a practical approach to
432-MHz SSB

this month

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A whole new class of broadband high-power rf amplifiers is about to hit the market; under study for some time, they use both vacuum-tube and semiconductor technology. The EBS—electron-bombarded semiconductor—amplifier consists of an electron-gun modulation system, semiconductor target and output coupling network, all within a glass or ceramic envelope. The semiconductor target is simply a pair of silicon diodes, each consisting of two metallic electrodes with a pn junction under the top contact.

Amplifier operation is based on a well-known fact: A modulated electron beam can control the current in a reverse-biased semiconductor junction. In the EBS system shown in fig. 1 the electron beam is intensity modulated by an input signal on the grid. The high-power beam electrons that strike the silicon target create thousands of electron-hole pairs. Since there is a high bias voltage across the target, the free electrons are attracted to the far contact; the holes return quickly to the bombarded contact.

In the absence of the electron beam there is negligible current flow through the silicon. However, when illuminated by the electron beam, output current is proportional to beam current, and the device acts as a linear amplifier. The rf gain of the EBS amplifier is controlled by the current gain in the silicon target and the modulation sensitivity of the electron beam. Present laboratory amplifiers provide gains in excess of 40 dB with efficiencies over 65%.

The electron beam can also be deflection modulated as in conventional cathode-ray tubes. With a deflection-modulated EBS amplifier and two semiconductor targets, no beam current is intercepted when the beam is not modulated. With an input signal, the electron beam is deflected from one target to another; the positive portion of the sine wave is generated in one diode and the negative portion generated in the other. This is true class-B operation and provides high power-output capability.

The EBS amplifiers presently reaching the commercial market are limited to operation below 1500 MHz. However, engineers are working on new designs that should provide operation up to 5000 MHz. Although it will be some time before these devices find their way into the amateur market—and then probably by way of the surplus market—the EBS amplifier offers an alternate approach to the serious uhf amateur who wants to generate prodigious amounts of rf power on 1296 MHz and above.

Jim Fisk, W1DTY
editor
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This article is the result of a one year study of techniques and devices applicable to 432 MHz ssb. I believe the techniques described here represent the best alternatives presently available. In each case I considered a number of approaches; the most efficient* are treated in detail, while the disadvantages of the others are discussed in an effort to acquaint you with some of the pitfalls. This by no means implies that the techniques not advocated are impossible; the non-recommended methods are feasible but at a much higher overall cost.

In an attempt to make this article as comprehensive as possible, all components were built in modular form. While this adds slight additional cost because of patch cables it permits the ultimate in versatility and allows verification tests of all circuit arrangements. Finally, all tests were made with calibrated laboratory test equipment. This provides a valid data base in areas which are normally troublesome to the amateur (i.e. spurious output and intermodulation distortion).

introduction

While operating on the 432-MHz band during the past several years I have noticed a definite lack of effective modulation on most signals. Although a large number of operators cling to cw (and its efficiency, number of components and cost.

Fred Telewski, WA2FSO, 460-40 Old Town Road, Port Jefferson Station, New York 11776.
weak-signal effectiveness cannot be disputed; it disturbs me to see many contacts severely limited in their ability to exchange information when conditions permit the use of higher density modulation. Though amateurs are not hampered in their ability to generate power at 432 MHz they are apparently limited in their ability to modulate it efficiently.

It is the philosophy of this article to provide you with more than a cookbook which tells you where to cut, bend and drill. While much of the equipment discussed here may be duplicated it is my belief that few amateurs make identical copies. However, sufficient information is supplied to help you make intelligent decisions on the basis of economy and already existing equipment. Although the equipment discussed here was evaluated with laboratory-grade test equipment, the ssb units were aligned for maximum output power in an amateur manner, then evaluated, so the data is meaningful to the amateur without access to sophisticated test gear.

power considerations

It is helpful to acquaint yourself with the various devices that will function as amplifiers at 432 MHz. Linear uhf transistors are prohibitive because they are expensive and limited to low power.

Klystrons, amplitrons and cross-field amplifiers, while capable of high power, are not suitable due to cost and complexity. This leaves us with the family of power-grid tubes. Table 1 shows popular vacuum tubes and approximate gains which may be obtained as 432-MHz linear amplifiers. To make this information pertinent to the amateur both new and used tubes were tested.

The third-order intermodulation distortion (IMD) values* for the tubes I tested fall in the 20- to 30-dB range. While this may sound low in comparison to 20-meter standards, an objective analysis is necessary to determine what ill effects if any this will have on 432-MHz operation. The major objections to IMD are its generation of signals outside the communications passband and wasted power. The former is a particular concern on the high-frequency bands because of

![Diagram](image)

**fig. 1. Proposed system for running 500 watts PEP input on 432 MHz. Efficiency of final stage is assumed to be 40%.**

<table>
<thead>
<tr>
<th>type</th>
<th>gain (dB)</th>
<th>power output (PEP watts)</th>
<th>3rd order IM (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6939</td>
<td>15</td>
<td>2.6</td>
<td>25</td>
</tr>
<tr>
<td>2C39, 2C39A</td>
<td>12.5-15</td>
<td>30</td>
<td>25-30</td>
</tr>
<tr>
<td>2C39B, 3CX100A5, etc.</td>
<td>14-16</td>
<td>40</td>
<td>25-30</td>
</tr>
<tr>
<td>4X150A (new)</td>
<td>15</td>
<td>80</td>
<td>20-25</td>
</tr>
<tr>
<td>(used)</td>
<td>14</td>
<td>80</td>
<td>20-25</td>
</tr>
<tr>
<td>4CX250B (new)</td>
<td>17</td>
<td>200</td>
<td>20-25</td>
</tr>
<tr>
<td>(used)</td>
<td>16</td>
<td>200</td>
<td>20-25</td>
</tr>
</tbody>
</table>
high signal densities. However, it is hardly worth mentioning at uhf. Wasted power seems to be of little consequence since an IMD ratio of 20 dB results in a 1% power loss. Most amateurs lose that adjusting his station for maximum power output.

Considering a medium power system, 500 W PEP input with final-amplifier efficiency of 40%, the output power

much power in the first few feet of transmission line. Consequently, all designs presented here are based on achieving less than 20-dB IMD at the output, and assume that exciter IMD is 30 dB down.

IMD performance is given constant attention throughout this article. Measured values of IMD are presented for various levels of operation. It should be noted that all IMD tests were made with the equipment optimized for maximum power output, not minimum IMD. Therefore, the measured values are in line with what an amateur might expect when should be in the neighborhood of 200 W PEP or +53 dBm. A 4CX250B is capable of 16-dB gain, so its drive requirement is +37 dBm (5W PEP). A good 2C39 linear will drop the drive requirement to +22 dBm (158 mW PEP). At this point assume a mixer which will produce between 0.1 and 1 W PEP output.

**Fig. 1** shows the proposed system. A power train of three stages will take low-frequency ssb and put it on 432 MHz at the 500-watt level. At this point, it appears to be no more difficult to put 500 watts on 3/4 meters than it is on 20 meters.
the mixer

The search for a suitable mixer covered a great deal of territory. It must be efficient, be stable, exhibit low IMD, The Amperex 6939 seemed to be a good choice since it has already been successfully used as a high-frequency mixer. However, it seems that most of the published designs are limited by their

be easily reproduced and, perhaps most important, have low cost. Although I considered parametric upconverters, and did make one work in the laboratory, the parametric device could not be deemed a reproducible unit for the amateur without access to sophisticated test equipment (the unit also required 15 watts of pump power at 382 MHz). The second consideration was in the area of transistor mixers. Those transistor stages which were economical operated at low power levels (less than -10 dBm) and required an unreasonable number of linear gain stages to achieve respectable output power. Those stages which could handle higher power were cost prohibitive. Various diode mixer configurations were also examined but their limitations fall in the first transistor category. This narrowed the mixer field to our old friend the vacuum tube.

*Full-size templates of fig. 3, fig. 8 and fig. 18 are available from ham radio for 25c.
adjusted for maximum output power. It is a well known fact of network theory that any lossless, reciprocal, passive, two-port network will have its output reflection coefficient equal in magnitude to its input reflection coefficient. Since our networks are certainly passive, reciprocal, and hopefully, not too lossy, this is a good beginning for optimizing any grid circuit.

An idea of grid-circuit loss may be obtained by shorting the grid to ground (with B+ and bias off) and noting the input vswr; it should be greater than 10:1 if circuit losses are low. With the tube operating normally the input vswr should be less than 2:1 for a reasonable grid circuit. In general, the problem of coupling to a high capacitance grid structure may be easily dealt with through the use of half-wave lines.2 Quarter-wave circuits are usually ineffective since tube capacitance severely forshortens the line and it is difficult to place a tuning capacitor sufficiently close to the grid for proper operation.

The half-wave grid lines used in this mixer provide a vswr of 1.3:1 or less after one or two passes of the tuning wand. The rest of the circuit is quite conventional. The tube is operated within the normal ratings specified by the manufacturer consistent with reliability and economy. Table 2 lists the operating parameters of the 6939 mixer tube.

<table>
<thead>
<tr>
<th>Static</th>
<th>(E_b)</th>
<th>225 Vdc</th>
</tr>
</thead>
<tbody>
<tr>
<td>plate voltage</td>
<td>(E_b)</td>
<td>225 Vdc</td>
</tr>
<tr>
<td>plate current</td>
<td>(I_b)</td>
<td>23 mA</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Driven with local oscillator</th>
<th>(E_b)</th>
<th>225 Vdc</th>
</tr>
</thead>
<tbody>
<tr>
<td>plate voltage</td>
<td>(E_b)</td>
<td>225 Vdc</td>
</tr>
<tr>
<td>plate current</td>
<td>(I_b)</td>
<td>28 mA</td>
</tr>
<tr>
<td>screen voltage</td>
<td>(E_c)</td>
<td>210 Vdc</td>
</tr>
<tr>
<td>screen current</td>
<td>(I_c)</td>
<td>6 mA</td>
</tr>
<tr>
<td>cathode voltage</td>
<td>(E_k)</td>
<td>9 Vdc</td>
</tr>
<tr>
<td>grid current</td>
<td>(E_c)</td>
<td>0 Vdc</td>
</tr>
</tbody>
</table>
A few words concerning spurious mixer outputs are in order. The diagram in fig. 4 describes the spurious and IMD evaluation tests for 50 MHz excitation. Directly at the mixer output the local oscillator is suppressed 15 dB and the image is down 32 dB (see fig. 4). At the output of the first gain stage local oscillator feedthrough is suppressed 45 dB and the image is down more than 60 dB.

If 28 MHz excitation were chosen, at the output of the first gain stage the local oscillator would be suppressed 25 dB, and the image would be 50 dB down. Considering the power level and typical off-resonance antenna efficiencies these numbers are adequate. With excitation below 28 MHz an interdigital filter such as the one described by W2COH should be used between the mixer and the first linear gain stage. With an interdigital filter in the system an excitation frequency as low as 9 MHz will provide spurious suppression superior to that obtainable with 28 MHz excitation without the filter.

The IMD performance of the 6939 mixer at various power levels is sum-
fig. 7. 2C39 amplifier intermodulation distortion tests. These tests were run simultaneously with the 6939 mixer test shown in fig. 6.

marized in fig. 6. The 6939 mixer, when operated according to table 2, with 240 mW PEP 50-MHz drive, is capable of 150 mW PEP output; IMD under these conditions is 30-dB down.

A chassis layout for the 6939 mixer is shown in fig. 8. If you use all new components in the construction of the mixer, total cost will be less than $20. The 6939 tube, the most expensive part, lists at $12.

linear amplifiers

Depending on the amount of power you want to put on 432 MHz, the linear amplifier can take any of the forms shown in fig. 9. This chart shows various vacuum-tube combinations for power level from 5 W PEP to 2 kW PEP.

The 6939 linear amplifier stage in fig. 10 is capable of 6 watts PEP input with approximately 2.6 W PEP output. This represents a stage efficiency of 43%. This design uses essentially the same circuit as the mixer except that the cathode is directly grounded, an external bias port is provided for the grid, and the screen is fed from a regulated source (to improve linearity). Mechanically, the 6939 mixer and amplifier layouts differ only by three holes, so both chassis plates may be drilled simultaneously. Table 3 lists the typical operating parameters of the 6939 amplifier.

the 2C39

I compiled a good deal of information about the operation of the 2C39 family. Older tubes such as 2C39s and 2C39As, and used tubes of newer varieties, offer an interesting bonus: they may be operated as zero-bias triodes. New 2C39Bs, 3CX100As, etc., require some bias to achieve reasonable plate currents. While best linearity and maximum output power occur when the tubes are idled at approximately 60% of their rated dissipation (60 W), they may be idled as low as 15 watts with reduced power output.

Under zero-bias conditions this dissipation range typically corresponds to a
plate voltage range of 350 to 700 Vdc and output powers from 4 to 30 watts PEP. The gain of the tube varies about 1 dB between these two voltage extremes with the higher gain at the higher operating voltage. Table 1 and fig. 11 detail the typical properties of the 2C39 family. The dc operating parameters of the 2C39 stage used earlier (in the IMD and spurious products evaluation) were, $E_b = 400$ Vdc, $I_b = 60$ mA, plate dissipation = 24 watts. Spurious and IMD characteristics of this 2C39 amplifier are summarized in fig. 7.

Since the 2C39 amplifier I used to compile the 2C39 data uses a surplus cavity, no actual homebrew amplifier is described in this article. However, several

![fig. 8. Layout template for 6939 mixer (fig. 2) and linear amplifier (fig. 10). For the mixer circuit omit holes for C9 and C10. For the linear amplifier omit the local-oscillator input. Hole sizes: A. 0.140"; B, 0.250"; C, 0.375"; D, 0.750".

fig. 9. 432-MHz power trains for various output powers, in approximately 3-dB steps from 5 watts to 2 kW. The listed powers are input; output power is approximately 40% of the input power. All configurations except the last (3CX1000A7) were verified by actual operational tests.](image)
The first consideration is that of drivers. (Power dissipation approximately 6 watts.) These may find their way into resistors, transformer windings, and other dissipative structures. Large grid compartment sizes are also a problem to many users. What do you do when you find that the driver stage's plate voltage is 225 vdc? The surplus 2C39 cavity used in the 432-MHz tests.

Higher power

The surplus 2C39 cavity used in my tests. Transformers and other dissipative structures may find their way into resistors. Transformer layout is very important when designing a large grid compartment. It may be that the tube is not well designed. Another problem which tends to plague large grid compartments is that of multimoding. When the size of the grid compartment coincides with certain preferred dimensions, the entire compartment may act as a resonator. Usually the

...
result is multiple tuning peaks and erratic grid-network behavior. Incidentally, multimoding is also a problem in plate tank compartments which are too large. It is a good rule of thumb to keep two dimensions of the box well below one-half wave at the operating frequency to eliminate multimoding (at 432 MHz this corresponds to approximately 13.5 inches).

grid circuit

Eimac engineers, when designing the SK610 socket, were kind enough to provide a means of fastening 1-5/8-inch tubing to the grid side of the socket, thereby allowing you to make a grid cavity. Since 1-1/2 inch copper plumbing pipe makes a snug fit to the base of the socket it's easy to make an efficient grid cavity.

You must now decide whether to use a 1/4- or 1/2-wave grid cavity. (Eimac Application Bulletin no. 14 gives many fine examples of 1/2-wave grid structures which are efficient and simple to construct.) In the amplifier discussed here a somewhat different approach to a 1/4-wave structure is taken.

The input reactance of the 4X150A, 4CX250B series of tubes is in the vicinity of 25 ohms capacitive. The length of the grid circuit in electrical degrees may be calculated from the equation:

$$\theta = \tan^{-1} \frac{X_C}{Z_0}$$

where $X_C$ is the capacitive reactance (25 ohms) and $Z_0$ is the characteristic impedance of the cavity. For the coaxial arrangement used here $Z_0$ is given by the equation:

$$Z_0 = 138 \log \frac{b}{a}$$

where $b$ is the inside diameter of the outer conductor and $a$ is the outside diameter of the inner conductor. K7UNL provided design data for other types of resonant lines in a recent article in ham radio. Choosing an inner conductor diameter of 3/4 inch and the outer conductor diameter of 1-1/2 inch, $Z_0$ is approximately 41 ohms. Running this through eq. 1 yields 31.4°. Proportion will provide the physical length of the line:

$$\frac{31.4^\circ}{360^\circ} = \frac{l}{\lambda}$$

where $\lambda = 69$ cm. (Equivalent wavelength for 432 MHz is 69 cm.) Therefore $l = 6$ cm or 2.3 inches. Unfortunately, this is a bit short and as yet there is no way of tuning the grid circuit. This verifies previous comments about quarter-wave lines being severely forshortened by high capacitance grid structures.

