfolding story.

Not that hams are all portrayed as knights in shining armor — their feet of clay are clearly evident so that the uninformed reader can see that they are ordinary human beings like everyone else. As such they have their hang-ups, problems, and families whose patience with this obsession wears thin at times. The attitudes and opinions about hams and their technical vices are all too familiar to many of us who have been the focal point of similar comments from friends and wives who are not

completely dedicated to the hobby of chasing DX or burning the midnight hours away conversing with a stranger in a far corner of the land.

To an experienced amateur, it would seem that the author knows about ham radio from the inside — the equipment is real, the procedures are correct, the language is right, and the bands go dead at the right time; there is even the right kind of nit-wit who clobbers the frequency in the middle of an important exchange. To balance the scale against the baddies, there is the good guy who provides a phone-patch across the continent to overcome the dead-band problem, and a very understanding ham on Long Island who cancels out of an important golf engagement to take part in the high drama.

The author *does* know about amateur radio — he is K6DXK, and has been as busy on the air as at the typewriter. The way he tells it, the time spent at the ham rig at times overshadowed the writing, so the book was somewhat of a combination of the two important factors in his life.

However, Lehman is definitely accustomed to writing top-grade material; he has written screen plays for several well-known films such as *West Side Story*, *The King and I*, and *Who's Afraid of Virginia Woolf*, and others. He has received six Writer's Guild awards and six Academy Award nominations.

*The French Atlantic Affair* was not written for hams alone — you don't pin your hopes of making a best seller

on a potential audience of a few hundred thousand. The book is written to appeal to people who would be spell-bound with such stories as *Hotel*, *Airport*, and *Where Eagles Dare*; it can be very favorable compared to these best sellers. The action is almost non-stop, and one segment builds suspense that is guaranteed to evoke interest in the next page or chapter — this reviewer suffered the consequences of lack of sleep all the next day because of the irresistible urge to see how things ended.

The book is recommended for adult reading, and, while it is unlikely that any of you hams who read it will become heroes of the level attained by the operators involved in this story, you will be comforted to know that you are not alone in being a member of a group whose hobby, ability, and dedication is misunderstood and underrated.

Amateur radio plays a vital part in *The French Atlantic Affair*, and the resulting publicity should be most beneficial to our hobby and image. If the story makes it into a hit movie (the screen rights have been purchased by MGM), that's all to the better.

*The French Atlantic Affair* has been selected by the Literary Guild and by the Playboy Book Club, and is being published by Atheneum Publishers; it is available from Ham Radio's Communications Bookstore, Greenville, New Hampshire 03048; \$10.95 postpaid. Not recommended for young readers.

## 80-Meter DX handbook

To a large number of amateurs, the 80- or 75-meter band is most useful as a rag-chewing spot. Daytime coverage is strictly local, and long paths open during the dark hours. Average contacts take place across distances that reach from one coast to the other during favorable conditions.

However, in the true amateur spirit, there is a core of DXers who are constantly probing to see what can be done on this "local" band to extend the communications range to the farthest parts of the globe.

John Devoldere, ON4UN, has compiled a handbook of things to do to squeeze the most out of this rag-chewer's haven; the *80-Meter DX Handbook*.

The handbook is a complete work on the art of DXing in this part of the HF spectrum, from why it happens (or does not happen), to what to build and how to use it. The book is arranged in four chapters: Propagation, Antennas, Stations, and Operating Practices. The propagation section covers magnetic disturbances, seasonal effects, twilight periods, paths, and more. As might be expected, the antenna section is the largest part of the book, with 15 distinct subjects — starting with the fundamentals and working through ZL-specials and Beverage antennas.

The section on stations contains a concise discussion of popular transmitters and receivers, and some hints as to their proper use. In Operating Practices, the author gives you information about what band segments are used in various countries, talks about procedures, types of operation, and points out some of the awards that have been won, and some that are much sought after.

The *80-Meter DX Handbook* ends up with a very good Bibliography for those who would like to explore some of the reference works in greater detail.

Published by Communications Technology, Inc., the *80-Meter DX*

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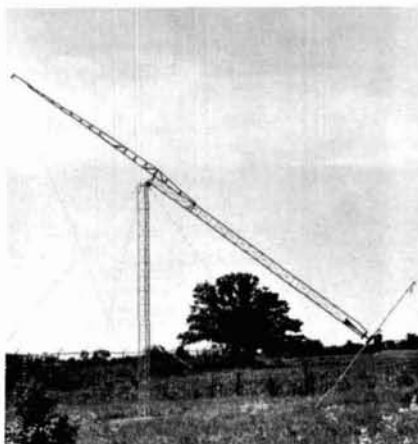
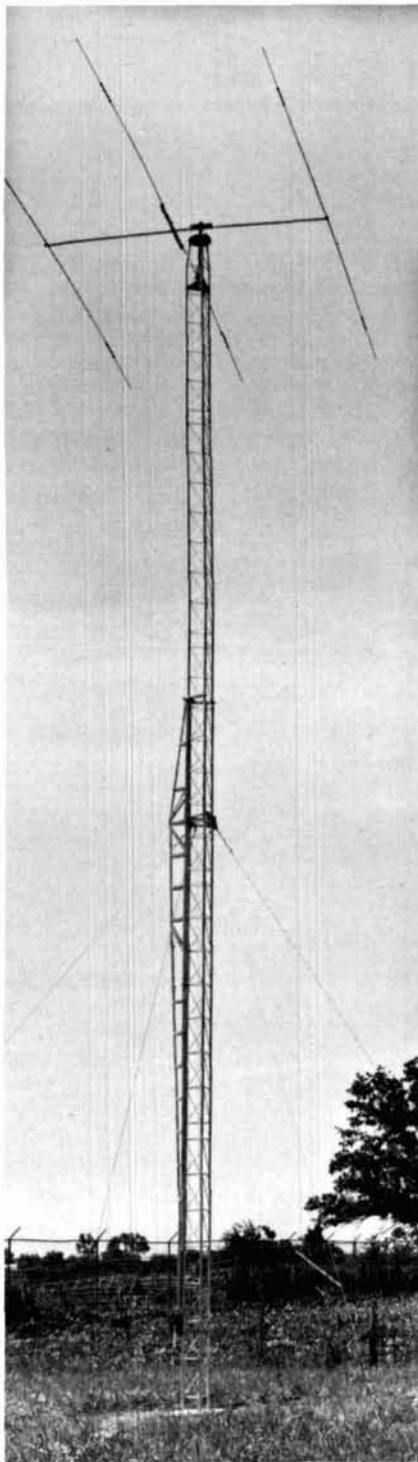
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*Handbook*, by ON4UN, is available from Ham Radio's Communications Bookstore, Greenville, New Hampshire 03048. Order HR-80M, \$4.50 postage paid.

