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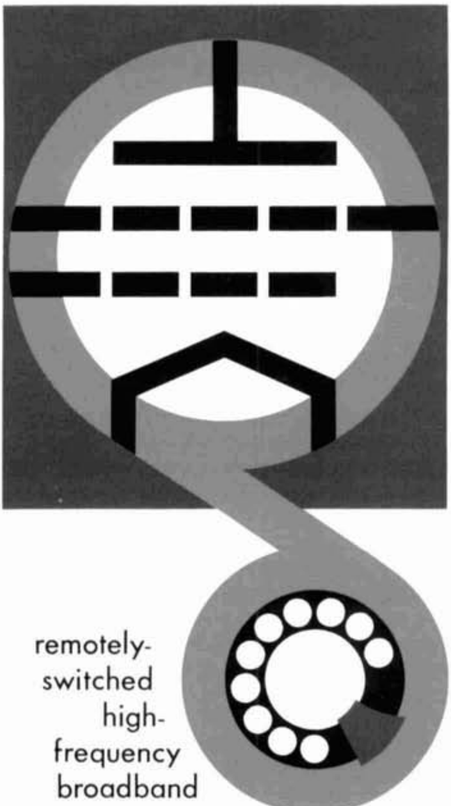
ham radio magazine

MARCH 1972



remotely-switched high-frequency broadband

linear amplifier

this month

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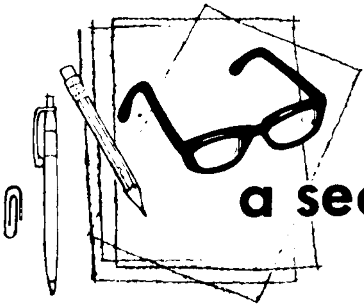

a second look

by jim fisk

During the 5th annual SAROC convention in Las Vegas in January, A. Prose Walker, W4BW, new Chief of the FCC Amateur Division, held forth for more than an hour, offering many of his personal views on important aspects of amateur radio.

On the current repeater proposal before the FCC, he favors minimal legislation. He feels that repeaters should only be linked together when it is justified in view of better emergency or public safety performance; linking repeaters solely for better range is absurd. Rather than tying up a number of repeaters and frequencies, it is much better to use a lower frequency. In his view, when repeater linking *is* allowed, it will be limited to two or three stations, and then only for a good reason.

As far as the new expanded phone bands are concerned, Mr. Walker said he feels there will be a token expansion of the 75-meter phone band. The 40-meter phone band is likely to be expanded too, but not enough to cover the inter-zone DX window below 7.1 MHz. In his opinion, expansion of the 20-meter phone band "will cause too much international ill-will and at this time we need all the friends we can get." He spoke of this in the context of what is in the best interest of the United States, not just amateur radio. He was very strong on this point, much to the chagrin of some of the big DXers in the audience.

Walker pointed out that running more than a kilowatt is illegal, unsportsmanlike and totally out of keeping with amateur tradition and the purpose of the amateur service. You know who is doing it, and the FCC knows. He advised amateurs to clean up their own house – or the FCC will do it well and do it painfully. His personal opinion is to prosecute to the fullest extent of the law.

Looking to the future, Mr. Walker suggests that we may not have to identify; all licensed stations will have *built-in* electronic identifiers which will do it automatically, at very high speed. This will automatically, and positively, identify jammers and bootleggers.

Far in the future he feels our whole callsign structure may be changed with distinctive calls for each class of license. There are enough letter combinations for all generals to have a one-by-three call (such as W1AAA). Higher classes of licenses may use calls like W1A, WA1A, W1AA, etc. There is also the possibility that the ITU-allocated block of U.S. calls from AAA to ALZ might be used for the amateur service, if and when Tibet, Sikkim and Bhutan amateurs stop using their AC1-ACØ callsigns. This is far in the future, though.

There's also a long-range possibility for more bands as more and more commercial and military traffic switches to land lines and vhf. Then the real frequency pressure will come on vhf and uhf. And, in light of the EIA proposal for 220 MHz, W4BW encouraged hams to, "Use it, or lose it!" That goes for all of our bands.

Jim Fisk, W1DTY
editor

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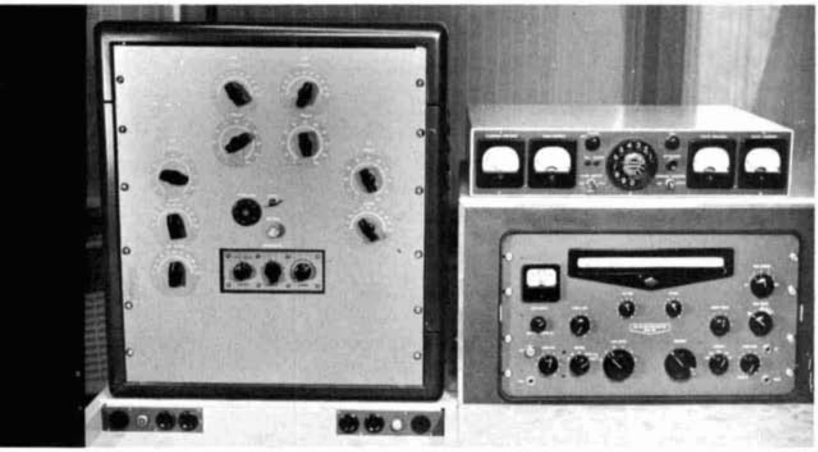


ecology linear

This high-power linear amplifier eliminates air-wave pollution of on-the-air tuneup with broadband circuits and nearly instantaneous band changing

Gene Hubbell, W7DI, 6633 East Palo Verde Lane, Scottsdale, Arizona

Waste, pollution, ecology – words much in evidence today, and meaningful in amateur radio, as well as in our living environment. For years I have, occasionally, blown my top over unnecessary signals that were "dirtying up" the bands. There seemed to be a quota of fellow hams who needed to test or tune up regularly on "my" frequency. Of course, many of them felt the same way about me.

Some time ago I adopted a tuning procedure that cut my own on-the-air tuning to a minimum. Even though I still make a final check with the antenna connected, I minimize this by setting all dials to recorded values, using a dummy antenna up to the last moment, and picking a test frequency carefully to avoid interfering with communications.

If all controls could be set for each band, and a rapid change made between preset circuits, I would not only avoid putting out unnecessary signals, I'd have an ideal transmitter for contest work. Of course, separate finals would do this, but that solution seemed a lazy man's way out. Besides, the space they required would crowd my shack. Remote control would save space in the shack if space were available elsewhere; it would be worth remembering.

After reading through many magazine articles on high-power linears, considerable doodling on paper and shuffling of parts on the workbench, I started to build. Some 800 hours of work later I had the linear amplifier shown in **fig. 1**. Input power runs from zero to well over 2 kW, complete band changing takes seven seconds or less. It can be switched from band to band by a local control on the front panel, or by a telephone dial on the remote-control unit. The plate supply is continuously variable from zero to 5000 volts, can be left on continuously or automatically keyed on and off by an auxiliary set of contacts on my antenna relay. Or I can control it with a vox relay. Time-delay circuits provide for gradual application of primary power to avoid surges, and also to hold the plate supply on during pauses in talking or keying.

the circuit

When planning the plate tank circuits I decided that only vacuum capacitors would fit into the desired space, so four 10- to 300- or 400-pF variables were acquired with a fixed unit of 12 pF planned for the 28-MHz tank. The inductances were wound of 3/16-inch copper tubing, except for 28 MHz, where small copper strap was used. The output coupling air variables were 30- to 500-pF units found in military surplus. The 14-MHz variable was shortened slightly to avoid touching the big tube.

On the three lower bands fixed mica capacitors shunt the air variables to provide a 50-ohm output impedance. All plate circuits were designed for a Q between 10 and 15, depending on the band and the plate voltage I planned to use.

The large ceramic band-switch decks were assembled with mycalex and bakelite spacers made up on a lathe, so there were no closed loops in switch construction. The turning mechanism for the plate tank band-switch was originally a Collins auto-tune. This motor-driven gear and clutch assembly ran from 117 volts ac and would turn a shaft to ten positions. A small control panel attached to the auto-tune had a 10-position switch to select these positions, each of which was independently adjustable over 360 degrees. A "local-remote" switch made these positions available through screw terminals which were connected to a stepping switch.

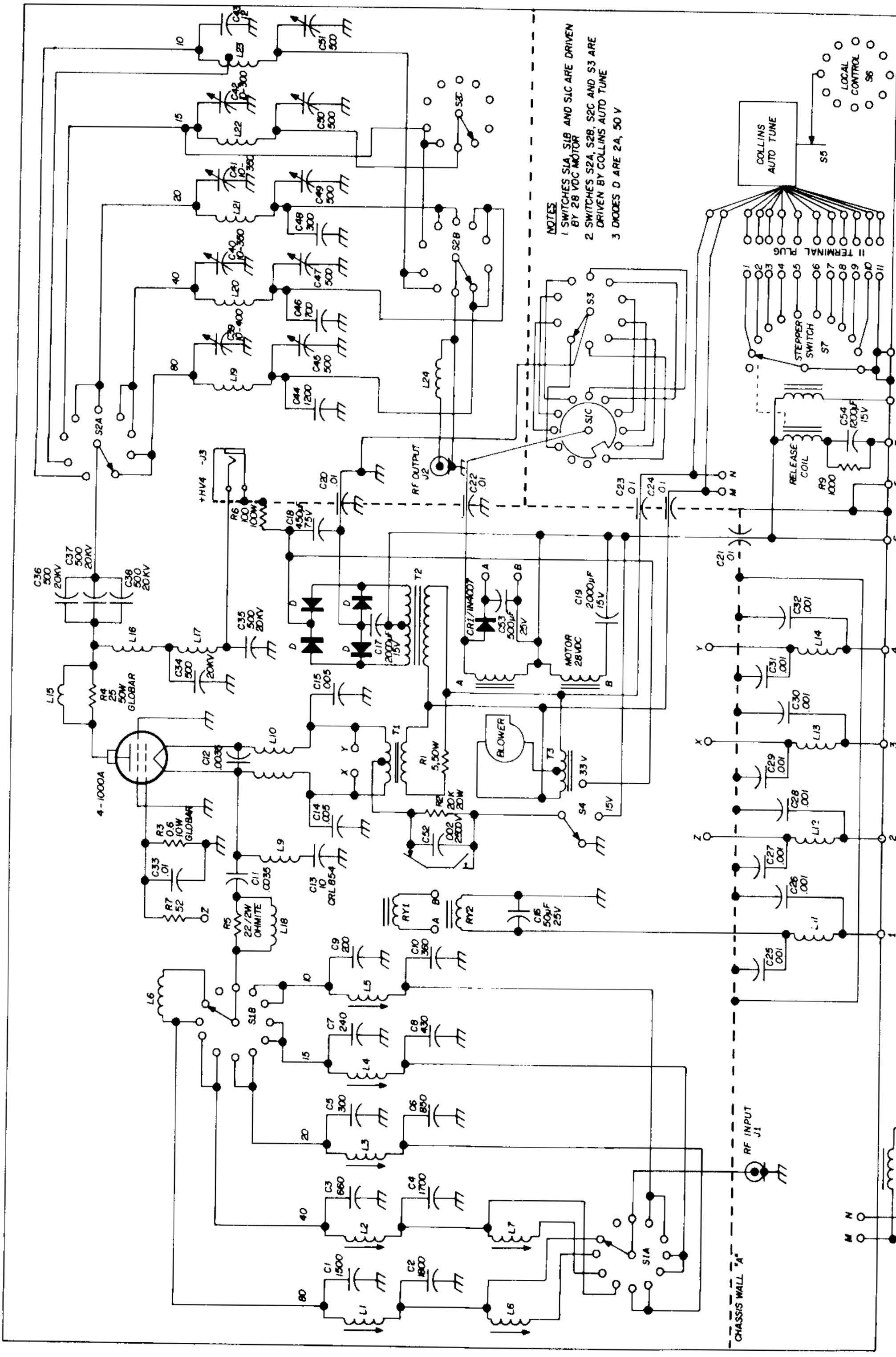
Another set of switch contacts made it possible to switch another circuit to 10 different connections and was used to control another motor-driven coil switch. This item was obtained from an old military receiver.

The reason for the separate bandswitching motor drives lay in the fact that the plate tank switch had 10 positions (9 active and 1 rotor) while the cathode tank switch had 12 positions. A suitable 5-to-6 gearing ratio was not readily available.

The cathode drive circuits were designed for low Q with slug-tuned coils wound of number-18 wire on ¾-inch diameter ceramic forms. Input and output capacitors are small silver micas, paralleled for needed capacity and also to carry higher current. Series inductances on other switch connections broadband the coverage on 3.5 and 7 MHz.

All tank circuits were initially adjusted by using a small 10-watt vfo-controlled transmitter with a Micro-Match swr bridge in the 50-ohm line to the circuit under test (input line to the cathode and the output line from the plate circuit). The cathode-to-ground impedance was simulated by a 100-ohm non-inductive resistor; the plate impedance was simulated by a group of resistors totalling 5000 ohms. L and C values were changed to obtain as low swr as possible. Other changes had to be made later when power was applied, but this initial procedure was very helpful.

The linear chassis included, in addition to the 4-1000A socket, a blower, filament transformer, input and output tanks and small dual-voltage dc power supply with


NOTES
1 SWITCHES S1A, S1B AND S1C ARE DRIVEN BY 28 VDC MOTOR
2 SWITCHES S2A, S2B, S2C AND S3 ARE DRIVEN BY COLLINS AUTO TUNE
3 DIODES D ARE 2A, 50 V
COLLINS AUTO TUNE
LOCAL CONTROL S6
11 TERMINAL PLUG
STEPPER SWITCH S7
RELEASE COIL
9 PRONG PLUG (CHASSIS MOUNT MALE)
CHASSIS WALL "A"
RF INPUT J1
RF OUTPUT J2
+HV4 -J3
MOTOR 28VDC
BLOWER
4-1000A
FAN MOTOR

nominal 15- and 30-volts output. The 15-volt supply is used for the cathode tank switch drive motor, the stepping switch, control relays for the plate supply, pilot lights on the control box, relay power for the cathode relays K1 and K2 and bias for the 4-1000A. The 30-volt output is also available for bias,

fig. 1. Broadband linear amplifier provides rapid bandswitching and variable output from zero to 2 kilowatts.

C39	10-400 pF, 10 kV vacuum variable capacitor
C40,C41	10-350 pF, 10 kV vacuum variable capacitor
C42	10-300 pF, 19 kV vacuum variable capacitor
C43	12 pF, 20 kV fixed vacuum capacitor
L1	12¼ turns no. 18, 7/16" long, wound on ¾" slug-tuned form (National XR72)
L2	6¼ turns no. 18, ¼" long, wound on ¾" slug-tuned form (National XR72)
L3	4¼ turns no. 18, 5/16" lnog, wound on ¾" slug-tuned form (National XR72)
L4	3¼ turns no. 18, ¼" long, wound on ¾" slug-tuned form (National XR72)
L5	3¼ turns no. 18, ½" long, wound on ¾" slug-tuned form (National XR72)
L6	22 turns no. 24, ¾" long, wound on ¼" slug-tuned form
L7	9 turns no. 18, 5/16" diameter, ¾" long
L8	12 turns no. 18, ¼" diameter, 5/8" long
L9	5¼ turns no. 14, 3/8" diameter, ½" long
L10	Bifilar filament choke, 30A (William Deane, 8831 Sovereign Road, San Diego, California 92123)
L11,L12 L13,L14	20 μH vhf choke
L15	1 turn no. 12, ¾" diameter 3" long
L16	90 μH, 2 amperes (William Deane)
L17	rf choke (Ohmite Z-50)
L18	3 turns no. 18, 1" long, wound on Ohmite 2-watt resistor
L19	17 turns 3/16" copper tubing, 4-3/8" diameter, 5¾" long
L20	14 turns 3/16" copper tubing, 3¼" diameter, 4¾" long
L21	13 turns 3/16" copper tubing, 2-3/8" diameter, 4½" long
L22	9 turns 3/16" copper tubing, 2¼" diameter, 3½" long
L23	5 turns copper strap, 3/8" wide, 0.10" thick, 2¼" diameter, 2¾"long
L24	2 mH rf choke

and three values, zero, 15 or 30 volts, can be switched in by S4.

With zero bias the 4-1000A drew plate current whenever plate voltage was applied. This gave rise to thermal emission noise which fed back to the receiver through the break-in system. Bill Orr advised that a small amount of fixed bias would not greatly affect the linearity, so the bias switching was added. With added bias drive requirements increased slightly.

Operation of the amplifier for initial tune-up is quite simple. With plate voltage off, the local control switch on the front panel, or the telephone dial on the control box, sets the auto-tune in motion to select the proper plate-tank circuit. This also activates the cathode-tank selection switch which locates the correct tank circuit. While this is going on, a maximum of seven seconds, the exciter is tuned up on the proper band segment, and as soon as cathode relay K2 closes, excitation is applied.

A dummy load is switched to the output of the amplifier and with excitation removed, the plate voltage is switched on and adjusted to a medium value of 2000 to 2500 volts. Next, with excitation applied, the plate tank input and output capacitors are adjusted for maximum output to the dummy load. If the plate current appears to be normal (250 to 300 mA) and the output is in the 200- to 400-watt range, the plate voltage is raised to maximum and the capacitors adjusted for maximum output.

With excitation and plate voltages turned off, and the receiver in operation, the antenna is switched in place of the dummy load and a tune-up frequency is chosen. Then excitation and plate power are applied and final tune-up made to the antenna. This usually requires about two or three seconds.

Once these adjustments are completed it is rarely necessary to re-tune unless an antenna change makes a considerable difference in loading. During the 1971 ARRL DX Contest, CW division, I changed bands at least 87 times according to my log, and not once did I have to tune up "on-the-air." Many times I wished that other stations could say the same.

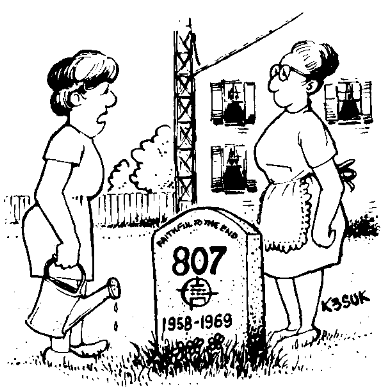
construction

A number of problems turned up during construction. While some required considerable effort to solve, others were handled with ease. One problem that showed up early was the "case of the too-large blower motor."

I had two blowers on hand; both were large affairs with four impellers each, made to cool a large cabinet. I cut one down to a single impeller but it still required 2.5 amperes at 117 volts ac. It blew a gale but was also very noisy; a large part of the noise was from ball bearings.

The second blower with sleeve was much quieter but still drew too much power from the line. Reducing the line voltage gave good air volume and much less power consumption, so I made an auto-transformer from an old filament transformer, teasing up the end turns on the primary until I found the right layer to tap. At 70 volts the motor only drew a little over 1 ampere.

The parasitic suppressor consists of a 25-ohm, 50-watt Globar resistor; copper end caps were forced on and a 3-turn coil of number-12 wire was wound from end to end. This did not completely suppress a parasitic around 130 MHz so a small series LC trap was installed from



"I sometimes think Henry takes his hobby too seriously."

cathode to ground. This is L9C13 on the circuit diagram. Later R5L18 was added in the cathode drive lead. This enabled a reduction in the size of L15 from 3 turns to 1 turn and decreased the power dissipated in R4.

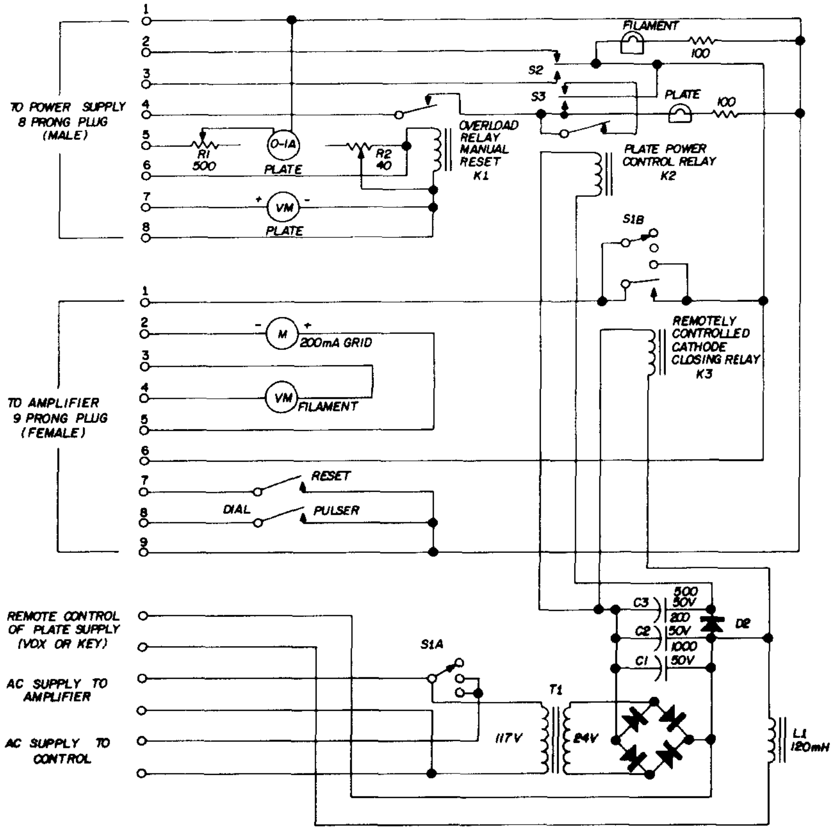
The 21-MHz tank circuit resonated fine on that band with the tube output capacitance, but resonance increased to 28 MHz when the tube was switched to the normal 28-MHz tank. No amount of tinkering with LC ratios, coil sizes or orientation seemed to keep these tanks from coupling with one another, and there was not enough room for shielding, so I resorted to a brute force solution; I added another switch deck to short out part of the 21-MHz coil when operating on 28 MHz; this effectively detuned it.

power supply

The power supply was designed for continuous duty without worry. The chassis was made from ¼-inch thick aluminum plate, 33½ by 14 inches, with vertical 2½ by 1½ sides of 1/8-inch aluminum channel. Thirty-two casters of the type used under refrigerators gave this chassis some mobility.

The plate transformer is rated at 4400 volts at 1 ampere with 230 volts input, and is fed from a 2.7 kVA variable transformer with an output from zero to 260 volts. A pair of 4- to 16-henry, 500-mA swinging chokes are used ahead of a 25-μF, 6250-volt oil-filled capacitor. The chokes were tried in parallel, but the series connection gave far better voltage regulation, and total plate and bleeder current runs only a little over the 500-mA rating.

The bleeder is made up of four 240-watt, 10,000-ohm resistors in series. A time-delay circuit powers a relay to short out a 12-ohm resistor in series with the line voltage to the plate transformer. A small fraction of a second delay allows the input power to be applied gradually, eliminating surges that might trip the circuit breakers or blow fuses or rectifiers. The bridge rectifier band consists of forty 2 amp, 1000-PIV



K1	spst, normally closed, plug-in relay, 8000-ohm coil	T2	filament transformer, 117 Vac primary, 25.2 Vct, 1 A secondary
K2	spst, normally open relay, 12-Vdc coil	T3	117-70 Vac autotransformer
T1	filament transformer, 117 Vac primary, 8 V, 21 A secondary		

fig. 2. Power supply for the high-power broadband linear amplifier. Each leg of the bridge consists of 10 diodes (2 A, 1000 PIV), 10 capacitors (0.0047 μF) and 10 resistors (470k, ½ watt). Plate and filament lamps are 6-volt, type 47.

silicon diodes, 470k, ½-watt resistors and 0.0047-μF capacitors.

The variable transformer in the plate supply primary is driven by a small Bodine geared-head motor with a 30-pm output shaft. Lamp L1 is included to provide motor protection when stalled at the end of rotation and also reduces the speed somewhat. There is some advantage in fast rotation, since it only takes a couple of seconds to shift from maximum to minimum plate voltage. Just a light tap on S2 on the control panel changes the plate voltage by 500 volts or so.

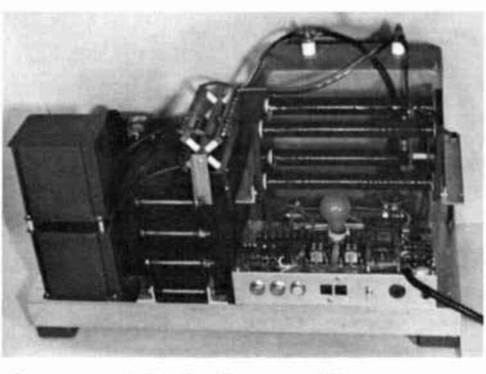
Metering of four items of current and voltage, remotely and safely, poses something of a problem. The ac filament measurement is simple, and luckily, the voltmeter error just about compensates for the voltage drop across the bifilar cathode choke. The plate voltage, plate current and grid current are all measured by setting up a small voltage drop in a part of the circuit to be checked, not much above ground, and calibrating a voltmeter to read in terms of the required units.

The plate voltage is read across a

portion of a 50-watt, 300-ohm potentiometer in series with and at the ground end of the 40,000-ohm bleeder string. The voltmeter actually reads about fifteen volts full scale, but the meter dial is calibrated to read to 6000 volts. By varying the potentiometer tap, the readings correspond accurately with a portable voltmeter temporarily connected across the power-supply output.

Amplifier remote control and metering unit.

The plate-current meter is calibrated to read 1000 mA dc, but actually measures the drop across a 1-ohm, 25-watt resistor in series with the negative high voltage to ground. The grid current is measured as a voltage drop across a 0.6-ohm, 10-watt Globar resistor from grid to ground. A 12-ohm, 20-watt resistor in series with the high voltage to ground and the 1-ohm resistor mentioned above develop enough voltage to trip the overload relay on the control panel if the current rises much over 500 mA, so an adjustable shunt was provided for higher current, if desired.



Power supply for the linear amplifier.