Front-panel layout of the 432-MHz power amplifier. Circuit is shown in fig. 12.
C6 loading capacitor. 0.4-8 pF piston (JMC1802 may be used) homemade capacitor used in amplifier in photos

C7 air disc capacitor. 1-3/4" diameter, 1/8" thick brass disc soldered to 3/4" length of 3/4" diameter threaded bronze pipe. Pipe is mounted through threaded bronze flange (available at plumbing supply) (see fig. 13)

C8 1" diameter, 1/8" thick brass disc capacitor (see fig. 15)

C9 1-1/4" length 1/4" brass rod soldered to BNC connector, braced with 1/4" Teflon rod (see fig. 13)

L1 grid cavity (see fig. 13)

L2 copper plate line (see fig. 15)

L3 copper output strap (see fig. 15)

RFC1 8 turns no. 22 enameled wire closewound on 1/8" form

RFC2,3,4,5 8 turns no. 20 Teflon-insulated solid wire closewound on 3/8" form

fig. 12. 432-MHz linear amplifier stage using a 4X150A or 4CX250B. Alternate output coupling at A. Screen bypass capacitor is part of tube socket.

fig. 13. Tuned grid circuit for the highpower 432-MHz linear amplifier.
table 4. 4CX250B linear operating parameters.

For the 4X150A, maintain 6-volt filament voltage and adhere to manufacturer's reduced ratings for uhf service.

<table>
<thead>
<tr>
<th>Power Input</th>
<th>375 W</th>
<th>500 W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plate Voltage ($E_B$)</td>
<td>1500 Vdc</td>
<td>2000 Vdc</td>
</tr>
<tr>
<td>Screen Voltage ($E_{C2}$)</td>
<td>350 Vdc</td>
<td>350 Vdc</td>
</tr>
<tr>
<td>Grid Voltage ($E_{C1}$)</td>
<td>-55 Vdc</td>
<td>-55 Vdc</td>
</tr>
<tr>
<td>Plate Current ($I_B$)</td>
<td>100 mA</td>
<td>100 mA (static)</td>
</tr>
<tr>
<td>Screen Current ($I_{C2}$)</td>
<td>8 mA</td>
<td>5 mA</td>
</tr>
</tbody>
</table>

The overall length of the grid line is increased to 5 inches to account for the 1 cm spacing between the plates, the thickness of the plates (approximately 1/4 inch) and any non-computed second order effects (see fig. 13). Remember, if the line is slightly longer than necessary it may easily be shortened; however, if the line is too short to begin with you will have trouble trying to stretch it!

Another interesting problem associated with these tubes is the matter of forced-air cooling. In linear service it is advisable to use maximum recommended plate voltage to obtain maximum linear power output. Under these conditions the tube runs hot, and cooling it requires large amounts of air — provided by a moderately large fan or a smaller one operating at high speeds. Large fans are expensive and bulky while small high speed ones are noisy. However, if you pressurize the plate compartment, disregard the conventional chimney and provide an exhaust passage from the anode radiator to the outside world (see fig. 14), the back pressure on the fan is considerably reduced. Under these conditions, the tube operates reasonably with a 3-inch 3600-rpm squirrel-cage fan at a pressure drop of 1.30 inch. This provides an added bonus in that the plate-tank components are air cooled; therefore the amplifier is free of resonance drift associated with the thermal expansion of the tank circuit.

The plate tank enclosure is made from 1/8-inch 2024-T3 aluminum stock with 1/2 x 1/2 x 1/8-inch aluminum angle at

![fig. 14. Air flow in the 432-MHz amplifier.](image-url)
the corners. The plate tank circuit is a conventional half-wave line. Output coupling may be accomplished with equal efficiency through inductive or capacitive probes as shown in fig. 12. Operating parameters are given in table 4.

filament voltage

Normally you reduce filament voltage at uhf to compensate for back bombardment of the cathode. Fortunately, back bombardment is minimized under the condition of linear operation. The usual criteria (i.e. minimum grid bias, high screen voltage and low grid drive) which minimize back bombardment are en-
Plate compartment of the 432-MHz power amplifier.

fig. 16. 127-MHz local oscillator uses International Crystal OE1 crystal oscillator with two-stage amplifier. Value of R1 is selected to give proper operating voltage for the OE1.

L1
6 turns no. 18, spaced one diameter, on 3/8" form
1 μH choke
3 turns no. 16 enameled close-wound on 1/2" form
forced in linear service. At the same time, in linear ssb service, the duty cycle of the amplifier is significantly less than 100% thereby further reducing back heating.

Consequently, the filament voltage is maintained at the normal 6V. Should you desire to operate this amplifier class C, you must remember to reduce the filament voltage accordingly. However, there is no practical reason for using class C since you already have the most effective voice system available. If you wish to operate cw the linear will not deliver sufficiently less power than its class C counterpart to make bias and drive-level changes worth-while.

**local oscillator chain**

The solid-state local oscillator chain described here uses an International Crystal OE1 overtone oscillator at 127.333 MHz followed by an amplifier (fig. 16) and tripler (fig. 17) to produce power at 382 MHz, which when heterodyned with a 50-MHz ssb exciter provides 432-MHz ssb. Other exciter frequencies (anything from 9 to greater than 50 MHz) may be used by altering the local-oscillator frequency. The circuit in fig. 16 uses two Amperex transistors to amplify the 1 mW OE1 output to the 1-watt level.

The oscillator amplifier was put together on a 4 x 6-inch piece of double-sided copper-clad board and mounted upside down in a 2 x 4 x 6-inch aluminum chassis. The 1 W output drives a varactor tripler which provides the 100 mW required for the mixer. A varactor tripler is used with the contingency that many amateurs presently on 432 probably have a varactor tripler which could be tuned down to the local-oscillator frequency, thereby saving a component. An equally adaptable vacuum-tube local-oscillator chain appeared in an article by K6JC.1

**summary**

Now that we have discussed the mixer, linear amplifiers and local oscillator chains as well as spurious and intermodulation distortion we have reached a point where everything needs to be put into perspective. The eight power trains shown in fig. 9, when properly operated, give IMD figures greater than 20 dB. In each case, spurious outputs were checked with the aid of a spectrum analyzer and found to be adequately suppressed (typically

---

greater than 40 dB for local-oscillator and image products. Power trains with two linear stages offer even greater spurious suppression.

Assuming tubes of reasonable quality the eight power trains in fig. 9 have a gain margin of 2 dB; that is, the amplifiers could produce up to 2 dB less than the maximum gain in table 1 and the circuits would still function adequately. The gain margin drops slightly more than 1 dB for excitation below 30 MHz. This is due to the insertion loss of the interdigital bandpass filter. Unlike the case of class-C amplifiers, if you fall short in gain by more than the margin, the system would still deliver a valid output but at a reduced level. This is because there is no drive threshold in linear amplifiers at which output suddenly falls off.

A power train using a 3CX1000A7 triode in grounded-grid linear service is described by W6SAI. This amplifier should easily be able to run one to two kilowatts PEP input. Although this particular configuration has not been verified by actual tests, calculations indicate that the 4CX250B should be capable of driving the high-power amplifier with ease.

Needless to say, there are more expensive tubes which will serve as excellent linear amplifiers at 432. There are also tubes which will operate satisfactorily at reduced input at this frequency. However, keeping in mind the philosophy of this article, I have endeavored to select the most economical tubes which are not on the verge of losing steam at 432 MHz.

I would like to thank the Microwave Instruments Division of AIL for permitting the use of their newly developed microwave spectrum analyzer as well as other rf test equipment. I would also like to thank R. Kandle, K2RIW, for his comments and suggestions concerning the text. Thanks are also extended to W. Doesschate of Amperex Corporation and Bill Orr of Eimac Division of Varian for their valuable technical assistance throughout the course of this project.

references
After the initial fascination of operating in the fm mode has worn off, the more technically adventurous want to add gadgets and refinements to their equipment. Preamps are popular; others go the route of tone calling, etc. Still others try the carrier-operated relay (COR), using it to trigger a tape recorder or activate a monitor for their private channel.

At this station I wanted to try some solid-state COR circuits and began experimenting with mockups using bipolar transistors (fig. 1). One of the problems encountered in using conventional transistors with a tube-type receiver was the undesirable loading effect introduced when the COR was attached to an i-f grid or to the squelch dc amplifier. Operation (especially in the squelch circuit) was upset considerably. By prefacing the relay driver with an fet (which has a very high input impedance) it is possible to attach the unit to the receiver without disturbing results.
carrier-operated relay

The COR shown in fig. 2 has been tried in a number of Motorola Sensicon A and G model receivers and seems to work best when attached to the grid of the last i-f amplifier (455 kHz). Referring again to fig. 2, a negative voltage at point A of approximately 3.5 volts or greater will stop the fet from conducting and allow the voltage at the base of the transistor to rise. When this occurs, the transistor will conduct and pull in the relay. Typical swing in the Sensicon G receiver at the grid of the last i-f amplifier is from -1 volt with no signal to -4 volts with a 1 μV signal. Operation of the fet stage in the monitor is similar to that of the COR circuit. Once the 3N84 is triggered, however, it will continue to conduct and operate the Sonalert until the anode circuit is broken. A suitable low-current bulb could be used in place of the Sonalert as an indicator is desired.

call monitor

Illustrated in fig. 3 is a call monitor that will latch on and give an indication that a carrier has appeared on a channel. Experiments have indicated that the monitor is best attached at the grid of the dc amplifier in the squelch circuit. This is necessary because the monitor should be biased positively in the NO CALL mode to prevent noise from inadvertently triggering the 3N84. Typical voltage change in the Sensicon G at the grid of the dc amplifier is from about +3 volts with no signal to -3 volts with a 0.5 μV signal. Operation of the fet stage in the monitor is similar to that of the COR circuit. Once the 3N84 is triggered, however, it will continue to conduct and operate the Sonalert until the anode circuit is broken. A suitable low-current bulb could be used in place of the Sonalert as an indicator is desired.

Although the ideas in these circuits are certainly not new or original, it is hoped they will prompt some experimentation and building along these lines. Thanks go to Reg (VE4RW) for assisting in the wiring and testing of the circuits.

Ham radio
one-man antenna matcher

A sensitive swr bridge and milliwatt signal source are featured in this compact instrument.

The adjustment of an antenna matching section (T-match, gamma, etc.) is usually a two- or three-man job—one at the antenna, one at the transmitter, and possibly a third to relay information. Because the matching adjustment involves the transmitter, some means must be used to reduce its output while carefully preventing overload of the final-amplifier tubes, particularly in many of today's rigs using TV sweep tubes. The radiation of considerable rf energy, necessary to give meaningful indications on swr meters such as the Monimatch and the wattmeter types, causes interference on already crowded bands.

The instrument described here eliminates all these problems. It's completely self-contained, weighs about a pound, and radiates only 0.1 watt maximum. One man at the antenna-matching section does the whole job; no assistants are needed, and the station transmitter is not used.

description

The instrument consists of a resistance bridge and transistor amplifier (fig. 1) and an rf signal source (fig. 2). The signal source, constructed of readily available modular units,* can be put together in minutes.

Unlike the Monimatch, this instrument isn't frequency sensitive. One hundred mW will drive the meter to full-scale deflection on 10 through 80 meters.

The bridge uses 1/2-watt composition resistors. Resistor Rs, which determines impedance, must be close to the desired value for your equipment (e.g., 52 ohms for most transmitters and transmission lines). Bridge-arm resistors R1 and R2 must be closely matched, although their exact value isn't critical.

R3 and R4 should be close in value if comparable input and output readings are to be obtained. Likewise, diodes CR1 and CR2 (1N34A's) should be closely matched.

Capacitors are disc ceramics. The 2N107 transistor has medium gain and works well with a 1.5-volt dry cell. A lower-gain device may require 3 volts to give full-scale meter deflection. Polarities shown are for a pnp transistor; an npn can be used by reversing supply polarity.

Switch S1 is a 2-pole, 3-position switch. A rotary type or a slide switch with center position off can be used.

bridge construction

The bridge, meter, and transistor amplifier are contained in a 5-1/4 x 3 x 2-1/8 inch aluminum mini-box. The shielded compartment may be made from heavy aluminum or flashing copper. The shield is in the form of a

*International Crystal Mfg. Co., 10 North Lee, Oklahoma City, Oklahoma 73102. The OX oscillator is $2.95; the PAX-1 amplifier is $3.75. Both in kit form.
Z-bracket, which is attached to the end wall of the minibox. The shield shown in the photo was made from two pieces of 1-inch aluminum angle stock fastened together to form a Z.

Shielding and parts assembly of the bridge are important. The only elements within the shield compartment are resistors Rs and R2, which are mounted at right angles to each other. A piece of RG-58/U cable is connected between the SO-39 chassis connector at the opposite end of the box and an insulated stud within the shielded compartment. The center conductor is connected to the stud and the shield braid to a ground lug next to the stud.

Connections to the remaining bridge elements are made through clearance holes in the rear wall of the shield. Short leads are required up to and including the point at which R3 and R4 are connected. The usual soldering precautions are suggested, and the use of heat sinks (long nose pliers, etc.) is recommended. The layout of the other parts is not critical and follows a logical sequence. If the box size and layout shown are followed, be sure the meter doesn't extend inside the box by more than 7/8 inch exclusive of terminals. Note that the SO239 output connector and the insulated stud are centered close (11/16 inch) to the open side of the minibox.

After assembly and wiring, and with the battery in place, it will be noted that a small reading (a few microamps) will be indicated on the meter with the switch in either the FWD or REF position. This is the "no-signal" current of the transistor and is the "zero" indication of a perfect match when the bridge is in use.

![fig. 2. Signal source and amplifier. Units are available in kit form; easily assembled.](image)

**signal source**

The OX Oscillator uses an EX Crystal of the frequency at which the antenna matching is to be accomplished. The OX – PAX-1 combination can be made to function over two adjacent ham bands by changing crystals and repeaking the coils. The OX – PAX-1 will put out up to 200 mW, which is more than enough to drive the bridge. The units are assembled in the same size minibox as the bridge. A much smaller box would accommodate the signal-source units, which are only 1-1/2 inch square, but it was desired to mount the battery, consisting of eight penlight cells inside the box, requiring the extra space.

Note that a double-pole switch is used to turn off both the 6- and 12-volt lines. Disabling only the negative line will result in a battery drain in the OFF position (between the 6- and 12-volt taps).

The rf generator may be connected to
the bridge by a double male adapter or by a length of RG-58/U cable if the rf unit is placed in your pocket.

The connection between the bridge and the antenna matching section must be as short as possible. The matching section can terminate in a female connector such as the SO-239, or a couple of inches of RG-8U and a PL-259 could be used. If the SO-239 is used, the bridge should be connected to it by a double male adapter.

checkout

Before using the equipment for matching or swr measurements, the bridge should be tested. Solder a 52-ohm resistor into a PL-259 connector as a dummy load, and insert it in the output connector of the bridge.

With the rf generator connected to the input of the bridge, position the switch to

FWD, and adjust the sensitivity control for a 1-mA reading on the meter. Positioning the switch to REF should reduce the meter reading to zero. If the meter doesn't drop to zero, bridge arms R1 and R2 are not equal, Rs is not 52 ohms, or coupling exists between the bridge elements.

If this test is satisfactory, remove the dummy load, and with the output open-circuited, adjust the meter reading for 1 mA in the FWD position. With the switch in the REF position, a 1-mA reading should be obtained. Repeat this last test

with the output shorted by a very short wire, resetting the meter to 1 mA in the FWD position. It should read 1 mA in the REF position.

Slight resistor and diode variations may make such correlations not quite as exact as indicated, but such differences should not exceed a few microamps.

calibration

If accurate swr measurements are to be made, the meter should be calibrated by using resistors of two, three, and four times the value of bridge resistor Rs. These resistors should be soldered into a PL-259 connector for such calibrations.

acknowledgement

I want to express my sincere thanks to my SWL friend and potential ham Herwart Werker for the photos.
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principles
and practice

Audio agc
has many uses in
amateur equipment —
this article describes
how it works
and presents
a practical circuit

This article should provide you with sufficient information to build a simple audio agc circuit, understand its operation, and integrate it into your particular application.

Agc stands for automatic gain control; audio agc is a means of equalizing weak and strong signals and prevents overload and distortion in the agc amplifier and following stages when strong signals appear at the input. Fig. 1 shows a widely used agc circuit in block form. Signals pass through the control element and are amplified to a level sufficient to be detected; the detector output is a dc voltage which increases when the input signal gets larger and decreases when the input signal gets smaller. This dc control voltage is fed back to the control element which attenuates the signal in proportion to dc control-voltage amplitude. The overall effect is that the output signal amplitude remains relatively constant as the input signal amplitude varies over a wide range, thus providing high gain for weak signals and low gain for strong signals. Manual gain control should always follow the agc circuit to adjust its relatively constant output to a level suitable for the following circuits.

applications

One of the most useful places for audio agc is between the microphone and transmitter. The agc circuit not only prevents overmodulation when speaking loudly into the microphone, it also minimizes decreases in modulation when voice level drops or the microphone is moved away. Once the manual gain control is set, no further attention should be required.

The current interest in direct-conversion receivers has brought another application for audio agc to mind. Several articles have been published describing these simple receivers, but few, if any, include any form of agc. Since most, if not all, of the gain of these receivers is provided in the audio amplifier, this would be the logical place for an agc
circuit. Audio agc would prevent distortion and ear fatigue caused by strong signals.