## **active filter design**

This new book by Claude Lindquist is an invaluable reference for engineers, technicians, and amateurs who must understand signal processing and filtering, and who must specify, design, or adapt active filters to their own uses. The book features standard design curves and tables, practical design examples such as *Touch-Tone*, Dolby B, amplitude and delay equalizers, and presents numerous problems with solutions (which form an encyclopedia of active filter design). Also included are extensive references and unpublished research results (including delay analysis, high-frequency filters, tuned filters, discriminators, etc.).

Hardbound, 749 pages, \$21.95 postpaid from Steward & Sons, Post Office Box 15282, Long Beach, California 90815.

## **printed circuit board kit**

Excel Circuits Company has recently introduced a kit for making your own printed circuit boards. The kit contains materials that will allow you to produce your own boards, starting with the artwork and ending with a finished board. In contrast to other processes, this kit uses a photo-positive method, meaning that no image reversal and hence darkroom facilities are required.

Included in the materials are sufficient supplies to do the layout of small PC boards. The kit contains integrated circuit layouts, tape and pads, 10 x 10 graph paper, and a mylar-based paper to hold the layout. With no image reversal being necessary, the finished layout can be used to expose the board. One other advantage of using a photo-positive system is that dirt and dust on the

layout will not cause holes in the eventual circuit traces. Also, the neat plastic container can be used to hold the etchant while etching a board.

From start to finish, the Excel Circuits Company has provided materials that permit the fabrication of quality circuit boards. In addition, they've eliminated the problems of obtaining supplies from different sources. The price of the complete kit is \$19.95, postpaid. For more information write to Excel Circuits Company, 4412 Fernlee, Royal Oak, Michigan 48073.

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The new WSU-30M "Hobby Wrap" tool performs the complete wire-wrapping function. First, the tool wraps 30 AWG (0.25mm) wire onto standard 0.025-inch (0.6mm) square DIP socket posts. Also, the tool unwraps and, finally strips 30 AWG (0.25mm) wire nick-free through a unique stripping blade.

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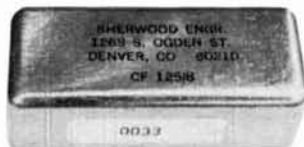
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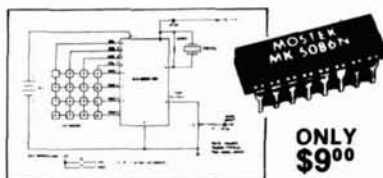
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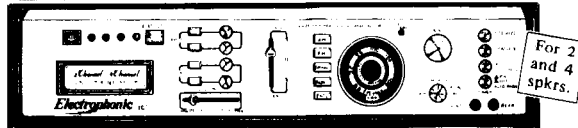
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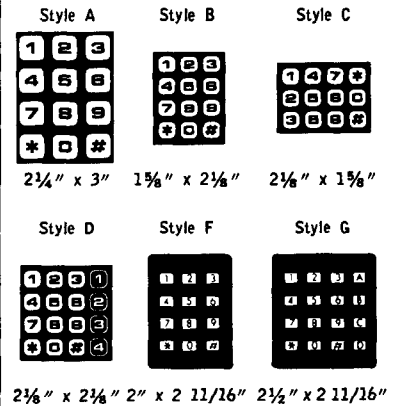
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**TELETYPE EQUIPMENT** for beginners and experienced operators. RTTY machines, parts, supplies. Beginner's special: Model 15 Printer and demodulator \$139.00. Dozen black ribbons \$6.50; case 40 rolls 11/16 perf. tape \$17.50 FOB. Atlantic Surplus Sales, 3730 Nautilus Ave., Brooklyn, N. Y. 11224. Tel: (212) 372-0349.

**COLLINS 755-3**, \$360 — Nems Clarke Rcvr. 15o1, \$180. Skysweep Rcvr. \$60 — all books. WA2EUS, 110 Lafayette St. Copiague, NY 11726.

**MOBILE BONDING STRAPS** under 50¢ each. Literature. Estes Engineering, 930 Marine Drive, Port Angeles, Wash. 98362.

**QSL FORWARDING SERVICE** — 30 cards per dollar. Write: QSL Express, 30 Lockwood Lane, West Chester, PA. 19380.

**FERRITE BEADS**: w/specification and application sheet - 10/\$1.00. Assorted PC pots - 5/\$1.00. Miniature mica trimmers, 3-40 pf. - 5/\$1.00. Postpaid. Includes latest catalog. Stamp for catalog alone. CPO Surplus, Box 189, Braintree, MA 02184.