The apparent extra leads in the metering circuits were found to be necessary. A common lead between two metering circuits caused a lot of trouble. High voltage was carried by a length of RG-11/U coax cable with modified connectors. The bakelite inserts on the PL-259 and SO-239 connectors were removed and the center conductor of the coax was allowed to protrude about three inches through the joined connectors, along with its polyethylene jacket and a piece of vinyl tubing to add stiffness. A banana plug was soldered at the end of the coax center conductor. A heavy bakelite tube was added to the inner, unthreaded, side of the SO-239 and a banana jack was installed at its far end. The high-voltage connection was made here; the shielded coax jacket served as ground and the high-voltage negative lead.

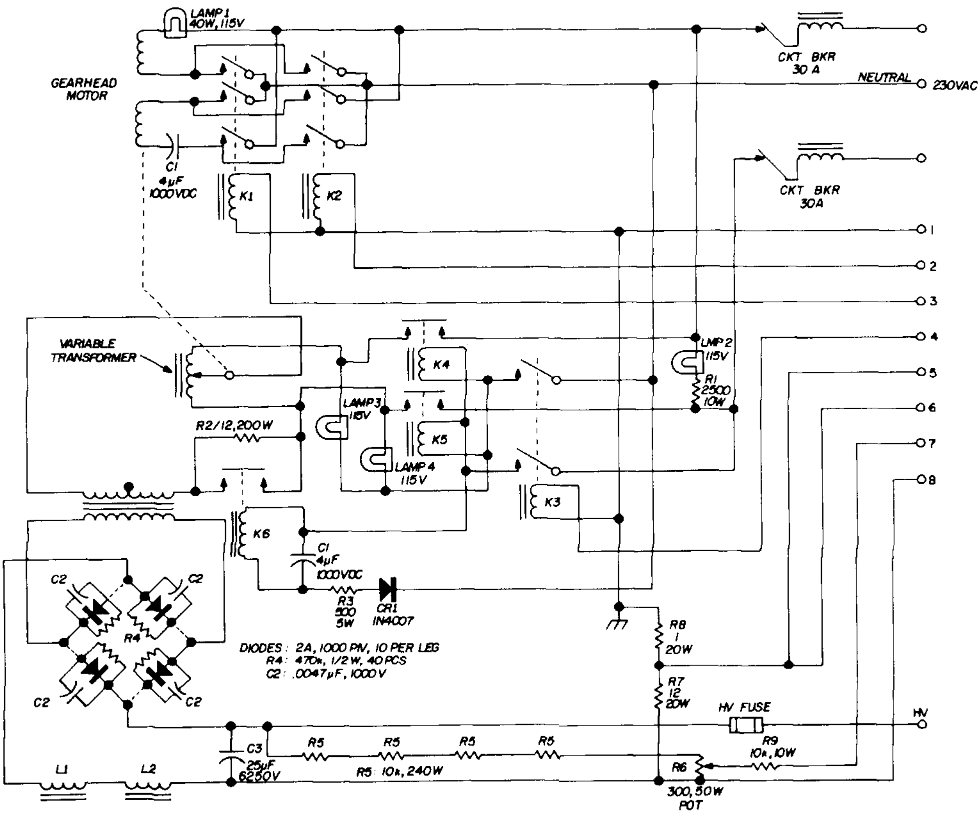
control

The control circuitry for energizing the high voltage supply was originally designed to operate from the same 15-volt supply which operated most of the relays in the system, closing K2 in the control box. It was desired that K2 and K3 close very quickly and open slowly, at different time delays, and eventually a separate power supply was added. This supply, from T1 in the control box, provided a no-load voltage of around 40 volts with a 1000-μF capacitor for energy storage.

When an external circuit was closed, this voltage was applied to K3 with a 200-μF capacitor across its coil, and to K2 with a 500-μF capacitor across its coil, but with a series diode preventing discharged more slowly, thus keeping the plate supply energized for a somewhat longer period of time. The delays are about 1½ and 3½ seconds, respectively.

construction

The linear cabinet was picked up at a



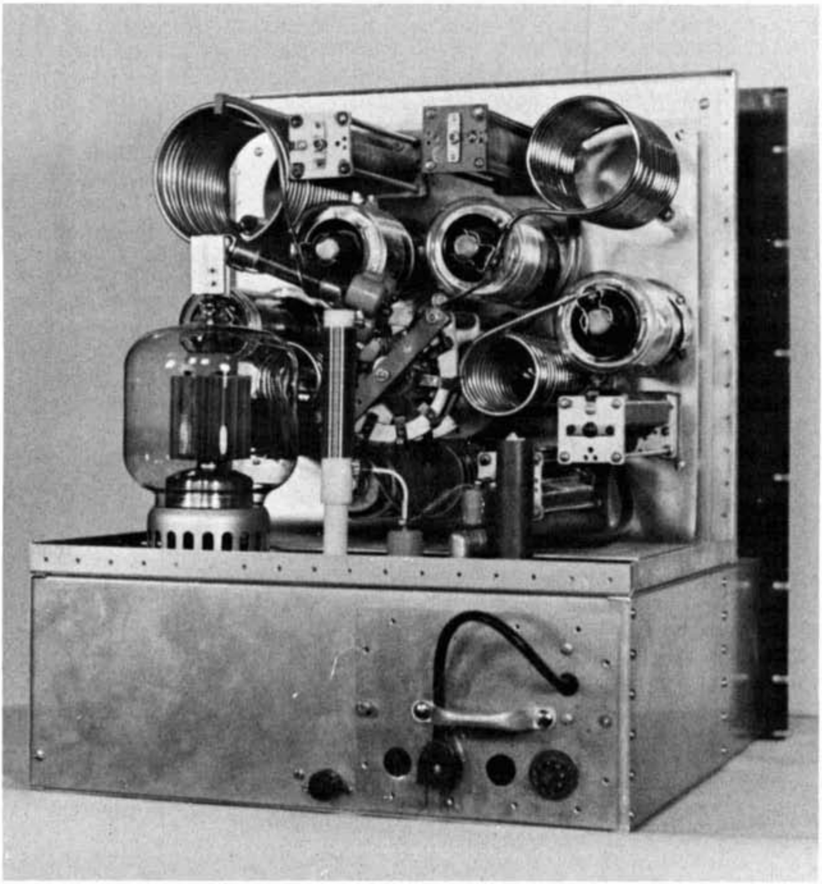
K1,K2, K3	triple pole, single throw relay, 24 or 12 Vdc coil	K4,K5, K6	dpst relay, 30 A contacts, 117-Vac coil
		L1,L2	4-16 henry swinging choke, 500 mA

fig. 3. Schematic diagram for the control unit. Diodes in the bridge circuit are rated at 2 amps.

discharge back through the coil of K3. A small inductance cut arcing at the closing contacts at the remote control point. Discharge of the 200-μF capacitor was relatively fast, allowing K3 to open soon and in turn release the cathode grounding relay, K2, on the main chassis. The 500-μF capacitor across K2 (control unit)

surplus store and has outside dimensions of 21½ x 24 x 18½ inches. The inner cabinet and chassis were fabricated of sheet aluminum from a local junkyard, cut and bent on machines in a nearby tin shop. Not counting the screws holding internal components, there are at least 350 machine screws holding the shielding together. The control-unit cabinet was built of wood, painted to match my console. The labeled front panel of the linear was put on top of the actual support panel, which held many support and mounting screw heads, all recessed. The using a dynamic brake circuit with capacitor C19 in series with winding B of the motor. Now the drive system stops – but quick.

To obtain added frequency coverage on 28 MHz with the fixed capacitor C43,



Rear view of the ecology linear shows separate tank circuit for each band and battleship construction throughout.

cabinet and front panel were painted with a two-tone metallic blue-gray at a local auto body shop.

Other little items that come to mind, which may be of interest, include the over-travel on the cathode tank switching motor. Even though the 28-volt motor was operating on about half voltage and the drive was through a Geneva gear, the drive sometimes ran past proper contact on the switch decks. This was cured by I used a tap just off the end of the coil, hooked to another plate-tank switch tap. This raised the resonant frequency nicely, from about 28.1 up to 28.6 MHz.

Relay K1 on the linear chassis was added to open the cathode circuit to ground (except for R2) when the cathode-switching motor started to operate and to close the circuit after the motor stopped, with time-delay capacitor C53.

All plate-tank circuit components were mounted on an aluminum sheet bent at right angles, parallel to the front panel and bottom chassis. This support is entirely insulated from the rest of the assembly except for one ground connection at the tube socket and the braid on the output coaxial cable feed line.

Connections were provided for high voltage, rf input and output, 117 volts ac and a 9-wire control cable socket, all in a 5 x 7 x 2-inch chassis, inside the rear surface of the main chassis. A cover over this opening was drilled for the coaxial cable connectors, and has male plugs mounted on it for the ac line and 9-wire cable connections.

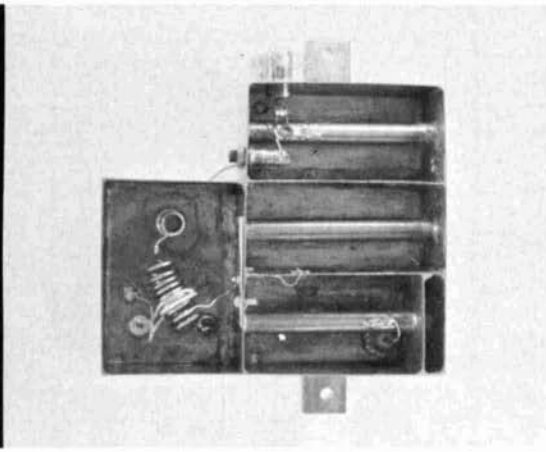
A small muffin fan was mounted on the rear door and the line voltage to it reduced with a series resistor. This fan helped take hot air out of the top of the cabinet, while the resistor kept fan noise down.

Details needing attention appeared after a period of operation. From the start, drive power requirements were higher than they should have been on any one of three tubes on hand, one supposedly "brand new." I made up a new set of cathode tank circuits of higher Q, but they improved matters only slightly. Finally, I obtained a fourth tube, and suddenly it became possible to drive to the legal limit with about sixty watts input. Moral: Make sure of your linear tubes!

It would have been nice if the second band-switch position for increased frequency coverage in the cathode circuit could have been used to shift the plate tank to a new frequency range. Thus, instead of requiring retuning for a shift from cw to phone on 3.5 and 7 MHz, the move could be accomplished as it is on 28 MHz.

I will be happy to correspond with anyone wanting to discuss any of the ideas incorporated in this linear amplifier. The courtesy of an sase would be appreciated. Let's keep the on-the-air testing to a minimum; no use dumping our garbage on somebody else's lawn!

ham radio



solid-state 2304-MHz converter

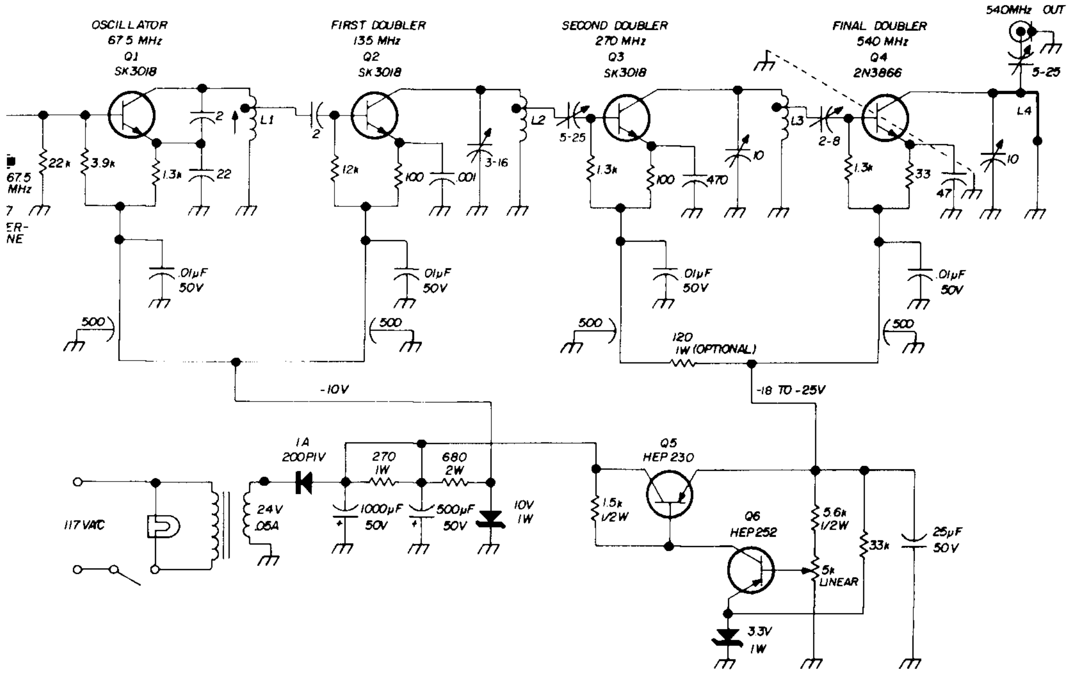
This high performance converter for the amateur 2300-MHz band boasts a noise figure of 8.5 dB when used with a low-noise 144-MHz i-f strip

Walter Stanton, K2JNG, Douglas Moser, WA2LTM, Dolph Vilardi, WA2VTR

There have been several articles covering converters and preamplifiers for the 1296-MHz amateur band, so amateurs have had several designs from which to select equipment for this band. Construction articles for 2300 MHz have been very scarce in the American literature, and most have involved designs which are often beyond the ability of the amateur to reproduce. With this in mind, K2JNG set out to design a converter for this increasingly popular band. His design had to be simple to construct and at the same time give adequate performance. Modification of the classic 1296-MHz design of W6GGV was the answer.[1]

The converter is presented as a practical unit to enable the amateur to operate on this band with reasonable success. This unit outperforms any of the wide-band surplus equipment usually available. Measurements of the converter's noise figure using professional laboratory equipment showed a noise figure of 12.5 dB with a 6-dB two-meter i-f, and 9.5 dB with a 3-dB two-meter i-f. Since noise figures of 2 dB are easily achieved in modern two-meter converters, an improvement of another I dB over these figures is readily possible.

Problems in building converters for these frequencies in the past have centered around the difficulty in obtaining local oscillator injection at the high frequencies involved without massive and elaborate local oscillators. With the advent of new inexpensive transistors and efficient low-power varacters, it is possible to obtain the necessary injection with a minimum of equipment, overall size reduction and simple construction. This



L1	11 turns no. 22 on ¼" slug-tuned form	L4	shim brass or copper, 3/8" wide, 23/32" long; length is in addition to tabs for soldering to capacitor and ground plane
L2	4¾ turns no. 18, 3/8" long, ¼" ID		
L3	2½ turns no. 18, ¼" long, ¼" ID		

fig. 1. Local-oscillator chain for the 2300-MHz converter. 540-MHz output is quadrupled to 2160 MHz with MV1622 varactor mounted in a trough line (see fig. 4).

converter is a collaboration of the three authors; WA2LTM was principally responsible for the oscillator chain, K2JNG and WA2VTR designed and optimized the multiplier and mixer trough-line components.

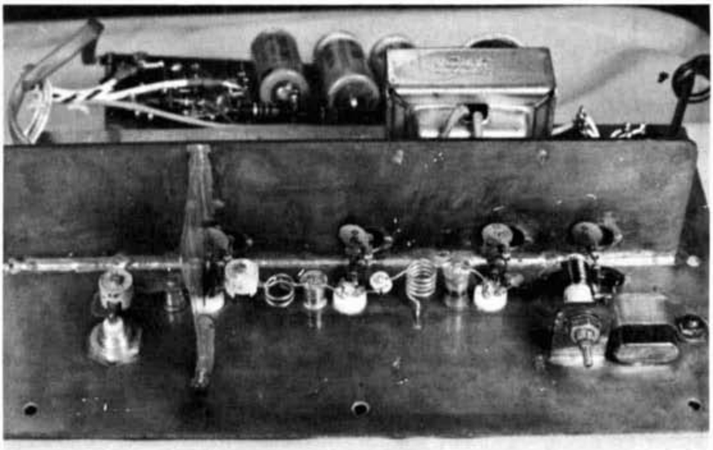
It should be pointed out that one of the major improvements was the HP2835 hot-carrier diode supplied by Hewlett Packard. This serves as a mixer and proved to be considerably superior to any other mixer diode tried at 2300 MHz. This diode is available for 90c from any Hewlett Packard sales office.

local oscillator

The local oscillator chain is transistorized for compactness. Although a variable regulated power supply is included in the description, it is not absolutely necessary. Any well-regulated supply capable of supplying 9 to 11 volts and 18 to 24 volts will adequately power the chain. This will provide approximately 250 milliwatts put at 540 MHz.

This 540-MHz signal is multiplied to 2160 MHz by the MV1622* epicap diode to provide sufficient injection at 2160 MHz to drive the hot-carrier diode mixer to 1 milliampere. Try any small varactor diode. Several versions of this converter have been built, and one of them uses a local oscillator injection frequency of 180 MHz which is multiplied in one step to 2160 MHz using a special abrupt-junction diode which is quite expensive and not easily available.

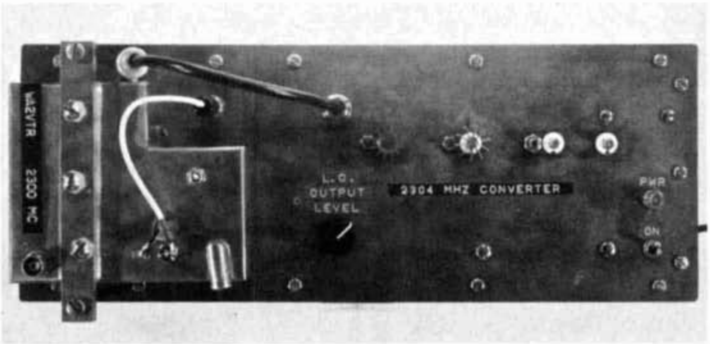
*Nearly any of the 1600 series diodes should work. The MV1622 is recommended. Some transistor junctions (base-emitter) will work as will any small abrupt-junction varactor rated at least to 8 GHz.



Construction of the 540-MHz local-oscillator chain.

Since the power required at 180 MHz is about 1 watt, many spurious signals are generated and this is not a recommended method of obtaining the required injection.

The local-oscillator chain as shown in **fig. 1** uses six inexpensive transistors. The circuit is a conventional common-emitter configuration. Oscillator Q1 uses a 67.5 MHz overtone crystal and Q2, Q3 and Q4



Top view of the complete converter shows layout of local oscillator components.

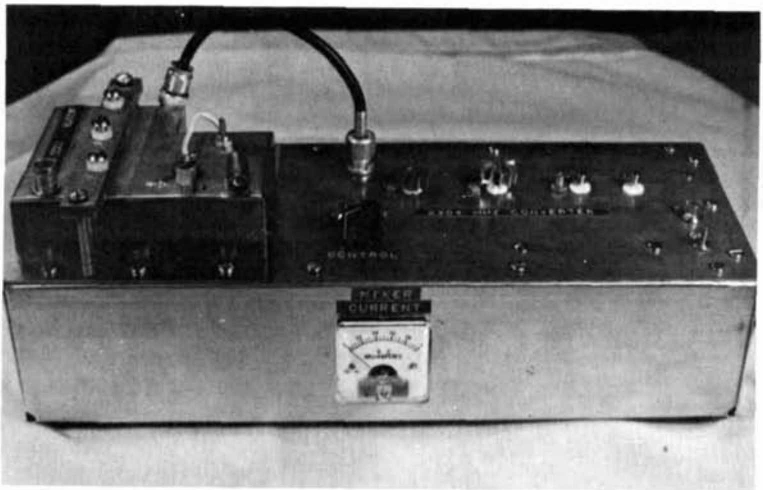
The photos and the schematic diagram of the oscillator chain should enable any experienced amateur to construct this portion without difficulty. It is recommended that the parts layout be followed closely, since it is important that parasitic and spurious signals be eliminated.

The trough line follows standard procedures and presents no major difficulties. For optimum rigidity use the heaviest brass sheet you can still bend. Flashing copper is not recommended, but good copper-clad material will work. Dimensions must be followed closely.

are frequency doublers, ending up with an output frequency of 540 MHz.

The supply voltage to Q1 and Q2 is regulated, while Q3 and Q4 have an adjustable supply voltage. The adjustable voltage allowed us to vary the output power of the local oscillator since it was not known how much mixer current would be obtained with the particular mixer diode used.

The circuit, as shown, can produce an approximate output power of 350 mW. If the variable coupling capacitors C1 and C2 are replaced by fixed values the



The complete 2304-MHz converter. Trough line is on top of chassis containing local-oscillator chain and meter for mixer current.

output may drop as much as 20% to 25%, but this should still be sufficient to drive the mixer diode to 800 μA.

It will be noted that coupling capacitor C3 has a low value for the frequency at which it is being used, but it was found that larger values made tuning more critical.

construction

Standard uhf building practices should be followed. Keep all leads as short as possible, especially the bypass capacitors. The local oscillator chain is built on double copper-clad board. Teflon sockets are used for all transistors to facilitate substitution and replacement. Shielding

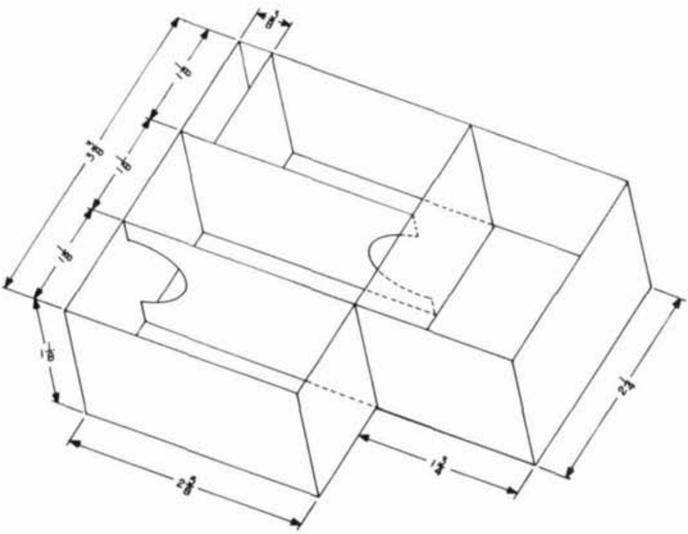


fig. 2. Internal dimensions of the 2304-MHz trough line. Material is sheet brass.

was necessary only at Q4.

Stability was improved by mounting the crystal inside the chassis so air currents would not effect the temperature of the crystal. It was found that grounding the crystal case was important for good oscillator stability. Johanson ceramic capacitors are used in the parallel-resonant circuits of Q2, Q3 and Q4. However, any good glass or quartz piston capacitors should work as well.

Several types of transistors were tried in the circuit. A HEP709 (equivalent for the RCA SK-3018) was tried at Q1, Q2 and Q3 with poor results. However a HEP-75 was tried at Q4 and found to be about equal in performance to the 2N3866. At Q5 and Q6, almost any inexpensive pnp transistors, with TO-3 and TO-5 cases respectively, may be substituted. This circuit has been duplicated three times by the authors and in each case it worked fine the first time it was tried.

the trough line

Brass should be cut and bent according to the dimensions shown. Hints on actual construction are presented in W6GGV's article or in the 1971 edition of the "ARRL Handbook" or "VHF Handbook" which describe the original 1296-MHz version. Techniques of soldering and construction are identical.

Since the HP2835 mixer diode is a pigtail version, the bypass capacitor for it differs from the original design (**fig. 5**). One lead of the mixer diode is bent to provide greater coupling into the signal trough. This is done experimentally after the converter is completed and aids in obtaining the best signal-to-noise ratio. Because the oscillator injection frequency is 540 MHz, the multiplier and filter troughs will not tune to a lower or a higher harmonic than the design frequency. Therefore, it is not possible to tune to any harmonic frequency other than the one desired (2160 MHz).

This simplifies tuneup, but in any case, it is best to start tuning with the capacitors screwed all the way in without touching the half-wave lines. It may be desirable to experiment with the antenna

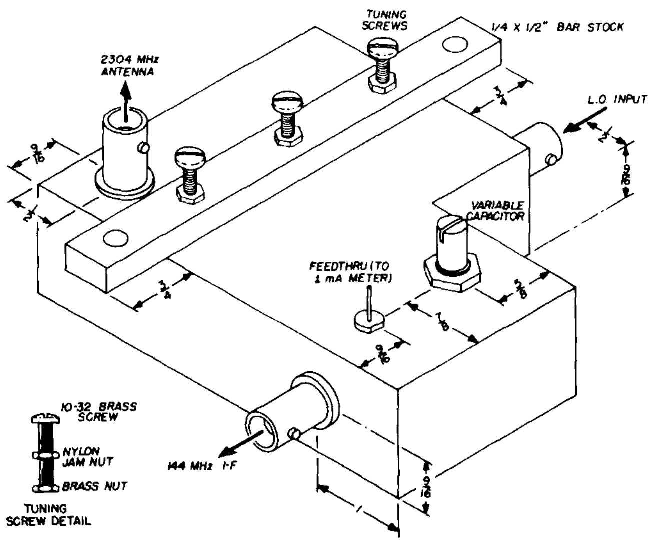


fig. 3. External construction details of the 2304-MHz trough-line converter. The ¼ x ½" bar stock is drilled and tapped for the 10-32 tuning screws used for C2, C3 and C4 (see fig. 4). Brass nut is soldered flush with the bottom of the tuning screw as shown in the detail. Nylon jam nuts hold the tuning screws in place after the converter is tuned up.

input coupling, but the tap shown appeared to be as good as any other coupling which was tried.

Lap or otherwise carefully machine the bottom of the trough flat. It is important that the trough be mounted solidly on top of the chassis, making good contact at all points between the trough and the chassis. Failure to do this will result in difficult and erratic tuning; also, the trough line will pick up stray rf which causes variations in crystal mixer current.