Other uses include telephone amplifiers and tape recorders. Audio agc is also a deterrent to audio howl or feedback common in public-address systems; the howl appears as a signal to the agc circuit which then reduces gain to control it.

**agc vs clippers**

Speech clippers are not uncommon in transmitters and usually include two diodes which clip the positive and negative excursions of the audio signal when its amplitude reaches a certain level. Such clipping circuits can prevent over-modulation, but they have two shortcomings compared to audio agc. When a speech clipper is limiting the audio signal, it is also distorting it and producing harmonic frequency components not present in the original speech signal; this distortion decreases intelligibility. Filters following the clipper do not remove harmonics of the lower speech frequencies which fall within the passband of the filter. In addition to distortion, the clipper circuit provides no increase in gain if the audio signal falls to an unusually low level; this does not improve intelligibility either.

Audio agc circuits do not have to introduce distortion to perform their function. They can be designed to hold output constant within a few dB while the input varies over a range of 60 dB or more.

You may think that clipping circuits have the advantage of simplicity but this argument is rather thin. Both techniques require an amplifier with enough gain to bring the signal up to the level required to forward bias a diode. The agc circuit requires no low-pass filter for the signal but needs a detector and control element. The advantages of a clean signal with almost constant amplitude should be weighed against the slight increase in complexity of an audio agc circuit.

**agc characteristics**

There are practical limits to the performance of any circuit, and conflicting requirements often dictate compromises in design goals. The following paragraphs describe the important characteristics and limitations of audio agc.

At extremely low input signal levels, the agc amplifier does not have sufficient gain to cause the detector diode to conduct; therefore the dc control voltage is zero, and the control element does not attenuate the signal. As the input signal is increased the agc amplifier output voltage increases linearly until the detector diode begins to conduct and produce a dc control voltage; this point is called the agc threshold because it is the point at which agc action begins.

Input signals below the agc threshold are amplified linearly, and input signals above the threshold are amplified or attenuated as needed to hold the output voltage constant. The agc amplifier gain can be increased until the threshold is so low that agc action occurs with circuit noise. This assures agc action on the lowest usable signal, but the signal-to-noise ratio of larger signals will be seriously degraded.

If amplifier gain is increased without discretion the dynamic range of the

---

**fig. 1. Block diagram of a basic agc circuit.**
control element may be exceeded with only moderately strong signals, causing overload and distortion. Amplifier gain must be selected so that the threshold is at the optimum point with respect to expected input signal levels and acceptable signal-to-noise ratio.

Attack time is the time required to reduce the gain when a strong signal suddenly appears at the input. It is important that attack time be relatively fast so that gain can be reduced before distortion occurs. This parameter is highly dependent on the charging time of the filter capacitor in the detector circuit.

Release time is the time required to increase gain when a strong signal is suddenly removed from the input. This time is relatively long, on the order of one second, so that gain does not fluctuate between words and syllables. Release time is controlled primarily by the discharge time of the detector’s filter capacitor.

Distortion is an important parameter in any audio system. A well designed audio agc circuit should not show any significant distortion of output waveform when viewed with an oscilloscope.

practical circuit

There are many configurations and variations used to accomplish audio agc. Discussion of all these techniques is beyond the scope of this article, so attention will be focused on one type of devices of the same type. However, the forward-bias characteristics of silicon diodes are relatively uniform. Therefore, diodes are desirable for use as control elements if circuit reproducibility without selected devices is important.

Fig. 2 shows the forward voltage vs current for a 1N914 silicon diode. At forward bias levels less than 0.3 volt the diode is essentially off and has a very high

![fig. 2. Forward characteristic of a 1N914.](image)

![fig. 3. Voltage-controlled attenuators. A shows a one-section attenuator; two- and three-section attenuators are shown in B and C.](image)
resistance. As forward bias voltage is increased, current begins to increase more and more rapidly, and the diode exhibits less and less resistance. Thus, the diode

can function as a voltage- (or current-) controlled resistor.

If the amplitude of the ac signal across this voltage-controlled resistor is kept small, resistance changes due to signal amplitude will be small, resulting in low distortion. The resistance shown by the diode to a low-level ac signal is called the dynamic resistance and is the reciprocal of the slope of the curve at any point. The slope of the diode's curve at 0.45 volt bias is approximately 1.1 milliampere-per-volt, and the dynamic resistance is about 910 ohms; at a forward bias of 0.55 volt, the slope and dynamic resistance are about 11 milliamperes-per-volt and 91 ohms, respectively.

A schematic of a single-section voltage-controlled attenuator using two 1N914 diodes is shown in fig. 3A. R1 acts as the series element of an L attenuator; CR1 and CR2 form the shunt element. C1 prevents control current from flowing in the input circuit; C2 bypasses the current limiting resistor, R2, out of the signal circuit. No dc control current should be allowed to flow in the output circuit.

Figs. 3B and 3C show two- and three-section attenuators, all sections being the same. Data taken on these attenuators is plotted in fig. 4. The input signal from a 1-kHz 600-ohm generator was held constant at 100 millivolts rms, and output signal voltage was plotted vs dc control voltage (from a power supply). Output waveform was monitored on an oscilloscope, and no significant distortion was detected.

The single-section attenuator appears to approach a limit of about 40 dB attenuation, indicating a minimum shunt resistance on the order of 50 ohms. More than 60 dB of attenuation is available from either the two-or three-section circuit. The two-section attenuator was judged to offer the best compromise between performance and number of components. Accurate readings below 100 microvolts were difficult because of noise.

If the two-section attenuator is followed by an amplifier having a voltage gain of 1000 (60 dB) the overall gain of the composite circuit could vary from less than one up to 1000, depending on the amplitude of the dc control voltage. Fig. 5 is a schematic diagram of a complete audio agc circuit. Q1, Q2 and Q3 make up the amplifier portion; CR5 is the detector. Q4 is a dc amplifier and C9 is the agc filter capacitor. The ratio of R9 to R7 determines the closed-loop voltage gain of the amplifier, which is 1000. If R7 is shorted the open-loop gain is about 56,000 (95 dB).

Amplifier bandwidth extends from 150 Hz, determined by C4, to 15 kHz, determined by C6. Other bandwidths can
be obtained by changing the values of these capacitors; the usual 300 to 3000 Hz communications bandwidth is obtained by using .01 μF for C4 and .05 μF for C6. R5, R10, and R11 provide dc bias stabilization, and C5 prevents signal feedback via this path. Power supply drain is about 7 milliamperes. The transistor types in parenthesis are epoxy devices which should perform as well as the hermetically-sealed types.

The input impedance of the amplifier, looking from C4, is about 56,000 ohms; this resistance and the two series resistors in the voltage-controlled attenuator form a voltage divider which reduces the maximum voltage gain of the circuit to about 860.

Test data on the circuit of fig. 5 is listed in table 1. The ratio of maximum to minimum gain is 1430, and the maximum amount of harmonic distortion was measured at less than 2.5%. Data is omitted where the signal was too small to be measured with reasonable accuracy. Input voltage vs output voltage is plotted in fig. 6. This graph shows that agc threshold occurs at approximately 300 μV of input voltage.

Attack time is in the neighborhood of 40 milliseconds; release time is on the order of one second. Release time can be increased by raising the value of C9 and attack time can be decreased by reducing R12, but there will be some interaction in these adjustments. Some experimentation should disclose the optimum values for these components. I have observed that when attack time is decreased below a certain point the circuit oscillates at about 1 Hz. This behavior has not been investigated to my satisfaction, but it is corrected by increasing R12, or by raising the amplifier's lower cutoff frequency (decreasing C4).

using the agc circuit

Successful incorporation of this circuit into an audio system depends heavily on proper interfacing at the input and output. If the agc circuit is inserted between the microphone and transmitter an attenuator should be placed between the

fig. 5. Schematic diagram of a practical audio agc circuit. Complete performance characteristics are shown in table 1. Input/output characteristic is plotted in fig. 6.
agc output and the transmitter’s mike input. The maximum agc output, nominally 0.5 volt, should be reduced to the order of one millivolt to provide normal input level to the transmitter.

Circuits connected to the agc output should not appreciably load the 1000-ohm output impedance, or the gain will be lowered. Assuming typical microphone output varies from 30 μV to 10 mV as sound level changes then a large portion of the lower level sounds would not be within agc range. If more complete sound leveling is desired, a 20-dB preamplifier could be connected between the microphone and the agc circuit’s input. This would have the effect of decreasing the input voltages in fig. 6 by a factor of 10, and the new threshold would occur at a microphone output of 30 μV. Assuming the preamp had the same equivalent input noise as the agc circuit the noise output from the agc circuit would be about 10 times higher or 22 mV. This would still provide a minimum signal-to-noise ratio of more than 20 dB in the agc range.

If the audio agc circuit is used with a simple receiver the receiver’s audio should be amplified or attenuated to a level consistent with good agc action and acceptable signal-to-noise ratio before feeding into the agc circuit. The receiver volume control should be connected between the agc output and the receiver’s output amplifier.

A useful item to include in the agc circuit is a meter to monitor dc control voltage; this would provide a visual indication that signals are within the agc range. Such a meter circuit should not load the detector dc amplifier. It has been found satisfactory to use a 50-μA meter in series with a 100,000 ohm resistor as a 5-volt full-scale meter connected between the collector of Q4 and ground.

**Conclusion**

This article is not intended to be an exhaustive study of audio agc theory and technique, but it is hoped that it will assist those readers who wish to experiment in this area.

**Table 1. Performance of the agc circuit of fig. 5.**

<table>
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<tr>
<th>input voltage (rms)</th>
<th>output voltage (rms)</th>
<th>voltage gain</th>
<th>harmonic distortion (%)</th>
<th>dc control voltage (volts)</th>
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<td>8.6 mV</td>
<td>860</td>
<td>–</td>
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<td>2.95</td>
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fixing a sticky 
AR-22 rotator

Most sticking 
AR-22 rotators 
are caused by 
the same problem — 
easily fixed 
with three rivets

Many amateurs use the CDE AR-22 rotator with great success, especially where there is little cold weather or icing. However, in areas subject to ice storms, operators may experience trouble with a sluggish rotator, or one that only goes part of the way around. When the AR-22 is strained by heavy loading, the rather husky motor tends to bend over the teeth in the drive gears.

The three drive gears, part number TRA-39, consist of three thin iron gears sandwiched together on one spindle. They drive the TRA-18 ring gear which goes around the perimeter of the rotator. If one of the gears in the sandwich happens to be a little larger, it will take all the strain and can wear to the point where the other two will wear unevenly. When all three gears are sufficiently worn, they start to bind. This usually starts at one particular point in rotation, but eventually spreads to the entire 360° and may cause the aluminum ring gear to snap in two.

The cure for this malady is rather simple: rivet the three stamped gears together. This way one gear won’t take all the loading, and the three gears will wear evenly. Remove the TRA-18 ring gear and TRA-39 drive gears (use your instruction book for guidance). If your rotator has been binding, order a new TRA-39 drive gear from CDE.* Even a slight bend in these gears will lead to eventual trouble.

*Send all parts orders to Cornell-Dubilier Electronics, Rotor Parts Department, Desplaines, Illinois 60018, not to their factory in Fuquay Springs, North Carolina.
Also inspect the TRA-18 ring gear for damage. Wash it off in solvent and look carefully for hairline cracks. This is also an opportunity to look over the rest of the parts in the rotator; if any are broken or badly worn, replace them.

Since each of the gears in the TRA-39 assembly was stamped out, each has a slight burr on one side. Do not try to file them flat. When mounting them on the spindle be sure to place them with the burrs toward the bottom; otherwise the gear stack will be too thick.

To drill the rivet holes in the TRA-39 gear, mount the ring gear on a piece of wood with screws as shown in the photo. Mesh the TRA-39 with the ring gear and hold it in place with a section of damaged ring gear. The beveled heads of the wood screws will force the gears together and hold them firmly in place. Drill three equally-spaced holes in the TRA-39 drive gear. If you have a drill press, use it; it will insure that the holes are perpendicular to the face of the gears. Use soft-iron rivets to hold the gears together; rivets 3/8-inch long are just about right. The rivets should be snug in the drill holes for maximum strength.

Remember when reassembling that the ring gear should be placed in position last. Make sure that the line stamped on the cam gear is parallel with the edge of the motor-mounting plate as shown in fig. 1. In this position the pulsing-switch points should open; rotate the gears until this

![Diagram of ring gear with stop arm and pulsing switch](image)

happens. The stop arm should be pushed to the left (counterclockwise) as far as it will go. In this position the stop lug on the ring gear should be up against the stop arm.

Be sure that all the ball bearings are in place in the retainer spring clips. Thoroughly grease the gears with a good silicone grease such as Dow-Corning 44 or Lubriplate, a white lubricant available in many hardware stores; an 8-ounce tube is sufficient. Also, when replacing the top cover of the rotator, make sure the lugs in the ring gear rest in the recessed sockets provided inside. When the rotator is assembled in this manner it is in the North position, against the stops from a counter-clockwise direction through East. The control box should be oriented to coincide with this setting.

To drill the rivet holes, the TRA-39 drive gear is held down with a TRA-18 ring gear and sawed-off section from a damaged ring gear. The small crosses mark the rivet-holes locations.
the electronic hand keyer

An ordinary hand key or bug can be used with this circuit to form perfectly shaped code characters.

Today's electronic keyers are controlled by some type of paddle with two sets of contacts—one for dots, the other for dashes. The “electronic hand keyer” is controlled by only one set of contacts. A standard hand key or a semiautomatic key (bug) will work perfectly. Dots or dashes can be made, and the spacing and ratio will be perfect. Suddenly your fist will sound like a million dollars!

operation

The electronic hand keyer will generate a dot or dashes depending upon how long the key is held closed. If the key is released before the correct dot interval is over, a perfect dot results. If the key is held down longer, a dash will be made. If the key is held down still longer, additional dashes or an additional dot can be made.

For example, to make a 9 requires only one press of the key. The key is pressed until four dashes are made and then released during the first one-third of the fifth dash, thus making it a dot. For characters similar to 9 the electronic hand keyer is superior to the fully automatic twin-lever keyer. Unfortunately, a study of the character 4 quickly puts the electronic hand keyer back into its place.

The key must be released quickly to make a dot, or else a dash will result; so to make a 4 requires the character to be sent just as it would be with a hand key. The electronic hand keyer essentially takes the 4, as sent by the hand key, and corrects the spacing and dot-to-dash ratio. A character sent by a bug is corrected in the same manner. All characters can be sent normally by a hand key or bug to be corrected, or reshaped, by the electronic hand keyer.

basic keyer

The circuit is essentially that of a simple electronic keyer with one connection changed. Only the basic function of the electronic hand keyer is discussed in this article. Detailed circuits with component values are not given. The electronic hand keyer is presented in this manner because of subparagraph 807 of Murphy's Law.* You are encouraged to study and understand the function of the circuit, then design and construct your own from available components.

A simple keyer is shown in fig. 1. The clock can be a free-running multivibrator, a unijunction relaxation oscillator, or almost any adjustable source of low-frequency periodic signal. FF1, FF2 can be any triggered flip-flop connected as a divider so that it will change state each time the negative (trailing) edge of the trigger signal is received. The Clear terminals (C1, C2) hold the Q terminal low as long as the Clear signal is high. A relay output is shown, but a keying transistor could easily be used instead.

The clock runs continuously, and both flip-flops are normally biased off (clear).

*Subparagraph 807 of Murphy's Law states that "The reader's junk box will never contain the components required by the magazine article."

H. Paul Clamptit, K5TCK, 1125 Ridgeview, Mesquite, Texas 75149

June 1971
A character is started only after the dot or dash lever is held closed until a negative edge comes from the clock. Fig. 2 shows the signals that occur when the dash lever is closed and held closed beginning during some time interval, A. A diode pulls \( C_1 \) low when \( C_2 \) is forced low. The diodes connected to \( O_1 \) and \( O_2 \) serve as an OR gate to pull in the relay when either \( O_1 \) or \( O_2 \) is high, thus making a dash.

**self-completion**

The circuit of fig. 1 does not self-complete because the flip-flops are forced clear immediately when a lever is released, allowing the Clear terminals to go high. The character in progress will then be chopped off immediately if the lever is released.

Fig. 3 shows this same keyer with two diodes added to make the keyer self-completing.
completing. The Clear terminal is now pulled low by the diode if the $\bar{Q}$ terminal is low. The shaded areas of fig. 4 show the times when the Clear terminal is held low by its associated $Q$ terminal. When a dash is started the dash lever can be released, and $\bar{Q}2$ holds the dash Clear terminal low for two-thirds of the dash; then $Q1$ holds the dot Clear terminal low for the remainder of the dash.

