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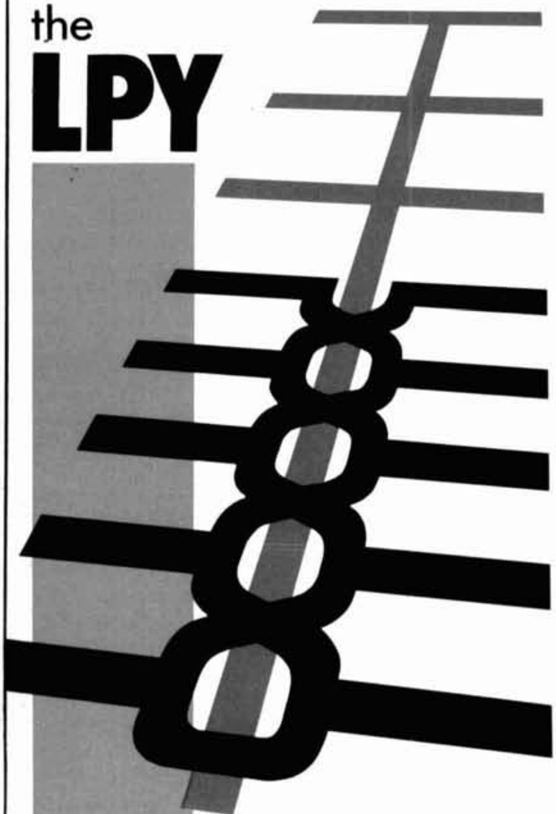
ham radio

magazine

JULY 1969

the

LPY



log-periodic
yagi
bandpass
beam antenna

this month

trading time

...but not for the KWM-2

At 100,000 miles, it's still the liveliest rig on the road.

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july 1969

volume 2, number 7

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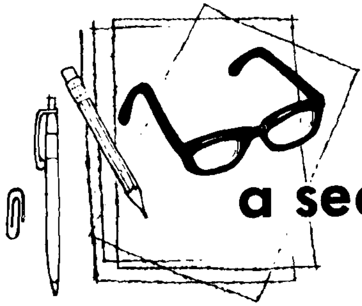

a second look

by jim fisk

One of the more worthwhile amateur radio projects I have heard about recently is the John W. Gore Memorial Scholarship sponsored by the Foundation for Amateur Radio. The scholarship for 1969 consists of a $500 award for either graduate or under-graduate study.

Licensed radio amateurs who intend to make their career in electronics or related sciences may request a scholarship application. To be eligible, applicants must have completed one year of an accredited program at an accredited college or university leading to a bachelor's or higher degree. They must also hold a valid FCC license of at least General class. Although preference will be given to applications from the area served by the Foundation for Amateur Radio—the District of Columbia, Maryland and Virginia, those living elsewhere are not excluded.

Scholarship applications should be completed and mailed not later than August 15, 1969, and should be sent to the Chairman, Scholarship Commitee, Foundation for Amateur Radio, Inc., 449 Greenwich Parkway, N.W., Washington, D. C. 20007. The recipient of the scholarship award will be announced on September 1st.

The Foundation for Amateur Radio, Inc. is a non-profit organization devoted to the advancement of amateur radio and is composed of trustees representing over 20 radio clubs in the District of Columbia, Maryland and Virginia. John W. Gore, W3PRL, in whose honor the scholarship is named, was, until his death in 1960, the president of the Foundation.

bonadio antenna

The article on the Bonadio antennas published in the April issue has received everything from brickbats to bouquets. One irate reader wrote in to say that, "Antennas and other equipment items are subject to measurements and reason; their operation must be explained and tested within the realm of physics—not metaphysics." More enthusiastic readers were unhappy when complete construction details didn't appear in the next issue—one amateur even had the support poles ordered for the space-dimension antenna.

Initial response to the Bonadio antennas has been for the most part emotional and the letters I have seen have contributed little to their understanding. Whether they work or not, I don't know, but W2WLR claims that they do. He has been trying for nearly 15 years to get something into print—now that it's in print, let's have some controlled experiments to determine if these antennas have any merit or whether the performance he is getting is a result of his particular location. Amateurs seriously interested in constructing one of these antennas can obtain more detailed constructional information from either W2WLR or myself.

An antenna that is apparently related to the Bonadio antennas was used with early English radar systems, type TRU. The TRU antenna consisted of two half-wave radiators, arranged in a cross configuration similar to the Bonadio square-diagonal arrangement, and fed through a Helmholtz coil. According to WØKWL they were able to track small bombers over 350 miles away without mechanically rotating the elements; frequency of operation was about 30 MHz. If any of you have more information on the TRU system—and particularly the unusual antenna—I would like to hear more details. The system is probably declassified by now, so perhaps someone even has an instruction manual they'd be willing to loan to me.

Jim Fisk, W1DTY
Editor

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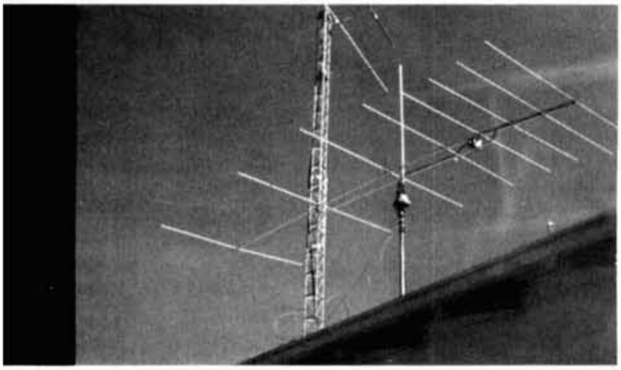


log-periodic yagi beam antenna

An adaptation of the Yagi array to obtain better bandwidth performance

Del Crowell, K6RIL, 1674 Morgan Street, Mountain View, California 94040
William Orr, W6SAI, Amateur Service Department, Eimac Division of Varian, San Carlos, California 94070

The Yagi parasitic beam antenna consists of a driven element plus a number of parasitic elements that increase the gain or directivity of the radiation pattern over that of a dipole antenna.[1] The number of parasitic elements, their tuning, and their spacing with respect to the driven element determine the characteristics of the array.

Generally speaking, the Yagi provides the greatest gain per unit size of any antenna array. Under normal circumstances, the more the elements, the greater the gain and the sharper the pattern of the Yagi. But as the number of elements increases, the more restricted will be the bandwidth of this popular antenna.

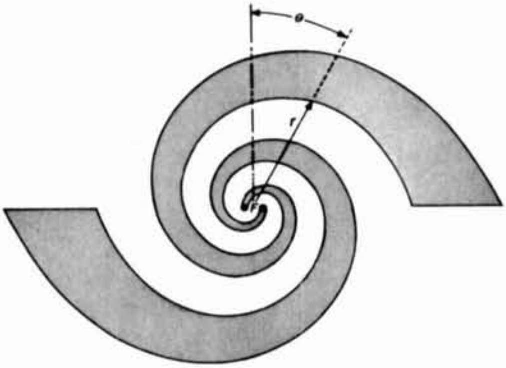
This bandwidth restriction, increasingly critical with respect to antenna gain, is of minor importance in the high-frequency bands, which are narrow, and where the Yagi is of modest size. However, antenna bandwidth becomes of paramount importance in the wider amateur bands where Yagi arrays are larger with respect to wavelength.

equiangular antenna concept

The restricted bandwidth of the Yagi beam may be improved by abandoning the parasitic element approach and applying instead equiangular principles. The equiangular principle deals with the design and assembly of frequency independent radiators. It is based on the unique idea that if the shape of an antenna can be specified entirely by angles, antenna performance would be independent of frequency.[2]

Practically speaking, this means that if all the dimensions of a radiator are scaled by a constant factor, the physical size of the antenna may be changed without changing any of its electrical characteristics, provided its operating wavelength is changed by the same amount.

fig. 1. Equiangular spiral antenna is symmetrical about feedpoint F and is described in terms of angle θ and radius r from polar axis.



A simple two-dimensional, equiangular spiral antenna that conforms to this requirement is shown in **fig. 1.**

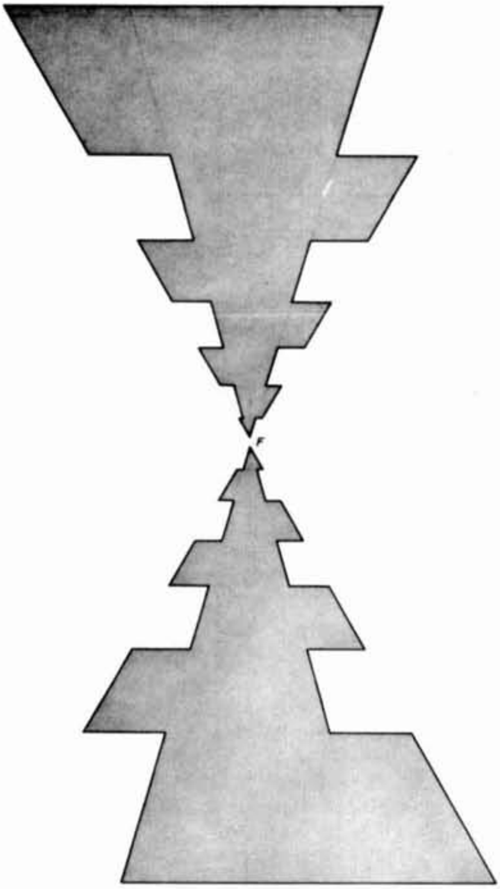
To be truly independent of frequency, the equiangular spiral antenna would have to start at an infinitely small point and expand to infinity. Practically, the antenna must have a feed point of finite dimension at the center and must have outer limits, as it cannot be infinite in size. Thus the frequency coverage of the structure is finite and is defined by physical, not electrical limitations.

Within the frequency limits imposed by these practical considerations, the equiangular spiral antenna resembles a frequency independent structure. This comes about because the transmission line is equivalent to the missing center portion of the structure, and the truncated outer portion does not affect the electrical properties to any significant degree. Most of the energy is radiated before it reaches the end of the structure if the antenna is large compared to the size of the radio wave.

the log-periodic antenna

The equiangular spiral antenna has limited use and exhibits little power gain over a dipole. A modification of the equiangular spiral antenna that provides power gain and directivity is shown in **fig. 2** wherein a planar structure is repeated periodically with respect to the logarithm of the frequency.[3] An antenna array of this configuration has characteristics that change with frequency, but before the change is very great in terms of wavelength, the structure **repeats itself**. A combination of the equiangular approach with the concept of periodicity results in a

fig. 2. Periodic planar antenna. Structures may be bent back upon themselves to form a three-dimensional array.



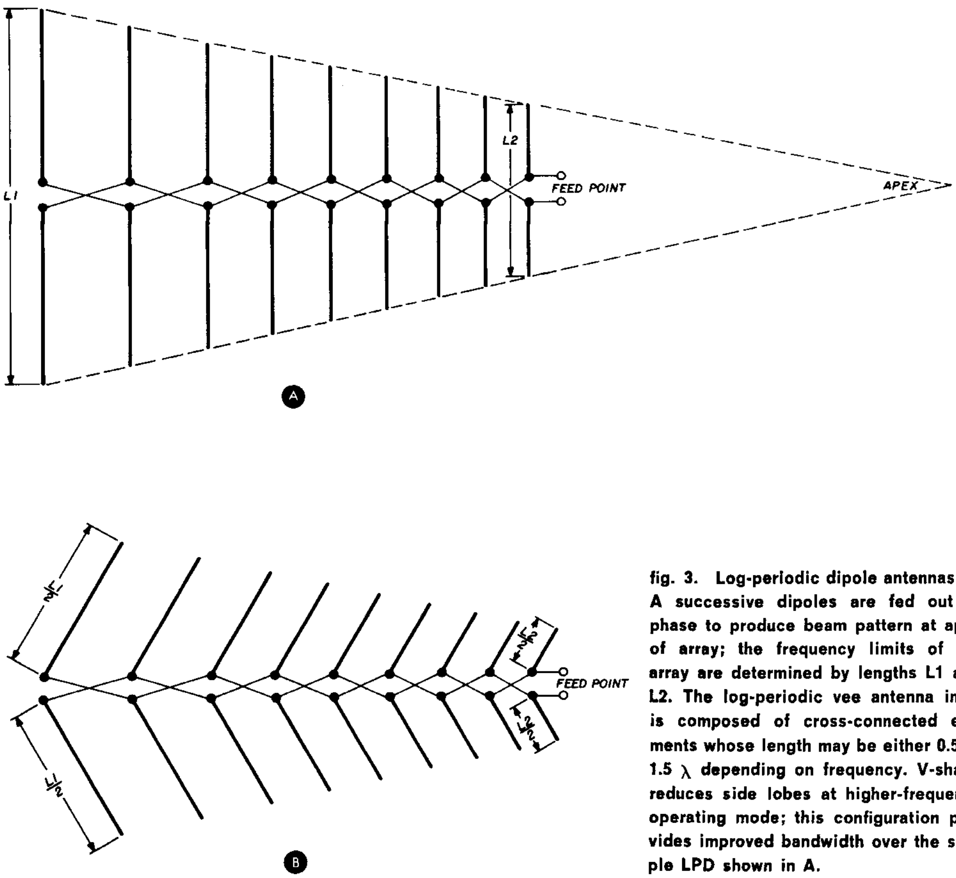


fig. 3. Log-periodic dipole antennas. In A successive dipoles are fed out of phase to produce beam pattern at apex of array; the frequency limits of the array are determined by lengths L1 and L2. The log-periodic vee antenna in B is composed of cross-connected elements whose length may be either 0.5 or 1.5 λ depending on frequency. V-shape reduces side lobes at higher-frequency operating mode; this configuration provides improved bandwidth over the simple LPD shown in A.

practical antenna with directivity and power gain and which has a bandwidth limited only by the antenna's physical size.

Various forms of the log-periodic antenna have been designed for specific uses. One of the most popular designs is the **log-periodic dipole** (LPD) array. The LPD antenna consists of a series of dipoles fed at the center and connected to the opposite wires of a balanced transmission line (**fig. 3**). The dipole lengths are consecutively shorter, and radio energy travels along the transmission line until it reaches a portion of the dipole structure where the length of the dipoles and their phase relationship combine to produce radiation.

The radiation is directed along the array toward the apex, so that the shorter elements either tend to act as directors or, if very short, are inactive. The LPD array can be fed at the apex with a balanced line, or with a balun and coaxial line. The antenna performs over a frequency span with limits defined by frequencies at which the extreme elements of the configuration are about one-half wavelength long. Antennas of this general type are commonly used for tv reception and are often used for amateur work at vhf.[4]

frequency limitations of the yagi

The Yagi parasitic beam functions as a directional antenna having power gain by virtue of the proper phasing of the parasitic elements. For high-frequency Yagi beams commonly used in amateur bands, the parasitic elements are spaced from the radiator by 0.15 to 0.25 wavelength and are about five percent longer or shorter than a half-wavelength, depending upon the function of the parasitic and the array spacing. Directivity is through the shortest parasitic element.

The number of parasitic elements also enters into the determination of optimum parasitic length, power gain, directivity, and bandwidth. Needless to say, as the operating frequency of the Yagi array is varied from the design frequency by a few percent, the parasitic elements become detuned from optimum, and over-all antenna gain drops sharply, especially when the parasitic elements become self-resonant. In some instances, depending on parasitic element tuning, the directional radiation pattern is obscured, or even reversed, with maximum gain occurring in the reverse direction of the array.

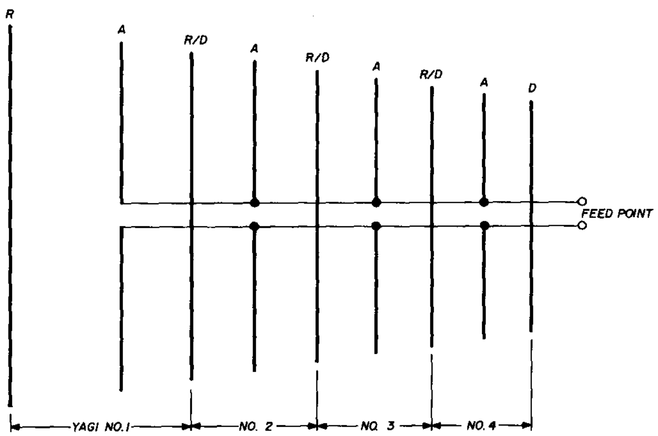


fig. 4. Log-periodic Yagi performance is a result of Yagi arrays with parasitic elements serving dual function of director and reflector for adjacent larger and smaller Yagi arrays.

Antenna power gain and beam directivity degeneration commonly occur when the parasitic element tuning is incorrect. Thus, the frequency span of the Yagi antenna must be restricted to that narrow region over which the parasitic elements remain in proper phase relationship. To increase the bandwidth of the Yagi, the parasitic elements must be detuned from optimum, which decreases power gain and reduces front-to-back ratio. The gain-bandwidth product of the Yagi must therefore be sacrificed to some extent to obtain an increase in either factor. In any case, the product is small but is a critical factor of adjustment. To increase the bandwidth without a corresponding decrease in gain, log-periodic principles may be applied to the Yagi antenna.

the log-periodic yagi

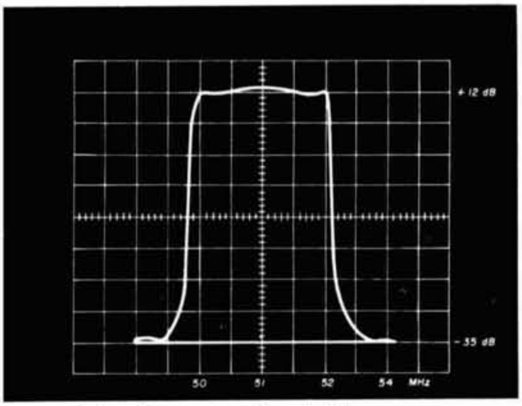
A log-periodic Yagi (LPY) array may be constructed of individual Yagi antennas differing in size by a geometric constant, properly arranged and fed. A simple LPY antenna is shown in **fig. 4.** The LPY is made of a series of end-fire Yagis, with each driven element fed from a common balanced transmission line. Unlike the driven element in an LPD antenna, those of the LPY are fed in a non-transposed manner. The in-between elements are parasitics, and log-periodic performance is obtained by making each parasitic element serve the dual function of director and reflector for the adjacent larger and smaller driven elements.

Practical LPY antennas with power gains of about 9 dB have been built for the 1.1- to 1.25-GHz range.[5] Over-all length of the LPY antenna is large for the gain produced, especially considering the high power gain per Yagi array normally obtained for a given size.

the bandpass antenna

An interesting and practical variation of the basic LPY antenna is the **LPY bandpass array**, which provides greater power gain per unit length. This unique antenna makes use of a log-periodic dipole structure having the frequency characteristic of a Chebyschev-type filter. A number of parasitic director elements, trimmed to cover the appropriate frequency range are used to enhance the power gain of the log-periodic array. A frequency sweep of such an antenna designed for the six-meter band is shown in the photograph. The LPY bandpass antenna is easy to build, simple to adjust, and provides good power gain considering the over-all length of the structure. The original LPY bandpass design was evolved for long-distance color-tv reception, which demanded a combination of good passband characteristics, high gain, and good adjacent channel discrimination. The LPY bandpass antenna combines these attributes, and various versions of this antenna are now used for tv and amateur two and six meter band operation. They are commercially available.*

An effective six-meter band LPY bandpass antenna is shown in **fig. 5** and the photo. It's composed of five log-periodic elements and three parasitic directors. The antenna has been in use for some months at K6RIL and at other California six-meter stations. Results compare favorably with an eight-element Yagi on a thirty-foot boom. Gain is estimated at 12 dB or better; front-to-back ratio is apparently about 24 dB. The design range is 50 to 52 MHz.



Gain-vs-frequency characteristic of the six-meter LPY antenna.

Response on reception is down about 20 dB at 47 and 53 MHz. It provides some receiver protection from spill-over from nearby channel-2 tv transmitters, because antenna response is down a comfortable number of decibels at frequencies higher than 54 MHz. Antenna response is down 20 dB at 45 degrees either side of center at 51 MHz. This is representative of the pattern over the antenna's operational range.

photo by W6BUR

Oliver Swan with a wideband 12-element 400 to 450 MHz antenna at the West Coast VHF Conference antenna-measuring contest; gain measured at approximately 7.5 dB.

Input impedance is about 75 ohms. The antenna can be fed with a 70-ohm coax line (RG-11A/U) and a balun, or a matching device can be placed at the antenna apex for use with a 50-ohm coax line or high-impedance balanced line. The line at K6RIL is 75-ohm heavy-duty tv ribbon.

construction

The commercial version of this antenna is built on a double boom, much in the manner of heavy-duty tv antennas (see

* LPY bandpass antennas were originally designed by Oliver Swan and are for sale by Swan Antenna Company, 646 North Union Street, Stockton, California 95205.

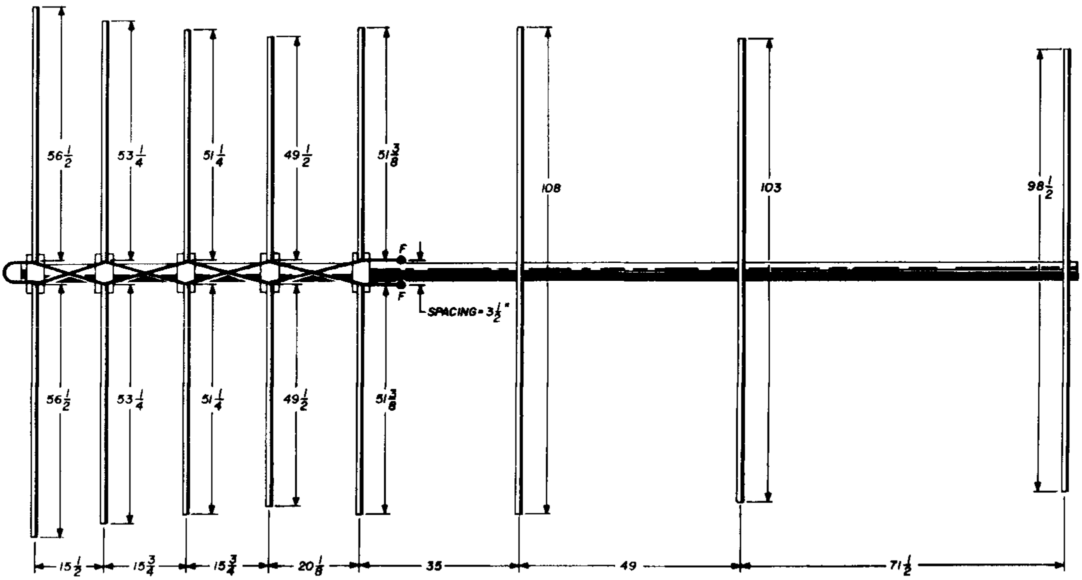


fig. 5. The LPY bandpass antenna. Dimensions (in inches) are for 6 meters (50 to 52 MHz) although they may be scaled for other frequency ranges. Elements are supported above a 2-inch aluminum boom. Half lengths are given for the log-periodic elements and full lengths for the parasitic elements.

photograph). A simpler configuration for those wishing to build their own array would be the use of sections of 2-inch aluminum tubing for the boom, as shown in **fig. 5**. The driven elements are supported at the center on insulating blocks, and the parasitic elements are mounted directly to the metal boom. Since a simple log-periodic structure is used with no interspersed parasitics, the driven elements are cross-connected with aluminum clothesline wire. The last driven element to the rear is shunted with a six-inch loop of wire at the end of the transposed feedline.

A balanced feedpoint exists at the front of the log-periodic assembly, and a balun or matching device may be mounted at this point. The array is supported from the vertical mast structure at the array's center of gravity. An overhead support to each end of the boom is recommended.

operation

The LPY bandpass antenna has been in operation at K6RIL for some months and is used in conjunction with an eight-element Yagi on a thirty-foot boom, mounted on a nearby tower. Numerous tests on transmission and reception have shown that the two antennas are nearly identical in performance as far as gain and front-to-back ratio are concerned, within the bandpass of the Yagi antenna. Operation of the LPY bandpass antenna at the extremes of the passband shows superior performance compared to the Yagi. The LPY bandpass array will be the "antenna to watch" on two and six meters in the coming months.

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ham radio

cw transceiver for 40 and 80 meters

The best features of transistors and tubes are combined in this complete station designed for portable use

Clifford Bader, W3NNL, 1209 Gateway Lane, West Chester, Pennsylvania 19380
Richard Klinman, K3OIO, 1339 Pennwood Road, Philadelphia, Pennsylvania 19151

A casual inspection of current amateur radio publications reveals an interesting fact: the huge rack-and-panel stations of fifteen or twenty years ago are gone. In their place are complete radio stations that occupy just about the same volume as a 1950 communications receiver. Today is the era of the transceiver, which is hard to beat for compactness and real operating convenience.

The transceiver described in these pages resulted from a desire for a good portable station for trips, hunting expeditions and contest work. A rather unorthodox circuit is used. The usual multiple-heterodyne circuits are eliminated together with their elaborate shielding systems. "Straight-through" transmitter circuits are featured, and the received signal is immediately converted to audio frequencies. The design objectives were:

1. Operation on the 40- and 80-meter cw bands.

2. Electronic and mechanical ruggedness.

3. Simplicity; a single vfo for receiver and transmitter.

4. Operation for at least twelve hours on a single 12-volt auto battery. The receiver must operate from a dry battery if necessary.

5. Power inputs from ten to thirty watts, preferably higher; but with good efficiency.

design considerations

Meeting these objectives isn't easy, especially if you're restricted by time and economic considerations. The problem was solved by using inexpensive bipolar transistors and junction fet's in all circuits except the transmitter driver and output stages. In these stages the old reliable 12AU6 and 1625 were used. This may seem to be a throwback to 1945, but it proved to be an excellent choice. The 1625 is practically indestructible, draws only 450 mA heater current, is inexpensive, and works well with low plate voltages. Also, with no modification, a higher plate voltage on the 1625 tube allows up to 75 watts input if energy consumption is not important.

On the other hand, rf power transistors for 40 meters are costly, were not immediately available, and would require more than 12 volts, so that no saving in power supplies would be obtained. Furthermore, it would be difficult to achieve efficient operation at 10 and 75 watts input; also, the risk of transistor burnout would be present when tired operators weren't careful in tuning up or in making sure the antenna still existed. The delicate nature of rf power transistors is widely noted in the literature.

This article is intended to present the amateur community with some new ideas and to stimulate the application of ingenuity and effort.