**FREE catalog**. Solar Cells, Nicads, Kits, Calculators, Digital Watch Modules, Ultrasonics, Strobes, LEDs, Transistors, ICs, Unique Components. Chaney's, Box 27038, Denver, Colo. 80227.

**THE "CADILLAC"** of QSL's! New! Samples: \$1.00 (Refundable) — MAC'S SHACK; Box #1171-D; Garland, Texas 75040.

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**FOR SALE**: 6 pole 250 Hz crystal filter for FT101, FR101 — \$41. Koichi Kawai JA2UEO Denden Tomioka 1, A506, 2154, Sugita, Isogo-ku, Yokohama 235, Japan.

**EXCLUSIVELY HAM TELETYPE** 23rd year, RTTY Journal, articles, news, DX, VHF, classified ads. Sample 35¢. \$3.50 per year. 1155 Arden Drive, Encinitas, Calif. 92024.

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**RUBBER STAMP**, name/call/QTH \$2.50 ppd. (CA residents add tax). LWM Press, Box 22161, San Diego, CA 92122.

**COMPUTER HOBBYISTS** — Classified advertising newsletter. Ads, New Products, etc. Every 3 wks. — Since Jan 76 \$3.75/year. Free Sample. ON LINE, 24695 Santa Cruz Hwy., Los Gatos, CA 95030.

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

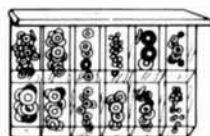
**TEKTRONIX 7000** series plug ins. Late eng. models. Work like new 7A22 2 \$250, 7B70 2 \$350, 7B71 @ \$350. Walt Williams, 1901 SEM Inter #76, Hillsboro, OR 97123.

**LET LaRue BE YOUR VHF GURU!** Factory-authorized dealer for: ICOM, Regency, Standard, Cushcraft and CES Touch-Tone pads. Antenna Specialists 2-meter 5/8 wave mobile antennas in stock. Bomar 2-meter crystals for the above radios on most standard ARRL repeater frequencies \$4.50 each postpaid. Mastercharge and BankAmericard accepted. For the greatest deal call or write LaRue Electronics, 1112 Grandview St., Scranton, Pennsylvania 18509. (717) 343-2124.

**FOR SALE**: Brand new boxed advanced coax relays. 6.12.24.100VDC. 117VAC. \$15.00 with aux. contacts, \$12.00 each without. Antique R.R. Sounders (new) \$50.00 each — have four. Add \$1.00 for shipping.

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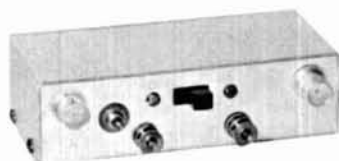
Includes convenient plastic storage box and one dozen each of FB43-101, FB43-801, FB64-101, FB64-801, FB73-101 and FB73-801 plus new spec sheets. Value \$7.50 for \$6.95.

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**RG8 foam Xtra-Flex coax,** 100' Braid coverage, 23' ft.

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# flea market

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**BUY-SELL-TRADE.** Write for free mailer. Give name, address and call letters. Complete stock of major brands new and reconditioned equipment. Call for best deals. We buy Collins-Drake-Swan etc. SSB & FM. Associated Radio, 8012 Conser, Overland Park, Kansas 66204. 913-381-5901

**LET'S TRADE.** I have new HORNET ANTENNAS. 6-10-15 & 20 meter beams; 10 to 80 element 2-meter antenna systems; stacking kits, antenna hardware, etc. I need good clean transmitters, receivers, transceivers, test equipment. Jack W5AJZ, Box 880, Duncan, OK 73533.

**R-4C, FL-6000, FL-1500, FL-500, FL-250, 4-NB** noise blander, 12 xtals and MS-4 speaker \$650.00; T-4XC, AC-4 power supply, two xtals \$550.00; MN-4 matching network with Waters 384 dummy load \$130.00; SB-610 monitor scope \$100.00; SB-620 scanalyzer \$120.00; SB-630 station console \$75.00; SB-650 Freq. Disp. \$150.00; Astatic T-UG8 transistorized stand with Astatic 77L dynamic cardioid microphone \$75.00; Brown CTL-A paddle and key \$25.00; Everything above mint \$1750.00; Ralph Conner, WA3OBW, 149 Gladstone St., Phila., PA 19148. Phone 215-HO 2-9293.

**SEVERAL NEW COAXIAL RELAYS,** 12 Vdc, leads, use favorite connectors, \$5; Three new regulated, variable, 12 Vdc 5A power supplies, \$20 each FOB. List shack cleanup SASE. W4API, Box 4095, Arlington, Virginia 22204.

## Coming Events

**THE FOUNDATION FOR AMATEUR RADIO** annual Hamfest at the Gaithersburg Fairgrounds, Gaithersburg, MD., Sunday, October 23rd, 1977. Large flea market, food service, exhibits, ladies events, supervised children's program, and many prizes. Main events are all indoors. Picnic grounds, free parking; will be held rain or shine; participation fee is \$2.00; sales space for flea market \$5.00 first-come basis; commercial exhibitors \$10.00, pre-registration required prior to October 20th; nearby motel rooms available. For information write or call Hugh Turnbull, W3ABC, 6903 Rhode Island Avenue, College Park, MD. 20740; telephone (301) 927-1797.

**WESTERN MICHIGAN UNIVERSITY** will hold its 23rd annual VHF Conference, November 19, 1977. Contact Dr. Glade Wilcox, W9UHF/B, Dept. of Electrical Eng., WMU Kalamazoo, Michigan 49008.