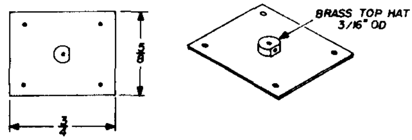
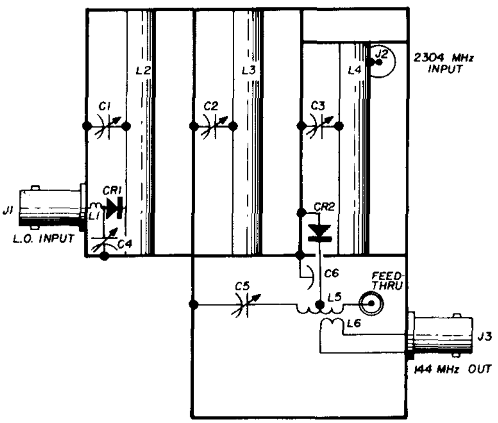


fig. 5. Construction of feedthrough capacitor C6 (see fig. 4). Brass plate is mounted on converter body with 4-40 nylon screws; use 0.005" to 0.01" Teflon between the capacitor plate and the converter chassis. The small brass top hat is drilled with a no. 60 drill and tapped on side for 8-80 set screw (for holding CR2). Alternately, CR2 may be soldered in place.

tuneup

Tuneup should proceed as follows. With approximately 200 to 250 milliwatts of 540-MHz signal injected into the trough line and a microammeter connected to the meter connection, tune the multiplier trough line for some meter indication. When this occurs, carefully tune the center trough (filter) for maximum indication. At this point, substitute a less sensitive meter, and tune both the multiplier and filter troughs for maximum indication; this should be somewhere in the vicinity of 1 milliampere. Peak up the L-network input to the varacter.

At this point, introduce a weak 2304 MHz signal into the signal trough. Connect the output of the two-meter i-f to a *good* two-meter converter which is in turn connected to the antenna input of a good communications receiver. Tune the signal trough for maximum signal. Tune the i-f tuning capacitor E for maximum S-meter reading. The input tap on the signal trough and the tap on the two-meter coil from the mixer may now be adjusted for best noise figure.



C1,C2,C3	10-32 brass tuning screws, see detail in fig. 3
C4	1-10 pF piston capacitor, miniature
C5	3-30 pF piston or air-variable capacitor
C6	bypass, see fig. 5
CR1	MC1622 multiplier diode
CR2	HP2835 mixer diode
L1	3 turns no. 30, 1/8" ID
L2,L3,L4	5/16" OD brass tubing
L5	10 turns no. 20, 3/8" ID, tapped for best noise figure
L6	2-turn link, position for best output

fig. 4. Construction of the 2304-MHz converter. Input signal from J2 is tapped 1/8 up from end of line L4. Feedthrough is 0.001 µF. Link coupling, L6, must be carefully adjusted for best noise figure; for more simple output arrangement, attach the cathode end of CR2 to the feedthrough end of L5, and use 0.001-µF capacitor from L5 to J3—tap capacitor down about 1 turn on L5. To tune 2287-MHz Apollo communications frequency, lengthen all trough lines by 1/16" and change local-oscillator frequency to 535.75 MHz (66.97-MHz crystal).

reference

1. H. M. Meyer, Jr., W5GGV, "A Crystal-Controlled 1296-Mc Converter," *QST*, September, 1962, page 11.

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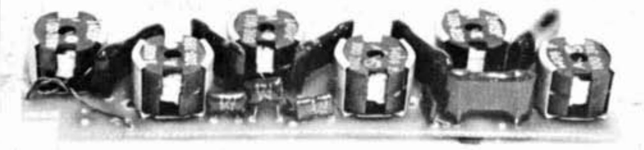

455-kHz filter for amateur fm

Ferrite pot cores in a tailored filter design

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Fm receiving techniques have been the subject of much attention in the amateur literature.[1-5] While some of these circuits use high-frequency crystal filters, many are dual-conversion circuits in which selectivity is developed at lower frequencies.[6]

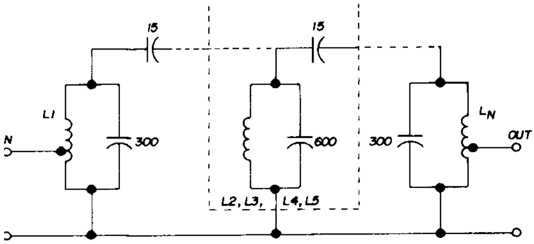
Crystal filters are commercially available, but LC filters are not. This article provides information for constructing a 455-kHz LC i-f filter with selectivity and impedance to meet fm receiver requirements.

Ferrite pot cores, although available for at least a decade, have not found widespread use in amateur radio circuits. An article by Hank Olson, W6GXN, describes pot cores and other ferrite and powdered-iron elements and how to use them.[7] The compactness and adjustability of ferrite pot cores, as well as their Q, put them ahead of the competition for fm receiver i-f strip application.

filter circuit

The basic filter is shown in **fig. 1**. Note that it has two LC end sections and up to four LC center sections. Less filtering is required by some detectors; others may require more, so the selectivity may be chosen by adding or deleting center sections.

The graph of **fig. 2**, which was plotted from a computer printout, allows you to select the number of LC sections, or poles, required for the desired selectivity.



L1,L_N	60 turns 9/41 or 18/44 Litz wire on ferrite pot core
L2	40 turns 15/41 or 30/44 Litz wire on ferrite pot core

See text pot cores suitable for this filter.

fig. 1. Filter circuit for fm receiver i-f strips using LC elements. Coils are wound on gapped ferrite (pot) cores. Theoretically, any number of center sections may be added to increase selectivity at the expense of increased insertion loss.

Eight LC pairs seem to be the maximum for amateur use.

The filter is designed for the popular amateur "bellyband," i. e., i-f circuits for

to narrow the passband slightly. This may be compensated by increasing the value of the coupling capacitors.*

Input and output impedances also may be tailored by choosing taps from **table 1**. These impedances need not be the same. The filter is an ideal circuit with which to transform impedances.

construction

The filter elements should be laid out linearly to avoid stray coupling. Pot cores in clamps are inherently well-shielded. Coupling between cores is not a serious problem, even when closely spaced. The pot-core clamps should be connected to the common side of the circuit.

tuning

Tuning the filter is simple if this procedure is followed. Note that tuning for maximum output *does not* yield the optimum filter shape factor. The method outlined was developed by M. Dischal, a pioneer in electric wave filter theory.

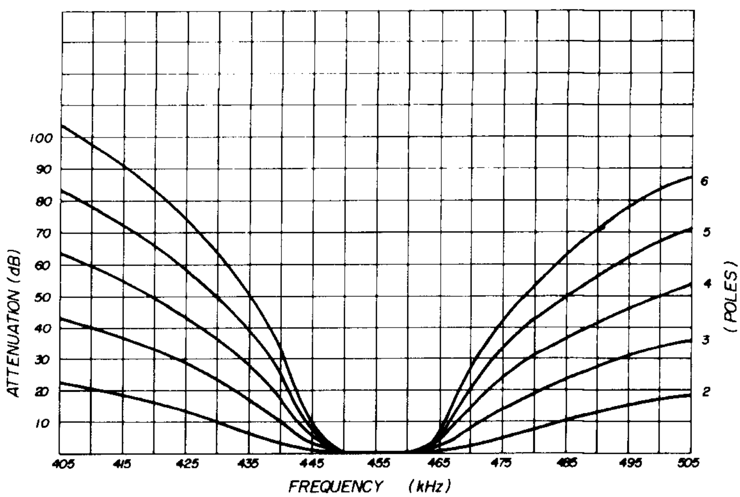
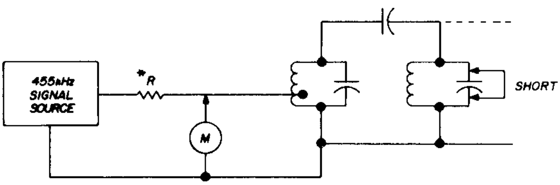


fig. 2. Selectivity curve for choosing number of filter poles for desired selectivity. Data were plotted from computer printout.

±7.5 kHz deviation. However, the circuit selectivity may be increased or decreased by increasing or decreasing the value of the 15-pF coupling capacitors in **fig. 1**. Adding several center sections will tend

*Filter insertion loss may be of concern to some readers. Author's computer printout shows filter insertion losses as follows: 2 coils, 0.77 dB; 3 coils, 1.5 dB; 4 coils, 2.27 dB; 5 coils, 3 dB; and 6 coils, 3.77 dB. *editor.*

The equipment required need not be expensive nor exotic. A 455-kHz signal is required. Since the signal need not be tuned or swept, a crystal oscillator is ideal (perhaps a Motorola test set). The signal-source impedance should be similar to the filter input impedance, but it is not critical. If the signal generator is a low-impedance device a series resistor may be added. If the signal generator is a high impedance unit, then a shunt resistor will be needed. The meter must be capable of reading the output of the signal source with about 30 dB additional loss. It's possible to use an existing i-f strip with an S-meter. A sensitive dc meter may be used with a crystal diode as a detector. The meter is used only as a peak and null detector.



*RESISTOR IF NEEDED TO MAKE THE GENERATOR IMPEDANCE SIMILAR TO THE FILTER IMPEDANCE.

fig. 3. Instrumentation for tuning filter. Resistor R may be required to match signal generator impedance to that of filter, as explained in text.

Connect the signal source, filter, and meter as shown in **fig. 3**. Adjust the frequency to 455 kHz and forget it. Short across the second coil and tune the first coil for a peak. Short across the third coil and tune the second coil for a null. Continue to move the shorting clip down the line, and tune the immediately preceding coil to peaks and nulls alternately. The last coil is tuned with no shorting clip.

Should there be difficulty in tuning a coil, remember that the above equipment setup may be used to tune a single coil by peaking the coil. If a variable oscillator is used, it may be tuned to find the circuit resonant frequency. A grid-dip meter is useless with pot cores.

The ferrite pot cores are available from several sources. Each of the following cores was tried with similar results:

Ferroxcube, part no. 1408 CA 100 3B9.

table 1. Impedance vs tap turns.

impedance (ohms)	no. turns
25k	no tap
10k	38
5k	27
2k	17
1k	12
500	8
50	2

Ferroxcube, part no. 1408 CA 100 3B7.
Magnetics Inc., part no. 1408 AL100 'D' material.
Indiana General, part no. TC7-01.

Be sure to specify an adjustable pot-core assembly with the least expensive clamp and a single-section bobbin.

This filter may also be constructed more economically, but with slightly reduced performance and much more difficulty in tuning, by using powdered-iron toroids. The T80-3 core would be a reasonable choice. Variable trimming capacitors may be used for tuning.

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6. Vaceluke and Price, "An FM Receiver for Two Meters," *ham radio,* September, 1970.
7. Olson, "How to use Ferrite and Powdered Iron for Inductors," *ham radio,* April, 1971.
8. Mole, *Filter Design Data for Communications Engineers,* E. and F. N. Spon, Ltd.

ham radio

improved two-meter preamplifier

An easy-to-build non-neutralized two-meter preamp

Jerry Vogt, WA2GCF, 182 Belmont Road, Rochester, New York 14612

As any writer knows (and I am a technical writer by trade), the hardest part of writing anything is just getting started. I've been meaning to write an article on the subject of two-meter preamps for quite some time, and I've never been able to think of a good gimmick to start it off with. I like to think that communications, to be effective, has to be somewhat like one person talking to another, with nothing holding you back. The constraints of writing military technical manuals prevents much of that type of thing, but I think that a ham journal can be an exception. So here is a little bit of my thoughts on the subject of preamps. Of course, everything you ever read has to be taken with more or less of a certain seasoning ingredient, so here is some background.

Not being a design engineer, I make no great claims as to scientific discoveries on preamps. Personally, I don't believe in a lot of the magic I read about; however, there are good and bad points which can be weeded out from various circuits which come along. Having been involved in a club project to build preamps, I have experimented with several circuits over the last few years; and I came to a surprising conclusion, which will be the subject of this article.

brief history

To review some recent innovations, and some of the circuits of the past as well, I should start with the frame-grid tube. That was the first new thing to come along in quite a while, for receiver front ends, when it was introduced several years ago. It boasted high Gm and low noise figure. Of course, there was the old 417A which did a pretty good job at that time, but you had to scrounge them from your friendly telephone company because you couldn't afford the price of a new one. I guess that I still didn't know for sure what Gm and low noise figure meant, but everyone said they were good to have; and we still hear it today. Except, now we take those features for granted.

Then, along came the nuvistor. It supposedly had the same features, only more so. But then, it had the drawback that all tubes have, namely that it takes extra wiring and power, that it has to warm up, and that it will wear out. It did make a pretty good front end, however. Then came bipolar transistors.

The appeal of getting away from tubes was very strong, and everyone wanted to make a completely solid-state receiver. Like a lot of new innovations, it was a long time growing up. Unfortunately, quite a few terrible front ends were built just for the sake of using transistors. The biggest problems were intolerable overload characteristics and poor noise figure. Several years passed and we finally got the field-effect transistor. This solved the overload bug, and before long, the 2N4416 was introduced, which gave us good noise figures.

So that was it for awhile; but alas – what had we learned from all the work that our predecessors had done to make an easy-to-duplicate circuit with good operating characteristics? Not a darned thing! Article after article came out with single, neutralized field-effect transistor amplifiers in converters and preamps. Baloney! I think back on the many occasions during which I had built converters and preamps and practically tore my hair out trying to neutralize the darned things. I don't have a single good thing to say for them. They were inexpensive and they were simple to build if you could figure out what value of inductance should cancel the output-to-input capacitance, but they certainly didn't tune up well. And afterward, if you changed the line voltage the feedback capacitance would change also. Change devices after a failure. All your values must be changed to make it play again. I built 25 preamps for our club with such a circuit. I think I aged ten years. Never again.

Then, along came the dual-gate mosfet. That is another subject. I like to call them moose-fets. I guess I kind of feel sort of cold about a transistor that blows before I even get it in the circuit. I heard so many tales about mosfets blowing that I've never tried them. So I won't criticize their performance. They probably work very well once you solder their delicate little legs to your board, but you couldn't prove it by me.

There are probably many readers who agree that one branch of Murphy's law says that even on a day with 101% relative humidity, you will have sufficient static electricity to blow every mosfet you even think about touching. Of course, there are proper methods to prevent said disaster from ever occurring; but that's kind of like picking up broken glass. There is no excuse for being cut, but you still get nervous. So much for slandering "the best thing yet in semiconductors." What can we learn from all of these things?

design criteria

I set out to design a good compromise preamp. One that I could mass-produce without getting ulcers, and one that I could recommend for others to build. So I sat down to find out what I wanted. I didn't want tubes, for obvious reasons, but they had worked well by past standards. I didn't want neutralized junction fets – at least, not any more! I didn't want ticklish little fellows which blew

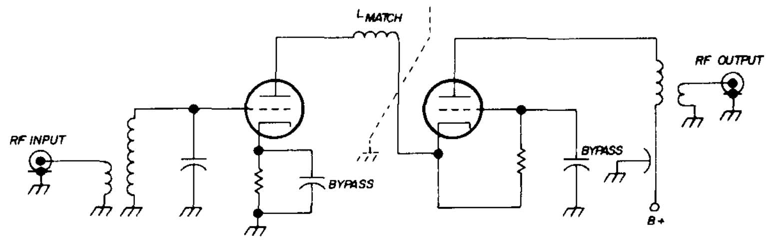


fig. 1. Classic vacuum-tube cascode amplifier for vhf receivers.

before I got them in the circuit; and I was too proud to think that I was going to get sucked into playing little games to keep the little devils from blowing up to defy me. So I referred to my library, which has many old books with not-too-well hidden secrets. Of course! Why didn't I think of it before?

the jfet

I set out to design a cascode preamp with jfets. A natural! Jfets are fine devices, readily available, and come in many flavors. Use a cascode circuit like in the days of tubes (you remember what those were) and you don't have to neutralize. Jfets have all of the required characteristics: good gain and low noise figure to hear with, and good square-law characteristics so you don't hear the taxi service or fm broadcast station two blocks away. Some educated types even admit now that it's possible that mosfets are only better for preamps because they are inherently cascode. Is that all? We can do that ourselves. Of course, if you want agc, then dual-gate mosfets are the thing. But, who needs agc? Ever looked through designs for the new ham transceivers and the commercial transceivers for business band? They don't use agc; not as a rule.

design hints

I am a great circuit snatcher. I never build anything exactly the way it was done in an article or in a piece of commercial gear. But I snatch a lot of ideas. I combine a stage from some past article with a few circuits from commercial radios. And I do a lot of homebrew work. At least, that's what my wife said the last time I saw her. Now, I want to let you in on something ironic. One day at the plant I was belly-aching to one of our better design engineers about all the grief in duplicating the ham-type circuits. The commercial ones are usually easier to copy. I told him exactly what I thought about neutralizing and combining functions in one stage (like oscillators and multipliers). He made me stop and think. He matter-of-factly designs things like a solid-state am-fm *kilowatt* 150-MHz power amplifier for a living. He told me that the biggest mistake that hams make in selecting circuits is that they count parts. They don't count labor or repeatability, just parts. This is probably due to the traditional pocket-book problem. But be practical! I have been using some of his ideas awhile, and I want to tell you that the pleasure is back in homebrewing for me now.

The philosophy is based on two premises. First, when designing a circuit, use more parts if that's what it takes to make it easier to build. Consider that your time is valuable. Don't waste it trying to figure out how to save five cents on a resistor. Even if it costs you an extra buck for the second transistor, it sure outweighs wasting a whole afternoon trying to make a silk purse out of a sow's ear. Secondly, transistors don't have all that much gain that neutralizing should be necessary. Mismatch a little. Throw away that last ounce of gain. Use more stages or devices instead. You'll be a better designer for it.

In industry, it is mandatory that you don't depend on every bit of gain. You have to consider other characteristics and repeatability. My friend's basic philosophy is, "If it oscillates, swamp it." In other words, if you have so much gain that it takes off, load it down with resistors until it stops. Then, if you need more gain, add another stage. If you need more selectivity, use a multi-pole filter or a different type of filter.

cascoded jfets

Having proven to myself that these premises do hold true, I took exactly that approach in designing the cascode jfet preamp. I didn't worry too much about noise figure and overload resistance. These are difficult to measure quantitatively. They pretty much take care of themselves if you use the traditional rules and use good devices. The biggest problem was how to make a cascode circuit.

For those who have forgetten what the old tube-type cascode circuit looked like, refer to **fig. 1**. I won't bother to explain all the details of circuit design; you can get that out of any old handbook. Basically, one stage acts as a voltage amplifier, and one acts as a current amplifier. The first tube's plate circuit is loaded down heavily by the cathode of the second. Therefore, the unneutralized common-cathode first stage doesn't oscillate. The grounded-grid second stage, of course, doesn't oscillate either. The two act together to give you about the same overall gain that a neutralized single-stage amplifier would yield.

Trying to visualize what the equivalent circuit in field-effect technology would be brings up an interesting point. Tubes of the type used in such circuits were usually of the close-spaced element design, apparently to obtain the high Gm desired. Therefore, it was necessary to use about half the normal B+ voltage of conventional tubes. That was great, though, because two tubes should be connected in series anyway to make a cascode circuit; so they were also connected in series for dc operation.

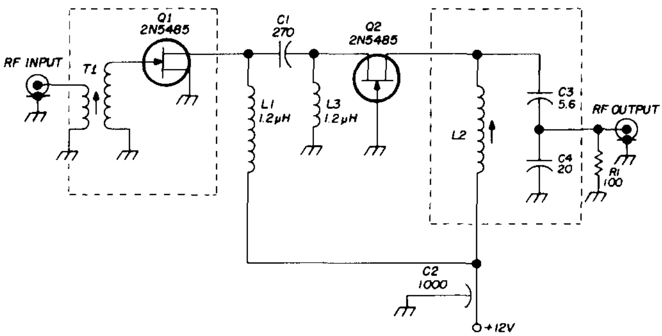


fig. 2. Schematic of the improved jfet preamp. Inductance values are discussed in the text.

Not so with fets. They work just fine on 10 to 15 volts, so why use a dc-series configuration? Indeed, the problems of determining the correct biasing method are also complex. The solution was to use an ac-cascode circuit. Further simplification was discovered that made biasing even easier. Selection of the 2N5485 resulted in obtaining optimum operation with no bias at all. No series source resistor is required, and therefore, no bypass is required in the source circuit.

actual circuit details

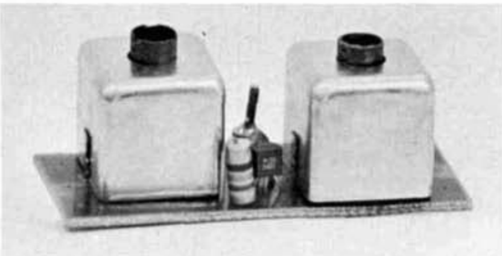
So much for my editorializing! The finished design is shown in **fig. 2**. The preamp is an ac-coupled cascode jfet amplifier. It provides 16- to 25-dB of actual gain between terminals. Empirical results (meaning that about 50 of them are already out in the field) seem to indicate that they work well. They improve reception on virtually all receivers.

The older receivers, of course, use tubes; and good low-noise gain to swamp out the noise in the present front end of the receiver is bound to make an improvement.

Oddly enough, even the latest solid-state equipment on the market today can be improved, simply because the manufacturers either cheapen the design to be competitive or, in the case of commercial radios, the manufacturer also has to meet a cross-modulation spec. In the case of the latter, radios are sold for use under unknown rf-pollution conditions, so the manufacturer is watching out for selectivity too, and is willing to sacrifice a few microvolts of sensitivity. In most cases, the commercial receiver will listen to a quarter kilowatt up on a prime antenna location, so who cares.

Of course, you don't get anything free. You do sacrifice some overload resistance by driving the front end harder with a preamp. In most cases, though, the somewhat increased overload susceptibility is negligible, especially in mobile sets.

Refer to **fig. 2.** The input of the preamp uses transformer coupling, with the secondary tuned by the 5-pF input capacitance of the fet. Coupling is such that a 50-ohm source resistance loads the gate of the fet to approximately 1000 ohms, a typical design parameter. To provide ac coupling to the next stage, the drain of the first stage is shunt fed through L1, a 1.2-μH choke. The signal is coupled to the source of the second stage through a bypass-type capacitor (C1), and the source of the second transistor is tied to ground for dc through L3.



View of the completed preamp with coil shields in place. L2 is at left, L3 in the center (looks like a resistor) and next to that is Q2 and T1. Directly behind Q2 is C1 and C2.

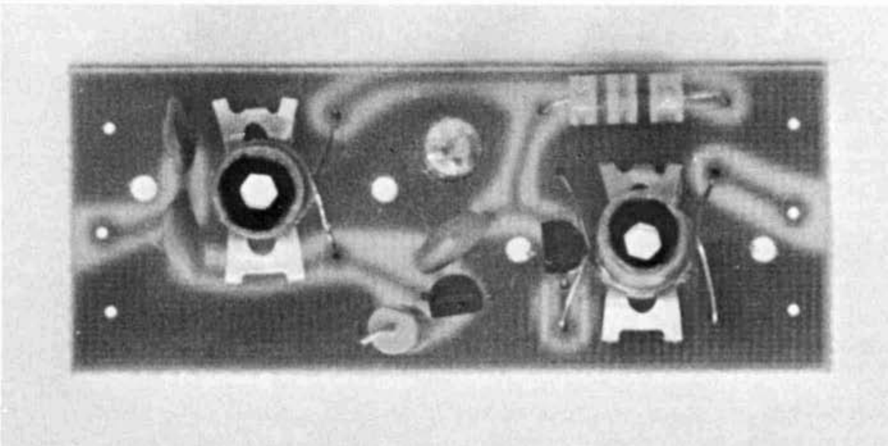
As previously mentioned, the second transistor, being fed at the source, loads down the drain impedance at the first transistor. The second stage runs as a grounded-gate amplifier, and its drain load impedance is established by a capacitive divider across the output coil, which is tuned by a combination of the divider (C3-C4) and the 2-pF output capacitance of the device. The capacitance ratio is set up to provide a load impedance at the drain of approximately 5000 ohms, another typical design parameter for such preamps. The B+ input to the output coil is fed through a bypass capacitor consisting of a solder-in feedthrough capacitor. This also provides a convenient tie point for connection of the B+ wire.

A feature of this design is the simple tuning after construction. Because no neutralization is necessary, and because the input and output coils are completely isolated, tuneup is a simple matter of peaking the coils. Of course, that depends on the proper range of the coil to begin with. In the model illustrated, the coils consist of four turns of number-22 Solder-eze wire, each with a one-turn input link on the input coil. Coil forms consist of paper-phenolic impregnated with silicon wax. Tuning slugs are of the ¼-20 type, 3/8-inch long, with an internal hex thru-slot to accommodate a standard J-tran tool. Slug material is iron-8. Special Tinnerman coil retainers are used to hold the forms in the printed circuit board, and special ¾-inch coil shields are used to cover the coils and some of the other parts as shown in the photo. Don't worry about the special parts, however, since I have arranged to make them available.*

installation

Each end of the board has two holes provided in the ground plane. One hole at each end is used for mounting, and the other is used as a ground connection for the coax input or output cable. Thus, the unit can either be mounted on standoffs on opposite corners, or it can be mounted with L-brackets attached to two holes on the same side. The latter method works out well in the Motorola tube sets which have rectifier cages. The preamp can be hung on its side from two brackets installed at the top of the cage which is located near the receiver input connector.

As you may be aware, the stripped and separated ends of a piece of coax have inductance, as does any straight wire. Keep the stripped ends extremely short to avoid loss and pickup of noise and stray rf. A good method of connection for the braid is to wrap the exposed braid end with number-22 bare wire, right around the cable. Tie or solder the ends to secure them around the cable, and then solder the bare wire to the board.



Components side of the printed-circuit board with coil shields removed. L1 looks like a resistor in the upper right corner; C4 is above C3 all the way on the left. The board, with an overall length of only 2½ inches, is very straightforward.