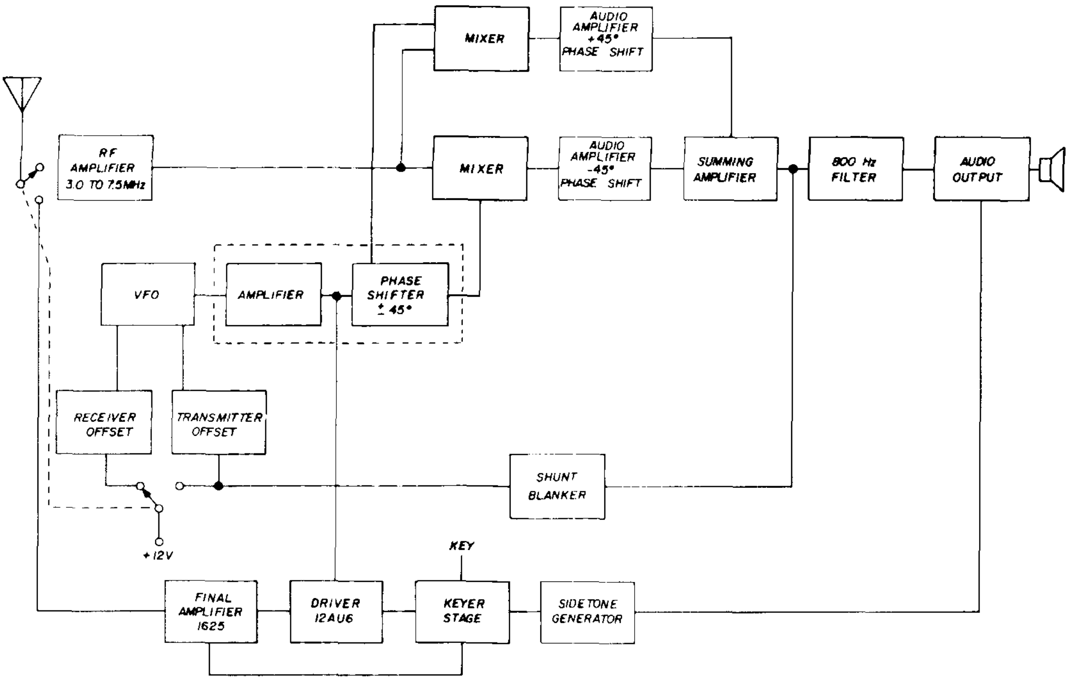


fig. 1. Block diagram of the CW transceiver for 40 and 80 meters.

results

The block diagram of **fig. 1** shows the receiver as simply a trf circuit with a product detector.[1] The same vfo and frequency multipliers are used for both transmitter and receiver. For receiving, all that's needed is an audio amplifier, which is easily constructed with transistors. Audio filtering at 800 Hz provides selectivity. The audio image is suppressed by a phasing system that reduces bandwidth and provides single-signal reception. The undesired sideband remains at least 10 dB down (calculated) at 1600 and 400 Hz.

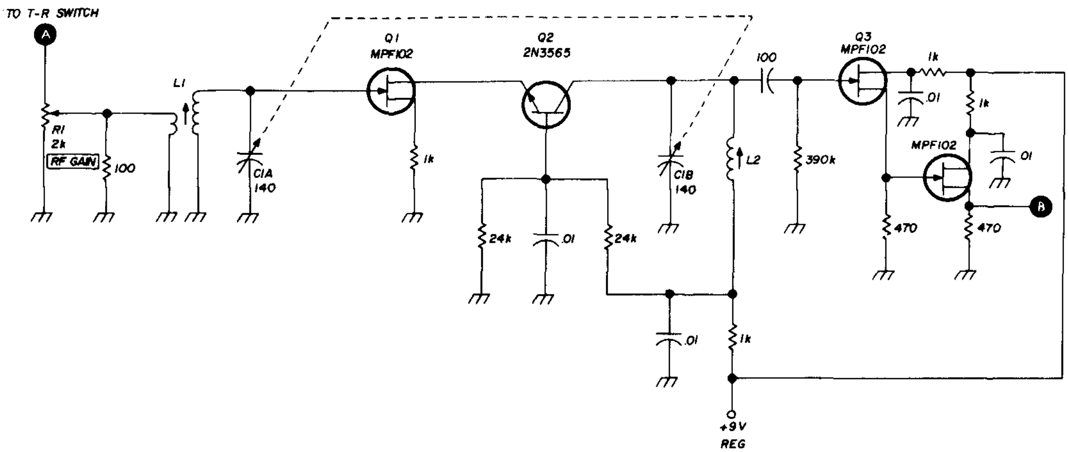
The transmit-receive function is accomplished by a toggle switch in the interest of simplicity. Cathode keying is used, and transistor buffering removes high voltage and current from the key. An audio oscillator is used for a transmitting monitor.

the receiving section

The receiver is shown in **figs. 2** through **7.** Only a small amount of rf amplification is needed at these frequencies, and most of the Tuning of these tanks is fairly critical. C1, a front panel control, must be repeaked at least every 50 kHz (during receive only) for optimum results. The circuits tune from 3 to 7.5 MHz.

the vfo

The vfo **(fig. 4)** consists of a jfet oscillator, Q8, and buffer, Q9, in a Hartley circuit operating between 1.75 and 1.85 MHz. No heat is present near the oscillator tank, so the vfo is extremely stable. The rugged construction of L3 and C2 provides good mechanical stability.



C1	**Dual 140-pF variable (Hammarlund HFD-140)**	**L1, L2**	**37 turns no. 27 enamelled, close wound on a Millen 69046 slug-tuned form; 3-turn link**

fig. 2. The rf amplifier uses a cascade circuit with an fet followed by a common-base buffer.

signal processing and amplification is done at audio frequencies.

Since it is difficult to control the gain of transistor stages while maintaining optimum intermodulation characteristics, the rf-gain control, R1, is a simple attenuator in the antenna circuit. The cascode rf amplifier uses an N-channel junction fet, Q1, followed by a common-base buffer stage, Q2. Both input and output tanks, L1, C1 and L2, are high-Q tuned circuits. High Q is very important here, since this is the only place where unwanted strong signals are rejected and cross-modulation effects minimized.

In the receive position of the t-r switch, S1, air trimmer C3 is inserted into the tank section by reed relay K1. Alternatively, K2 selects trimmer C4 during transmit. These trimmers provide receiver offset (incremental tuning). Incremental tuning is required after calling CQ or during a contact, because any tuning with the main tuning capacitor, C2, will also change transmitter frequency.

exciters

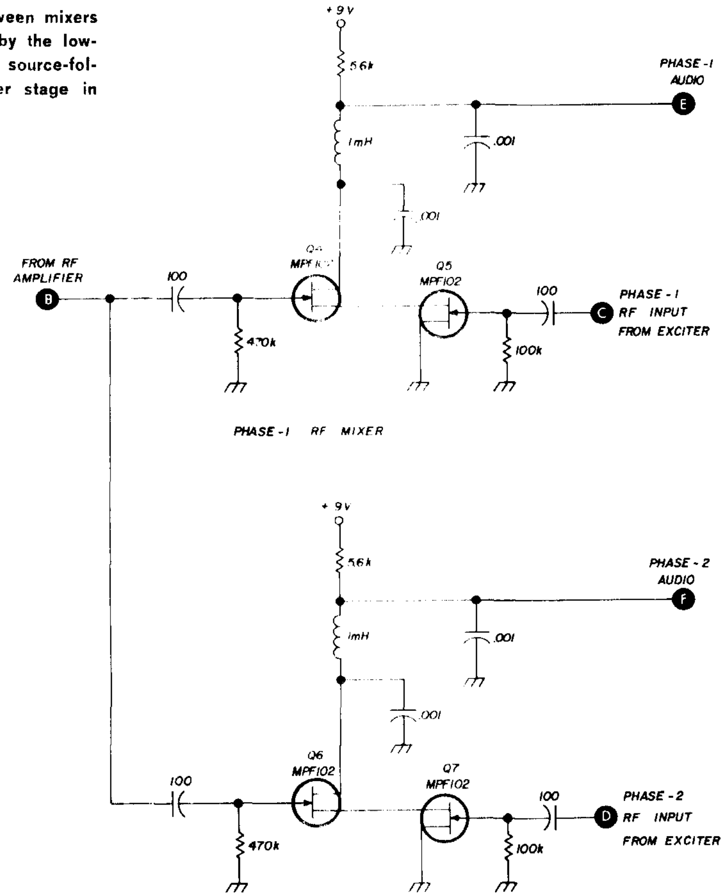
Two plug-in jfet exciters are used, one per band for 80 and 40. (See **fig. 5** and **6.**) These provide transmitter drive voltage and the

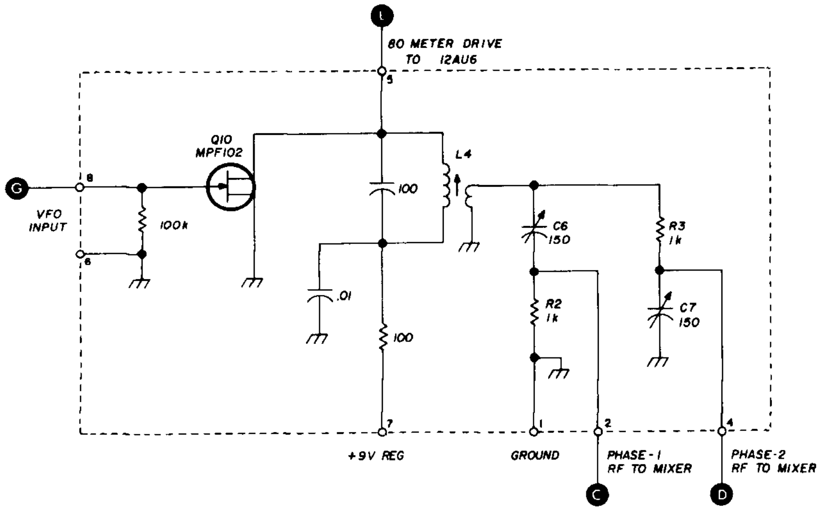
±45-degree phase shift for the vfo signal during receive. The driver output, Q10 or Q12, is fed to the 12AU6 grid and to RC phase-shift networks, C6, C7, R2, R3; or C9, C10, R4, R5, which yield two 80- or 40-meter voltages 90 degrees out of phase. Tuned circuit L4 or L5 ensures the proper harmonic of the vfo.

A jfet source follower buffer, Q3, provides a low-impedance source and prevents interaction between the series mixers. The same rf signal is mixed with each of the vfo outputs, yielding two audio signals 90-degrees out of phase at 800 Hz. The audio signals are preamplified by Q13, Q14, Q15 and Q16. One channel has a +45-degree phase shift at 800 Hz provided by C11 and R8; the other has a −45-degree phase shift provided by R9 and C12. The result is a second 90-degree phase shift difference added to the quadrature audio signals. The phased audio signals are summed in amplifier Q17-Q18, and one sideband is cancelled. Prior to summing, the signals are adjusted to identical amplitudes by balance control R7.

Depending on the way the rf and audio phasings are compounded either upper or lower sideband may be selected for single-

fig. 3. Series mixer stages for the receiver section. Interaction between mixers is limited by the low-impedance source-follower buffer stage in fig. 2.





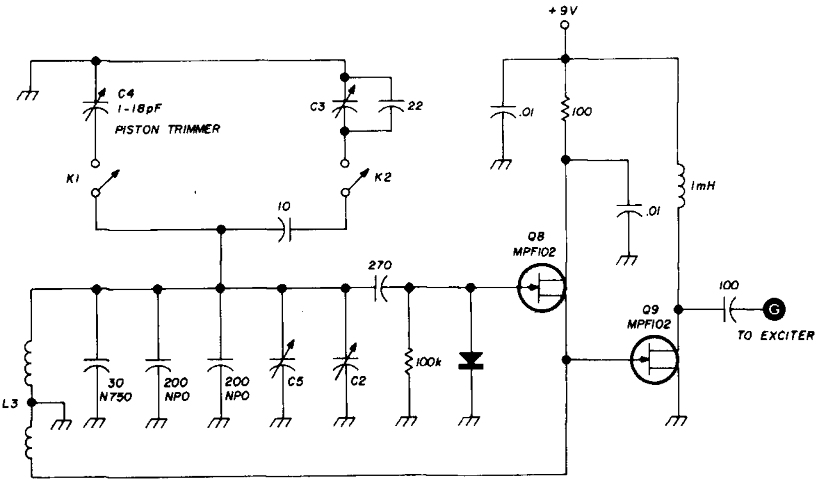
L4 45 turns no. 36 enamelled close wound on Millen 69058 form, slug-tuned; link is 25 turns no. 36

C6, C7 150-pF double mica padders (El Menco type 424)

fig. 5. Plug-in exciter unit for 80 meters.

signal reception. The unit currently tunes **above** zero beat.

The audio signal is amplified in an operational amplifier, with a bridged-T selective filter at 800 Hz in the feedback loop. Gain is high through the amplifier only at the fil-



C2 100-pF double-bearing variable

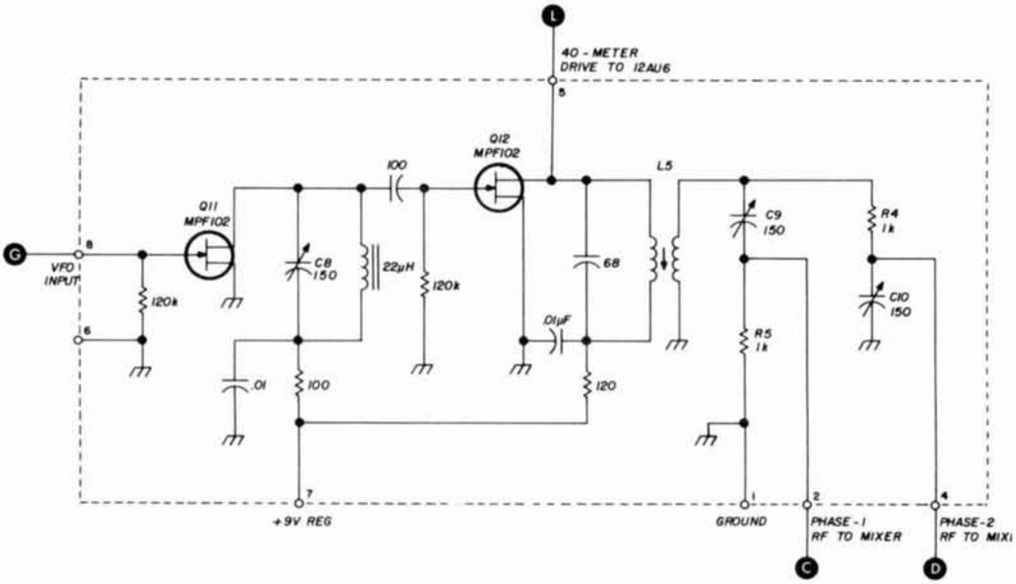
C3 Hammarlund APC-35 with all but three stator and three rotor plates removed

C4 18-pF piston trimmers (JFD VC32GWY)

C5 50-pF variable (APC-50-screw adjustment only)

L3 24 turns no. 24 enamelled on 1 1/4" diameter form, wound to occupy 1 1/4" with 7-turn link of no. 24 enamelled interwound at ground end of main coil

fig. 4. The vfo uses a Hartley circuit that tunes from 1.75 to 1.85 MHz.



C8, C9, C10 150-pF double mica padders (El Menco type 424)

L5 30 turns no. 36 enamelled close wound on Millen 69058 form, slug-tuned; link is 10 turns no. 36

fig. 6. Plug-in exciter for 40 meters.

ter frequency **(fig. 7).** Selectivity is adequate for cw, and sufficient skirt response makes tuning uncritical. The receiver is blanked during transmissions by shunt gate Q19, which is across the gain control, R6.

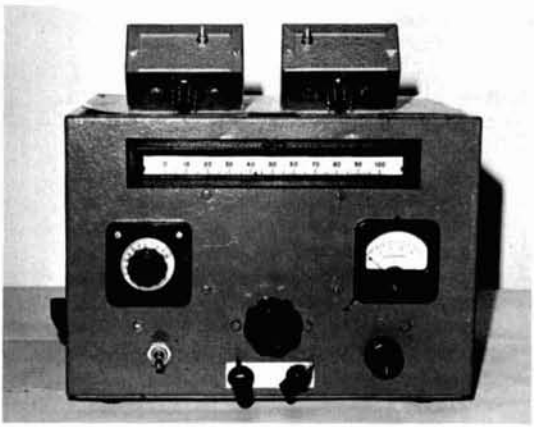
Operational amplifier Q23, Q25, Q26, Q27 and Q28 provides power amplification. A transformerless complementary output stage is provided by Q26 and Q27. The circuit is conventional except for the fet constant-current source composed of Q28 and Q29. This circuit provides adequate drive to Q27 during negative-signal excursions, while minimizing the current drain on Q25 during positive signal excursions.

Either the received signal or the sidetone oscillator output of Q37 is fed to Q23 base, which is the summing input. The output stage will drive loads as low as eight ohms, although a higher impedance is preferable. A 25-ohm speaker is normally used, but high impedance headphones can be substituted.

The only remaining receiver circuit is a 9-volt regulator for stable vfo and rf operation, **fig. 8.** The reference is the reverse-biased, base-emitter junction of Q30 acting in the breakdown mode. The regulator is a feedback type using difference amplifier Q31-Q32 to drive a series regulator, Q33.

transmitter section

The transmitter is conventional **(fig. 9).** The exciters, which are the same units used for receiving, provide frequency multiplica-



The 80- and 40-meter transceiver. Plug-in exciter units are on top.

tion and drive for straight-through operation of the driver and final amplifier tubes. The 12AU6 provides more drive with fewer stages than could be obtained with transistors. Drive is controlled by a potentiometer in the 12AU6 screen grid. The final grid tank tunes 3.5 to 7.5 MHz without switching. The final is capacitance-bridge neutralized. Its pi-network output tank will match a wide range of input impedances. The taps and capacitors, switched by S2, will match high or low tube impedances to reasonably flat coax.

keyer, monitor and t-r switch

Both tubes are keyed simultaneously by Q34, Q35 and Q36. Cathode keying eliminates the standby current drain of the 12AU6. For the 12AU6, an ordinary transistor (Q36) that can take more than 50 volts at low current is used as a keyer; an inexpensive RCA 40327 (Q35) is used for the final keyer. The 1625 cathode contains a shaping circuit composed of C16, C17, D17, R12, R13 and R14. The diode-resistor network prevents the capacitors from discharging too rapidly through the transistor on "make." The keying wave shape on "break" is affected by the 12AU6 cathode bypass capacitor. A conventional metering circuit is used to measure final cathode current.

Audio oscillator Q37 provides a sidetone for monitoring. This is a simple unijunction relaxation oscillator powered from the same transistor (Q34) that gates and provides current to cathode switches Q36 and Q35.

The t-r switch is a dpdt toggle switch. One contact transfers the antenna; the other selects the proper vfo shift relay and supplies the keyer with power during transmit.

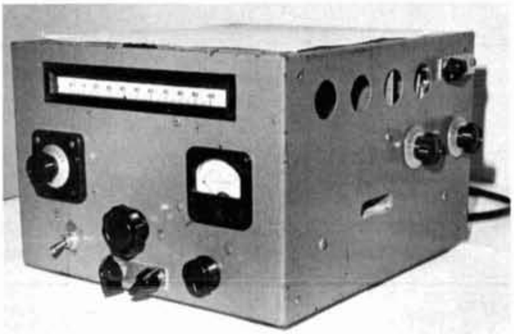
power supply

The power supply shown in **fig. 10** is the one used for fixed station operation. It is presented in the interest of completeness, but of course, any conventional supply could be used that delivers the voltages shown. Surplus transformers can be used, and the diodes are available from many surplus sources listed in the amateur literature. The values for all components were chosen with conservative ratings to ensure reliability for portable use.

construction

Circuit layout isn't critical, although good construction practice should be followed to ensure stable and reliable operation. Parts substitution is recommended, and a well-stocked junk box would be an asset.

The transceiver was built into the case and chassis of an old National FB7 receiver because it was available and was the right size (8-inches high x 12-inches deep x 12-inches wide). It happened to contain an excellent 160-meter vfo built by Earle Lewis, W3JKX. In fact, the vfo was used exactly as it was with the exception of a 6SJ7, which was replaced by jfet's Q8 and Q9. A few resistors were changed, and the supply voltages were adjusted for the transistors.



Side view showing the pi-network controls. Grid tuning and drive level controls are on the other side.

There were plenty of holes to mount circuit boards and controls. Most of the transistor circuits were built on printed circuit cards containing a matrix of rectangular pads, but tie strips or made-to-order printed circuits could be used. The exciters are built in 3¼-inch x 2-inch x 1½-inch miniboxes fitted with chassis-mounting octal plugs.

controls

The front panel controls are main tuning, which is the original receiver dial with a linear logging scale; receiver incremental tuning; rf and af gain controls; t-r switch; and a final-amplifier cathode-current meter (200 mA full scale). Other less-used controls are located where convenient. The set-and-

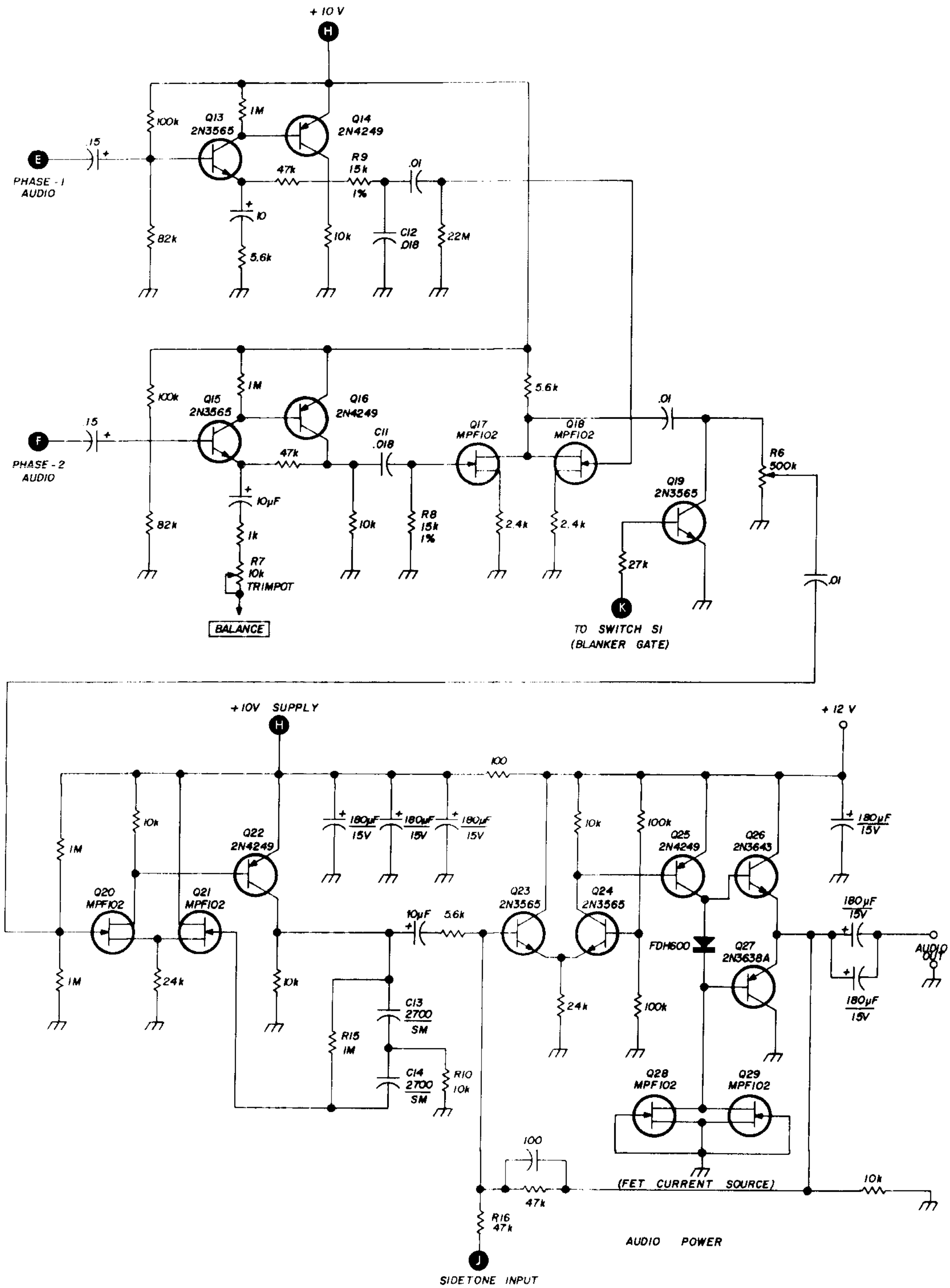


fig. 7. Audio section includes a summing amplifier, blanker gate, 800-Hz filter and audio power stage. R7, a 10-turn pot, should be grounded.

forget neutralization capacitor, C21, is above the torpedo-mounted 1625. The rf plug-in exciters are accessible through the top lid. On one side of the cabinet are the final grid tuning, C15, and drive-level control, R11. On the other side of the case are the final amplifier pi-network components, C18, L7, S2 and C19. The audio output, key jacks, and antenna connector are on the rear wall. Power is brought in by an eight-wire cable terminated with an octal male connector.

As we said before, construction is not critical as long as good layout procedure is followed. A few noteworthy points are in order though. The receiver 12-volt supply and the transmitter filament grounds are fed through separate wires. This keeps tube filament currents and corresponding IR drops from appearing as modulation on the receiver supply. During ac operation, this voltage may cause hum.

Physical layout of the phase-shift networks should be symmetrical to provide identical electrical operation. Also, short rf and ground leads are essential.

Transistor circuits should be isolated from the final amplifier tank. In the unit shown, the t-r switch is on the front panel, but is enclosed in an aluminum box for isolation. The reed relays are mounted next to the vfo tank circuit. Short leads of heavy wire are used for mechanical and electrical stability.

audio and sidetone frequencies

If you don't particularly like an 800-Hz note, filter C13, R10, C14 and R15 can be tuned to another frequency. Any good handbook will give values for a bridged-T network. Sidetone volume can be changed by adjusting R16 (**fig.** 7); higher values will reduce audio level. Sidetone frequency can be changed by varying C20, R17 or both (**fig.** 9).

receiver section adjustment

You'll need an auxiliary receiver to calibrate and adjust the transceiver. With application of receiver voltage only, the vfo can be set by adjusting C15 while monitoring the signal on another receiver. Only a logging scale is used, so desired bandspread is ensured by choice of vfo tank LC ratio.

