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FEBRUARY 1972

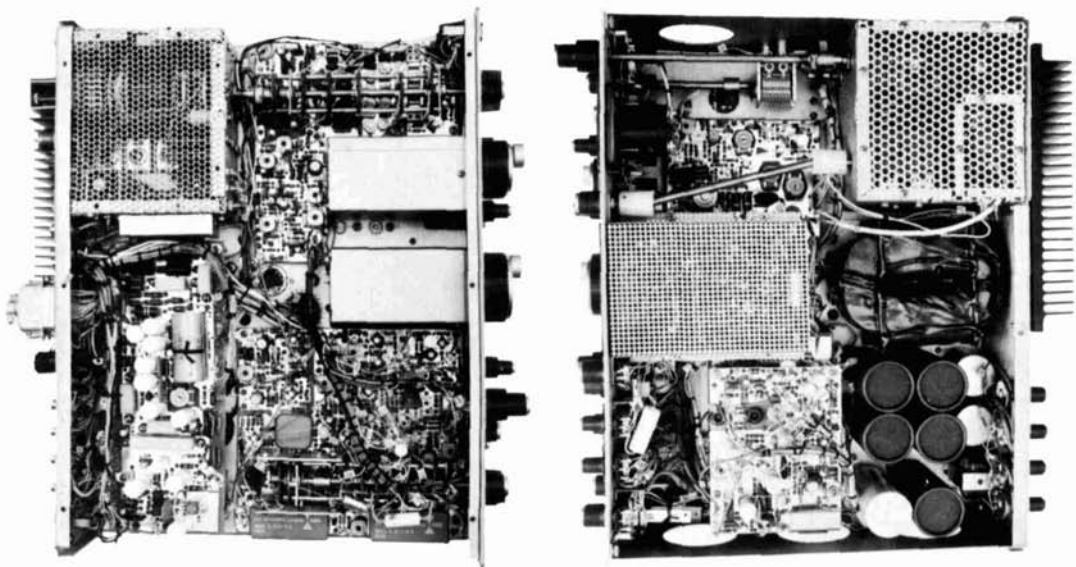
DIGITAL READOUT STATION ACCESSORY



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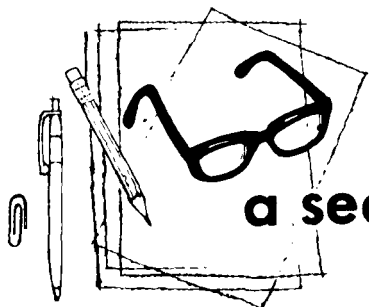
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a second look

by jim
fisk

As more and more amateurs switch to factory-made gear, and as industry uses more ICs and disposable plug-in modules, the life of the dyed-in-the-wool homebrewer gets tougher and tougher. If you've recently tried any of the construction articles in *ham radio*, you are already well acquainted with the hassle involved in obtaining a few needed components.

At one time you could drop in at your local corner radio store with a list of parts and the man behind the counter would fill your order. But that was when the vacuum tubes, resistors and capacitors in your ham gear were the same as those in the family radio. It's not the same anymore — now the transistors and ICs in radios and television sets are apt to be designed specifically for that purpose and have operating characteristics that are of little use elsewhere. There are exceptions, but they are few and far between.

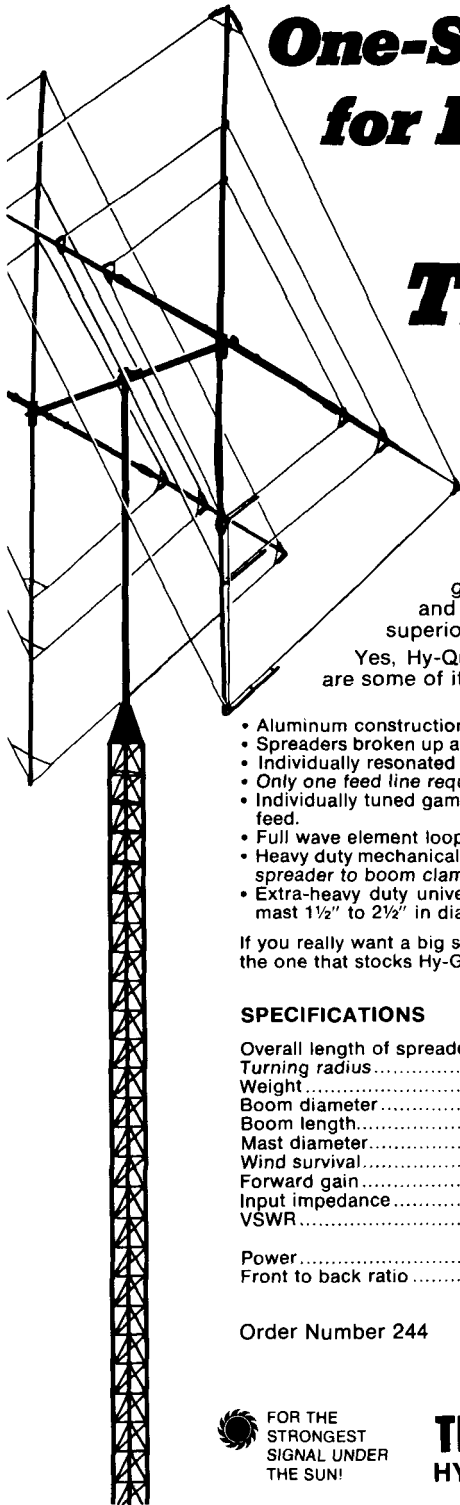
Another problem that faces the serious home builder is the generous variety of transistors and ICs available from different manufacturers. Although some types of devices are made by more than one company, in most cases the semiconductor manufacturers crank out devices that are completely different from those of their competitors. And to add insult to injury, the same device may carry a dozen different part numbers: a 2N number, a replacement number plus special numbers for units sold in large quantities to equipment manufacturers.

There is only one way to combat this lunacy: arm yourself with a good semiconductor cross-reference guide and a wide selection of electronic parts catalogs.

Tops on the list of replacement guides is Howard Sams "Transistor Substitution Handbook." This handy little paperback, which is updated every year, covers practically every transistor ever made, from 2N34 to 2N6000, with recommended substitutes. It also covers devices from Japan and Europe, as well as replacement types manufactured by Delco, General Electric, International Rectifier, Motorola, RCA, Semitronics, Sylvania and Workman. Most of these manufacturers also publish replacement guides, available for the asking from their authorized distributors.

If you live in a large metropolitan area, chances are that there is an industrial electronics supply house that can fill your parts need. Many of these firms don't advertise, because they are not particularly interested in small quantity sales, but if you show up at their office, they will sell you the parts. If you want to find them, pick up your telephone directory and check the Yellow Pages; look under "Electronic Equipment and Supplies." If you live out in the sticks, the problem is more difficult, unless you can get into the city. If you can't, you must purchase your components through the mail. Allied Radio is the best bet in this case and you can get a catalog from any Allied/Radio Shack store. Be sure you get the Industrial catalog though, the more common entertainment catalog is devoted primarily to hi-fi, CB and simple experimenter's stuff.

Jim Fisk, W1DTY
editor



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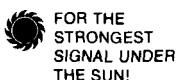
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The most attractive magazine articles may be those that provide instructive or interesting reading to a large percentage of readers, including those readers who do not plan to build or use the device described. It is hoped that this article will be of that type.

Possibly each of us should plan to build one electronic gadget every year, just to avoid becoming entirely an "appliance operator." This is not easy to do under present conditions other than for small items of accessory or test equipment. Of all the gadgets other than kits, digital nonlinear integrated circuits offer perhaps the most pleasant areas in which to experiment, design and build an accessory for your station. There is widespread interest in such devices, as will be seen from the many technical papers which have been published during recent years.

Instead of building a series of devices to accomplish different things, I have given consideration to the idea that one cabinet, chassis, power supply and readout can be used for an almost endless number of jobs. This saves construction, space and expense. By using some form of plugboard for the circuitry, new active devices can be added, or replaced even temporarily, such as when you are asked to time a swimming meet or auto race to a thousandth of a second.

I plan to cover the basic unit at this time, and the detailed accessory devices in coming months. Some of the accessories will not be the subject of an article because of the number of similar units already in print. These can be built on suitable plugboards and used in the accessory unit.

In the meantime, general planning and

E. H. Conklin, K6KA, Box 1, La Canada, California 91011

background reading well may be in order to acquaint you with the subject. This will make the subsequent plug-in devices very easy to understand. In fact, they may not even require a circuit diagram, except for block diagrams and switching plans for the station maintenance files.

Some of the items that can be worked into the accessory are: high-stability crystal calibrator, harmonic generator, frequency counter, digital clock, identification timer, receiver digital dial, transmitter digital dial, general-purpose receiver dial, electronic keyer, event timer or stopwatch, auto speed trap, photo timer and *wife-reminder*. The *wife-reminder* refers to anniversaries, birthdays and the like. These, and license renewal date, can be added, with suitable alarms for the purpose!

In preparing such an article, it is desirable to simplify parts procurement in order to eliminate a month or two of planned purchasing, with the inevitable back-ordering and interdependence of one item on what is obtained for some other requirement. Also, chassis and cabinet dimensions given are for the very few that matter. And finally, difficult machining problems and other sources of frustration and discouragement should be avoided.

nixie read-out displays

Chassis construction depends to a considerable extent upon the type of read-out displays that you select. Tube-types such as Nixie (a Burroughs trade name) and Numatron (RCA) may require a specific chassis height, or shelf, or mounting on the forward edge of vertical epoxy-glass circuit boards. It is feasible to use a chassis only in the center to support the read-out tubes and the power supply with all other parts except panel switches mounted on plugboards (such as Vector *plugboards*).

The widely known Nixie gas-discharge display device requires a few milliamps at about 180 volts. It also requires a high-voltage BCD-to-decimal decoder/driver IC. As in other uses of decoders and

drivers, care must be taken to obtain those with *active high* or *active low* operation as required by the particular type of read-out. A current-limiting resistor is used as with neon tubes. Sometimes a grounded wire-mesh screen is placed over the panel window to prevent inside radiation from leaking out, or the reverse.

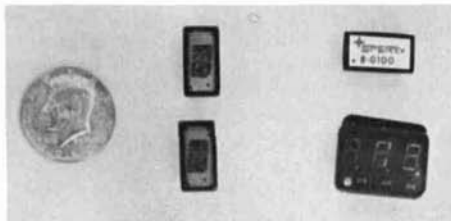


fig. 1. Two Minitron readouts are shown on the left. A three-digit Sperry cold-cathode display, resting on its special socket, and one of the decoder/driver ICs, are on the right.

These read-outs will be found in large mail-order industrial catalogs. However, note that this is a fast-moving field, and spare tubes should be on hand to prevent running short if the type you use is not available in the future.

Burroughs has extended the cold-cathode gas discharge design into *Panaplex*, a single tube with eight or more 7- or 9-segment digits, including driver circuitry. A strobed or multiplexed time-sharing method is used to minimize decoder/driver cost. The hoped-for cost of \$1 per digit is a few years away.

In the meantime, Sperry Information Displays* is producing some very pretty replacements for Nixie tubes. These are 1½-, 2- or 3-digit flat glass plates, a socket and active-low 7-segment decoder-driver units, shown on the right in fig. 1. Sperry offers demonstration kits including read-out, socket and decoder/driver, and may furnish the 2- or 3-digit ones on request at \$14.95 for the lot, thus being one of the low-cost devices. They do

*Sperry Information Displays Division, Box 3579, Scottsdale, Arizona.

require the low-current 180-volt supply, though.

General Electric offers the Y-1938 7-segment low-voltage tubes with filament. They have an unusual blue-green character color and require 1.6 volts on the filament and 25 volts dc on the anode, but can be driven by suitable IC decoder/drivers. General Instrument and Hughes make up/down counters, buffer storage, and decoder/drivers in a single large 24-pin dual in-line package (DIP) IC that will operate the GE tube. These combined counter ICs have merits but are not desirable for digital clock purposes.

incandescent displays

The RCA Numitron is a 7-segment incandescent tube, taking up to 5 volts, but at 24 milliamperes per segment. This requires one of the high-current decoder/drivers.

There are other simple incandescent lamp displays, some requiring higher current than is provided by a 7-segment decoder/driver IC. One made in Japan, however, built like a 16-pin DIP IC, is the Minitron, shown on the left in **fig. 1**. Its 5-volt and low-current requirements are well within normal 7-segment decoder/driver output, like the inexpensive active-low Monsanto MSD 047 and the Texas Instruments 7447, all available from Circuit Specialists.* These have provision for decimal, lamp test and read-out blanking input and output. Currently the Minitron and MSD 047 decoder/driver combination appears to be the lowest-priced read-out system available.

light-emitting diodes

The Monsanto MAN3A light-emitting diode read-outs are built somewhat like a ten-pin IC flat-pack, with pins spaced 0.034 inches. The 7-segment display is only 0.115 inches high, thus about the smallest in the business. At around \$6.50 a digit this is the lowest cost of the bright red-colored light-emitting diode displays. The Heath 14-pin DIP LED display, used

in their 80-MHz counter, sells for \$8.50.

Light-emitting diodes are attractive and will be very popular when the small-quantity cost comes down a bit. They require a dropping resistor in each segment lead and each decimal-point lead. LEDs are compatible with systems that include the decoder/driver, latch, and possibly the decade counter, all in the same IC.

other displays

Sigmatron* has a light-emitting film multidigit display; in large quantities, this runs only \$1.50 a digit, but unit prices are much higher. These units require an audio-frequency multivibrator driver which can be time-shared by all of the digits with a multiplexing device.

Optel† offers liquid crystal displays. These require a small 20-volt supply. With the decoder/driver and Hughes HCTR 0107 display driver the small-quantity cost is much higher than many other read-outs.

color filters

Usually a color filter is placed over a numeric display to increase the contrast between the read-out's light and the background. Most displays are red, but a few are blue-green. The incandescent ones are close to an orange-white color, depending upon the voltage at which they are operated.

Litronix mentions that the Rohm & Hass no. 2423 acrylic plastic has 71% light transmission, and that the Polaroid HRCP-7 has only 40% light transmission but offers a nonglare surface. In a test, Circuit Specialists did not find any advantage in the Polaroid material compared with sticking red Scotch tape on individual Minitrons and trimming the edges even.

Plain half-sheets of thin flexible plastic cost about \$1.50 at art supply stores; similar colors are available at school supply stores as "report covers" at 19c

*Sigmatron, 849 Ward Drive, Santa Barbara, California 93105.

†Optel, Box 2215, Princeton, New Jersey.

*Circuit Specialists, Box 3047, Scottsdale, Arizona 85257.

each, which is quite a bargain. The red looks good. For incandescent displays, the rose (not quite amber or orange) probably passes more visible light, even when two thicknesses are used.

It is desirable to minimize light spread by having the plastic window close to the read-out. The chassis described in **fig. 6** has the plugboard holding the displays directly behind the panel window with the Minitrons actually touching the plastic. The plastic can be glued to the rear of the panel or it can be secured with flat-head 2-56 machine screws with a washer and nut on the rear side of the panel.

For trying different colors, a 3 x 5-inch card holder can be purchased at a builders' hardware store. This can be held in place on the rear of the panel with flat-head machine screws. It is practical to cut out a section on the 3-inch dimension, mounting the old top and the remaining side lengths from the upper machine screws. This has been done on the panel shown in **figs. 2** and **6**. Inasmuch as the Minitron read-outs are thicker than the other ICs there is no problem in clearances from the panel. If fewer than eight read-out digits are planned, such as by omitting the megahertz, smaller escutcheons can be used without modification.

number of read-outs

The unit pictured in **fig. 2** has eight Minitron read-outs in one row, shared for all purposes, so that 99 MHz can be displayed right down to the last cycle. In some applications it is feasible not to bother with counters, latches and decoder/drivers for the MHz digits; if these are available they can be activated by a bandswitch to connect 5-volts dc through steering diodes to the correct read-out segments.

Some read-outs can be omitted, such as the MHz ones, or the units or tens of Hertz. It is quite useful to have only three kilohertz digits and one for tenths-of-kHz, thus requiring only four read-out tubes.

Another option is to use two rows of read-outs, with frequency (counter) on one row, and time of day on the second row — if sufficient plugboard contacts are available. In this way, by not sharing these displays, there will be the added cost of the extra read-outs and their decoder/drivers for the extra four units or more used to display time.

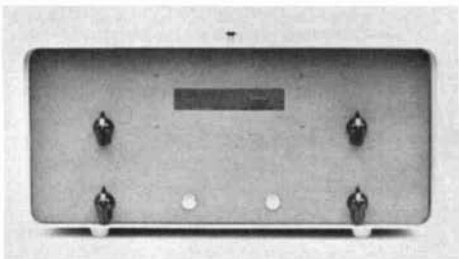


fig. 2. Front panel and cabinet of the digital accessory prior to the application of panel lettering.

There will be some saving on switching, and also about \$5 for the four quadruple 2-input AND gates used as data selectors on the displays alternately used for time and for counting. Texas Instruments promises production of their SN74157N quadruple 2-line-to-1-line data selectors to do this same job of switching between two types of input data to the read-outs, but prices are not yet available.

cabinet and chassis

With IC-type read-out displays a miniature unit is possible, but it limits flexibility in usage and may complicate experimentation, test and maintenance. Readers with other Heath equipment can select from a number of cabinets used in many Heath units.

As a first attempt at packaging, I decided to use the gray CO-1 cabinet made by LMB shown in **fig. 2**. It measures 14½-inches wide, 6½-inches high and 13½-inches deep including the shadow front. It closely matches Collins S-Line cabinets and the original Henry 2K.

Through separate order, the alternate 1½-inch-high chassis — not the more popular 2-inch-high chassis — was ordered. These are obtainable through supply stores. Unlike the Collins cabinets, it does not come with a rectangular hole for access to the rear apron of the chassis. Such a large rectangular hole can be cut out, or small guide holes can be drilled from the rear of the cabinet into the rear of the chassis and later enlarged to pass phono plugs through the cabinet into phono jacks mounted on the chassis.

This operation is facilitated by shimming the rear of the chassis 1/16-inch

cabinet and the aluminum chassis to identify the phono plugs. The Letraset is smaller than that offered by electronics mail-order houses; it and other alternatives are available from art supply stores. Crystal-clear Krylon spray coating over the transferred letters will make them permanent.

There is no provision for a chassis fuse nor for a complete on-off switch inasmuch as the oven and clock components will remain turned on except during trips abroad. The unit is fused in the power plug (Allied Radio Shack no. 270B1249).