On the subject of power, any source of filtered 10 to 15 volts can be used. Gain is relatively flat above 10 volts, so regulation is unnecessary. Also, tuning is not particularly affected with changes in voltage as is usually the problem with the neutralized types. Power connection is made to the top terminal of the feedthrough capacitor. (Note that the cold end of the winding on L2 is soldered to the board and continued on to be soldered to the bottom terminal of the feedthrough capacitor.)

A word of caution is in order. One of the previous builders, figuring the current drawn by the preamp as being about 5 mA (which it is), decided that he could use a dropping resistor to reduce the receiver's 200-volt supply to 12 volts. His calculations were fine, but he should have

*The following are being made available in conjunction with this project. A complete parts kit, including the G10 pc board already drilled, is available for $6.00 postpaid. Completely built preamps, tuned to any frequency in the 144-172 MHz band, are available at $10 postpaid. Quantity prices are available to clubs to allow clubs to make a profit. Factory built preamps can be returned for repair (prepaid) for a fixed repair charge of $3, anytime during the first 90 days. Contact HAMTRONICS, 182 Belmont Road, Rochester, New York 14612.

used a zener diode in addition to the resistor. The transistors failed, of course, due to high voltage surges. Another word of caution, which should be obvious, is that you can't transmit through your preamp. Remember that when you outboard a preamp on the back of your new Japanese transceiver!

tuning

After testing your preamp on a signal generator and a 50-ohm load, you should repeak the coils slightly when the unit is installed in the set. At two-meters, a slight amount of reactance in your external circuit will detune the preamp slightly. But, being a cascode design, retuning is very simple; you need not worry about oscillation. (You may notice that no attempt was made to keep you from tuning it; such is not the case with a popular preamp which is soldered shut at the factory to prevent the neutralized circuit from taking off when you play with it.)

The cascode circuit shouldn't oscillate. However, remember that any circuit exposed to another circuit at the same frequency may cause the combination to oscillate. Some of the inexpensive radios on the market today (and I don't know how they do it) have absolutely no shields around coils in the frontend. This may be fine if you don't have a lot of gain (which may be the case); but if you add a preamp anywhere near the frontend coils in such a unit, I'm afraid that you will have to provide a shield box around the preamp to prevent pickup from the receiver's coils. Otherwise, you may find that the whole set takes off when you upset the apple cart by adding your preamp.

Well, that's the story of what you go through to design a preamp. Whether you build one or not, I hope that some of the hints and kinks will help you in building your next transistor rf project. If you have questions, feel free to write to me. Please enclose a sase, and I will try to jot down a few notes to help you if I can.

ham radio

reciprocating detector

This novel circuit has many advantages over conventional detectors since it automatically adjusts its bfo level in proportion to the average signal level

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A paper presented at the International Communcations Conference[1] during June 1971 described a synchronous detector which should be of interest to amateur radio operators. The circuit was designed by R. S. Badessa while working on a project at Massachusetts Institute of Technology. Mr. Badessa made further investigations through support given by Damon Corporation where we both are employed.

The circuit was primarily designed for double-sideband, suppressed-carrier (dssc) detection. It has been used in several communication receivers as a second detector and exhibits features which make a superb demodulator for CW, a-m, dsb and ssb.

The name, "reciprocating detector," seemed appropriate to the inventor who described the detector's operation thus: "Because a suppressed carrier wave assumes either of two diametrically opposite phases in sequence, the detector channels these into a smoothly rotating reference vector."

The design features a carrier-synthesized reference signal and therefore does not require an external beat-frequency oscillator. Because of other characteristics of the circuit, impulse noises are rejected. Also, the average reference level is proportional to the average signal level. The CW DX chaser and moonbounce enthusiast can appreciate the desirability of this important feature of the detector when he remembers what bfo hiss noise does to a weak signal as it goes into a fade.

circuit operation

To aid in a brief discussion of the circuit operation refer to **fig. 1**, a signal flow diagram. An rf signal from the receiver i-f system is presented to a half-wave diode detector. The detector provides a signal current source which is fed to an electronic bidirectional switch. The two outputs of this switch are directed into the inputs of a differential amplifier. The amplified output is fed into a narrowband i-f filter and a low-pass filter. The narrow-band filter, approximately 500-Hz wide, is coupled to a phase splitter which returns the outputs to the inputs of the bidirectional switch; this filtered signal is the reference. The low-pass filter allows the audio component to pass into the receiver audio system.

Previous experiments allowed the investigator to choose, by means of a selector switch, existing detectors in a Collins 51S1 receiver or the reciprocating detector. Later, simultaneous records were made from each detector for comparison.

The circuit diagram, **fig. 2**, is for incorporation into a Drake R4A receiver. It is possible to use the same circuit in any other communication receiver with appropriate modifications to the filter FL1.

The modification to the Drake R4A involves rewiring the CW/SSB/AM selector switch. All changes are temporary; this allows the receiver to be restored to its original state. At W1SNN the detector was permanently installed in the R4A. The crystal switch, designated S4A/B in the Drake Manual, located on the left side of the R4A receiver, was disconnected from the vfo/crystal circuitry. The vfo was permanently connected, freeing the switch used for S1. A dpdt toggle switch can be externally mounted in a convenient location on the operating table if you don't want to use S4A/B for this modification.

The schematic diagram shows the rewiring of the CW/SSB/SW switch. It should be wired exactly as shown. Otherwise, problems with the receiver bfo will result. The bfo must be off when the reciprocating detector is switched in or a steady beat will be heard due to bfo leakage into the receiver i-f circuits. This switch is designated S2 rear in the schematic diagram and in the Drake instruction manual.

The power supply circuit shown in **fig. 3** provides the required voltages. The voltages are higher than called for in the diagram. It is important that the voltages be very nearly the same level; in excess of six volts is permissible, provided that the two are equal. They should not exceed 10 volts, however.

Resistor R24 must be included to complete the voltage drop through the voltage divider when the bfo is removed. Therefore, when the reciprocating detector is switched in the connections to S1 must be made as shown.

The direction in which the windings for FL1 must be wound is important. If they are in the wrong "sense" the filter will not operate.

tuneup

FL1 has a small adjusting slug which tunes the filter to the center frequency, 50 kHz. Put the CW/SSB/AM switch on ssb and S1 on the receiver's own detector; tune in an ssb station, and switch S1 to the reciprocating detector position. If the voice sounds higher or lower in pitch than

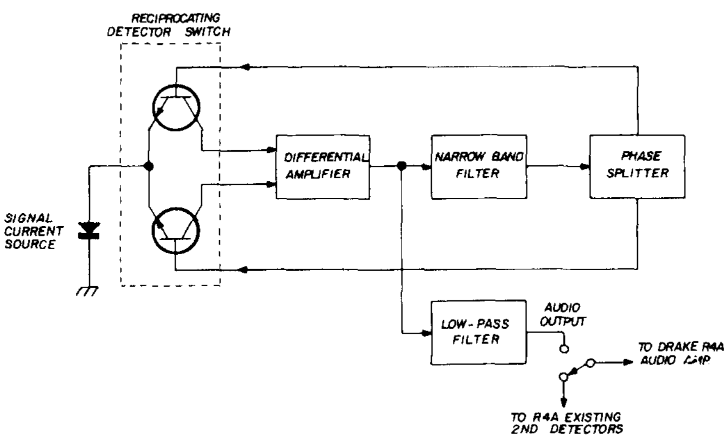
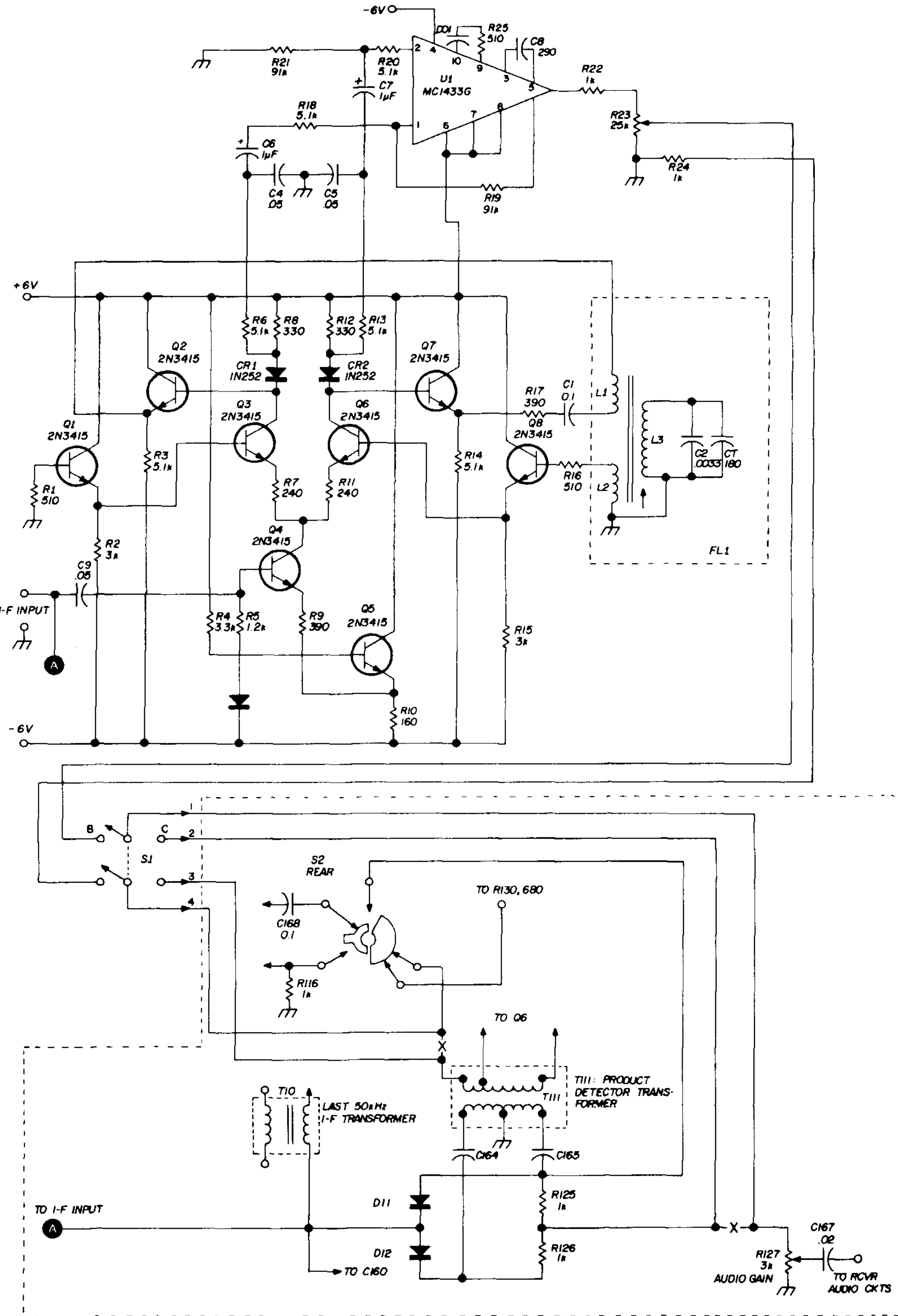


fig. 1. Block diagram of the reciprocating detector.



-6V
R21 91k
R20 5.1k
C7 1μF
R18 5.1k
C6 1μF
C4 .05
C5 .05
C01
R25 510
C8 290
U1 MC1433G
R19 91k
R22 1k
R23 25k
R24 1k
+6V
R6 5.1k
R8 330
R12 330
R13 5.1k
CR1 1N252
CR2 1N252
Q1 2N3415
Q2 2N3415
Q3 2N3415
Q4 2N3415
Q5 2N3415
Q6 2N3415
Q7 2N3415
Q8 2N3415
R1 510
R2 3k
R3 5.1k
R4 3.3k
R5 1.2k
R7 240
R9 390
R10 160
R11 240
R14 5.1k
R15 3k
R16 510
R17 390
C1 0.1
C9 .05
L1
L2
L3
C2 .0033
CT 180
FL1
I-F INPUT
A
-6V
S1
B
C
S2 REAR
C168 0.1
R116 1k
TO R130, 680
TO Q6
T111: PRODUCT DETECTOR TRANSFORMER
T111
T10
LAST 50kHz I-F TRANSFORMER
C164
C165
D11
D12
R125 1k
R126 1k
TO I-F INPUT
TO C160
C167 .02
R127 3k AUDIO GAIN
TO RCVR AUDIO CKTS

normal, adjust until the voice pitch sounds correct, by switching back and forth between the two detectors. Adjustment is complete when no difference in voice pitch is noticed. R23, an audio gain trim potentiometer, can be adjusted at the same time, rocking the switch in the same manner; this pot will set the audio output level of the reciprocating detector the same as the receiver detector output level.

operation

When the detector installation adjustment is complete, you can compare signals by simply flipping switches. At first very little difference will be noted in the comparison between detectors.

On 160 meters, with the receiver a-m detector switched in and the noise blanker off, an a-m signal was tuned in. Some interference from a Loran station was present. Switching to the reciprocating detector a beat signal was heard; re-tuning the signal very slightly produced a zero beat which has a very narrow lock-in range. No difference in audio quality could be noticed, and the Loran signal was greatly subdued.

Switching in the noise blanker eliminated the Loran signal pulses completely; switching back to the receiver a-m detector with the noise blanker on, the pulses were subdued but very difficult to copy through. The reason the reciprocating detector eliminated the Loran pulses is because the reference filter Q is too high to allow the filter to "build up." Ignition pulses, static crashes and flat-topped linears are treated in the same way.

Tune in the Canadian Standard Time Signal or an overseas broadcast (plenty of them on 40 meters). The receiver detector should be on a-m. Notice when the signal fades that sometimes the modulation will become distorted; this is selec-

fig. 2. Reciprocating detector circuit, showing its installation in a Drake R4A communications receiver. Windings of filter FL1 are wound on Ferroxcube pot core and bobbin type 1811CA250-3B7; L1 is 5 turns no. 32 enameled, L2 is 43 turns no. 32 enameled, L3 is 109 turns no. 31 enameled. CT turns L3 to 50 kHz.

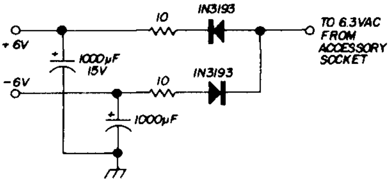


fig. 3. Simple power supply for the reciprocating detector.

tive fading. Switch in the reciprocating detector and the distortion will disappear.

Next try CW. Look for the very weak ones and notice that when fades occur on the conventional detector, the signal disappears. Switch to the reciprocating detector, it's still there! This is because the reciprocating detector produces its own beat signal which is proportional to the received signal level. When the conventional detector is on, its bfo level is constant, and so is the low level hiss it produces, acting as a mask for the weak signal.

Sideband operators will appreciate the reciprocating detector because adjacent channel signals which chop up a QSO because they are near the i-f passband are now subdued. Flat-topped linears and lightning noises are almost eliminated by the reciprocating detector; the latter will be completely out of the picture if the noise blanker is used as well.

summary

This unique circuit is well worth the work that has gone into its installation. It is hoped that other amateurs will try it and perhaps find some features we missed; or try to shoot down those reported. To Steve Badessa goes my thanks for the circuitry and his help in incorporating it in my receiver. To my wife, WA1IKR, who typed and typed and typed, many thanks.

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1. R. S. Badessa, "A Communications Detector with Signal-Synthesized Reference," IEEE International Conference on Communications, Montreal, Canada, June, 1971.

ham radio

monitoring ssb signals

Ssb signal reports based on monitor scopes are misleading if the signal is received via typical narrowband i-f strips

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Although available for some time, little information is known to have been published[1] on the requirements for evaluating received ssb signals using oscillographic techniques.

The purpose of this article is two-fold: (a) to dispel the misconception on the part of many amateurs that accurate appraisal of ssb signals is possible when such signals are received on modern equipment with relatively narrow passbands, and (b) to describe a monitoring method using oscillography that yields an accurate representation of the received signal.

A plug-in module is described for use in an empty filter socket in the Collins 75A4 receiver to increase i-f bandwidth so that a true representation of the signal may be observed and analyzed. No other modifications are necessary to the receiver; that is, the existing socket for the mechanical filter is left untouched and the module is merely plugged in — no holes; no rewiring.

The Collins 75S3 receiver also may be used in conjunction with the signal-analysis methods described here. The plug-in module isn't necessary, however i-f transformers T4 and T5 must be tweaked slightly to obtain the required response. The monitoring method is adaptable to other receivers as well — the only requirement is that their bandwidth pass the signal components necessary for accurate analysis.

bandwidth considerations

According to accepted engineering practice, a bandwidth at least ten times the modulating frequency is necessary to produce a square wave. Such bandwidth allows one to evaluate components of the signal to its tenth harmonic. Relating this fact to popular ssb receiving equipment, which has a passband of 2.1-2.5 kHz, it is obvious that a bandwidth of 21-25 kHz would be necessary to provide meaningful information on ssb signals. Stated differently, a square wave of only 200 Hz would be faithfully reproduced when received through a 2.1-kHz passband.

monitor system

With the above in mind, I decided to

devise a method to accurately evaluate signals received on my Collins 75A4 as well as on the popular 75S3. In the 75A4, a broadband i-f system was installed,

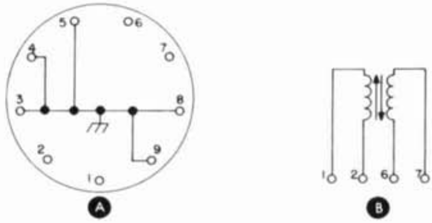


fig. 1. Sketch at A is existing wiring at filter socket XFL in the Collins 75A4 receiver. Broadband i-f transformer, B, may be plugged directly into the filter socket.

consisting of a simple plug-in module (**fig. 1**). The plug-in module consists of a surplus Vanguard 22-331-331P double-tuned i-f transformer soldered into a Vector type K1.434 9-pin tube socket.

The i-f transformer was adjusted for a 20-kHz bandwidth at the 6-dB points using an HP-8601A sweep generator and a Tektronix 7704 scope. With this transformer plugged into a vacant mechanical-filter socket of the 75A4, a broadband monitor system for checking ssb signals is readily available to anyone with an oscilloscope of moderate bandwidth; i. e., 500 kHz or more.

Any small 455-kHz double-tuned i-f transformer may be used, such as the Miller 12-C30. The i-f can should be set up using a sweep generator; however, you can accomplish this on a point-to-point basis with a signal generator and oscilloscope, since the response doesn't have to be perfect.

system constraints

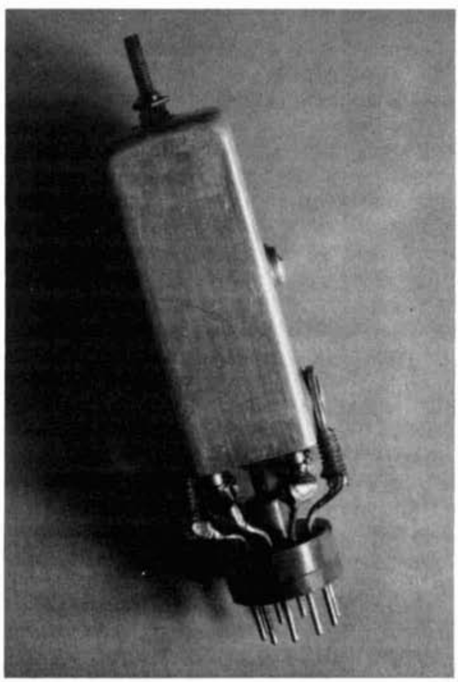
Once the module is installed, the receiver will sound like a party line, with many signals audible, so only the loudest may be evaluated because of the signal-to-noise ratio and interference problems. During my investigation I noted that, in the absence of a mechanical filter, sufficient signal leakage existed around the socket and switch so that very strong signals degraded the true i-f selectivity.

One might immediately ask, "Why do all this when you can look at the output of the second mixer, which feeds the filters, as in most modern receivers?" The reasons are that the signal levels at this point are relatively low; and, more importantly, the reflected input impedance of the filter actually limits the bandwidth so that much of the real value of the system is lost.

In the 75A4, sample the signal to your scope at the plate of V8 with a small capacitor. Retune L27, using the internal 100-kHz internal calibrator. Don't forget to repeak L27 with the system removed, or if the coax isn't terminated.

using the 75S3

Collins 75S3-series owners are fortunate in that the foregoing has been essentially accomplished in the original design. I-f transformers T4, T5 replace a mechanical filter for a-m selectivity. The bandpass of T4, T5 is called out in the



The plug-in module for the 75A4.

instruction book as 5 kHz with unspecified limits. The response of this circuit was measured with a Heath SM105A counter at the receiver vfo, with the S-meter as a readout. The measured response was 5 kHz at the 6-dB points. By readjusting the top and bottom slugs on T4, T5, bandwidth may be extended to 10 kHz at the 6 dB points. This can be done with the aid of a sweep generator or by an approximation using the receiver S-meter and internal crystal calibrator as the signal source.

The 75S3B receiver I checked had almost exactly 6 dB per S-point at S9, as measured using a Kay Lab 6-dB pad. With the 5-kHz bandwidth, in conjunction with a Central Electronics MM-2 monitor scope, absolute correlation was obtained with a slightly flat-topped ssb test signal using an MM-2 scope for direct transmit monitoring.

As expected, no limiting was observed in the 2.1-kHz bandwidth at the same time. From this it is concluded that, while a wideband system is desirable (i. e., more than 5 kHz) it is not mandatory since the observed limiting is relative. This is further substantiated by the fact that, with the relatively narrowband 2.1-kHz filters employed in the transmitters, many of the distortion products will fortunately fall outside the filter passband. Therefore, only the more severe cases of limiting will be observable.

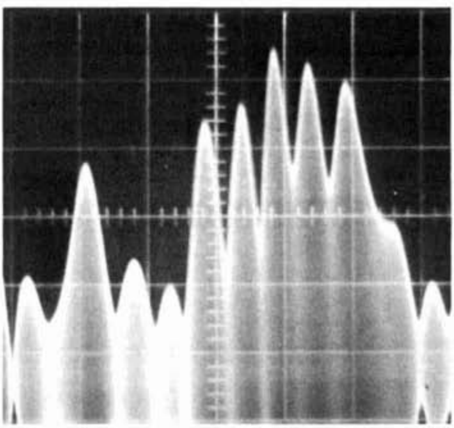


fig. 2. Typical oscillograph display of a clean ssb signal, which was used by author to set up monitoring system.

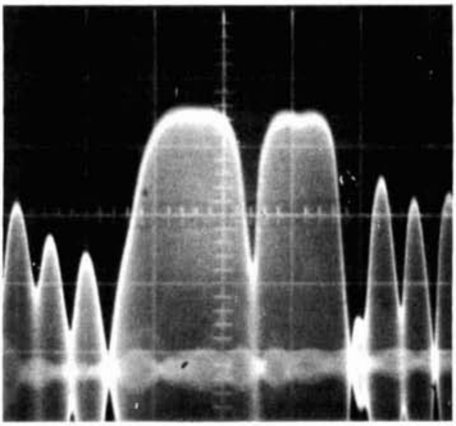


fig. 3. Strong local signal received through 20-kHz-wide i-f strip. Horizontal display is magnified to show detail.

Summarizing, findings with the 75S3B proved that the 5-KHz a-m bandwidth is sufficiently wide to observe moderate limiting. If you wish to see everything, it will be necessary to extend the bandwidth beyond 5 kHz. This is easily accomplished by slightly adjusting the top and bottom slugs on T4, T5 in the 75S3. Sample the signal through a small capacitor at the plate of the i-f amplifier V6 (pin 5) and repeak L9. Turn the *mode switch* to the a-m position. For those wishing to retain the bfo function on ssb, it will be necessary to sample the signal at T4 lug 3. The bandwidth is much greater here, but the signal level is lower.

Other receivers may be used accordingly, bearing in mind that it's necessary to avoid the relatively narrow selectivities, reflected or otherwise, through the filter and its associated i-f system. In any receiver monitor setup, a simple test for adequate bandwidth is that there will be some noise on the pattern, as in **fig. 7,** and some adjacent signals will be seen that are not audible in the receiver.

test results

Upon completion of the modifications described, you are ready to do some serious looking. The scope display will

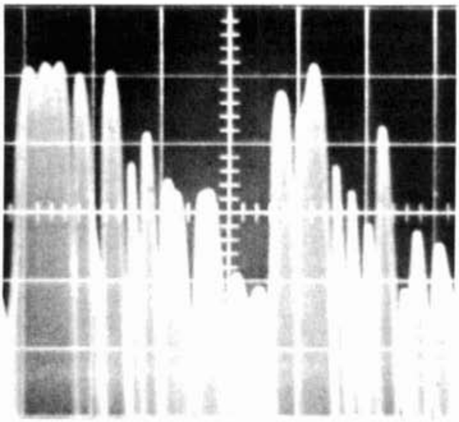


fig. 4. Same signal as in fig. 3. Narrowband (2.1 kHz) filter was used, which presents misleading information as to the true characteristic of a flat-top ssb signal. Compare with fig. 5.

now appear as in a panadaptor. At this point it should be noted that all the photos in this article were candid shots taken with a Polaroid camera mounted on a Tektronix Model 515 oscilloscope.

Tune across the band for a loud signal, turn off the avc and look for a familiar pattern as in **fig. 2.** This was WA8OWU, who was using an S-Line driving a pair of grounded-grid 4-400s. I just happened to tune across his signal, which is typical of Collins equipment. I used it to set up my scope camera (exposure, etc.). To get this pattern, I used the equivalent of a 30-Hz horizontal sweep rate.

After you become familiar with the system, quickly switch between the 2.1- and the 5-kHz or greater passband, and watch the blinders come off of your eyes! On a linear signal, the peaks will be clean and sharp in either case. Find one that is flat topping on the broadband system and note how it *appears* to look cleaned up in the narrowband system.