Notice that $Q1$ must go high before $Q2$ goes low or the self completion will be lost, and the dash will be terminated when it is only two-thirds complete. Fortunately, since FF2 is triggered by FF1, this condition is always met.

the electronic hand keyer

If FF2 is triggered from $Q1$ rather than $Q1$, as shown if fig. 5, the timing diagram of fig. 6 results. The shaded areas again indicate intervals where the Clear terminal is held low by the associated $\bar{Q}$ terminal of the flip-flop. Notice that during intervals C, D and K, L $Q1$ goes low before $Q2$ goes high. If a dash is started and the lever released, the self-completion is lost when $Q1$ first goes low, and the dash is terminated when it is only one-third complete. If the dash lever is held for over one-third of the dash interval, $Q2$ takes hold, and the full dash will be made.

summary

Fig. 7 shows the shaping capability of the electronic hand keyer. Poor code is reshaped perfectly if it is sent at or near the same speed as that to which the circuit is adjusted. To send a dot or a dash, it is necessary only to hold the key down until the character starts, then release it at the proper time.

The electronic hand keyer will also make an interesting and educational project for the beginning digital and solid-state experimenter. The forward-looking amateur might want to add a switch at the T2 terminal to change the electronic hand keyer back to a regular keyer once he has progressed that far.
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More Details? CHECK-OFF Page 94

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integrated circuits

The foreboding opinion that integrated circuits will stop amateur experimentation and stymie ingenuity is unfounded. In fact, so much reliability and versatility have been built into these devices that there appear to be an infinite number of external circuits and systems yet to be tried. Each amateur can look forward to a lifetime of fun and experimentation with solid-state devices and systems; the integrated circuit is just an extension of the solid-state science of packing active devices into ever smaller spaces. Diodes, transistors and resistors are the primary components used in integrated circuits although a limited number may include an occasional capacitor or coil.

Since capacitors take up considerable space it is customary to use circuits that do not require capacitance. Also, it is difficult to design a precise value resistor into an integrated circuit. On the other hand, there is no great problem in including two or more resistors of exactly the same value even though a certain absolute value is difficult to attain. Hence, internal circuitry uses balanced configurations that require equal-value resistors but are not critical as to absolute value. All of this boils down to the fact that the most common integrated circuit is the balanced dc amplifier.

basic differential amplifier

The differential amplifier is the mainstay of integrated circuits. It is basically an emitter-coupled configuration (fig. 1); as a dc amplifier it has fine stability and good rejection of undesired signal components. Since it is a direct-coupled amplifier no interstage coupling capacitors are needed.

Ideal differential operation requires that the two collector resistances be the same and the characteristics of the two transistors be identical. In terms of discrete component circuits this is a disadvantage because perfectly matched transistors and resistors are necessary. However, in ic production these conditions are met quite readily and at low cost. In basic operation the differential amplifier emphasizes the signal difference that exists between base inputs, developing equal-amplitude and out-of-phase collector signals.

It is stated that a differential-mode input signal is applied. In practice this is done by applying the desired ac signal to just one of the base inputs. Since no signal is applied to the opposite base the difference voltage between the two equals the magnitude of the signal applied to the one base.

When two equal-amplitude similar-polarity signals are applied to the base inputs the ac signals across the common emitter resistor are subtractive. When in perfect balance the differential amplifier
performs in bridge-like manner — there is no output observed from collector to collector and very reduced output from each collector and common. Such an applied signal is referred to as a common-mode input signal. This is usually the form of undesired signals such as hum and interference.

In the difference-mode operation a signal applied to base 1 appears at the collector output of transistor 1 and also across the common emitter resistor. The latter signal component serves as the input signal for transistor 2. As a result the output at collector 2 is opposite from that at collector 1. The differential amplifier acts as a phase splitter, developing two equal-amplitude but opposite-polarity signal components at the output.

The differential amplifier has a high order of dc stability, reducing the influence of supply voltage changes, temperature, etc. It is even practical to construct a multistage affair using the difference concept. A differential amplifier or a group of them connected in cascade arrangements are the most common circuit configurations built into integrated circuits.

In the differential amplifier, not only are the interstage coupling capacitors eliminated, the emitter bypass capacitors are eliminated as well. In making a

comparison between ics and discrete circuits it should be noted that an integrated circuit has fewer passive components (resistors, capacitors and coils) and more active components (transistors and diodes) than a comparable amplifier built of discrete active and passive components.

stability

In a perfectly balanced differential amplifier there is stable amplification with changes in dc operation conditions and temperatures. A change in leakage current and/or gain in one side of the differential circuit is balanced out by a like change in the second side. Such balance, and the ability to compensate for any imbalance, sets the operating limits of the differential amplifier.

Reduction of common-mode signals depends upon the degenerative effects of the common-emitter resistor. Of course, the higher the ohmic value of this resistance, the greater the rejection. Such increase is limited by supply voltage requirements and the greater difficulty of including high-value integrated resistors.

The answer to this problem is to include a constant-current emitter source composed of an additional active component, rather than a high value resistance. The fundamental arrangement is

Performance of the Motorola MC1590 integrated circuit.
shown in fig. 2. In this circuit the combination of the transistor and its low value emitter resistor acts as a high-resistance constant-current source. The presence of a common-mode signal on the differential transistors affects base voltages and junction resistances. However, emitter and collector currents are held constant by the constant-current emitter source. In fact, the undesired voltage change appears totally across the constant-current source, which is highly degenerative. Thus, the differential gain of the amplifier in terms of common-mode signals is greatly reduced.

The diode in the base circuit of the constant-current source provides temperature compensation. Exact compensation is obtained when the characteristics of the base-emitter junction of the constant-current transistor and the diode junction are identical. With a rise in temperature there is an increase in the conductance of the base emitter junction. Since the compensating diode is physically near the transistor there is a similar change in its conductance, and a compensating change is made in the base bias, keeping the collector-emitter current constant. The circuit of fig. 2 is a very common integrated-circuit configuration.

darlington circuit

The differential amplifiers in figs. 1 and 2 have low input impedances. High input impedances can be obtained by using Darlington circuitry which involves the addition of two more active elements. A simplified Darlington combination is shown in fig. 3; a typical application in an integrated circuit differential amplifier is shown in fig. 4.

In the normal transistor operation the base-emitter junction is forward biased and conducts. Resistance is low and approximates the product of beta times the emitter resistance. To some degree the input resistance can be increased by increasing the ohmic value of the emitter resistance at a sacrifice in gain. A better
tial-amplifier configuration using paired transistors instead of single devices. If desired, an external stabilizing constant current source can be added at pin 4; equal 3.6k collector load resistances are included. Series base resistances increase input resistance, reduce tendency to parasitic oscillations and provide additional isolation.

Fig. 6 shows two ways that are used to depict integrated circuits. The differential approach is to use the input resistance of a second transistor as the emitter resistance of the first transistor; the input stage then operates with a highly degenerative emitter circuit, and consequently, high input resistance. Both stages contribute output with a gain figure that is comparable to that obtained using a single transistor of the same type but operating with a much lower input resistance. Two such identical circuits are needed for the two separate inputs of a differential amplifier.

Motorola HEP580

The HEP580 is a low-cost integrated circuit composed of six resistors and four transistors. Internally the transistors are connected in pairs with separate base inputs (fig. 5). All emitters are joined together at pin 4. It is a basic differential circuit in fig. 6A is arranged around base pin designations of the IC. The triangular arrangement of 6B is more common, and more instructive, because the circuit layout can be set down with well defined input and output sides regardless of pin numbers.

fig. 5. The Motorola HEP580 integrated circuit.

fig. 6. Two methods of representing the Motorola HEP580; arrangement in (B) is preferred.

fig. 7. Integrated-circuit transmitter has output of 100 mW on 40 meters.

june 1971
ic transmitter

A 100-milliwatt QRP transmitter can be built from two HEP580s, fig. 7. I have had no trouble working several hundred miles on 40 meters with this simple ic rig. The first section of one of the ics operates as a crystal oscillator; the second section as a phase inverter. Choke output is used, and approximately equal-amplitude and opposite-polarity rf signals are available for driving the output ic which operates as a push-pull amplifier. It will draw 20 to 30 milliamperes from a six-volt lantern battery. Dc input power is 120 milliwatts or more.

RCA CA3028

The RCA CA3028 integrated circuit is a high-frequency unit that will function to 100 MHz and higher. It can be used successfully as an rf amplifier, converter, mixer, oscillator or limiter.

The internal diagram of the CA3028 is shown in fig. 8. The circuit is the classic arrangement consisting of a differential pair and constant-current bias source. Bias resistors are included. Fig. 8B shows the very few external components needed to use this ic as a differential rf amplifier. Signal is applied between pins 1 and 5 which connect to the bases of the differential amplifier. Output is taken from pin 6. Schematic 8C shows how the same ic can be connected as a cascode rf amplifier. Signal is applied to pin 2 which connects to the base of transistor Q3. Its collector is direct coupled to the emitters of transistors Q1 and Q2 in cascode fashion. Output is taken from pin 6.

ZL4LV has used the RCA CA3028 integrated circuit as a balanced modulator, fig. 10. The carrier signal is applied to the base of Q3 (pin 2) while audio is applied to the base of differential transistor Q1 (pin1). The audio signal is applied in a differential mode while the
carrier is applied as an in-phase component. Therefore, with proper balance, the carrier cancels in the collector-to-collector output circuit of the differential pair. Double sideband components are developed across the same output.

The Motorola HEP590 is a similar integrated circuit except that a temperature-compensating diode is a part of the package (fig. 9). Bill Hoisington, K1CLL,² has used the HEP590 successfully as an rf amplifier on both 6 and 40 meters, fig. 11.

Although these integrated circuits have been used principally in receivers they have dissipation ratings of several hundred milliwatts and would no doubt work well in QRPP transmitter circuits and in the earlier stages of QRP transmitters.

**balanced modulator/demodulator**

The Motorola MC1596G has been designed specifically for use in sideband systems. Internal circuit configuration and external circuit plan for a double-sideband suppressed carrier generator are given in fig. 12. Two differential amplifier pairs are included and incorporate individual transistors in their common emitter circuits to supply constant current bias. A second transistor is included in each leg for injecting the modulating signal. Carrier is applied in differential mode to the pairs of differential transistors. Outputs of the differential pairs are out-of-phase and under true balance the net carrier voltage is zero. Out-of-phase audio is applied to the transistors located in the emitter legs of the differential pairs. Upper and lower sideband frequencies develop across the output while the modulating wave is canceled.

The carrier signal is applied between pins 8 and 7; the modulating signal is between pins 1 and 4. Biasing for these latter two transistors is obtained from the -8 volt source connected to the arm of the carrier-null potentiometer. This
biasing sets bias and permits an appropriate adjustment for balancing out the carrier.

A balanced output is available between pins 6 and 9; single-ended output can be derived between either pin and common.

**more power fets**

The Siliconix 2N3970 is a switching fet that performs well as a high-frequency amplifier and oscillator. Its power output is about one-half that of a U222 power fet but at only one-quarter the cost. Device dissipation is 1.8 watt. Maximum drain voltage is 40, and in typical circuits the transistor draws 50 to 100 milliamperes. A TO-18 heat sink helps heat dissipation.

The 2N3970 performs well in a variety of oscillator circuits including the Miller, Pierce, Colpitts and push-pull. It oscillates efficiently 10 through 160 meters. A Pierce crystal oscillator and class-C amplifier is shown in fig. 13. This effective QRPP transmitter requires only a single resonant transformer.
fig. 13. Simple two-stage fet transmitter for 40, 80 and 160 meters.

<table>
<thead>
<tr>
<th></th>
<th>160</th>
<th>80</th>
<th>40</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>65 turns no. 26 on 1-1/4&quot; coil form</td>
<td>40 turns no. 24 on 1-1/4&quot; coil form</td>
<td>21 turns no. 22 on 1-1/4&quot; coil form</td>
</tr>
<tr>
<td>L2</td>
<td>20 turns no. 26, bifilar wound on cold end of L1</td>
<td>13 turns no. 24, bifilar wound on cold end of L1</td>
<td>7 turns no. 22, bifilar wound on cold end of L1</td>
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Note how the fundamental class-C fet circuit closely matches conventional vacuum-tube practice. The resistor-capacitor combination at the fet gate develops the required cut-off bias. The source resistor, like the cathode resistor of a vacuum-tube amplifier, limits device current to a safe value when rf excitation is lost. A source current meter shows a dip when the drain is tuned through resonance. Likewise, the magnitude of the dip current rises as antenna coupling is increased.

Power outputs up to one-half watt are obtained on 40, 80 and 160 meters with somewhat less on 20 meters. A supply voltage of 36-volts is obtained by connecting three 12-volt lantern batteries in series. Drain current is typically 60 to 75 mA.

Outputs of 1 watt and higher can be obtained on 40, 80 and 160 meters using the push-pull circuit of fig. 14. The circuit arrangement is similar to that given for the U222 160-meter cw transmitter presented in the April issue of ham radio.3

References

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More Details? CHECK-OFF Page 94
low-noise transistor
1296 MHz preamplifier

This high-performance 1296-MHz preamplifier provides a real breakthrough in noise figure and may spell the end for paramps on 1296 MHz.

The state of the art in amateur receiving techniques has made dramatic strides during the last few years. Noise figures for devices available are now less than 1.5 dB at 432 MHz, and a recently announced Japanese transistor provides a noise figure of less than 3 dB at 1296 MHz with gain in excess of 13 dB.*

The 1296-MHz preamplifier developed by K2UYH,¹ and described in an improved two-stage version by myself² used KMC 5200 and 5500 transistors with noise figures less than 3 dB at 1000 MHz. Early reports of “around 3 or 4 dB at 1300 MHz” proved optimistic; noise figure measurements conducted by W2CCY, W2CQH and W21MU showed that most devices were nearer to 5 or 6 dB with a few as low as 4.5 dB noise figure, although K2TKN claimed some devices he measured were around 4.0 dB.

With the best diode mixers available at that time the noise figures of the better front ends were measured optimistically at 7 dB — but most were nearer to 9 or 10 dB and many have been measured as high as 18 dB. With these noise figures it is easy to see why you needed two stages.

*The Nippon Electric V766B, available in single units for $18 from California Eastern Laboratories, 87 Terrace Hall Avenue, Burlington, Massachusetts 01803.
to have sufficient gain to overcome mixer noise and establish a reasonable front-end noise figure.

Modern converters with hot-carrier diode mixers and filters between the multiplier trough and the mixer can achieve noise figures of about 8 dB with inexpensive hot-carrier diodes such as the Hewlett-Packard HP2800. With such a converter it is now feasible to establish a front-end noise figure based on the pre-amplifier parameters with a single stage if the preamplifier has a gain of at least 11 or 12 dB. The preamplifier described here meets these requirements.

the circuit

The circuit (fig. 1) is essentially that of the first stage of the 1296-MHz amplifier described in the 1970 ARRL Handbook with an rf choke substituted for one of the resistors. This provides slightly better gain. Also, the bias adjustment pot is changed to give smoother control with the parameters of the V766B transistor.

The physical changes from the original design are very important from the standpoint of stability and protection of the parts. Dimensions should be followed closely. An alternate and preferred method of mounting of the transistor is shown in fig. 3B. This construction makes it easy to remove and replace the transistor without damaging it.
construction

The preamplifier is built into a mini-box for convenience and shielding, but all construction is done on 3/32 or 1/16-inch thick brass plate which is held in place by the base lead opposite; the two remaining leads are emitter leads.

The minibox shown in the photographs is slightly deeper than necessary since I built an ac power supply into my unit.

---

fig. 2. Construction details of the 1296-MHz preamplifier. For shield detail, see fig. 3. This unit is designed to fit into 4x2¼x2¼" minibox. RFC1 should be air supported; use a ¼-watt 1000- or 2000-ohm resistor if oscillations occur. This illustration is full size.

four screws (see fig. 2). This makes assembling and construction much easier as well as making the whole device very rigid. When working with the transistor, the collector lead is the longest one with If the power supply is external the minibox can be much shallower.

If silver-impregnated epoxy is available it can be used at the transistor junctions and at the no-lead disc capacitors to avoid

---

fig. 3. Transistor shield. Layout in (B) is preferred to arrangement in (A) as it permits easy transistor removal.

june 1971
heat damage. The no-lead capacitors are difficult to find. You can make a good substitute by completely cutting off the leads from a ceramic disc capacitor and carefully filing the ceramic off the flat surfaces. You may spoil one or two disc capacitors but you'll eventually get the hang of it. Connections are soldered directly to the exposed surfaces.

The vertical partitions in the preamplifier are made of the same brass stock as the base and are preferably hard soldered, although regular "soft" solder will do.

Handle the transistor with care, especially when soldering it into the circuit. The Brookstone Company* sells a high-conductivity, low-temperature solder (TIX) which melts at 250° F and is excellent for this purpose.

The tuning capacitors are Johanson 0.8-8 pF units, but JFD equivalents, or any good quality short piston capacitors, will work. Use thin brass for the striplines to avoid overheating the capacitors when soldering. The brass striplines are mounted on top of the tuning capacitors and soldered directly to the tops. The capacitors are mounted on 5/8-inch centers; the part of the strap left over is bent upward at about 45° to accommodate the modified disc capacitors between the stripline and the BNC connectors.

**tuneup**

Initial tuneup is best accomplished with a 1296-MHz signal (a typical 1296-MHz weak-signal source is shown in fig. 4). Apply about 6 volts to the transistor preamplifier and monitor collector current with a 10-mA meter. Adjust the bias control so collector current is 1 to 2 mA.