**"GREATER LOUISVILLE HAMFEST** Sunday Sept. 25, 1977. Kentucky Fair and Exposition Center, West Wing Pavilion. Indoor exhibitors area. Indoor and Outdoor Flea Market. Admission \$2.00. Vendors, admission plus \$2 indoors space or \$1 outdoors space. For further info, or hotel, motel or camping reservations contact K4GOU, Denny Schnurr, 2415 Concord Dr., Louisville, KY 40217, phone #502) 634-0619."

**REPEATER ASSOCIATION DOWNRIVER AMATEUR RADIO** Swap & Shop Hamfest - October 16, 1977 9 AM to 3 PM at Kennedy High School, Northline Road (East of US 24) Taylor Michigan. Talk in on 147.93/33 .52 and .94 simplex. Door prizes, food, fun. Admission \$2 - YLs free. For information: RADAR, Inc., Box 1023, Southgate, MI 48195.

**HAMFEST** Lima, Ohio, October 9. The Northwest Ohio ARC 3rd annual hamfest at the Allen Country Fairgrounds. Two large buildings, tables and table space available. Dealers welcome. For information and reservations write: N.O.A.R.C., P.O. Box 211, Lima, Ohio 45802. Phone 640-1433 or 991-2716.

**AMSAT** annual meeting Saturday, October 8, 1977 at the Goddard Space Flight Center Employees Recreation Center in Greenbelt, MD. Everyone invited. The afternoon of technical and general interest talks has been greatly expanded and will begin at 1 P.M. The meeting location is easily accessible by major highways, and parking is at the door. For a map and a list of talks please send an SASE to AMSAT, Box 27, Washington, DC 20044.

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2N3375 3W 400 MHz.....5.50	2N8080 4W 175 MHz.....5.40
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2N5590 10W 175 MHz.....7.80	2N6083 30W 175 MHz.....10.30
2N5591 25W 175 MHz.....10.95	2N6084 40W 175 MHz.....16.30
2SC517.....3.95	2SC1307.....5.25
2SC1226.....1.25	2N4427.....1.35
2SC1306.....4.30	2N5109.....2.05

**NOW NEW IMPROVED DIGITAL ALARM CLOCK KIT** Hours + Minutes + Seconds displayed on six BIG 0.5 Fairchild 7 Segment Display LEDs. 12-hour format 24-hour alarm with snooze feature, plus elapsed time indicator and freeze feature. Eight pages of pictorials and instructions. NEW on-board power transformer and circuitry for optional time base with simulated wood grain cabinet \$23.95

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**COMBINATION DIGITAL CLOCK AND FREQUENCY COUNTER KIT** 6 digit 40 MHz counter AND 12-24 hour clock kit. Battery operated with 110V charger.

5 A.A. NiCad batteries not included. 2" x 4-1/4" x 6" cabinet. ONLY \$99.95 Assembled unit complete for \$139.95

**VARIABLE POWER SUPPLY KITS** - 600 Ma, 5-15 VDC \$6.95 12-28 VDC \$8.95 75 cents per unit shipping

**NOW!**

## Dual Digital 12-24 hour clock kit



MODEL ALDS:

Six big .5 display LEDs in an attractive black plastic cabinet with a red front filter. Great for a ham or broadcast station. Set one clock to GMT for the other to local time. Or have a 24 hour format on one clock and 12 hour on the other. Freeze feature lets the clock be set to the second. Each clock is controlled separately. Cabinet measures 2" x 4-1/4" x 9-1/2". Complete Kit \$44.95.

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BOONTON 190A Q-mtr 30-200MHz	\$425
BOONTON 202E AM-FM sig gen	
54-216MHz	425
DEI TDU-4 30MHz video display	55
GR1001A LF sig gen 5kHz-50MHz	385
HP100ER Freq stand .05 parts/mil	
Outputs 10,100Hz; 1,100,100kHz	155
HP160B (USM105) 15mHz scope with reg horiz, dual trace vert plugs	375
HP166B (Mil) Delay sweep for above	130
HP170A (USM140) 30mHz scope with reg horiz, dual trace vert plugs	475
HP175A 50mHz scope with reg horiz, dual trace vert plugs	565
HP185A Sampling scope to 1ghz	
186B xstr rise time plug	585
HP202B LF Osc .5Hz-50kHz 10v out	75
HP205AG Lab audio gen .02-20kHz	195
HP212A Pulse gen .06-5kHz PRR	65
HP524D Freq counter-basic range 10Hz-10mHz extends w/plug-ins	195
HP540B Trans osc to 12.4ghz for use w/HP524-tyoe counters	145
HP616 Sig gen 1.8 4ghz FM-CW	365
HP686 Sweep gen 8.2-12.4ghz sweep range 4.4mHz-4.4ghz	495
HP803A VHF Ant bridge 50-500MHz	135
SOLITRON 200A SCR tester - all functions w/scope output	135
Tek181 Time mark scope calib.	55
Tek190 Sig gen (const ampl) 50mHz	125
Tek536 11mHz X-Y scope - uses two letter-series plug-ins	295
Tek565 Dual beam 10mHz scope less plug-ins (3 series)	625
TS505 Std VTVM (rf-500mHz)	65

For complete list of all test equipment send stamped, self-addressed envelope

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## Tone Encoders

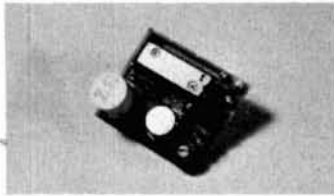
For Continuous Tone Coded Squelch Systems (CTCSS)

Compatible with subaudible tone systems such as Private Line, Channel Guard, and most others

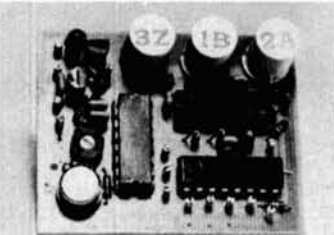
And a new dual encoder for both CTCSS & DTMF

### Features:

- Temperature and frequency stability of  $\pm 0.1$  Hz from  $-25^{\circ}\text{C}$  to  $+80^{\circ}\text{C}$
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- All EIA frequencies available, 67.0-203.5 Hz
- Other EIA frequencies available on special order
- 9-16 VDC, reverse-polarity protection
- Adjustable tone output level



TG-1A miniature encoder. Will fit into most FM radios. Only three connections to make—ground, +VDC, and tone output. Wired and tested, with one tone element. Size: approximately 1" x 1.2" x 0.6". Price: \$24.95.