A strong local signal was evaluated; see **fig. 3.** Note that successive peaks begin to decrease in amplitude from the left and moderate-to-heavy limiting exists at the center. Also it should be noted that (a) the scope baseline is near the bottom of the screen and (b) the horizontal display is magnified, providing the fewest possible patterns to permit greatest detail.

In **fig. 4** the same signal is shown a few minutes later through the 2.1-kHz filter. This signal appears to be fairly acceptable, because the filter eliminates the harmonics (but not the excessive fundamental bandwidth associated with this condition).

To verify the results of **fig. 3** a Tektronix Model 515 scope, which has a 15-MHz bandwidth, was placed directly across the coax transmission line as a broadband receiver. The same local signal was being received. The Model 515 produced a pattern identical to that in **fig. 3,** which verified that the receiver and the 20-kHz monitor i-f system were doing their job.

In order to verify the linearity of my receiving system, a 14-MHz signal greater than 10^5 μV was injected by a Measurements Corp. Model 80 signal generator into the 75A4 receiver antenna terminals. (The 75A4 had been previously modified with 7360 tubes in the mixers.)[2] Gain was adjusted to provide substantially more than the amplitude on the scope for the setup described, with no limiting. **Figs. 4** and **5** are the same signal received on a narrow- and wide-band system, respectively, which demonstrates how a significant loss of information can result.

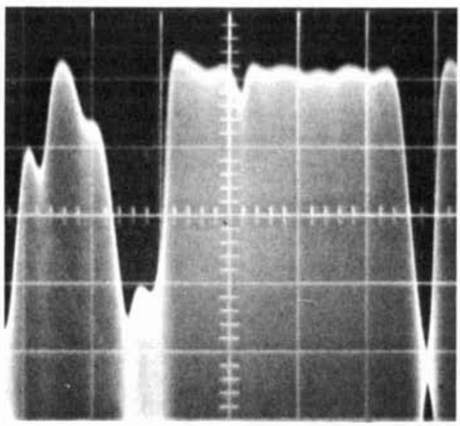


fig. 5. Another wideband presentation of the strong local signal of fig. 3, which demonstrates loss of essential information when received through a narrowband i-f strip, as in fig. 4.

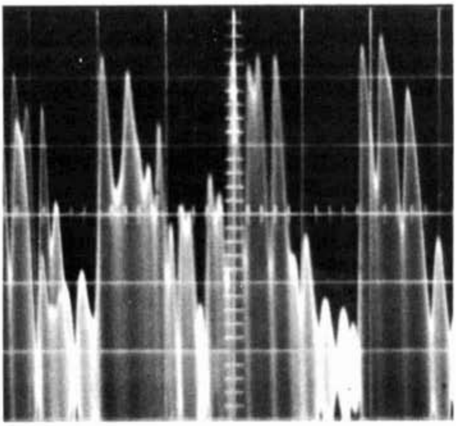


fig. 6. Example of a compressed display resulting from improper horizontal sweep voltage in the oscilloscope. Results are misleading and do not truly represent the signal.

Fig. 6 is an example of a compressed ssb display due to improper horizontal sweep, which also causes misleading information. The objective of the viewer should be to examine only a few highest peaks on the largest and fewest patterns. In other words, you should concentrate only on about one square inch of the scope-tube face.

Fig. 7 is a display of ZS5KI's signal received via long path on 14 MHz, a bit of DX photography I couldn't resist. It demonstrates what a capable system will do under 14-MHz skip conditions. Some noise is in evidence, which accounts for the slightly jagged trace. He used Collins S-Line equipment.

From the above, it may be seen that properly used test equipment is desirable at the receiver and transmitter, especially the latter. No serious ssb station operator should be without a scope to monitor transmitter output. Most any type will do. With direct coupling and a slow sweep, no bandwidth problems exist, and the receivers will take care of themselves.

Most receiver monitor scopes are, in general, improperly used to evaluate ssb signals for linearity when used with narrowband i-f strips. Also most monitor scopes and their receivers probably could be modified to do a proper job if they possess sufficient gain and bandwidth.

In general, linearity is "built into" a transmitter and is governed by the operator. Proper adjustment and choice of operating parameters, such as rf inverse feedback, alc, and rf processing[3, 4, 5] are among the many well-known techniques for control.

In conclusion, all equipment can be made more linear by reducing power, proper loading and tuning, and by operator-control techniques; i. e., monitoring. These actions must be combined, however. Most importantly, a sincere desire on the part of the operator to exhibit an exemplary signal, rather than the loudest and sometimes broadest signal, is necessary.

I wish to express my appreciation to K6JYO and W6KJD for their assistance in making the 75S3B measurements.

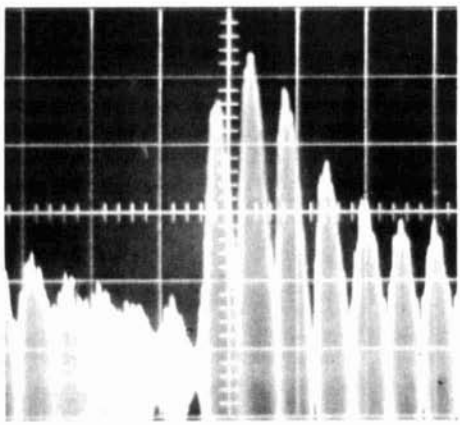


fig. 7. Display of a DX signal received via long path on 14 MHz.

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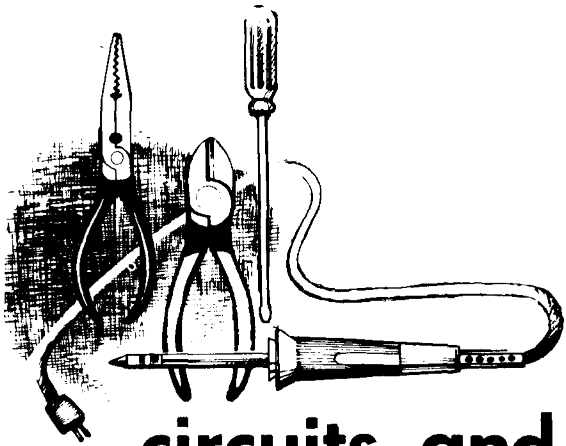
5. K. Squires, W2PUL, and E. T. Clegg, W2LOY, "Speech Clipping for Single Sideband," *QST,* July, 1964, p. 11.

ham radio



circuits and techniques

ed noll, W3FQJ

digital integrated circuits

Digital ICs are appearing in a host of amateur, commercial and homebrew equipment. Calibrators and counters, indicating instruments, frequency synthesizers, phase-lock loops, ham television circuits, scanners, keyers, RTTY devices, remote control and switching systems, multipliers and dividers, etc. are some applications. Digital devices are entrancing, and delving into then can sharpen your wits and ingenuity. So often we are told with abandon that we need not know any digital concepts nor need any knowledge of what goes on within a complex electronic device. (In fact, modern man is engulfed in a plague of superficial thinking because we are being told continuously we need not understand anything deeply.)

Maybe we can escape for a bit the degenerate philosophy which states, "The only thing important is that which is relevant." Start here by learning a bit about digital concepts even though you don't need to know this to wire a digital device into a circuit and put it in operation. You may even become a bit more conversant with your son's mathematics!

During the next several months I'll gather in some digital fundamentals and show how some simple digital devices carry out these operations. Then you can mount a few of these digital devices on an experiment board and watch their operation with a vom and/or oscilloscope. Lastly, I'll put together some interesting little projects.

counting a new way

Just as there are many languages there is more than one numbering system. Most of us have been hooked thoroughly onto the decimal system. A group of numerals are designated that permit us to count from zero to nine. Then we start over again by placing a one ahead of a zero to give us ten. This will take us up to nineteen; then we start over again by placing a two in front of a zero, etc.

In the binary numbering system, which is adaptable to digital operations, there are only two numerals, 0 and 1. Our brain crevices have become so entrenched that we are astonished to learn we can count with only zero's and one's.

Initially we learn this counting system by associating its concept with the decimal system. We do this in learning languages too. Although we may learn Spanish quite well, our mind does some fast switchovers between Spanish and our native English tongue. When we really learn Spanish we then begin to think in Spanish. So it is with a new mathematical language. The real digital expert thinks in binary mathematics and in other bases as well. Most of us follow binary with association to the well-worn decimal path.

Nothing in binary and decimal language is zero. Likewise, one apple (now you know when I went to school), is written as 1 in both systems. However, in the binary system two apples suddenly becomes ten. At this point we must make a new crevice in our brain and throw out ten. What we are doing is setting down a one and a zero to indicate in binary form that there is one two (1) and no one (0).

Let's try a three. Are three apples written as eleven? Binary form states that there is (1) two, plus (1) one to represent a three.

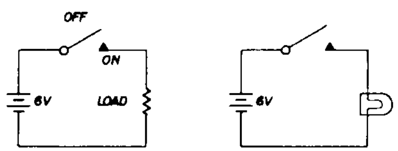


fig. 1 Binary action of a simple switch.

Write a four. You must start out with a new digit. (No wonder we speak of digital concepts and digital circuits and digital computers.) 100 represents four apples is not a true statement. You must think the the (1) represent one four, plus (0) two's, plus (0) one's.

Although a dozen apples is still twelve apples, how would you write it in binary language? The answer is 1100 or (1) eight, plus (1) four, plus (0) two's, plus (0) one's. **Table 1** shows the decimal and binary equivalents up to 15. Four binary digits (called bits) are needed to count from zero through fifteen.

The third column is the customary way of writing on the basis of a four-bit presentation. Decimal 1 is equivalent to 0001 in four-bit binary or, (0) eight's, plus (0) four's, plus (0) two's, plus (1) one. The actual count is shown in the fourth column.

table 1. Decimal, binary and code relationships.

decimal	binary	four-bit	weight 8,4,2,1
0	0	0000	(0) 8, (0) 4, (0) 2, (0) 1
1	1	0001	(0) 8, (0) 4, (0) 2, (1) 1
2	10	0010	(0) 8, (0) 4, (1),2, (0) 1
3	11	0011	(0) 8, (0) 4, (1) 2, (1) 1
4	100	0100	(0) 8, (1) 4, (0) 2, (0) 1
5	101	0101	(0) 8, (1) 4, (0) 2, (1) 1
6	110	0110	(0) 8, (1) 4, (1) 2, (0) 1
7	111	0111	(0) 8, (1) 4, (1) 2, (1) 1
8	1000	1000	(1) 8, (0) 4, (0) 2, (0) 1
9	1001	1001	(1) 8, (0) 4, (0) 2, (1) 1
10	1010	1010	(1) 8, (0) 4, (1) 2, (0) 1
11	1011	1011	(1) 8, (0) 4, (1) 2, (1) 1
12	1100	1100	(1) 8, (1) 4, (0) 2, (0) 1
13	1101	1101	(1) 8, (1) 4, (0) 2, (1) 1
14	1110	1110	(1) 8, (1) 4, (1) 2, (0) 1
15	1111	1111	(1) 8, (1) 4, (1) 2, (1) 1

It does not all end here. Higher decimal numbers can be represented using more bits. For example, decimal 30 becomes 11110 or (1) sixteen, plus (1) eight, plus (1) four, plus (1) two, plus (0) one's. Also, more complex four-bit codes can be employed which provide a means of representing higher decimal numbers with special four-bit groups.

binary codes

Digital systems, instruments and devices respond readily to binary information. For example, a simple switch is binary in its activity. The switch of **fig. 1**, when closed, produces 6 volts across the output. This voltage can be arbitrarily assigned a value of binary (1). When the switch is open there is zero output voltage which can be assigned a binary value of (0). If the load is a small bulb, light *on* becomes binary 1 and light *off* binary 0.

Assume four bulbs are used to obtain a binary representation of a decimal number as in **fig. 2**. How would you use the switches to indicate decimal number 6 in binary form? The binary value for decimal 6 is 0110. This would be indicated by closing switches 2 and 3. Therefore bulb 1 would be off, bulb 2 on, bulb 3 on and bulb 4 off.

In practical digital equipment the

switches are not manual; they are diodes, transistors or complex groups of switches and other circuits mounted in a digital integrated circuit. In fact, in a practical piece of equipment you would not have to make the conversion between the binary number and its decimal equivalent. This would be done automatically with digital ICs that convert binary information to signals that operate decimal readout devices.

All of these devices respond at high rates of speed that, in a suitable circuit, could read out a very accurate measurement of an incoming radio frequency. In fact, all sorts of quantities and events, regardless of their rate of occurrence can be evaluated with digital instruments.

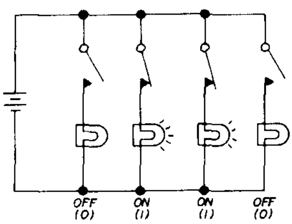


fig. 2. Use of four bulbs and switches to represent a binary number.

High-speed on-off solid-state devices make it all possible.

bcd code

Various codes based on the binary (1) and (0) concept have been evolved to meet the requirements of digital equipment operation and objectives. A pure and simple code which is used extensively is known as the binary-coded-decimal (BCD). Four binary bits are employed. It is said to have a weight of 8, 4, 2, 1 in the order of digits from left to right as shown in **table 1** and **fig. 2**. Each digit position has a definite value (weight). In the pure binary case it is 8, 4, 2 and 1 for a four-bit character. Conversion to decimal values involves simply adding the weights of the digits. For special needs there are various other types of weighted and unweighted codes. Some codes include more than four bits per character.

In the basic BCD code a four-bit number is used to express all decimal signals 0 through 9. Although a four-bit

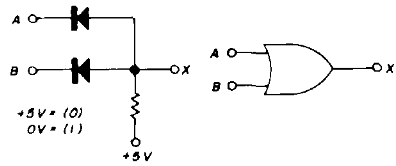


fig. 3. OR-function circuit, negative logic.

number can designate higher numbers (up to 15, as you learned) the BCD code restricts each four-bit character to decimal numbers from 0 through 9.

When a higher number is to be represented in binary form using the BCD code, additional four-bit characters are conveyed. For example, the number 25 in the BCD code becomes 0010, 0101.

2	5
0010	0101

Note the first four-bit character is the binary representation of decimal 2, while the second is the binary representation of decimal 5.

Use the BCD code to write decimal 854.

8	5	4
1000	0101	0100

logic and switching

The closed position of each switch in the circuit of **fig. 2** is customarily called the *on* position; open is the *off* position. However, in the language of two-stage or two-logic Boolean algebra (the base upon which computer systems evolved), the closed position could be designated *true* and the open position *false.* True corresponds to binary logic 1; false, to binary logic 0 in switching systems.

In the operation of switching devices there is also an important connection between logic 1 and logic 0 and signal polarity. If the voltage that represents logic 1 (true) is more negative than that which represents logic 0 (false), the table 2. OR-function truth tables.

chart 1			chart 2		
A	B	X	A	B	X
0	0	0	$\overline{A}$	$\overline{B}$	$\overline{X}$
0	1	1	$\overline{A}$	B	X
1	0	1	A	$\overline{B}$	X
1	1	1	A	B	X

system is said to use negative logic. Conversely, if the signal voltage that represents logic 1 is more positive than that which represents 0, the system uses positive logic. These signal voltages are relative to each other and not necessarily with respect to circuit common (ground).

Often when a negative voltage represents logic 1, it is called a down-level or down-state signal; a positive logic 1, and up-level or up-state signal. Sometimes the terms low and high are used.

OR function

A very basic OR function circuit and its schematic symbol are shown in **fig. 3**. The two diodes function as switches. When the left side of either switch (diode) is at zero volts, the switch closes (positive voltage on anode and negative voltage on cathode). The output voltage is then zero and the input and output voltages correspond to logic 1. In fact, the output voltage is zero or logic 1 when the voltage at either or both inputs is zero. If the voltage at A and B is +5 volts, both switches are open and the output voltage X equals +5 volts or logic 0.

The characteristics of the OR circuit can be set up in the form of a so-called truth table, as shown in **table 2**. A truth table is written in terms of logic 1 and logic 0. The first column states that when A and B are at logic 0 potential the output is also logic 0. When logic 1 potential is applied to B, and logic 0 to A,

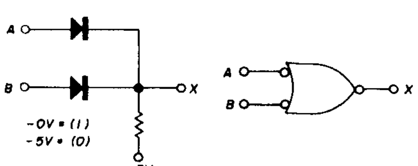


fig. 4. OR-function circuit, positive logic.

the output equals logic 1. Similarly, with logic 1 at A and logic 0 at B, the output is again logic 1. Logic 1 voltage at A and B also results in logic 1 output. Negative logic is used because the logic 1 potential is more negative than the logic 0 potential.

In a logic diagram the actual schematic diagram is not shown. Instead, the corresponding curved line symbol is used to

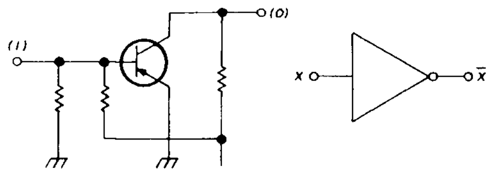


fig. 5. Inverter circuit.

represent a two-input OR-function circuit. This applies regardless of the type of switch – diode, transistor, vacuum tube or integrated circuit.

The OR circuit can also be expressed as a Boolean equation as follows:

$$A + B = X$$

The plus sign in Boolean algebra is not a *plus* but an *OR*. The equation says,

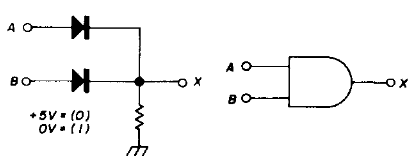


fig. 6. AND-function circuit, negative logic.

"When either A or B (or both) is true, then X is true." The corresponding truth table is shown in **table 2B**, indicating the same truths as chart 1. A line over the letter indicates false or logic 0. No line indicates true or logic 1. Note that X is true whenever A, B or both are true. The output is false whenever A and B are false.

A similar but positive logic circuit requires a reversal of the diodes and circuit arrangement, **fig. 4**. Zero volts is again logic 1. However, logic 0 is −5 volts because positive logic requires that logic 1 be more positive than logic 0. The diode switches close when zero volts is present at A or B. The output is again zero volts or logic 1. A potential of −5 volts at A and B opens both switches and the output is −5 volts or logic 0. The truth table is the same. The symbol is the same except for the bubbles which indicate that logic 1 is more positive than logic 0.

the inverter

Many solid-state circuits, such as a common-emitter stage, result in signal inversion, **fig. 5**. The inverter symbol is a simple triangle with an appropriate bubble to indicate signal inversion. In this case a logic 1 signal at the input becomes a logic signal 0 at the output; a logic 0 signal at the input, a logic 1 at the output.

AND circuit

In the simple AND-function circuit of **fig. 6** negative logic is used with zero logic represented by +5 volts and logic 1 by 0 volts. When logic 1 (0 volts) is present at A and B, neither diode conducts and the output is also logic 1 (0 volts). Both diodes must be nonconducting to obtain a logic 1 output. If logic 0 voltage is applied to A and B both diodes conduct and the output voltage is positive, logic 0. If logic 1 voltage is applied to either A or B the particular diode stops conducting but the opposite one continues to conduct. Therefore the output voltage is again positive or logic 0.

The truth table for the AND-function is shown in **table 3**. Note that when either or both inputs are of the voltage corresponding to logic 0, the output is logic 0. Only when logic 1 voltage is present at both outputs do you obtain logic 1 output.

table 3. AND-function truth table.

A	B	X
0	0	0
0	1	0
1	0	0
1	1	1

table 4. NOR-function truth table.

A	B	X
0	0	1
0	1	0
1	0	0
1	1	0

The Boolean equation for the AND function is:

$$A \cdot B = X$$

However, the point between A and B is not the ordinary symbol for multiplication but AND. Equation states that, "when A and B are true, then X is true."

NOR and NAND functions

Basically, a NOR-function is an OR-function with inversion. A typical circuit using the common emitter configuration is shown in **fig. 7** along with its symbol; the truth table for the AND circuit is **table 4**. The common-emitter configuration is a basic inverter because the output is an inverted input signal.

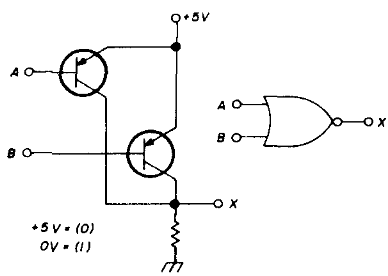


fig. 7. NOR-function circuit.

Negative logic is assumed. If zero volts (logic 1 or true) is applied to one or both inputs, one or both of the transistors conduct. At the output a +5 volts (logic 0 or false) signal appears. Note from the truth table for these three outputs there is logic 0.

Refer to the truth table of the OR function (**table 2**). Observe that for the same three conditions the output is logic 1 or true. In other words, the output of each is NOT OR which is abbreviated NOR.

When +5 volts (logic 0 or false) is applied to both inputs, both transistors are cut off and the output voltage is zero (logic 1 or true). This too is the inverse of the OR function. Recall that the OR circuit develops a logic 0 output when its two switches are open.

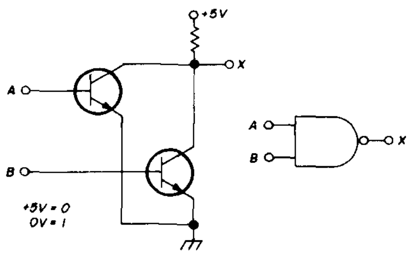


fig. 8. NAND-function circuit.

A NAND circuit is shown in **fig. 8**. In this negative logic arrangement zero volts (logic 1 or true) at both inputs shuts off both transistors and a +5 volts (logic 0 or false) develops at the output. Again there has been an inversion from logic 1 to logic 0. Compare this operation with the AND function circuit of **fig. 6**. Here again the output is NOT AND which is abbreviated as NAND.

When +5 volts (logic 0 or false) is applied to one or both inputs, the transistors conduct, and the output voltage is zero (logic 1 or true). Reference to the AND truth chart (**table 3**) shows, that with the same input conditions, a logic 0 output is obtained.

Next month I will discuss the special usefulness of the NOR and NAND arrangements and go on to various arrangements of these logic circuits in several basic digital integrated circuits. A bibliography will be given at end of the series.

vhf propagation

The excellent vhf propagation work of R. A. Ham, FRAS, was mentioned in the December column. An article, "The Solar Link," by the same writer in the August issue of "Radio Communication" should be read by every vhf enthusiast and especially by every licensed technician. If you wish to predict openings sooner and add more credibility to your propagation studies, you can find data here.

Mr. Ham uses a solar radio telescope, **fig. 9**, for sporadic-E work. Sounds complex, but it isn't. Solar signals are picked up on 136 MHz using a 4-by-4-element Yagi. A converter moves the incoming signal frequency down to 26 MHz and then into a communications receiver. Detector output is applied to a dc amplifier and pen recorder. Usually solar noise is recorded over the noon hours (1130 to 1330 gmt). Long individual bursts or a continuous noise storm could foretell happy events on 10 and 6, and occasionally 2.

Abnormal tropo reveals its arrival time on Mr. Ham's barometer. Could concerted weather data correlation in U. S. A. give us some more well-defined propagation patterns on 50, 144 and up?

table 5. NAND-function truth table.

A	B	X
0	0	1
0	1	1
1	0	1
1	1	0

phase-lock thought

Here is an appreciated letter from Thomas H. Morrison, WA3GBU: "In Experiments with Phase-locked Loops" (Circuits and Techniques), *ham radio,* October, 1971, W3FQJ notes that the Signetics 561B IC is not a device applicable to ssb or CW. He is right, of course, regarding this particular chip, but perhaps another chip in this same series deserves a little recognition, especially since it could be useful to those of us who know fm as "chirp." My speculations regarding this IC are not based on personal experimentation, but I feel they are well founded.

The Signetics SE567 chip is a PLL and lock detector in one package. The lock detector is necessary because the PLL itself cannot indicate lock in any way. The typical application of the 567 is as a tone decoder. The brief article, "Need A Tone Decoder?" (*Electronic Design,* October 14, 1971) describes the use of the SE567 in a Touch-Tone decoder, as well as the general principles of tone detection with a PLL.

Only three capacitors and three resistors are needed externally to adjust the center frequency, bandwidth and dc threshold level for the output stage. Center frequency can vary over a wide range, easily covering the normal audio output frequencies of ham receivers. Bandwidth is typically 5 to 10% of the center frequency. Most important is the ability of the PLL to operate in the presence of noise that would make normal LC or active RC networks unusable.

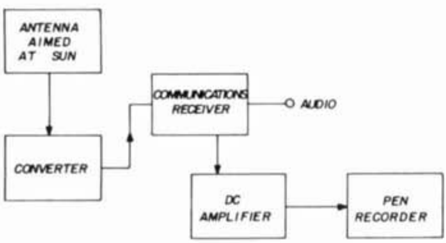


fig. 9. Basic plan of solar radio telescope.

The output of the IC is a logic level indicating lock (tone detected) or no-lock (no tone) which can be used to gate the output of a local audio oscillator (W2EEY, *ham radio,* June, 1970). The user hears the clean, noise-free output of this oscillator (hopefully!).

The SE567 costs the same as the SE561. As soon as I can afford the luxury of experimenting with such toys, I will follow up on my speculations. I would be interested in learning of other hams who are using this device.

Thank you, Tom.

ham radio

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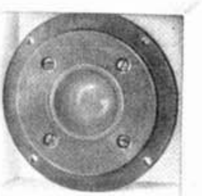

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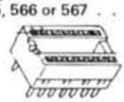

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More Details? CHECK—OFF Page 94

digital station accessory

Installing the time base, calibrator, identification timer and 24-hour clock

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

Last month I described a number of functions that can be performed by a single digital station accessory sharing a common read-out display. This section will discuss the time-base, digital clock, harmonic calibrator and identification timer. All of these functions are related to a chain of dividers from a highly stable, temperature-controlled, crystal oscillator. In a few cases, no doubt, the power-line frequency will be used until a suitable crystal oscillator is obtained.