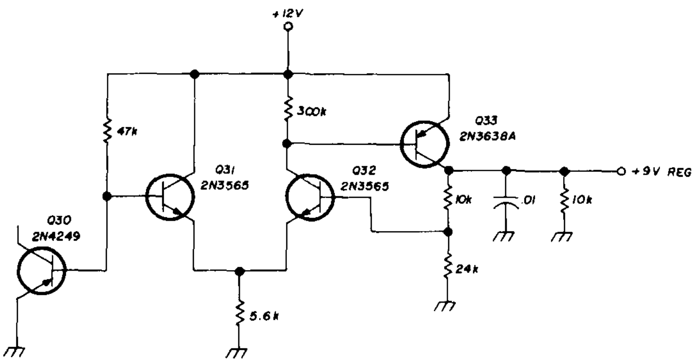


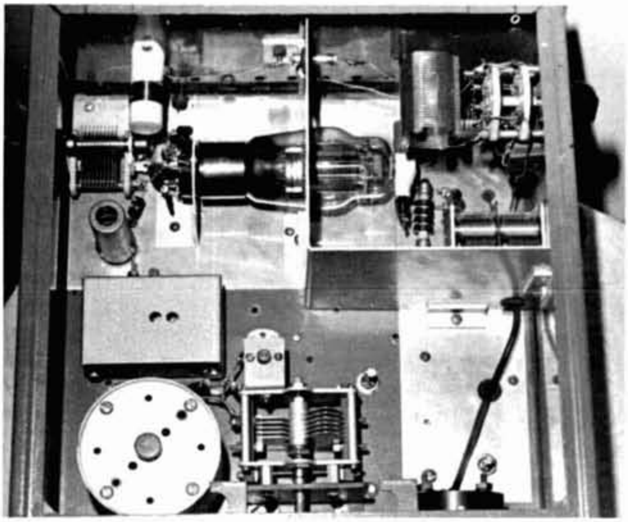
fig. 8. Nine-volt regulator circuit for stable operation of the vfo and rf operation.

The rf section must be peaked to the desired band after the exciter is plugged in. This is done by setting C1 and varying L1-L2 for maximum received signal. Signals on both bands are peaked by setting C1 and varying L1-L2. L4 (3.5 MHz) and L5 (7 MHz) should be tuned for maximum signal.

After setting main tuning capacitor C2 on the high side of a received signal to obtain an 800-Hz note, or at the audio frequency peaked by the audio filter, the signal is peaked by carefully setting C6-C7 on 3.5 MHz and C9-C10 on 7 MHz. The phasing is now approximately correct, but the audio channel gains must be equalized by adjusting balance control R7. The receiver is now tuned to the same beat frequency on the undesired sideband, and R7 is adjusted until the best null is obtained, which should also correspond to a good signal on the proper sideband. Finally, C6-C7 or C9-C10 may be retrimmed for greatest null depth on the undesired sideband.

The final part of the receiver adjustment is the frequency offset. Incremental tuning control C3 should be set near midrange. While listening to the vfo on a receiver, C4 is adjusted for no change in vfo frequency when switching S1 from receive to transmit. This means that the receiver and transmitter are in zero beat. Incremental tuning is provided with a numbered knob.

After the offset is set to zero beat and the position of C3 recorded, C3 is set to receive a note of approximately 800 Hz on the proper (high) side of zero beat as determined by peak-audio response. This normal setting is recorded for future reference and will be different for each band, while the zero offset point will be the same.



Internal layout of the transceiver. Power amplifier and pi network are in the rear; vfo and plug-in exciter are to the front.

transmitter section adjustment

The first step is to neutralize the amplifier, using C21, according to the procedure outlined in the ARRL handbook.

Fig. 9 can be used for setting the pi-network tap positions. After moving the t-r switch to transmit, the sidetone note should be audible when the key is closed, even with no high voltages. With plate and screen voltages present, cathode current should also flow when the key is closed.

Advance the drive control, R11, to maximum. Set C15 near maximum capacity for 80 meters and near minimum capacity for 40 meters. Quickly dip the final using C18, with C19 at maximum capacity. Load the final to 50 mA cathode current (with 750 volts on the plate), then back off on the drive, R11, until an increase in plate current is just barely noticed. Tune the final grid for minimum plate current. The final may now be loaded to the input power desired.

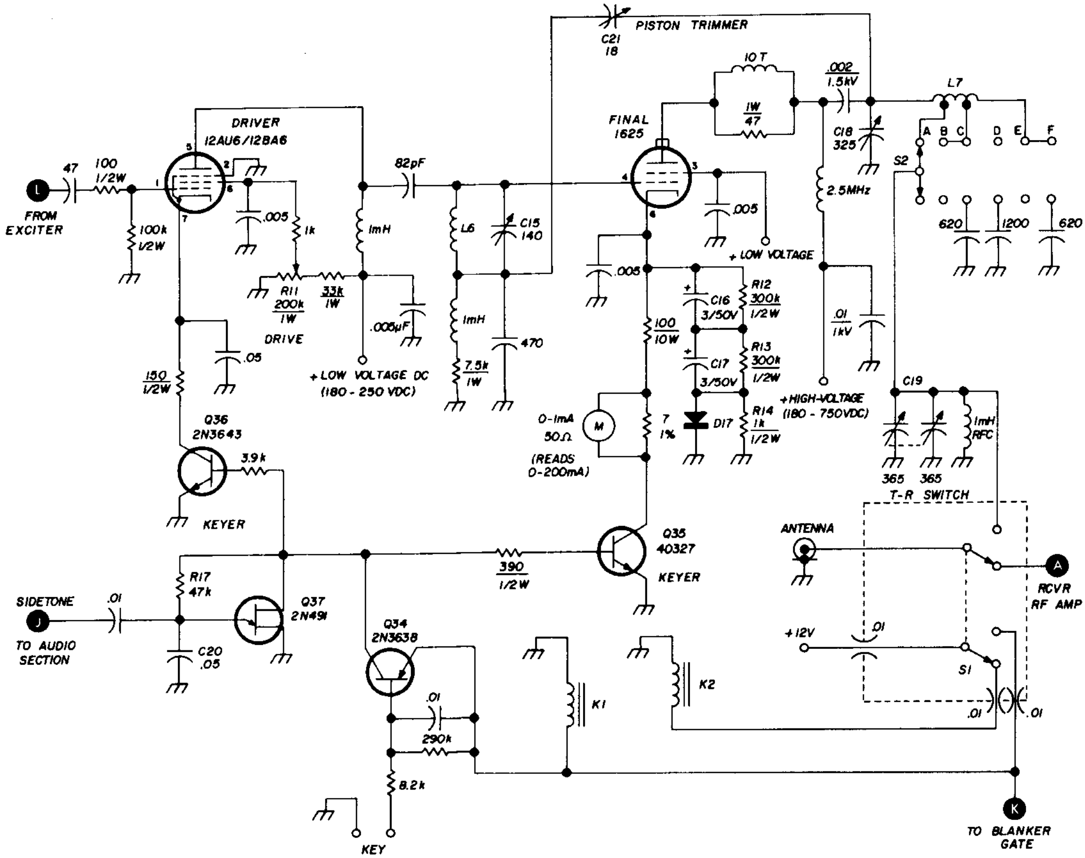
operation

It was a pleasant surprise to find that in no case did any transistor stage react unfavorably to the full 75 watts input. With full input the vfo remains exactly on frequency, and the transistor keying stages don't latch up. In fact the rig is now used with no ground, a random-length antenna is fed through an LC tuner, and performance is unaffected.

During transmit the vfo determines the frequency, but in receive the frequency may also be changed by the incremental tuning control, C3. When answering or calling stations the received signal is peaked at an 800 Hz note, while the offset tuning is set at the predetermined "normal" point.

Since C3 and C4 have been adjusted for an 800 Hz offset between received and transmitted frequencies, you can be reasonably sure of being in zero beat with the desired station. Precise zero beat is obtained by adjusting the receiver offset tuning to the predetermined zero offset point where the received and transmitted frequencies coincide. Zeroing the received signal with the vfo then ensures zero beat. The offset tuning may then be adjusted for the best signal, which should be at about the normal setting.

After contact is made, the receiver should be tuned with the offset control, C3, because changing the main tuning will change transmitter frequency.



C15	140-pF air variable (Hammarlund MC 140)
C18	325-pF air variable (Hammarlund MC 325)
C19	dual 365-pF (broadcast receiver type)
L6	27 turns no. 25 enamelled close wound on 3/4" diameter form
L7	30 turns B&W 3019, tapped at 11 turns (A) and 19 turns (tap B-C) from plate end of coil
K1, K2	Miniature reed relay, 200-ohm coil (Wheelock 3421)
S1	dpdt toggle
S2	6-position, 2-pole, rotary ceramic switch

fig. 9. Transmitter driver, final and keyer circuits. Switch S2 different ranges of antenna and vacuum-tube impedance: A, 40 meters, low tube impedance; B, 40 meters, high tube impedance; C, 80 meters, low tube impedance; D and E, 80 meters, high tube impedance.

progress report

The transceiver has been operating since June, 1968. During the ARRL field day contest, nearly 300 contacts were made, including some with the West Coast, using 10 watts input.

At present, K3010 is using the transceiver as a permanent station. It runs 50 watts input and feeds a 100-foot wire antenna with excellent results. Much DX is heard and worked; the best to date is Europe on 80 meters and Australia on 40. You can hear the rig on the 80-meter Eastern Pennsylvania Traffic Net. The transceiver is ideal for this purpose because it's ready to go with no warm up.

improvements

Among the improvements that would be desirable are break-in operation and in-

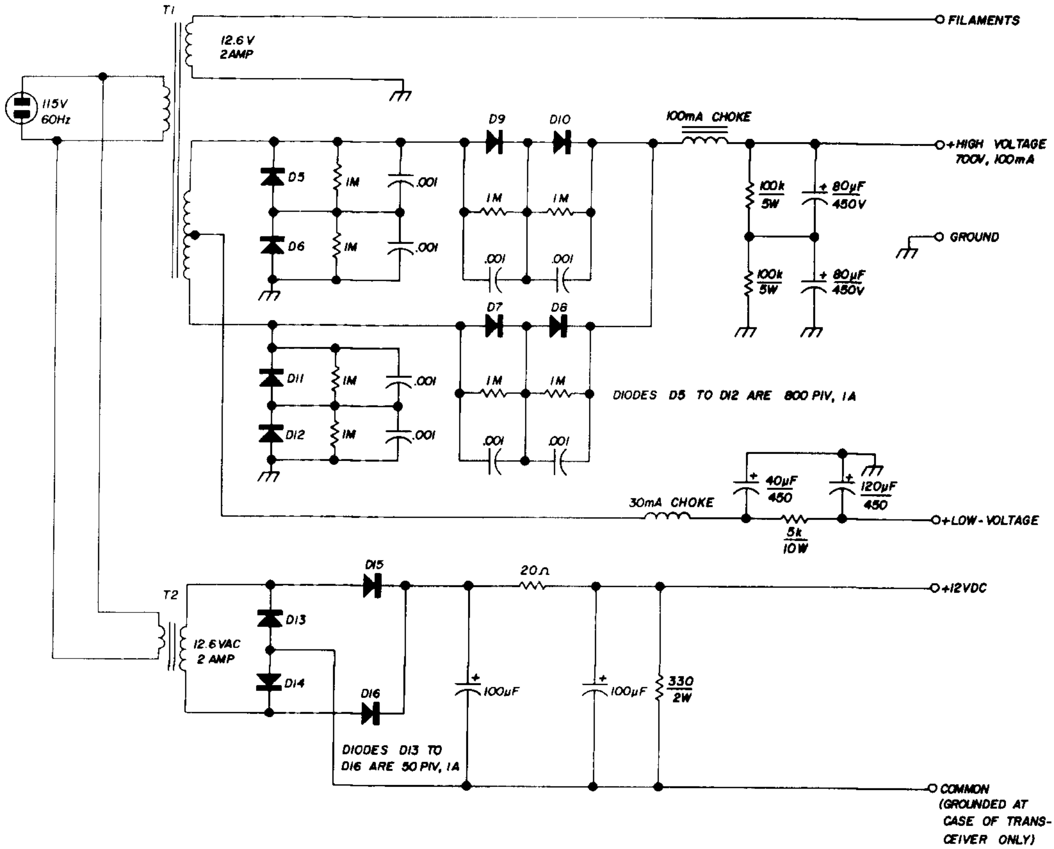


fig. 10. Fixed-station power supply which is suitable for this transceiver. Transformer T1 is an old tv power transformer; T2 is a 12-volt filament transformer.

creased selectivity and sensitivity. Also, cross-modulation could be reduced by optimizing the circuits. The mixers should have good intermodulation characteristics, since any beats between adjacent strong signals in the rf passband will appear in the audio output. Also appearing in the audio output will be modulation on signals strong enough to cause significant variation of mixer operating point due to a limited dynamic range.

The receiver is less tolerant in this respect than a superheterodyne, since many beats generated by nonlinearity in the first mixer of the latter will fall outside the i-f passband. The best arrangement would appear to be a balanced mixer in which device nonlinearities tend to cancel and dynamic range is increased. In addition, an increase in local-oscillator drive amplitude would be helpful. Such measures might be necessary, for example, if the transceiver were to be used in a field-day setup with adjacent 80- and 75-meter stations.

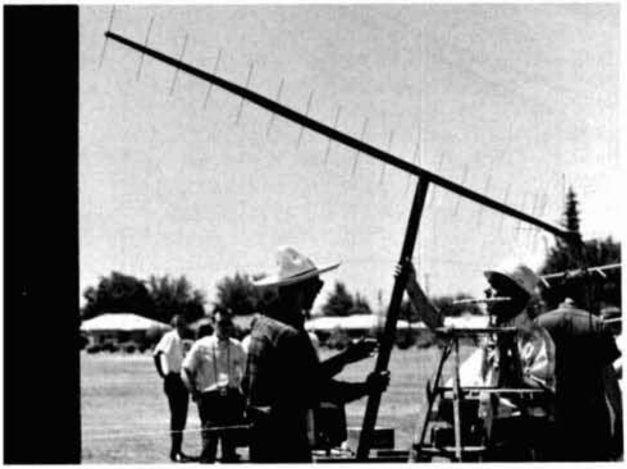
ssb operation

The receiver does a good job on single sideband. However, sideband suppression for transmitting would require a wideband audio phase-shift network. The audio-frequency amplifiers and wideband network could be switched between transmitter and receiver sections. With this and linear operation of the final amplifier, the transceiver could be used on single sideband. Anyone interested in this challenging project is invited to suggest ideas.

reference

1. White, "Balanced Detector in a TRF Receiver," *QST*, May, 1961.

ham radio



direct methods for measuring antenna gain

How to obtain meaningful data using simple equipment

Bruce Clark, K6JYO, RdF Corporation, Western Regional Office,
Suite 401, 19702 South Main Street, Gardena, California 90247

For the amateur interested in top station performance on any band, antenna refinement definitely produces the most rewarding return per unit of effort and expense.

Only in the antenna system, which includes the feedline and supporting structure as well as the radiator, can improvements increase performance for both transmitting and receiving. Unfortunately, however, the antenna system is usually the most neglected part of an amateur station. Performance tuning, if done at all, is usually limited to adjusting the driven element length, sliding the clamps on the T match, or adjusting the gamma capacitor for the lowest standing wave ratio. Except for using the swr bridge, "antenna scope" impedance bridge or field-strength meter, most amateurs seem content to leave antenna tuning to the manufacturers.

The manufacturers can't build antennas to meet all performance demands. Commercially built antennas are designed for "average" installation conditions. All too often these just don't exist in most amateur installations. Most amateurs are plagued by poor soil conductivity, height restrictions, nearby objects and a host of other adverse conditions that affect antenna performance. These adverse effects can be reduced by tuning the antenna system once you have some dependable quantitative data as a baseline for optimization.

The degree of improvement by tuning is limited with simple antennas. With the more elaborate arrays used above 14 MHz, it's possible to obtain performance increases up to 3 dB with small antennas. Improvements of 7 to 8 dB are possible with larger arrays.

The following paragraphs present simple methods for measuring vhf antenna gain directly, with good accuracy. Once you **know** what your antenna is doing, you can make the right adjustments to optimize performance. A few examples are also given of some rather startling results obtained by amateurs who were introduced to these methods.

direct measurements

The average amateur can measure antenna gain with adequate precision using simple equipment. The measurement results are much more meaningful than, say, a measured standing-wave ratio of 1.02-to-1 on the transmission line. All this indicates is that the antenna is taking power. It may or may not be radiating in the desired direction or with the desired efficiency.

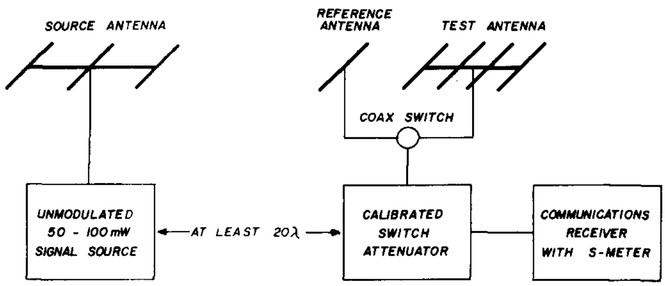
Of the many methods of measuring antenna gain, two are within the capability of the amateur. These are **(a)** the attenuator/receiver method, and **(b)** the matched-detector method. Both are comparison tests using a reference antenna and the antenna to be tested. Received signals provide the measurement data.

These methods are more reliable and provide more repeatable data under varying site conditions than those using transmitted signal/field-strength meter or measured-pattern methods.

attenuator/receiver method

The attenuator/receiver method is block diagrammed in **fig. 1.** Basically, the system uses an accurate attenuator combined with the station receiving system. The signal-source output should be as low as possible and still provide a usable signal at the receiver S-meter when the reference antenna is connected. For most situations 100 mW is adequate. The source should be stable and free of spurious outputs.

fig. 1. Test equipment for the attenuator/receiver method. The source antenna should be as high as possible, in the clear, and at least 20 wavelengths from the antenna under test.



procedure

Set up the source antenna in the clear at least 20 wavelengths from the test antenna. A nearby amateur's tower, flag pole or tv mast is a good support. Turn on the source, and adjust the attenuator for a reference level on the receiver (anywhere between S-6 and S-9 will do). Record the number of dB used on the attenuator to obtain the reference value on the S meter. Switch to the test antenna, and peak the antenna for maximum signal. Adjust the attenuator for the same S-meter reading obtained with the reference antenna. Record the new attenuator reading. The difference between attenuator readings is the amount of gain (or loss) between the two antennas.

Repeat the process several times, moving the reference antenna for an average level. Note that some variation is introduced by moving the reference antenna. This can be reduced by using a directional source antenna to reduce ground reflection contributions to the received signal (discussed later). In addition, the source antenna should be moved between several different sites at varying distances. Several measurements should be made at each site. The resultant gain figure should be the average of at least six readings.

Note also that feedline losses are included in these measurements. If known, they can be added to the measured antenna gain to get the actual gain of the antenna. Although less impressive, the measured figure is a more practical value, especially above 50 MHz where feedline loss contributions are significant.

The attenuator/receiver method will give accuracies on the order of ±1 dB. It's limited by the accuracy and resolution of the attenuators, but is probably the most applicable method for amateur work.

matched detector method

The matched detector method is very popular with the West-Coast vhf crew. It requires more sophisticated equipment, but gives greater resolution and quicker readout. The absolute accuracy is still limited by the reference antenna performance due to reflections. The averaging procedure should be used here also if absolute gain figures are desired.

Either a high (1-W) or low (10-mW) source signal, modulated with a 1-kHz audio tone is used **(fig. 2).** The type of source determines the detector type. A crystal diode detector similar to a Telonic XD-series, or a homebrew equivalent[1], will give a square-law output at low input levels. This is ideal for the vswr meter readout.

procedure

The vswr meter is a 1-kHz, sharply tuned, gain-stable, low-noise audio amplifier driving an rms ac vtvm. The 1-kHz modulation is detected and amplified. This signal drives the meter, which is calibrated directly in dB. By adjusting the vswr meter gain range (0-60 dB in 10-dB steps), a reference level can be obtained with the reference antenna. The test antenna is then connected to the detector, and the gain increase (or decrease) noted.

Although the initial cost is high ($200), the vswr meter is available in surplus outlets

K6JYO's extended 32-element collinear provides 15 dB gain.

for approximately $40 to $60 for the earlier Hewlett-Packard HP-415 series. Others by PRD and General Radio are also available.

If the source power is too high, the crystal diode detector will be driven out of the non-linear, square-law portion of its curve. The resultant output will deviate, and the vswr meter reading will be high. This can be prevented by:

1. Keeping the source power output very low.

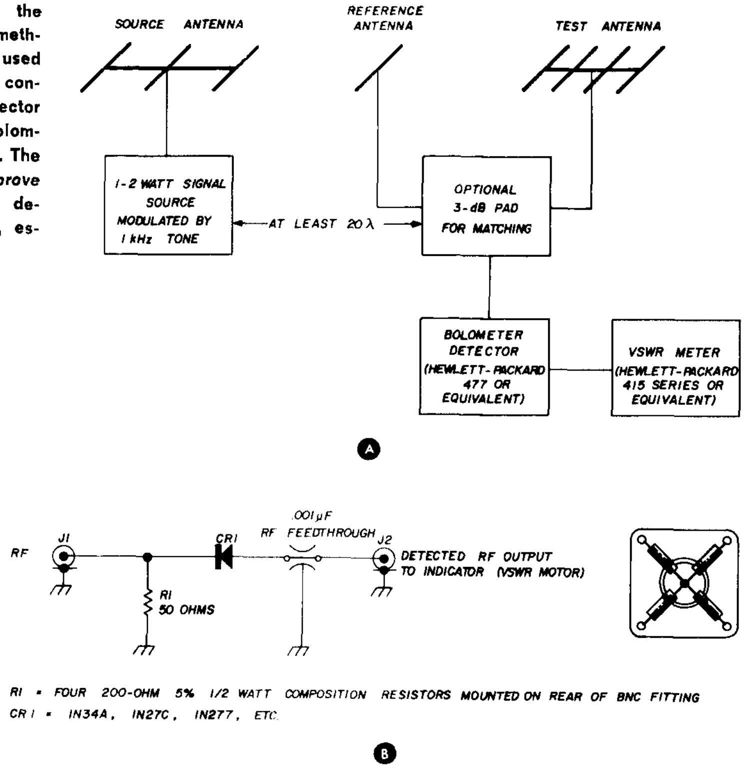
2. Inserting a calibrated attenuator (3 to 6 dB) ahead of the detector mount **(fig. 2).**

3. Using the vswr meter with a wider range detector called a bolometer (thermistor) mount. Although not as sensitive, the bolometer mount provides good results when used with sources of 1 to 2 watts output.

the reference antenna

No study of antenna gain measurement would be complete without a word on reference antennas. Classically, the isotropic radiator is a point source that illuminates all points equally on the inside surface of a sphere. It is used as the reference antenna reference dipole readings under different site conditions. Recently, highly accurate standard reference antennas have been designed and employed by the National Bureau of Standards (NBS) and some amateurs, among them W6VSV and W6HPH. Basically a simple directional array designed for low side-

fig. 2. Setup for the matched detector method. A bolometer is used in (A). An easily constructed diode detector substitute for the bolometer is shown in (B). The 3-dB pad will improve the match between detector and antenna, especially at uhf.



in nearly all theoretical work. However, it's not possible to produce such an antenna, so the matched 1/2-wave dipole[2] is used as a reference antenna.

The dipole has a disadvantage. Because of its broad pattern, it's extremely sensitive to ground effects and to near-field reflections from the signal source. These reflections add or detract from the desired free-space signal and produce an output that varies from the ideal (average) value.

nbs standard reference antenna

Absolute accuracy of measurements depends on the accuracy of the reference dipole. Hence it is important to average the lobe content and high front-to-back ratio, the NBS standard antenna has a gain of 7.7 dB over a reference dipole, measured under laboratory conditions in an anechoic chamber.

The measurement repeatability is on the order of ±0.1 dB or better. The NBS standard antenna is used in a manner identical to that of the reference dipole, but there is less variation due to reflections. Also, one must remember to add the 7.7 dB reference-antenna gain figure to those from the vswr meter with the test antenna in the line. For example, if the test antenna measures 2.3 dB when the reference antenna measures 0 dB, the antenna gain is 10 dB.

results

These techniques are regularly employed by top vhf-uhf amateurs to obtain the most from homebrew and commercial arrays. In the past few years, antenna contests at hamfests have become popular proving grounds where new winning combinations have been discovered. A case in point is the reawakened popularity of the Yagi antenna at 432 MHz. It has resulted from careful optimization of several scaled-down designs that didn't work at all (or poorly at best). Another case is the 1 to 2 dB gain increase from adding directors to collinear arrays—a method now adopted by at least one manufacturer.

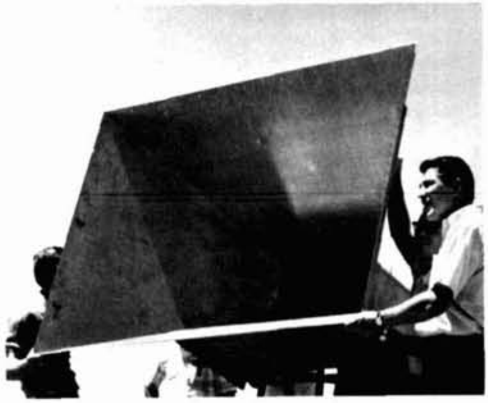
The accuracy of the results is amazing. My own 32-element, 432-MHz array measured 15 dB at the West-Coast Uhf Conference in Fresno and 16.2 dB at the Hughes Radio Club contest in Fullerton (after some matching deficiencies were discovered).

As for the repeatability of results from site-to-site, tests of the popular 6-foot boom "Tilton" Yagi at 432 MHz resulted in consistent measurements yielding 12 to 13 dB in contests from Missouri to California. W5ORH's twin bi-square beam measured 8.0 dB at three different sites using three different test methods. These examples are exceptions. Typically, however, results haven't varied more than ±2 dB when good equipment and normal care were used in making the measurements.

W6FZJ and his 13.3-dB 1296-MHz array.