The large hole required for a power-

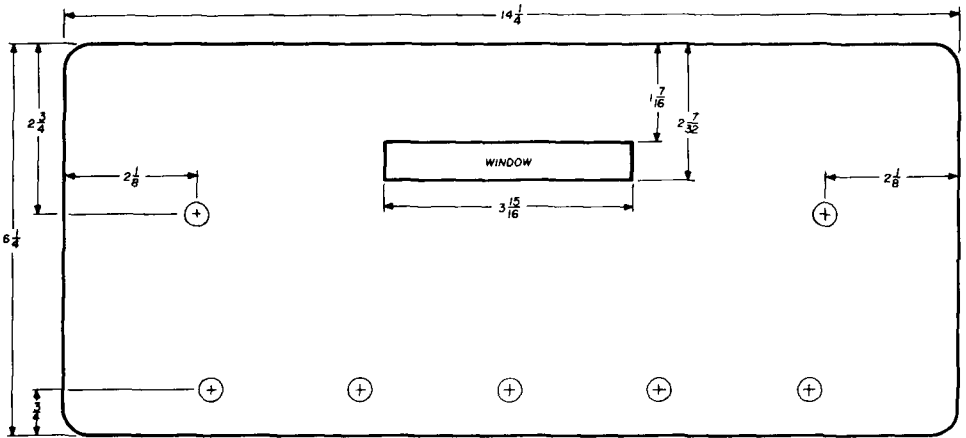


Fig. 3. Front panel drilling instructions.

with washers held in the corners with masking tape or by a 4-40 machine screw permanently threaded into each of the two rear chassis angle brackets. Scrap pieces of Vector T-strut can be used to hold the chassis by placing these pieces in the guide rail at the sides of the chassis. By blocking up the chassis from the front and holding it from popping out, guide holes for the entire set of phono jacks can be drilled.

Subsequently, sets of black and white letters* can be applied to both the gray

*Letraset 10-point Helvetica light (1573), catalog number 48-10-CLN, upper and lower case, available at art supply stores.

cord strain relief is beyond many home drilling facilities; a grommet with suitable tight-fitting hole will do a reasonable job. Stretch the grommet onto the power cord, then drill out the chassis hole that will accept the grommet but retain the power cord.

The cabinet's cover has no provision for a handle or finger hole. However, a 4-40 machine screw with fibre washers and spacer under the head, will pass through a ventilation hole, to be used as a cover handle.

If the unit will be near Collins equipment, obtain two or four tapered feet (Collins 543-8101-002). Four are used

when stacking above or below S-Line units, maintaining ventilation space. Rubber feet are Collins 200-5010-000.*

the panel is the right distance back at its bottom, then drill new screw holes up through the bottom. A sheet-metal screw

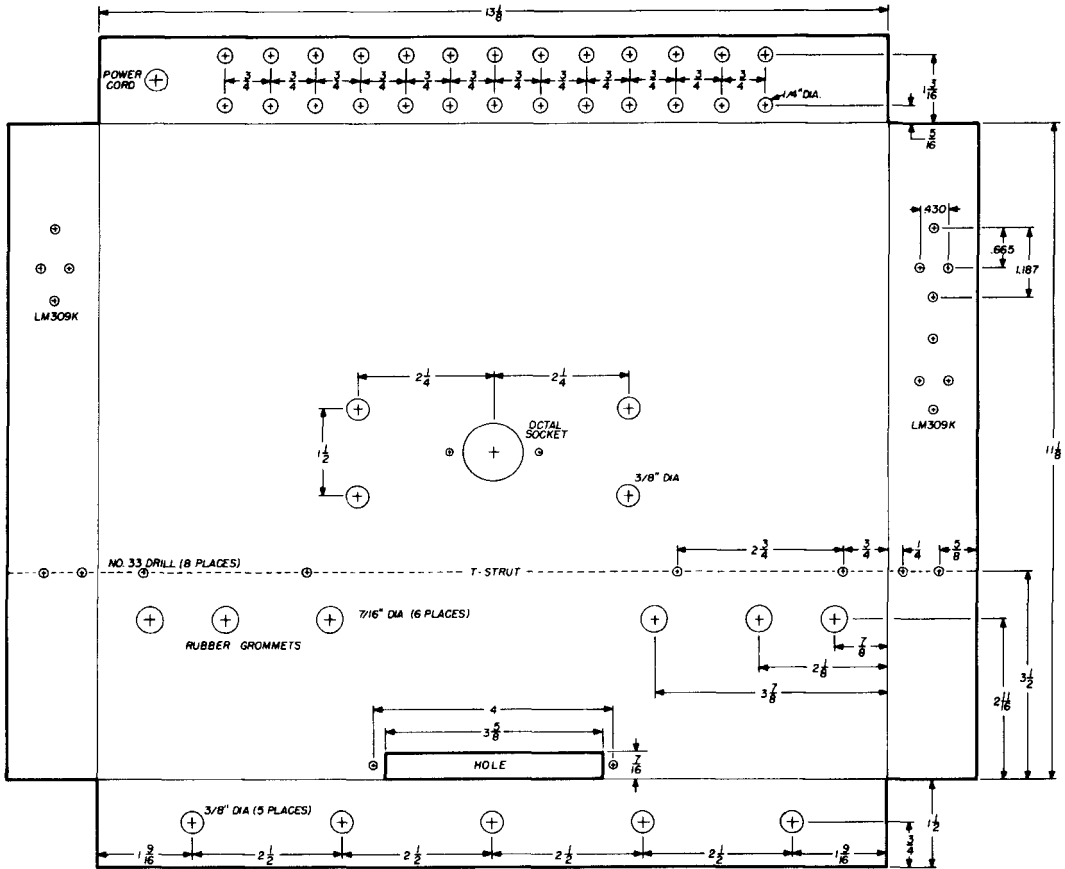


fig. 4. Chassis drilling instructions; the power-supply holes are omitted because they will not apply for different parts.

panel

The front panel angle comes secured under the cabinet cover by two sheet-metal screws which also hold down the hinged top. This is inconvenient for adjusting the crystal oscillator and setting the clock. The answer is to clamp a piece of wood to the lower cabinet lip so that

*Collins parts may be ordered from Customer Service Representative, Collins Radio Company, Cedar Rapids, Iowa 52406.

should be put into the first hole before the second is drilled. In this way, the chassis and the front panel are held firmly, even when the cabinet lid is opened.

The lower set of controls will require holes 3/4-inch up from the panel bottom, through the chassis, as shown in figs. 3 and 4. Old controls or their bushings then can be inserted to hold the chassis and panel in place as additional holes are drilled.

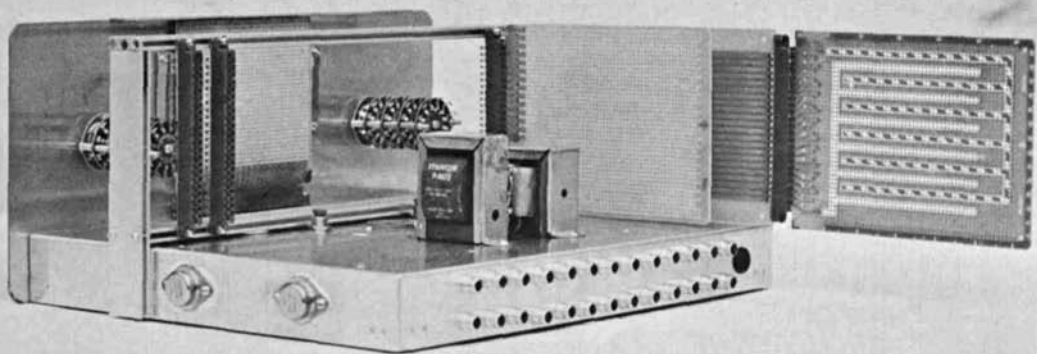


fig. 6. Rear view of digital accessory showing the mounting of Vectorboard to hold Minitron readouts and T-struts for other circuit boards prior to above-circuit chassis wiring.

It can be seen in fig. 5 that the small space under the chassis permits a switch only as large as the Centralab PA-1000 and PA-2000 subminiature series. Even then the switch must be wired when dismantled, bending contacts in, and applying plastic tape to the chassis and cabinet to prevent the contacts from shorting.

These switches are attractive because spare parts and wafers are available for possible future expansion. Smaller switches may require smaller panel holes and 1/8-inch shafts. The small Daka-Ware knobs that were supplied with the switches are helpful when positioned so close to the bottom of the cabinet.

Some controls can interfere with the

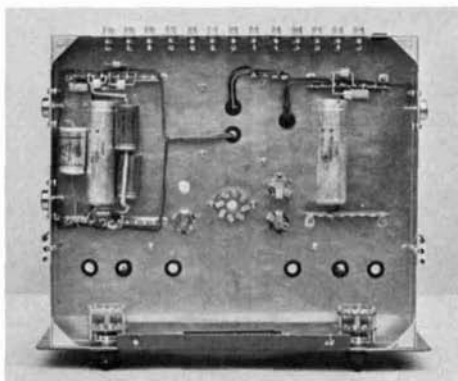


fig. 5. Bottom view of digital accessory showing power supply and unwired switches and other controls.

read-out plugboard receptacle contacts. In this case, two control nuts can be used to mount the central controls far enough behind the panel in order to clear the receptacle contacts.

More holes for controls are shown in fig. 3 than were planned for expected requirements. Unused holes can be filled with snap-in plugs until required by future expansion.

read-out window

A rectangular hole is required in the panel for the read-out display. This can be slightly smaller than IC-type read-outs. The old way of drilling a series of small holes, then connecting them by one of several means, is a lot of work. There are two easier ways.

First, lay out the desired rectangle on the back side of the panel, marking all four sides. Drill small holes in all four corners just inside the rectangle. Then back away from the corners and drill large holes inside of the rectangle. If a neighbor has home shop equipment with a milling device, a small milling tool can be used to rout out the metal within the rectangle.

Without this, borrow a sabre (scroll) saw with a fine-tooth nonferrous metal-cutting saw blade. These saws are priced from under \$10 at Sears and about twice that in the Skil tool line. Cloth should be placed on each side of the panel, then

wood blocks, before putting it in a vise for sawing. The rectangle can be cut by sawing in different directions from a starter hole, even by using the side of the saw blade as a file for thin cuts.

After the panel work is finished, hang the panel by a wire or cord through a screw hole in the bent-over angle lip (or through both holes), and spray with Krylon all-purpose gray (no. 1318) or a suitable alternate.

The same type of cutting operation can be used for the rectangular hole for the contacts of an R-644 Vector *plugboard* receptacle on the front of the chassis below the rectangular window in the panel.

Later, a Vector 3662 *plugboard* (\$6.95), with P pattern 0.1-inch hole spacing, can have two inches sawed off the end of the board, 4-7/16 inches from the plug end, to retain 36 rows of holes including the two rows connected to the 44 contacts. This board will mount up to eight read-out units such as Minitron or light-emitting diodes, plus their decoder/drivers, and considerably more DIP ICs if desired.

The drivers should be mounted with the read-outs in order to have only four data leads per decade, not seven, to keep within the limit of 44 contacts. Boards with more contacts are available, but may not be necessary.

Normally, mounting the SN7475N quadruple bistable latches on this board is not desirable, because latches are to be omitted from the circuit when time is being displayed. Of course latches for the digits not required to display time can be mounted on this board to use up some of the available board space here, and relieve the other circuit boards which will be used for the time base, and for the counting functions.

If light-emitting diodes are used as read-out displays the voltage dropping resistors required between the decoder/drivers and the read-outs should be on this board. There must be sufficient contacts to handle decimal points. With eight digits displayed, there may not be

sufficient contacts for future expansion.

hardware

Most of the circuitry is on Vector *plugboards* using the 3662 mentioned above for linear rf uses and the 3682-2 (\$8.49) which has convenient ground and + V_{CC} busses printed on it for nonlinear ICs and the input circuitry.

These boards mount in the R-644 receptacles as shown in fig. 6. A convenient means of mounting is available by obtaining two 24-inch Vector TS240

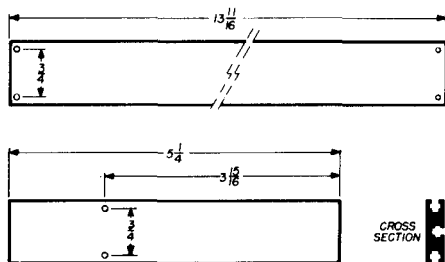


fig. 7. T-Strut lengths and locations of holes. Two pieces of Vector no. TS-240 24-inch stock are required.

T-struts.* The company continues to use this address although the earthquake caused them to move to another area.

Also, order a package of 24 NT6-3 plastic inserts, with no. 6 sheet-metal screws, SC6-11; and a package of 25 square 4-40 nuts, NT4-7. The screws and inserts make right-angle butt joints possible, and the square nuts are used to secure to chassis by the center T-slot nut cavity, and to fasten R-644 receptacles by one of the two edge T-slot nut cavities. (Small hex 4-40 nuts *will* work.)

Saw off, and file smooth, one top T-strut, one bottom T-strut, and two side T-struts as shown in fig. 7. Fig. 6 shows the side T-struts 3/8-inch longer than the dimension in fig. 7. This is satisfactory if the bottom chassis guide rails are wide enough to take the chassis plus both side

*Vector Electronics, 12460 Gladstone Avenue, Sylmar, California 91342, \$1.50 each.

T-struts without more than minor springing, but it is a close fit.

It is necessary for the bottom strut to be shimmed up 0.1-inch above the chassis with two large washers so that the lower edge of the plugboards will be above the chassis surface. Some chassis space could be saved for pushbutton location by using two short pieces of strut in lieu of the long bottom one, and shimming their ends with washers held in place with screws through the chassis and up into nuts in the central T-slot nut cavity. This would result in a small loss in strength.

chassis holes

The more critical chassis holes are marked on *fig. 4*. Adequate 7/16-inch holes for large-hole grommets may be drilled in front of the lower T-strut and located convenient to the below-chassis control wiring. The holes for the crystal oscillator oven and clock reset push-buttons were originally planned to be in front of the bottom T-strut. However, that results in possible conflict should nearby panel holes be used for longer switches or controls in the future.

The hole for an octal socket for the crystal oscillator oven should be punched or drilled with a fly-cutter; due to the thin, soft aluminum the 1/4-inch fly-cutter center guide drill should pass through a 1/4-inch bushing taken from an old switch or potentiometer, temporarily mounted to keep the drill from wandering.

Suitable holes for the transformers and power-supply parts, and for adequate pushbuttons for reset and adjusting the clock, should be drilled. Switchcraft type 103 are suitable spdt pushbuttons. The holes for the grounded and the insulated LM309K 5-volt voltage regulators can be drilled in the side aprons of the chassis to save top chassis space and provide adequate heat-sinking.

t-strut assembly

Prepare the lower T-strut (it has no holes) by inserting a plastic screw insert, properly oriented in the slot, into each side T-slot at one end of the lower

T-strut, then cutting off the flat plastic that continues to extend beyond the end of the T-strut. Next, put a sufficient number of square 4-40 nuts, or small hex nuts if you do not have the Vector square ones, into the rear T-slot to take care of any future expansion. Eight or ten should be sufficient.

Now put plastic screw inserts into the other end of the side T-slots, again cutting off the flat surplus material. Put a 4-40 x 3/8-inch machine screw up through each of the four holes in the top of the chassis with a lock washer. On top of the chassis put on a shimming washer (not retained by the nut), and then a square nut, on the two screws that are clear of the sides. Before tightening the nuts, slide the lower T-strut onto these nuts using the central T-slot. Adjust the position at the sides and tighten the machine screws.

Next, place plastic screw inserts into the side T-slots at the top of each side piece of T-strut (away from the mounting holes), again removing excess plastic. Put 4-40 x 1/4-inch machine screws, lock washers and a square nut through the four holes provided, from inside the chassis, using the mounting holes. Slide the side T-struts down over the square nuts, using the central T-slots, so that the side T-struts stand up outside of the sides of the chassis. Secure the machine screws. Insert no.-6 round-head sheet metal screws through the T-strut mounting holes drilled through the side T-slots and into the plastic inserts in the ends of the lower T-strut.

Now, using no.-6 flat-head sheet-metal screws, secure the top T-strut to the top of one side T-strut. Then insert the same number of square nuts into the rear T-slot of the top T-strut as were put into the bottom T-strut, and secure the remaining end of the top T-strut to the vertical side T-strut. Later, the R-644 receptacles can be attached — probably after soldering wires to the contacts. The completed assembly appears in *fig. 6*.

After the R-644 receptacles are attached it may be necessary to bevel

with a file the lower side edges of the Vector 3682-2 *plugboards* in order to ensure that there will not be a short circuit from the edge printed buss to the chassis (though both may be at ground potential). Later, it may prove to be advisable to place a strip of plastic tape

power supply

Inasmuch as the provisions for digital clock, latches, decoder/drivers, read-outs and digital dial mixers may consume considerable power, adequate amperage has been provided in the design. The most

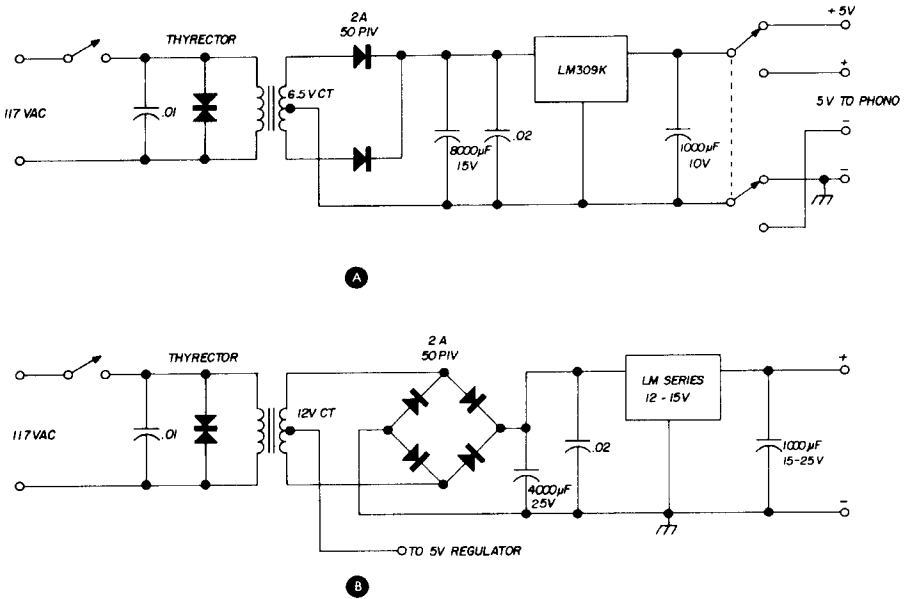


fig. 8. Power supply options. Center-tapped transformer, LM309K five-volt regulator and switched ungrounded output for experimental connection elsewhere is shown in (A). 12- or 15-volt supply using LM336 or LM337 regulator, with centertap to five-volt filter and regulator in (B).

along the top of the chassis where the plugboard will be, or to place tape around the bottom edge of the plugboard.

The rear view, fig. 6, shows the far plugboard with its printed +V_{CC} and ground busses extending out from the receptacle by use of a Vector 3690 card extender. This permits operation of a board in the clear for maintenance or test purposes. In a few cases the extension may change the operating characteristics of the board somewhat. An alternate method is to make up a cable extender using the R-644 receptacle and a 3662 board connected by 44 wires. The wires can be flat ribbon cable, but it is difficult to obtain this in less than 100-foot lengths.

convenient 5-volt regulator with internal overload protection appears to be the National Semiconductor LM309K for currents around one ampere. These will be seen in figs. 5 and 6 mounted on the chassis skirt to conserve chassis space.