Start the tuneup procedure with all the capacitors at minimum capacitance; turn the output capacitors in one-half turn at a time until obtaining maximum reading on the receiver S-meter. Now adjust the input capacitor one turn at a time, repeaking the input capacitor near the transistor for maximum.

*Available from the Brookstone Company, 5 Brookstone Building, Peterborough, New Hampshire 03458.

![Simple construction of the low-noise preamplifier for 1296 MHz.](image)
fig. 4 1296-MHz weak-signal source uses 72-MHz injection and diode frequency multiplier. Diode may be a varactor, 1N914, 1N916 or 1N82. Input is link coupled to crystal-controlled oscillator.

Repeal all capacitors, and apply 9 volts to the preamplifier while adjusting collector current for maximum gain with lowest noise. Do not exceed 6 mA collector current. My V766B preamplifier worked best at 3.5 mA.

When tuning up (or using) the preamplifier do not allow the transistor to go into oscillation (as evidenced by sharply increased collector current) for more than a very short time or the transistor will be destroyed. The input and output networks are essentially pi networks but can be tuned to other modes. The function of these pi networks is to provide the transistor with a proper match; if the input of your converter is not close to 52 ohms you may need a 3-dB 52-ohm pad between the preamplifier and converter.

Final tuneup must be accomplished with the antenna connected to the input terminals. Put the 1296-MHz signal source near the antenna and connect the transmission line to the amplifier. Tune in the signal and repeat all adjustments for best signal-to-noise ratio.

If you happen to purchase a particularly "hot" V766B transistor you may have trouble with oscillations, although this is very rare. However, if you do have oscillation problems, replace the collector rf choke with a 1000- or 2000-ohm, 1/4-watt resistor; this will reduce the Q and gain of the stage.

summary

With this new low-noise transistor many serious 1296-MHz enthusiasts believe now is the time to discard the cranky parametric amplifier—the so-called advantages are hardly worth the added effort and complexity of the paramp. As W2IMU said recently, in relation to this 1296-MHz preamplifier, "We have entered a new era in EME for the amateur."

references


Ham radio

"Boy, you're in for the surprise of your life when you get out of here!"
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ELECTRONIC KEYER
$53.00

THE most versatile keyer available.
Send for full details on the HAL 311BC and the complete line of HAL electronic keyers. There is a model to fit your requirement and budget from $16.50 to $53.00. Shipping extra. Available in kit form for even greater value.

HAL TOUCHCODER II KIT
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For the DBM in March 1970 Ham Radio
7/8 x 2" drilled G10 glass PC board
4 HP-2800 hot carrier diodes matched by HAL.
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Wire and instructions included. $6.50

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Generates 50 KHz or 25KHz markers from 100 KHz oscillator (not supplied).
Drilled 1 x 2" G10 glass PC board
Strong markers to 148 MHz. Divides any signal up to 2MHz by 2 or 4, $4.25 kit form.

HAL MAINLINE ST-6 RTTY TU

Complete parts kit for the W6FFC ST-6 now includes all parts except cabinet. Only 7 HAL circuit boards (drilled G10 glass) for all features. Plug-in IC sockets. Custom transformer by Thordarson for both supplies, 115/230V, 50-60Hz. $135.00 kit. Wired units available. Shipping extra. Write for full details.

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ST-5 kit now includes drilled G10 glass boards, custom Thordarson transformer, meter and metering components. Boards accept both round and DIP 709 IC's. $50.00. Less boards, meter & meter components $37.50. Boards only $6.00. Shipping extra.

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HAL now offers a parts kit for the AK-1 AFSK osc. Drilled G10 glass PC board plugs into 12 pin edge connector for compatibility with the HAL ST-6, or for ease of use alone. Requires 12vdc. $27.50. Board only $4.00. Shipping extra.

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TTI logic. Power line frequency counter for 3 minute or less timing and control. Easily reprogrammable diode ROM uses only 27 diodes (depending on call) to send DE "any call". Low impedance audio with volume and tone control. All circuitry including PS on small G10 glass PC board. Write for full details $70.00 Kit.

ORDERING INFORMATION

Postage is not included in the prices of HAL products. Please add 50¢ on small parts orders, and $2.00 on larger kits. Shipping is via UPS when possible, and via insured parcel post otherwise. Please give a street address. Catalog of all items 24¢ postage.

HAL DEVICES, Box 365H Urbana, IL 61801
The power dissipation of a transistor depends upon the size and efficiency of the heat sink — here's how to determine practical power ratings.

Have you ever ruined a transistor by operating it in excess of its rated temperature? Or have you ever bought a transistor with a large dissipation rating simply because you weren't sure whether a smaller device could withstand the power requirement? If you have, then this article is for you. I will discuss how to keep a transistor below its maximum temperature, and you will find that in some cases a device rated at 100 watts may be good for only a fraction of that much power.

safe operating area

The data sheets of most power transistors provide a safe-operating-area graph. Fig. 1 shows such a graph for an imaginary transistor capable of dissipating 100 watts. As shown on the graph, the maximum voltage which may safely be applied to this device is 40 volts; maximum current is 10 amps. The space enclosed by the black line represents the safe operating area — that is, the values of current and voltage at which the transistor may be operated without exceeding its maximum dissipation capabilities. Any value of voltage and current within the enclosed area may be safely applied to the transistor.

For example, the intersection of 4 amps and 20 volts lies within the line, indicating that the device may be used at these ratings without damage. On the
other hand, the intersection of 5 amps and 30 volts falls outside the enclosed area, indicating that the transistor, when operated at these values, will be generating more heat than it can dissipate, and will likely be destroyed.

It is possible to calculate the thermal resistance between the junction and the case ($\theta_{JC}$) of any transistor if its power rating and its maximum permissible operating temperature, $T_{J(max)}$, are known. These values can be found on the data sheet.

To find $\theta_{JC}$ for the 100-watt demonstration transistor, we will assume a metal-encased silicon unit. For such a transistor, $T_{J(max)}$ would be 200 °C. The thermal resistance may be found from the following formula:

$$\theta_{JC} = \frac{T_{J(max)} - T_A}{P_D}$$

where $T_A$ is the ambient temperature, $P_D$ is the power rating of the transistor, and $\theta_{JC}$ and $T_{J(max)}$ are as explained above.

Inserting the values given for the 100-watt transistor at 25°C ambient:

$$\theta_{JC} = \frac{200 - 25}{100} = 1.75 \, ^\circ C/W$$

For a given temperature, the thermal resistance of the semiconductor determines the maximum power dissipation.

Before the transistor can be used, an additional thermal resistance, between the case and the ambient environment ($\theta_{CA}$) must be known. This is because the heat generated at the semiconductor junction can only be transmitted through the case and must be dissipated into the surrounding environment whether it's air, a heat sink or a liquid coolant.

To determine $\theta_{CA}$, you must know how the transistor is to be mounted. If the transistor is mounted in free, still air with no heat sink, $\theta_{CA}$ will be quite high and the power capabilities of the device will be greatly curtailed. The amount of power that may be dissipated with no heat sink depends on the junction-to-ambient thermal resistance, $\theta_{JA}$. This factor can sometimes be found on the

*This value can also be found on the data sheet, but the reader should understand how it was obtained.

fig. 1. Typical safe-operating-area graph. The 100-watt transistor may be safely operated at any voltage and current values under the heavy line.

thermal resistance

The above explanation may seem very straightforward but unfortunately complications arise. Another factor, called thermal resistance, must be included in any calculations concerning a transistor's dissipation abilities. Thermal resistance is the resistance material offers to the conduction of heat. When used in conjunction with semiconductors, it is expressed in degrees centigrade per watt ($^\circ C/W$). This means that for a specific number of watts dissipated, the temperature of the semiconductor will rise a definite number of degrees C above the ambient temperature.
data sheet, and when used in eq. 3 below it can be used to determine the maximum power that may be applied without a heat sink:

\[
P_D(\text{max}) = \frac{T_J(\text{max}) - T_A}{\theta_{JA}}
\]  

(3)

Hence, it is seen that the \( \theta_{JA} \) of the complete assembly is \( 6.15^\circ \text{C/W} \). If this value is inserted into eq. 3, you can determine the maximum power that can be safely applied to the transistor:

\[
P_D(\text{max}) = \frac{200 \times 25}{6.15} = 34 \text{ watts}
\]  

(6)

In this arrangement the maximum power that can be dissipated by the transistor is only 29 watts. To safely apply more power to the device you must use a larger heat sink, or the sink must be cooled with forced air. If you try to dissipate more power than that calculated without additional cooling, the transistor will be destroyed.

You may ask why a semiconductor is rated at 100 watts when it cannot practically dissipate that much power. The answer is simple: Transistor manufacturers, having no idea of the specific type of heat sink to be used, publish the maximum power that the unit can dissipate when used with an \emph{infinite} heat sink.

**pulse operation**

If a power pulse is momentarily ap-
plied to a transistor, higher dissipation is possible. Fig. 2 shows a second safe-operating-area graph on which several dark lines are drawn. The line labeled dc is the maximum power-dissipation limit. If, for example, the demonstration transistor experiences stress for only 1 millisecond it can be seen from the graph that the device can dissipate 300 watts. Since the transistor is operated at three times its rated power the thermal resistance $\theta_{JC}$, for a 1-millisecond pulse is reduced by a factor of 3 to 0.58°C/W. However, this holds true only if the transistor case is at a temperature of 25°C prior to applying of the pulse. For other case temperatures the following formula is needed:

$$P_{D\text{pulse}} = \frac{T_{J(\text{max})} \cdot TC}{\theta_{JC\text{pulse}}}$$  \hspace{1cm} (7)

where $T_C$ is the case temperature and $\theta_{JC\text{pulse}}$ is the pulse thermal resistance as calculated above.

The case temperature may be found from:

$$T_C = P_{DC} (\theta_{CS} + \theta_{SA}) + T_A$$  \hspace{1cm} (8)

where $P_{DC}$ is the steady state value of power being dissipated by the transistor prior to the application of the pulse, $\theta_{CS}$ is the thermal resistance of the pulse, $\theta_{SA}$ is the thermal resistance of the heat sink.

As an example, assume that the 100-watt transistor, using the heat sink discussed previously, is dissipating 10 watts just prior to the application of a 1-millisecond pulse. From eq. 8 (at 25°C ambient)

$$T_C = 10(3 + 0.4) + 25 = 59°C$$  \hspace{1cm} (9)

Inserting the result into eq. 7 gives:

$$P_{D\text{pulse}} = \frac{200 \cdot 59}{0.58} = 243 W$$

The transistor can withstand 243 watts for a period of 1 millisecond. Wattage ratings for other pulse widths are found in a similar manner by substituting the desired values.

**pulse-train dissipation**

Since mathematical calculation of permissible power becomes rather unwieldy for repetitive pulses, at least one manufacturer, Motorola, has included graphs specifically for this purpose on his data sheets. As a result it is quite simple to find the maximum power dissipation for a wide range of pulse widths and for various duty cycles. A normalizing factor is obtained from the graph and multiplied by the dc value of $\theta_{JA}$. The resultant factor may then be used in eq. 3 to determine maximum power dissipation.

**references**

transmitter-tuning
unit
for the blind

The Noise Maker is an aural tuning meter that allows a blind person to tune his rig for maximum output.

Slow-scan television enthusiasts have a saying, "Hams should be seen as well as heard." I am an active slow scanner, but I was forced to admit one morning on 20 meters that this might not always apply, and in special circumstances, "Hams should be heard and not seen."

For many months several of us in the ninth call area have maintained contact with each other on the 20-meter band while driving to work on a newly built interstate highway. This highway provides superior radiation capabilities due to the excellent ground plane effect of the metal reinforcing in the concrete pavement. During this period of time W9TCT, myself and others were joined by a fixed station in the immediate area, KSMIB/9.

Wes soon told us that he was blind and that he lived in the area only during the winter months. Working Wes became routine, but his signal varied in strength from week to week and sometimes from day to day. It eventually occurred to us that this variation was due to the fact that his transmitter was not properly...
tuned after moving from different parts of the band. When we inquired how he tuned his rig we were told that hams in the area occasionally dropped in and peaked the final.

On one particular morning Wes was so weak that his signal was barely readable just a few miles outside of town. W9TCT stopped in and tuned the rig for him. W9TCT and I felt that something had to be done, and decided that a simple device was needed to help Wes tune his rig to maximum output.

**the circuit**

Most slow scanners are familiar with the voltage-controlled multivibrator. The pitch of the oscillator can be changed over a rather wide range by providing a variable voltage to the base of the oscillator transistors. If the rectified rf current
from the output of the transmitter could be used to control the audio oscillator frequency a blind ham could easily tune his transmitter to maximum output by just listening to the highest pitch of the audio output frequency of the multivibrator. A simple diode output circuit and a 709C operational amplifier to supply the variable bias voltage were easily designed. A simple audio output transistor stage gave enough output to drive a small speaker.

theory of operation

The resistance divider consisting of the 56k and 1k resistors connected to the coaxial cable are adequate for power levels from 200 watts to 2 kW on all bands from 80 to 10 meters.

The gain of the 709C operational amplifier was set at 100. This amplifier has been compensated as recommended in the application sheets. A small voltage of about .01 volt is fed into the non-inverting input of the operational amplifier; this voltage provides the offset bias return of +1 volt for the base resistors of the multivibrator with no rf signal, telling the blind ham that the equipment is turned on.

The 709C amplifier has a positive swing of about +10 volts. The maximum pitch of the multivibrator can be changed over a small range by adjustment of the 15k pot. The lowest frequency is set by the small voltage fed into the non-inverting input of the 709C.

The multivibrator is conventional, and any npn transistors can be used. None of the components in this circuit are critical. The audio output stage uses a small imported high-impedance to low-impedance transformer to provide an impedance match between the collector of the multivibrator and the base of the audio transistor stage. The output circuit consists of a small output transformer and speaker to provide the audible output signal.

A center-tapped junk-box transformer was used for the power supply. The current drain is extremely small, and available parts from around the shack should work nicely. The complete circuit is shown in fig. 1. An Amphenol T-connector was used to provide the housing for the rf detector circuit shown in fig. 1.

The Noise Maker was enclosed in a small sloping metal cabinet. The entire circuit was built on vector board.

In the photograph K5MIB/9 is happily adjusting his Swan 350 to maximum output. Strange as it might seem, several hams that have sight have asked for the circuit for their rigs. I am indebted to W9TCT for help and inspiration in the design and construction of the Noise Maker.
Ten-Tec RX10
communications receiver

A lot of performance in a small, low-cost package

In these days of increasingly sophisticated and complex electronic communications equipment it is a pleasure to see a new product which fills an important need in a very simple and effective manner. The new Ten-Tec RX10 communications receiver is a natural for the beginner, or for the old timer who is looking for a good emergency receiver. The RX10 will give many hours of service from a handful of flashlight batteries.

In the Ten-Tec RX 10, direct conversion is used to provide complete coverage of the 80-, 40-, 20- and 15-meter amateur bands. The critical conversion stage uses an RCA 40604 dual-gate mosfet to provide low noise figure, high sensitivity and good overload characteristics. The balance of the receiver is built around straightforward bipolar devices. An oscillator/buffer/multiplier section provides an appropriate injection signal to the 40604 mixer, while a filter and four-stage audio amplifier arrangement deliver a more than adequate signal to the headphone output.

An added feature is the cw practice oscillator that is included; this helps the beginner get going with his code-practice program. The receiver also includes a built-in 115-volt ac power supply for home use.

The RX10 receiver is quite stable. The manufacturer claims no more than 100-Hz drift from turn on, and our experience at ham radio backs this up. Just for fun we connected the RX10 to a HAL Devices ST-6 RTTY Demodulator and tuned it to a teletype signal on 20 meters. Much to our surprise and delight we were treated to nearly ten minutes of perfect "hands-off" copy before the station signed. And this was with a cold receiver!

Although no specific measurements were made, the sensitivity was very good on both the 80- and 40-meter bands; both 20- and 15-meter performance seemed to
BOOKS...