WA6KKK and WB6MGZ aim 18.6-dB 1296-MHz dish.

W6MMU's big horn for 432—11.7 dB.



K6MYC's 12-element 432-MHz quad gave 7.9 dB.

K7ICW's 30-element Yagi for 1296 MHz yielded −2.5 dB!

VK3ATN, W1DTY, K6JYO and W6DOR discuss some of the intricacies of antennas for 432 MHz while attending the antenna measuring contest held at the West Coast VHF Conference in Fresno.

photos by W6BUR

some surprises

At one contest several owners of supposedly high-gain commercial arrays really had their eyes opened. One 432-MHz Yagi, with a manufacturer's claim of "over 17 dB forward gain," measured **negative** 2 dB off the front and +6 dB off the back. Cutting the antenna in half got about +8 dB forward gain.

Another homebrew 13-element Yagi from a popular vhf handbook measured +1.9 dB gain over a dipole. (The owner had substituted a wooden boom for the original metal boom and hadn't reduced the element lengths to compensate. Trimming the elements and matching the feed brought the gain up to 12.3 dB—not a bad increase.)

It should be obvious that antenna gain measurement is worthwhile for the amateur. From my experience, it gets results we all desire: better reports and more consistent contacts.

reference

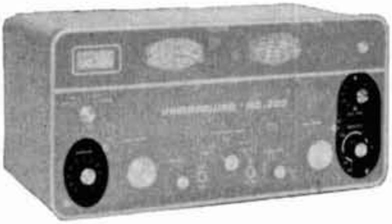
1. Fred W. Brown, W6HPH, "The Matched Detector," *VHF'er*, June, 1965.
2. Loren Parks, K7AAD, "The Reference Dipole," *VHF'er*, April, 1965.

ham radio

SPEC-I-FI-'CA-TION

. . . A DETAILED, PRECISE PRESENTATION OF FACT—

SEN-SI-'TIV-I-TY



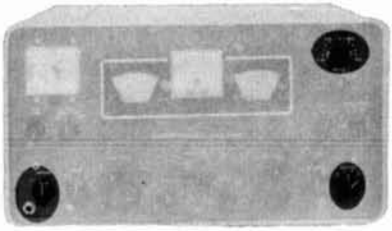
BRAND NEW MODEL HQ200

The correct matching of the antenna to the tube input impedance is of great importance in securing an optimum signal to noise ratio. A reactive antenna will usually produce a detuning effect on the input R.F. circuit. A good way of overcoming this problem is to tune the circuit with a panel mounted antenna trimmer or with a variable capacitor ganged with the VFO tuning capacitor. (A Hammarlund Feature for Years!)

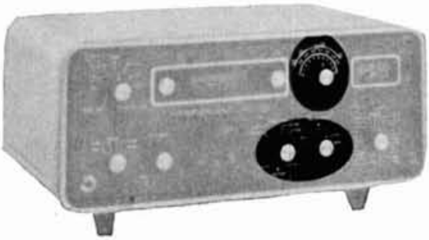
SE-LEC-'TIV-I-TY

Maximum pre-mixer selectivity is a valuable aid in reducing spurious responses and such selectivity is most easily achieved with an R.F. stage. (See *all* Hammarlund receivers for this - -)

The ability of a receiver to separate stations on closely adjacent frequencies is a measurement of its selectivity. To compare receivers, look at their selectivity curves. The curves show the *nose figure,* which represents the bandwidth in KHz over which the signal will suffer little loss of strength; the other figure, the bandwidth over which a powerful signal is still audible, is termed the *skirt* performance. The ratio of the two is the *shape* factor of the receiver. The ideal would be a shape factor of *one*—but this is presently impractical. The inclusion of step selectivity by use of a mechanical or crystal filter or by changing LC circuit parameters can provide shape factors close to the ideal. (Check the front panel of any Hammarlund receiver!)



MODEL HQ-180A



MODEL HQ-215

At Hammarlund, we believe in specifics—every one of our products meets published specifications—not just our engineering samples. Some of our receivers are still in daily use after thirty years and numerous owners! We'd like to tell you more about our radios—General Coverage—Ham Band—Commercial. Drop us a line at our sales office—20 Bridge Ave., Red Bank, New Jersey 07701—or see your favorite Hammarlund dealer.

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K4DZT	K4HCS	W2HEL/4	W4HHR	W4AEY	K4BHN	W4MVC/W2ERV	W4TYQ	WB4LTL	W6NRT/4	W9KPD/4

the crystal oscillator

This complete summary of solid-state devices as crystal oscillators will enhance your technical reference file

Hank Olson, W6GXN, P. O. Box 339, Menlo Park, California 94025

In a previous article,[1] I discussed the general nature of crystal oscillators using tubes, transistors and field-effect transistors (fet's). Since 1966, when that article was written, a great deal has happened in the semiconductor industry that might affect your choice of an active device for use in a crystal oscillator. In the following paragraphs, I've considered all the solid-state devices available at reasonable cost that can be used in crystal oscillator service.

A brief review of their application in conventional circuits is first presented. This is followed by an extensive treatment of these units as used in modified versions of the basic circuits. I've also given some recommendations for certain precautions and design considerations that should be used. If you're solid-state oriented, this article will be invaluable as a reference source the next time you consider a crystal oscillator design.

Prices have dropped, and performance has increased significantly on n-channel junction fet's, insulated gate fet's, digital integrated circuits and linear integrated circuits. The price reductions appear to be due mainly to lower-cost plastic packaging and the acceptance of these devices by large commercial makers of computers and television sets. The lower costs and the increased performance are just what the doctor ordered for amateur applications.

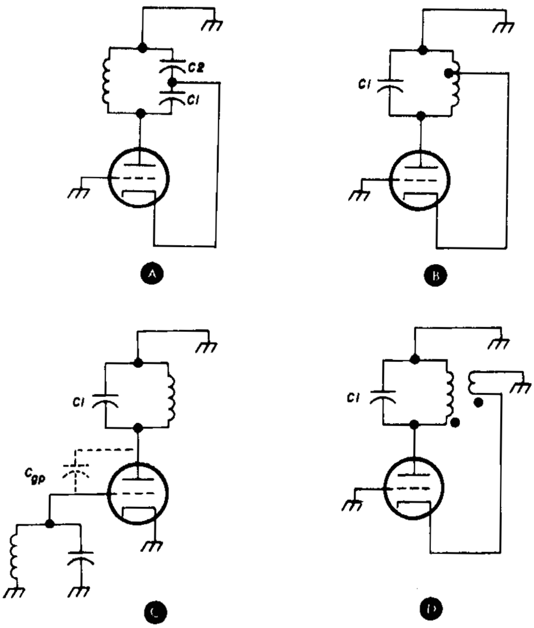


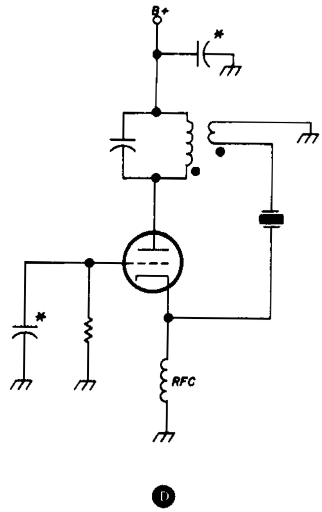
fig. 1. The four basic oscillator circuits: Colpitts (A), Hartley (B), tuned plate-tuned grid (C) and tickler-feedback (D).

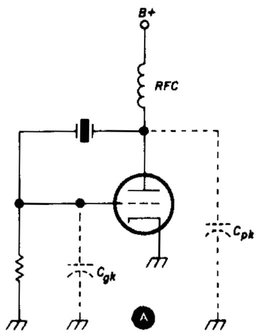
basic circuits

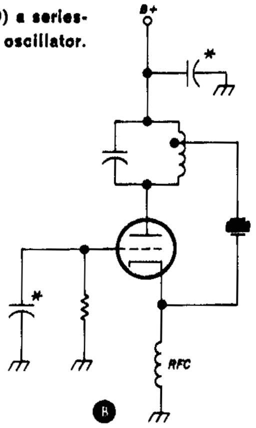
Four forms of the vacuum-tube oscillator are generally used in amateur designs. These are the Colpitts, Hartley, tuned-plate-tuned-grid and tickler-feedback circuits, as shown in **fig. 1**. They can all be modified to incorporate a crystal, as shown in **fig. 2**. Note that some of these circuits use the crystal as a series-resonant circuit, and others as an inductance. A single crystal can present either of these characteristics, as shown in **fig. 3;** but you must account for the fact that **each occurs at a different frequency.** This is one reason for the various "CR" specifications; some crystals are cut for series-resonant and some for near parallel-resonant operation. A listing of military CR specifications is given in **table 1**.

modified forms

One of the most successful of the vacuum-tube circuits, for use with series-resonant crystals, is shown in **fig. 4**, the Butler oscillator. It's similar to that in **fig.**







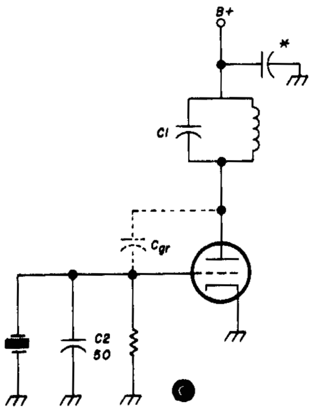
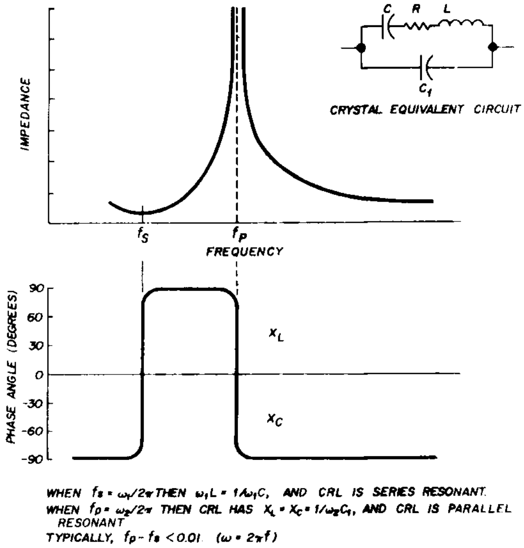


fig. 2. Descendants of the oscillators in fig. 1 using crystals for frequency control. In the Pierce (A) Cpk and Cgk replace C and C2 of fig. 1(A). Series-mode crystal is used in the Hartley circuit (B). The Miller oscillator (C) is a version of the tptg. In (D) a series-mode crystal is used in a tickler-feedback oscillator. Blocking capacitors are denoted by *.

fig. 3. Series and parallel resonance impedance characteristics of a crystal.



1A, except that an impedance-lowering cathode-follower has been added, so that the low impedances of the series-resonant crystal and cathode of V_1 can be more easily driven.

Two other types of crystal oscillators somewhat familiar to hams are the negative-resistance oscillator, as exemplified by the transitron and dynatron oscillators using tubes, and the tunnel-diode oscillator of the solid-state world. The general negative-resistance crystal oscillator is shown in **fig. 5**, and the transitron and dynatron in **fig. 6**. Two tunnel-diode crystal oscillators are shown in **fig. 7**.

From **fig. 5** it might seem that the obvious way to build a tunnel-diode crystal oscillator is as shown in **fig. 7A**. This is

fig. 4. The Butler oscillator—a modified Colpitts for use with series-mode crystals.

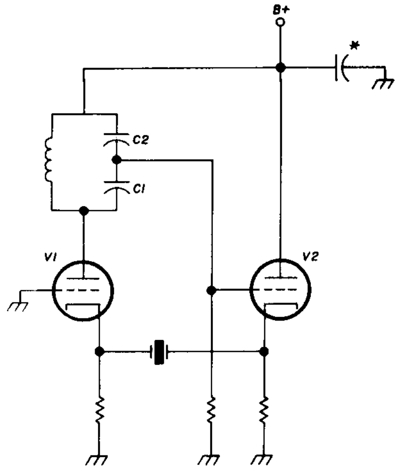


fig. 5. Negative-resistance, or two-terminal oscillator.

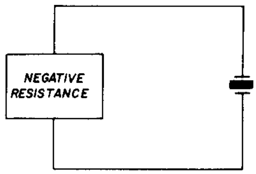
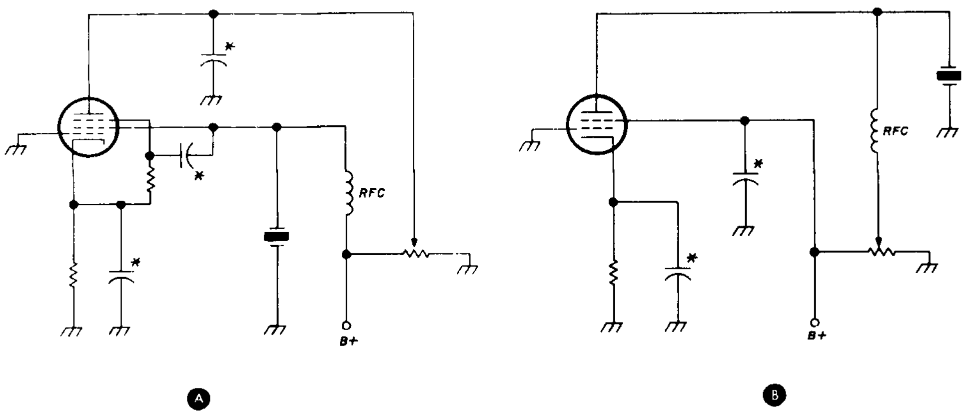


fig. 6. Transitron (A) and dynatron (B) crystal oscillators. Blocking capacitors denoted by *.



crystal unit, (military)	military holders	nominal frequency range (kHz)	frequency tolerance (± percent)	resonance	load capacitance (pF)	mode of operation
CR-1(A)/AR	HC-11 or 12/U	2,000-15,000	0.02	Parallel	35.0 ± 0.5	Fundamental
CR-2/U	FT-241A, HC-17/U	200	0.009	Parallel	125.0	Fundamental
	FT-241A, HC-17/U	500	0.010	Parallel	64.0 m	Fundamental
CR-3/U	FT-241A, HC-17/U	300-600	0.02	Parallel	—	Fundamental
CR-4/U	FT-241A, HC-17/U	500-1,200	0.02	Parallel	—	Fundamental
CR-5/U	FT-241	2,000-10,000	0.02	Parallel	25.0 ± 0.5	Fundamental
CR-6/U	FT-243	2,000-10,000	0.02	Parallel	12.0	Fundamental
CR-7/U	HC-14/U	3,750-10,000	0.004	Parallel	28.0 ± 0.5	Fundamental
CR-8/U	FT-243	1,000-10,000	0.02	Series	—	Fundamental
CR-9/U	HC-10/U	15,000-50,000	0.01	Series	—	Overtone
CR-10/U	FT-243	5,000	0.005	Parallel	25.0	Fundamental
CR-12/U	FT-243	2,000-10,000	0.02	Parallel	32.0	Fundamental
CR-13	FT-243	455	0.02	Series	—	Fundamental
CR-13/U	FT-243	5,250	0.02	Series	—	Fundamental
CR-14/U	FT-243	2,000-10,000	0.01	Parallel	32.0	Fundamental
CR-15/U	HC-5/U	80-200	0.01	Parallel	32.0 ± 0.5	Fundamental
CR-16/U	HC-5/U	80-200	0.01	Series	—	Fundamental
CR-17/U	HC-10/U	15,000-50,000	0.005	Series	—	Overtone
CR-18/U	HC-6/U	800-16,000	0.005	Parallel	32.0 ± 0.5	Fundamental
CR-19/U	HC-6/U	800-20,000	0.005	Series	—	Fundamental
CR-23/U	HC-6/U	10,000-75,000	0.005	Series	—	Overtone
CR-24/U	HC-10/U	15,000-50,000	0.005	Series	—	Overtone
CR-25/U	HC-6/U	200-500	0.01	Series	—	Fundamental
CR-26/U	HC-6/U	200-500	0.002	Series	—	Fundamental
CR-27/U	HC-6/U	800-15,000	0.002	Parallel	32.0 ± 0.5	Fundamental
CR-28/U	HC-6/U	800-20,000	0.002	Series	—	Fundamental
CR-29/U	HC-5/U	80-200	0.002	Parallel	32.0 ± 0.5	Fundamental
CR-30/U	HC-5/U	80-200	0.002	Series	—	Fundamental
CR-31/U	HC-6/U	1,000-10,000	0.005	Parallel	12.0	Fundamental
CR-32/U	HC-6/U	10,000-75,000	0.002	Series	—	Overtone

table 1. Specifications for military crystals.

similar to one shown in reference 2. While it may be possible to make such a circuit work, if just the right rf choke can be found, I had no luck with it. The circuit oscillates, but the crystal has no effect other than that of its holder capacity on the frequency. Instead of oscillating at the crystal frequency, the circuit oscillates at the series-resonant frequency of the rf choke and the diode equivalent capacity.

A more satisfactory crystal oscillator can be built as shown in **fig. 7B.**[3] At the crystal's series resonant point, the two resistors are effectively in parallel (because the crystal is a "short" between them). The two resistors must be smaller than the absolute magnitude of the tunnel-diode negative resistance yet large compared to the equivalent series resistance (at series resonance) of the crystal. Also, L and C are the same impedance as the resistors. That is, at 8775 kHz, L equals +j51 ohms and C equals −j51 ohms.

Since the equivalent series resistance at series resonance is so important to tunnel-diode crystal oscillators (and to many others as well), the resistances of different crystals for various frequencies must be known for good design. Such a listing is shown in **table 2.** Note that these figures were taken from one manufacturer's data sheets; resistances of other manufacturer's crystals will vary from these somewhat. Nevertheless, the table provides a "ball-park" figure upon which design can be started.

crystal unit, (military)	military holders	nominal frequency range (kHz)	frequency tolerance (± percent)	resonance	load capacitance (pF)	mode of operation
CR-33/U	HC-6/U	10,000-25,000	0.005	Parallel	32.0 ± 0.5	Overtone
CR-35/U	HC-6/U	800-20,000	0.002	Series	—	Fundamental
CR-36/U	HC-6/U	800-15,000	0.002	Parallel	32.0 ± 0.5	Fundamental
CR-37/U	HC-13/U	90-250	0.02	Parallel	20.0 ± 0.5	Fundamental
CR-38/U	HC-13/U	16-100	0.012	Parallel	20.0 ± 0.5	Fundamental
CR-39/U	HC-15/U	160-330	0.004	Series	—	Fundamental
CR-40/U	HC-15/U	160-330	0.003	Series	—	Fundamental
CR-42/U	HC-13/U	90-250	0.003	Parallel	32.0 ± 0.5	Fundamental
CR-43/U	HC-16/U	80-860	0.035	Parallel	45.0 ± 1.0	Fundamental
CR-44/U	HC-6/U	15,000-20,000	0.002	Parallel	32.0 ± 0.5	Fundamental
CR-45/U	HC-6/U	455	0.02	Series	—	Fundamental
CR-46/U	HC-6/U	200-500	0.01	Parallel	20.0 ± 0.5	Fundamental
CR-47/U	HC-6/U	200-500	0.002	Parallel	20.0 ± 0.5	Fundamental
CR-48/U	HC-6/U	800-3,000	0.0075	Parallel	32.0 ± 0.5	Fundamental
CR-49/U	HC-6/U	800-3,000	0.0075	Parallel	32.0 ± 0.5	Fundamental
CR-50/U	HC-13/U	16-100	0.012	Series	—	Fundamental
CR-51/U	HC-6/U	10,000-61,000	0.005	Series	—	Overtone (Pressure)
CR-52/U	HC-6/U	10,000-61,000	0.005	Series	—	Overtone (Plated)
CR-53/U	HC-6/U	50,000-87,000	0.005	Series	—	Overtone (Pressure)
CR-54/U	HC-6/U	50,000-87,000	0.005	Series	—	Overtone (Plated)
CR-55/U	HC-18/U	17,000-61,000	0.005	Series	—	Overtone
CR-56/U	HC-18/U	50,000-87,000	0.005	Series	—	Overtone
CR-57/U	HC-6/U	500	0.001	Parallel	32.0 ± 0.5	Fundamental
CR-58/U	HC-17/U	3,000-20,000	0.005	Parallel	32.0 ± 0.5	Fundamental
CR-59/U	HC-18/U	50,000-91,000	0.002	Series	—	Overtone
CR-60/U	HC-18/U	7,000-20,000	0.005	Series	—	Overtone
CR-61/U	HC-18/U	17,000-61,000	0.002	Series	—	Overtone

the multivibrator

The multivibrator crystal oscillator didn't really come into its own until the advent of bipolar transistors, although it has been built using tubes. It is simply an astable multivibrator with one of its coupling capacitors replaced by a crystal (or with a crystal and series-tuning capacitor). **Fig. 8** is representative of such an oscillator. This circuit was used as a one-megahertz crystal calibrator in vhf receivers.[4]

The multivibrator crystal oscillator isn't particularly noteworthy as shown (built with discrete components), but it's the basis for most of the crystal oscillators using digital integrated circuits.

The main use of multivibrator-type crystal oscillators has been for frequencies be-

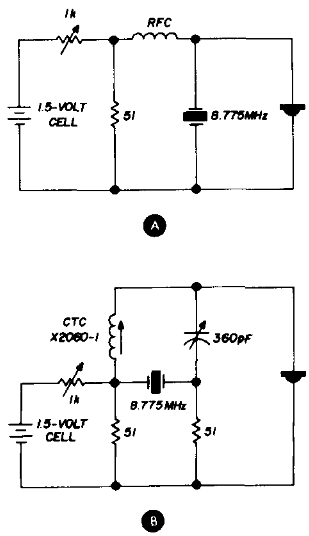


fig. 7. Tunnel-diode oscillators. Circuit at (A) is not recommended because of critical adjustment of rfc.

table 2. Series-resonant resistances of crystals for different frequencies.

Reeves-Hoffman type	Frequency (kHz)	Series-resonant Resistance (ohms)	Remarks
J element	1	150,000	+5° X cut
J element	2	75,000	+5° X cut
J element	4	36,000	+5° X cut
J element	8	30,000	+5° X cut
J element	12	15,000	+5° X cut
N element	20	9,000	NT cut
N element	50	10,000	NT cut
E element	100	1,800	+5° X cut
D element	200	950	Y cut
C element	500	1,000	Y cut
A element	1×10^3	300	AT cut (fundamental)
A element	3×10^3	65	AT cut (fundamental)
A element	6.5×10^3	15	AT cut (fundamental)
A element	1.15×10^4	12	AT cut (fundamental)
A element	2.08×10^4	8	AT cut (3rd overtone)
A element	4.04×10^4	35	AT cut (3rd overtone)

low 100 kHz, where it's impractical to provide large inductors for conventional oscillators.

using bipolar transistors

The translation of tube-type crystal oscillators to solid-state circuits must be approached with some caution. Too often a bipolar transistor symbol is just drawn in place of a triode tube symbol. This sort of "engineering" has resulted in circuits like that of **fig. 9**, which **sometimes** oscillate.

A bipolar transistor is quite unlike a vacuum tube; a **current** into the base controls the collector current in the transistor. In a tube, a **voltage** on the grid controls the plate current. As a result of these different behaviors, the base of a common-emitter bipolar transistor has a much lower input impedance than the grid of a grounded-cathode vacuum tube.

The lower impedances presented by the bipolar transistor make it difficult to use in crystal oscillators that use parallel-resonant crystals. However, for use with series-resonant crystals, the bipolar transistor is just great. **Fig. 10** shows how series-mode crystals and bipolar transistors can be used to take advantage of the compatible impedances of each.

Note also in the circuits of **fig. 10** that a 6.8-μH inductor is placed in parallel with the 26-MHz crystal. This inductor forms a parallel-resonant circuit with the holder capacitance of the crystal. Looking at **table 1**, the CR24/U has a holder capacitance of 7 pF. At 26 MHz, approximately 6 μH resonates 7 pF, so the closest

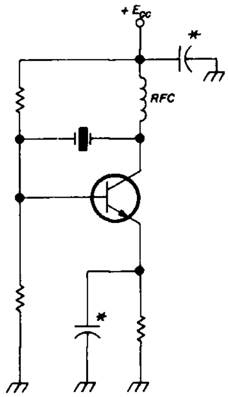
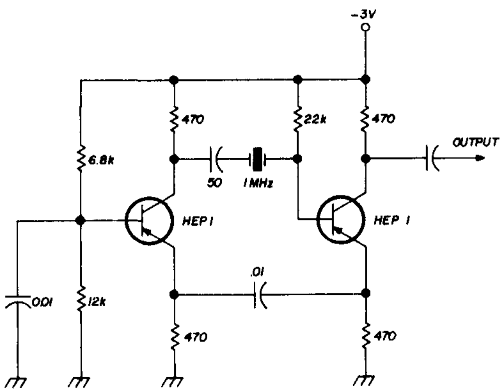


fig. 9. Pierce oscillator using a bipolar transistor—not recommended (see text). Blocking capacitor denoted by *.

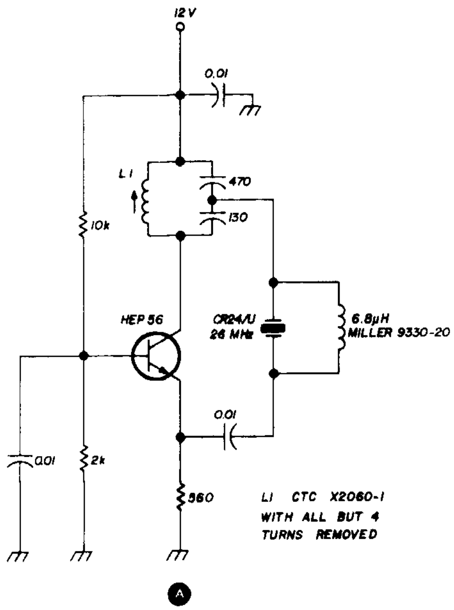
fig. 8. Multivibrator crystal oscillator. The HEP 1's can be replaced with 2N1204's.



standard inductor (6.8 μH) in the Miller 9330 series was used.

Balancing the holder capacitance in this way acts as a simple form of mode filter,

fig. 10. Series-mode crystal oscillators using a bipolar transistor—Colpitts (A), Hartley (B) and tickler-feedback (C).