The LM309K is in a diamond-shaped TO-3 case which requires heat-sinking if its full capability is to be used. This regulator has only an input, an output and a ground (negative) connection. It does not provide any other voltage, although there is a way to vary it by lifting the ground voltage with respect to the output. It is recommended that silicone heat-conducting heat-sink compound be used under the regulators, on both sides of the mica insulator.

Apparently the LM309K was designed to have an input voltage of 7 to 25 volts. Avoid loading the transformer, rectifier and input capacitor to a lower input voltage to the regulator. This is provided by a good 6.3-volt transformer; with a large filter capacitor of some 8000 μ F for the 5-volt supply, and half that for 10 to 15 volts. A good 2-ampere transformer for under \$4 is the Calectro D1-747 (GC Electronics), producing over 9 volts input to the regulator from a 12-volt center-tapped rectifier, before a load is applied. The use of a 12-volt center-tapped winding permits a bridge rectifier for the higher voltage, and half that voltage from the center tap, as shown in **fig. 8**.

higher voltages

National Semiconductor also produces the LM336 for 12 volts at about 500 mA, and the LM337 for 15 volts at about 400 mA, depending upon both the input voltage (which should not be excessive) and the adequacy of the heat sink. With one of these regulators a center-tapped transformer of sufficient voltage can be used simultaneously for the 12- or 15-volt regulator, and also for the 5-volt regulator.

For that matter, it is feasible to use two regulators or more for different voltages from the same higher-voltage rectifier, provided that the maximum regulator voltage and heat dissipation ratings are not exceeded. The higher-voltage regulators are priced around \$6. All three of these ICs are protected by internal current-limiting.

With any of these power supplies rectifier diodes that handle 1.5 to 3 amperes may prove convenient. Glass-amp units can break unless all bends in the leads are made between two long-nosed pliers so that there is no strain on the glass.

For current less than about 45 mA the adjustable type 723 IC voltage regulator (made by Fairchild and others) may be used. It is rated up to 150 mA, which would require a 0.335-inch clip-on heat

sink if the metal package is selected. The total internal power dissipation must be limited to 800 milliwatts. The input voltage must not exceed 40 volts. There must be at least a 3-volt drop between input and output voltages.

The current-limiting resistor, R_{sc} , can be selected by dividing 0.65 by the desired limiting current in amperes, and frequently is ten ohms (see **fig. 9**). Approximate values for the R1/R2 voltage divider are given in **table 1**. These figures are derived from a Fairchild application note with some adjustment to approach standard resistor values. R3 is needed only for minimum temperature drift; it can be calculated from $R1 \times R2 / (R1 + R2)$, and frequently is around 3k ohms. **Fig. 9** shows a circuit used for an output above 7 volts.

Avoid blowing out the 723 IC by accidental application of reversed rectifier voltage. This can be done by using a series diode between the rectifier and the IC.

Circuits, including those for external-pass transistors, will be found in the Fairchild application note for cases where more than the rated current is to be regulated by the 723, or the output voltage is to be below 7 volts.

Keep in mind the much higher peak input voltage to the regulator. A 15-volt capacitor or larger is required for the first filter capacitor at the output of the 5-volt rectifier diodes, and a 25-volt or larger capacitor in the 12-volt supply. A lower break-down voltage capacitor is satisfactory for the output side of the voltage regulators, just exceeding this regulated voltage. Generally, a smaller capacitance is suitable on the output of the regulator, since additional capacitors generally are placed on the circuit boards because of the tendency of TTL flip-flops to create spikes and noise which can trigger other flip-flops.

If mica mounting kits are used to insulate the TO-3 regulator cans, be sure that there are no burrs around any holes, and test the unit for high-resistance isolation from chassis or heat-sink with an

Products.* One has a 400-kHz crystal, IC flip-flop oscillator and two frequency-dividers which use cross-connected gates. The 100-kHz output is suitable to drive DTL and TTL dividers with fair isolation. However, if the output is taken to other devices it would be well to connect these and the time-base dividers to the oven output through isolating gates.

The oven operates on 120 volts ac, though proportional control would require at least pulsating dc. The oscillator operates on 10 to 12 volts, being zener-regulated internally to 5 volts. A 20-percent change in voltage causes about a 3-Hz change in the 14-MHz harmonic, so it is well to feed the oscillator from a regulated power supply or, at least, from a stable power supply that does not feed a varying load.

The oven is left on except during foreign trips; no adjustment in crystal frequency appears to be needed except possibly once a month, or for an ARRL frequency-measuring test in which an error of one or two Hertz may be undesirable.

C. & H Sales* has sold a large number of James Knights (now CTS Knights), oven/oscillators, 1 MHz, model JKO-PIP-X96D, with proportional ovens. These ovens also plug into octal sockets but operate from 23 to 36 volts dc, both for the oscillator and the oven. Varying the voltage on the oscillator down to eight volts controls the frequency over a considerable range. A hole plug in the top can be unsoldered in order to reach the frequency-adjusting capacitor.

Probably there are other oscillator/oven sources, both surplus and new, such as Bliley and CTS Knights. Only mercury thermostats and proportional control will be free of occasional clicks in a receiver.

*Monitor Products Company, 815 Fremont, South Pasadena, California 91030.

*C & H Sales, 2176 East Colorado, Pasadena, California 91107.

*The SN74162N synchronous up/down decade counter is available from Polypaks, Box 942, South Lynnfield, Massachusetts 01940.

up/down counters

Before concluding it may be desirable to make preliminary mention of the SN74162N synchronous up/down decade counter, which is fully programmable⁵ — that is, it can start counting at any number, and even divide by odd figures like seven. This has become available under \$5 and need be used only in decades that are displayed on the read-out.*

For a year or more these devices have provided a newer approach to decade frequency division; like the 7490 decade they divide the frequency, but they also provide a down-counted read-out. There is good reason to mention these because of a possible simplification of equipment by eliminating all circuitry used for synthesis of the original signal frequency before counting it.

reading material

Preliminary reading material on non-linear ICs, counters and clocks will be found in the following reference material.

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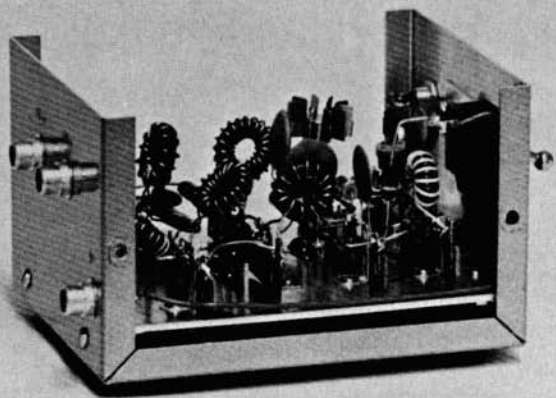
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antiresonant traps,
making band switching
unnecessary

C. E. Galbreath, W3QBO, 8326 Still Spring Court, Bethesda, Maryland

This two-band solid-state transmitter was designed for use with a vfo such as the one described in an earlier issue of *ham radio*.^{1, 2} It operates on 40 and 80 meters, consists of only two stages, and incorporates the best design practices for stabilization and unwanted signal suppression. The unit is easy and inexpensive to build and is an excellent performer. Output can be varied from a few milliwatts to over two watts.

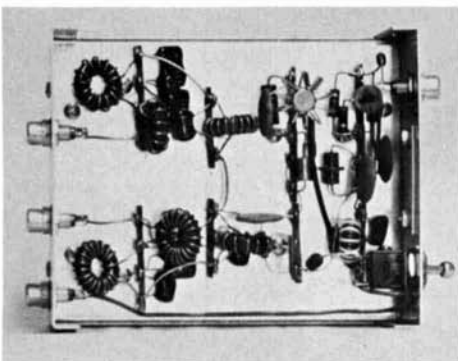
the circuit

The driver stage (fig. 1) uses an inexpensive Motorola 2N4124, Q1, which operates as a class-B amplifier with its base biased through a voltage-divider to obtain approximately collector-current cutoff. With no signal applied collector current is near zero, which minimizes current drain during key-up conditions. As a class-B amplifier, the stage is easier to drive than if operated in class C. The signal input from the vfo is coupled to the base of Q1 at low impedance. A 100-ohm resistor in series

with the input at the base of Q1 eliminates any tendency to self-oscillation, which sometimes may occur without it. The signal input at the base of Q1 is not appreciably reduced by this resistor.

Other transistors may be substituted for Q1; for example, I've used a Motorola 2N3904 with good results. No heat sink is required for Q1.

The driver tank circuit includes a broadband toroidal inductor, L1, which is



Wiring of the 40-80 meter transmitter.

fixed-tuned by C1. L1 resonates on both bands without changing the tank-circuit capacitance. The emitter-bias resistor of Q1 is unbypassed to provide a small amount of degenerative feedback, which increases driver stability. Interstage coupling through the B+ line is reduced by the 25 μ H choke between driver and amplifier. Added protection is provided by the .05 μ F bypass capacitor between B+ and the chassis.

The driver output is inductively coupled to the amplifier transistor through L2, which is wound over L1. L2 also provides the correct impedance match for the excitation voltage to the amplifier.

output stage

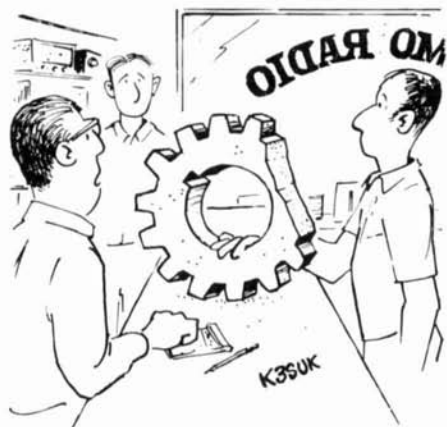
The final amplifier consists of a 2N2102 transistor, Q2, whose tank cir-

cuit is a double pi network for each band. Toroidal inductances are used in the pi networks as they are self-shielding and occupy little space. They are also easy to make and mount in the circuit. The output impedance of the final stage is approximately 50 ohms. A heat sink is required for Q2.

No switching is needed to change bands. An antiresonant trap is inserted ahead of each pi network. On 80 meters the trap ahead of the 40 meter pi network is resonant at 80 meters and isolates the 40-meter tank from the output circuit. On 40 meters the trap ahead of the 80-meter pi network is resonant at 40 meters and isolates the 80-meter tank from the output circuit. I've used traps for this purpose since early 1968.* When changing bands, it's necessary only to insert the transmission-line plug into the appropriate output jack at the rear of the Minibox.

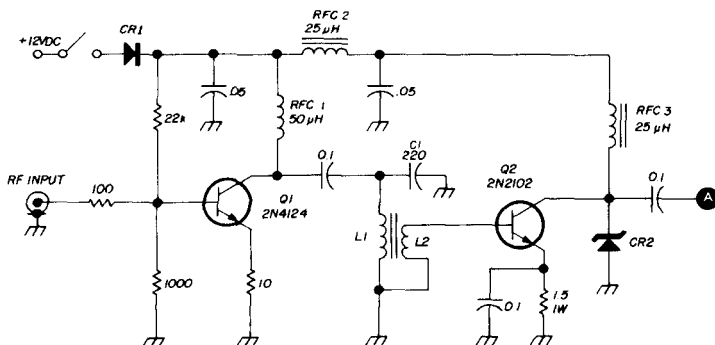
performance

The rig runs about 2 watts output using a 12 V supply. The two stages together draw about 320 mA. The voltage drop across polarity-guarding diode CR1 is over 1 volt. The transmitter will operate on as little as 3 volts, reducing the output to a few milliwatts. For regular duty, a 12-volt lantern battery makes a good power supply. A battery pack of 8 or 10



"Joe, we got any parts for those 160-meter beam rotators we were selling last year?"

*They were used in 1967 in a transmitter known as the ARP-1.



C1	220 pF dipped silver mica capacitor	L1	24 turns No. 24 enamelled on Amidon T-50-2
CR1	50 volts, 1.5 amps	L2	12 turns No. 24 insulated over L1
CR2	39-volt, 1 watt zener, American Semiconductor Corp. 1N3034 or equivalent		

fig. 1. Schematic of the 40-80 meter transmitter. Traps ahead of each output network eliminate bandswitching.

D cells in series will also do very well. For reduced power a 6-volt lantern battery or a 6-volt battery pack will work well. Although I have operated the transmitter on 15 volts, I have not established a safe maximum B+ voltage. †A 100 µF electrolytic capacitor across the battery terminals provides an ac path to ground.

A zener diode, CR1, between the collector of Q2 and ground protects the transmitter from spikes in excess of 36 volts. Too much voltage on the collector will destroy the transistor. Normally the peak rf swing on the collector will not exceed twice the supply voltage.

construction

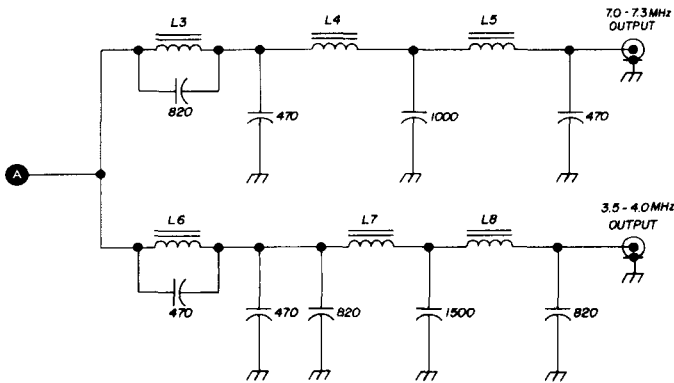
The transmitter is housed in a 3 x 4 x 5-inch Minibox. Components are mounted on terminal strips for ease of construction. The terminal strips may be mounted either on the base of the Minibox or on an aluminum plate, which may be inserted into the box after component wiring is completed. I prefer the second method, as it simplifies component mounting and wiring, and the unit can be

†Motorola's Semiconductor Data book lists maximum V_{cb} ratings of 30 V (2N4124) and 120 V (2N2102). editor.

tested before inserting it into the box. The aluminum plate is bolted to ½-inch right-angle brackets at each end of the Minibox.

Start construction with the angle brackets. I used ½-inch right-angle aluminum purchased at the local hardware store. Cut two brackets about 3½ inches long and mount one at each end of the Minibox. Cut a piece of aluminum 3½ x 4-7/8 inches and bolt on the brackets in the box. Now remove this piece with the brackets attached and use it outside the box as the chassis on which to mount the terminal strips and assemble and wire all components.

The driver stage is located at the front end. All components for the driver stage except the tank circuit are mounted on a 5-lug terminal strip, center lug grounded. The driver-stage tank is mounted on a 3-lug terminal strip in line with the 5-lug strip. Similarly, all components for the final except the tanks are mounted on a 5-lug terminal strip. A 3-lug strip in line with this 5-lug strip holds the B+ line decoupling choke and bypass capacitors. Q1 and Q2 may be soldered directly into the circuit, or transistor sockets may be used with two of the socket terminals in



- L3,L7,L8 18 turns No. 20 enamelled on Amidon T-68-2
- L4,L5,L6 13 turns No. 20 enamelled on Amidon T-68-2
- Q1 Motorola 2N4124
- Q2 Motorola 2N2102 (heat sink required)
- RFC1 50 μ H rf choke, Millen 34300-50
- RFC2,RFC3 25 μ H rf choke, Millen J-300-25

each case soldered firmly to two lugs on the terminal strips. Placement of resistors and capacitors on the terminal strips is not at all critical. The use of terminal strips assures ease of mounting and short direct connections.

Each trap is mounted on a 3-lug terminal strip, center lug grounded. Each double pi-network tank is mounted on a 4-lug terminal strip, one lug grounded.

table 1. Typical rms signal voltages.

	80 meters	40 meters
output of vfo	4.0	4.4
at base of Q1	3.0	3.4
output of Q1	9.2	8.0
at base of Q2	2.7	2.9
output of Q2	15.0	8.0
final output (tank)	10.0	9.0

The two tanks with their associated traps are positioned on either side of the centerline toward the rear of the chassis.

After all components have been mounted on the chassis and wiring completed, check the circuit, point to point, for possible wiring errors. Operation of the two stages can then be tested before mounting the chassis in the Minibox. Use a two-watt, 50-ohm composition resistor as a dummy load. A sensitive swr bridge and reflected-power meter connected be-

tween transmitter and dummy load is most useful for checking operation. The swr should be 1:1; there should be no reflected power indication on the meter. Meter deflection in the forward direction indicates transmitter output. Those with a vtm and an rf probe can check rf voltages at various points in the circuit. Table 1 gives typical rms rf voltage readings as measured by a Heath vtm and a Heath rf probe when using a 12-volt power supply. Different transistors of the same type will often produce somewhat different results.

On the front of the Minibox is the on-off switch for the power supply and the phono jack for the vfo line. On the rear of the box are 3 phono jacks, one for the output on each band and the third for the power-supply connection. The holes should be drilled and the switch and jacks fitted before the completed chassis is put back into the box. The switch and jacks, of course, must be removed to permit installation of the chassis.

For good results on the air be sure to use an efficient antenna system.

reference

1. C. E. Galbreath, W3QBO, "A VFO for Solid-State Transmitters," *ham radio*, August, 1970, p. 36.
2. C. E. Galbreath, W3QBO, "VFO Buffer Amplifier," *ham radio*, July, 1971, p. 66.

ham radio



the TR-144

a transverter for two meters

Introducing another vhf
transmitting converter
and power amplifier
compatible with
Drake equipment —
a companion to
the TR-50

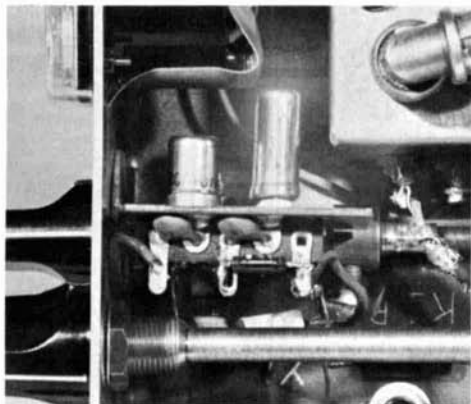
The TR-144 is a two-meter version of the TR-50 transverter described in an earlier issue of *ham radio*.¹ Like the TR-50, the TR-144 is compatible with Drake TR-3 equipment. Features include 350 watts PEP input (two-tone test signal), self-contained power supply, relay switching circuits, and a high-performance mosfet receiving converter. An Eimac 4X150 is used in the power amplifier. Full metering of critical circuits is provided. Additionally, the screen-current meter doubles as an rf-output indicator, which is desirable for initial tuning and on-the-air monitoring.

packaging

The cabinet is a TR-6 unit, purchased from Drake for \$20. The chassis is made of .047 copper-plated steel (the plating isn't necessary; merely a preference). Chassis measurements are 10½ x 13 1/8 x 2 inches. The front panel, which is secured to the chassis by the switch and panel-light hardware, is .060 aluminum, 5½ x 10½ inches.* Captive hardware is pop-riveted to match mounting holes in the TR-6 cabinet.

*Full-scale drawings of the TR-144 front panel and chassis are available from *ham radio* for \$.50 and a self-addressed stamped business envelope. *editor*

Louis E. Savoie, K1RAK, 29 Hillsdale Road, Holbrook, Massachusetts 02343



New oscillator circuit is built on a single-side PC board and mounted under the retaining hardware of the driver tune control.