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2027 A/B CTCSS and DTMF encoder. Both types of encoding are combined onto one small board for most hand-held and mobile radios. Only three connections are required from the encoder board: +VDC, ground, and tone output. Wired and tested, with one tone element and a 12- or 16-key DIGI-TRAN<sup>®</sup> keyboard. Size: approximately 1.8" x 2.3" x 0.6". Price: \$71.95 for 2027A (12 key); \$78.95 for 2027B (16 key).

NEW! MTG-1 Tone Encoder Fits HT220 slim line, PL model, and OMNI PL models. Price: \$27.95 wired & tested with one tone element.

Additional tone elements \$3.00 each.

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## flea market

**SANGAMON VALLEY** Radio Club Second Annual Hamfest on Sunday, September 25th, at the Sangamon County Fairgrounds, New Berlin, Illinois, 16 miles west of Springfield. Indoor display area and covered pavilion. Exhibits, food and ladies activities. Overnite camping! Tickets: \$1 advance, \$1.50 at gate. First Prize — Wilson HT. Talk-in: 146.28/88 and 52 MHz. Information: WB9-QWR, Carole Churchill, 622 Magnolia, Rochester, IL, 62626.

**OCTOBER 9, 1977** in Yonkers, NY at Redmond Field, Cooke Ave. Talk In 146.265 and 146.52 simplex. Further info from Douglas McArtin, WA2AUJ, 411 Bellevue Ave., Yonkers, NY 10703.

**PAN AMERICAN HAM JAMBOREE/EXPOSITION.** Ft. Lauderdale, FL, October 29 & 30 at the National Guard Armory (State Road 84). Hours: Saturday, Noon to 10 PM; Sunday, 9 AM to 5 PM. Talk-in on 31/91 or 52 simplex. Additional info from WA4ZRW (305) 581-2718.

**FLORIDA GULF COAST CONVENTION.** Clearwater Beach, November 19 & 20. Sponsored by Florida Gulf Coast A.R.C. Exhibits, flea market, technical sessions, FCC exams, forums and much more. Full info and reservation for Sheraton Hotel, contact: F.G.C.A.R.C. Convention, P.O. Box 157, Clearwater, FL 33517.

**THE MARION AMATEUR RADIO CLUB'S** Annual "Heart of Ohio Ham Fiesta" is Sunday, October 23, at the National Guard Armory from 8 AM to 5 PM. Free Parking. Admission \$1.00 advance, \$2.00 at gate. Tables must be reserved \$3.00 each. Refreshments available. Write Earl Adey WB8EDO, 2697 Curren Drive, Marion, Ohio 43302.

**THE REPEATER ASSOCIATION** of Downriver Amateur Radio (R.A.D.A.R.) Hamfest will be held on Oct. 16, 1977 at the Kennedy High School in Taylor, Michigan, on Northline Rd. east of Telegraph (U.S. 24). Talk-in will be on 52-52, 34-94, 93-33. Door prizes and food. Admission \$2.00/YI's free. Reserved Tables \$1.00. Open 9 AM until 3 PM. For further info write: R.A.D.A.R. Inc., P.O. Box 1023, Southgate, Michigan 48195.

**RADIO AND ELECTRONIC SWAP AND SHOP,** sponsored by the Marshall County Amateur Radio Club, will be held on Sunday, October 30, 1977, at the Plymouth, Indiana National Guard Armory, located at 1220 West Madison Street, from 8 AM to 5 PM. Free tables, no charge for set-up. Tickets \$2.00 at the door. Food, drink, and door prizes. Talk-in on 146.07-67 and 146.52 simplex. For further information contact Wayne Zehner, WA9INM, Rt. 3, Box 526, Plymouth, Indiana 46563.

**BLOSSOMLAND** annual fall Swap-Shop, October 2nd, Berrien County Youth Fair Grounds, Berrien Springs, Michigan. Large, convenient facilities. Prizes, refreshments, fun. Open all night for set-up. Table space restricted to radio and electronic items. Advance ticket donation \$1.50. Tables \$2. Write: John Sullivan, P.O. Box 345, St. Joseph, Mich. 49085. Make checks payable to Blossomland Hamfest.

**MEMPHIS IS BEAUTIFUL IN OCTOBER!** The Memphis ARRL-sponsored Hamfest, bigger and better than the 4,500 who attended last year, will be held at State Technical Institute, Interstate 40 at Macon Road, on Saturday and Sunday October 1 and 2. Demonstrations, displays, MARS meetings, flea market, ladies flea market, too! Hospitality room, informal dinners, XYL entertainment, many outstanding prizes. Dealers and Distributors welcome. Contact Harry Simpson W4SCF, PO Box 27015, Memphis, TN 38127 for further information.

**NORTHEASTERN STATES** 160 Meter Amateur Radio Association annual election and banquet. Saturday, October 8, 1977 at Kozel Tavern, 5 miles northeast of Hudson, NY on Rt. 9H. Flea market in rear parking lot starting at 1 PM. Dinner at 6 PM. For any further information, write or contact W1EUB, Sec. Treas. on 160 meters.