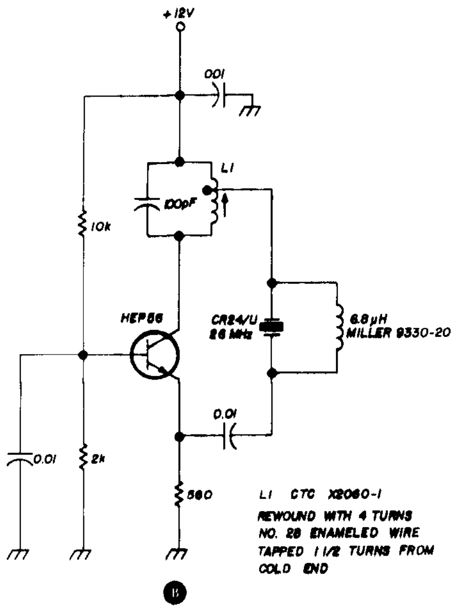


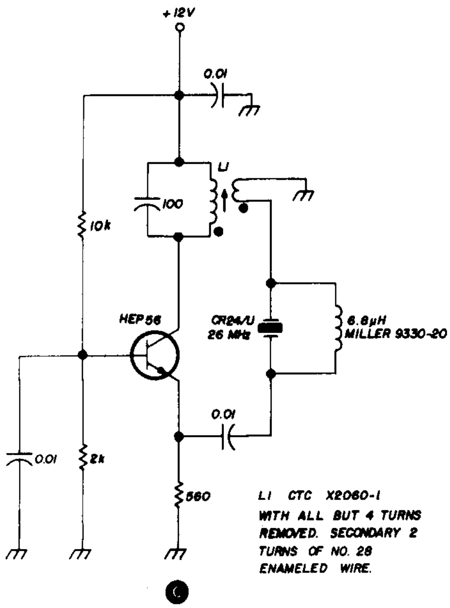
assuring that the crystal oscillates as marked. I found this simple method to be adequate even with seventh-mode overtone crystals in the 170-MHz range. The method can be applied to nearly any crystal oscillator where the crystal is to be operated in the series mode. However, the addition of a series-blocking capacitor may be necessary (since the **crystal** may have blocked dc in the original circuit).

fet crystal oscillators

These devices, on the other hand, are quite similar to tubes because the gate **voltage** controls drain current in the common-source connection. So almost any vacuum-tube crystal oscillator finds its direct equivalent in an fet circuit. Two are illustrated in **fig. 11**. Notice that both use junction fet's. This was done because the diode junction between gate and source conducts (like the grid and cathode of a tube) when forward-biased, and allows "gate leak" action. If an insulated-gate field-effect transistor (igfet) is used, a separate diode is usually added across gate and source, as in **fig. 12**.

Fig. 12 is an ultra-simple Pierce oscillator (a version of the Colpitts), which finds





its counterpart vacuum-tube circuit in **fig. 2A**. It's useful for checking the general activity of fundamental-mode crystals in the 2- to 20-MHz range. Since fundamental-mode crystals aren't usually cut above 20 MHz, if a higher frequency rock is plugged in (say a 26-MHz, 3rd-mode) it won't oscillate as marked. One indication of oscillation in this circuit is a decrease in drain current, since the nonoscillating circuit draws I_{DSS} until gate-leak action is established.

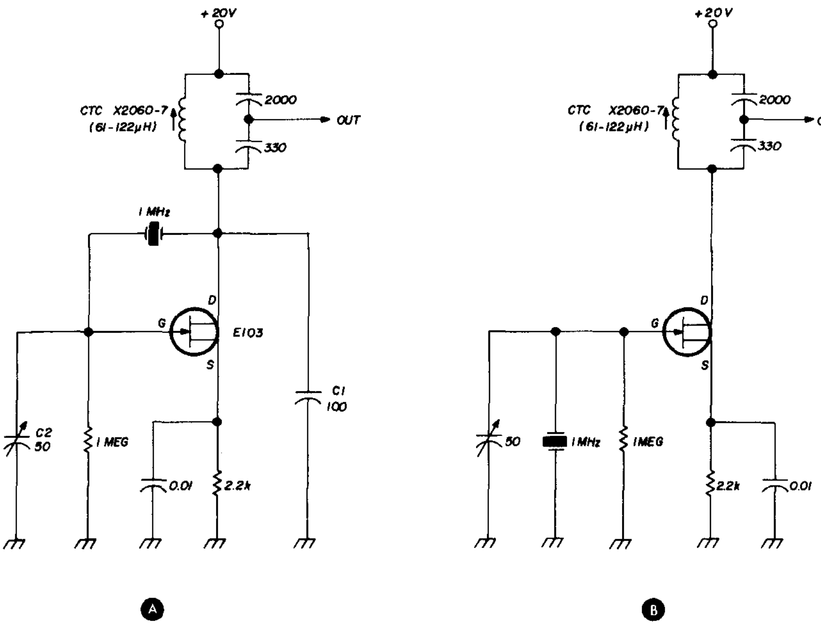


fig. 11. Crystal oscillators using n-channel junction fet's. In (A) crystal performs as an inductor between drain and gate of the fet, with capacitive divider formed by C and C2. Circuit (B) is the Miller oscillator, which is useful with crystal having one terminal connected to the can (as in DC-9 octal style).

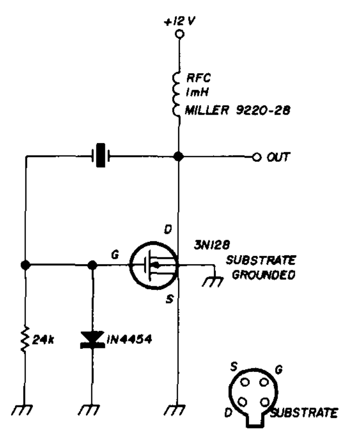


fig. 12. Pierce circuit using n-channel igfet; useful with fundamental-mode crystals from 2 to 20 MHz.

No circuits using p-channel fet's are shown (either junction or insulated-gate types) because rf types haven't become available at the low prices of the n-channel units. The germanium TIXM12 was one of the exceptions (a p-channel JFET, good to over 100 MHz for $1.07), but it has been discontinued like the TIXM05 we all loved. If and when p-channel fet's for rf become available again, the circuits of **fig. 11** and **12** can be used by reversing the supply-voltage polarity (and reversing the diode in the circuit of **fig. 12**).

There are, of course, a number of ways in which npn and pnp bipolar transistors can be combined with n-channel and p-channel jfet's and igfet's to provide combination circuits. An example is shown in **fig. 13**, a Butler oscillator using an npn bipolar transistor and an n-channel jfet.

integrated circuits

In recent years, one of the largest areas of growth in the semiconductor industry has been in integrated circuits. These can be used as crystal oscillators in a number of configurations. Digital IC's, which are the least expensive units, can be made to function as crystal oscillators of the multivibrator-type. **Figs. 14** through **17** show the RTL, DTL, TTL, and ECL families as crystal oscillators. Resistor-transistor logic (RTL) is the least expensive family and has been widely used in amateur systems because of its low cost. It is relatively slow, however, and the circuit of **fig. 14** can't be expected to work reliably at frequencies higher than a few megahertz.[6] By using a pair of the higher-power μL900 buffers, oscillation can be obtained up to about 8 MHz.[7] The circuit of **fig. 15** apparently operates at higher frequencies because of lower inherent resistances.

Although RTL is the least expensive, the prices of diode-transistor logic (DTL) and transistor-transistor logic (TTL) have been steadily decreasing, and they're now feasible for ham construction. A cost comparison of several quad-dual gates shows the price per gate to be within reason (**table 3**).

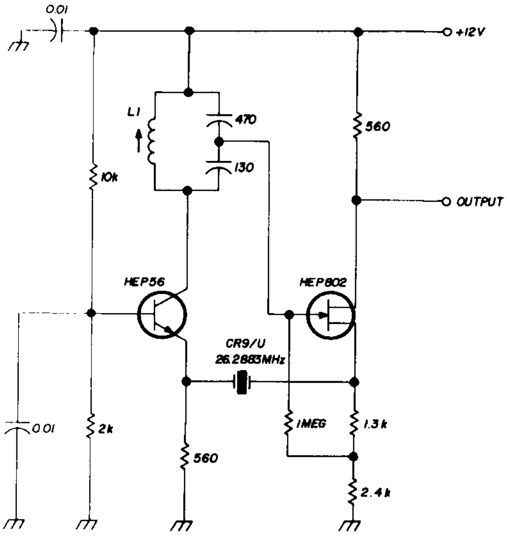


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fig. 13. Butler oscillator using npn transistor and n-channel fet.

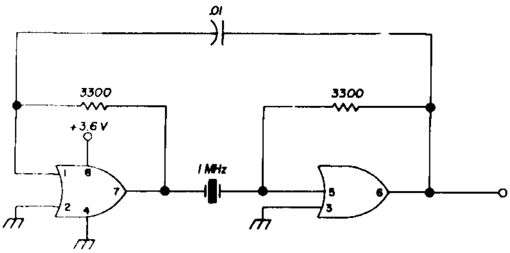


fig. 14. Crystal oscillator using resistor-transistor logic (RTL) integrated circuit.

fig. 15. Using RTL buffers in a crystal oscillator circuit.

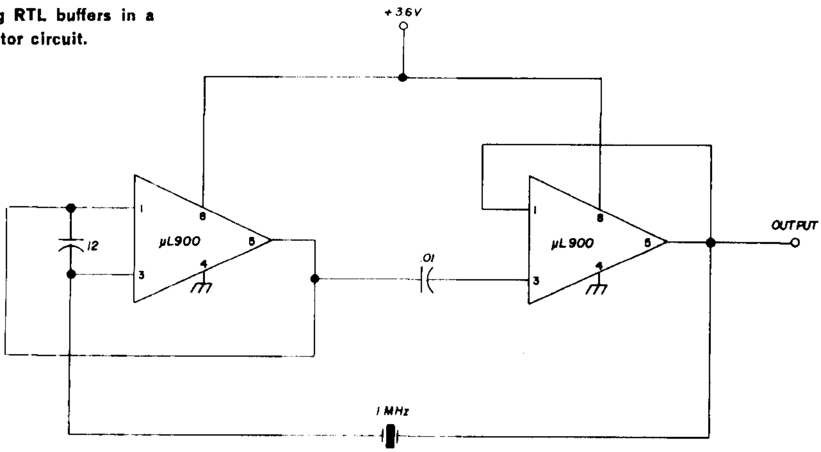


table 3. Cost comparison of popular integrated circuits.

Logic	Company	Part Number	Cost	Cost Per Gate
RTL	Motorola	MC717P	$1.08	$0.27
DTL	Motorola	MC846P	1.65	.41¼
TTL	TI	SN7400N	2.25	.56¼
ECL	Motorola	MC1010P	1.80	.45

Fig. 16 shows how DTL and TTL units can be used as a crystal oscillator. Note that the same pin configuration and voltage are used for the two IC's.[6] Also, since only two of the four gates are used, the others can be used as isolation stages or as another crystal oscillator.

One word of caution about use of TTL's, however: the pins shown are **only** for the SN7400N. If you try the military version (SN7400 or SN5400), pin connections are quite different!

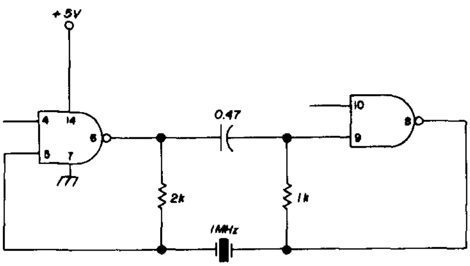
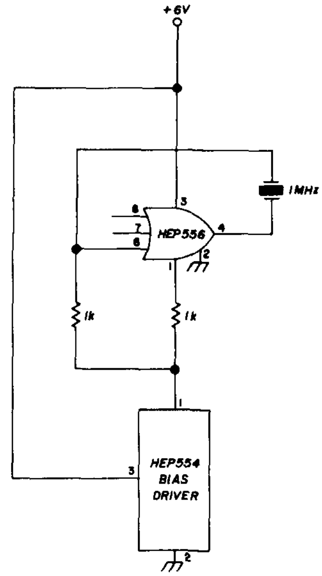


fig. 16. Transistor-transistor logic (TTL) or diode-transistor logic (DTL) gates in a crystal oscillator.

The emitter-coupled logic (ECL) family is the only one where the internal transistors aren't switched into and out of saturation. This feature makes ECL inherently fast, allowing the MECL I series of Motorola to operate to 30 MHz, and the MECL II series to approach 100 MHz as crystal oscillators. **Fig. 17** shows how an MECL I gate can be used as a simple 1-MHz oscillator.[8] Reference 9 covers in more detail the ECL at higher frequencies.

A separate bias driver (MC354G or HEP554) is required with the MECL I series, but it's built in on the MECL II series. The cost per gate of MECL II, using the MC1010P (quad 2-input gate, at $1.80) is $0.45. This compares closely with DTL and TTL units.

fig. 17. Emitter-coupled logic (ECL) gates used in a crystal oscillator.



the operational amplifier

In linear IC's there is almost limitless variety, but one of the *main* building blocks is the direct-coupled differential amplifier. Two forms of this monolithic IC have become more or less standard in the semiconductor industry: the operational amplifier (like the Fairchild μA709 and its descendants) and the rf/i-f amplifier (the Fairchild μA703 and similar units). Both can be used as crystal oscillators; the operational amplifier is limited to the lower frequencies.

An operational amplifier used as an oscillator brings out many of the basic fundamentals of oscillator design. Because the operational amplifier is such a nearly ideal device, it affords ease of feedback design. Inverting and noninverting inputs are provided on most op-amps, both positive feedback (used to cause oscillation) and negative feedback (used to reduce gain and stabilize output) can be selectively used to produce exactly the oscillator design you desire.

An example of an op-amp crystal oscillator using both positive and negative feedback is shown in **fig. 18**. This circuit uses a nonlinear resistor in the negative feedback resistive network to adjust the gain and thereby assure sinusoidal waveform. The technique is similar to that used in the Wien Bridge audio oscillator, and is covered in reference [10].

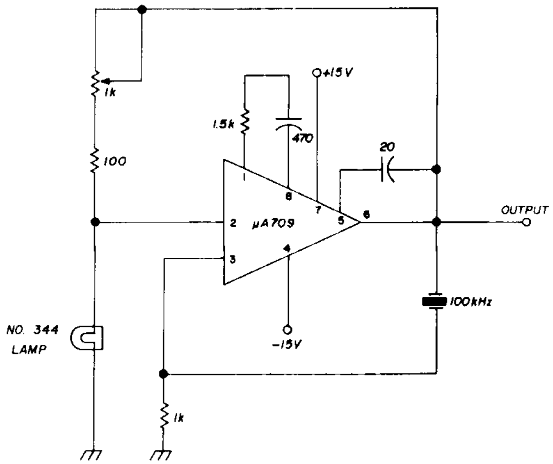


fig. 18. Monolithic operational amplifier as a crystal oscillator.

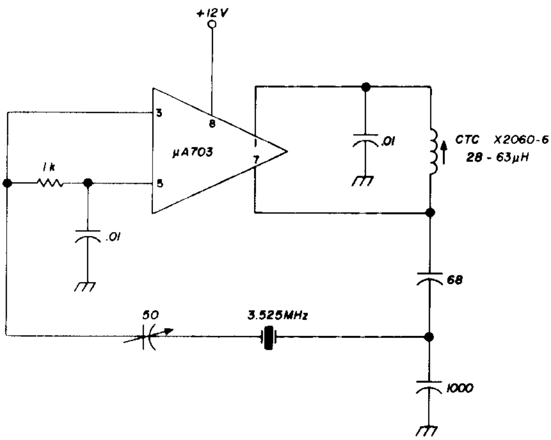


fig. 19. The μA703 as a 3.525-MHz crystal oscillator.

A number of other linear integrated circuits have been used as crystal oscillators and are described in various application notes.[11,12,13] The main impetus for the use of IC's in crystal oscillators has been in 3.58-MHz TV colorburst generators; so most of the circuits shown in these references are for 3.58-MHz oscillators.

You might ask what advantage these IC crystal oscillators have over those built from discrete components—if any. The answer is that there's little advantage in using IC's in this way, unless you consider it avante-garde to have **your** piece of equipment "all IC." The IC **does** offer a rather large stable gain in one package, however, as evidenced by the large capacitive divider across the tuning coil.

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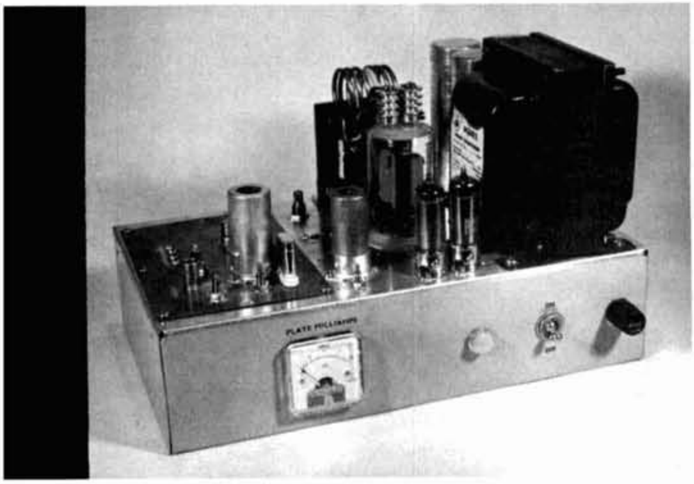


complete transverter for six meters

If you have a single-band ssb transceiver, it's easy to get on 50 MHz with the 6/40 'verter

R. L. Winklepleck, WA9IGU, 107 Berkeley Drive, Terre Haute, Indiana 47803

Every time the six-meter skip comes in you're no doubt impressed by the rapidly increasing number of single sideband stations. "Maybe it's time to plan for that sideband rig," you think. Then you look at the price tags on the commercial outfits and decide, "Not yet." Even the kits are expensive, and whipping one up from scratch is both expensive and complex.

A much more attractive answer to a good sideband signal on six meters is a combined receiving and transmitting converter. If you have a low-band ssb transceiver, a grid-dip meter and a little homebrew experience, this can be a very happy solution to the problem.

I went through these mental gymnastics for a couple of years before deciding to take soldering gun in hand and build the **6/40 'verter.** One of Mr. Heath's excellent Single-Banders for forty meters was in the shack. I put together a conventional converter to shift the six-meter sideband signal down to forty. You've probably had some experience along this line and this is half the job. A somewhat similar converter was built alongside to swing the forty-meter ssb signal from the transceiver up to six meters. A simple power supply for both converters was added, and the job was done. Both converters use the same oscillator, so both the received and transmitted signals are on the same frequency. Once tuned up, the transverter can be disregarded, and operation is with the transceiver only.

Right about here you're probably saying, "It can't be **that** simple. The generation of ssb signals is complex, and homebrewing of such equipment just isn't for me." You're absolutely right. But, the difficult part has all been taken care of by those smart people at Benton Harbor. All we're talking about here is beating signals to produce heterodynes, as in that ten-dollar table radio in the bedroom. The fact that one of the signals is modulated ssb instead of a-m doesn't change the operation.

the circuit

With this description in mind let's examine the schematic **(fig. 1)**. Note that the top half, consisting of the 6CW4, 6EA8 and associated circuit is the familiar receiving converter. The one used here isn't original—it's borrowed from "The Radio Handbook." It's a good one, but there's no reason to use this if you have a converter on hand or wish to buy a commercial unit.

For transmitting, the conversion signal from the triode section of the 6EA8 is fed to a 6DJ8 cascode amplifier. The boosted rf is then inserted push-pull into the grids of a 5894 serving as a mixer-final. The forty-meter ssb signal from the Single-Bander is inserted at the screen grids of the 5894, and a six-meter, single-banded signal comes out. The 5894 dual tetrode is a relatively high-power, easily driven tube that isn't exactly cheap, but it can be found in some of the bargain-priced tube lists.

It does a beautiful job in this application, but maybe you have an 815 or 6360, or a couple of 2E26's you'd like to use. A few component values would require changing, but these tubes would all work—at lower power. By the same token, there's no reason why you can't start with a twenty-meter signal and end up on two meters. The approach would be the same. It all depends on what you have to build with and where you want to operate.

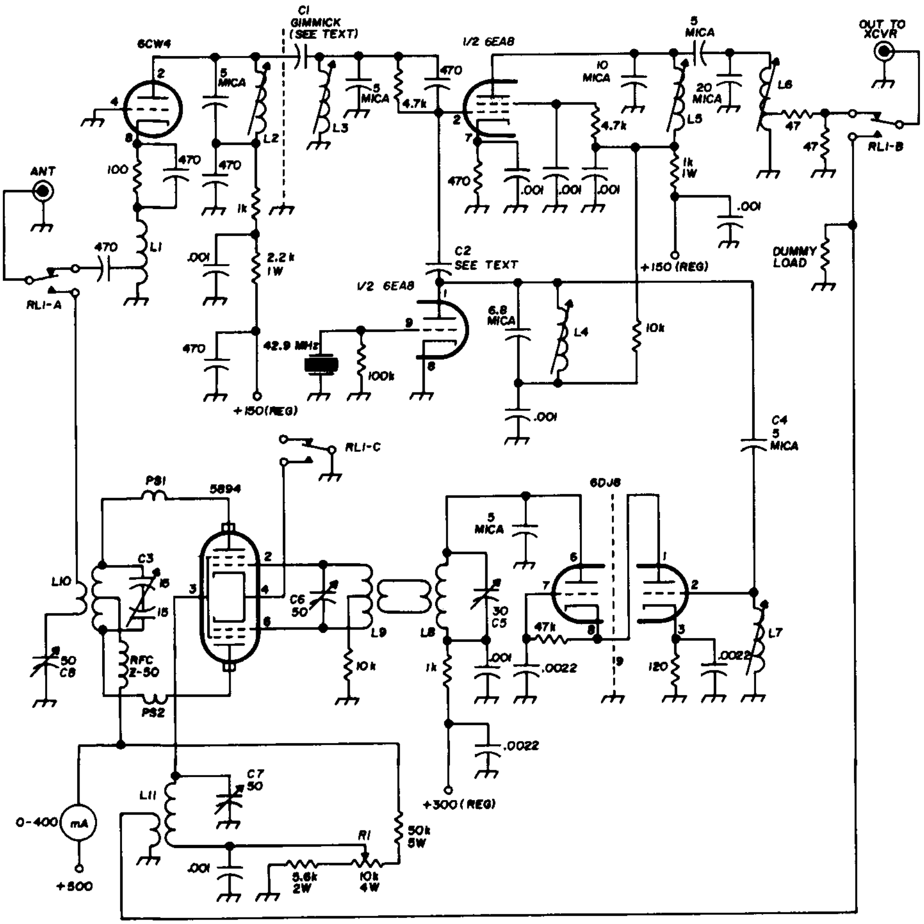
assembly

Construction practices are standard for these frequencies. Good grounds, short leads, many bypasses and shielding are very important. The layout shown in the photos is compact, and it works, but it isn't necessarily the last word. The receiving converter was built on a four- by six-inch sheet of flashing copper. Good rf grounds are no problem since many of the components can be soldered directly to the copper.

The 6CW4 is a grounded-grid nuvistor rf amplifier. It's lightly coupled to the 6EA8 mixer section via C1, which consists of two lengths of hook-up wire with about one inch of each parallel with the other, inserted from opposite sides through a hole in the shield between the two tubes. Coupling between oscillator and mixer portions of the 6EA8 is via the spacing of about 3/4 inch between L3 and L4. The coax input and output fittings can be eliminated—they're a reminder of when this converter was used alone.

The same crystal oscillator signal used for receiving is taken from the plate of the converter portion of the 6EA8 via C4 to the first grid of the 6DJ8. Here it goes through two stages of amplification needed for the transmit conversion. The 6DJ8 output is inductively coupled to the 5894 signal grids.

A very low level forty-meter signal is required. This is achieved by dissipating most of the output in a dummy load. A sur-

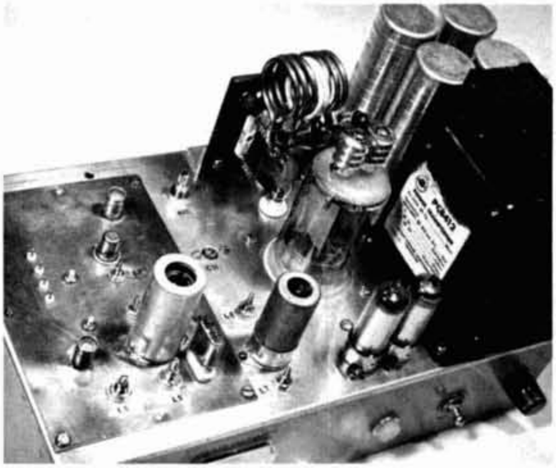


C1	0.5 pF gimmick (see text)
C2	capacitive pickup between L3 and L4
C3	15 pF butterfly
L1	10 turns B&W 3003, tapped 2½ turns from ground end
L2, L3	0.87 μH (J. W. Miller 40A827CBI)
L4	1.0 μH (J. W. Miller 40A106CBI)
L5, L6	Miller 41A000CBI wound full with no. 26 enamelled; L16 tapped 15 turns from ground end
L7	2.2 μH (J. W. Miller 41A226CBI)
L8	8 turns no. 28 enamelled on a ¼" slug-tuned form (J. W. Miller 41A000CBI); link is 2 turns of hookup wire on the cold end
L9	9 turns B&W 3004, center tapped with 2 turns of hookup wire around center
L10	6 turns no. 12, 1-inch ID, spaced 1 wire diameter, with 2-turn insulated loop at wider-spaced center
L11	48 turns B&W 3004; link is 4 turns of hook-up wire around cold end
PS1, PS2	6 turns no. 18, spaced one wire diameter, on high-value, 2 W resistors

fig. 1. Schematic diagram of the 6/40 'verter.

plus three-pole, double throw dc relay switches the antenna circuit alternately through the receiving and transmitting converter sections and turns on the final for transmit by grounding its cathode. Any similar commercial relay will do this job, and by choosing a six-volt ac coil, the rectifier diodes and filter capacitors, which can be seen in one of the photos, can be eliminated. The Single-Bander has an extra set of relay contacts that activate the transverter relay to make the switching automatic.

The entire outfit, including power supply, fits neatly on a commercial 3x7x12-inch



Top view showing the general layout with the receiving converter at the left on its copper plate, the transmitting converter in the center, and power supply on the right.

chassis base. A hole was cut in the top at one end to accept the copper sheet of the receiving converter. The photos show the placement of the other components. Note that C3 is ungrounded. It mounts on a vertical square of phenolic board to which the output winding of L10 is also attached. The parasitic chokes for the 5894 are soldered across loops in the copper straps connecting its plates to C3 and L10.