Radio Society of Great Britain publications

RADIO COMMUNICATIONS HANDBOOK
An outstanding technical guide to all phases of amateur radio. In 832 pages 20 complete chapters are devoted to such subjects as single-sideband, antennas, mobile equipment, RTTY and much, much more. This excellent book has received wide acclaim on both sides of the Atlantic and belongs in your library . . . now. $12.95

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RADIO HANDBOOK — 18th Edition — How to design, build and operate the latest types of amateur transmitters, receivers, transceivers and amplifiers. Provides extensive, simplified theory on practically every phase of radio. 848 pages. Only $13.50

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Robert Lewis, W6MQU — All about design, construction — layout and testing of electronic equipment. Non-technical guide for kit-builders and your best key to better performance of your equipment! $3.95

Box 592 Amherst, New Hampshire 03031

RX10 Specifications

<table>
<thead>
<tr>
<th>Frequency range</th>
<th>3.5-4.0 MHz, 7.0-7.3 MHz, 14.0-14.6 MHz, 21.0-21.9 MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>modes</td>
<td>upper and lower ssb, cw and a-m</td>
</tr>
<tr>
<td>sensitivity</td>
<td>less than 1µV provides readable signal</td>
</tr>
<tr>
<td>stability</td>
<td>less than 100-Hz drift; no warm-up</td>
</tr>
<tr>
<td>selectivity</td>
<td>2 kHz at 6-dB down</td>
</tr>
<tr>
<td>audio</td>
<td>3 volts across 1000-ohm load</td>
</tr>
<tr>
<td>antenna</td>
<td>50 to 75 ohms, unbalanced</td>
</tr>
<tr>
<td>power</td>
<td>115 Vac, 50/60 Hz, 1/8 A, or 12 Vdc, 35 mA</td>
</tr>
<tr>
<td>size</td>
<td>10-3/8&quot; wide, 4-1/2&quot; high, 6-5/8&quot; deep; 21/4 pounds</td>
</tr>
<tr>
<td>price</td>
<td>$59.95</td>
</tr>
</tbody>
</table>

Other than satisfactory operation although it was a bit lower than on the lower bands. However, in all cases performance was well above the simple type superhetrodyne which beginners have traditionally used.

Selectivity was also quite acceptable, even in the crowded 80-meter novice band. An audio filter with a 2-kHz bandwidth at 6 dB seemed to handle things quite well; in conjunction with the reasonably slow tuning rate for a simple receiver, it made it easy to find your way around. Of course, with the direct-conversion system you will hear the audio image of nearby stations, but in view of the excellent performance of this modestly priced receiver, I don’t think this is an important consideration.

Please don’t go out and buy a Ten-Tec RX10 for RTTY. However, I am sure that you will agree that for $59.95 there is a lot of performance in this little package. Ten-Tec products are available from your local dealer or Ten Tec, Inc., Sevierville, Tennessee 37862.
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RECEIVERS F-4 Magazine
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BC-455
BC-456
1.5-3 Mc.
R-25

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$22.50
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TG-34A CODE KEYER, self-contained, automatic, reproduces code practice from paper tape...

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4-tube PP power amplifier with dynamotor, works on 20 VDC. Automatic gain control.
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80 to 108 Mc, EXC, Used ........... $5.95
BC-732A Control box for above, New ........... 1.75

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ANTENNA UNIT designed for 115 V 800 to 1400 Mc. Tubes included are two 15€ and one 12K, Complete with shock mounts and solor motor.7xh18", NEW .... $8.95

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BRAND NEW ............. $27.50

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LIKE NEW ............. $5.95

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G & G RADIO ELECTRONICS COMPANY
45-47 Warren St. (2nd Fl) New York, N.Y. 10007 Phone 212-267-4605
economical decade standards

Resistor decades are convenient for experimental use but are bulky and expensive, especially the higher-accuracy units. A more convenient and compact precision, direct-reading variable resistance may be easily assembled using the ten-turn potentiometers and dials now available on the surplus market. Pots with accuracies of 1% and 0.1% linearity are available — which is more than adequate for most applications.

Potentiometer values in multiples of ten are used so that the selected resistance value may be read directly from the 10-turn dial by adding the proper number of zeros. Several potentiometer/dial units may be assembled in the form of the usual decade box.

The versatility of this arrangement may be expanded by bringing all three potentiometer terminals to binding posts on the front panel. With three binding posts continuously variable voltage dividers of accurately known ratio are conveniently available to the experimenter.

Gene Brizendine, W4ATE


switching counter readouts

One of the more expensive parts of a frequency counter, or counter dial*, is the indicating or readout equipment. As a result many applications provide the readout for only three or four digits of the count. In some cases you might want to read kHz but not individual Hz; in other cases you may want to read kHz or Hz but not MHz.

One way to obtain a readout when needed, without providing more Nixie tubes and associated storing and decoding circuitry, is to switch the indicating system from one part of the counter to another so all digits can be read when required. This can be accomplished by switching half as many indicators as the available total of digits counted, or by having just one digital indicator which is switched from one digit to another. A

fig. 1. Using dual-input gates a readout can be switched to the Q output of either flip-flop to reduce cost. If the gates do not permit tying the outputs together, use steering diodes or a third gate.
rotary switch, with four double-throw contacts per decade, will do the job.

Digital logic handbooks often show a "data selector" circuit using a gate in each data stream with provision for applying a signal to select which data stream appears at the output. Fig. 1 shows one way to do this when the gate design permits output ORing. It uses a dual-input gate for each flip-flop output, or four gates per decade. Four more gates may be needed for the alternate decade which might be switched to the readout. A single toggle switch is sufficient for all gates.

Since no operation is required of the later flip-flops when the earlier ones are connected to the readout equipment, half the gates can be eliminated. This can be done by providing preset or clear signals or removing the B+ from the later flip-flops which are not to operate the digital readout indicator. If direct interconnection of flip-flop outputs causes a problem, steering diodes can be inserted.

Surplus diodes and a few resistors can perform the gate functions if a steering diode is included between the gate and the digital readout. This diode prevents the two interconnected gates from operating as a single gate. Again, a single toggle switch is sufficient for all gates involved in the readout switching (see fig. 2).

In addition to other types of diode switching that probably can be worked out to do the job at little cost, some other simplifications appear possible. One possibility is the elimination of one gate on the output of the tail-end flip-flops, turning these off by other means.

RTL and DTL flip-flops usually have their Q outputs connected to transistor collectors; the collectors are connected to $+V_{CC}$ through a resistor. Shorting the output of these circuits may overheat the resistor (although it can be replaced externally to the IC. Putting $+V_{CC}$ on the Q outputs can result in too much collector voltage on the transistors.

One simplification which I have not tried is shown in fig. 3. Diode CR1 forms a one-input gate when FF2, in an earlier position in the counter, is connected to the readout by the switch placing $+V_{CC}$ on the resistor. Whenever FF2 is high there is little voltage drop across $R$, so the high passes through steering diode CR3 to the readout equipment. When FF2 is low the voltage from $R$ goes into the flip-flop, creating a low input to the readout equipment. The other switch position puts $+V_{CC}$ on FF1 and other tail-end flip-flops to be read out. This allows these flip-flops to operate, feeding the FF1 Q output through steering diode CR2 to the readout equipment. Diode CR2 prevents the voltage across the resistors from feeding back into the Q output of FF1 when FF1 is turned off by the switch. CR2 may not be necessary if the voltage on the Q output is not harmful when FF1 has no $+V_{CC}$ supply.

Bill Conklin, K6KA

June 1971
three channels from two

Many of the common fm mobiles are equipped for two-channel operation. However, with the different frequency combinations in repeaters using simplex, it might be necessary to transmit on channel B and receive on channel A (or vice versa). This can be accomplished easily with the addition of steering diodes (fig. 4). All you'll need are four diodes capable of carrying the current of the circuit and a single-pole, triple-throw switch. This system has been used in commercial applications for a private mobile system in this area.

The circuit shown in fig. 4B provides two simplex channels with a modified two-channel set. The idea for this application is from VE7BDY, to whom I'd like to express my thanks.

Vern Epp, VE7ABK

loose HW100 tuning knob

Many builders find that the main tuning knob on the HW100 is loose even though the dial mechanism is properly assembled and working well. The remedy is very simple.

Remove the tuning knob and place a washer on the end surface of the flexible spline. The washer must have a hole large enough to pass the collar on the spline on the vfo shaft (see fig. 5); otherwise the knob will not fit. The added washer fills up the space between the spline and the inside of the knob, applying an outward force on the knob that keeps it from wobbling. With just the right washer thickness, and an even coating of silicone grease on both sides, the action is "silky" smooth. If the washer is too thick, the knob will either not go on, or tuning will be very stiff. Several very thin washers may be needed to get the right feel.

Al Lightstone, VE3EPY

---

fig. 4. Method for increasing channel coverage in a typical fm oscillator circuit. Steering diodes, B, allow an extra transmit receive channel.

fig. 5. Remedy for loose tuning knob on the HW100.
NATIONAL TMC-300, 300 pf. transmitting capacitor. .07" spacing. .......... $6.95

6.3 VAC @ 2A fil. xfmr. (115 VAC) .......... $1.95

833/833A tube socket. Johnson #212. ......... $12.95

HAMMARLUND 140 pf. MC 140M variable capacitor. ........ $1.75

T.M.C. RF SWITCH. # SW-206. ......... $3.95

DYCOMM "Block Booster" FM (2 mtr) amplifier, 50 watt output. .......... $89.95

DYCOMM "Brick Booster" 2 meter FM amplifier, 12 watt output. .......... $69.95

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COLLINS MECHANICAL FILTER, Type F250A-67. Center frequency 250kc, Bandwidth -6db is 6.7kc ±5%. Bandwidth @ 60db is 14kc. Resonating capacity 110 mmfd., Sig. input voltage from 0 to 5y RMS, DC voltage 300 volt maximum. Signal source impedance 50kc, Load impedance 50K Ohms. .......... $7.95

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The new Dycomm Echo II is the first commercially available repeater for amateur radio use. It is completely solid state, uses no relays, is ultra stable, portable and FCC type accepted. The Echo II is designed to withstand the most severe environment, features 12 to 15 Vdc operation, multiple channel operation and comes equipped with full input/output option capability.

The Echo II transmitter will operate into an open or short circuit or any other mismatch. Input and output impedances are 50 ohms; connectors are type-N UG-58/U (mate with UG-1185/U). The unit has built-in carrier-operated relay, metering terminations for rf output, limiter current and discriminator output. The second optional frequencies may be remotely selected (by terminal connection) for either transmit, receive or both. Local/remote-control point is provided for local use as a transceiver so repeater may be used as a mobile or base-station transceiver. Guaranteed transmitter power output is 12 watts; typical output is 15 watts.

Useable Echo II receiver sensitivity is 0.2 $\mu$V; sensitivity for 20 dB quieting is typically 0.4 $\mu$V. Desensitization is less than 0.25 $\mu$V with 200-kHz channel spacing (no cavities). With 300-kHz channel spacing desensitization is negligible. Current consumption on receive, 40 mA; on transmit, 1.5 amperes. Inter-modulation interference, 70 dB minimum; spurious response attenuated more than 60 dB.

The repeater may be controlled with positive power up/down, timer, tone-burst entry, audio identification, etc. The Echo II is priced at $700 and includes two 6-dB antennas. For more information write to Dynamic Communications, Inc., Post Office Box 10116, Riviera Beach, Florida 33404, or use check-off on page 94.

The new Radiation Devices CRD-2 coaxial detectors provide an economical means for rf demodulation and voltage measurement or monitoring over the frequency range from 1 to 1000 MHz. Units are available with or without terminating resistors. Either point-contact or hot-carrier diodes may be specified, with positive or negative output polarity. Frequency response is within 0.5 dB to 500 MHz; $\pm$1.0 dB to 1000 MHz. Rectifica-
tion efficiency is greater than 65%; maximum input voltage, 3 volts rms with point-contact diodes, or 25 volts rms with hot-carrier diodes. Lower frequency limit may be extended by addition of capacitor to internal terminals. Furnished with BNC or type-N input connector. Priced from $20 to $25, depending on options. For more information write to Radiation Devices Company, Post Office Box 8450, Baltimore, Maryland 21234, or use check-off on page 94.

**two-meter fm transceiver**

The new *Gladding 25* two-meter fm transceiver features 6-channels with 25-watts output. Designed and built by Pearce-Simpson, the world's largest manufacturer of marine communications equipment, the *Gladding 25* fills the requirement for the amateur who wants high power and multichannel fm capability. Crystals are factory-installed for 146.3411-46.94 and 146.9411-46.94 MHz.

The solid-state receiver uses an fet front end and integrated-circuit i-f strip. An 8-pole crystal filter provides superior selectivity. The transmitter is all solid state except for the driver and power output stages; power output is 25 watts in the high position, 1 watt in the low position. Output is ±5 kHz phase modulation with automatic deviation limiting. Harmonic and spurious emission is more than 60-dB down.

Receiver sensitivity of the *Gladding 25* is 0.5 µV. Squelch is adjustable, 0.4 µV or less for 80% rated audio output. Audio power output is 2 watts (10% distortion).

Receiver spurious rejection is 60 dB or greater. Selectivity is ±7.5 kHz at 6 dB down; ±15 kHz maximum at 60-dB down.

Nominal supply voltage is 13.6 volts dc, negative ground. Current drain on receive is 400 mA; standby, 1.2 amps; transmit, 10 amps. An optional matching ac power supply is available. The *Gladding 25* comes complete with mounting cradle and push-to-talk handset. Price, $249.95; accessory ac power supply, $69.95. Special combination price, transceiver and ac power supply, $299.95. For more information write to Pearce-Simpson, Division of Gladding Corporation, Post Office Box 800, Biscayne Annex, Miami, Florida 33152, or use check-off on page 94.

**mobile antenna system**

The Mosely *Rode-Master* is an all new amateur mobile antenna system that offers many significant money-saving options. The antenna covers 6, 10, 15, 40 and 75 or 80 meters with an adjustable vswr of 1.5:1 or better at any given frequency on each band. The *Rode-Master* features interchangeable coils for 10, 15, 20, 40 and 75/80 meters, and is power rated for 400 watts PEP ssb (200 watts a-m). The DX matching network is the reason Mosley can guarantee an adjustable vswr - the network is simple to install and operate the provides fine tuning on 20, 40 and 75/80 meters.

The upper mast section of the *Rode-Master* antenna doubles as a 6-meter whip, adjustable for the entire band. The telescoped whip-lock device permits precision tuning with little more than fingertip pressure. The antenna may be either bumper or trunk mounted, and includes break-over (hinge) for garaging or low overhangs. The antenna rotates 360° in the break-over position; this is convenient for coil insertion, antenna adjustments, etc. For more information, write to Mosley Electronics Inc., 4610 North Lindbergh Boulevard, Bridgeton, Missouri 63044, or use check-off on page 94.
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Curtis Electro Devices has announced a completely solid-state fm repeater identifier designed to provide low cost, reliable call-letter identification in accordance with FCC regulations. The new unit, the ID-401, provides an audio tone output in the form of a Morse code identification (such as DE WIDTY) in addition to carrier keying. Identification is transmitted initially on repeater activation and subsequently every three minutes as long as the repeater is being used. A final identification is transmitted after repeater activity ceases. Contact closure in the repeater control circuitry initiates identification.

Relay contacts are provided to key the repeater carrier when necessary. Provision is also made to transmit a continuous audio tone on command, and an audible monitor may be switched on for convenience in set-up. A cw output mode is available for direct keying of transmitters used in vhf aurora and meteor scatter work and similar applications requiring periodic identification.

The compact unit, which uses 12 complex integrated circuits, is completely enclosed in a heavy metal case and requires 700 mA from a -12 to -24 Vdc supply. Code speed, interval length and tone pitch and volume are adjustable. Operating temperature range is -40° F to +140° F.

Code speed range of the ID-401 is 5 to 50 words per minute; interval time range is ½ to 7 minutes. The capacity of the memory is 127 bits (one dot or one space = 1 bit). The unit has a built-in monitor speaker, and audio output of 0.5 volts p-p, 400 to 1500 Hz; the internal keying relay is rated at 2 amps, 500 volts.
motorola mosfets

Three new dual-gate mosfets furnish low-cost high-performance amplifier/mixer applications in communications equipment, i-f strips and demodulators. The MPF120-122 are 50-cent range, plastic flat-pack cased devices with efficient agc control, low cross-modulation distortion, low feedback capacitance and high power gain plus gate diode protection. The MPF120 is an rf amplifier to 105 MHz with two separate channels. It provides excellent agc action, and a zener diode across the gate that shunts out voltage transients, adds reliability and stability.

The MPF121 is a vhf amplifier to 200 MHz. The MPF122 mixes rf with guaranteed frequencies of 104 and 244 MHz (optimum IdSS). The new series of mosfets uses Motorola-developed silicon nitride passivation that ensures long-term stability under high-temperature and reverse bias conditions. Cross-mod for any of the devices is 1% (typical) with 100 mV of unwanted signal.