It's the big brother of the six-meter mixer described in the same article, which used a 12AT7 oscillator feeding a 6360 doubler into a 6360 mixer-driver. (This circuit was changed for the TR-144, as shown later.) Initial bench tests of the mixer showed an output of 1½ watts with the voltages suggested. The mixer board requires no modification. However, some of the coils in the oscillator and buffer sections must be changed to accommodate the 28-MHz heterodyning system. Visual monitoring of the mixer output with a scope indicated a faithful reproduction of the Drake sideband generation.

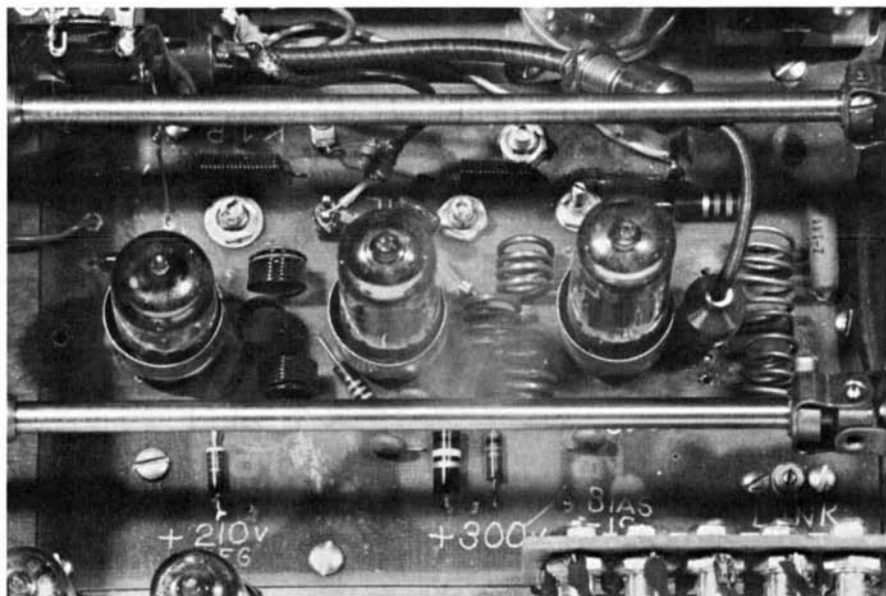
power amplifier

Based on previous experience and the success of the TR50, I decided to stay with the 4X150/4X250B power-tetrode family for the TR144 power amplifier. A push-pull circuit would yield more output power, but limited cabinet space dictated a single-ended power stage.

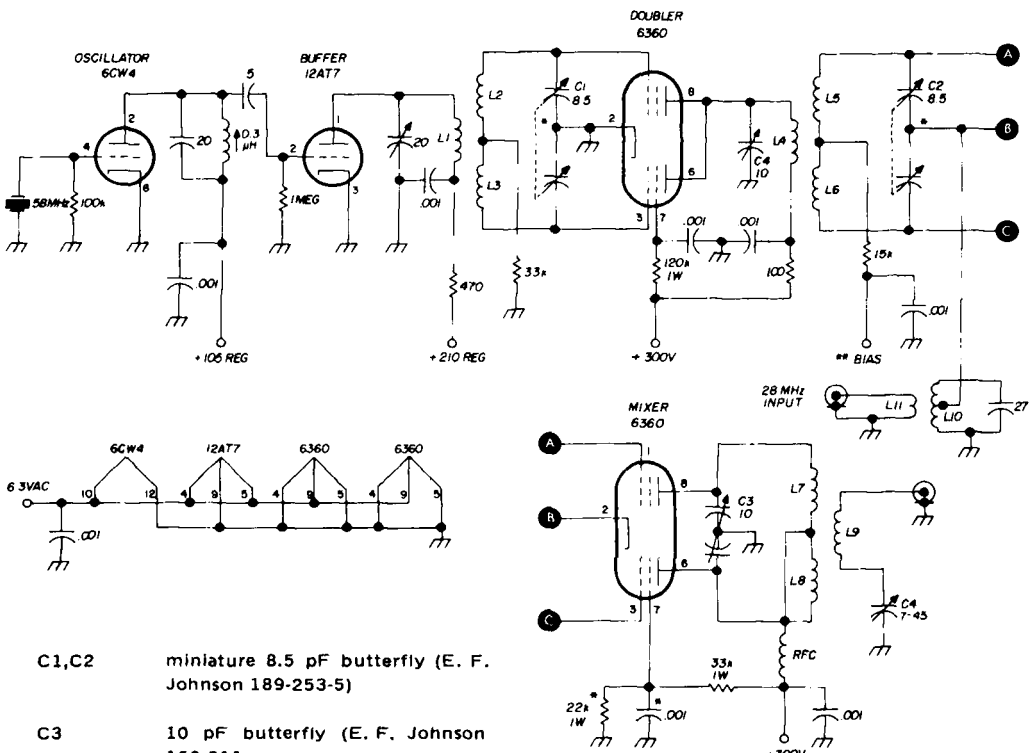
The circuit (fig. 2) is straight-forward. Conventional vhf construction practices should be used. The power-amplifier plate circuit is enclosed in a 3 x 4 x 5-inch

Much of the power and control circuitry had been designed for the TR-50 and is adaptable to the TR-144. The power transformer provides high and low B+ voltages, bias voltage, filament power, and relay-switching power. A series-phasing circuit provides the bias and relay voltages from the multiple secondary windings of the transformer.

The mixer (fig. 1) is the PC transmitting converter described previously.²



Top view of transverter. A double flex shaft arrangement connects front-panel control to mixer output-tuning capacitor.



C1,C2 miniature 8.5 pF butterfly (E. F. Johnson 189-253-5)

C3 10 pF butterfly (E. F. Johnson 160-211)

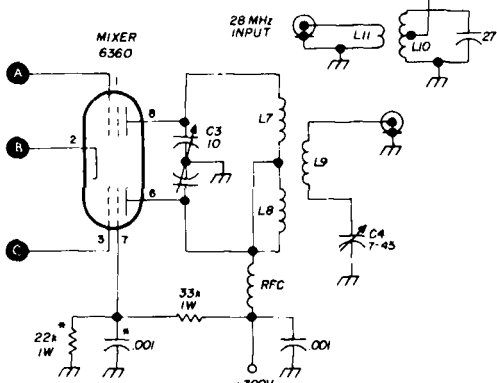
L1 7 turns no. 20 AWG Formvar, air wound, 3/8" dia., close spaced

L2,L3 9 turns no. 20 AWG Formvar, air wound, 3/8" dia., close spaced

L4,L5,L6 4 turns no. 16 AWG tinned copper wire, air wound, 3/8" dia.; turns spaced one-half wire diameter

L7,L8 4 turns no. 16 AWG tinned copper wire, air wound, 3/8" diameter; turns spaced 1 wire diameter

L9 2 turns no. 16 AWG tinned copper wire, air wound, 3/8" diameter; spaced 1 wire diameter



* LOCATED ON FOIL SIDE OF PC BOARD

** BIAS: -18V XMIT, -125V STANDBY

L10 12 turns no. 20 AWG Formvar, close wound on 1/4"-diameter slug-tuned form, tapped 4 turns from cold end

L11 2 turns no. 20 AWG on cold end of L10

L12 8 turns no. 26 Formvar on 1/4" dia. slug-tuned form

RFC Ohmite Z-144

Xtal 58 MHz third-overtone

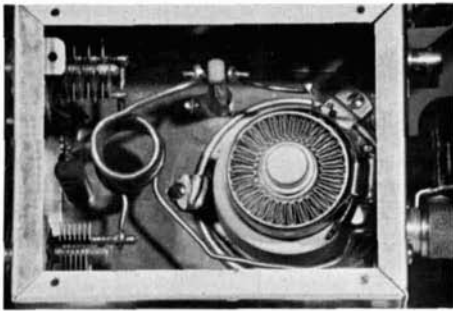
fig. 1. Modified two-meter transverter (from an original circuit by K1ISP in the April 1969 issue of ham radio).

aluminum utility box mounted on the chassis. Universal joints and 1/4-inch steel shafts connect tuning controls to the front panel.

The grid-compartment box is made of 0.47 steel and mounted on the chassis

underside flush with the rear-chassis panel. The 4X150 tube-socket hardware secures the box to the chassis underside.

The blower is a 15 cfm unit bracketed to the rear chassis wall and utility box. A



TR-144 plate-circuit compartment. Output link to antenna is mounted directly below plate coil. Plate-tuning capacitor is modified with alternate rotor and stator plates removed.

one-inch-diameter hole through chassis and grid box accepts the blower output. The mating edges of the blower outlet and chassis are sealed with a fillet of RTV

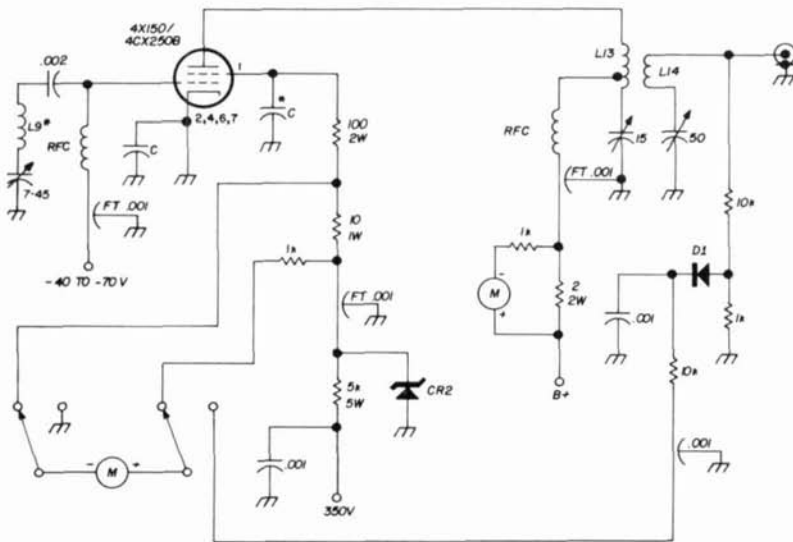
silicone. The grid-box cover has a rubber gasket to inhibit air leakage.

Power- and filament-supply connections to the 4X150 are via .001- μ F feedthrough capacitors. Rf coupling from the mixer link to the 4X150 grid is via an unbypassed ceramic feedthrough (photo). This arrangement provides excellent grid/plate circuit isolation, and the amplifier requires no neutralization. Should instability occur, conventional stub neutralization should stabilize the circuit.

power supply

Power for the TR-144 is supplied by a single transformer (fig. 3).^{*} A full-wave rectifier/filter provides 900 Vdc (key down) for the amplifier B+. Twelve Vdc for the receiving converter and relay-switching circuits are obtained from

fig. 2. Power amplifier circuit. Metering scheme features switching circuit to monitor rf output.



C* .001 μ F 600 V disc from each cathode pin to ground screen by-pass (part of Eimac SK600 socket)

L9* link on mixer board

L13 4 turns no. 10 5/8 in. dia., 1 in. long. Tap 1 turn from bottom end

L14 2 turns no. 12 5/8 in. dia. spaced 1 wire dia. Mount 1/4 inch from cold end of L13

RFC Ohmite Z144

D1 1N34

CR2 1N2990B (ten 33V 10 W zeners in series)

M Micronta 0-1 mA (Radio Shack, \$2.98)

^{*}The transformer is available from J. Reeves, WA9HKE, 2207 Columbus Ave., Anderson, Indiana 46014. Ask for P&H transformer.

switching and controls

The relay controls are identical to those in the TR-50 (fig. 4). The 10-dB pad, which must be used to reduce ssb exciter output, is switched into the system in the transmit mode.

All rf connections between the TR-3, TR-144, and 10-dB pad are via short lengths of RG-58/U cable and BNC connectors. The main control relay, K3, is a 110-Vac unit by Potter-Brumfield, type KA4314-1, which is actuated by the keying line from the TR-3. Relay K3, in turn, actuates the Dow-Key antenna changeover relay, K1, and the miniature coax relay, K2 (a surplus item). Relay K2 switches the TR-3 to the 10-dB pad on transmit. Relay timing causes no problem, and VOX action is good.

receiving converter

The receiving converter, available from Spectrum International,* is model DGTC 22 and features mosfet rf and mixer stages. It has a gain of 25 dB and is designed for 28-32 MHz output.

The converter is mounted in a 4 x 2

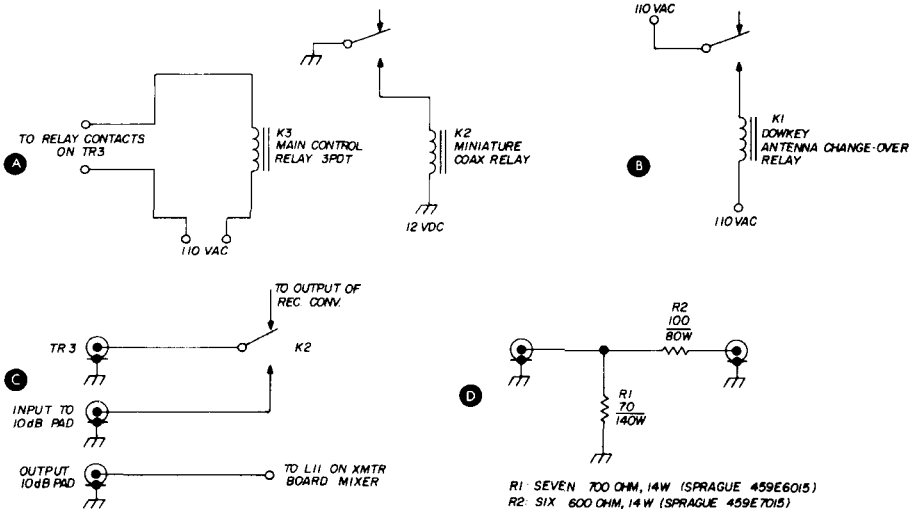
1/8 x 2¼-inch Minibox. The box cover has BNC fittings and feedthroughs for 12 Vdc and oscillator input. The feedthrough for oscillator injection is an unbypassed type.

The converter must be modified slightly for transmitter operation. The converter oscillator was disabled and the 0.5-pF coupling capacitor removed. It took some looking to find this capacitor in the converter. It turned out to be nothing more than a small loop of wire mounted next to the coil in gate 1 of the 3N140 mixer mosfet.

Remove the cover can of this coil by carefully unsoldering its tabs from the PC board. Unsolder and discard the wire loop, then resolder the shield can. Connect a 1-pF capacitor between gate 1 on the PC board and the junction of L4, C4 on the mixer board. Interconnections between boards are via RG-174/U coax. This change makes the 116-MHz oscillator common to transmit and receive

*Spectrum International, Box 87C, Topsfield, Mass. 01983.

fig. 4. Control circuits. A and B are primary control and antenna switching circuits. Circuit C switches the TR-3 exciter between receiving converter and the 10-dB pad during transmit mode. D is the attenuator necessary to reduce exciter output power.



functions. No further changes are required in the receiving converter.

A pair of 1N100 diodes connected back-to-back between receiving-antenna terminals and ground will provide front-end protection.

alignment and test

After completing the wiring shake the chassis vigorously to remove wiring debris.* Inspect all soldered connections on tube sockets, tie points, and terminals. A 5X magnifying glass is helpful here. Often an unsoldered wire will be revealed beneath top connections on tie points. A toothpick is a useful device to test the integrity of soldered connections while inspecting the work through the glass.

I follow a standard procedure after wiring circuits, which consists of cleaning all soldered connections with a 50/50 mixture of toluene and alcohol to remove solder flux and grime. Next I check all point-to-point wiring with an ohmmeter. With all tubes removed I then check voltages throughout the unit. (Voltages will be slightly on the high side with tubes removed.) These checks are worthwhile, and often a wiring error can be detected and corrected before damage occurs. A time-consuming and tedious procedure — but well worth the effort!

After completing the post-wiring checks, install the 12AT7, 6360s, and OB2s. Solder a 50-ohm noninductive 2W resistor between link output and ground. Apply power and tune the oscillator and doubler circuits for maximum output. Turn off the TR-144 and install the 4X150 in its socket.

Remove the 50-ohm resistor. Apply power and, after sufficient warmup, key the exciter. With no drive applied, adjust the bias pot for 50 mA of resting plate current on the 4X150. Apply drive and tune L10, C3 and C4 for maximum screen-current indication, then tune plate and load controls for maximum rf output. Plate current should be 200 mA. Power input with the transformer I used was 180 watts dc — power output was 108 watts as measured with a Bird Thru-

line wattmeter into a Heath dummy load.

mixer output control

The TR3 tunes from 28 to 29.7 MHz. Tuning the TR144 from the low to the high end indicated a significant reduction in output power. This reduction was traced to the output circuit of the 6360 mixer. The 6360 mixer output circuit is not sufficiently broad to accommodate a 1.7-MHz bandwidth. To obtain maximum output over the entire range, I added a front-panel tuning control for C3 in the mixer output. A Rube Goldberg lashup of two flexible shafts from a panel bearing mount is shown in the photo. A machinist friend is making a miniature right-angle drive so the installation can be improved esthetically. This control allows the mixer output to be peaked over the full tuning range of the exciter.

oscillator pulling

The unit was tested on the air for about a week. A shift in frequency between transmit and receive modes was noted. Circuit analysis suggested only one possibility — the 12AT7 oscillator was pulling. Coupling between oscillator and doubler had to be reduced.

Several changes in coil positions were tried without success. An outboard oscillator using a 6CW4 was constructed, and the 12AT7 was changed to a buffer amplifier. The 6CW4 oscillator voltage is 105 Vdc regulated. Oscillator output is coupled to the 12AT7 with a 5-pF capacitor. The grid resistor in the 12AT7 was changed to 1 megohm.

The oscillator was built on a piece of scrap PC board and mounted by the retaining hardware of the driver tune-control panel bearing. When air tested again, no frequency shift was observed between transmit and receive modes. Sufficient room is available on one corner of the mixer board to mount the 6CW4 tube socket, coil, and other components. The board was bench tested and worked perfectly.

*A small bicycle air-pump is also helpful when cleaning a chassis. *editor.*

painting

Sanding with light horizontal strokes, using fine-grade emery cloth, yields a brushed aluminum finish on the panel. The shiny center strip was made by using a ¼-inch masking tape mask. The upper panel half is dove gray; the lower half equipment gray (both are Krylon colors).

Each panel half was painted with *light* coats of paint and baked for 30 minutes. Front panel lettering consists of press-on transfers—black on the light-gray and white on the dark-gray panel halves. Three coats of clear acrylic lacquer spray, baked for 30 minutes, protect the lettering.

conclusion

The TR144 completes my original project to design and build six- and two-meter transverters to match Drake TR-3 equipment. Switching the TR-3 rf connector through a Waters coax switch allows for easy selection of either six- or two-meter output.

An auxiliary rocker switch was installed on the panel to switch the TR-3 keying line to either transverter. The TR-144 faithfully transverts the TR-3 sideband quality, and on-the-air reports have been excellent.

It's quite satisfying to look over one's operating position, see identical cabinets, and be able to say, "I built it!" This is the prime source of my enjoyment in ham radio.