The power supply is conventional **(fig. 2)** It provides 500 Vdc at 300-plus mA for the 5894 (which, incidentally, can be pushed much harder); 300-volts regulated for the 6DJ8; and 150-volts regulated for the 6CW4 and 6EA8. Signal stability is essential on single sideband. This depends on your transceiver, but the voltage regulation provided here ensures against any frequency drift in the transverter. Capacitors C1 and C3 are mounted on insulated bases, and the cans are insulated to prevent accidental shock.

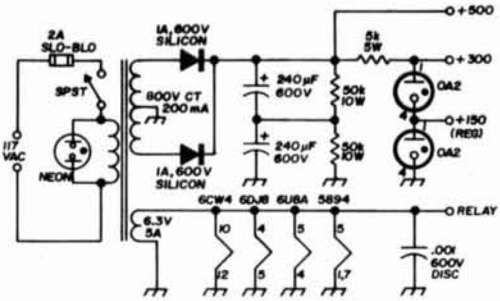
appearance

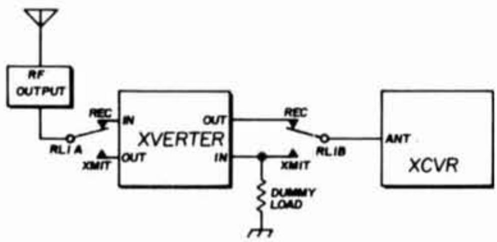
Finishing touches include a ventilated top cover, formed from sheet aluminum, and a ventilated bottom plate. The shielding is required for best results. A coat of spray paint and decal identification of controls will give a professional appearance.

tuning up

The forty-meter Single-Bander tunes only 100 kHz—from 7.2 MHz to 7.3 MHz. Thus, a 42.9-MHz crystal will cover 50.1 to 50.2 MHz. This is the portion of six meters where

fig. 2. Power supply for the transverter and relay switching arrangement. Relay is a 6.3 Vac unit.





Relay switching arrangement.

most ssb signals are heard. Crystals can be chosen, however, to put you anywhere you want in the band.

Assuming you plan to operate 50.1-50.2 MHz, a grid-dip meter can be used to resonate L2 and L3 a little under, and a little over, 50.15 MHz. L4 is tuned to the crystal frequency; 7.25 MHz is bracketed with L5 and L6. This should give a good, flat response across the 100 kHz used. When you get far enough along to copy signals over the air, these adjustments can be touched up to produce the best signal-to-noise ratio.

L7, C5-L8, and C6-L9 are resonated to the crystal frequency. C7 is adjusted to peak L11 at 7.25 MHz. Adjust C3 and the spacing of L10 to 50.15 MHz. By making these adjustments to the center of the 100-kHz segment of interest, it will be unnecessary to do any further tuning of the transverter as you change frequency.

on-the-air tests

After checking and rechecking your work, you're ready for the smoke test. Connect your **6/40 'verter** between your transceiver and your six-meter antenna. Turn on the power and listen for signals. Listen on the upper sideband, because stations on six are almost always on upper sideband and those on forty are on lower sideband.

With the receiving converter working, adjust L4 for maximum using your dipper as an absorption wavemeter. Move to L8 and adjust L7 and C5 for a peak, which will be very much stronger. Touch up C6 for a high reading at L9.

Now, with no forty-meter input, close the relay manually and adjust R1 for a plate current of 50 to 75 mA. Connect a dummy load in the **transceiver** output to reduce the forty-meter signal to one or two watts, and attach a dummy load to the **transverter** output. Insert a power-output meter between transverter and dummy load. Interconnect the relays so the transceiver and transverter transmit together. Turn the transceiver to **tune** position to provide a carrier, and adjust C3 and C8 for maximum output. C7 and R1 can be readjusted to peak the output. During tune-up, the injected carrier level should be low enough to keep the 5894 plate current under 200 mA. **Don't let this tube run red.**

Return the transceiver **tune** control to transmit, and speak into the mike. The plate meter should kick on voice peaks to approximately 300 mA. This completes tune up, and you're ready for on-the-air tests. Listening tests will provide the best criteria of correct adjustment. Important: correct adjustment should occur when the **least** amount of ssb drive, as established with R1 and C7, produces the greatest output. The quality of your six-meter sideband signal should be as good as your forty-meter signal. Reports for the **6/40 'verter** have been uniformly good.

The ventilated cover improves appearance and provides essential shielding and protection from accidental contact with the high voltage.

a final note

This probably shouldn't be your first construction project, but you don't have to be an engineer to achieve good results. Single sideband isn't all that difficult when you do it the easy way. The idea is to proceed slowly, plan each step, and follow my instructions and suggestions. If you can solder and use simple shop tools, you can build the **6/40 'verter** in a few week ends.

ham radio

stub bandswitched antennas

Two multiband verticals are described: a fixed-station antenna and a twinlead portable— no loading coils; no traps

John J. Schultz, W2EEY, 40 Rossie Street, Mystic, Connecticut 06355

One of the problems in designing vertical antennas is finding a simple bandswitching method. To decouple portions of the antenna for different bands, you can use (a) basemounted switched loading inductors, or (b) traps. Each method has disadvantages. A remotely controlled switching system adds extra wiring and cost, and traps are difficult to build, adjust and mount.

This article describes a simple and inexpensive method of bandswitching using *the principle of stub decoupling.* I used it with two antennas: a portable multiband wire antenna and a fixed-installation vertical. The idea can be extended to many other antennas as well.

stub switching

A 33-foot vertical is shown in **fig. 1A.** This antenna would function as a quarter-wave vertical on 40 meters. If a stub approximately 15½ feet long were added, as shown in **fig. 1B**, tri-band operation would be possible.

Operation on the various bands is as follows. On 40 meters, the stub is too short to have any effect, and the antenna performs as a simple ¼-wavelength vertical. On 20 meters, the 15½-foot stub is a quarter wavelength long; the short circuit at the base of the stub is reflected as an open circuit at the high end of the stub. Thus the upper portion of the 33-foot vertical is decoupled, and the antenna performs as a ¼-wavelength vertical on 20 meters.

On 15 meters, the 15½-foot stub has no switching effect since it is neither ¼-wavelength or ½-wavelength long. The 33-foot section is active, and the antenna functions as a ¾-wavelength vertical. Such a length will present a low impedance at the antenna base to match a coaxial transmission line.

There is some disadvantage to this antenna length, however. It is slightly longer than the optimum length for maximum low-angle radiation. Therefore, some high-angle radition will also occur on 15 meters.

Still another stub can be used to extend operation to 10 meters. This stub can be placed in a number of ways, but the most advantageous arrangement seems to be that shown in **fig. 1C.** An approximate 8-

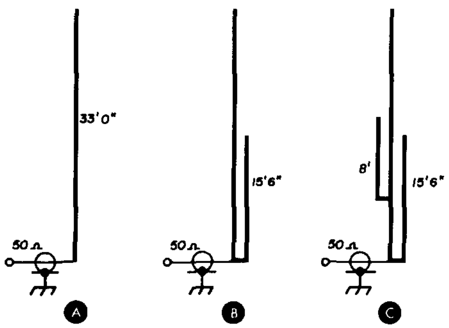


fig. 1. Various arrangements with a 33-foot vertical antenna. Simple vertical in A performs on 40 and 15 meters. The 15½-foot stub in B adds 20-meter capability. Another stub, approximately 8 feet long, makes the vertical operational on all bands from 40 through 10 meters.

foot stub is placed about 8 feet from the base of the antenna. The stub acts as a phase reversal device to couple the lower 8-foot section (¼ wavelength on 10 meters) to the upper 16-foot section (½ wavelength on 10 meters) on the main antenna. A collinear vertical array results as a consequence of the phase reversal. This keeps the antenna radiation at a low vertical angle and produces a slight gain (1 to 2 dB) over a simple ¼-wavelength vertical. The 15½-foot stub has no effect on 10 meters since it is ½-wavelength long and simply reflects a short circuit at its upper end. The 10-meter stub has no effect on operation on other bands.

The over-all result is a 4-band antenna that performs as a ¼-wavelength vertical on 2 bands, a ¾-wavelength vertical on 1 band, and a collinear array on the highest-frequency band. The dimensions of the antenna differ slightly from those of a basic ¼-wavelength antenna, because the stubs affect the diameter-to-length ratio of the antenna on the various bands. Provision must be made during construction for adjusting the antenna element lengths and for initial stub placement in some cases.

fixed vertical antenna construction

I experimented first with a tri-band antenna of the type shown in **fig. 1B.** A multisection *telescoping aluminum element* was used for the antenna section, which had a maximum diameter of 1¼ inches. The stub was made of similar material but with fewer sections. Spacing between stub and antenna was determined by the type of insulating spacer used as shown in the photograph; about 4½ inches between stub and main-element centers.

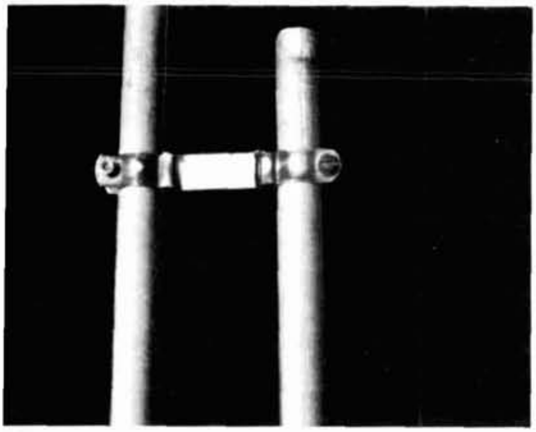
Birnbach Company produces a series of pillar insulators that can be used for stub holders of almost any desired size. Their type 445H, for instance, is 3 inches long and ¾-inch in diameter. Both ends are threaded for 10-32 hardware. The holders on each end of the pillar insulator can be purchased or you can make your own.

At the base of the antenna, the stub and main element ends are joined by a piece of Belden braid. The center conductor of the 50-ohm coax is connected to this braid and the shield of the coaxial cable to another braid, which connects two 6-foot ground rods spaced 3 feet apart, centered on the antenna base. I used only ground rods because the soil is fairly moist in the vicinity of the antenna. Dry locations will require a radial system. The antenna is physically supported by a wooden post. There is nothing special about the construction, and almost any method for vertical antenna construction can be used.

Little adjustment is required for tri-band operation. With the antenna excited on 40 meters, the **main element** length is adjusted for the lowest swr in the transmission line. A value of 1.5-to-1 or less should result.

Switching to 20 meters, the stub is adjusted for the lowest swr. No significant interaction should occur between these adjustments unless you started with element lengths that were out of resonance. Once adjusted on 40 meters, the antenna should be properly tuned on 15 meters to a compromise setting for coverage between 40- and 15-meter band segments.

Pillar insulators are used between the stubs and the main antenna element.



If an additional stub is added for 10-meter coverage, the preceding adjustments should be made before the stub is mounted. Then the stub should be placed about 8 feet from the base. With the antenna excited on 10 meters, both stub location and length should be varied slightly until the lowest swr is achieved. It would be useful to have another station or a field-strength meter a few wavelengths away to help indicate the stub location for maximum signal.

Finally, the antenna should be rechecked on the other bands to ensure that no significant detuning has occurred. If so, a back-and-forth tuning procedure must be used until proper tuneup is achieved on all bands.

twinlead stub antenna

The basic simplicity of the multi-band vertical stub system produced the idea for a similar antenna made only of 300-ohm twinlead. The twinlead antenna was made for portable use as a multiband antenna that could be strung up and used without an antenna coupler.

Since the twinlead provides only two conductors, a somewhat different stub was used (**fig. 2**). The conductors are connected together at the far end of the antenna, and **one** conductor is cut a little less than 16 feet from the far end to form the 20-meter stub. This stub is 1/4-wavelength long on 20 meters and reflects an open circuit, so the lower portion acts as a 1/4-wavelength antenna on 20 meters.

On 40 meters, the 20-meter stub adds some top loading, but essentially it's not active, and the unbroken conductor forms a 1/4-wavelength antenna. A 20-meter stub can be added in the same manner as for the fixed-station vertical by using the remaining twin-lead conductor after forming the 20-meter stub. On 15 meters the 40-meter section is used as a 3/4-wavelength antenna.

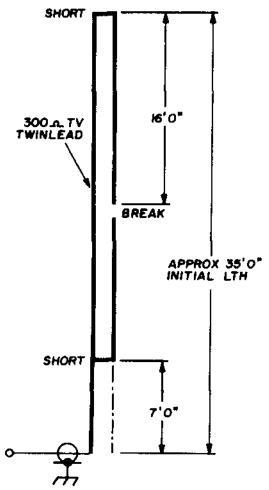
tuning up

Because of the twinlead velocity factor and the nature of the stub arrangement, pruning this antenna is a bit more tedious than the fixed-station vertical. However, twinlead is inexpensive, and even if you foul up the tuning the first time around no great loss will result. In fact, experimenting with the twinlead version is a good way to gain confidence in the basic antenna operation before constructing a more expensive fixed-station version.

As a first step in the tuning process, choose a 35-foot length of twinlead and leave the conductors at the far end disconnected. Connect one conductor to the transmission line and excite the antenna on 40 meters. Then cut the antenna (both conductors) at the far end until the lowest swr is obtained. After this, connect the other conductor at the far end to the 40-meter conductor element and cut about 16 feet from the far end.

Now switch back and forth between 40 and 20 meters, and trim the total antenna length (always leaving the two conductors shorted together at the far end). Trim the 20-meter stub to less than 16 feet from the far end. With care, lengths will be found that give a very low swr on both

fig. 2. Construction of a stub-switched antenna made from 300-ohm twinlead; complete tuneup procedure is outlined in the text.



bands. If triband operation only is desired, the antenna can be operated as is. If 10-meter operation is also desired, cut the 20-meter stub side of the twinlead about 7 feet from the antenna base. Excite the antenna with ten-meter energy and try shorting positions between the upper portion and the 40-meter connector until minimum swr is obtained. Then cut the upper point of the 10-meter stub until a final swr minimum is attained.

This procedure tends to mess up the twinlead unless done with care. When trimming a conductor, the dielectric should not be cut away entirely. The conductor should be separated from the dielectric and then cut. Also, the proper shorting point between the two conductors can be found by pressing a pin through the dielectric to short the conductors. Only after the proper point is found should a jumper be soldered between the conductors. A proper ground connection is just as necessary for effective use of the twinlead antenna as it is for the fixed-station vertical.

summary

The stub decoupling method for multiband antennas is an effective, no-compromise method of automatic antenna bandswitching. Some designs require careful initial adjustments to establish initial dimensions, but the effort is well rewarded since no later maintenance work need be done. The basic idea of stub multiband operation can be used for any band where a suitable harmonic relationship exists.

The twinlead version of the antenna suggests the possibility of combining two such sections to form a multiband dipole antenna or inverted vee. Although this has not yet been tried, it would seem to be an extremely simple way to build an inexpensive multiband horizontal dipole for 40-10 meter coverage. No traps are required, and the stub arrangement should allow operation over a wider portion of each band with lower swr than is possible with high-Q traps.

ham radio

". . . 50 in a 35-mph zone. Besides that, you were QRMing my receiver."

glass semiconductors

Jim Ashe, W1EZT

Several newspaper, technical and scientific reports have appeared since last July about a new solid-state technology called "ovonics." Some of these reports suggest ovonics is a has-been before it ever arrived, and others say ovonics is a powerful new technology. I think we are going to hear a lot more about ovonics in the next few years, and possibly, eventually see ovonic IC's in communications gear.

glass semiconductors

The insulating properties of glass are well known. But not all "glasses" are glass, and glassy materials are apparently more organized in their structure than some recent reports suggest. The key to understanding what ovonics is all about is in the special almost-crystalline structure of glassy solids (see **fig. 1**).

At the left you'll see what I'll call a BS crystal; *B for big atoms and S for small* ones, in equal proportions. Now, looking at this we shortly observe that each B atom has four S atoms, and each S atom four B atoms, in its immediate vicinity. The entire assembly is arranged in neat ranks like the squares along and across a chess board.

At the right of **fig. 1** is a BS glass. It looks quite disorganized, but if you start counting you will see that practically every B atom has four S neighbors, and every S atom has four B atoms, just as in the crystalline state.

It turns out that the electronic behavior of semiconductors depends upon short-range order, within a few interatomic spacings of any given atom, and not upon long-range crystal-type order. If the BS crystal is an intrinsic semiconductor (will work without p or n doping) then the BS glass could be one also and offer fewer manufacturing problems. This is the way things have worked out in glassy-state physics.

For example, a glass laser rod three inches in diameter by four feet long does the same job as a crystal that would be nearly impossible to make. And once researchers understood some glassy state theory, engineers were able to develop an electronic conducting glass that carries an electron current in much the same way as a piece of wire for use in image-orthicon tubes. Targets made of the new glass do not fail from electrolysis, so tube life is much better than earlier tubes using natural-glass structures.

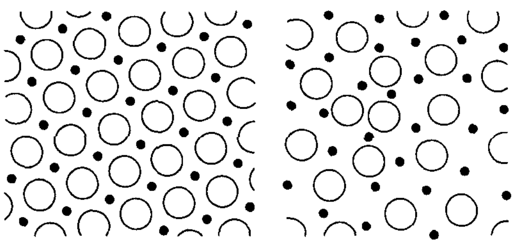


fig. 1. Glassy-state structure resembles crystal structure in that a given atom has about the same neighboring atoms in either case.

ovons: the new devices

In 1962, Bell Telephone Labs constructed some simple glass semiconductor devices but they dropped this work in favor of the more familiar crystal physics semiconductors. This left the field open for Stanford Ovshinsky, who already had some strong patents and was working hard to improve the technology and build a company, Energy Conversion Devices.

Ovshinsky called his new semiconductors "ovons," and it seems likely this name will stick. While working hard, he has been very close-mouthed about his results until recently, and this has given his work something of a crankish appearance. The competition, perhaps slightly upset by thin-film ovons in transistor cases which appeared to be empty when opened, has failed to compete. Now Ovshinsky and Energy Conversion Devices seem to hold dominant patents in the new field.

An early ovon construction is shown in **fig. 2.** This is simply two graphite beads coated with some glass semiconductor material and held in mechanical contact. This package may be the origin of some early reports of erratic ovon performance. Later devices are assembled as shown in **fig. 3**—as thin films applied to an insulating substrate. It is reported that ovons can be made considerably smaller than transistors, and it appears this is because there are no multiple diffusion and electrical connection processes in manufacture.

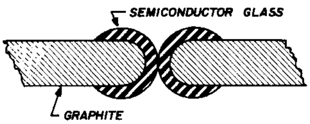


fig. 2. Mechanical construction of an early ovon. Improved thin-film ovon structure shown in fig. 3 to the right; the active material is applied without critical diffusion operations.

Published reports are not very clear on how ovons work. This may be Ovshinsky's close-mouthed policy again, making the competition work harder. Or it may be that details are not completely worked out yet. One suggested mechanism is a kind of solid-state lightning, in which an applied voltage leads to gradual warming of a channel between the two electrodes. This warming encourages current to flow, and a regenerative situation develops that leads to an abrupt breakdown. This is consistent with the input-output characteristic shown in **fig. 4**, but does not square with another fact.

That is, a minor adjustment in the glass chemistry results in an ovon that remembers which state it was in the last time power was applied to it. This is like a bistable that remembers if it was holding a zero or a one before it was turned off, and comes back on in the same state.

Ovons also show a much greater resistance than transistors to the degrading effects of nuclear radiation. As a result, the new technology is already being applied to satellite computers and other applications where environmental conditions are too harsh for transistor technology.

Circuits in ovonics tend to resemble those of two-terminal pnpn devices (see **fig. 5**). Here is a very simple relaxation oscillator that will generate an approximate sawtooth or a pulsed output. Other circuits use pairs of ovons in series as shown in **fig. 6.** Here, two 20-volt ovons in series are connected to a 35-volt supply. They do not break down until a five-volt pulse of either polarity is applied to the input terminal. This biases one ovon into conduction, and the other ovon follows.

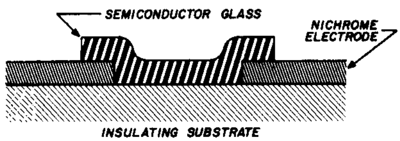


fig. 3.

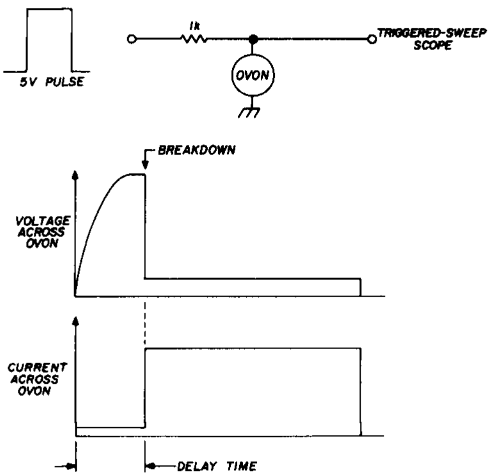


fig. 4. Ovon action when a square wave is applied.

the future of ovonics

Any estimate of a new technology's future must be at least 50% guess, but I think ovonics will eventually amount to something. I noted Stanford Ovshinsky seems to be playing his cards very close, seeking a long-term business advantage at a small price in short-term losses. I read that ovonic devices are actually in laboratories, and people are thinking very hard about their applications.

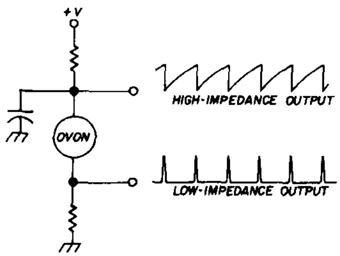


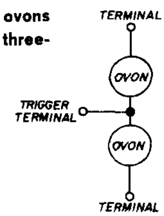
fig. 5. A simple ovon relaxation-oscillator.

For instance, the Johns Hopkins Applied Physics Laboratory has carried out extensive work in satellite computer design using ovons. And a reliable report that Energy Conversion Devices has been producing up to 150,000 ovons per day is also a convincing fact. Finally, there was a scientific paper describing the key principles thoroughly enough to enable a competent worker to make his own ovons. All this is too strong a basis for a trivial fad.

So what will this come to? Since ovons do not, at present, seem to have any linear-amplification capability, I think they will appear largely in computer applications over the next few years. But that is not as far from communications electronics as it used to be. An elaborate tv receiver, recently introduced in Europe's confused tv systems arena can receive color or black and white in any of the French, Russian, German or American systems of transmission. Priced at around $1,000, the receiver contains a considerable amount of computer information processing circuitry. Computer techniques have been used successfully in tv picture transmissions from Mars, and in the radar exploration of Venus. Finally, we have the class-D system of using switching circuits to develop audio power and manage power supply systems.

These considerations suggest there is a strong place for ovonics technology in coming transmitting and receiving gear—as computer-type circuits doing jobs now assigned to linear circuits. In transmitters, you may find tiny ovonic integrated circuits digitizing speech and image signals. And in receivers you may find inexpensive ovonic IC's doing computer analysis of incoming signals, in real time, paring off unwanted natural and manmade noise to achieve good reception at very poor signal-to-noise ratios. Finally, it appears very likely that ovonic technology will find applications in power handling circuits at lower costs and greater reliability than present crystal semiconductor technology can offer.

fig. 6. Using a pair of ovons in series to obtain a three-terminal active device.



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Want to have a lot of puzzled hams throwing questions at you over the air? It's easy. Just say you're using a bobtail-curtain array for an antenna. This is guaranteed to keep you busy for an entire evening, especially if you're laying down a healthy signal. This is what happens to me when I use this antenna on 40 meters. Its name gets everyone so worked up that I've stopped being honest and just say I'm using a vertical.

Despite all the confusion, this is an antenna worth knowing more about. It has the advantages of simple construction and tuning, low cost, and gain at low radiation angles. It's an excellent antenna for any of the low-frequency bands, and performs especially well on 40 and 80 meters. The only major disadvantages are height and area requirements and the necessity for an antenna tuner.

description

Over-all dimensions are shown in **fig. 1**. It is an offshoot of the three-element vertical broadside array. In the classical version, three elements are fed in phase with equal currents, and the elements are spaced one-half wavelength apart. This arrangement theoretically has no radiation off the ends because of the phase relationship existing between elements. In the bobtail array, there is some high angle radiation off the ends. This occurs because of imperfect cancellation due to the flat top portion. So there's a small compromise. Compared with the three-element co-phased vertical array, the bobtail's front-to-side discrimination is somewhat degraded. But its broadside gain is still pretty good—7 to 10 dB over a reference dipole.

The height requirement for 80 meters will be about 70 feet, but for 40 meters it's only about 35 or 40 feet. The flat top portion of the 40-meter version is just an 80-meter dipole with no center insulator, so if you have room for this you can build the bobtail.

construction

There are several ways to go about construction. If you can get the two ends supported about 40 feet or more above ground, there will be just about enough sag in the flat top to allow the center wire to hang straight down to the tuner. However, I didn't have quite enough height at the ends, so I used a different approach. My center element is actually a 40-meter ground plane, made of three 12-foot lengths of aluminum tubing, telescoped together and adjusted to approximately 34 feet over-all. The joints are split and clamped tightly with stainless-steel hose clamps well coated with zinc chromate to prevent oxidation.

The element is mounted on an insulator originally used for whip antennas on tanks (bought through surplus channels). This insulator is mounted on top of an adjustable tripod mount (also surplus), and the whole element is guyed with three sets of three guys each, made of nylon cord. Bear in mind, when choosing the insulator, that rf voltage is high at this point.

The two half-wave phasing lines are soldered to heavy lugs and bolted to the top of the center element. At each end of the phasing wires, another vertical wire is connected, made of number 10 or number 12 wire. The ends of the flat top are then pulled up to full height so the verticals hang straight down. A little compromise will do no harm. I've used the antenna with the two end elements almost 45 degrees with respect to ground, and results have been just as good.

