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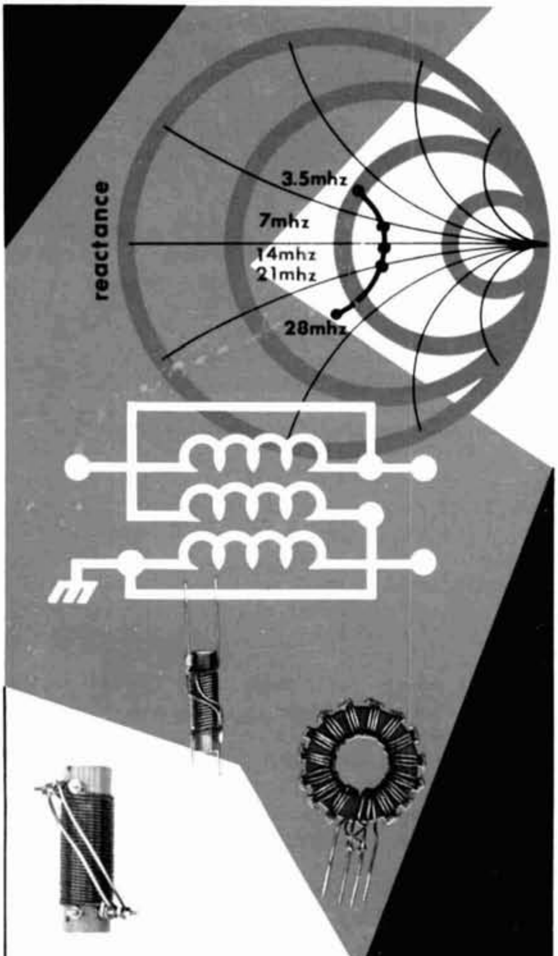
ham radio

JUNE 1968



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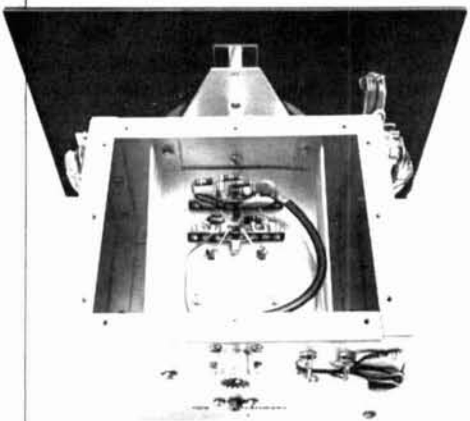
Solid-State Projects for the shack

Build this high stability VFO

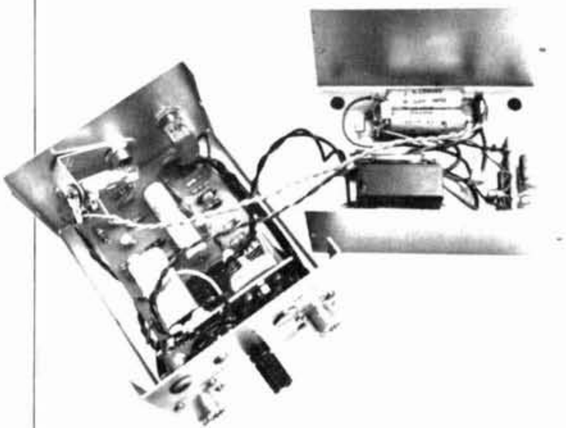


Here's an almost drift-free VFO built around the RCA-3N128 MOS/FET for flexible operation. After just 30 seconds warm-up, it tests out at less than 30 cycles drift in a two hour period.

Look in The Radio Amateur's Handbook, 1968 edition or write to RCA, Commercial Engineering, Sec. F175SD, Harrison, N.J. 07029 for full design details, including parts list, schematic, and building tips.

All listed RCA devices are available from your RCA Industrial Semiconductor Distributor

Build this VFO calibrator



If you're interested in MARS and have just a "ham-bands-only" receiver, this may be your answer to VFO calibration outside normal bands. It uses two RCA-1N3193 rectifiers; two 1N34A signal diodes; one RCA-2N2614 and seven RCA-2N3241A transistors—provides calibrating beats at 100 kHz points as well as 50, 33, 25 and 20 kHz. Handy, too, for calibrating test equipment.