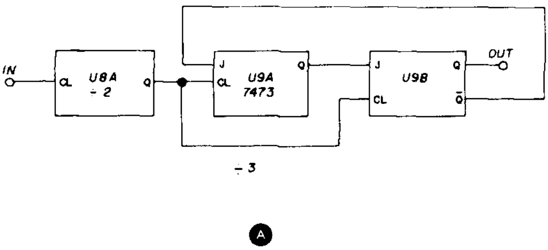
power-line frequency

If only for test purposes, in the absence of suitable audio-freqency oscillators, the 60-Hz power line can serve as the time standard. Many circuits have been published for doing this but they appear to be excessively complicated.

When using a 12.6-volt centertapped power transformer and two rectifiers, about seven volts appear from one side of the transformer to ground. Using two resistors in a voltage divider, about two volts rms can be applied directly to the input of a Fairchild 9093 dual JK flip-flop, a SN7490N decade or a Sylvania SM-90 divider (no counting outputs). Some application notes recommend using a diode to remove the negative voltage excursion.

If a bridge rectifier across a 6.3-volt transformer is used, there will be about three volts of ac from one end of the transformer to ground. This will be superimposed upon dc which may prevent toggling the flip-flop. A capacitor in series between the power-supply transformer and the input to the IC will remove the dc. At 60 Hz, the series capacitor can be several microfarads, with its plus lead connected to the transformer. A resistance of 1k or more may be placed across the IC so that the input pin will not build up positive voltage sufficient to prevent it from falling to a "logic-low" or "logic-zero" below about 0.8 volts. Frequently, this current-sinking

A JK flip-flop can divide by two, and two FFs can divide by three instead of four without any gates by using feedback. This is done by making use of the Q and not-Q outputs and the J inputs as shown in **fig. 1**.



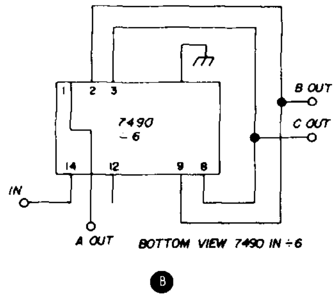


fig. 1. Divide-by-three and divide-by-six using JK flip-flops in feedback method (A), and SN7490N decade counter in reset method (B).

resistor will not be needed. This situation is parallel with "gridleak and condenser" operation of a vacuum-tube detector.

After one toggling flip-flop, almost any FF can follow it. However, the SN7573N does not toggle directly from the 60-Hz sine-wave power source. There are several ways to obtain a divide-by-six, or divide-by-three, using feedback or coincidence gating, so the total division including a decade will be to one cycle per second. **Fig. 1** shows these methods.

The SN7490N can divide by any number from two to ten (except seven) without any external gate. This is done by making use of the two R_O reset inputs. One can be connected to each 7490 output pin that comprises the binary code for the desired division. The output must be taken at the highest output that toggles. That is, to divide by six, the binary code is 0110. The B and C outputs on pins 8 and 9 should be connected to the two R_O reset pins, 2 and 3. The C output is taken from pin 8. An external gate will be needed to divide by seven (binary code 0111). This requires the equivalent of three gate inputs to detect the coincidence of a logic-high on the A, B and C outputs.

If the above divide-by-sixty time-base is used from the power frequency, any output can provide a test signal for FFs and for sections of a time-base divider. Should it be used to gate a counter, however, it is usually followed by another divide-by-two flip-flop in order to provide a full one-second *on* time for the count. There are exceptions to this when the *count* and *off* periods are not equal.[1]

crystal oscillator

Crystal oscillators may be ac-coupled (through a stopping capacitor) to the first IC divider. In that case, note that a resistor of 1k to 50k may be required to permit the divider to toggle by providing a drain ("grid leak") from input to ground.

Last month I mentioned Monitor Products Company* ovens and crystal oscillators. Inquiries to Bliley and International did not develop any comparable unit produced for stock. I have a 12-volt version of the SO3233 from Monitor. In normal production this is made for a 30-volt dc supply on the oscillator. It

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

would be more convenient to use a 5-volt supply, but then the internal zener would not be able to regulate at five volts so sharing the same voltage regulator with flip-flops may cause slight frequency changes.

Usually these oscillators are dc-coupled and TTL-compatible, which means that they burn out immediately if the output from the oscillator is shorted. Some have been made, upon request, with a stopping capacitor (ac-coupled) output; there may be other ways to prevent accidental burn-out, such as using a series resistor or a "one-input gate" with a resistor from the V_{cc} and a diode, as shown in **fig. 4C**. A good ovenized crystal oscillator should be given full protection.

toggling flip-flops

A number of letters have been received from amateurs who ask for help to make their flip-flops toggle – that is, to flip and flop alternately on a pulsating input. Some comment and suggestions along this line appear to be in order.

It is advisable to test all ICs before installing them; a test socket should be built. Use a high-grade type like the Vector R716-1 16-pin socket. Mount it in P-type plugboard (such as the piece to be sawed off the read-out board). Long wires, machine screws or special Vector pins can be mounted and connected to the socket terminals. Colored short, flexible clip leads can be attached to these. Surplus sockets may lead to erroneous tests results due to contact failure.

In general, finite resistances will be found primarily in the V_{cc} to ground pins of digital ICs. When a V_{cc} close to five volts is applied, the unconnected pins mostly will assume a logic-high of about three volts. This is why the J, K and reset pins of a JK flip-flop need not be connected. However, the SN7490N decade counter has reset-9 and reset-0 pins. There are two of each, connected through internal inverting gates. As a result, 7490s should have one R9 pin grounded to permit toggling. If no external gate output is connected to the R_0 pins, one of these, too, must be grounded.

When an external gate output is connected to a 7490 reset, the unused reset pin can be connected to V_{cc}. Then, when the gate is at a logic-low, the IC may toggle; if it is at a logic-high, it will reset. However, if the gate's input is in parallel with another reset, such as from an SN7473N dual JK flip-flop, the voltage from the other IC's reset pin may put the gate at an in-between voltage so that the 7490 will not toggle. This may occur rarely. A resistor of up to 56k, depending on the time constant and frequency, can be connected from the gate input to ground to drain off any voltage from the 7473's reset pin. Operation will become normal.

Interrupted direct current on the input is a poor way to test a flip-flop because of contact bounce. One way to avoid this is to switch the input voltage through a cross-connected pair of gates or inverting amplifiers that hold to one side or the other during contact bounce. Another way is to drive the IC under test from a square wave or, for those FFs that toggle on a sine wave, from an audio or power-line source. Of course, it may also work on rf from a grid-dip oscillator which has sufficient output. (ICs may operate on sine waves at some frequencies and not at others.)

The unused negative excursions of the ac drive should be held down to a small value. It the IC is driven hard, these negative peaks can cause damage. This is prevented by connecting a diode's anode to ground, and cathode to the IC input.

The next step is to ensure a swing in voltage below 0.8 volts (logic-low) in DTL and TTL units, and up above two volts (logic-high). Often, FFs will toggle on much less, but this cannot be guaranteed for all types. A dc component, therefore, can prevent toggling.

If the FF is driven from a very short pulse, a few nanoseconds in length, this pulse can be below specification length and not give the FF time to toggle. In general this is associated with the maximum toggling frequency of the unit. There are similar limits on the length of preset, clear, transfer and load pulses in some ICs.

U60, may be used after the crystal oscillator; this is to minimize any effect of load upon frequency and to help ensure against shorting the crystal oscillator's output. Once is enough! The gates

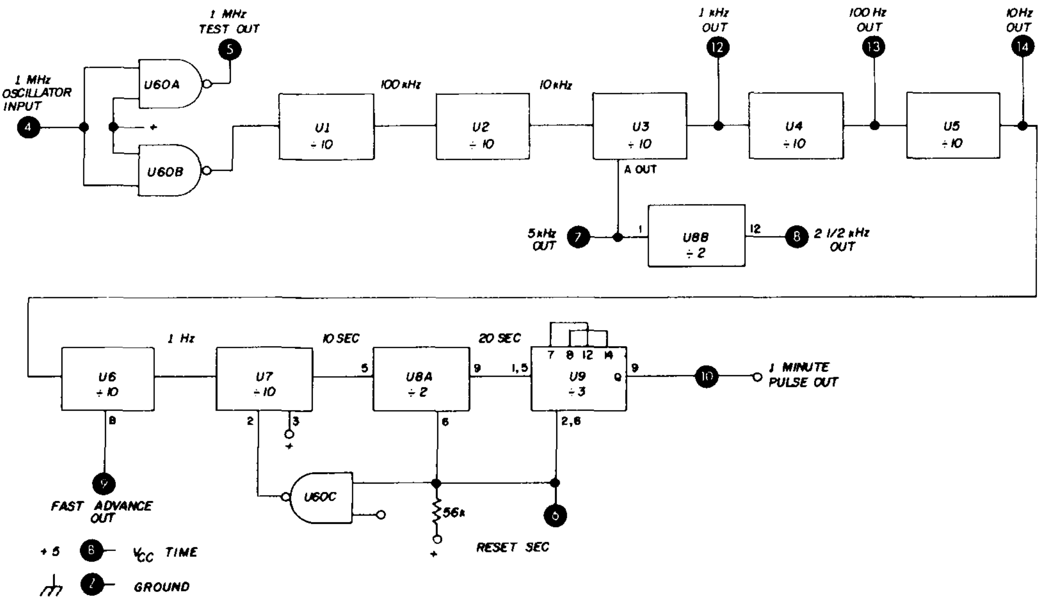


fig. 2. Time-base and clock-driver IC flow chart on the input-time-base board.

Another factor is the *sink* of the input circuit, already mentioned. The plus voltage assumed by some IC inputs must be drained off through the input circuit or the resulting dc build-up will prevent toggling. Overload of the output may have a similar result and may damage the unit if it represents more than a *normal fan-out* given in the specifications. When FFs or gates are ac-coupled to their drive, such as through a stopping capacitor, it is sometimes necessary to use a resistor from input to ground. As already stated, this is a parallel to the old grid-leak-and-condenser tube detector circuit. If the capacitor has a leakage of about 50k ohms there may be no difficulty.

time-base flow chart

Fig. 2 is a flow diagram of the input-time-base board from the crystal input to the one-minute pulse. An isolating gate, feed a string of dividers, mostly SN7490N decades, and also a 1-MHz output phono jack. Three other frequencies are brought out to plugs 12, 13 and 14 for test purposes and to feed a resolution switch for counting, to be described later.

The B output on pin 12 of the sixth decade divider, U6, is fed out to the clock fast-advance pushbuttons PB2 and PB3 to facilitate setting the clock.

An aid to clock setting is a seconds-reset pushbutton, PB1. Although seconds are not displayed at present, they may be, inasmuch as the read-out displays and their decoder-drivers are provided. Even showing only minutes and hours, the seconds-reset is needed so that minutes start in phase with WWV, and do not move up during a specific minute.

The divide-by-six arrangement is the upper one shown in **fig. 1A**. This was selected to provide the extra FF, U8B, in the calibrator. Otherwise, an SN7490N would be more simple. With the SN7473s, (U8 and U9), the seconds-reset pushbutton shorts to ground to reset them, and also feeds an inverting NAND gate to reset the preceeding 7490 decade, U7.

A problem arose here. At a time when the extra V_{cc} filter capacitors were not yet mounted, the minutes output was present but would not reset properly. It was found that the 7490, U7, was always in the reset condition, and spurious peaks in the V_{cc} line caused the next FF to toggle without an input. The cause of the reset condition was an indefinite voltage from the reset pins of the 7473 FFs, U8 and U9. When the latter pins were provided with a sink to ground of up to 56k ohms, the inverting gate, U60C, operated normally and allowed U7 to toggle and reset from the seconds-reset pushbutton.

Inasmuch as divide-by-three outputs can be taken from either the Q or not-Q output of U9A and U9B, the seconds-reset may not recur at the same part of, the minute at which the button was pushed. The output must be taken from the unused Q output shown in **fig. 1A** in order to have the minutes display change later at the correct second.

calibrator

A 5-kHz output is taken from pin 12 (A-out) of the third decade, U3, for crystal adjustment, for receiver calibrator purposes, and also to feed an otherwise unused FF, U8B, to provide 2.5-kHz calibrator points. When using an audio oscillator and a counter these points are desirable in a ssb receiver to avoid complicating the calculation of frequency by going to lower sideband to hear both the signal and the calibrator. These outputs feed a phono jack on the rear apron of the chassis through the timer panel switch, TS1.

count board

The original idea was to keep similar functions on the same board. This ran into a plug shortage that would increase expense. The solution was to have the time-base to the minute output, the input amplifier, the gating circuitry and the first two count decades on the input-time-base board. Then, the remaining clock circuitry, ID timer, AND-gate switching and four count decades with their latches were placed on the count board, as shown in **fig. 3.** The final two (megahertz) counters and latches were moved to the read-out board. The advantages of this arrangement will become clear later.

The minute pulses from U9 on the IT board go to its plug 10, and then through a stopping capacitor to the spdt minute-adjust pushbutton, PB2, and on to plug N of the C board. Capacitors from .001 up to 15 μF have been tried, with the large values giving slightly better freedom from irregular contact-bounce pulses when releasing the fast-advance pushbuttons PB2 and PB3. Plug N feeds another stopping capacitor and the first minutes decade, U10.

This in turn feeds U11, a 7460 connected to divide by six, as shown in **fig. 1B**. Note that the hour-pulse output is taken from C, on pin 8, inasmuch as no pulses reach the D output on pin 11. The output goes to plug T and out to the hours-adjust pushbutton, PB3, then back to the C board through plug U. Another stopping capacitor feeds the unit-hours decade, U12, then a dual SN7473N FF, U13, which will count to four. This is sufficient for 24-hour time.

Inasmuch as the hour dividers must reset at 24 and return to 00, the units-hours 7490, U12, has its two R_0 reset inputs connected to its C output, and to the B output of the two FFs, U13B. The reset inputs are also fed to inverting gate U70A, so that the number 24 will cause the output of gate U70A to fall, resetting the 7473, U13, as well. This arrangement did not require any sinking resistor as did the seconds-gate, U60C, on the IT board.

time output circuits

It is desirable to retain the time accurately when the read-out is in use for counting. To do this the V_{cc} must remain on U10 through U13 and their associated gates. Therefore, the 13 needed outputs are brought to the inputs of four SN7408N quad 2-input AND gates, U71-U74, for isolation. These list at $1.08 each. (The announced SN74157N quadruple 2-line-to-1-line data selectors were not yet available at this writing.) The low-power SN74L98N 4-bit data selector/storage registers are very expensive.

Resistance measurements showed a high resistance from the SN7475N latch outputs to ground in the absence of V_{cc}, so it was decided that the switching between time and count would be by a "wired or" between the AND gate outputs and the latch outputs from the counting decades. "Wired or" means to solder them together and allow a logic-high from either to pass to the read-out board. Later, when using the count mode, the V_{cc} will be switched off the AND gates and on to the latches. At this point in construction, however, neither the AND gates nor the latches are needed. The method requires that only 16 BCD outputs be passed from the C board to the RO board.

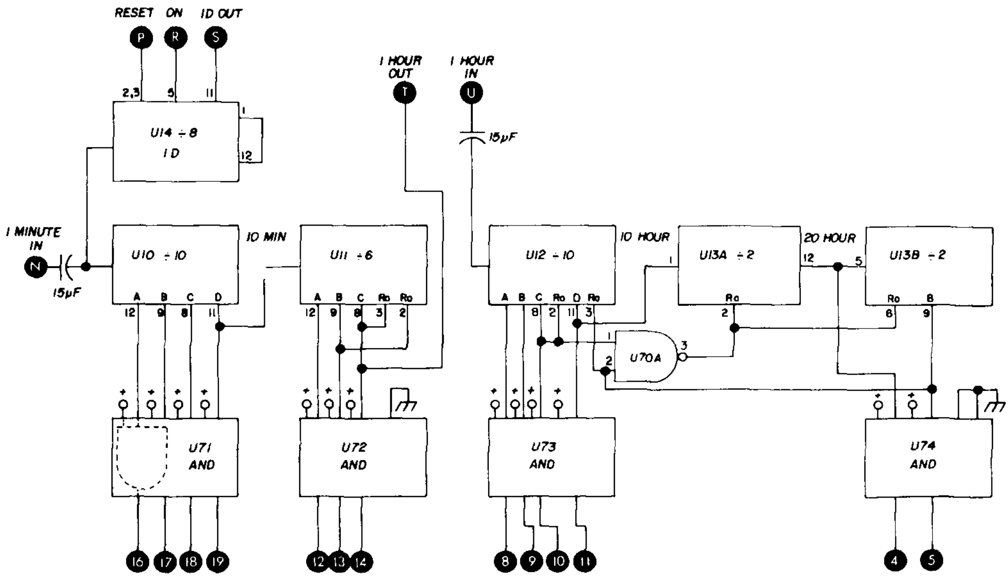


fig. 3. Identification timer, clock ICs and switching AND gates on count board.

id timer

One ID timer on the market carefully provides a coarse and a fine adjustment of the identify time delay for 10-minute accuracy. When the ten-minute signal is produced, it seems to say, "That means that you have just broken the regulations, Bub!" In short, the identification should be made *before* the ten minutes. This may not be convenient if someone else is transmitting. The answer seems to be to use the timer for 9, 8 or some other number of minutes or fractions below a full ten minutes.

The timer should be resetable, to start a new period when the identification has been made. This reset must not change the clock setting. This requires at least one separate IC, U14, driven by a one-minute (or shorter) interval in the timing chain.

The easy figure is eight minutes, by feeding a .7490 in parallel with U10's input, pin 14. However, the seconds status of U9 at the time of reset will differ, making the period eight to nine minutes. If greater accuracy in timer operation is desired, an additional line can be brought from the seconds divider on the IT board, or the timer can be moved entirely to that board. Then, a resetable decade divider can be run from the input to the seconds-dividers. Adding just one decade to the ID timer will reduce the error or variation to a maximum of six seconds, an average of three.

The C output from pin 8 can be fed to a resistor of at least 3.9k, and up to 10k depending on the transistor, which should be an npn device such as 2N497 or 2N1302.[2] The emitter will be grounded. The collector will light a Sylvania 5ESB lamp (49c from Allied or Newark) connected to V_{cc}. See **fig. 4.** A suitable relay or other device can be driven by the collector current or another transistor. Ac can be used to create a tone in the loudspeaker.

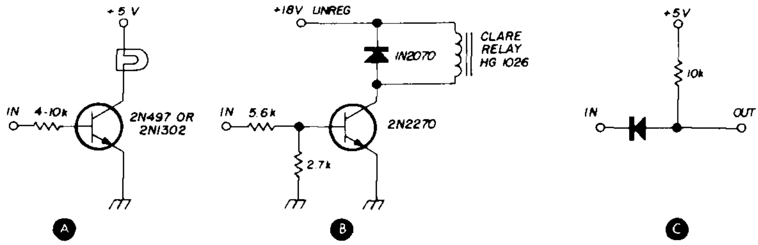


fig. 4. Lamp driver transistor (A). Relay driver transistor with protection from inductive kick (B). Simple one-input AND gate for short-circuit protection of ICs and crystal oscillator (C).

days and months

Ordinarily, it is not desirable to add dates to the time, particularly in areas where power outages are likely to take place. However, a few words on this might bring out some thinking.

By adding a counter driven by the hours output – one pulse per day – the dates will be automatic. This will take a decade counter and a dual JK FF, gated at 32 to preset to 1, for a 31-day month. It is possible to switch the coincidence gate to preset at 31 or 29 days. This requires a three-input gate (7410). Alternately, several gates can be installed, and the outputs switched. If this switch is set any time during the month to match the number of days in the month, the date will be accurate.

Note that date and month counters require a preset to 1, not a clear to 0. This can be done. The 9093 dual JK presets, rather than clears. Either this or the 7473 dual JK can be reversed by making connections to Q and not-Q (and to J and K if used) in the reverse. That is, a *clear* pulse clears the Q output, but *sets* the not-Q output in the 7473. Both can have one FF preset and the other FF clear. 32 days require a decade and a dual JK FF. One part of the dual JK FF should be used as the first A divider before the BCD part of a 7490, so that it can be preset to 1. The A section of the 7490 can be used with the second half of the dual JK FF, for the tens count to 30.

Counting months is simple with a decade and a JK FF, gated to clear at the count of 13 and preset to 1, which again requires the JK FF to preceed the BCD divide-by-five section of a 7490 for the units decade. Then the A section can follow for the tens count.

At this point it becomes easy to set up more gates to provide reminders of various dates during the year, should there be any desire to do so. The gates could drive a suitable alarm, from the starting circuits in **fig. 4.** It is interesting that the Sylvania 7420 dual 4-input gate has five inputs on one side, which may be very useful in the more complicated coincidence-gating of reminder dates.

read-out display

Last month I suggested mounting the Minitron displays and their MSD047 Monsanto decoder-drivers (see TI 7447) on a cut-down Vector 3662 *Plugbord*.

To equalize plug requirements between all three boards the last two counters and latches have been placed on the read-out board, along with a 7400 quad 2-input gate to transfer the latches and provide the 7490 reset.

The positioning of the Minitrons is selected to be visible through the panel window. With some adjustment, the *Plugbord* receptacle could have been raised above the chassis with spacers to give complete freedom of positioning of under-chassis controls.

As designed, the chassis requires that the Minitrons (eight of them) should go into the third column of holes from each side of the *Plugbord.* Including contact holes, the bottom and top pins of the Minitrons go into rows 16 and 23. The bottom and top pins of their drivers go into rows 7 and 14. There is one unused column of holes between drivers.

wiring

Except for the special arrangement of the RO board, all input amplifier parts, gates and divider ICs are mounted on two Vector 3682-2 Plugbords. The DIP ICs are all turned in the same direction to avoid wiring errors.

To prevent damage due to accidental reversal of the boards in their receptacles some thought has been given to reserving the reverse plugs from the V_{cc} inputs. This could receive more study. However, mechanical protection is possible except when using the Vector 3690 card extender (and could be added to that) for test purposes.

Inasmuch as the boards must come very close to the chassis near the receptacle, it is necessary only to add an upward extension to prevent their being inserted. A washer, or a V of wire, can be fitted to the top of the board, extending above the board at about the first row of holes. Then, if the board is inverted, it will be raised above the chassis by this washer or wire key and cannot enter the receptacle.

The Vector 3682-2 boards have printed V_{cc} and ground busses suitable for six rows of dual in-line ICs. The clear space near hole rows 1 through 4 can be used for input amplifier parts, and V_{cc} transient filter capacitors. The buses crossing at rows 47-48, are for V_{cc}. These will be straddled by six rows of DIP ICs. The one row at the bottom, hole columns 38-39, can take five ICs. The others can take four conveniently, if needed.

Space is at a premium, particularly near the IC pins. An Ungar 37- or 44-watt iron does the job, especially with the 1/8-inch round iron-clad tip. This tip should be unscrewed occasionally because the working end lasts longer than the threads. Old copper tips cannot compete.

Solder is a problem because of a need for flux with a minimum of solder. This is met with Kester 44 resin-core solder, core 66, 0.025-inch in diameter. It looks like no. 22 wire.

Miniature precision tools from Sears and others are a necessity, particularly semi-flush diagonals and extra-long-nose pliers.

On a few occasions, a Soldapullt desoldering tool made excess solder disappear. This is available from MacDonald & Company, Glendale, California 91204.

For wire, untwisted light Belden 8430-25 phono pick-up arm cable usually is preferred. About the biggest might be no. 26 (Belden 8505), without having it bend the IC pins. An unusual one, however, is the solder-through insulation *Belsol* wire, Vector 2323A-32-2, which permits crossovers without shorts to an unlimited extent without having to strip the wire. It is useful in series connections like the lamp-test, reset and other lines going from one IC to another. It does take a firm application of heat to get through the insulation, which might best be done when not in contact with the IC pin. None, however, have been damaged so far.

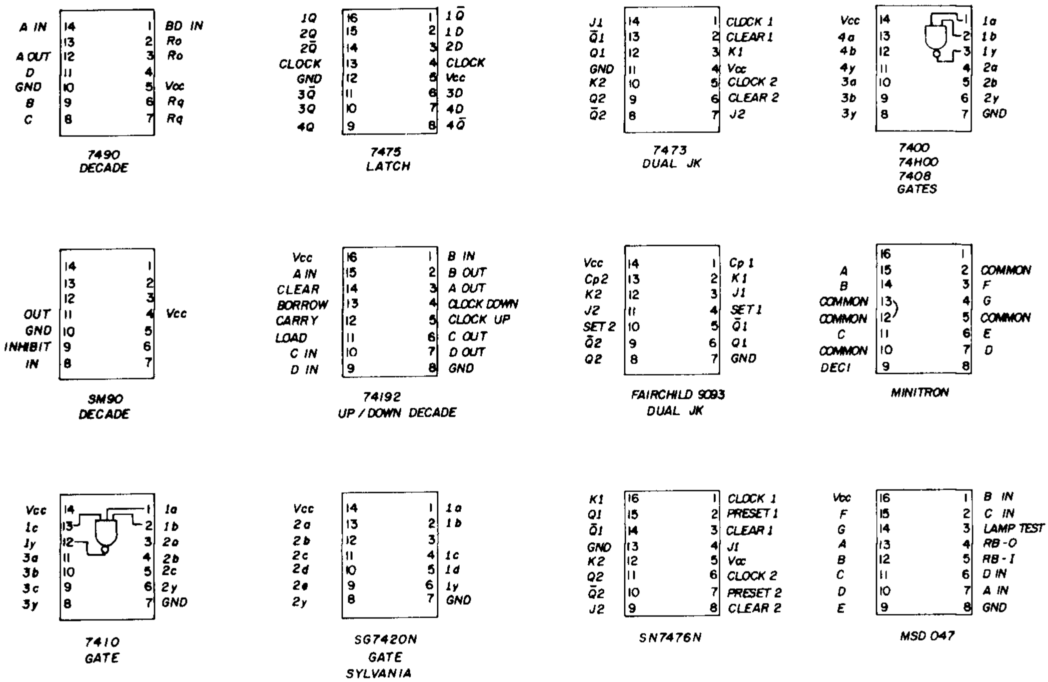


fig. 5. IC base diagrams (bottom view for wiring).