**HAMARAMA '77 & Mid-Atlantic States VHF Conference.** Conference to be held Oct. 1, Treadway Inn on Easton Rd., Willow Grove, PA 19090. Flea Market to be held Oct. 2, Bucks Country Drive-In Theater, Easton Rd., Warrington, PA. For further info contact Ron Whitsell, WA3AXV, P.O. Box 353, Southampton, PA 18966. Phone: 215-355-5730.

**NEW YORK** Radio Amateurs of Greater Syracuse (RAGS) Hamfest Saturday, October 8 from 9 A.M. to 6 P.M. at the Syracuse Auto Auction, 4 miles south of Syracuse, N.Y. on U.S. Route 11 between Nedrow and LaFayette. Flea market, CW and wiring contests, forums, panels and eyeball QSOs. Lunch counter, nearby campsite and Apple Festival for the family. Talk-in on 31/91. Tickets are \$1.50 before October 1 and \$2.00 at the gate. For further information, contact Roger Hamilton, WA2AEW, c/o RAGS, P.O. Box 88, Liverpool, New York 13088.

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1N4005	600v	1A	.08
1N4007	1000v	1A	.15
1N4148	75v	10mA	.05
1N753A	6.2v	z	.25
1N758A	10v	z	.25
1N759A	12v	z	.25
1N4733	5.1v	z	.25
1N5243	13v	z	.25
1N5244B	14v	z	.25
1N5245B	15v	z	.25

**SOCKETS/BRIDGES**

8-pin	pcb	.25	ww	.45
14-pin	pcb	.25	ww	.40
16-pin	pcb	.25	ww	.40
18-pin	pcb	.25	ww	.75
22-pin	pcb	.45	ww	1.25
24-pin	pcb	.35	ww	1.10
28-pin	pcb	.35	ww	1.45
40-pin	pcb	.50	ww	1.25
Molex pins	.01	To-3 Sockets		.45
2 Amp Bridge		100-prv		1.20
25 Amp Bridge		200-prv		1.95

**TRANSISTORS, LEDS, etc.**

2N2222	NPN	(Plastic .10)	.15
2N2907	PNP		.15
2N3906	PNP		.10
2N3054	NPN		.35
2N3055	NPN	15A 60v	.50
T1P125	PNP	Darlington	.35
LED Green, Red, Clear			.15
D.L.747		7 seg 5/8" high com-anode	1.95
XAN72		7 seg com-anode	1.50
FND 359		Red 7 seg com-cathode	1.25

**C MOS**

4000	.15
4001	.20
4002	.20
4004	3.95
4006	1.20
4007	.35
4008	.95
4009	.30
4010	.45
4011	.20
4012	.20
4013	.40
4014	1.10
4015	.95
4016	.35
4017	1.10
4018	1.10
4019	.60
4020	.85
4021	1.35
4022	.95
4023	.25
4024	.75
4025	.35
4026	1.95
4027	.50
4028	.95
4030	.35
4033	1.50
4034	2.45
4035	1.25
4040	1.35
4041	.69
4042	.95
4043	.95
4044	.95
4046	1.75
4049	.70
4050	.50
4066	.95
4069	.40
4071	.35
4081	.70
4082	.45

7400	.15
7401	.15
7402	.20
7403	.20
7404	.15
7405	.25
7406	.35
7407	.55
7408	.25
7409	.15
7410	.10
7411	.25
7412	.30
7413	.45
7414	1.10
7416	.25
7417	.40
7420	.15
7426	.30
7427	.45
7430	.15
7432	.30
7437	.35
7438	.35
7440	.25
7441	1.15
7442	.45
7443	.85
7444	.45
7445	.65
7446	.95
7447	.95
7448	.70
7450	.25
7451	.25
7453	.20
7454	.25
7460	.40
7470	.45
7472	.40

7473	.25
7474	.35
7475	.35
7476	.30
7480	.55
7481	.75
7483	.95
7485	.95
7486	.30
7489	1.35
7490	.55
7491	.95
7492	.95
7493	.40
7494	1.25
7495	.60
7496	.80
74100	1.85
74107	.35
74121	.35
74122	.55
74123	.55
74125	.45
74126	.35
74132	1.35
74141	1.00
74150	.85
74151	.75
74153	.95
74154	1.05
74156	.95
74157	.65
74161	.85
74163	.95
74164	.60
74165	1.50
74166	1.35
74175	.80

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74176	1.25
74180	.85
74181	2.25
74182	.95
74190	1.75
74191	1.35
74192	1.65
74193	.85
74194	1.25
74195	.95
74196	1.25
74197	1.25
74198	2.35
74221	1.00
74367	.85
75108A	.35
75110	.35
75491	.50
75492	.50
74H00	.25
74H01	.25
74H04	.25
74H05	.25
74H08	.35
74H10	.35
74H11	.25
74H15	.30
74H20	.30
74H21	.25
74H22	.40
74H30	.25
74H40	.25
74H50	.25
74H51	.25
74H52	.15
74H53J	.25
74H55	.25

74H72	.55
74H101	.75
74H103	.75
74H106	.95
74L00	.35
74L02	.35
74L03	.30
74L04	.35
74L10	.35
74L20	.35
74L30	.45
74L47	1.95
74L51	.45
74L55	.65
74L72	.45
74L73	.40
74L74	.45
74L75	.55
74L93	.55
74L123	.55
74S00	.55
74S02	.55
74S03	.30
74S04	.35
74S05	.35
74S08	.35
74S10	.35
74S11	.35
74S20	.35
74S40	.25
74S50	.25
74S51	.45
74S64	.25
74S74	.40
74S112	.90
74S114	1.30