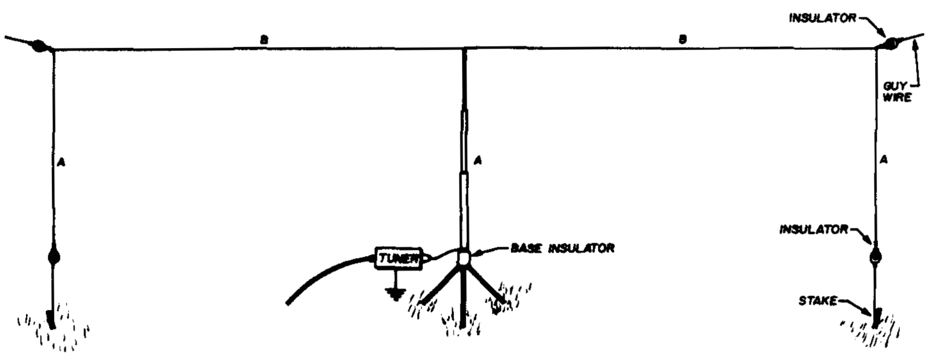


fig. 1. A bobtail-curtain antenna for the lower amateur bands; dimensions in the table are in feet.

Band	A	B
80	66	132
40	33	66
20	16.5	33

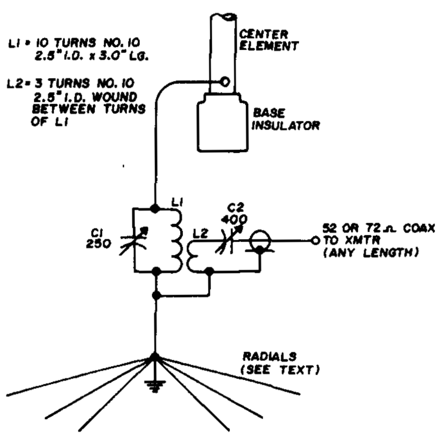


fig. 2. Tuning unit for the 40-meter array. For 20-meter operation, L1 and C1 should be approximately one-half the values shown here; C2 is the same.

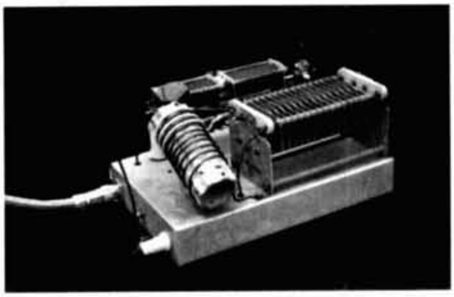
antenna tuner and adjustments

The antenna has a high input impedance, so an antenna tuner must be used. **Fig. 2** shows the circuit, and the photos illustrate tuners used for 40- and 20-meter versions. The coil for the 20-meter tuner is a B&W BEL-150. For 40 meters, the coil and link are wound on the ceramic form from a BC-375 tuning unit. The small capacitor tunes out reactance in the transmission line, which in my case is over 100 feet long.

Tuneup consists of adjusting both capacitors to obtain minimum standing-wave ratio. I made use of my ever-patient wife and my children's walkie-talkies to overcome the distance problem from tuner to shack. Only a few minutes were required to bring the standing-wave ratio to almost 1:1, and I have had equally easy tuneup with two other bobtails, which I built in the past for 40 and 20 meters.

To avoid hanging the antenna so the driven element would have to come into the shack to the tuner, I left the tuner at the antenna base and made it waterproof. After tuneup was completed, I enclosed the tuner in a box made from clear sheets of plexiglass. This makes an excellent weatherproof container, and the components can be seen at a glance.

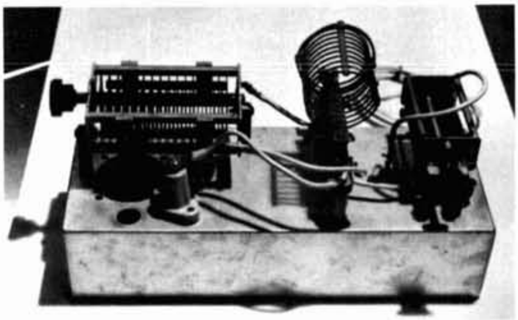
Tuner for the 40-meter bobtail.



ground system

Undoubtedly if you researched enough antenna handbooks, you'd find a lot of information on the bobtail, but I have found very little. It appears that an elaborate ground is not necessary, and a 4- to 6-foot ground rod seems ample,[1] connected to the tuner through a flexible piece of braid or heavy wire.

I still had the eight radials used for the center element when it was just a ground plane, so I decided to bury the radials directly under the center element. If I were to say this made a fantastic difference or even any difference for that matter, it wouldn't be true. However, it seems logical that a good radial ground system should be just as effective for this antenna as for any other vertical array, so I like to think that those fine reports on 40-meter DX contacts are just a bit better because of the radials. I've been tempted to install radials under the outer elements also, but so far I haven't done so.



Tuner for the 20-meter bobtail is similar to 40-meter unit but with smaller components.

results

The antenna tunes broadly, and the standing-wave ratio remains reasonable over the whole band. My broadside pattern is beamed northeast—southwest, and the antenna has produced many good comments from European, Near-East and Pacific stations. Results in North America aren't spectacular, because the radiation angle is low. It's a DX antenna, and doesn't really start to perform until the distance is greater than 2000 miles or so. After that, it's a great antenna! It would be interesting to hear from others who may be using this antenna so I could compare notes.

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1. *The Radio Handbook*, Editors and Engineers, Santa Barbara, California, 1959 edition, pp. 472-473.

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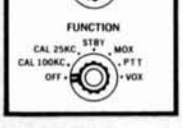

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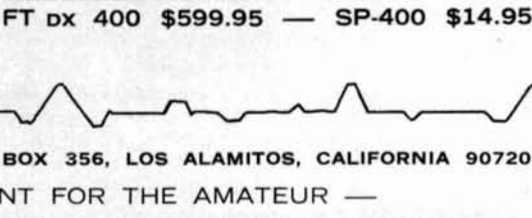

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propagation predictions for july

Victor R. Frank, WB6KAP, 12450 Skyline Boulevard, Woodside, California 94062

March and April were months of frustration for many six-meter operators. I mentioned in my September 1968 column that **then** was the time to send equipment and line up 50-MHz activity in the South Pacific; I pointed out that places like Easter Island, Pitcairn, Tahiti, Samoa and Fiji could be worked **if** amateurs there were active on 50 MHz. My predictions were borne out, as amateurs in the Caribbean, Mexico and Gulf States will testify.

Although few contacts have resulted, ZK1AA's beacon has been heard in these places and others during February, March and April. Perhaps the most widespread, strongest opening was between 2100 and 0038 gmt on April 11 to Louisiana, Mississippi and Alabama. K5AGI again heard the beacon weakly between 1913 and 2010 gmt on the 12th. HI8XDS, VP2AD, XE1GE and XE1PY also report hearing the beacon frequently. The first I heard the beacon this year was on April 17 between 0500 and 0645 gmt by nocturnal TE. ZK1AA was copied in Northern California and Washington (by W7FN) again on the 19th (0429-0550 gmt), the 20th (0712-0734 gmt) and the 21st (0520-0812 gmt). The beacon was also heard in Northern California on April 24, 27 and 28. It was heard in Southern California on the 25th and 28th.

ZK1AA indicates that his receiving system was improved considerably on April 19th. Also, W6ABN sent him a four-element beam. I worked him on April 21st at 0535 gmt for his first W QSO. He reported working ZF1AA on the 19th at 2030 gmt and XE1PY at 2040 gmt as well as about twenty JA's. During the last week of April he worked W6ABN, W6YDF, K6QEH and KH6GMV.

To work him, weekends and weeknights, attract his attention with a string of dots swept across his frequency and call him about 500 Hz higher. His transmitter is remote controlled from his home. As of this writing his receiving installation is somewhat under par and amateurs are advised to use cw rather than ssb when calling.

Also, 5W1AR in Western Samoa is scheduled to have his beacon on; it's of the simplex variety so he is not able to listen while transmitting.

Openings between the West Coast and South America were reported on March 16 and 30, and April 5, 8, 9, 10 and 11. Backscatter and sidescatter openings from the West Coast were reported on March 30 (W3, W5 and W6), April 1 (W4, VP2MJ), April 4 (HI8XDS), April 5 and 6 (W6). Other F2-layer openings include March 24, when KH6NS, KH6EQF and KH6GHC worked from VE7, W6, W7 and W5; March 25, when KH6EEM and KH6EQF worked 5W1AR and KH6EQF worked K7HER/KG6; and April 11 when XE1PY worked ZF1AA.

One of the rare openings of the year was the aurora of March 23 to 24 which extended as far South as the San Francisco Bay area (I worked K7ZIR in Portland on 144 MHz).

W7FN, Seattle, reports aurora as early as 1400 pst; he worked KL7GLL, all 7th District states except Nevada and Arizona and as far east as North Dakota on 50 MHz.

I believe that these 50-MHz openings were due to the general increase in peak solar activity that began about February 20, combined with seasonal effects. There are some mysteries, however, like why the ZE1AZG beacon (50.05 MHz) was not heard in the Americas—the path is similar to the ZK1AA—Caribbean path. Also, why was nocturnal TE so late getting to the Bay area?

sunspot numbers

I read WAØIQN's predictions in **QST** about increased solar activity in upcoming months with great interest. Don even suggested that the sunspot numbers might go as high as 200 this year. Upon investigation, however, I do not see such an optimistic view—here's why. There are more than one "brand" of sunspot numbers in use, a fact I neglected to mention last month when I gave daily sunspot number counts between 200 and 300 for February 20 to 27, 1969.

These numbers came from preliminary ESSA reports of solar-geophysical activity. They are perfectly valid sunspot numbers, but they were taken at the ESSA-Boulder or Sacramento Peak (Colorado) observatories—not at Zurich. You may remember that in my November 1968 column on sunspot numbers, I mentioned that a correction factor had to be applied to observations taken at observatories other than Zurich to account for differences in observation.

Actually it's not quite that simple, and most ionospheric forecasters stick with the sunspot numbers measured at the Swiss Federal Observatory at Zurich. The difference between the ESSA and Zurich sunspot numbers can be quite substantial.

I have plotted in **fig. 1** the provisional daily sunspot numbers observed at Zurich vs those observed by ESSA between January 3 and February 28, 1969. You may ask, "Is that really the same sun they're observing?" Yes, it is, with an 8-hour time difference, but it appears that ESSA can frequently count 50 percent more spots than Zurich.

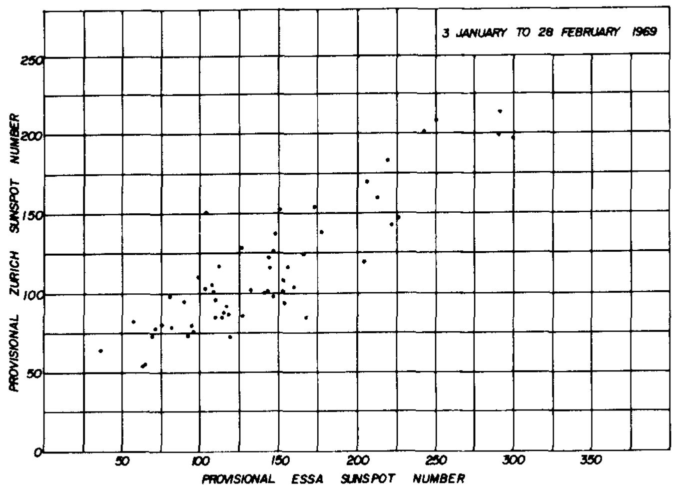


fig. 1. A scatter plot of daily sunspot numbers measured by the Swiss Federal Observatory vs those measured by ESSA for the period January 3 to February 28, 1969.

With this in mind, I'll admit that if solar activity continues its February/March rise, monthly average ESSA sunspot numbers of 200 are not inconceivable, but I doubt that the smoothed Zurich sunspot number will exceed 120 (this spring or summer). I am basing my predictions on a smoothed Zurich sunspot number of 100. The highest smoothed sunspot number for cycle 20 to August 1968 is 107.6, which occurred in May 1968.

In view of the present uncertainty in the course of cycle 20, last year's ionospheric observations are as good an indicator of probable ionospheric conditions this year as any. Thus, I scaled some July 1968 ionograms from Pt. Arguello, California to determine the absolute muf (somewhat greater than the 4000 km muf) for the hours of 0500, 1300 and 2100 local time (pst).

fig. 2. Daily F2-layer absolute muf's scaled from Pt. Arguello ionograms, daily sunspot numbers and magnetic activity indexes during July 1968.

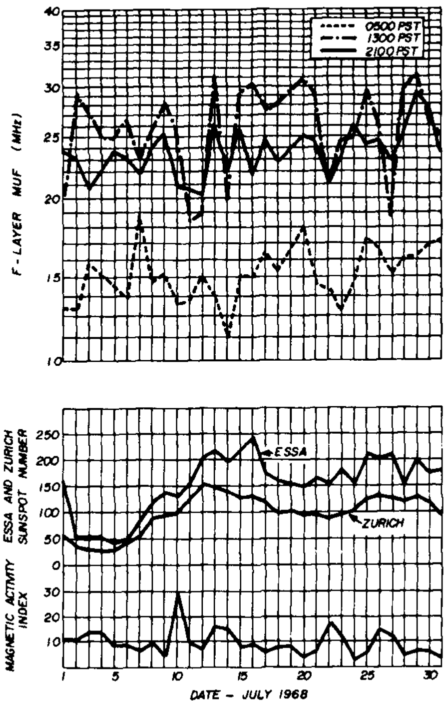
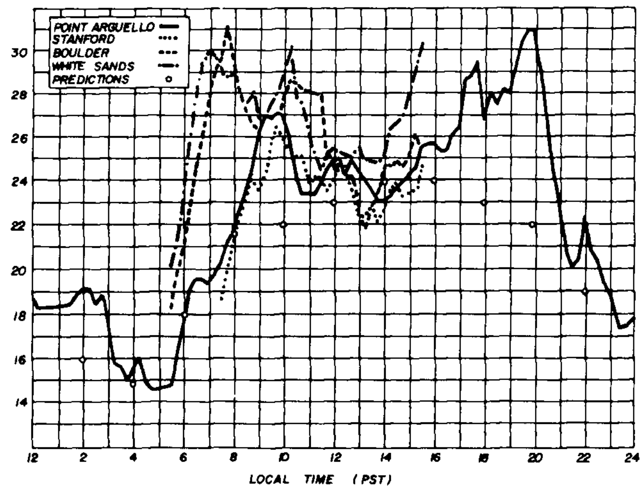


fig. 3. Absolute muf's scaled from July 10, 1968 ionograms from four stations in the Western United States.



The day-to-day variation throughout the month, shown in **fig. 2**, is quite substantial. Based on these measurements, ten meters should open to control point latitudes of 35.5° N. at 1300 local time more than 33 percent of the days of the month. Fifteen meters should be open more than 80 percent of the days at 1300 and 2100 local time. Twenty meters should be open more than 75 percent of the days of the month through the predawn minimum at 0500 local time.

Plotted along with the Pt. Arguello muf's are the daily sunspot numbers of ESSA and Zurich and the magnetic activity index. The most important solar event of July 1968 was an importance-3B flare on the 8th which produced intense vhf/uhf radio noise bursts and moderate x-ray emission and SID (sudden ionospheric disturbance). It was followed by particle emission reaching the earth 29 hours thereafter (1400 pst on the 9th); this caused a minor magnetic disturbance which continued for some 30 hours and depressed ionospheric critical frequencies as late as the evening of the 11th.

Another magnetic disturbance was produced as this spot group passed the solar central meridian commencing on the 13th (8 am pst). Note the rise in muf's on the first day of the disturbance and the depression on the following day and night. Muf's were also depressed on the 22nd and 17th due to minor magnetic disturbances.

Since the normal summer daytime muf and evening muf's are not very much higher than the ten and fifteen meter bands, any reduction of muf's due to minor magnetic storms may be more noticeable than during winter months. Frequently during these storms sporadic-E will be present, allowing contacts to 1400 miles or so, but no DX. Also, in addition to decreased F2-layer critical frequencies, the F2-layer virtual heights may rise to over 500 km indicating possible long-skip, single-hop paths as long as 3000 to 3600 miles.

When considering paths of this length, however, the variation of ionospheric parameters along the path becomes important. Ionospheric soundings taken at the oblique path midpoint may no longer furnish a sufficient model of the ionosphere to explain all the observed phenomena.

To demonstrate the variability of the ionosphere in distances as short as 300 to 1000 miles, I have scaled daytime ionograms taken on July 19, 1968 at four stations: Stanford, California, Pt. Arguello, California, Boulder, Colorado and White Sands, New Mexico. As I pointed out in the August 1968 column, prediction methods assume that, over a limited range of longitudes, the muf contours are fixed in space relative to the sun and the earth rotates underneath. You would expect the muf-vs-time curves of the California stations to be offset one hour from the other two. You would also expect, from the pronounced north-south gradient of ionization predicted that White Sands would have the highest muf's, followed by Pt. Arguello, Stanford and Boulder in that order.

Fig. 3 shows the scaled absolute muf vs time (pst) for each station along with ESSA predicted muf's for Pt. Arguello. Changes taking place simultaneously at all stations would likely be due to changes in the incident solar ultraviolet flux. Changes that occur with time delays from north to south between the stations may be due to large traveling ionospheric disturbances or transport of ionization. Changes that occur with time delays of one hour east to west are likely due to the normal diurnal variation. The picture is not clear from just one days' data—but it shows what differences you might expect from the standard predictions.

Between 1030 and 1130, the normal north-south ionization gradient was reversed at both pairs of stations. The eastern pair of stations held the edge on muf's (shifting to local times) until late afternoon. According to predictions (**fig. 4**) the daytime F2-layer 4000-km muf at Boulder should have been 3 MHz lower than that at White Sands.

One of the major problems facing ionospheric scientists in interpreting long distance propagation is the development of suitably accurate models of the ionosphere. The four stations at Stanford, Pt. Arguello, Boulder and White Sands are quite closely spaced compared to other sounders. Could you imagine ESSA trying to forecast weather with a network of observing stations spaced this far apart? There are still frontiers to be conquered with the vertical-incidence sounder, but after 33 years it is still the prime tool of the ionospheric physicist.

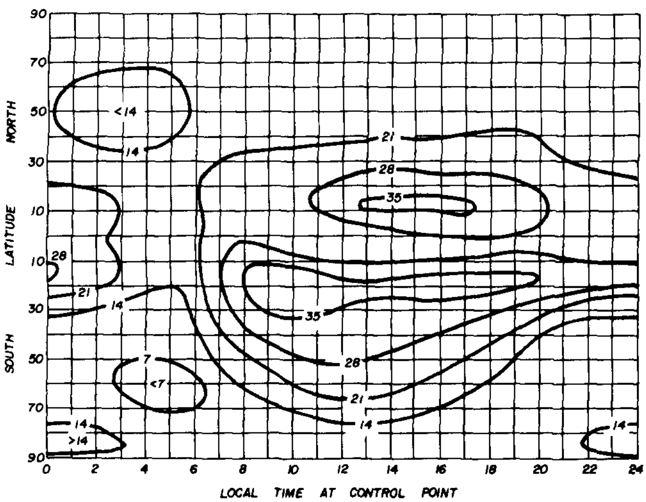


fig. 4. Predicted median muf (4000) F2 for July 1969 centered on longitude 105° W.

propagation during the month

Summer is still with us, and propagation during the first half of July will be very similar to that during June. The same maximum range charts may be used. Some idea of occurrence of sporadic-E may be gained from the propagation column in the June issue of **ham radio.**

Table 1 lists some specific predictions for Northern California. They may be of use to other areas the same distance and bearing from mid-latitude United States. San Francisco to Anchorage is equivalent to Washington,

Table 1. Times (pst) of predicted band openings to San Francisco for July 1969.

From	Distance	Bearing	40 Meters	20 Meters	15 Meters	10 Meters
KL7, Anchorage, Alaska*	1960	332	2000-0700	0630-0200	nil	nil
3W8, Saigon, Vietnam	7650	306	0200-0700	2120-0400 0600-1030 (0100-0430) (1500-1900)	1930-2030 0930-1100 (1500-2200) (0815-1130)	(1700-1730)
KR6, Okinawa, Ryukyus	5960	303	0030-0700	1930-0400 0600-1130	1900-2030 (1430-2200) (0600-1130)	(1530-1730)
JA3, Tokyo, Japan	5020	303	0000-0700	1830-0400 0600-1130	1900-2030 (1330-2200) (0615-1130)	nil
KG6, Guam, Marianas*	5620	282	2330-0720	1930-1100	1140-2200	nil
KX6, Kwajelein*	4650	265	2200-0730	1730-1120	1030-0200	1930-2030
VK6, Perth, W. Australia	9100	259	0320-0600	2100-1030 (1500-2300)	1400-0200 (1730-1830)	1800-2100
VK3, Melbourne, E. Australia*	7000	245	2300-0630	1900-0900	1130-0130	1400-2100
KC4, Antarctica*	7590	180	1900-0300	0800-0900	0930-1600	1130-1400
LU, Buenos Aires*	6700	128	1820-0200	0200-0640 1420-0030	0500-2200	1100-1830
KZ5, Canal Zone	3280	116	1740-0320	24 hours	0600-2130	1200-1700
ZS1, Capetown, S. Africa	10150	76	1900-2100 #	2130-000 (2300-0800)	0900-1030 (2015-0200)	nil
DL, Berlin, W. Germany	5540	25	1900-2100 #	0530-0030 (0230-0700) (1530-1830)	(0700-1600) (2100-0200)	(1300-1230)
W3, East Coast USA*	2420	74	1720-0300	0700-2330	1500-1900 **	nil**

( ) Time of long path opening (opposite bearing)

* No long path calculations made for these paths

\# Difficult circuit—high path losses

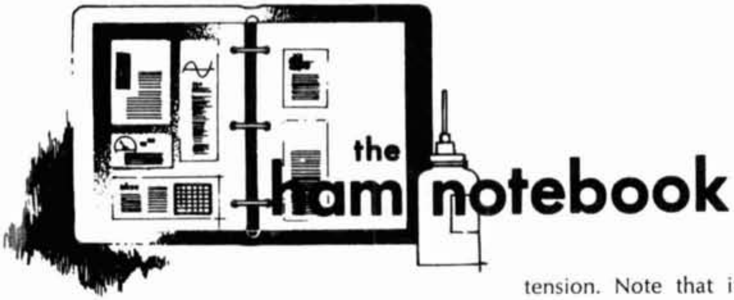
nil Muf not supposed to rise this high—possible opening during middle of lower band opening on less than half the days of the month

** Fifteen may open as early as 0600 on days with high muf's, ten may open a half-hour later and close a half-hour earlier than fifteen. Double-hop sporadic-E may occur anytime.

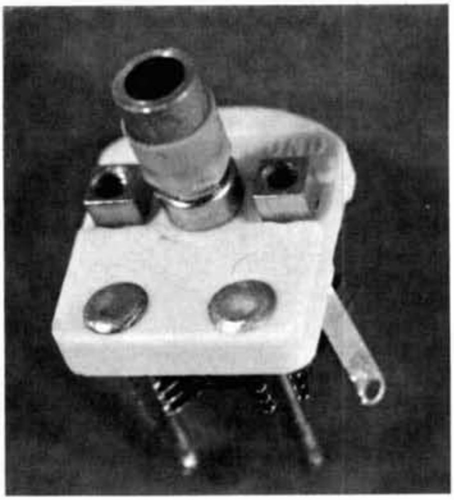
D. C. to Yellowknife N.W.T., SF to Saigon is equivalent to Kansas City to Guam and SF to Melbourne is equivalent to St. Louis to Auckland, New Zealand. Times are your local solar time.

Late note: as of May 20, ZK1AA had over 50 contacts in less than two months—all in the Northern Hemisphere. His beacon is operating daily from 1730-0930 gmt. 5W1AR, Western Samoa, now has a beacon on 50.105 MHz operating 1900-2400 gmt and 0400-0600 gmt; he is bothered by interference from television on American Samoa that comes on the air at 0600 gmt.

ham radio



adding shaft to apc trimmer



Ever faced with that very frustrating situation where the only variable capacitor in the junk box with the required value is an APC trimmer—and you need one with a shaft? Although several solutions have been presented in the past for this problem, the following one is easy, effective, and thus, my favorite.

Slip a piece of shrinkable tubing over the hexagonal rotor extension, and trim to extend at least $^1/_8$-inch. Insert a suitable length of $^1/_4$-inch diameter metal tubing into the open end; apply sufficient heat to shrink the tubing. Now, gently slide the shrinkable tubing and shaft extension back off the hexagonal rotor extension. Note that it comes off easily but retains the hex shape. Put epoxy on the exposed inner surface of the shrinkable tubing and replace on the rotor extension. Now pour epoxy through the center of the metal tubing, making sure it flows into the original screwdriver slot and that no air pockets are left.

Let it stand for at least twenty-four hours before attempting to turn the shaft. You now have an APC trimmer with a rugged shaft extension; add a knob and you're in business.

V. M. Scott, Jr., W1ETT

the multi-box

Anytime you put a piece of audio gear on the bench there is the problem of mixing and matching the variety of connectors used in current equipment. My little multi-box has proven invaluable when working on such gear. In its present form it consists of three types of jacks mounted in pairs on a $2^1/_4 \times 2^1/_4 \times 5$ minibox. A terminal strip mounted on the left-hand end of the box accepts pigtail connections. The jacks and terminal strip are all wired in parallel so that any signal fed into one jack is available at any other jack. The three types of jacks on my personal version of the multi-box are standard phone jacks, mini jacks (á la transistor-radio practice) and RCA phono jacks. The RCA phono jacks were mounted with the aid of pop rivets; this is a very neat way to mount this style jack in any gear you may construct.

Al Joffe, W3KBM

simple scope calibrator

An accurate scope calibrator is a very useful tool where an oscilloscope is frequently used. It eliminates calculations due to scope gain controls or a 10:1 probe since the tip of the probe can be inserted into the calibrator output jack for comparisons with the signal voltage.