For more information, write to Motorola Semiconductor Products, Inc., Post Office Box 20912, Phoenix, Arizona 85036, or use check-off on page 94.
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With external tuner, Model 330: General coverage from 3 to 30 mc.
External crystal oscillator, Model 510X: 2 to 24 mc, 10 crystal positions.
These external oscillators plug directly into the 600R.
TUNING SYSTEM: The lower bands, 80 through 15 mc, are covered in 200 kc segments. 10 meters is covered in 500 kc segments. 100 kc and 25 kc crystal calibrator markers provide for highly accurate frequency readout on a large, easy to interpret dial.
Ultra smooth vernier tuning with large knobs gives you the incomparable feel of a Swan tuning system.
SENSITIVITY: Superior front end design gives you 1/4 microvolt sensitivity for 10 db signal to noise ratio at 50 ohms input impedance. At the same time, front end overload, cross modulation, image, and spurious responses have been reduced to "state-of-the-art" minimums.
R.F. SELECTIVITY: Antenna tuning circuitry in the 600R front-end provides continuous coverage from 3 to 30 mc. This is accomplished in 5 frequency ranges selected by the band switch: 3 to 5.5 mc, 5.5 to 10 mc, 10 to 16 mc, 16 to 24 mc, and 24 to 30 mc.
Reception outside the normal VFO range of the receiver requires an external oscillator which can be the Swan 510X crystal controlled oscillator, or the Model 330 general coverage tuner. Either of these external oscillators plugs directly into the 600R.
Image rejection is a minimum of 55 db at 30 mc, increasing to better than 75 db at 3 mc.
I.F. SELECTIVITY: Swan's standard crystal lattice filter with 2.7 kc bandwidth, a 1.7 shape factor, and ultimate rejection in excess of 100 db makes the 600R's selectivity superior to any other production receiver on the market.
With installation of the optional 16 pole crystal lattice filter (SS-16B), the 600R offers selectivity that far exceeds any receiver at any price, anywhere. Selectivity then becomes truly incredible, with a shape factor of 1.28 and ultimate rejection exceeding 140 db. Two additional crystal lattice filter options are available: One is a narrow band CW filter, the other is a broad band AM filter. There are provisions in the 600R for the installation of up to 3 filters, with front panel selection.
A.F. SELECTIVITY: Audio response of the 600R is 300 to 3000 cycles, ± 3 db, with 3 watts output to a 4 ohm external speaker. Headphone jack is provided with the speaker accessory unit. An optional IC Audio Filter accessory is available for installation in the 600R. It provides a choice of either notch or peaking a selected audio frequency, and greatly enhances both phone and CW reception.
I.F. NOISE BLANKER: (optional) installs inside 600R. Extremely effective in suppressing impulse noises such as auto ignition interference.
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DIMENSIONS: 15" wide x 6 1/4" high x 12" deep. Weight: 32 lbs.

TUNING: Internal VFO system is identical to that used in the 600R.
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Installs internally in 600R ......................................................... $44
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600 cycle bandwidth CW Filter ................................................... $20
6 kc bandwidth AM Filter ......................................................... $22
SS-16B Super Selective 16 pole .................................................. $75
PLUG-IN VOX FOR 600T, Model VX-2 ....................................... $29
SWAN DESK MIKE Model 444 ..................................................... $25

*Factory price.
The Triplett model 310-FET vom is an all-solid-state instrument that features a 10-megohm input impedance. The battery-operated unit has a single selector switch and provision for attaching an ac clamp-on adapter. It has high sensitivity of 300 mV full scale for transistor bias measurements, and resistance measurements to 500 megohms. Accuracy is 3% of full scale on dc, 4% of full scale on ac, and 3% of dc arc on ohms. The meter has a zero-center mark for null measurements, and a polarity reversing switch for dc and ohms. Sixteen ranges include dc current to 12 mA, dc voltage to 600 volts, ac voltage to 600 volts, and ohms to 600 ohms. Price is $77.00 complete with leads, instruction manual, and batteries from Triplett Corporation, Bluffton, Ohio 45817, or use check-off on page 94.
especially designed for two-way radio repeater or shared repeater systems, where the high reliability of solid-state circuitry is required at low cost. The RCP-760 will respond to the receipt of any of up to ten tone frequencies by keying and modulating the transmitter with regenerated received tone. The desired tone frequencies are determined by merely plugging in circuit board modules; up to twenty combinations can be achieved by the addition of the RCP-769-1 accessory panel.

When ordered with at least one set of tone modules, the RCP-760 comes complete and ready to install. Built-in voltage regulation allows efficient operation over a wide range of input voltages (normal 12.6 Vdc). Dimensions are only 3-1/2 high, 3-3/4" deep, on a 19" panel. A 117-Vac Power supply is available.

For more information, write to Alpha Electronic Services Inc., 8431 Monroe Avenue, Stanton, California 90680, or use check-off on page 94.

communications ic

National Semiconductor has started production of an integrated circuit which may qualify as a general-purpose communications subsystem. The LM373, designed for a-m, fm and ssb applications, contains two amplifier sections (four gain/limiters), a gain-control stage, fully balanced fm and ssb detector, and an active a-m/ssb peak detector whose output matches the agc input characteristics. The bandpass characteristics can be shaped from audio to 15 MHz with a single external filter — crystal, ceramic, mechanical of LC. An LC tuned quadrature circuit gives 80-mV audio output for 75 kHz deviation at 10.7 MHz in a typical wideband fm application. In a-m operation typical sensitivity is 5 microvolts for 10 dB signal and noise. Price is $4.85 each in small quantities. For sales information, write to National Semiconductor Corporation, 2975 San Ysidro Way, Santa Clara, California 95051.
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new fcc form

Effective July 1, 1971, the Federal Communications Commission will accept for filing only editions of FCC Form 610, Application for Individual Amateur Radio Station and/or Operator License, dated July, 1970 or later. These forms are currently available. No applications on FCC 610 forms dated before July, 1970 will be accepted for filing after July 1, 1971.
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Typical #10-32 threaded stud devices which can be mounted by the stud-nut shown at the upper right.

The stud-nut consists of an internally threaded, cadmium plated brass insert molded in a high-temperature, glass-filled nylon base. The unique patented design of the molded base insures perfect centering of the device stud for maximum voltage insulation and locking action. Thru holes are provided in the upper end of the metal insert for external lead connections.

**PACKAGE OF FOUR STUD-NUTS — $1.00 (Quantity Discounts Available)**

SCF CORP., P. O. Box 999, Hightstown, N. J. 08520

More Details? CHECK-OFF Page 94
**Digital Frequency Meter**

- Monitors your "transmitted" signal
- Measures kHz and MHz
- Operates with any exciter-transmitter (1 to 600 watts — up to 35 MHz)
- Large-bright "Nixie" display
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FM-6 Kit... $119.50

(170 MHz Prescaler - $45.00 extra)

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Box 2426 Rolling Hills, Calif. 90274

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**NEED CRYSTALS?**

We can supply crystals from 2KHz to 80 MHz in many types of holders.

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<tr>
<th>Description</th>
<th>Price</th>
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<tr>
<td>Color TV crystal (3579, 545KHz) wire leads</td>
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<tr>
<td>100 KHz frequency standard crystal (HC13/U)</td>
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<tr>
<td>1000 KHz frequency standard (HC8/U)</td>
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</tr>
<tr>
<td>Any CB crystal, trans. or rec. (except synthesizer crystals)</td>
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<tr>
<td>Any amateur band crystal in FT-243 holders</td>
<td>1.50</td>
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<tr>
<td>80 meter crystals in FT-243 holders</td>
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- Special Quantity Prices to Jobbers and Dealers.
- ORDER DIRECT with check or money order to 2400H Crystal Drive Fort Myers, Florida 33901

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**F.M. MOTOROLA GOVERNMENT SURPLUS**

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<td>Also — Power Supplies</td>
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<td>CY-938 CABINET</td>
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<td>CY-938 CABINET</td>
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<td>C-847 CONTROL BOX</td>
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**Radio Amateur**

Emblems engraved with your call letters.

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<th>Gold</th>
<th>Rhodium</th>
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<td>$6.00 Ea.</td>
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Send us a list of your needs and we will give you a quotation on any standard American parts which you may require.

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More Details? CHECK-OFF Page 94


ELECTROSTATIC PHOTOCOPY SERVICE - 8 1/2 x 11 or 8 1/2 x 14 - any original - 1 to 10 @ .10¢ - 10 and on @ .05¢ - immediate postpaid return, complete drafting service also available. R. K. Wildman, 6142 Gienbrook Lane, Stockton, Calif. 95207.

EVANSVILLE, INDIANA HAMFEST, 4H grounds (Highway 41N 3 miles north) Sunday, July 11, 1971, air conditioned, auction, overnight camping, ladies bingo, reserved flea market booths, advance registration. For flyer contact Morton Silverman W9GJ, 1121 Bonnie View Drive, Evansville, Indiana 47715.

SURPLUS CRYSTALS BLANKS: Range 4100-6800 kHz. 7200-8600 kHz. Assorted freq. our selection. 30$/1. Nat Stinnette Electronics, Umatilla, FL 32784.


MECHANICAL FILTERS: 455 Khz, 2.1 Khz $18.95, 300 Hz $22.95. J. A. Fredericks, 314 South 13th Ave., Yakima, Washington 98902.

VHF NOISE BLANKER — See Westcom ad in Nov., Dec. 70 and Mar. '71 Ham Radio.

MUST SELL - T150 with new 6146A's $45, Lafayette 74 VFO 80-6 meters mint condition $25, Lafayette He 33 VFO 80-6 meters transverter, mike crystals $25, WA2UKI, 8337 256 Street, Floral Park, New York, (212) 343-5371.

ORIGINAL ZIZIN DOUBLE HOLDERS display 20 cards in plastic, 3 for $1.00, 10 for $3.00 prepaid. Guaranteed. Patented. Free sample to dealers. Tepabclo, John K4NMT, Box 198R, Gallatin, Tenn. 37066.

ASK FOR FREE LIST of used Ham gear or for if you order your orders through SickSpect Radio, W9K, at Indianapolis, Indiana 46205. 40 years experience.

THE ZERO BEATER AMATEUR RADIO CLUB will hold their annual Hamfest at the Washington, Mo. City Park on August 1st, starting at 10 a.m. Free Ham Gear Auction. Many fine Ham gear, door prizes and free entertainment for the children and YP's.

WANTED, WALKIE TALKIE, hand held type, World War II vintage. Selwyn Luben, W0ERF, 3641 Troost Avenue, Kansas City, Missouri 64109.

CONNECTICUT HAMS: Come and see all the goodies at Roger S. Miner Surplus Electronics, 246 Naugatuck Ave., Milford, Conn. 06460. Telephone 277-8555.

WANTED R390, R330A, R389, 51J4, 51S1, Racal, Nems, Clarke, Marconi receivers, SWRC, P. O. Box 348, Kansas City, Missouri 64111.

WANTED JOLY ACCUTRON TE15 series clocks. 1 1/32" diameter dial. Please give condition and lowest price. N. Ross, 1425 Walnut, Berkeley, California 94709.

FOR SALE - KNIGHT T-150A transmitter, 150 watts AM' and CW, 80-6 meters, built-in VFO or crystal. Good condition. Also Eico 753 SSB and CW Transceiver, does not work, for parts or repair. Bill Jennings, 47 Allen Road, North Haven, Connecticut 06473.

THE SECOND ANNUAL MUSIC CITY HAMFEST will be held in Nashville, Tennessee on Sunday, July 11, 1971, 10 a.m. to 5 p.m. Lots of free parking, shelter and a playground for the children. Bring a picnic lunch, or food and soft drinks, ice cream, etc. will be available at the site. Main drawing will be at 3:30 p.m. Three main prizes plus many other prizes, with a special drawing for the ladies and favors for the children. Main prizes will be an HW 101, with power supply, an HA 460 Xceiver and a portable transceiver.

EXCLUSIVELY HAM TELETYPE — 19th year. RTTY Journal, articles, news, DX, VHF, classified ads. Sample 30¢. $3.00 year. Box 837, Royal Oak, Michigan 48068.

QSLS: SECOND TO NONE. Same day service. Samples 25¢. Ray, K7HLR, Box 331, Clearfield, Utah 84015.

YOU ALL COME TO International Independent Convention at Convention Center, 3rd Ave. and 3rd St., 2, 3, 4, 1971. SASE to WA0SHF for information.

The LINCOLN, NEBRASKA AMATEUR RADIO CLUB will operate a special prefix amateur radio station using the call KQONHE. Operations will commence at 2100 GMT September 1, 1971 and will be continued 24 hours a day through 0500 GMT September 9, 1971. Transmitters will be on 10, 15, 20, 40 and 80 meters, both CW and SSB. DX contacts will be QSLd. Any State contacts must send cards with SASE to WOY0Y, Box 5006, Lincoln, Nebraska 68505. As with past operations of the Club, a special QSL card will be used.


THE TWO RIVERS AMATEUR Radio Club will hold its annual hamfest July 18 at the Balcon Hotel grounds in Menkeson located 15 miles east of Pittsburgh. For information write Charles E. Thomas WA3MMW, 7022 Blackhawk, Pittsburgh, PA 15218.

TELL YOUR FRIENDS about Ham Radio Magazine.
THE BEST
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CONVERTER

Model 407
$42.95

144-146 MHz in, 28-30 MHz out or 146-148 MHz with a second crystal available for $5.95 each

A full description of this fantastic converter would fill this page, but you can take our word for it (or those of thousands of satisfied users) that it's the best. The reason is simple - we use three RCA dual gate MOSFETS, one bipolar, and 3 diodes in the best circuit ever. Still not convinced? Then send for our free catalog and get the full description, plus photos and even the schematic.

Can't wait? Then send us a postal money order for $42.95 and we'll rush the 407 out to you.

NOTE: The Model 407 is also available in any frequency combination up to 450 MHz (some at higher prices) as listed in our catalog. New York City and State residents add local sales tax.

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- Fully guaranteed

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- Zero adjust sets to WWV. Exclusive circuit suppresses unwanted markers.
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- Send for free brochure.

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Here is 13.6 Volt D.C.
POWER

For your Regency, Standard, Varitronics or similar 10 watt, solid-state FM transceiver.

100-130 volt 50-60Hz input

BLULYNE XP-500

13.6V Nominal at 2.5 Amp Transmit.
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A well filtered, regulated solid state power supply ready to plug in and use.

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NOTE: THE AMATEUR RADIO FIELD
THE PINE RIDGE AMATEUR RADIO CLUB of Chadron, Nebraska will hold the seventeenth annual hamfest, located 9 miles South of Chadron on Highway 385, Sunday, June 6, 1971. All amateurs and families welcome. Bring a couple of drinks and your own utensils. The Club will furnish soft drinks and coffee, no charge.

DON’T BUY QSL CARDS from anyone until you see my free samples. Fast service. Economical prices. Little Print Shop, Box 9848, Austin, Texas 78761.

SURPLUS MILITARY RADIOS, Electronics, Radar Parts, tons of material for the ham, free catalogue available. Sabre Industries, 1370 Sargent Ave., Winnipeg, Man., Manitoba, Canada.

TELETYPE #2 LRXB2 - reperforator-transmitter "as is" $100; checked out $175; includes two-speed gearshifts. Alltronics-Howard Co., Box 19, Boston, Mass. 02101. 617-742-0048.


WANTED: HEATHKIT PANADAPTER, any model or surplus 455 Khz model. Used Hy-Gain 14AVQ vertical. R. J. Brubaker, 900 WODYR, 3932 Charlotte, Kansas City, Missouri 64110.

PLAN AHEAD! June 19th & 20th, Colorado Springs, Antlers Plaza Hotel. 1971 ARRl Rocky Mountain Division Convention is coming! Pass the word! Contests - Prizes - Top Speakers - Wulf Wong. The biggest Ham event of the year! Watch for your pre-registration blank in the mail — take your vacation! Quit your job! GET HERE SOMEHOW!!

TOROIDs 44 and 88 mhy. Unpotted, 5 for $1.50 ppp. W. Weinschenker, Box 353, Irwin, Pa. 15642.


WORLD QSL BUREAU — see ad page 88.

SALE: COLLINS 7544 Receiver. mods per factory, $300.00. Heathkit SB610 Scope, $60.00. HD15 Phone Patch, $20.00; HM15 SWR Bridge, $20.00; 14AVQ Antenna, $25.00; Phasor 40 Antenna System, $50.00; WB67PO Filter, $125.00; BROWNIETE TELESCOPIC S.A. Holder, $60.00.

SELL OR TRADE for two meter equipment: Mobile six meter FM GE Progress Line Transistor Supply, 100 watt output. Very clean on 52.525. With box. Champaign, Ill. 61825. Samples provided.

JOHNSON VIKING 1 kilowatt amplifier - 80 thru 15 meters, SSB-AM-CW for sale or trade for SSB transceiver. Jack Hamilton, Route 1, Sylvester, Georgia 31791.

"DON AND BOB" NEW GUARANTEED BUYS. Dealer Tempco, Kenwood write specifications. Monarch KW SWR relative power duometer bridge 14.95; Amphenol PL29/30/39/329 3.90/10; Swen 1011 demod 399.00; Hy-Gain Hy-Quad 99.00; Ham-M 99.00; TR44 59.95; AR22R 29.95; write quote SPR4, GT550, TRI- EYE, Ray-Lite 6LD 3.95; Motorola HD170 epoxy dice 2.5A/1000V 39c; GE 3A/600V 33c; transformer Stancor RT202 12-28V/2A 6.95; BA, RT204 10.95; RT205 15.95; AV-12V-28V/1A 1.95; 1000KHz Knight crystal 9PN 3.95; PB relay 1.95; KHPT7D1 4PDT/48V 1.95; 4 ft. test leads Simpson Triplet 12/14/16 NEU lamp 6c ea; Prices FOB Houston, GECC, Masterqing and BAC. Quotes specific items. Service guaranteed. Madison Electronics, 1508 McKinney, Houston, Texas 77002. (713) 224-2668.