After skinning the plastic-covered wire with a Miller wire-stripper, twisting and tinning, bending a small hook into one end, and putting it on a tinned IC pin makes a good, quick joint. Even three wires can be on one pin.

If several wires are to be soldered to one pin, do them separately. Otherwise the bottom one may not be connected. Test them all with a light pull. After wiring is completed, run a knife point all around each pin to ensure that no stray conducting strand causes a short. Lift the wire from the bus foil and separate adjacent wires to ensure that there is no migration through the insulation due to the heat of soldering.

In the case of the Minitron which may not like to be tinned, it helps to have a loop of wire around the pin and then to solder it. With this procedure no poor contacts have shown up.

Be careful not to put solder bridges across the small space between the pads connecting plugbord contact plugs.

input-time board wiring

On the input-time-base board the crystal oscillator input gate (if used) and the first four decades of the time-base, U1 through U4, can be on the bottom over hole columns 38-39. The second row carries four more time-base ICs, U5 through U8, over hole columns 32-33. Because of using two 7473 dual JK FFs to provide one FF for the 2.5-kHz calibrator output, as well as the divide-by-six seconds-count which could have been accomplished by a single 7490 decade,

table 1. Common plugbord plug assignments. IT is input-time-base board; C is count board; RO is read-out board; TS is the timer switch.

plug	to	purpose
A	IT-C-RO	+5 V_{cc} switched
B	IT-C	+5 V_{cc} continuous
Z	IT-C-RO	-12 ground
Z	TS4B	-5 V
4-7	RO-C	ABCD for U35
8-11	RO-C	ABCD for U34
12-15	RO-C	ABCD for U33
16-19	RO-C	ABCD for U32

table 2. Input-time-base board interconnections. The letter U refers to IC numbers of sections. Small letter P refers to pin numbers.

from	to	purpose
plug 4	U60Ap13	crystal in
U60Ap13	U60Bp9	gate in
U60Ap12	Vcc	unused
U60Ap11	plug 5	1 MHz out
U60Bp10	Vcc	unused
U60Bp8	U1P14	A in
U1p11	U2p14	100 kHz
U2p11	U3p14	10 kHz
U3p12	plug 7	5 kHz
U3p12	U8Bp1	2.5 kHz
U8Bp12	plug 8	2.5 out
U3p11	U4p14	1 kHz
U4p14	plug 12	1 out
U4p11	U5p14	100 Hz
U5p14	plug 13	100 out
U5p11	U6p14	10 Hz
U6p14	plug 14	10 out
U6p9	plug 9	PB2/3
U6p11	U7p14	1 Hz
U7p2	U60Cp3	invert
U7p3	Vcc	reset
U60Cp2	Vcc	unused
U60Cp1	56k R	Vcc
U60Cp1	U8Ap6	reset
U8Ap9	U9Bp6	reset
U9Bp6	U9Ap2	reset
U9Bp2	plug 6	PB1
U7p11	U8Ap5	10 seconds
U8Ap9	U9Bp5	20 seconds
U9Bp5	U9Ap1	x3
U9Ap14	U9Bp8	x3
U9Ap12	U9Bp7	x3
U9Bp9	plug 10	minute

there is one 7473 in the third column over holes 26-27. Lower-numbered columns of holes will be used later for the final time-gating decade for producing count-gate, tranfer, clear or reset and load pulses (for 74192 up/down programmable counters). Note that the negative V_{cc} bus is broken between the top three rows and the bottom three rows of ICs (with Vector line-cutting chisel, P139, $1.50).

General wiring instructions for the IT board are: Cut the V_{cc} bus at row 47, column 24; jumper bottom of V_{cc} bus to plug B. Jumper plug Z to ground-bus. Cut the edge ground bus at row 49, column 1, for 12-V use. Connect all V_{cc} pins to V_{cc} bus. Connect all ground pins to ground bus. Solder one input of all unused NAND gates to V_{cc} bus. Solder one pin of all R_9 resets of 7490s to ground. On all 7490s having no gate output to a reset pin, U1 through U6, connect one R_0 pin to the ground-bus. Connect the upper V_{cc} bus to plug A. Connect the long edge ground bus to ground bus (plug Z). On all 7490s, U1 through U7, connect A-out pin 12 to BCD-in pin 1. Further wiring details are given in **table 2**; plug assignments are in **tables 1** and **3.**

count board wiring

On the count board U70 provides for 24-hour clock gating and inverting the reset. Its remaining gates are reserved for the transfer signal to the latches. U14 is for ID-timer use. U10-U13 are the minutes and hours counters. U71-U74 are SN7408N AND gates to be used later in switching between clock and count modes. The top two rows are dividers and latches for the count mode. Note that there are two cuts in the connecting V_{cc} buses to divide the ICs into three groups of two rows. This facilitates leaving V_{cc} on the clock counters while the AND gates can be turned on for clock display and off for count display.

Series capacitors, to take dc off the clock fast-adjust lines, are mounted on the count board. If necessary, a few 50k resistors can be added if needed to sink voltages on gate inputs and on stopping capacitors.

Because TTL ICs have noticeable spikes that can trigger unintended ICs, V_{cc} filtering to ground can be placed about every four or five ICs. These can range from discs to substantial 6-V electrolytics from 10 to 100 μF.

The count board requires the follow-

table 3. Input-time-base board plug assignments.

plug	to	purpose
4	crystal	oscillator in
5	phono	1 MHz test
6	PB1	seconds reset
7	TS1D	5 kHz calibrator
8	TS1E	2.5 kHz calibrator
9	PB2-3	fast adj. out
10	PB2	1 minute out

table 4. Count board interconnections.

from	to	purpose
plug N	15 μF C	input
15mfd C	U14p14	timer
U14p5	plug R	Vcc
U14p3	plug P	reset
U14p11	plug S	alarm
U14p14	U10p14	input
U10p12	U71Ap1	A out
U10p9	U71Bp4	B out
U10p8	U71Cp10	C out
U10p11	U71Dp13	D out
U71Ap3	plug 16	A out
U71Bp6	plug 17	B out
U71Cp8	plug 18	C out
U71Dp11	plug 19	D out
U10p11	U11p14	10 minutes
U11p9	U11p3	reset
U11p8	U11p2	reset
U11p2	plug T	1 hour out
Plug U	15 μF C	hour in
15 μF C	U12p14	hour in
U12p8	U12p2	reset
U11p12	U72Ap1	A out
U11p9	U72Bp4	B out
U11p8	U72Cp10	C out
U72Ap3	plug 12	A out
U72Bp6	plug 13	B out
U72Cp8	plug 14	C out
U12p8	U70Ap1	reset
U12p3	U70Ap2	reset
U12p11	U13Ap1	10 hours
U13Ap12	U13Bp5	20 hours
U13Ap2	U13Bp6	reset
U13Bp6	U70Ap3	reset
U13Bp9	U70Ap2	reset
U12p12	U73Ap1	A out
U12p9	U73Bp4	B out
U12p8	U73Cp10	C out
U12p11	U73Dp13	D out
U73Ap3	plug 8	A out
U73Bp6	plug 9	B out
U73Cp8	plug 10	C out
U73Dp11	plug 11	D out
U13Ap12	U74Ap1	A out
U13Bp9	U74Bp4	B out
U74Ap3	plug 4	A out
U74Bp6	plug 5	B out

ing: Cut the V_{cc} bus at row 47, column 18; and again at row 47, column 30. Jumper the bottom of V_{cc} bus to plug B. Jumper plug Z to ground bus. Solder all V_{cc} pins except U14 to V_{cc} bus. Connect all grounds to ground-bus. Solder one input of all unused NAND gates to V_{cc} bus. Solder one input of unused AND gates to ground. Connect the upper V_{cc} bus to plug A. Connect the middle V_{cc} bus, used for AND gates, to plug W. On all 7490s, U14, U10, U11 and U12, connect A-out pin 12 to BCD-in pin 1. Additional instructions are in **table 4.** Plug assignments are in **tables 5** and **6.**

read-out board

The middle four Minitrons and drivers, U32-U35 and U40-U43, receive their V_{cc} from the time-base supply, plug B. All others get their V_{cc} from plug A when operating in a counting mode. See pin diagrams in **fig. 5** and plug assignments in **tables 1** and **6**. The Minitron pins 12 or 13 must be connected to V_{cc} and to the other common pins 2, 5 and 10.

All lettered inputs must be connected to the respective lettered outputs of the associated MSD047 drivers. V_{cc} is applied to pin 16 from either plug A or plug B as above. Ground is connected to plug Z. The lamp-test pins are connected together to a wire extending out the back of the board, to which a ground clip can be attached whenever it is desired to display all figure-8s. The ABCD inputs to the decoder/drivers are connected to plugs in accordance with the common assignment **table 1**.

The blanking of left-edge zeros is a little unclear from some data sheets, but the left-hand driver (ten million), U45, should have its RB-I pin 5 connected to ground, and its RB-O pin 4 connected to the adjacent U44 Minitron's RB-I pin 5. This may be continued to the units digit to the right, if desired. It does not blank the time, because of removal of V_{cc} on the end decoder/drivers. For electronic digital dial purposes, it may be desirable not to blank leading-edge zeros of any digits that normally will be displayed for the method to be used. This will be discussed later.

The detailed wiring instructions for the counter and latch operation for the two left-hand digits will be covered later when I discuss counting.

Keep in mind the relatively heavy V_{cc} and ground conductor currents on this board for the small wire size. Use more than one conductor, entering the ICs at

table 5. Count board separate plug assignments.

plug	to	purpose
B	TS2F	+5 timer
N	PB2	1 minute in
P	PB4	ID reset
R	TS2C	ID V_{cc}
S	alarm	ID timer
T	PB3	1 hour out
U	PB3	1 hour in
W	RS3E	AND V_{cc}

places that will minimize voltage drop.

Sufficient detail is given in the above discussion of the read-out board to wire it without further detailed instructions.

switching

The switch in the upper left position is the *mode* switch (designated MS in interconnection tables), a Centralab PA-1015 4-pole, 11-position non-shorting rotary switch. Tentative future assignments indicate that there is no spare pole which may be needed for up/down count, load pulse control and loading, to be discussed in a future article. Some of the positions may not be used unless the frequency of several five-band receivers is to be indicated, or other types of counting functions are incorporated in the digital accessory.

Below, on the left, is a PA-1005 2-pole, 11-position nonshorting switch. This will be needed to switch to various receiver bands including WWV frequencies (thus it is designated BS) using one pole and over half of the available 11 positions. The second pole, or more, may be necessary for control of up and down counting, load pulse and preset loading in some types of equipment.

On the upper right is the *resolution* switch (designated RS) which controls displays, presentation of time and decimal-point position. It is a PA-1027 8-pole, 5-position switch; half the poles will be needed and all of the positions. *Off* can be added at the right-hand end of rotation, which can remove the time display while time continues to be available. Some of the spare poles can be used to provide full switching without use of steering diodes.

The final switch, in the lower right-hand position, is a PA-1013 with 4 poles and 5 positions. I plan to use this (designated TS) to control the ID timer, select 5-kHz or 2.5-kHz calibrate signal when desired, and to switch reversed-polarity power to a Palomar electronic keyer currently in use.

The removal of stops should be done accurately, for they probably will fall off if bent back again. Also, note that the switches having fewer than 11 positions, such as the two 5-position switches on the right-hand side of the panel used for resolution, timer and calibrator, are constructed so that it is best to have the *off* position (if any) at the clockwise end of rotation when it is to be separate from five active positions.

Where the usual counterclockwise position is used for *off* the two poles on the same wafer probably will short for an instant. This may not matter unless power is applied by the contact, in which case the short may damage some ICs. This would happen on the timer switch with some types of ICs unless steering diodes are placed in the 5- and 2.5-kHz calibration outputs. Also, it may short the power supply in the polarity-reversing sections if these are on the same wafer.

table 6. Read-out board separate plug assignments.

plug	to	purpose
B	RS1F	+5 display
K	RS2E	decimal U35

A 100-ohm Mallory U1 composition potentiometer, with switch, has been included. This will facilitate adjustment of the calibrator output to match the incoming signal such as WWV, in order to provide a strong beatnote. The 39-ohm resistor shown in **fig. 6** should be increased until the maximum calibrator signal only slightly exceeds the maximum volume of WWV. The switch may be used later to release some other control, if necessary.

For timer reset, a Switchcraft Littel no. 103 pushbutton, PB4, is mounted on the panel. This type is used also on the chassis for time adjustments. Smaller types are available if desired.

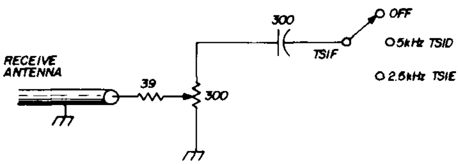


fig. 6. Calibrator output selector. The 39-ohm resistor may be increased to equalize maximum signal with WWV.

Switch contacts in connection **table 7** following numbered designations for each pole, will be given clockwise from the front panel by letters. For example, RS3B indicates the resolution switch, third pole, second contact clockwise from the front. Time-adjust pushbutton circuits are shown in **fig. 7**.

operation

It is well to test the string of dividers on each board on the bench to be sure that they do not present a shorted input or load and that they toggle.

Before the crystal oscillator is plugged in the socket pins should be checked to avoid a short or putting ac on the oscillator input or output; the resistance from the output to all boards should be measured. Then power may be applied to the regulated power supplies. The Minitrons can be tested by grounding the interconnected lamp-test pins with a grounding clip.

Ac and dc tests can be made with a vtvm and scope to show the output at each step in the frequency division. A dc meter usually settles down at about half the V_{cc} (except for the D output from decades) when driven with square waves which are all on one side of the zero line. Be sure that V_{cc} has been switched on the four AND gates for display of time.

When setting the clock, you may reset the seconds (PB1) with WWV even though these are not displayed. They should change the minutes display with the start of the next minute on WWV; if they do not, the output may have been taken from the incorrect divide-by-three output that produces the minute pulse. Next, the minutes fast-advance pushbutton (PB2) should be held down until the minutes are correct, then the button should be lifted promptly. Inasmuch as this count may trigger an increase in the hours display, hours are set last with the hours fast-advance pushbutton (PB3). The hours should pass from 23 to 00 automatically, and be displayed without blanking either of these zeros.

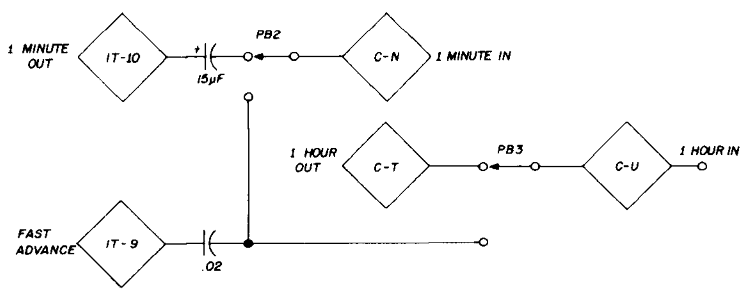


fig. 7. Fast-advance clock pushbutton circuit.

count mode

The next part of this series will cover the input amplifier and count mode using SN7490N decades up to the final digit. Following that, work will be done on the

table 7. Switch interconnections.

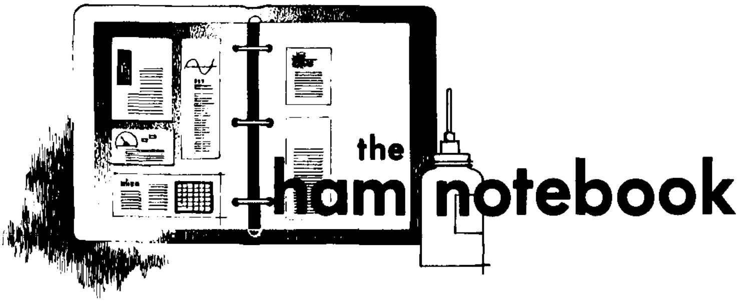
lug	to	purpose
RS1B	RO plug B	time readout
RS1B	RS3F	+5 B
RS1C	RS1B	+5 B
RS1D	RS1B	+5 B
RS1E	RS1B	+5 B
RS1F	IT plug B	+5 B
RS2B	RO plug X	decimal
RS2C	RO plug 21	decimal
RS2D	RO plug 22	decimal
RS2E	RO plug K	decimal
RS2F	ground	decimal
RS3E	C plug W	AND +5
RS3F	RS1B	+5 B
RS4B	IT plug 12	1 kHz
RS4C	IT plug 13	100 Hz
RS4D	IT plug 14	10 Hz
RS4F	IT plug 15	resolution
RS5B	TS3B	+5 A
RS5C	RS5B	+5 A
RS5D	RS5B	+5 A
RS5E	RS5B	+5 A
RS5F	plug A	+5 A
TS1D	IT plug 7	5 kHz
TS1E	IT plug 8	2.5 kHz
TS1F	capacitor	receive antenna
TS2C	C plug R	timer
TS2F	C plug B	+5 B
TS3A	phono	+5 keyer
TS3B	RS5B	+5 A
TS3C	TS3B	+5 A
TS3D	TS3B	+5 A
TS3E	TS3B	+5 A
TS3F	+5 V	A supply
TS4A	phono	-5 keyer
TS4B	plug Z	-5 A
TS4C	TS4B	-5 A
TS4D	TS4B	-5 A
TS4E	TS4B	-5 A
TS4F	-5 V	A supply

synthesis method of counting a receiver or exciter frequency with an up-counter, and the use of the 74192 up/down counter with programmed error correction for giving dial indication with a single connection to the receiver or exciter.

references

1. Kenneth MacLeish, W7TX, "Frequency Counter for the Amateur Station," *QST*, October, 1970, page 15.
2. E. H. Conklin, K6KA, "Calibrators and Counters," *ham radio*, November, 1968, page 41.

ham radio



testing high-power tubes

Many amateurs would like to take advantage of the vacuum tubes which often appear on the surplus market at very low prices. While a simple emission test, similar to that shown in **fig. 1**, may indicate that the tube has sufficient filament emission and is relatively gas free, something further than such a simple test is needed before attempting to put bargain tubes into service. Most vacuum tube manufacturers test their power tubes with highly sophisticated apparatus which the typical ham can not afford. Very slight leakage can be detected by applying two or three kilovolts on the tube for momentary application and observing what happens. Such a crude test, though effective in some ways, is neither safe for the tube undergoing testing or for the experimenter.

While searching for a better way, the vtvm setup shown in **fig. 2** was developed. The usual grid bias is applied to the tube, in addition to the necessary filament supply, and the vtvm – upon appropriate scale – is touched to the anode of the vacuum tube under test. We checked out fourteen tubes with this method, and in every case those tubes which would take normal high voltage in extended service without trouble showed no grid bias on the anode. Those which were excessively gassy showed close to 100% of the bias voltage whenever the vtvm was connected to the anode of the tube under test.

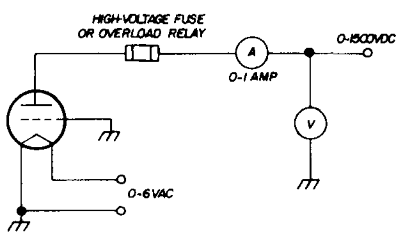


fig. 1. Simple test setup for checking vacuum tube emission.

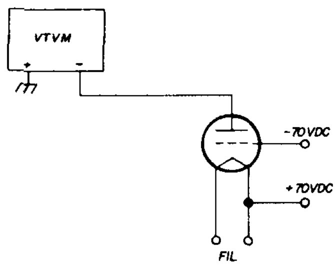


fig. 2. Improved test setup does not use multi-kilovolt power sources. The bias voltage will, of course, vary from tube to tube. The vtvm is set to read negative dc voltage.

Obviously, the bias voltage will vary with the type of tube under test, but it is much safer to experiment with 100 volts than to handle, for example, 2,000 volts. This simple method of testing has worked satisfactorily in all cases where triodes had to be checked, and there is no good reason why tetrodes and pentodes could not be similarly tested.

Neil Johnson, W2OLU

diode surge protection

Since building my first power supply using semiconductor rectifiers, I have always been a little uneasy because I never bothered to but in diode surge protection, as in the case of power supplies shown in the *ARRL Handbook.*[1] This bothered me, because I was always uncertain as to the day when I would turn on the power supply and blow the diodes. This has never happened though, and it is a result of this personal experience that I began to investigate surge currents and diodes.

All of the high-voltage transformers I have used have had secondary resistances of between 70 and 300 ohms at voltages from 770- to 1600-volts rms. For example, let us use a transformer model with a peak to peak secondary voltage of 1000 volts and a secondary resistance of 70 ohms. This transformer is fed through a full-wave bridge rectifier to an output capacitance of 60 μF. And for our diode model a set of 1N4007s has been chosen.

At the instant power is applied to the primary of the transformer the load across the secondary represents a dead short (uncharged capacitor). So, until this capacitor is charged, the only current-limiting device in the secondary is the resistance of the secondary winding. For 1000 volts and 70 ohms there is a maximum current flow of 14.28 amperes. And how long this maximum current will flow is determined by the time constant of the secondary (time constant refers to the rate of charge of an RC circuit). For a secondary resistance of 70 ohms and an output capacitance of 60 μF, the time constant is 4.2 milliseconds, and represents the amount of time it will take for the capacitor to charge to 63% of its full value. So what this means then, is that if your diodes can withstand a surge current of approximately 15 amperes for 4.2 ms then they should not be damaged.

Let us examine the 1N4007 diodes with the information shown in *The Semiconductor Data Book* published by Motorola.[2] Here, the maximum surge capability is plotted on a graph of surge current versus number of cycles at 60 Hz, (**fig. 3**). In this case the graph shows that the diode will withstand safely, at room temperature, a surge current of 50 amperes for one duty cycle, which is 16.6 ms. Obviously then, if the 1N4007 can withstand 50 amperes for a duty cycle of 16.6 ms seconds, it will safely carry a surge current of 14.28 amperes for a period of 4.2 ms. After this initial 4.2 ms the surge current will reduce as the output capacitor approaches full charge voltage.

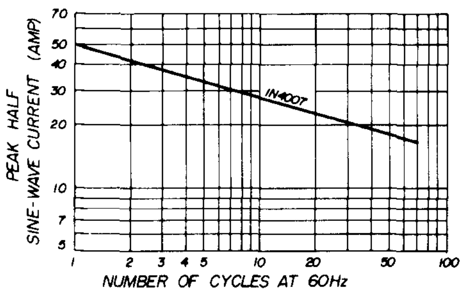


fig. 3. Maximum surge current capability of the 1N4007 diode at room temperature.

Discussions with fellow amateurs about this subject has confirmed my suspicions that surge protection is a needless feature in power supplies. For, of those amateurs spoken to who had built their own supplies, none had bothered to use surge protection. Perhaps this bothersome circuitry was necessary in the days of the top-hat rectifiers; but it now seems to be an anachronism in the days of the epoxy rectifiers.

Here's hoping this article will be of some help to future power-supply builders.

John Lapham, WA7LUJ

references

1. "The Radio Amateur's Handbook," 47th edition, ARRL, 1970.
2. "The Semiconductor Data Book," 3rd edition, Motorola, Phoenix, Arizona, 1968.

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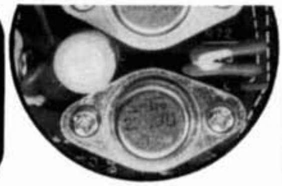

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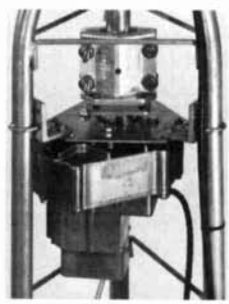

Up to 10 times the mechanical and braking power of any rotator. Handles big beams and stacked arrays with ease. 4000 in/lbs. of rotating torque. Brake slips in at 5000 in/lbs.to prevent damage. Accepts up to 3" O.D. Mounts on standard tower plate. Requires minimum 10" leg spacing. Mounting kits available for poles, small towers, towers without plates. Wt. 28.0 lbs. Same as Famous R-400 except without control unit. Use with RB550A.

ORDER NO. 300

Precision radio equipment from Galaxy Division of

HY-GAIN ELECTRONICS CORPORATION

Box 5407-WC Lincoln, Nebraska 68505

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Everything you always wanted in keyers and QRP equipment.

■ POWER-MITES

MODEL PM2B

MODEL PM2B. Popular two watt CW transceiver. Operates on 80-40-20 meters. Side-tone. Lantern battery or 12 VDC power source. Size 10⅜″ W × 4½″ H × 6⅝″ D. Weight 2¾ lbs. **Price $64.95.**

MODEL PM3A. Advanced 5 watt CW transceiver. Operates on 40-20 meters. Side-tone. Push pull final. Pi Network. Break-in keying. Size 10⅜″ W × 4½″ H × 6⅝″ D. Weight 3 lbs. **Price $79.95.**

■ ANTENNA TUNER

MODEL AC5. Matches 52 ohm output of Power-Mites to open wire on random length antennas. Maximum power 10 watts. Size 4″ W × 2″ H × 4″ D. Weight 1 lb. 4 oz. **Price $8.95.**

■ SWR BRIDGE

AC4

MODEL AC4. Favorite for QRP. Measures from ¼ watt to 200 watts. Size 4″ W × 2″ H × 4″ D. Weight 1 lb. 4 oz. **Price $14.95.**

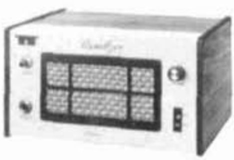
Argonaut

The Argonaut is for every ham.
A transceiver that operates
on an AC pack or lantern battery.
Covers Amateur bands 80-10, SSB and CW.

Completely solid state. Permeability tuning. Less than 100 Hz drift. ½ uv sensitivity. 9 MHz crystal filter. 2.5 kHz bandwidth, 1.7 shape factor. Amateur bands 3-30 MHz. AGC. Speaker, SWR bridge, S-meter built-in. Instant CW break-in. Side-tone. Plug-in circuit boards. Selects normal side band, reversible. One control tune-up. 50-75 ohm push-pull output. Direct frequency read out.