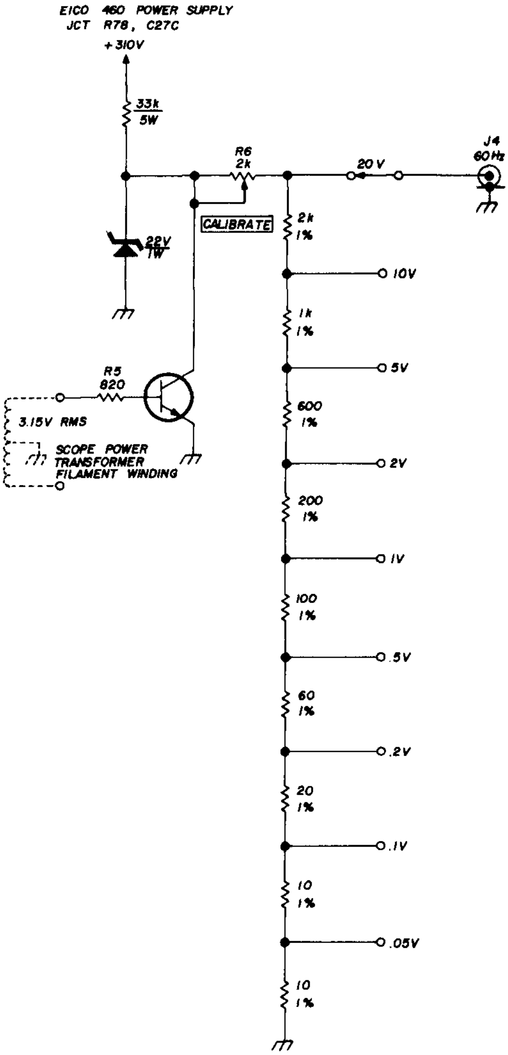
The calibrator shown in **fig. 1** was built in one afternoon and added to an Eico 460 oscilloscope. The same circuit could be added to other inexpensive scopes or built as an output accessory in a minibox. It's simple, the cost is low and the added current drain on the scope power supply is negligible.

The calibrator voltage is derived from a 22-volt zener diode. It is chopped at 60 Hz by the transistor and the resulting 60-Hz square wave is trimmed to exactly 20 volts and applied across a precision resistor voltage divider. The calibrator can be adjusted with an accurate dc volt-meter by disconnecting the transistor collector and adjusting for 20 volts at the top of the divider.

To install the calibrator in the Eico 460 scope, remove the pilot light, X1, and resistors R5 and R44. The pilot light is a filament tie point, so the new wiring must take this into account. The best procedure is to run new wires from TB2 along the path of the old leads. Wiring to the phasing control (R45) is checked for continuity, and the scale dimmer (R80) is wired directly to TB2. The pilot light mounting hole is used for the calibrator rotary switch, and the "60-Hz" binding post is used for calibrator output.

The rotary calibrator switch is completely assembled before it's put into the scope; 1% resistors are used in the divider for maximum accuracy. After mounting the rotary switch, the zener and chopper transistor are mounted on an additional two-terminal tie strip mounted over TB4 and near XV6. The calibrate potentiometer (R6) is rotated 180 degrees in its hole and wired into the circuit as a voltage trimmer. The 820-ohm resistor, R5, is re-used in the base circuit of the transistor.

The transistor may generate voltage spikes that will crosstalk into the scope input unless the new wiring is dressed close to the panel where it's connected to the 60-Hz post. Also, the divider ground lead should not be connected to the scope in-



put ground post—return it to the point where the transistor emitter is grounded near XV6. Nearly any npn transistor will work as the chopper; I tried surplus 2N706's and 2N1302's among others.

Bert Kelley, K4EEU

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new products

communications receiver

Hallicrafters has just announced an advanced version of their popular SX-122—a dual-conversion receiver providing general coverage am, cw and ssb reception. The new receiver, the SX-122A, covers standard broadcast (540 to 1600 kHz) plus 1750 kHz to 34 MHz in three bands. Bandspread is calibrated for 80, 40, 20, 15 and 10 meters. The SX-122A features extensive temperature compensation, voltage regulation and a crystal-controlled second-conversion oscillator for improved frequency stability. The dual dials provide fast and easy dial setting plus smooth flywheel tuning.

Other features of the SX-122A are a precisely tuned and tracked rf stage, variable selectivity (500 - 2500 Hz and 5 kHz), antenna trimmer, separte rf gain control, automatic noise limiter, s-meter, provision for an optional front-panel-controlled 100-kHz crystal calibrator and balanced or unbalanced antenna inputs. $350 from your local distributor, or write to the Hallicrafters Company, 600 Hicks Road, Rolling Meadow, Illinois 60008.

gate-protected dual-gate mosfet

RCA has just announced a new gate-protected dual-gate mosfet—the 40673—that has essentially the same electrical characteristics as 3N140 and is interchangeable with it. Gate protection is provided by back-to-back zener diodes which limit the voltage excursion of the gates to ±10 volts; by adding this protection from static burnout, the gate capacitances are increased about 1.5 pF. Noise figure of the basic device increases 0.2 dB, and power gain decreases 0.2 dB at 200 MHz; both changes are considered negligible. The price of the new RCA 40673 is about $2.00 in small quantities; since this is a brand new transistor, it may take awhile to reach the shelves of your local distributor, although he should be able to special order them for you. According to RCA, more gate-protected mosfet's will be available in the next few months.

dipole antenna kit

The new Mosley Electronics DIV-80 dipole antenna kit is designed to be constructed horizontally or as an inverted-V on any single amateur band from 10 to 80 meters. The amateur is supplied with all the necessary parts plus easy-to-follow instructions to determine the length required for specific frequencies within a given band. The DIV-80 is rated at 1000 watts a-m or CW and 2000 watts PEP ssb.

When assembled as a horizontal dipole, the antenna is raised between 35 and 65 feet above the ground and is approximately 135 feet long on 80 meters. When used as an inverted-V, the center support point is 35 to 65 feet above ground with the ends of the antenna insulated about 10 feet above the ground. The DIV-80 kit includes 140 feet of copperweld wire, a high-strength Mosley dipole connector, high-grade ceramic end insulators, all necessary hardware and complete instructions. For more information, write to Mosley Electronics, Inc., 4610 N. Lindbergh Boulevard, Bridgeton, Missouri 63042.

fet vom

The newest of a series of precision electronic instruments has been announced by Delta Products. Their new model 3000 fet volt-ohmmeter features ac and dc ranges from 300 millivolts to 1000 volts full scale; the instrument reads down to 10 mV. Current ranges are from 0.03 μA to 300 mA, and resistance ranges run from 10 ohms to 20 megohms center scale. Dc accuracy is $\pm 2\%$ of full scale and ac accuracy is $\pm 3\%$ of full scale below 500 Hz.

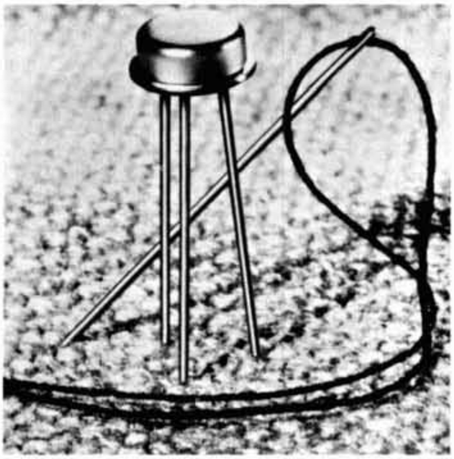
The model 3000 has an fet input stage with current regulator for 10-megohm input resistance; an integrated-circuit operational amplifier is used for extreme accuracy. The meter is fully compensated for low zero drift and has built-in voltage clippers for input stage protection. Special features include a mirror-scale meter movement, enclosed switches, and ten-turn potentiometers for zeroing and ohms adjust.

Available in kit form with preselected components for the feedback network to eliminate all calibration, $59.95 ($74.95 completely assembled and tested) from Delta Products, Inc., Department 147, Post Office Box 1147, Grand Junction, Colorado 81501.

solid-state tv camera modules

If you're interested in building your own vidicon-type tv camera or updating existing cameras, you'll be interested in the new line of solid-state modules announced by ATV Research. A complete camera can be built in one evening by using these wired and tested modules; and according to the manufacturer, no previous tv knowledge or special test equipment is required. The modules presently available include a video module, vertical-sweep module, horizontal-sweep module, rf modulated oscillator module and high-voltage dc-dc converter. Prices range from $10 to $20, and units are available for immediate shipment. For more information, write to ATV Research, 13th and Broadway, Dakota City, Nebraska 68731.

millisecond fuse



Beckman Instruments has just introduced a new high-speed fuse designed specifically to protect integrated circuits and power transistors. The series 817 fuse is inexpensive and available with ratings of 0.5, 0.75 and 1.5 amperes. All three units will blow as fast as 50 microseconds. The miniature fuses are housed in a TO-46 can. For more information, write to Technical Information Section, Helipot Division, Beckman Instruments, Inc., 2500 Harbor Boulevard, Fullerton, California 92634.

short circuits

silver plating

In the article on silver plating in the December 1968 issue of **ham radio,** it was stated that immersion plating is also known as electroless plating. This is an error. Immersion "plating" only puts on a surface film, then ceases to deposit. Electroless plating continues to deposit for the life of the solution.

220 mosfet converter

The 470-ohm isolation resistor in **fig. 1,** page 30 of the January 1969 issue does not isolate the hot end of L2—the hot end of L2 should be connected to the junction of the 470-ohm resistor and the 500-pF buttom mica bypass capacitor.

solid-state BC348

Several errors appeared in the circuit diagrams of this article on the solid-state BC348 which appeared in the February 1969 issue. The squelch switch, as drawn, shorts out the agc—the switch should be turned around so the arm is connected to the base of the 2N2924. In the negative 6.3-volt regulator, the collector of the 2N3638 should run directly to the base of the 2N1132/2N3638. In the positive 12.5-volt regulator, the 2N3766 driver should be a 2N3642 or 2N697; the main regulator **is** a 2N3766.

In the text, it was stated that the gain control range was 40 dB. Actually, for three stages, range is more like 140 dB! Fairchild Semiconductor no longer markets the 2N4122—use 2N4121's instead. Another solution, offered by W1OOP, is to use Motorola 2N3906's for all pnp types except the negative 6.3-volt regulator. For all npn types except the above mentioned 2N3642/2N697, use 2N3904's. Price is 82c each.

repeater identifier

In the power supply circuit in **fig. 1,** page 19 of the April 1969 issue, the plus 4.5-volt supply should be connected to the emitter of the transistor, not the base—emitter is lifted off ground of course. Also, in **fig** 5, page 22, the 1.8 k resistor from pin 5 of IC1 should be connected to the collector of Q23, not the emitter.

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39th — ARRL WEST GULF Division Convention August 15, 16 & 17, Amarillo, Texas. For an ideal summertime weekend of ideas, fellowship, entertainment, fun (and maybe good luck) you can't miss at $10.50 for registration. W5WX Panhandle Amateur Radio Club, Box 5453, Amarillo, Texas 79107.

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INTEGRATED CIRCUITS: New RTL 900, 914 60¢, 20 up 56¢. 923 90¢, 20 up 87¢. Add 15¢ postage H A L, Box 365, Urbana, Illinois 61801

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SET OF 4-VOLUME USAF directory of surplus military, commercial test gear, 1,500 pages, on 'scopes, counters, signal generators, etc. $5.50; also shack-cleaning list of surplus stuff: G. White, 5716 N. King's Highway, Alexandria, Va. 22303.

GB3SUA will operate from Stratford-upon-Avon, in England, 11-13 July, to celebrate the 700th anniversary of the beginning of local government in the town. Operation will be 80 through 10 meters, SSB, AM and CW. A special QSL will be issued. Further information from M. Webb, G300Q, 14 Townsend Road, Tiddington, Stratford-upon-Avon, Warwickshire, England; or R.S.G.B. Public Relations Officer, Sylvia Margolis. Touring amateurs who expect to be in the district at that time are particularly asked to contact R.S.G.B.

NORTHERN CALIFORNIA Hams: Best deals — new and reconditioned equipment. Write or stop for free estimate. The Wireless Shop, 1305 Tennessee, Vallejo, California 94590.

WANTED TO BORROW: Instruction manual for Dumont 304H oscilloscope. Will return after I make a copy. W1DTY, Box 25, Rindge, N. H. 03461.

THE OAK RIDGE RADIO OPERATOR'S CLUB will sponsor the 20th Annual Crossville Hamfest at the Cumberland Mountain State Park July 26-27. For information, write The Oak Ridge Radio Operator's Club, Inc., P. O. Box 291, Oak Ridge, Tenn. 37830

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GREENE — center of dipole insulator with or without BALUN . . . see ad page 82, June 1969, Ham Radio.

TENTH NEW JERSEY QSO PARTY — August 16-17 from 1900 GMT Saturday, August 16 to 0600 GMT Sunday, August 17 and from 1200 GMT to 2300 GMT on Sunday, August 17. Phone and CW are considered the same contest. A station may be contacted once on each band — phone and CW are considered separate bands. New Jersey stations may work other New Jersey stations. General call is "CQ New Jersey" or "CQ NJ". New Jersey stations are requested to identify themselves by signing "DE NJ" on CW and "New Jersey calling" on phone. Suggested frequencies are: 1810, 3555, 3740, 3930, 7060, 7275, 14075, 14285, 21100, 21375, 28800 kHz, 50-50.5, 144-146 MHz. Suggest phone activity on the even hours. Exchanges consist of QSO number, RST, and QTH (ARRL Section or country). N. J. stations will send county for their QTH. Full information from Englewood Amateur Radio Association, Inc., 303 Tenafly Road, Englewood, New Jersey 07631. Stations planning active participation in New Jersey are requested to advise the EARA by August 2nd of your intentions so that we may plan for full coverage from all counties.

CRYSTALS FOR AMATEURS. All meters ± 1K C at 20pf. HC6/U holders, .093 pins, 10¢ extra. Crystal frequencies 3501 to 3999; 7000 to 7300; 8001 to 8221; 8334 to 8900 K C. $2.95 each prepaid. Add 12¢ for postage. Listed dealers inquiries solicited. American Crystal Co., Box 2366, Kansas, Mo.

FOR SALE: 75S3, $375. T4X, R4-A, AC-4, MS-4, $600. 75S3-B, 0.5 & 2.1 kcs filters, $575. KWM-2 #12,566 (latest series), 516F-2, $850. KWM-1, 516F-1, $245. Johnson "Messenger" 115VAC/6VDC, new, $75. P & H LA-500 "Spitfire" linear, (new), $75. Raytrack "Auto-Level" Compressor, $50. SR-160, PS-150-AC, PS-150-DC, Calibrator, $250. Tektronix 514-D, $195. Match-Box 250-23-1, $55. Heath HO-13, $45. Transformer, 220V/2500V (no C. T.), 11 KVA, $100. Stancor P-3060, P-6309, PT-8311, C-1646; UTC CG-305, CG-312, S-37, S-38, S-44, S-63; all half-price. Sola #23-25-230 Constant-Voltage Transformer, 3 KVA (new), $175. Sola #23-22-125, $27. Transformer, 220V/6.3V, 100 amps, $15. Power Supply, 115/220; output 2500 VDC @ 400 ma, $50. Capacitors: 50 mfd/3KV (oil-filled), new, $25. 16 mfd/4KV (laser discharge type), new, $15. RM-50 and RM-80 IF adaptors (for C. E. MM-2 RF Analyzer), $5 each. Collins MM-2 mike, $35. 10-D & G-Stand, $25. Variac, 220V/20 amps, $45. Line filter 3 X 15 amps/220 VAC, new, $10. HT-32-A, $300. HT-32-B, $400. James W. Craig, W1FBG, 29 Sherburne Ave., Portsmouth, New Hampshire 03801, Phone: 603-436-9062

DECADE COUNTER KITS — $13.95. Professional quality readout. Free information. Display Electronics, Dept. HR, Box 1044, Littleton, Colorado 80120.

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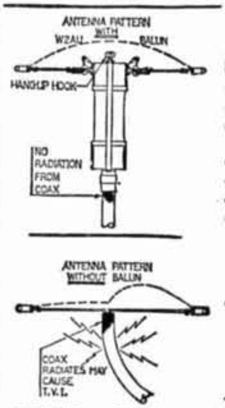

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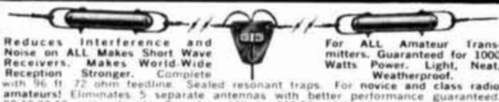

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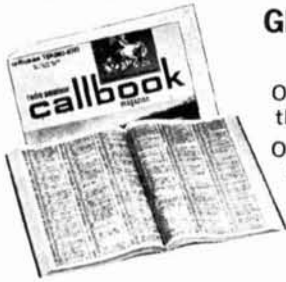

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FAIRCHILD SOLID-STATE SCOPES *all w/dual-trace* plug-ins 25 & 50 MHz, w/delayed time-base plug-ins, w/books, overhauled & grtd. As low as **825.00**

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Just to see if ayone reads our ads . . . because if you do you can't pass this up! #545 is DC to 30 MHz pass with calibrated variable sweep delay . . . take note all you who work with pulses! Included will be a dual-trace 24 MHz plugin and a 30 MHz single-trace plugin . . . TWO plugins! As received from a large prime Contractor, as is **595.00**

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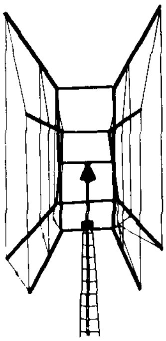

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FOR 10 - 15 - 20

The "JOGA QUAD" is rated at 1KW AM and 2KW P.E.P SSB. Features a single feed line Enjoy maximum forward gain and very low SWR over the full bandwith. The unique shape allows proper element spacing for all bands. It is easy to assemble and resists winds up to 100 MPH. It's lightweight with only a 4'6" boom length A brochure with further information is free for the asking

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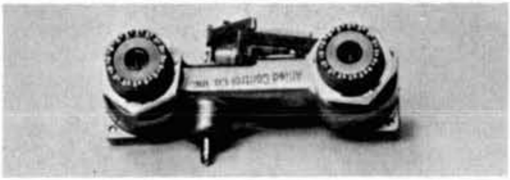
Electronic indicating decade, vacuum tube type, 4 tubes. Displays 0-9 counting input pulses. One unit may be used to drive another. Removed from equipment, w/tubes, w/ schematic. **$8.00 each, 2/$15.00, 10/$60.00**



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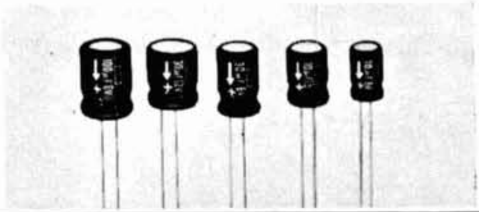
Unused coaxial switch, 12 volt coil, standard UHF fittings. Made by Allied Control. **$5.00**



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Volts	Mfd	Each	12
25	1	$ .10	$ 1.00
15	5	.10	1.00
15	10	.12	1.20
15	500	.20	2.00
12	15	.12	1.20
12	150	.15	1.50
8	300	.20	2.00
6	10	.09	.90
6	30	.10	1.00
6	50	.12	1.20
6	200	.15	1.50

Your choice of the above as listed . . . or . . . grab-bag our choice, **10 different $1.10**

LOW PASS FILTER

Brand new, w/UHF fittings, good for 100 watts, up to 30mc. 52 or 72 ohm line, attenuation min of 60 db from 35 mc thru FM & TV bands. **$4.00**

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The following CB crystals offered at 50¢ each, you pick 'em. Or, we will give a grab bag of **6 different (no choice) $1.50**

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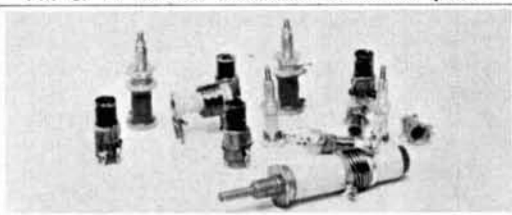
RECEIVE: 6-7-9-11-13-15-17-18-19



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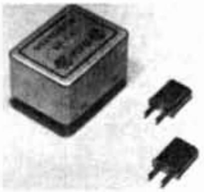
Walter Schilling modules are manufactured in West Germany to the highest standards of quality and workmanship. All printed circuit boards are glass-epoxy, silverplated. High-quality, name brand components are used throughout. Components are rated conservatively.

HS1000C 9 MHz transmitter exciter module for SSB, AM, FM, CW **$66.50**
HS1000D 9 MHz transceiver exciter module (as above, but with steep flank 2.4 KHz b/w crystal filter) **77.75**
HS1000S VOX/Anti-trip module for HS1000 C, D **16.00**
HS1000V VFO, 5-5.5 MHz **48.00**
HS1000Mx Mixer-Osc. 10-80 mtrs. Output sufficient to drive 150-200 watt linear. **108.00**

Other modules, such as IF sections, linear amplifier, two meter VFO, mixer-oscillator (all solid state) are available.

KVG MINIATURE CRYSTAL FILTERS

KVG miniaturized high performance crystal filters with symmetrical attenuation characteristics for use in AM, CW and SSB transmitters and receivers. Circuit matching is simplified by the use of input and output transformers, which are an integral part of the filters.



Filter Type		XF-9A	XF-9B	XF-9C	XF-9D	XF-9M
Application		SSB-Transm.	SSB	AM	AM	CW
Number of Filter Crystals		5	8	8	8	4
Bandwidth (6 db down)		2.5 kHz	2.4 kHz	3.75 kHz	5.0 kHz	0.5 kHz
Passband Ripple		1 db	2 db	2 db	2 db	1 db
Insertion Loss		3 db	3.5 db	3.5 db	3.5 db	5 db
Input-Output Termination	R +	500 ohms	500 ohms	500 ohms	500 ohms	500 ohms
	C +	30 pF	30 pF	30 pF	30 pF	30 pF
Shape Factor		(6:50 db) 1.7	(6:60 db) 1.8	(6:60 db) 1.8	(6:60 db) 1.8	(6:60 db) 2.5
			(6:80 db) 2.2	(6:80 db) 2.2	(6:80 db) 2.2	(6:60 db) 4.4
Stop Band Attenuation		45 db	100 db	100 db	100 db	90 db
Price		$19.95	$27.50	$29.50	$29.50	$20.95

Matching HC 25/U crystals: 8998.5 (USB), 8999.0 (BFO), 9000.0 (carrier), 9001.5 (LSB) **$2.50 each**

VHF COMMUNICATIONS
TOPSFIELD, MASSACHUSETTS 01983

VHF COMMUNICATIONS is an international, English language quarterly magazine for amateurs interested in VHF, UHF and microwave technology.
VHF COMMUNICATIONS devotes most of its sixty pages in each issue to practical construction articles. Featured are transmitters, receivers, converters, antennas, test equipment, etc. The designs reflect the latest advances in electronics, with emphasis on solid state and printed circuitry. Special components, such as p. c. boards, as well as complete kits are made readily available.

US $3.00 per calendar yr.
Single issues US $1.00.

TWO METER FET CONVERTER KIT

Contains all major components for the two-meter FET converter designed by DL6SW and described in VHF COMMUNICATIONS of February 1969. Inexpensive, simple to build and align, yet with excellent performance characteristics.
Included are: Five transistors (incl. 3 FET/s), 38.7 MHz KVG crystal, five miniature coil forms, five miniature trimmers, one glass-epoxy, silverplated printed circuit board (component layout printed on the reverse side), one special p. c. board drill.
IF Output 28-30 MHz (others upon request).
Noise figure: 2.
Price $12.95. With a new subscription to VHF COMMUNICATIONS $11.95 (offer valid until August 31).
Other kits for 50, 220, 432 and 1296 MHz converters, receivers and transmitters will be available in the near future.

Semcoset of West Germany is a manufacturer of top-performance solid state VHF receivers, transceivers and printed circuit modules. The Semcoset line is now available in North America through Spectrum International. Featured are complete two-meter receivers, transceivers and portable transceivers in attractive, modern cabinets. Printed circuit modules include MOSFET two-meter converters with extremely low noise figures, AM transmitters of 4 to 15 Watts PEP output, VFO's for VHF, tuners, IF strips, audio units, SSB exciters, a solid state linear amplifier, a 100-500 MHz stripline reflectometer, etc. All units are entirely solid state. Extensive use is made of FET's, MOSFET's and Overlay RF power transistors. Semcoset catalogues will be available in August.

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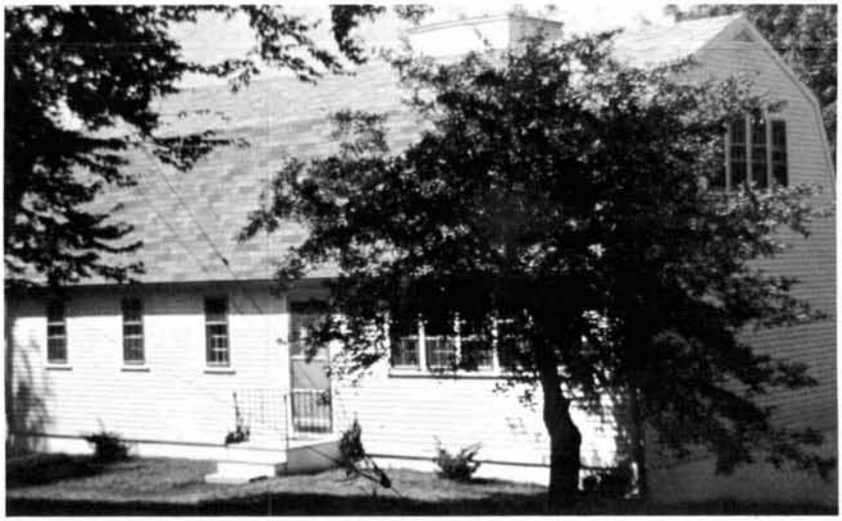
MASSACHUSETTS 01983



INSIDE THIS MODEST BUILDING LIES ONE OF THE MORE UNIQUE BUSINESS ESTABLISHMENTS IN THE WORLD OF AMATEUR RADIO. HERE IS PROBABLY THE LARGEST COLLECTION OF GEAR, BOTH OLD AND NEW, TO BE FOUND IN THE NORTHEAST, IF NOT IN THE WHOLE COUNTRY.

THERE ARE THREE STORIES OF TRANSMITTERS, RECEIVERS, TRANSCEIVERS, TEST EQUIPMENT, ANTENNAS AND PARTS. ANY PIECE OF EQUIPMENT IN THE DEMONSTRATION ROOM CAN BE IMMEDIATELY SWITCHED TO OUR ANTENNA FARM WHICH INCLUDES 44 DIFFERENT ANTENNAS SPREAD OUT OVER SEVERAL ACRES AND FOUR TOWERS.

IF YOU LIVE IN OUR PART OF THE COUNTRY YOU CERTAINLY OWE YOURSELF A VISIT TO THIS INTERESTING BUILDING. WE CAN PROMISE YOU SEVERAL HOURS OF THE MOST INTERESTING BROWSING. IF YOU ARE LOCATED FURTHER AWAY CONTACT US BY MAIL FOR PROMPT, COURTEOUS SERVICE AND PUT US DOWN FOR A VISIT ON YOUR NEXT TRIP TO NEW ENGLAND.

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