74S133	.45
74S140	.75
74S151	.35
74S153	.35
74S157	.80
74S158	.35
74S194	1.05
74S257 (8123)	.25
74LS00	.35
74LS01	.35
74LS02	.35
74LS04	.35
74LS05	.45
74LS08	.35
74LS09	.35
74LS10	.35
74LS11	.35
74LS20	.35
74LS21	.25
74LS22	.25
74LS32	.40
74LS37	.35
74LS40	.45
74LS42	1.10
74LS51	.50
74LS74	.65
74LS86	.65
74LS90	.95
74LS93	.95
74LS107	.85
74LS123	1.00
74LS151	.95
74LS153	1.20
74LS157	.85
74LS164	1.90
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LM310	1.15
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LM318 (Mini)	.65

LM320K5 (7905)	1.65
LM320K12	1.65
LM320T5	1.65
LM320T12	1.65
LM320T15	1.65
LM339	.95
7805 (340T5)	.95
LM340T12	1.00
LM340T15	1.00
LM340T18	1.00

LM340T24	.95
LM340K12	2.15
LM340K15	1.25
LM340K18	1.25
LM340K24	.95
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LM747	1.10
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9309	.35
9322	.85
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9601	.75
9602	.50

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2102-1	1.75
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- Sensitivity: less than 25 mv.
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- Gate time: 1 second, 1/10 second, with automatic decimal point positioning on both direct and prescale
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- Accuracy: 10 ppm, .001 ppm with TV time base!
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- High Accuracy (1 minute/month)
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- Super instructions
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Automatically adjusts display brightness according to ambient light level. For DC-11 Car Clock.