Once again I must express my thanks for the photographic talent and equipment of Dick McGinn, WA1IMS. I'll be happy to answer any inquiries about the construction of this unit upon receipt of a stamped, self-addressed envelope.

references

1. Louis E. Savoie, K1RAK, "TR-50 Customized Six-Meter Transverter," *ham radio*, March, 1971, p. 12.
2. D. W. Bramer, K2ISP, "Heterodyne Transmitting Mixers for Six and Two Meters," *ham radio*, April, 1969, p. 8.

ham radio

2 Rigs in one!

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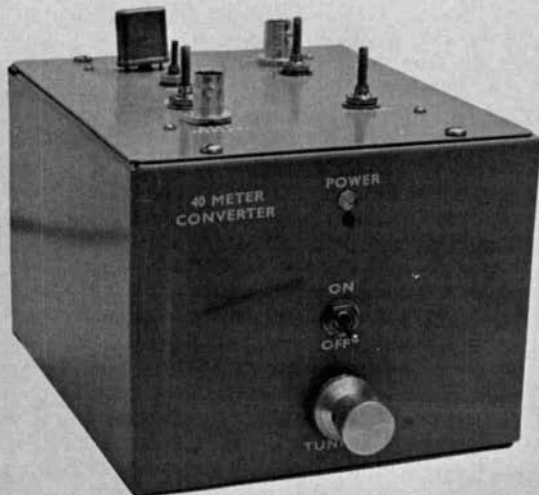
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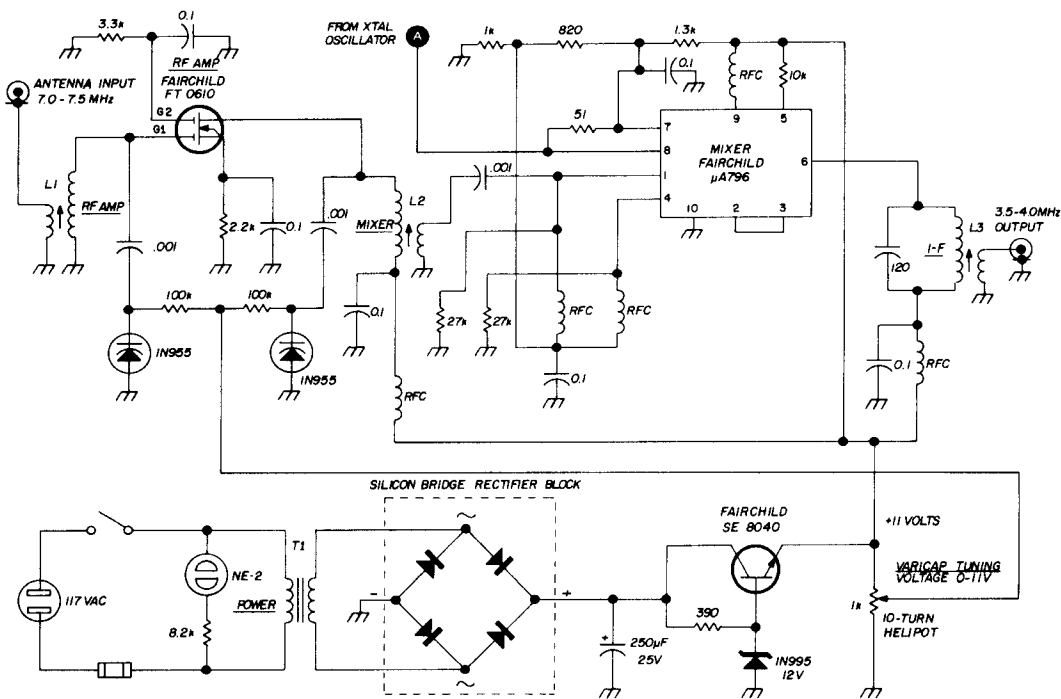
third-generation solid-state high-frequency converter

This converter
combines ICs
with transistors
to provide optimum
monoband performance

Mike Goldstein, VE3GFN

Anyone who spends a lazy afternoon thumbing through the past few years' ham publications is bound to notice the rapid advances in solid-state technology. This is true not only of commercial equipment but of the homegrown variety as well. For example, a few years ago the "in thing" was a receiver with a bipolar transistor frontend; even with the low-impedance problems and poor cross-modulation characteristics they presented. Today, to the knowing builder, they are passé; design has already run the gamut from jfet frontends through unprotected and then protected mosfet designs, and new ground is being broken using integrated circuits. How's a guy supposed to keep up to date when things move so fast?

A few years ago, I built a fet converter which seemed to work pretty well.¹ Shortly afterward, they introduced the dual-gate mosfet, which put my converter back into the Dark Ages. I went back to



40-meter circuit values

- L1,L2 35 turns no. 29 closewound on Cambion 1534/2/1 form. L is 12 μH, Q is 50. The link is 6 turns of no. 27 wire on the cold end of L1.
- L3 50 turns no. 29 wire closewound on Cambion 1534/2/1 form. L is 17 μH and Q is 40. The link is 6 turns of no. 27 wire on the cold end.
- L4 75 turns no. 37 closewound on Cambion 1536/2/1 form. L is 30 μH and Q is 70.
- RFC 1 mH at 35 mA.
- T1 Hammond 166D20, primary: 120 V, secondary: 20 V centertapped at 0.1 A. Note: only one half of secondary is used.
- Y1 3.5 MHz.

For 20-meter operation, parts values are:

- L1,L2 15 turns no. 27 closewound on Cambion 1534/2/1 form. L is 2.5 μH and Q is 100. The link is 4 turns of no. 27 wire on the cold end.
- L3 50 turns no. 29 closewound on Cambion 1534/2/1 form. L is 17 μH and Q is 40. L3 is shunted with a 5.6 k resistor. The link is 3 turns no. 27 wire on the cold end.
- L4 20 turns no. 27 closewound on Cambion 1534/2/1 form. L4 has 50 pF connected across it instead of the 82 pF used in the 40-meter converter.
- Y1 10.5 MHz.

fig. 1. Schematic diagram of the third-generation mobile converter for 40 meters. For 20-meter operation, parallel the primary of L3 with a 5.6k resistor and change the tuned circuits to appropriate values.

the drawing board and came up with a second generation converter.² Then Motorola came up with an IC double-balanced modulator (the MC1596G)

which turned out to be a superb mixer, and I was done in again!³

This third-generation converter, unlike previous efforts, is a single-band converter

designed to deliver optimum performance on 40 meters for net operation during the poor summer conditions. Low noise, high gain and good dynamic range were all important design requirements, as well as the usual high-stability and image-rejection performance necessary for smooth operation. The circuit can be used to cover any band right up to ten meters merely by substituting the proper tuned circuits and crystals; a version of the same circuit has been used at 100 MHz with no noticeable instability. Making such a converter bandswitching would be quite easy.

circuit

Varactor diode tuning is used in the rf amplifier which uses a Fairchild FT0601 dual-gate protected mosfet. The RCA 40673 could be used as a direct substitute. The tuning is very smooth, with no instability of any sort, even though the amplifier is not neutralized. It is possible to peak the converter on a signal anywhere in the band, but the tuned circuits are broad enough that constant retuning with frequency change is unnecessary. This is a refreshing change from previous

efforts in which all circuits were deliberately resistance-loaded to broadband them, which compromised the stage gain and increased the chance of images appearing.

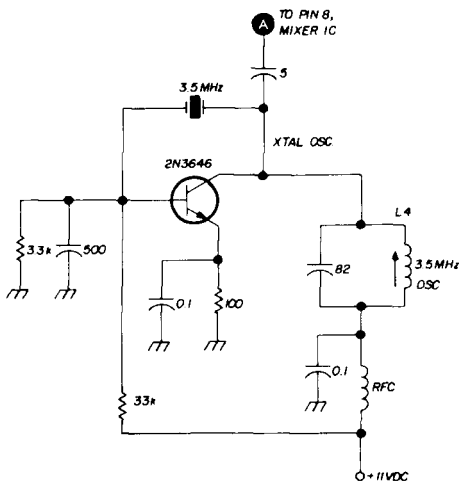
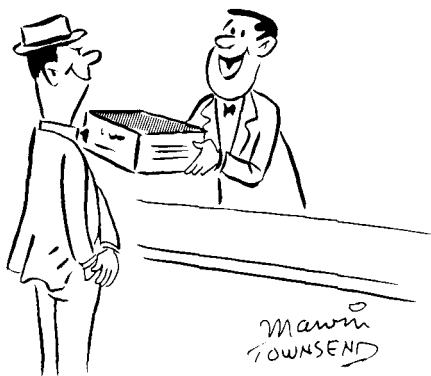


fig. 2. Schematic of the local oscillator for the hf converter. For 20-meter operation change the 5 pF oscillator-output coupling capacitor to 2 pF and change the crystal to 10.5 MHz along with re-resonating the tuned circuit.

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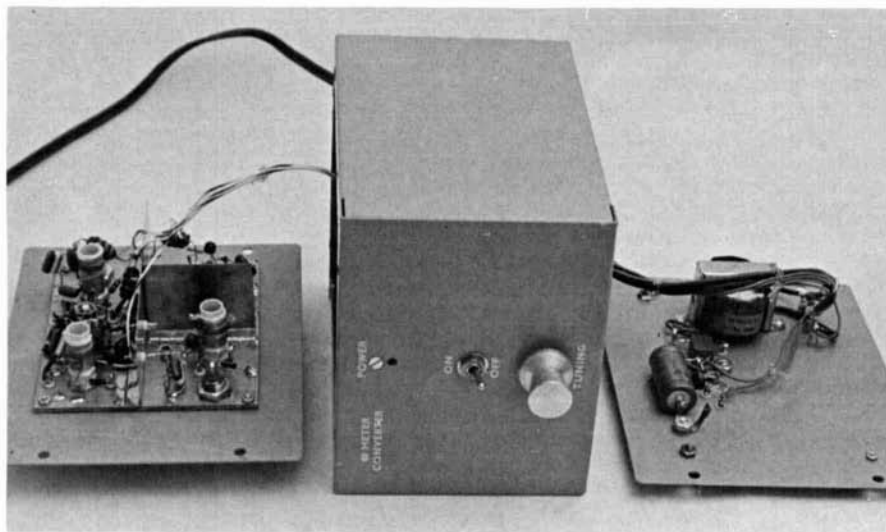
A double-balanced modulator was used for the mixer. The Fairchild μ a796, or the Motorola MC1596G or 1496G may all be used in the same circuit. These IC devices make excellent mixers, with *only* the sum and difference of the two input frequencies appearing at the output. A lot of the spurious rejection takes place in the mixer which seems to actually refuse to process anything other than the correct input coming from the rf amplifier. The chance of any spurious crossproducts appearing in the output is very low. In fact, the output waveform is such a clean sinusoid (at 3.5 to 4.0 MHz) that it can be used to drive a digital frequency counter — an instrument easily confused by input waveforms containing more than one frequency.

The oscillator is an old reliable circuit, and almost any npn high-frequency transistor can be used. I used the 2N3646 for this unit, but the 2N706, 2N4124 or

HEP50 would work as well, and the circuit should work right up to ten meters even with overtone crystals.

You can use any low-power npn transistor in the series-pass regulator in the

None were available at the time of building. The type of construction used added to circuit stability, allowing very short leads and solid ground connections. Nothing less than a good hot soldering iron



Overall view of the 40-meter converter board, cabinet, power supply and connecting wiring.

power supply. The design is simple, and you can use any bridge block rectifier or discrete diodes. The converter draws only 7.8 mA from a 12-volt supply, so the unit could be powered by a 9-volt transistor-radio battery for quite a while without battery deterioration. If battery operation is likely, use a 100k tuning potentiometer.

construction

The converter is built directly on a piece of glass-epoxy printed-circuit board using press-fit terminals where needed and with shields and ground connections directly soldered to the copper. This type of construction is excellent for rf work, eliminating the usual mess of nuts, screws and lugs needed for grounding to an aluminum chassis, and the time and materials needed for printed circuitry. An alternative would be to use the new *Circuit-Stik* instant printed-circuit decals.

should be used to make all ground connections, as a cold joint anywhere could be fatal to circuit stability.

All semiconductors are soldered directly into the circuit, using a heat sink when soldering each lead. Keeping leads short and eliminating the possibility of lead-to-socket capacitance assures stability without neutralizing — even on ten meters.

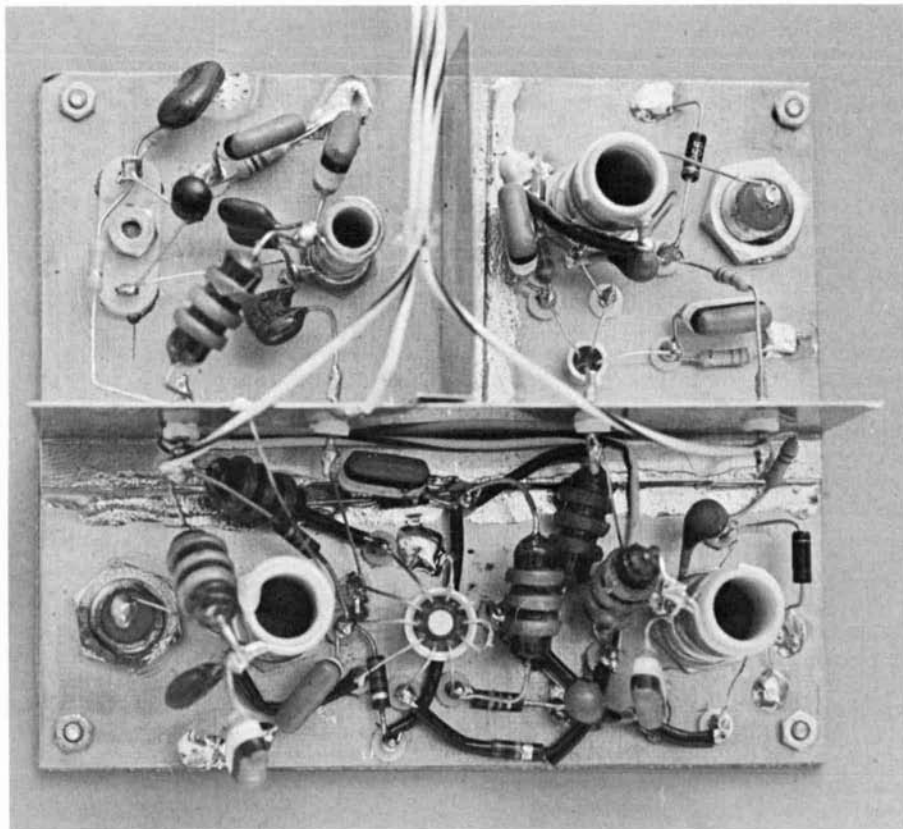
The general layout of the circuit board can be easily seen in the photograph. The layout minimizes stray capacitance and isolates inputs from outputs; it should be followed quite closely.

To make sure the holes in the circuit board line up with the utility-box cover upon which the board is mounted, the board was mounted on the cover and all centering holes for coils and connectors were drilled through both; the circuit board was then removed from the cover while the circuitry was installed. In this way the holes for the terminals are

concealed when the final assembly is completed.

When construction is completed, set the varicap tuning voltage at the potentiometer wiper at 7 volts, tune in a signal at 7.15 MHz, and adjust the rf amplifier,

verter has too much gain for the receiver used, insert a resistance (1000 ohms or more) between pins 2 and 3 of the mixer IC. Note that the 3.5-MHz crystal oscillator will be heard when the receiver is tuned to 7 MHz.



The 40 meter converter circuit board. Upper right section: rf amplifier. The Varicap can be easily seen just to the right of the antenna coil. The FT0601 is in the lower left area of the section, upside down, with the drain connected directly to the feedthrough terminal. Upper left section: oscillator. Lower section: mixer. The IC is turned upside down and mounted directly by its terminals. Pins 2 and 3 are clipped short and soldered directly together. Note how all ground connections are soldered directly to the copper board.

mixer, and i-f coils for maximum signal. You're in business.

The converter input and output impedance, with the coils constructed as shown, is 50 ohms. When driven and terminated in this impedance the system gain is about 30 dB, so keep the receiver gain low to avoid overload. If the con-

references

1. Mike Goldstein, VE3GFN, "Bandswitching FET Converter," *ham radio*, July, 1968.
2. Mike Goldstein, VE3GFN, "Second Generation FET Converter," *ham radio*, January, 1970.
3. Roy Hejhall, K7QWR, "An Integrated-Circuit Balanced Modulator," *ham radio*, September, 1970.

ham radio

SBE

feature
after
feature
after
feature

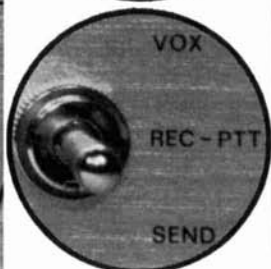
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in ssb rigs

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Single-sideband transmitters are usually rated in terms of peak envelope power (PEP). According to one authority,¹ the average output power of an ssb transmitter is one-half the peak envelope power if no distortion is present. This statement is made on the basis that measurements are taken when the ssb transmitter is modulated with a standard test signal of two equal-amplitude signals.

It can be shown that the ordinary voice contains high-amplitude peaks that are about 14 dB greater than the average level.² Furthermore, it is well known that ssb transmitters are peak-power limited. This means that an ssb linear amplifier may be able to handle 1000 watts average power but will begin to flat top when peak power approaches 2 kW.

From the considerations above, it may be inferred that many amateur ssb transmitters are not being used to their full capability. If the peak-to-average ratio of the ssb transmitter output power can be reduced, then the talk power, or articulation index, can be increased. Speech processing circuits have been introduced to reduce the ratio of peak-to-average power; however if the processing scheme

introduces distortion, then the articulation index is reduced. The best method of speech processing, for ssb transmitters, is one that provides maximum increase in talk power without distortion and subsequent flat topping.

Let's look at two popular methods of speech processing in amateur ssb equipment: the speech compressor and speech clipper.

compressor

The speech compressor, which is used in the audio circuits of the ssb transmitter, has a typical attack/release time constant of 5×10^{-3} and 5×10^{-1} second. As the ratio of these time constants is made shorter, the compressor action approaches that of a clipper. However, audio compressors do not affect the peak-to-average power ratio of the ssb transmitter; therefore we'll not discuss them further.

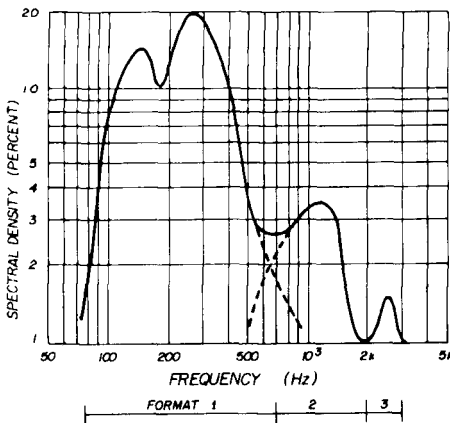


fig. 1. Profile of speech spectral density.

clipper

A speech clipper affects the ratio of peak-to-average power in an ssb transmitter, which is of interest here. First,

let's see what is clipped. Speech spectral density is distributed according to fig. 1. This curve isn't quite accurate, because speech characteristics vary with differences in languages and with male and

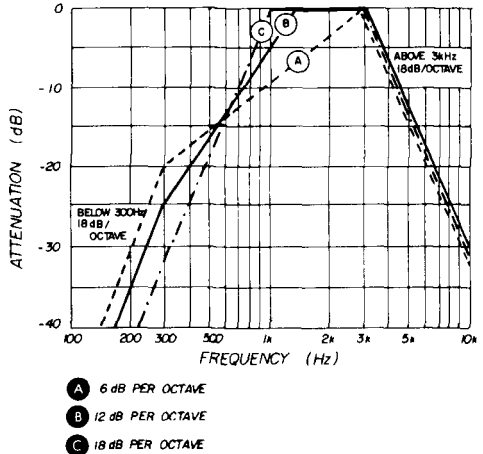


fig. 2. Results of different pre-emphasis networks analyzed in reference 3. Optimum performance was obtained with curve B.

female voices; however it is sufficiently accurate for our purposes.