Argonaut price	**$288.00**
Power supply	**$24.95**
Microphone	**$17.00**

■ SIGNALIZER



S20

MODEL S20. Complete audio and speaker system for receivers / tranceivers. Plugs into headphone jack. *Provides maximum AGC to keep all* signals constant level. Front panel headphone jack. Size 8¼″ W × 4½″ H × 6½″ D. Weight 3½ lbs. **Price $39.95.**

MODEL S30. Similar to S20 but has built in FR4 CW filter; switchable. Size 8¼″ W × 4½″ H × 6½″ D. Weight 4 lbs. **Price $49.95.**

■ KEYERS AND KEYER PADDLES

KR40

KR5

MODEL KR40. Squeeze keyer. Iambic sequence. Full memories. Variable weighting. With dual paddles. Speeds *from* 6-60 wpm. 115 volt AC operation. Side tone. Size 4¾″ W × 2½″ H × 8″ D. Weight 4 lbs. **Price $89.95.**

MODEL KR20. Keyer. Self-completing. *On/off weighting. With dual paddles.* Speed 6-60 wpm. Monitor side tone. 115 V AC operation. Size 4¾″ W × 2½″ H × 8″ D. Weight 4 lbs. **Price $59.95.**

MODEL KR5. Keyer. Self-completing. Optimum weighting. Single paddle. Speed 6-60 wpm. Operates from 6 or 12 volts DC. Size 4″ W × 2″ H × 6″ D. Weight 1 lb. 6 oz. **Price $34.95.**

MODEL KR1. Paddles as used in KR40 and KR20. Mounted in formed aluminum case. Size 4¼″ W × 2″ H × 6″ D. Weight 1 lb. **Price $18.95.**

MODEL KR2. Paddle as used in KR5. Mounted in formed aluminum case. Size 4¼″ W × 2″ H × 6″ D. Weight 1½ lbs. **Price $12.95.**

Ask your TEN-TEC dealer to show you our complete line. If there is no dealer in your area, send your order direct. Include $2.00 shipping for each Argonaut, all other items shipped postpaid.

Dept. V-2
TEN-TEC, INC.
Highway 411 East ☐ Sevierville, Tennessee 37862

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ARGONAUT

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WITH HIGH POWER?

GET YOUR KICKS

with the

NEW TEN-TEC ARGONAUT

"FIVER" (5 watts, 5 bands, 5 lbs.)

IN STOCK AT

ELECTRONIC DISTRIBUTORS, INC.

Communication Specialists for 33 Years

1960 Peck St., Muskegon, Mich. 49441

ARGONAUT

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A R G O N A U T A R G O N A U T

PATCH PLUS

GALAXY PHONE PATCH PR-550A

Deluxe hybrid phone patch and recorder control circuitry. Panel jack accepts S260 (PL68) plug. Selector switch (lock or momentary) controls unit PTT line. Function switch selects desired audio routing for record with tape recorder or play-back to equipment or phone line. Gain controls on receive or transmit. Wt. 2.0 lbs.

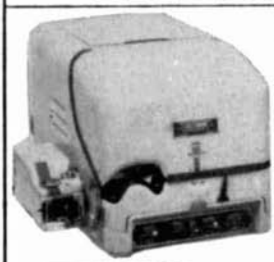
Order No. 812 **$49.00**

Precision radio instruments from Galaxy Division of

HY-GAIN ELECTRONICS CORPORATION

Box 5407-WC Lincoln, Nebraska 68505

ELECTRONIC SURPLUS BARGAINS



KLEINSCHMIDT TELETYPWRITERS

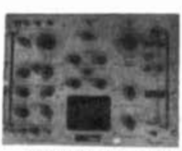
Model TT-100. Capable of sending 60-100 WPM., 115 v, 60 cyc. Self contained pwr. supply. Shipping wt. 70 lbs. ...... **$59.50 ea.**
Model TT-843 - Same as above.
UNUSED .... **$150.00 ea.**

REPERFORATOR-TRANSMITTER

Model TT-179/FG Mfg by Kleinschmidt
Tape printing & punching, also transmitter-distributor. 115 volts, 60 cyc, shpg. wt. 90 lbs. Used, excellent cond., (gov't. cost $2,000). **$59.50**

TELETYPWRITER TABLES

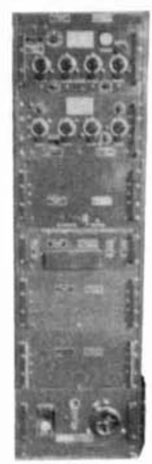
Heavy duty construction, shpg. wt. 20 lbs. for page printer, 22" x 18" x 27" ht. $15.95



A wide-range, high gain, portable test unit for observation of pulses, short-period electrical disturbances, sine waves, Band width 3 cyc.-15 mc. 105/125 VAC, 50-1000 cyc.
AN/USM-50 OSCILLOSCOPE $79.00

TEST SCOPE

TDMS Transmitter used in testing of teletype equipment, contains 1-3RPI, 1-5687, 1-6N030, 2-12AX7 & 13-12 AU7. No pwr. sply.
Shpg wt. 20 lbs. **$15.00**



2-METER-VHF
BC-640 X'MITTER
50 watt - CW and AM. Freq. range 100-156 MC crystal controlled Pwr. rqmt. 100/125 60 cyc. Crated wt. 600 lbs. 6' x 22" wide.
$49.50

ANDY ELECTRONICS — DIV. OF ANDY INTERNATIONAL

6427 Springer Houston, Texas 77017 713-645-7057

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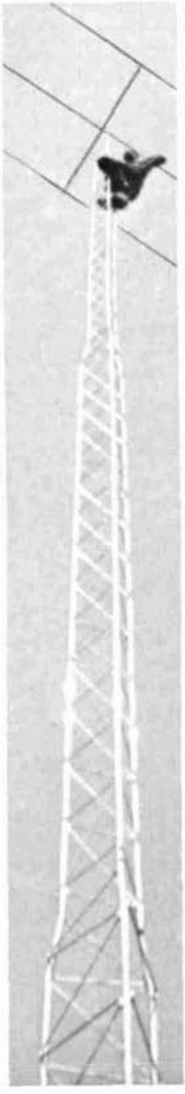

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First of its Kind !

DIGITAL AUDIO FREQUENCY METER

featuring

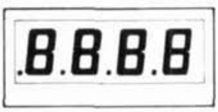
- XTAL CONTROL
- 10 Hz–2 MHz
- LSI DESIGN
- 4 DIGIT DISPLAY
- 7 DIGIT RESOLUTION

The model 1200 is indispensable when accurate audio or broadcast frequency measurements are required. Crystal control allows precision calibration of electronic organs as well as I.F. strips. LED display life is 100 years.

1200 AUDIO FREQUENCY METER KIT $149.95

1200 W assembled & tested $179.95

LIQUID CRYSTAL READOUT ASSEMBLY



The most advanced readout device on the market! 4 digits, 4 decimal points, 6VDC operation, 1 μA per segment, black numbers on white background. Perfect mate for LSI chip below. Data sheet and application notes provided.

LCR-4 . . . . $29.95

LSI

Do it yourself instrument chip. Has 4 decade counters, 4 latches, seven segment decoder, 2 oscillators, display multiplex circuitry, etc. Make freq meters, DVM's, etc. Comes with free 16 page booklet of specs and app notes. Interfaces with all seven segment displays. DIP package.

5002 ———— $24.95 5005 Booklet only —— $1.50

FREE CATALOG

epd Environmental Products
BOX 406 Lafayette, IN 47902 Ph 317 743 1893

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flea market

■ **RATES** Commercial Ads 25¢ per word; non-commercial ads 10¢ per word payable in advance. No cash discounts or agency commissions allowed.

■ **COPY** No special layout or arrangements available. Material should be typewritten or clearly printed and must include full name and address. We reserve the right to reject unsuitable copy. **Ham Radio** can not check out each advertiser and thus cannot be held responsible for claims made. Liability for correctness of *material limited to corrected ad in next* available issue. Deadline is 15th of second preceding month.

■ **SEND MATERIAL TO:** Flea Market, Ham Radio, Greenville, N. H. 03048.

HAMFEST — WABASH COUNTY ARC *fourth annual* hamfest, Sunday, May 21. Rain or shine. Admission is still only $1. Flea-market, food, tech. talks and much more. For information write Bob Mitting, 663 Spring, Wabash, Indiana 46992.

EVANSVILLE, INDIANA HAMFEST 4H Grounds (Highway 41 North 3 miles) Sunday, May 7, 1972; airconditioned, auction, overnight camping, ladies' bingo, reserved flea market booths. Advance Registration. For flyer, contact Morton Silverman, W9GJ, 1121 Bonnie View Drive, Evansville, Ind. 47715.

TELETYPE: Model 14 TD, $25; Electronic Frequency Counter, HP-521C, $99; 40 rolls 11/16" perforator tape, $8; page paper, $3/box. Jim Cooper, POB 73-H, Paramus, NJ 07652.

AUCTION: Radio Association of Erie annual Ham Auction starts 2:00 Saturday, April 8. Doors open 12 noon. St. Geodge's Gym. 1½ miles north of I-90 on U.S. Route 19. Bring your goodies. Ample free parking. Indoors. No stairs. Refreshments available on premises. Free map and details. RAE Auction, Box 844, Erie, PA 16512.

SWAN SW-240 80-40-20M SSB xcvr, 117XC pwr supply, mobile cable, new final, turner PTT mike, factory manual. Very clean, but I'm a CW fanatic. $190 plus shipping. Roger Alan Jones, K1NTS, Box 51, North Attleboro, Mass. 02760.

BUILT TO SELL SB-102, HP-23A, HDP-21A and SB-600, complete station, factory aligned and tested. Best offer over $600.00. Jim Carollo, 611 Smith St., Iron Mountain, Mich. 49801.

GALAXY V MK2 and ac power supply $340.00. Mint condition: Ken Simmons, 2777 So. 38th Street, Lincoln, NE 68506. Phone 402-488-1065 or 402-434-9151.

"MOORY ELECTRONICS COMPANY" wants "you" as a customer! Write or call "HOSS TRADER" Ed Moory for the best deal on new or used equipment in 1972: NEW EQUIPMENT: "Specials": Mosley MCQ-10, 1 KW 10 Meter Quad, Mosley MCQ-15, 1 KW 15 Meter Quad, Amateur Net each $67.25, Cash Price, $44.00 each: New Yaesu FVdx-400 VFO (operates with FTdx-400 Transceiver), Reg. $99.00, Cash $49.00: New Collins MP-1 DC Supply, Reg. $235.00, Cash $149.00: USED EQUIPMENT: "Excellent" Drake 2A, $145.00: Drake 2B, $175.00: HT-37, $179.00: 32S-1, $349.00: GT-550, AC-400, SC-550, $389.00: IN STOCK: New Drake, Galaxy, National, Robyn "Ditigal" and lots more. Write or call "Ed Moory" or "Charlotte Matlock" for quotes. Moory Electronics Co., P. O. Box 506, Dewitt, Arkansas 72042. Phone (501) 946-2820.

BLOSSOMLAND AMATEUR RADIO ASSOCIATION presents it's annual Ham Auction, Sunday, March 12, 1972 at the Shadowland Ballroom, St. Joseph, Michigan. Doors open 7:00 a.m. Admission $2. Auctioning free. Display tables available with one-half acre under roof. For additional information write: BARA, P. O. Box 175, St. Joseph, MI 49085.

1972 ARRL GREAT LAKES DIVISION Convention/Hamfest, Muskegon, Michigan, March 17-18, 1972, Muskegon Community College. Large social hour Friday evening at local motel with possible Wouff Hong initiation. Registration begins at 8:00 a.m. Saturday. Meetings for all nets and MARS groups. Ladies program in Overbrook Theatre on Campus. Forums on: VHF Repeater Frequency co-ordination, Amateur Radio Public Service Corp, Net and traffic handling. ARRL. Technical Sessions: Slow scan TV, RTTY, VHF-1FM, VHF Repeaters, DX Hounds, Antennas, Equipment design. Swap & shop. Parking, Dining Room open all day, Banquet for 300+ Saturday evening. Advance reservations available. Any special information or requests: Please contact WA8GVK.

MID-WINTER SWAPFEST. National Guard Armory, Whitewater, Wisconsin, March 5, 1972, 9:00 a.m.-5:00 p.m., March 12 'snow-date'. Tri-County Amateur Radio Club, P. O. Box 314, Whitewater, Wisc. 53190. $1.00 advance; $1.50 at door. Extra $1.00 reserves display table. Talk-in freq. 3.985. Refreshments, free parking, prizes, everything indoors. Contact: WB9DWG, R. Lust, R. R. 4, Box 235, Fort Atkinson, Wisc. 53538. 1-414-563-4598.

WANT CLEAN COLLINS 51J-4; and late Meat Ball 75S-3C, 32S-3, 312B-4, 516F-2; manuals, shipping containers. No junk! Give serial number, condition, price first letter; also price for all if have all. Watson, 700 West Willow Street, Long Beach, CA 90806.

MOULTRIE AMATEUR RADIO KLUB, 11th annual Hamfest, Wyman Park, Sullivan, Illinois, April 30, 1972, Indoor-outdoor market. Ticket donation $1.00 in advance — $1.50 at the gate. Open 8:30 a.m. W9BIL - 146.94mhz. M.A.R.K. Inc., P. O. Box 327, Mattoon, Illinois 61938.

QSL'S — BROWNIE W3CJI — 3111B Lehigh, Allen-*town, Pa. 18103. Samples 10¢. Cut catalogue 25¢.*

QSLS. Second to none. Same day service. Samples 25¢. Ray, K7HLR, Box 331, Clearfield, Utah 84015.

FOR SALE: SBE-33, HW-101, HW-12A, HP-23, Drake 2B with 2BQ, Johnson Thunderbolt amp. and KW Matchbox. W2BLM, Box 332, Windsor, NJ 08512.

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

GALAXY V MK3 and ac power supply. Like new; has less than 80 hours use: $385.00: R. A. Kobold, 4242 Northwest 50th, Lincoln, NE 68524. Phone: 402-799-3531 or 402-434-9151.

TELL YOUR FRIENDS about Ham Radio Magazine.

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"DON AND BOB" GUARANTEED BUYS. Motorola HEP 170 epoxy diode 2.5A/1000PIV 39¢; MOT MC170 CG OPAMP (709) 50¢; Sangamo DCM600 MFD/450V 4.95; Vacuum 50PF/7.5KV 1.95; Ham-M 99.00; TR44 59.95; Mosley CL33 114.00; CL36 134.00; TA33 105.00; Hy-Gain TH6DXX 139.00; Tri-Ex MW 50 tower 229.00; Airdux 2408T coil 5.00; Ray 6LQ6 3.50; ¼" copper ribbon 10¢/ft; Clairex 604 photocell 1.00; used, guaranteed gear: Hallicrafters SX115 250.00; Collins 51J4 350.00; Galaxy V 250.00; 75A4 (clean) 395.00; KY65 code identifier 5.95; Tempo Kenwood dealer. Write quote note. Mastercharge, BankAmericard. Prices collect. Warranty guaranteed. Madison Electronics, 1508 McKinney, Houston, Texas 77002. (713) 224-2668.

32S-3, 516F-2, $500. Functioning perfectly. Tom, 803-359-2057, Box 278, Lexington, SC.

TECH MANUALS — $7.50 each: R-388/URR, R-389/URR, R-220/URR, 51J4; following manuals $6.50 each — URM-25D, TS-497B/URR, R-274/FRR, SP-600JX, OS-8C/U, CV-591A/URR. Hundreds more. S. Consalvo, W3IHD, 4905 Roanne Drive, Washington, DC 20021.

INSTANT NOISE LIMITER MODULE — Easy 20-Minute installation for Heathkit, Galaxy, Swan and most other amateur equipment; $8.95 Postpaid. Welborn Electronics, 133 Linden Street, Henderson, Nevada 89015.

REGENCY, GALAXY, HY-GAIN, Rohn, SBE, Hallicrafters, Hammarlund, Barker and Williamson, CAI, Scientific Radio Systems, Simpson, DyComm, Gladding, Harmon-Kardon, Midland, Scott, Sherwood, Altec, Ampex, RCA, GE, Zenith, Kodak, Polaroid, Bell-Howell, Argus, GAF, Pentax, Gruen, Lucien Piccard, Jules Jurgensen. Write Steven Kullmer Evergreen Inc., Dysart, Iowa 52224.

DX'ERS — Dig Them Out of the Mud. New low noise Dual Gate MOSFET Preamplifier. Nominal 20db gain. 10-30 MHz. Complete in cabinet. $29.96. Dynacomm, 1183 Wall Road, Webster, NY 14580.

MUST SELL: Galaxy V Transceiver and dc power supply: $350.00 or best offer: John Fuhrmen, 2901 South 57th, Lincoln, NE 68506. Phone 402-488-1453 or 402-434-9151.

THE THIRTEENTH ANNUAL HAMFEST sponsored by the Southern Tier Radio Clubs, is scheduled at St. Johns Ukranian Hall, Johnson City, N. Y. on April 15th at 2 p.m. Tickets or additional information from John Pike, WA2UKS, 635 Lacey Drive, Endwell, N. Y. 13760.

BRAND NEW COAX CONNECTORS PL-259 (male) or UG-260D (BNC male) 7 for $2.00; nice low impedance headphones reconditioned $5.00 each; New carbon paper black typewriter ribbons for IBM executive models A, B, C $1.50 dozen. All plus postage. Bill Hayward, W0PEM, 1307 NE 57th Terrace, Gladstone, Missouri 64118.

4-1000A TUBE new 75.00, I193 manual & chest 15.00, TS34A scope 25.00, HP560 recorder 80.00, Tek 514AD 135.00, Beckman 7360 140.00, USM103 425.00, USM105 350.00, GR1330A 280.00 with manual, adapter & calibrated 350.00, GR1001-A TDA-2 35.00. SASE for list of excess and new components. Douglas Craton, 5625 Balfrey Dr., W. Palm Beach, Florida 33406.

SBE-33 Excellent condition, factory aligned, new mike & manual. $140.00 or will trade for a HAL Mainline ST-6 TU. R. M. Lee, WB6LCJ, 42 North Drive, Freedom, CA 95019.

GREATER BALTIMORE HAMBOREE. Sunday, April 9 at 10 a.m. Calvert Hall College, Goucher Blvd. and LaSalle Road, Towson, Maryland 21204 (1 mile south of Exit 28 Beltway-Interstate 695), Food Service, Prizes, Flea Market, $1.50 Admission, NO TABLE CHARGE OR PERCENTAGE.

AUTOMATIC MORSE CODE Copying Machine. Featured in Ham Radio Magazine November 1971. Copy up to 120 wpm without knowing Morse code. Simply hook to your receiver's audio and read printout. Send $14.95 for detailed construction plans. VMG Electronics, 2138H West Sunnyside, Phoenix, Arizona 85029.

HOOSIER ELECTRONICS Your ham headquarters in the heart of the Midwest where only the finest amateur equipment is sold. Authorized dealers for Drake, Hy-Gain, Regency, Ten-Tec, Galaxy, Electro-Voice, and Shure. All equipment new and fully guaranteed. Write today for our low quote and try our personal, friendly Hoosier service. Hoosier Electronics, Dept. G., R. R. 25, Box 403, Terre Haute, Indiana 47802.

SOUTHWEST HAM ROUND-UP AND FIASCO: will be sponsored by Old Pueblo Radio Club on April 29-30, 1972. Headquarters Ramada Inn, Tucson, Arizona. Banquet, Technical Sessions with Ham applications and demonstrations. Ladies prizes, luncheons and tours. Pre-registration prize plus other prizes. Swapfest, Auction and other activities on the 30th. Plan to enjoy the hospitality and fun in the sun. Contact: Al Summers, Chairman, W7MGF, c/o O.P.R.C., Box 6497, Tucson, Arizona 85716.

2-METER FM INOUE IC-20, Brand New, 1 & 10 watts, solid state, 12 channel, w/xtals, w/accessories, $235.00. Bob Brunkow, 206-747-8421, 15112 S.E. 44th, Bellevue, Washington 98006.

FOR SALE. GLOBE KING 500A FB 500 watt CW transmitter $110.00, with spare set of tubes. WRL 755A VFO $20.00. Hallicrafters SX-100 receiver $85.00. All with original instruction books. All equipment now on the air. Pick up only. W8CVA Don Baker, 4606 Wickford Dr. E., Sylvania, Ohio 43560. 419-882-4581.

21st ANNUAL DAYTON HAMVENTION will be held on April 22, 1972 at Wampler's Dayton Hara Arena. Technical sessions, Exhibits, Hidden transmitter hunt, Flea market and special program for the XYL. For information write Dayton Hamvention, Dept. H, Box 44, Dayton, Ohio 45401.

FREE INFORMATION. Get FCC license new, easy way. Academy of Communications Technology. HR-1, Box 389, Roswell, New Mexico 88201.

7289 (3CX100A5) CERAMIC REPLACEMENT for 2C39A. Top quality pullouts, pretested at 449MC and guaranteed. Have several dozen at $5 ea or $50 dozen. J. E. Howell, W4SOD, Folly Beach, South Carolina 29439.

ROCHESTER, N. Y. is again Hamfest, VHF meet and flea market headquarters for the largest event in the northeast, May 13th. Write WNY Hamfest, Box 1388, Rochester, N. Y. 14603.

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! LOWEST PRICE ANYWHERE. 40/$10.00 POSTPAID (5/$2.00). Center tapped, 44 or 88mhy. 32KSR page printer, reconditioned, perfect $225. MITE UGC41KSR page printer, reconditioned, $250. Model 28 sprocket to friction kit, $25. Model 15KSR, $65. Matching RA87 P.S. unused, $5. Sync motors, $7. 14TD 60 speed, $25. 14DPE tape punch, $15. HP 200CD audio oscillator, $75. 11/16" reperforator tape, 40/$1.00. Model 33ASR complete $650. Stamp for listing. Van, W2DLT, 302H Passaic, Stirling, N. J. 07980.

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

TV & RADIO TUBES 36¢. FREE CATALOG. Cornell, 4219 N. University, San Diego, California 92105.

NEW ELECTRONIC PARTS. Buy-Sell. Free Flyer. Large catalog $1.00 deposit. Bigelow Electronics, Dept. HR, Bluffton, Ohio 45817.

HEATH SB-100 with AC supply, absolutely mint condition $300. Hallicrafters HT-32 transmitter FB $180. Both shipped prepaid. Cline, WB6LXI/7, Box 6127, Salt Lake City, Utah 84106.

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

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T.V.I. PROBLEMS?

T.V.I. Filter B & W Model 424 designed for C. B. and Ham up to 100 watts. Input & output impedance 50 ohms more than 60 db of attenuation of harmonics.

Price—$10.88

See your dealer or write:

Barker & Williamson, Inc. B&W

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2 METER FM TRANSMITTER KIT
5 WATTS – 4 FREQ.

Featuring: Step-by-step instructions — 3″ x 7″ Glass Epoxy P.C. Board — 16 Transistors — 9 diodes — Plug in Crystals — Separate Oscillators for each frequency — only 1 Amp @ 13.6 V for 5 Watts (typical) output — ±10 KHz dev.

PRICE $59.95 plus $1.40 Postage in U.S.A.

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will bring most receivers
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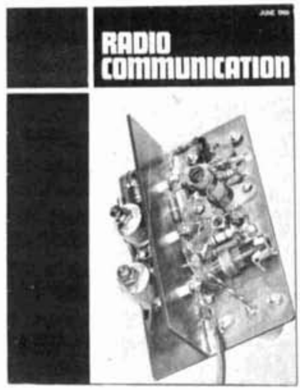

Many thousands of you have become very familiar with the various Radio Society of Great Britain books and handbooks, but very few of you are familiar with their excellent magazine, Radio Communication.

It includes numerous technical and construction articles in addition to a complete rundown on the month's events in amateur radio. Surely a most interesting addition to your amateur radio activities.

We can now offer this fine magazine to you along with the other advantages of membership in the RSGB (such as use of their outgoing QSL Bureau) for $9.95 a year.

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Greenville, New Hampshire 03048

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WORLD QSL BUREAU — See ad page 88.

ASK HARRY FIRST Ameco, Clegg, Cushcraft, Galaxy, Hallicrafters, Hy-Gain, Mosley, Regency, Sonar, Simpson, TenTec others. Good trades accepted. S.A.S.E. Name literature wanted. Harry's Amateur Radio Supply, 3528 Gaskin Rd. (Belgium) Baldwinsville, N. Y. 13027. 10AM-9PM. Closed Sunday. 315-635-7452.

B.A.R.T.G. SPRING RTTY CONTEST. 0200 GMT Saturday, March 25th until 0200 GMT Monday, March 27, 1972. Not more than 36 hours of operation is permitted. Times spent listening count as operating time. The 12 hour non-operating period can be taken at any time but off-periods may not be less than two hours. Times on and off the air must be on the Log and Score sheets. The Contest is also open to SWL RTTYers. 3.5, 7, 14, 21 and 28 Mhz. Amateur Bands. Stations may not be contacted more than once on any one Band. ARRL Countries List. except KL7, KH6 and VO to be considered as separate Countries. Messages exchanged will consist of: (A) Time GMT. (B) Message Number and RST. All two-way RTTY contacts within one's own Country will earn **TWO** points. All two-way RTTY contacts outside one's own Country will earn **TEN** points. All stations will receive a bonus of **200** points per Country worked including their own. **NOTE** any one Country may be counted again if worked on another Band but Continents are counted once only. Two way exchange points times total Countries worked plus total Country points times number of Continents worked gives total score. Use one log for each Band. Logs to contain Band, Time, GMT, Message and RST Numbers sent and received and exchange points claimed. **ALL logs must be received by May 31, 1972 to qualify.** Send to: Ted Double, G8CDW, B.A.R.T.G. Contest Manager, 89 Linden Gardens, Enfield, Middlesex, England.

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