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7475	.50	LED DRIVER		7812	.89	FET MPF 102 type	3/\$2.00
7490A	.55	75491	.50	7815	.89	UJT 2N2646 type	3/\$2.00
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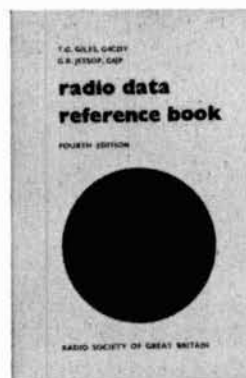
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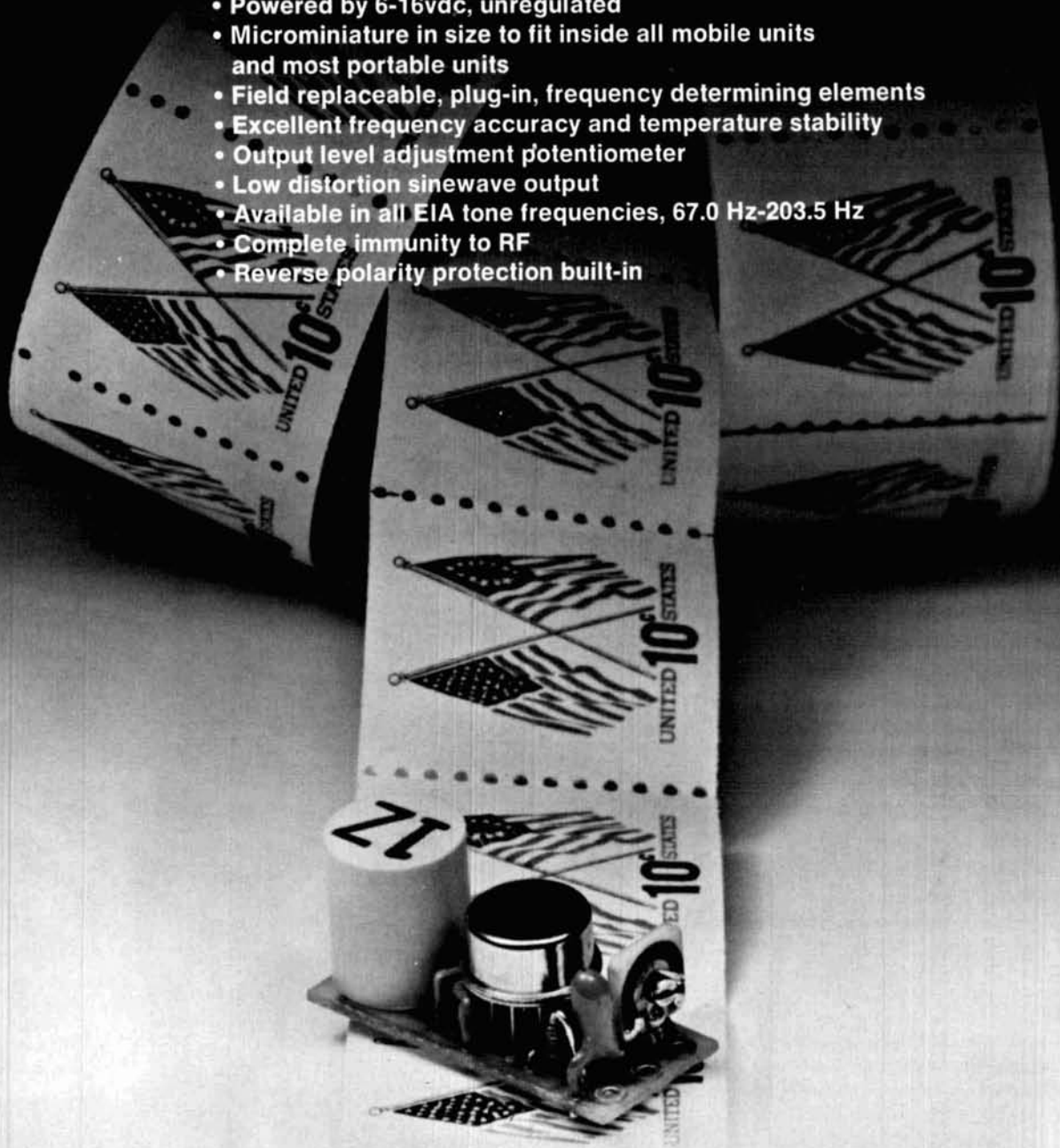
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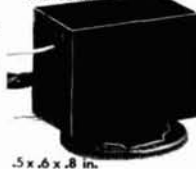
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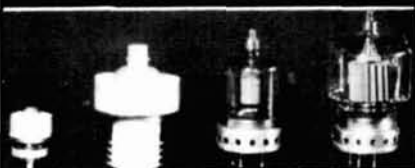
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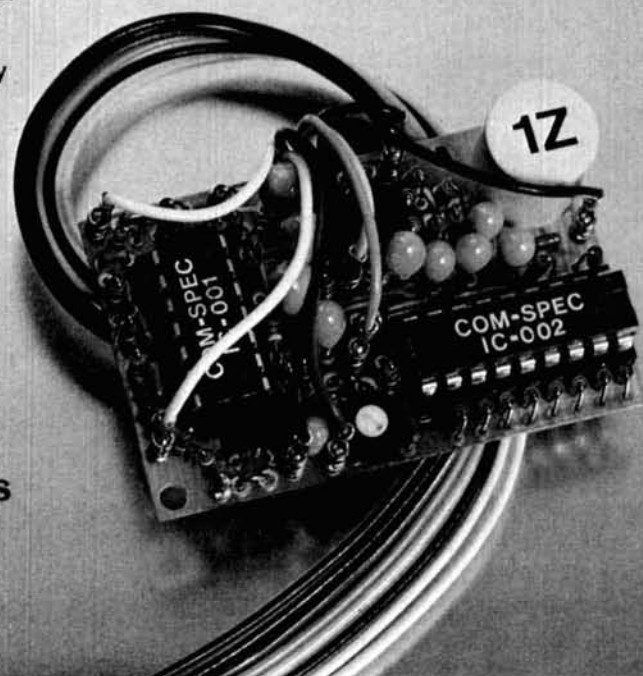
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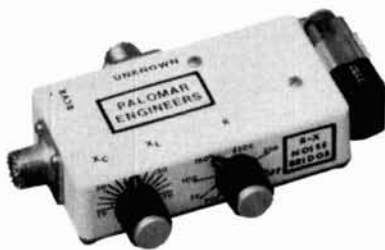
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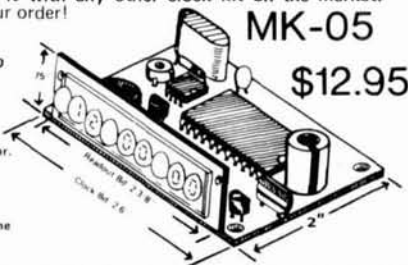
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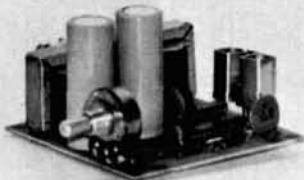
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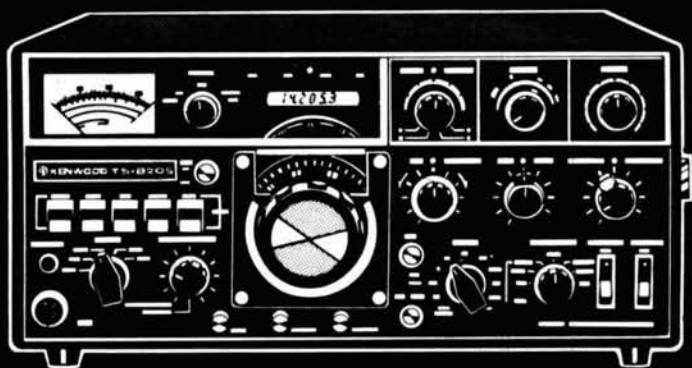
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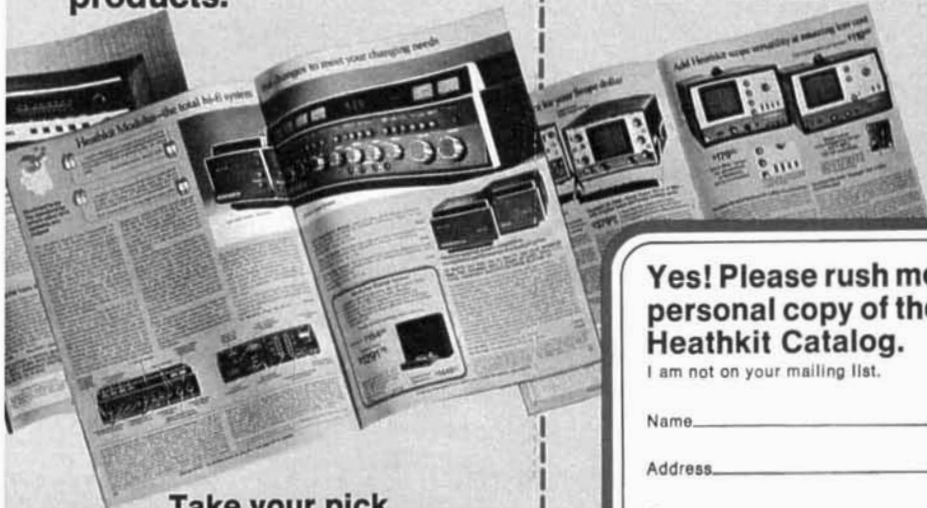
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