Note that spectral density is distributed into three formants. The first formant is dominant and lowest in frequency. This formant includes most of the sounds in personal voice characteristics. Such voice power has little to do with readability in an ssb radio circuit; it merely adds fidelity to the transmission. Audio-frequency compressors emphasize this speech-energy formant, which is why they don't do much good in ssb communications systems. When clipped, the energy envelope in formant 1 creates strong harmonics, which create harmonic distortion.

Formant 2 contains most of the communications intelligence, but it is of much lower power level. Reference 3

examines different types of pre-emphasis circuits and gives optimum slopes of audio-response curves. From fig. 2 it is seen that the lower in frequency at which

tioning by a low-pass filter, noise was added until the signal-to-noise ratio was unity. The criterion for evaluating test results was the percentage of words

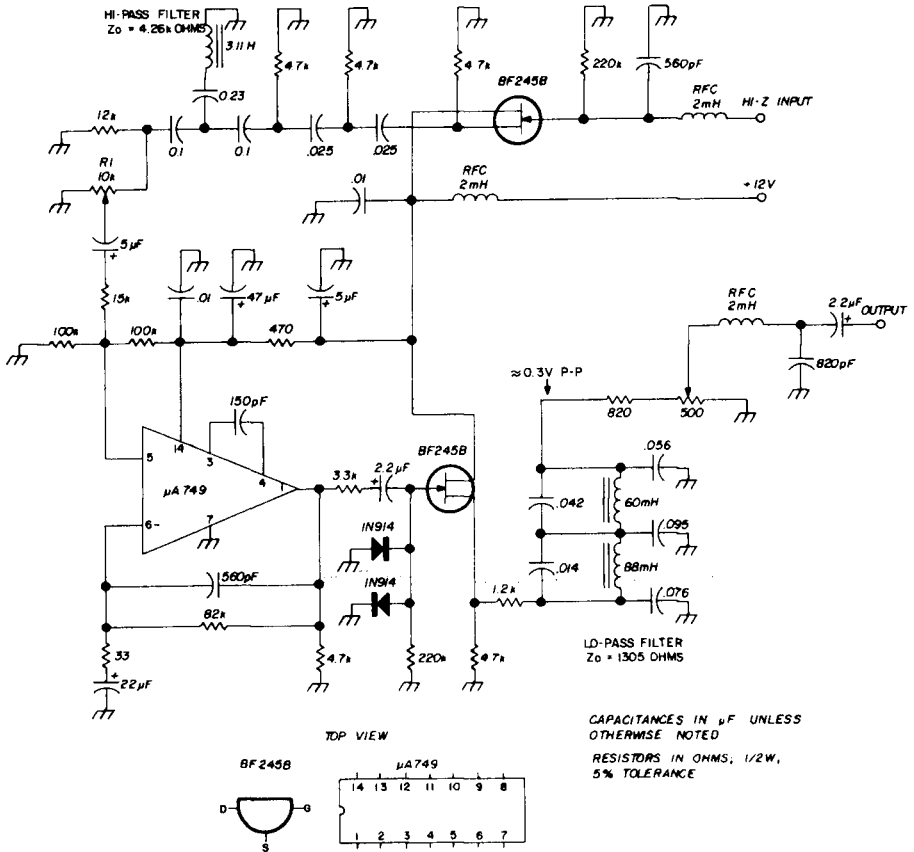


fig. 3. Pre-emphasis circuit used by the author. High- and low-pass filters are those shown in reference 4. Diodes should be matched for symmetrical clipping action. Inductors in the low-pass filter are toroids, available from many surplus sources. Capacitor values are important for proper operation; correct capacitances may be obtained by combining standard units. Pot R1 adjusts clipping level.

the knee of the response curve occurs, the steeper will be the slope. Best results have been obtained with curve B of fig. 2, where the kneepoint is at 1.1 kHz. The slope of this curve is 12-dB/octave.

test results

Tests were made as follows. Pre-emphasis was first applied to the signal, then the signal was clipped with a Schmitt trigger. After clipping and condi-

understood in the transmission. Test results were:

1. Linear nonclipped speech – 10 percent.
2. Linear response with "infinite" clipping – 60 percent.
3. Pre-emphasis and clipping – 90 percent.

The most interesting observation was

that no equalizer was needed after the processor (e. g., in the receiver).

The benefits of pre-emphasis circuits are most noticeable in af clipping. Pre-emphasis circuits reduce the harmonic content in the microphone channel, whereas rf clippers must use elaborate filters to accomplish the same objective at radio frequencies.

pre-emphasis circuit

The schematic is shown in fig. 3. The input circuit uses a source follower for high-impedance microphones. If you have a low-impedance microphone, this stage may be omitted. Two RC networks in the input circuit shape the slope for a response of 12 dB/octave below 1.4 kHz (see fig. 4).

A high-pass filter⁴ attenuates frequencies below 300 Hz. A low-noise, high-gain amplifier (Fairchild μ A749) increases the microphone signal for the clipping diodes, a pair of 1N914s. The degree of clipping can be controlled with a pot at the amplifier input (R1, fig. 3).

The diodes must be matched pairs to obtain symmetrical clipping action.

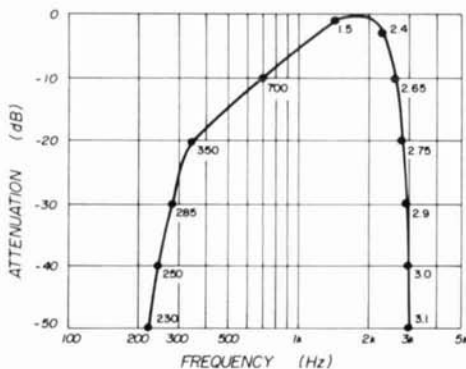


fig. 4. Speech-processor response without clipping. An optimum slope of 12 dB/octave below 1.4 kHz is obtained with two RC networks in the input circuit.

A source follower is used after the clipper to obtain the proper impedance for a low-pass filter. This filter, also shown in reference 4, reduces frequency

response above 2.4 kHz and attenuates harmonics. The processor output is sufficient for most solid-state balanced modulators.

conclusion

I have used this processor in a solid-state 10-watt mobile transceiver with



The speech processing unit described in this article is included in the 10 watt transceiver shown in this photograph of the author, OH2CD.

encouraging results. Approximately 20 dB of clipping resulted in 6-9 dB output improvement in speech intelligibility.

Thanks are due OH10Y, who inspired me to build this unit while a larger unit, using rf clipping, was being developed. But that's another story, as Kipling used to say.

references

1. Keith Henney, *Radio Engineering Handbook*, Fifth Edition, McGraw-Hill, N. Y., p. 18-64.
2. Bill Sabin, W0IYH, "RF Clippers for SSB," *QST*, July, 1967, p. 13.
3. Thomas and Niederjohn, "The Intelligibility of Filtered-Clipped Speech in Noise," *Journal of the Audio Engineering Society*, Vol. 18, No. 3, 1970.
4. Ed Wetherhold, W3NQN, "An Amateur Application of Modern Filter Design," *QST*, July, 1966, p. 14.

ham radio

modular receiver

for
two-meter fm

Modular construction
with inexpensive
kits produces an
easy-to-build
two-meter fm
receiver or converter

Over the past few years vhf fm has moved from the private domain of a few hardy experimenters to an increasingly popular mode of communications. One drawback still exists for amateurs who wish to get on fm: good equipment is either expensive, or as in the case of surplus gear, takes modifications which are enough to discourage the average appliance operator from digging in and learning what radio is all about. Because of these factors — expensive equipment on one hand and apparent complexity on the other — I set out to find a reception method that would give the average amateur a chance to hear what fm is really like before making the commitment in time and money that current equipment demands.

receiver design

Keeping in mind that the receiver must be simple enough for an appliance operator to build and inexpensive enough so that even an out-of-work college student (like myself) could afford it, modular construction was chosen as the simplest and cheapest system on which to base a workable receiver. The heart of this receiver (or hearts, I should say) are transistor module kits from International Crystal which tremendously simplify construction and subsequent modifications of the unit. The design uses an fm broadcast receiver for i-f, detector and audio output stages; leaving only the

Harvey L. Wagner, WA2GBF, 83-19 141 Street, Jamaica, New York 11435

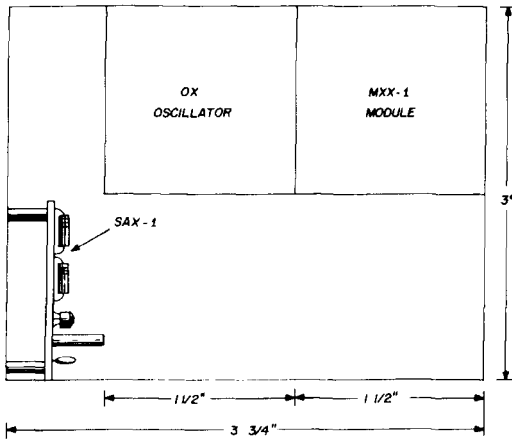


fig. 2. Converter is built into an ordinary minibox.

front end, mixer and local oscillator stages for the builder. If you wish, this system can be built as a converter to be connected to an existing broadcast receiver or it can be built as a complete receiver utilizing the circuit board from the now ubiquitous Japanese a-m/f-m radio.

Fig. 1 shows the block diagram of the basic modular receiver. The SAX-1 module which is used as the front end, is a small-signal amplifier with a sensitivity of 1 microvolt and about 10 dB gain at two meters. The MXX-1 module, designed specifically as a mixer, has a conversion gain of about 6 dB and a sensitivity of one microvolt. The local oscillator in this circuit is the OX oscillator module with a type EX crystal.

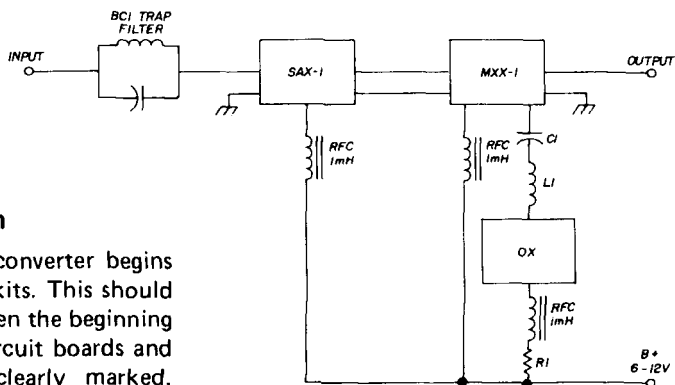
When wiring the circuit boards, the builder will have to select the proper coil and capacitor combination for the tuned circuits from several supplied. When making this selection, bear in mind the input and output frequencies of the converter and the crystal frequency needed to produce this conversion.

Assembly of the converter section is simple and straightforward. The circuit is housed in a 2 x 3 x 3 3/4 inch minibox, and suggested placement of the modules within the box is illustrated in fig. 2. The SAX-1 module is mounted vertically at one end of the box next to the input jack. The OX and MXX-1 modules are mounted horizontally with the MXX-1 closest to the output jack.

Connections carrying rf between modules should be made with small shielded cable such as RG 174/U, and all power leads should be choked to prevent the circuit from oscillating. The value of resistor R1 in the B+ lead to the OX module is determined by the voltage used to power the converter and can be found in table 1.

The selection of a crystal frequency for the converter will depend on the output frequency used. For the 88- to 108-MHz band, the frequency of the crystal may be found by using the formula $f_{\text{crystal}} = f_{\text{in}} - f_{\text{out}}$. For output frequencies below 88 MHz the crystal frequency is found by using the formula $f_{\text{crystal}} = (f_{\text{in}} - f_{\text{out}})/2$. If outputs below 88 MHz are used, it will be necessary to use the series tuned circuit L1 - C1

fig. 1. Block diagram of the complete converter.



converter construction

Construction of the converter begins with wiring the module kits. This should present no problem to even the beginning builder as they are all circuit boards and have parts placement clearly marked.

table 1. Supply voltage vs R1.

voltage	R1 (ohms)
6	0
9	150
12	300

which is tuned to the local-oscillator injection frequency, which is the second harmonic of the crystal frequency. The values of L1 and C1 will depend on the injection frequency, and can be determined by the use of a nomograph such as the one which appears in all recent issues of the *ARRL Handbook*. For injection of the fundamental crystal frequency, L1 and C1 may be omitted, using shielded cable between the OX and MXX-1 modules.

In some areas, it may be necessary to install a parallel-tuned trap filter at the antenna input of the converter to eliminate feedthrough of local fm broadcast stations. The filter should be tuned to the frequency of the offending station.

Before power is applied, all tuned circuits should be adjusted to their proper frequencies with a grid-dip meter. Although this procedure is not absolutely necessary, it is a good idea as it makes alignment much simpler, and if an error has been made in component values in a tuned circuit, this procedure will allow you to detect and correct it before things reach the hair-pulling stage. If you do not own a grid-dip meter it may be a good idea to buy or build one as it is one of the most useful pieces of test equipment you can have around the shack.

If the converter is to be used as part of a receiver rather than as an outboard converter it is worth pointing out that most, if not all, of the imported transistor radios use a positive ground system; this converter uses a negative ground. If the receiver board has a positive ground, care should be taken to isolate the board from the chassis ground used for the converter. It may be simpler to power the receiver board with a separate battery and to leave it in its plastic case.

operation

When power is applied to the converter there will be a slight increase in receiver background noise. If there is an extremely high noise level and all manner of whistles, blurps and birdies appear, or if the converter draws more than about 35 mA, the circuit is probably oscillating. If oscillation occurs and the power leads have all been choked, it will be necessary to shield the MXX-1 module with grounded partitions made of flashing copper or copper-clad circuit board.

When the converter is operating properly it is aligned as follows:

1. Using a signal generator, grid-dip oscillator or received signal, peak the coils on the SAX-1 and MXX-1 modules for maximum audio output at the receiver.
2. If a tuned circuit is used between the OX and MXX-1 modules adjust it for maximum audio output at the receiver.
3. If you used a trap filter tune it for maximum attenuation of the interfering signal.
4. All of these adjustments are slightly interlocking, and it may be necessary to repeat this procedure several times until maximum performance is obtained from the converter.

The prototype receiver, which consisted of the converter feeding a hastily repaired GE portable receiver, performed better than expected. Although the receiver has a wide i-f and uses a wideband detector, the only difficulty encountered in copying narrow-band signals was that of adjacent-channel interference from strong signals during crowded-band conditions.

This design is an adequate receiver for monitoring the local repeater. For higher performance several modifications can be made to the original design. The addition of an fet preamp will provide more sensitivity and greater overall gain. It may also be desirable to include a second SAX-1 module between the MXX-1

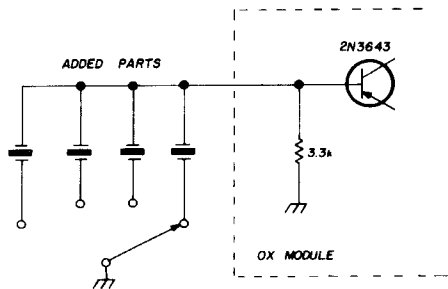


fig. 3. Fixed-frequency modification.

module and the receiver if the converter does not provide sufficient gain.

You could add a noise-operated squelch and an improved tuning mechanism. Although the receiver can be tuned with its main tuning capacitor, the designed bandwidth of 20 MHz does not lend itself to tuning easily between channels spaced 60 kHz apart. You can add a small variable capacitor in parallel with the main tuning capacitor to provide a slower tuning rate over a limited range of frequencies. Another method which may be used is shown in fig. 3. This method uses switch selected crystals to determine frequency and guarantees that the receiver will always be right on frequency and will allow the receiver to find and monitor an inactive channel. Although I did not try either of the above methods, there is no reason why they should not work as long as you use good construction techniques and keep lead lengths short.

Transistor modules provide an easy way to get on fm. The flexibility provided by this method of construction encourages experimentation and optimization of designs. The receiver design presented in this article is only one of many possible ways for the amateur to get decent performance at two meters for reasonable cost. It is hoped that the design presented here will not be considered a cut and dried cookbook recipe, but rather a starting point for experimentation with various receiving techniques.

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a simple crystal checker

An old circuit
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makes a handy
one-evening project
for testing
surplus crystals

Hank Olson, W6GXXN, Box 339 Menlo Park, California 94025

Often I have wanted to check a crystal for activity and frequency before using it in an electronic project. Many surplus crystals have two or three numbers on them, any one of which could be the crystal frequency; and it is sometimes unknown *which* mark to believe. By plugging the unknown crystal into the checker described here, it will oscillate at its first mode, allowing me to tune it in on a nearby *hf* receiver. Also, a high impedance voltmeter connected to the test point of the checker gives a dc indication of oscillation.

The circuit of the crystal checker is presented in **fig. 1**. It is the old familiar Pierce Oscillator, with an insulated-gate fet substituted for the original vacuum tube. Unlike a vacuum tube, however, an insulated-gate fet cannot draw dc grid current, and so D1 has to be added if we intend for the grid-leak bias system to work. (Perhaps "gate-leak" bias system is more correct in this case.) The diode should be fast enough to rectify up to 20 MHz, I suggest three devices in order of

their preference. The Hewlett-Packard HP 5082-2800 and the Motorola MBD 501 are both Schottky Barrier (or hot carrier) types, and the Fairchild FD 700 is an extremely fast silicon switching diode.

The MFE 3004 insulated-gate fet is best *soldered* into the circuit so that it cannot be destroyed by static voltages between the gate and either source or drain. The MFE 3004 comes with a small metal sleeve that shorts all four of its leads together. Before removing this sleeve, the circuit should be finished and ready to receive the fet. Then wrap several turns of fine tinned wire (one strand pulled from a short piece of stranded hookup wire) around the MFE 3004 leads, so as to short them all together. Remove the metal sleeve and solder the fet into the circuit, leaving the shorting wire in place until finished soldering.

The Pierce circuit is fundamentally a form of the Colpitts oscillator, where the crystal looks inductive, and parasitic capacitances of the fet form the capacitive tap. This is shown in fig. 2; note that

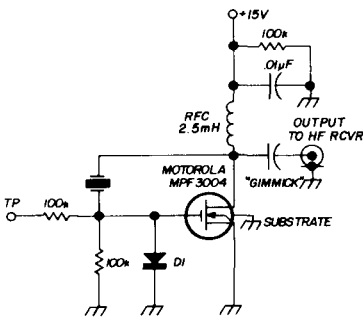


fig. 1. Schematic of the crystal checker. D1 is explained in the text. The checker is made for fundamental mode operation only.