ATLANTA HAMFEST AND GEORGIA ARRL CONVENTION
JUNE 12 & 13, 1971
LENEX SQUARE, ATLANTA, GEORGIA

The Atlanta Radio Club is pleased to announce the annual Atlanta Hamfest and Georgia ARRL Convention. Events unprecedented in history. Highlights will include:

- ARRL Forum
- Mars Meetings
- Manufacturer's Displays
- FM Technical Sessions
- Left Foot CW Contest
- Carnival for the Harmonics

Ga. Banquet and Dance Saturday Evening. Prizes will be the largest and best ever!

YOUR CHOICE OF A COLOR-TV OR DRAKE TRANSCEIVER
REGENCY HR-2 TEN-TEC RECEIVER
COMPLETE ANTENNA SYSTEM

A SURPRISE (A TRANSCEIVER THAT WE'RE OBLIGATED NOT TO DISCLOSE 'TILL SUNDAY, JUNE 13th).

Reservations are available at the Roadway Inn, 3387 Lenox Road (261-5500). This fine motel is directly across from the Hamfest site. If you don't get to Atlanta, you won't need your car again.

For fun, fellowship and an all around good time bring the family. (Note the carnival, bowling and a fine selection of ladies prizes.) Join us in Atlanta, June 12 & 13, 1971, Lenox Square.

FOR FURTHER INFORMATION CONTACT WA4VVW, STEVE SMITH 5258 SEATON DR., DUNWOODY, GA.

ALL SOLID-STATE SSB TRANSCEIVER

$195.00

- Complete single-band SSB transceiver 4 to 5 watts PEP output 15, 20, 40, or 75 mtrs.
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- Suitable for dry battery operation.
- Light weight, small size makes excellent portable - boat, aircraft, field or mobile.
- Contains 15 transistors, 1 MOSFET, 2 darlingtons, 1 I.C. and 17 diodes. Four-pole filter.
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KCOKC WILL BE HEARD on all bands for the period July 1st 1971 through July 5th 1971 GMT around the clock. KCOKC will be on 10, 15, and 20 meters beginning around 1300 GMT until late in the evening. Activity on 40 and 80 meters will probably begin around 2200 hours GMT until 1300 GMT the following day. However, activity will generally be on any band at any time that band is open. Activity is planned around the following frequencies: CW 3550, 7050, 14050, 21050, 28050; Phone 3800, 7205, 14205, 21280, 28660. For Special QSL cards send SASE or 2 IRC's to: KCOKC, P. O. Box 753, Shawnee Mission, Kansas 66201.

826 TUBES WANTED FOR CASH. Pay $100 each for 445A WE Kloysters, C. Hutnan, 308 Hickory St., Arlington, N. J. 07032.

THIRD ANNUAL HAM CAMPOREE — Florida Camplands, June 11-13. Contact W4YNW or Brandon Amateur Radio Society, Box 828, Brandon, Florida 33511.


OLD TIME RADIO SHOWS. SASE, Box 724, Redmond, Washington 98052.

THE PENTICTON CIVIL DEFENSE — Amateur Radio Club are pleased to announce their sponsorship of the annual International Okanagan Hamfest in cooperation with the clubs in Kelowna, Vernon and Kamloops. This year we plan to change the location to the Gallagher Lake Lodge and grounds of RR#2, Oliver, B. C. Dates July 24 and 25. Motels, trailer, tenting and camping space will be available, as well as bowling, water sports, laundry, small lake and pool with crystal water. There will be a giant auction, transmitter hunt, contests and games for both young and old. Evening entertainment assured. A registration door prize value $40-$50 and big raffle price value $175-$125. Admission for licensed OM's, $3.00. XYL's and YL's $2.00, Family Ticket $5.00. Registration begins 10:00 a.m. Saturday, July 24. For further information contact: Donald Parker, VE7ASY, Secretary, RR#4, Crawford Road, Kelowna, B. C., Canada.

For sale: Drake 1-A, Heath HD-10 keyer, HG-10B VFO, HM-15 SW bridge, Collins 353C-31 mechanical filter, plug-in adapter (3KHz BW), and never used SWR meter with socket. No trades please. All other offers considered. R. O. Crosser, 1241½ Columbia, Orange, California 92668.

2m FM TRANSISTORIZED TRANSCIEVER. Multichannel 12 vdc/110 vac, 1-10W. J. D. Anderson, (213) 478-6738.

For sale: SALL Nixies, new, 0 to 9. B-5440, B-5991, $5.00 each. H. P. 512A Freq. Converter 0-100 MHz, Hughes Memo-Scope 104; H. P. P. C. Mixers: Model 10249, 1500MHz; Philips, L225, 1225 Hillsdale Place, North Bend, N. J. 07047.

CINCY STAG HAMFEST — Attention hams: Mark this date, Sept. 26, for the 1971 Cincinnati 34th Annual STAG Hamfest, the one big STAG Amateur Radio event of the year. Meet all of your friends here. More details later. W8DSD, Hamfest Secretary.

WIRED AND TESTED INTERDIGITAL PRE-AMPLIFIERS by CADCO

Factory wired and aligned 6, 2 and 1-1/4 meter state of the art ultra low noise Interdigital Pre-amplifiers and filters - as featured in February 1971 HAM RADIO!

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INTERDIGITAL BANDPASS FILTERS

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<tr>
<td>IS-BPF-220</td>
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*Plus $0.50 postage

Allow 3 weeks for receipt of order

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(405) 232-1384

CAMP ALBERT BUTLER INVITES HAM RADIO ENTHUSIASTS OF ALL AGES TO TRY FOR YOUR GENERAL CLASS TICKET

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LEADING TO GENERAL ADVANCE and AMATEUR EXTRA LICENSE

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Entire staff consists of licensed hams who are instructors in electrical engineering in some of our finest colleges and universities. Camp opens July 31st and closes August 14th. Tuition of $200.00 includes all camp expenses, room, meals, notebooks, textbooks, and insurance. Send for our brochure.

C. L. Peters, K4DNJ

General Secretary

Gilvin Roth Y.M.C.A., Elkin, N. C. 28621

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June 1971
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WORLD PREFIX MAP - Full color, 40" x 28", shows prefixes on each country. DX zones, time zones, cities, cross referenced tables. Postpaid $1.25


RADIO AMATEURS MAP OF NORTH AMERICA! Full color, 30" x 25" - includes Central America and the Caribbean to the equator, showing call areas, zone boundaries, prefixes and time zones, FCC frequency chart, plus informative information on each of the 50 United States and other Countries. Postpaid $1.25

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88 June 1971

More Details? CHECK-OFF Page 94
WANTED: CUSTOMERS: No experience necessary:
Shack Clearance: Heath HW-20 Pawnee, 2 meter, excellent conds. $90.00, Heath Tunnel Dripper, $120.00, CV-253 ARLR convertor, $38.00.
RF, 30 MHz; VHF; 40 Hz. $40.00, Jennings UCSLPS-750, 750PF/SKY New, $15.00, Jennings ECGS-30, 30PF/10KV New, $10.00. Much more: RTY, VHF, REPEATER GEAR, ETC. Send S.A.S.E. for list and photos. Gerry, K7UGD, 945 Cottage, Pocatello, Idaho 83201.

SWAN 500CX, 117XC, 14X, DC module, VX2 VOX. Excellent conds. $495 firm. Bob Dunf, 4114 Northcote, East Chicago, Indiana 46312.

OSCILLSCOPE, 3", Military OS-34/USM-32. Compact modern styling. 4 MHz Vertical Bandwidth, 10-20000 usec Sweep Time, Time Marker Generator and Voltage Calibrator are some of its features. $95.00. Other scopes from $45.00 to $500.00. James R. Walter, 2697 Nickel, San Pablo, California 94806.

Last 1972 - The Las Vegas FUN convention, January 6-9. Watch for further details. SAROC, Box 73, Boulder, Nevada.

CALIFORNIA VACATION, XYL and I want to trade Pullouts. Guaranteed. Amateurs from the Pan-American countries. Contact for standing ads not changed each month. Your AD belongs here too. Commercial ads 25¢ per word. Non-commercial ads 10¢ per word. Commercial advertisers write for special discounts. For standing ads not changed each month.

WANTED: Customers: No experience necessary:
Shack clearance: Heath HW-20 Pawnee, 2 meter, excellent conds. $90.00, Heath Tunnel Dripper, $120.00, CV-253ARLR convertor, $38.00.
RF, 30 MHz; VHF; 40 Hz. $40.00, Jennings UCSLPS-750, 750PF/SKY New, $15.00, Jennings ECGS-30, 30PF/10KV New, $10.00. Much more: RTY, VHF, REPEATER GEAR, ETC. Send S.A.S.E. for list and photos. Gerry, K7UGD, 945 Cottage, Pocatello, Idaho 83201.

SWAN 500CX, 117XC, 14X, DC module, VX2 VOX. Excellent conds. $495 firm. Bob Dunf, 4114 Northcote, East Chicago, Indiana 46312.

Last 1972 - The Las Vegas FUN convention, January 6-9. Watch for further details. SAROC, Box 73, Boulder, Nevada.

CALIFORNIA VACATION, XYL and I want to trade Pullouts. Guaranteed. Amateurs from the Pan-American countries. Contact for standing ads not changed each month. Your AD belongs here too. Commercial ads 25¢ per word. Non-commercial ads 10¢ per word. Commercial advertisers write for special discounts. For standing ads not changed each month.

WANTED: Customers: No experience necessary:
Shack clearance: Heath HW-20 Pawnee, 2 meter, excellent conds. $90.00, Heath Tunnel Dripper, $120.00, CV-253ARLR convertor, $38.00.
RF, 30 MHz; VHF; 40 Hz. $40.00, Jennings UCSLPS-750, 750PF/SKY New, $15.00, Jennings ECGS-30, 30PF/10KV New, $10.00. Much more: RTY, VHF, REPEATER GEAR, ETC. Send S.A.S.E. for list and photos. Gerry, K7UGD, 945 Cottage, Pocatello, Idaho 83201.

SWAN 500CX, 117XC, 14X, DC module, VX2 VOX. Excellent conds. $495 firm. Bob Dunf, 4114 Northcote, East Chicago, Indiana 46312.

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RF, 30 MHz; VHF; 40 Hz. $40.00, Jennings UCSLPS-750, 750PF/SKY New, $15.00, Jennings ECGS-30, 30PF/10KV New, $10.00. Much more: RTY, VHF, REPEATER GEAR, ETC. Send S.A.S.E. for list and photos. Gerry, K7UGD, 945 Cottage, Pocatello, Idaho 83201.

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90 june 1971

More Details? CHECK-OFF Page 94
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<thead>
<tr>
<th>Model</th>
<th>Resolution</th>
<th>Price</th>
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<tbody>
<tr>
<td>503</td>
<td>450 kHz</td>
<td>$95.95</td>
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<tr>
<td>519</td>
<td>DC-1000 MHz</td>
<td>$275.00</td>
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<tr>
<td>535</td>
<td>Blue, round-corner DC-11 MHz. .02 usec/cm.</td>
<td>$495.00</td>
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<tr>
<td>535A</td>
<td>Later model, DC to 15 MHz, already overhauled and calibrated.</td>
<td>$595.00</td>
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<td>541A</td>
<td>DC to 30 MHz, 20 res./div. and up</td>
<td>$550.00</td>
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<tr>
<td>545A</td>
<td>Same plus calib. variable delay</td>
<td>$750.00</td>
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<tr>
<td>RM45A</td>
<td>Same, for rack mounting</td>
<td>$700.00</td>
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<tr>
<td>RM545B</td>
<td>Rack-mtg 33 MHz part, w/cabinet</td>
<td>$750.00</td>
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<tr>
<td>545B</td>
<td>Cabinet model</td>
<td>$925.00</td>
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<tr>
<td>564</td>
<td>Storage with 383 and 2-trace 3A1, already OHC'd</td>
<td>$1650.00</td>
</tr>
<tr>
<td>570</td>
<td>Tube curve tracer</td>
<td>$275.00</td>
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<tr>
<td>575</td>
<td>Transistor curve tracer</td>
<td>$675.00</td>
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<tr>
<td>661</td>
<td>With 451 &amp; 511A, 2-trace self-triggering sampling scope, DC-1000 MHz</td>
<td>$850.00</td>
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**PLUGINS:**

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<tr>
<td>1A2</td>
<td>2-trace 33 MHz</td>
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<td>5</td>
<td>5 mv/12 MHz</td>
<td>$40.00</td>
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<tr>
<td>2A3</td>
<td>2-trace 24 MHz</td>
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<td>310</td>
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<td>$150.00</td>
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<tr>
<td>325</td>
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<tr>
<td>534</td>
<td>5 MHz</td>
<td>$100.00</td>
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**HEWLETT-PACKARD SCOPE BARGAINS:**

<table>
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<tr>
<th>Model</th>
<th>Specifications</th>
<th>Price</th>
</tr>
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<tbody>
<tr>
<td>140A</td>
<td>With 140SA 2-trace 5 MHz &amp; 142A sweeper plugins &amp; 2 probes.</td>
<td>$600.00</td>
</tr>
<tr>
<td>1402A</td>
<td>2-trace 20 MHz &amp; 142A sweeper, no probes</td>
<td>$750.00</td>
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OVERHAULED & CERTIFIED COUNTERS

<table>
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<tr>
<th>Model</th>
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</thead>
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<tr>
<td>Solid-State 220 MHz</td>
<td>CMC 737CU, 7 axles, plus 525A &amp; B. Light &amp; compact</td>
<td>$150.00</td>
</tr>
<tr>
<td>510 MHz</td>
<td>Substitute 525C for 525B, add</td>
<td>$100.00</td>
</tr>
<tr>
<td>10 Hz-15 kHz</td>
<td>Read freq. on 7 DCU's, no algebra</td>
<td>$150.00</td>
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AND PLENTY MORE! Ask for List g11a.

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<td>STREET</td>
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<td>CITY</td>
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<tr>
<td>STATE</td>
<td>ZIP</td>
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94 June 1971
Now you don't have to pay twice the price to get twice the rig.

Picture this pair in your shack. The Yaesu FLdx 400 transmitter and the FRdx 400 receiver. Loaded with power. Loaded with sensitivity. Loaded with features. Loaded with value. Read on, and discover how you can have the most up-to-date receiver-transmitter rig in the world... and at an unbelievably low price.

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We rate the FLdx 400 very conservatively. That rating guarantees you 240 W PEP input SSB, 120 W CW and 75 W AM. The FSK option will go all day at a continuous 75 W. And you get full frequency coverage on all amateur bands—80 meters through 10 meters—with an optional provision for certain other bands that you can personally specify. For all that, you pay just $299.95.

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More Details? CHECK-OFF Page 94

june 1971
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The FT-101 is a thirty-pound package of DX punch, air-ready when you are, wherever you are. Just add an antenna, feed it 12 or 117 volts, and you're ready to work the world.

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You get a powerful, air-ready station. A handsome, completely hand-crafted transceiver that's fully guaranteed for one year.

You'll have maximum input of 560 watts PEP in the SSB mode or 500 watts CW. And except for speaker, mike and antenna, you'll have nothing else to buy. Power supply, WWV, calibrators, VOX, warranty and all the other items you usually have to pay extra for are included.

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Send for our free information packet that tells the Yaesu story and gives you facts, specifications and schematics for the FTdx 560. The radio you can steal.

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Address _________________________

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All prices F.O.B. Signal Hill, Ca.
EIMAC’s new 8877 high-mu triode delivers over 1500 watts output at 220 MHz. (2000 watts output at 30 MHz is easy)

On your right is the new, rugged, ceramic/metal 8877 high-mu power triode by EIMAC. Another state-of-the-art tube. Only three and one-half inches high, this low-profile, heavy-duty tube has a plate dissipation rating of 1500 watts, a maximum plate voltage rating of 4000 and a maximum plate current rating of one ampere. In the HF region, typically, the 8877 coast along at a continuous duty level of 3500 watts PEP input. A peak drive signal of only 65 watts is required. This impressive power gain is achieved with 3rd order intermodulation distortion products — 38 decibels below one tone of a two equal-tone drive signal.

This magnificent power triode is rated at full input to 250 MHz. The low impedance grid structure is terminated in a contact ring about the base of the tube, permitting very effective intrastage isolation to be achieved up to the outer frequency limit of operation. The close tolerance grid, moreover, is composed of aligned, rectangular bars to achieve maximum grid dissipation and controlled transconductance. This aligned grid, plus the EIMAC segmented, self-focusing cathode provide low grid interception and the low grid drive requirement; both of paramount importance in the VHF region. Although primarily designed for superlative linear amplifier service demanding low intermodulation distortion, the 8877’s high efficiency permits effective operation as a class C power amplifier or oscillator, or as a plate modulated amplifier. The zero bias characteristic is useful for these services, as plate dissipation is held to a safe level if drive power fails, up to an anode potential of 3 kV.

The sophisticated circuit connoisseur will appreciate the many advantages of this newly developed power tube. Write for detailed information. And remember — the 8877 is another example of EIMAC’s ability to provide tomorrow’s power tube today. For additional information on this or other products, contact EIMAC, 301 Industrial Way, San Carlos, California 94070. Phone (415) 592-1221 (or call the nearest Varian/EIMAC Electron Tube and Device Group Sales Office.)