C_{gd} is in parallel with the crystal, and the net reactance of the crystal and C_{gd} is inductive.

The crystal checker will only work with fundamental mode crystals in the 1- to 20-MHz range. Below 2 MHz, the impedance of the rf choke becomes too

low to allow the drain to appear to be floating. AT-cut crystals are not generally made for the fundamental mode above about 20 MHz. Many surplus crystals in

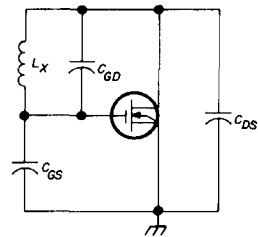


fig. 2. Equivalent circuit of a Pierce crystal oscillator, showing that it is, in fact, a form of Colpitts oscillator.

the 20-MHz range (particularly CR9/U and CR24/U) are third-overtone types. If such a crystal is used with the checker (with appropriate pinning adapter) it *will not* oscillate as marked, but at approximately one-third that frequency. For instance, a CR9/U crystal marked 19.825 MHz oscillated at 6.615 MHz.

As shown, the crystal checker was built to accommodate either the FT 243 or HC6/U styles of crystals, because these are by far the most common. Other crystal sockets could, of course, be added. The checker is constructed in an LMB-00 box chassis with the battery terminals out one side. Since I only use the unit occasionally, no power switch was included; I simply connect the 15 volts for use. A Burgess U10 or Eveready 411 battery is adequate as a 15 volt source.

With the 15-volt battery connected, the fet will draw I_{dss} , which is rated 2 to 10 mA for the MFE 3004. A high-impedance voltmeter (such as a vtm) measuring the voltage between ground and test point should read about zero before a crystal is plugged in. When the crystal is plugged in, the voltage at the test point should jump to some negative voltage (-10 volts for a good, active crystal) indicating oscillation.

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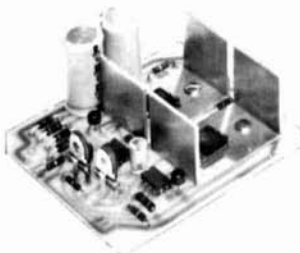
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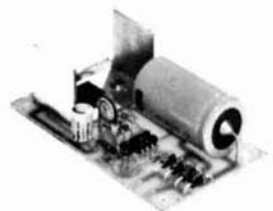
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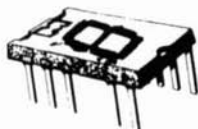
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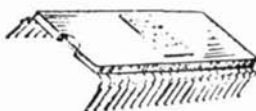
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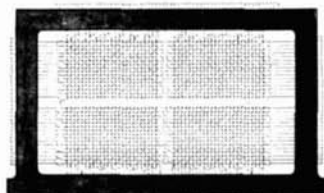
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calculating the inductance of toroids

Two handy formulas
and a table
give quick
approximations
of the inductance
of homemade toroids

Toroid inductors, with their high Q, small size and self-shielding properties, are excellent for use in modern solid-state gear — especially where space is a valuable commodity. In the past, however, there has been one drawback: It was very difficult to calculate how many turns it would take to give you a desired inductance. In a back issue of *QST*, there were instructions for doing this, provided you

owned an *ARRL Lightning Calculator Type A*, or a *Coil Winding and L/C/F Calculator Type A*.¹ I did not have one of those devices, so, rather than waiting until I could get one, I sought a formula which could be used without any special apparatus.

I found the equation:

$$N = K\sqrt{L} \quad (1)$$

Where N is the number of turns, L is the desired inductance in microhenries and K is a constant dependent on the toroid being used. **Table 1** lists this constant for a number of Amidon cores in common use. In this table, K is printed to eight decimal places. It is not necessary to use all of these places, and your results will be close even if you truncate the last 6 or 7 digits. For example, suppose you need a 10- μ H coil and have a T-68-2 core. Substituting the known values into the equation, you obtain

$$N = 13.71\sqrt{10} = 13.71(3.162) = 43.35102$$

Since there is no such thing as a fraction of a turn on a toroid, you should round the answer off and use 43 turns.

If you desire to use a core other than one of those in **table 1**, you can calculate K for yourself. The formula is

$$K = \frac{N1}{\sqrt{L1}} \quad (2)$$

Where N1 is the number of turns on the particular form you are using which gives the inductance L1. To illustrate, suppose

Michael J. Gordon Jr., WB9FHC, 203 Woodbine Avenue, Wilmette, Illinois 60091

table 2. Maximum number of turns of various gauge wires on standard Amidon toroid cores.

T-94	T-80	T-68	T-50	T-37	T-25	T-12	T-05	wire size
15	14	10	8	5	3	—	—	10
20	18	13	10	7	3	—	—	12
25	22	16	13	9	4	—	—	14
32	28	20	17	11	6	—	—	16
41	36	26	21	14	8	3	—	18
51	45	33	26	18	10	4	—	20
64	57	42	33	23	13	6	—	22
80	72	53	42	29	16	8	3	24
101	90	66	53	37	20	10	4	26
127	113	83	67	47	26	13	5	28
158	141	104	84	59	33	16	7	30
198	176	130	105	73	41	20	8	32
250	223	165	133	93	53	26	11	34
307	273	202	163	114	65	32	13	36
393	350	259	210	147	83	41	18	38
495	441	326	264	185	105	52	23	40

you have a toroid form of unknown properties and you need a specific inductance. The first thing to do is put on a test winding and measure it's inductance.

The easiest way to do this is by making a tuned circuit with the test coil and a capacitor and finding the resonant frequency with a grid-dip meter. I have experimented with this and have found that the best way to couple to a toroid is by using rather long leads on the capacitor and draping the tuned circuit over the gdo pickup coil. An alternate method is to make the tuned circuit with the shortest leads possible and putting a length of wire through the core and shorting the ends. *Coupling to the tuned*

table 1. Toroid-core constants for use in equation 2.

type	K
T-94-2	10.87375857
T-80-2	13.09481019
T-68-2	13.71166566
T-50-2	13.49065790
T-37-2	15.09667411
T-25-2	16.76244696
T-12-2	21.17423645
T-94-6	11.64825226
T-80-6	14.54857791
T-68-6	14.61045410
T-50-6	15.31238723
T-37-6	17.48997890
T-5-6	18.97143316
T-12-6	23.75741463
T-50-10	16.71056534
T-37-10	19.07988330
T-25-10	20.87788877
T-12-10	27.84454642

circuit is made through this pickup loop.

In any case, once the resonant frequency is known, the inductance of the trial winding can be calculated. Now you are ready to use eq. 2. Simply substitute in the now known values of N1 and L1. In case you need it, the formula for inductance is

$$L = \frac{25330}{F^2 C}$$

Where F is in MHz, C is in pF and L is in μH.

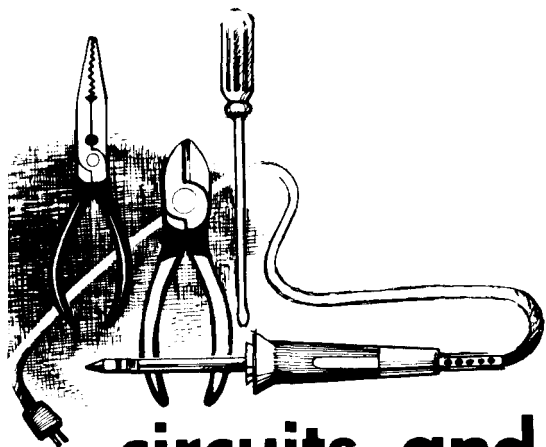
One other thing you might need to know is how many turns of a given size wire you can fit on a given toroid. Table 2 gives this information for most of the toroids in table 1. In general, use the largest size wire you can, since this will help to insure maximum Q. At first glance, it might seem that many of the cores on table 1 are not listed in table 2. Keep in mind that the first two numbers in the type designation specify the size of the core (a T-94-2 has the same physical dimensions as a T-94-6 and will hold the same amount of wire).

These formulas should provide the correct answers to the nearest turn or two — accurate enough for most amateur work.

reference

1. "Technical Correspondence," QST, April, 1971, page 48.

ham radio



circuits and techniques

ed noll, W3FQJ

fm deviation measurements

In the enjoyable task of learning technical techniques, the knowledge gained from making tests and measurements is especially rewarding. This is particularly true when learning the makeup of the fm wave. In spite of this, very few amateurs make deviation measurements, and the carrier-zero technique of deviation measurement has been almost ignored by most radio amateurs. It should be better known.

A complete fm wave has a constant amplitude and a varying frequency. It is composed of a carrier component and a number of sideband pairs that depend upon the modulation index. The carrier and sideband spectra for an fm wave of ± 10 -kHz deviation and 2000-Hz modulation is shown in fig. 1.

If the magnitude of the fm wave is to be kept constant and at the same time contain a number of changing sideband pairs, it is obvious that the carrier amplitude itself must vary up and down with modulation. In fact, at certain index values the carrier level reduces to zero. The first five

such null points are: 2.405, 5.52, 8.654, 11.792 and 14.931.

Spectra distribution for the first two index values are given in fig. 2. A 1000-Hz modulating tone is assumed. You can gain a practical understanding of the technique by considering what happens when a 1000-Hz tone is applied to the input of the fm transmitter and its amplitude is increased gradually from zero to produce higher and higher deviation levels. Obviously there is an increase in deviation and an increase in the modulation index. If this is done gradually and the level of the carrier only is measured, it is found that its magnitude moves up and down. When the amplitude of the 1000-Hz notes rises to a point at which the modulation index is 2.045, the carrier magnitude falls to zero. At this point the deviation would be:

$$\text{deviation} = \text{modulation index} \times \text{audio frequency}$$

$$\text{deviation} = 2.405 \times 1000 = \pm 2.4 \text{ kHz}$$

If you now continue to increase the audio, the carrier once again rises and falls in magnitude. When the index of 5.52 is reached, the carrier again falls to zero. The deviation at this carrier frequency is:

$$\text{deviation} = \text{modulation index} \times \text{modulating frequency}$$

$$\text{deviation} = 5.52 \times 1000 = \pm 5.52 \text{ kHz}$$

As the magnitude of the audio frequency

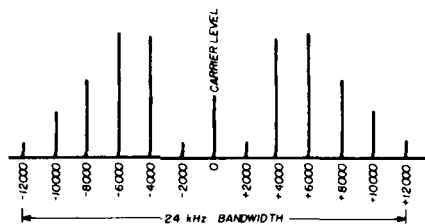


fig. 1. Carrier and sideband distribution for modulation index of 5. Modulating frequency = 2 kHz.

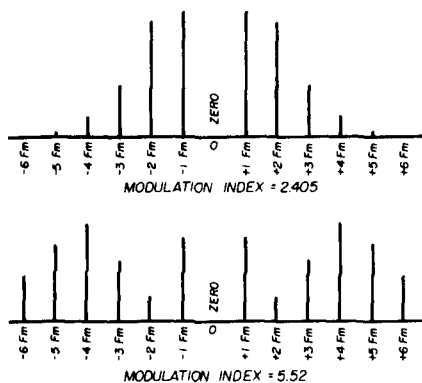


fig. 2. Spectrum distribution for first two carrier-zero positions.

is increased the carrier will pass through a succession of zero positions. For the fifth carrier-zero point (using 1000-Hz modulation), transmitter deviation would be approximately ± 15 kHz.

You can use these carrier-zero points to advantage in making carrier-deviation checks. To use them the emission spectra must be displayed on the screen of a spectrum analyzer. Alternately, a frequency meter or receiver could be used if they contain sharply tuned resonant circuits able to delineate the carrier from the first pair of sidebands. The functional block diagrams of fig. 3 show typical test setups. A spectrum analyzer permits the display of carrier and sidebands in accordance with figs. 1 and 2. Such an oscilloscopic analyzer can be connected directly to the i-f system of an fm receiver. More expensive analyzers that operate in the vhf band can be connected directly to the transmitter output using an appropriate dummy load.

You can make carrier-zero measurements with relatively inexpensive setups. A vhf converter can be used to supply signal to a high-frequency a-m receiver. The S-meter circuit of the receiver must be such that it responds to carrier level only. One of the older a-m receivers with a sharp crystal filter is ideal; I have used the old National NC-109 successfully. Use a high-enough modulating frequency that the first pair of sidebands (1000 Hz and up) does not influence the deflection of

the S-meter measuring the carrier amplitude. The S-meter reading should fall off to zero as you tune between the carrier and the first sideband. Remember that you need a highly selective a-m receiver with an S-meter that responds faithfully to carrier level but not to modulation. The modern single-sideband receiver cannot be used for this type of measurement because of its S-meter system.

An accurate and highly selective frequency meter can also be used to identify a center-frequency null. Such a frequency meter must have sharply-tuned and high-Q resonant circuits to be able to delineate between carrier and sidebands.

practical audio frequencies

In amateur and commercial fm two-way radio systems, narrow-band (± 5 kHz) and wide-band (± 15 kHz) deviation are common. Many radio amateurs settle on an in-between value of approximately ± 10 kHz so their signals might be demodulated by receivers designed for either narrow-band or wide-band demodulation. Practical tone frequencies of 1000, 1200 and 1800 Hz are attractive for making deviation measurements. An oscillator can be set precisely on frequency by choosing the standard tone transmitted by WWV and a Lissajous pattern display.

The second carrier-zero checkpoint of 5.52 in conjunction with a 1000 Hz note

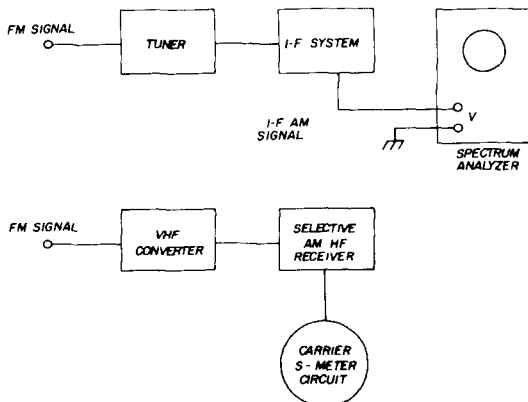


fig. 3. Carrier-zero test setups.

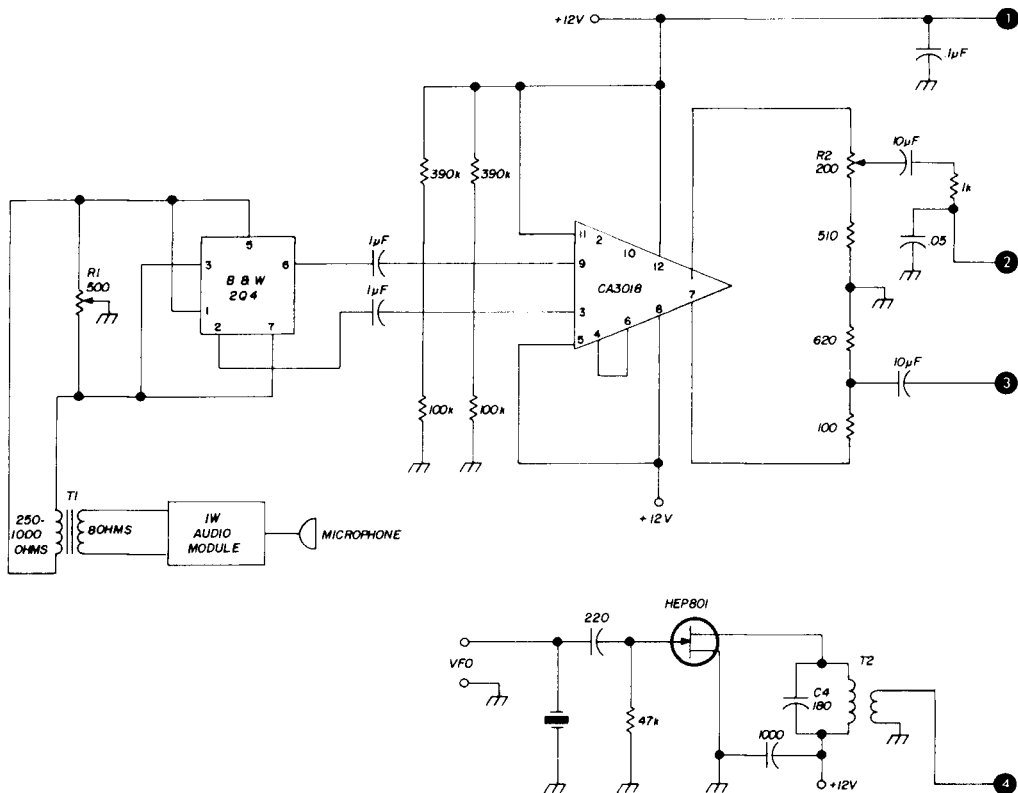


fig. 4. IC phasing-type sideband generator for 160 meters.

can be used to determine the setting of the deviation control needed for ± 5.52 -kHz deviation. If you now measure the audio-input amplitude to the fm transmitter you will know just how much voice signal is needed for this amount of deviation.

A 1200-Hz tone and the third carrier-zero point is an excellent checkpoint for determining deviation of ± 10 kHz.

The third carrier-zero point and 1800-Hz tone or the fourth carrier-zero point and 1200-Hz tone can be used as check points for indicating maximum wide-band deviation. Corresponding calculations are:

- deviation = $5.52 \times 1000 = \pm 5.52$ kHz
- deviation = $8.654 \times 1200 = \pm 10.30$ kHz
- deviation = $8.654 \times 1800 = \pm 15.58$ kHz
- deviation = $11.792 \times 1200 = \pm 14.15$ kHz

The carrier-zero method of measurement is especially useful in checking out home-built fm transmitters. You can use inexpensive equipment and make use of one of the good old a-m receivers that have been sitting idly around the shack. Most importantly it gives you a better insight into just what takes place in using frequency modulation.

top-band sideband generator

In the August issue¹ I presented a general schematic diagram for a phasing-type single-sideband generator using two RCA integrated circuits. I build a 160-meter version of this generator using the B&W 2Q4 audio phase-shifter shown in fig. 4. The balanced center-tapped primary and low-impedance output winding were wound on a toroid core.

tuning

A good first step is to adjust the audio and rf phase-shift networks. The audio-input attenuator R1 is set to midposition. Set potentiometers R3 and R4 to midposition. An oscilloscope or audio voltmeter can be used to observe the 1000-Hz tone at terminals 10, 5 and 8 of the CA3050. Place a 50-ohm carbon resistor across the sideband-generator output. Potentiometer R2 can then be adjusted so the audio level at pin 10 is the same as at pins 5 or 8, depending upon the position of the sideband switch.

The objectives of the rf phase-shift adjustments are to supply equal-level and 90°-related rf components to pins 1 and

Initially, the 50-ohm potentiometer R6 is set to midposition. Potentiometer R5 is also set to midposition. Capacitor C1 is adjusted for equal-magnitude levels across R7 and C1. Likewise the trimmer capacitor of the C2 combination is adjusted for equal levels across the C2 and R6 series combination.

Keep the 50-ohm terminating resistor across the output and connect the output of the sideband generator to the antenna input of the sideband receiver. Apply the rf-carrier component only. Turn back the rf gain-control setting or detune the pre-selector so you do not overload the receiver. Adjust the level for an S9 meter reading. Open up capacitor C3 several

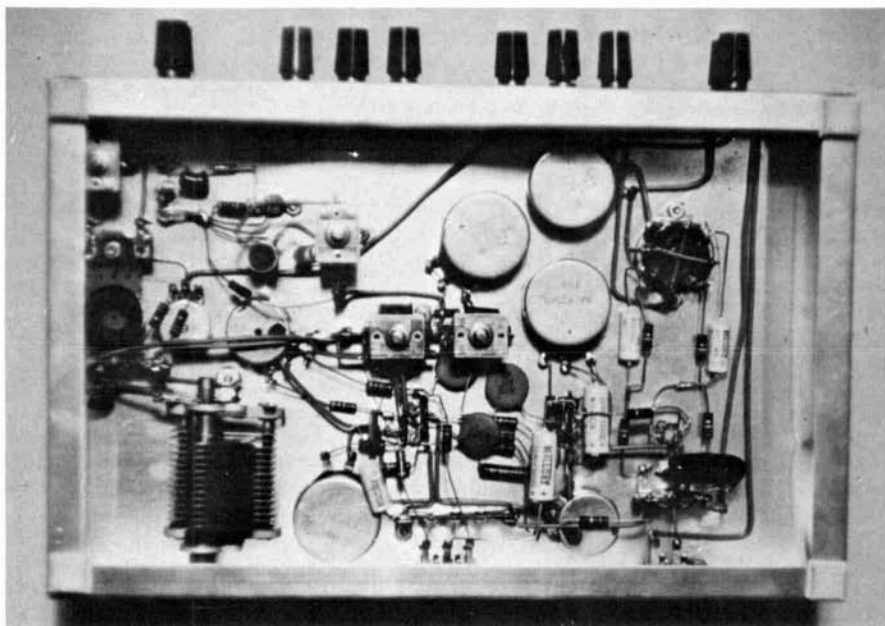


Photo of the ssb generator. The phase-shift network is the socket in the right hand corner.

13 of CA3050. How do you determine when a 90° phase shift occurs? Forty-five degree networks are involved, and in any series resistor-capacitor combination voltages of equal value appear across the resistor and capacitor when a 45° relationship is established. Your indicating instrument can be an oscilloscope or rf voltmeter that can measure up to 2 MHz.

turns away from its maximum setting. Now adjust the tuning-capacitor C4 for maximum S-meter reading.

Adjust capacitor C3 and potentiometer R8 alternately for minimum S-meter reading. A slight readjustment of potentiometers R5 and R6 may help a bit in further reducing the carrier level. Make these readjustments carefully and be

certain that you can return them to their initial positions if necessary.

You can also make oscilloscopic observations with a high-impedance probe.

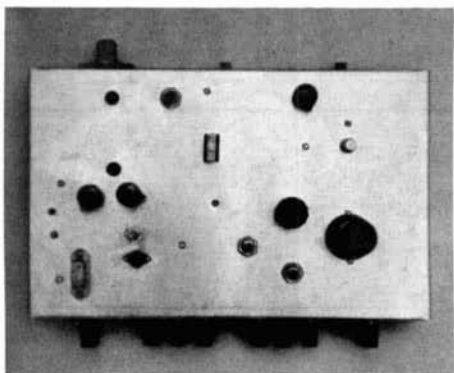


fig. 5. Chassis layout for the 160-meter ssb generator.

Since the probe attenuates the desired signal a problem that often arises is direct carrier pick-up by the scope lead which can result in a false pattern display.

Apply a 1000-Hz audio tone, tune in the modulation on the receiver and check the upper and lower sidebands to determine which position provides the highest ratio between the desired sideband and the undesired sideband. This procedure permits you to determine the position to set your phasing sideband switch.

Throw the phasing sideband switch to the opposite position. Also change your receiver sideband switch to the other position. Your dominant sideband should now have moved from one side of the carrier frequency to the other.

Set up the combination for operation on lower sideband. Now tune to the opposite sideband and adjust potentiometer R1 for minimum undesired sideband. Very slight readjustments of potentiometers R3 and R4 as well as R2 may aid in the reduction of the undesired-sideband level.

reference

1. Ed Noll, W3FQJ, "Circuits and Techniques," *ham radio*, August, 1971, page 50.

ham radio

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High selectivity can also be added to

oscillator circuit shown in fig. 1. For 144 MHz the fet circuit in fig. 2 is doing wonders.

Gus Gercke, K6BIJ

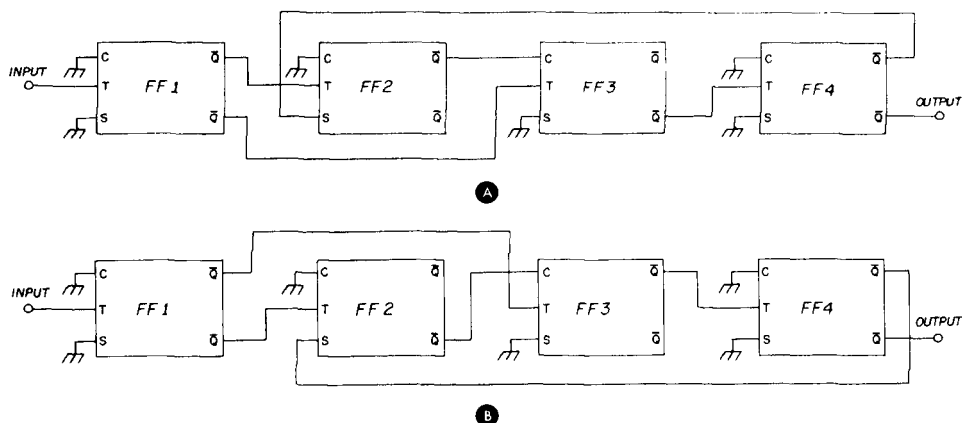


fig. 4. Standard divide-by-10 circuit is shown in (A). In (B) flip-flops 1 and 3 are reversed internally and must be wired as shown to divide by 10.

the rf stage by introducing some regeneration, much in the same fashion as is used in Q-multipliers. This approach will provide insertion gain instead of loss, and you don't have to be a plumber.

An oscillator circuit that is sufficiently stable for use as a vfo can be used as a selective rf amplifier by simply loosely coupling the antenna and receiver input to the oscillator tank coil and adding a potentiometer to drop the supply voltage to the point where oscillation just ceases. Gain and selectivity of this system can be adjusted (one at the expense of the other) by moving the two coupling coils closer or further away from the vfo tank coil. On 80 meters I use the modified Vackar

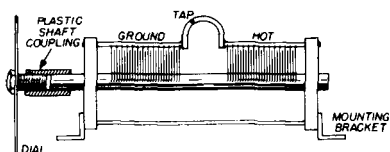


fig. 3. Tank circuit for selective two-meter rf amplifier. Split-stator capacitor is 35 pF per section insulated shaft. For two meters, coil is 1/2 turn, 1" diameter; six-meter coil is 2 turns, 1" diameter.

using the flop-flip

A recent bargain hunt turned up some RTL flip-flops in TO-5 cans; I bought some to make up a logic demonstration board for my sons to work with. Unfortunately, they could not get the modulo-ten minimum hardware circuit to count by ten as it should. After checking the patch connections I put a meter on the flip-flops and found that some of them were actually *flop-flips*.

With the normal RTL flip-flop connected as a binary divider (all inputs but toggle grounded), when you initially apply power Q should be low and \bar{Q} should be high. If some of your bargains are *flop-flips* the reverse is true. I got the modulo-ten circuit to count by ten by treating the normal Q and \bar{Q} outputs of the *flop-flips* as though they were reversed at the pins of the IC. Fig. 4A shows the normal circuit if all flip-flops were actually flip-flops. Fig. 4B shows a circuit where flip-flops 1 and 3 are *flop-flips*. These inverted ICs are usable in this fashion once you understand their peculiarities.

Allan Joffe, W3KBM



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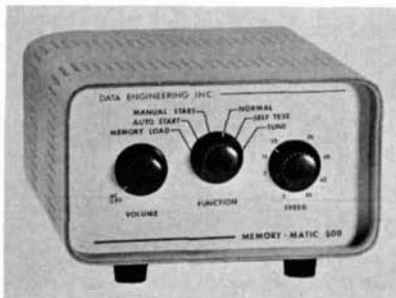
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The memory system included with each Memory-Matic 500 provides the serious DX, contest or traffic operator with provision for instant storage of code characters or messages, for an immediate reply to on-the-air contacts.

Messages of approximately 40 code characters are easily keyed into the memory for calling stations, giving a contest exchange, calling CQ or testing. Loading code characters into memory or transmitting messages from memory is accomplished at the same speed and weighting ratio in use by the operator. The memory allows continuous transmission on a repetitious basis of any message in storage.

Iambic squeeze keying is provided through the use of twin paddles. Iambic operation provides alternate dots and dashes when both paddles are squeezed. Advanced dot-dash memories automatically insert a dot in a series of dashes or a dash in a series of dots and insure against missed or extra dots or dashes.

Jam-proof spacing is provided for dots, dashes, characters and words. Dot and dash spacing is automatically added following each dot or dash. Character spacing is automatically added following the last dot/dash element which make up each character. Word spacing is automatically added following the last character which makes up each word.

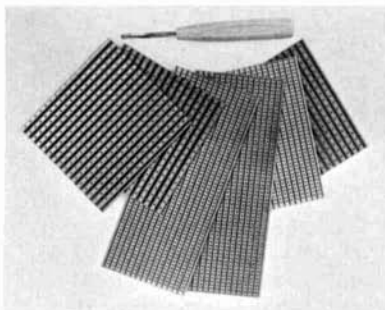
A 500-bit instant-load memory is provided in the Memory-Matic 500 which can be programmed or updated by moving the function switch to *memory-load* and keying any message into memory. When 50 storage positions remain in memory the monitor's sidetone pitch automatically increases, indicating to the operator that the memory is *near-full*. The monitor will emit a steady sidetone if the memory overflows; this condition necessitates reprogramming of the memory-load sequence. Once a message is entered into memory it can be transmitted manually or automatically at intervals ranging from a fraction of a second to several minutes. Adjustment of the automatic transmission interval is accomplished by a rear panel control.

Both the Memory-Matic 500 with the 500-bit memory and the Space-Matic 21 without the memory feature have a speed range of 5 to 85 words per minute with adjustable weighting, independent of speed. They have provision for keying

with a regular straight key and keyer activation by either a single or dual paddle key. Tune switch, variable pitch sidetone oscillator, 117-Vac power supply, and off-the-air self-testing circuitry are built into both keyers.

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Vero offers an introductory BK-6 Vero-board kit designed for experimenting with discreet components.

The BK-6 Kit consists of six Vero-boards, two with a 0.2 x 0.2-inch matrix and four with a 0.156 x 0.1-inch matrix, both having a 0.052 diameter hole. The Vero BK-6 Kit sells for \$5.95.

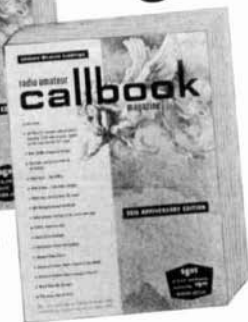
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For more information write to Vero Electronics, Inc., 171 Bridge Road, Haverhill, New York 11787 or use *check-off* on page 94.

new callbook

Marking it's fiftieth anniversary, the Radio Amateur Callbook Magazine is changing to a new format of one major edition per year. This first of the new Callbooks will be the Winter 1971-72 issue, published on December first.

A "new information service," in Callbook form, consisting of new licenses, silent keys, call letter and address changes for the preceding three months, will be initiated on a quarterly basis — every March 1, June 1 and September 1 — to those who have purchased the previous December issue. This information service will be available by subscription only, through the order form printed in the December edition. The price for this service will be \$6.00 per year for the United States series, and \$4.50 per year for the foreign series. The subscription is on a consecutive, annual basis only.

The Winter U. S. Callbook and three supplements will cost \$15.20 per year, and the Foreign Callbook and supplements will cost \$11.70. The U. S. Callbook alone will remain at \$8.95; the Foreign Callbook is \$6.95.

For more information use *check-off* on page 94 or write to the Radio Amateur Callbook Magazine, 925 Sherwood Drive, Lake Bluff, Illinois 60044.

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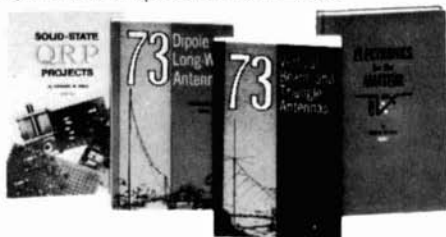
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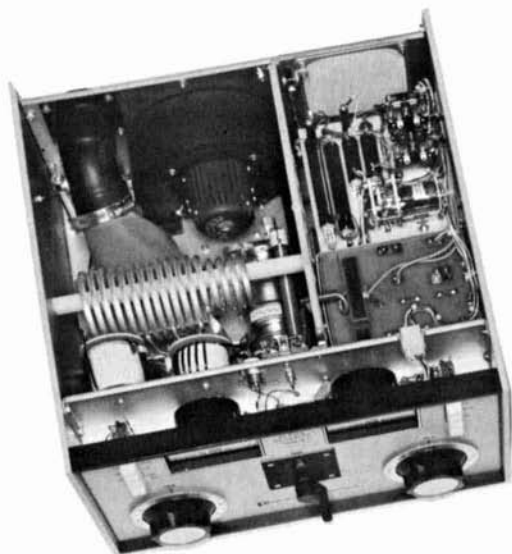
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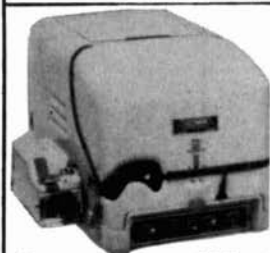
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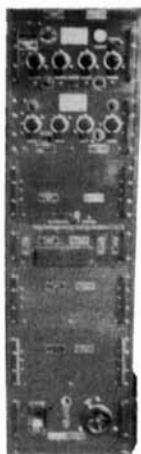
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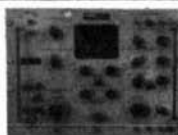
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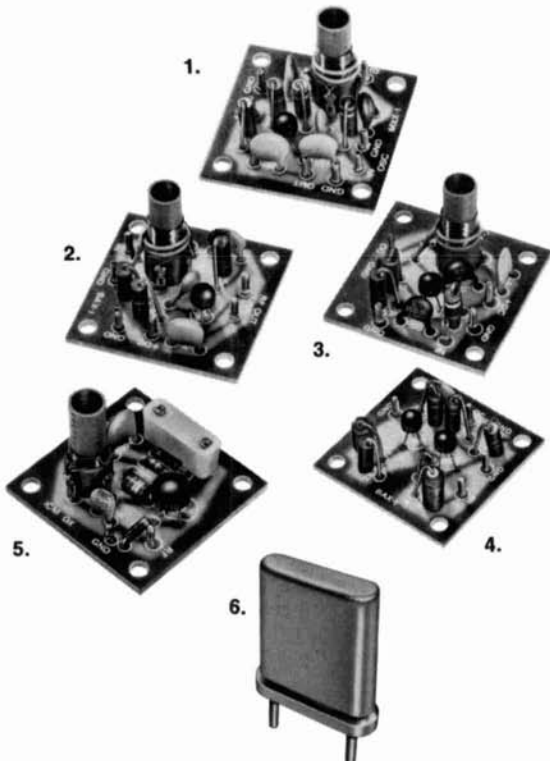
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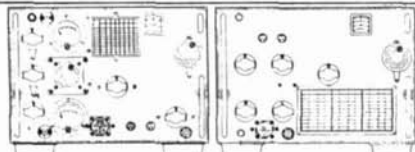
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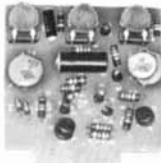
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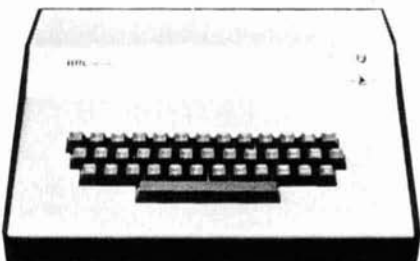
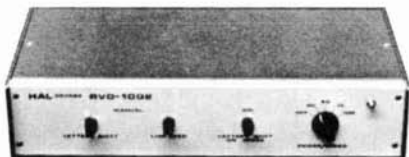
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TOLEDO MOBILE RADIO ASSOCIATION'S 17th Annual Hamfest and Auction will be held February 20, 1972. \$1.00 registration, open table sales, map and info write: TMRA, W8HHF, Box 273, Toledo, Ohio 43601.

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SURPLUS MILITARY RADIOS, Electronics, Radar Parts, tons of material for the ham, free catalogue available. Sabre Industries, 1370 Sargent Avenue, Winnipeg 21, Manitoba, Canada.

TOROIDS 44 and 88 mhy. Unpotted, 5 for \$1.50 ptd. W. Weinschenker, Box 353, Irwin, Pa. 15642.

KIT BUILDERS — All American Sports Amplifier (featured Sept. 1971 Popular Mechanics) now available with step by step instructions. Fantastic new (patent pending) amplified filter concept doubles normal TV viewing range. Free data sheet. CADCO SYSTEMS, Box 18904, Oklahoma City, Oklahoma 73118.

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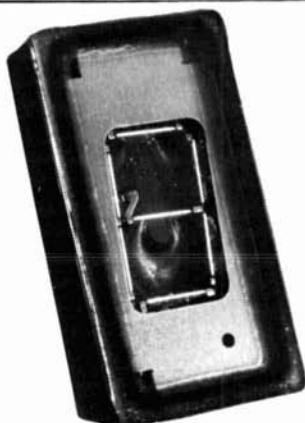
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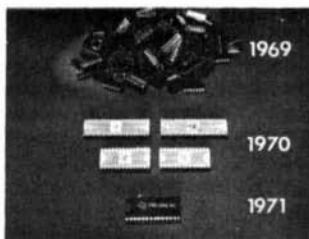


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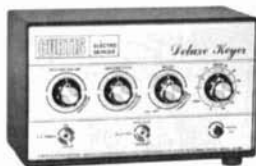
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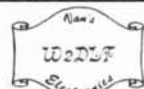
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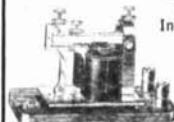
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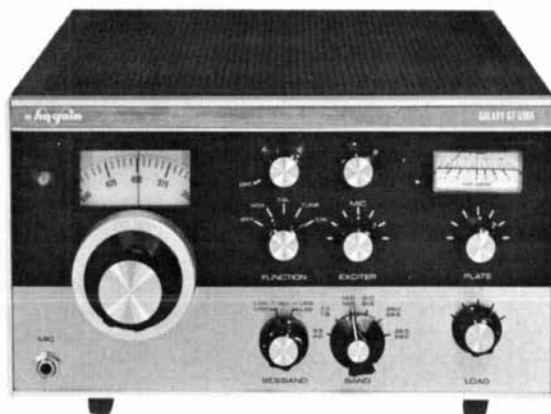
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