Look in August 1967 QST or write RCA, Commercial Engineering, Sec. F175SD, Harrison, New Jersey 07029 for August 1967 "Ham Tips." RCA Electronic Components, Harrison, New Jersey.

RCA

june 1968
volume 1, number 4

ham radio

offices

Greenville, New Hampshire 03048
Telephone: 603-878-1441

ham radio is published monthly by Communications Technology, Inc., Greenville, New Hampshire 03048. Subscription rates: U.S.A. and Canada, one year, $5.00, three years, $10.00. Printed in Montpelier, Vermont 05602, U.S.A. Postmaster: Please send form 3579 to **ham radio,** Greenville, New Hampshire 03048.

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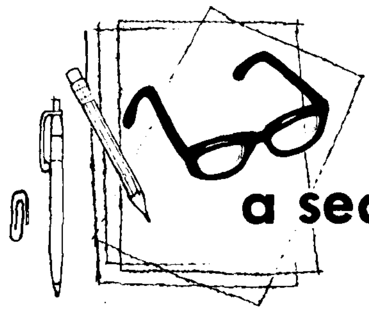

a second look

by jim fisk

Did you ever wonder why we are called hams? I suppose we all have at one time or another. We'll probably never know where the term really started, but there have been a lot of stories down through the years.

The first story I heard about "hams" related how the British amateurs referred to themselves as "am's." Because of the British pronunciation of the word, the Americans immediately picked it up as "ham." Since there were no other conflicting stories regarding the derivation of the word, I accepted it at face value.

However, in looking back over the story, this would mean that "ham" did not appear until radiotelephony became popular. Although old timers can't definitely remember the use of the word before the advent of radiotelephone, they're not sure exactly when it came into general use.

A story which was pretty widely circulated a couple of years ago indicated that H.A.M. was derived from the first letter of the last names of three prominent hams in the Boston area around 1910. This story seems to be concocted and apparently has no basis in fact.

The latest story I've heard tells of the derivation of the word ham as used in the theatre and how it was applied to the amateur radio operator. It seems that in the late 1880's there was a popular minstrel show on Broadway put on by one of the greatest blackface teams of all time, Heath and McIntyre. Their show was called "The Ham Tree." This show ran for a long time and eventually the word ham was applied to all minstrel players. Later on, any person who was not in the professional theatre was called a ham.

As many of you may remember, broadcasting on the ham bands was perfectly legitimate in the early days of amateur radio telephone. In fact, many of our famous radio personalities got their start by broadcasting on the amateur bands. They put on news shows, sports shows, music shows, and general-interest entertainment. These people were called hams, probably quite properly, and through usage, all amateur radio operators became hams.

Of all the stories I've heard, this one seems the most probable. I'm sure that there are a lot of other stories relating how the word came into use. If you have any stories along these lines, I'd be very glad to hear about them. They are just as much a part of ham lore as the story of the "wouf hong," the "retty snitch" or the "old man." These stories are a lot like the lumberjacks' Paul Bunyon. Some of them are pretty far-fetched, but they are always good for a few laughs. Hams we are, and hams we'll stay, but we'll probably never know the true story of the word.

Jim Fisk, W1DTY
Editor

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Output Power, W	655	644	1770	1170	5500	24,200
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Filament Current, A	14.5	14.5	21.5 23.0	28/33	51	94/104

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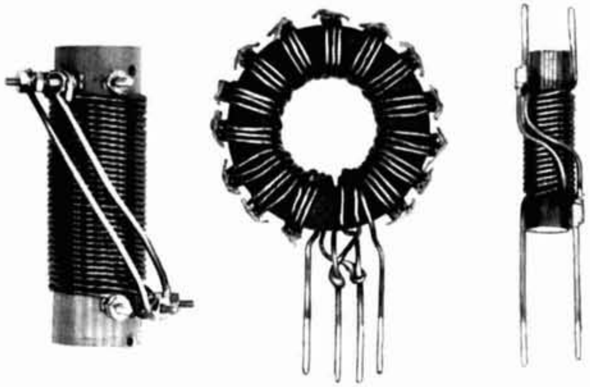


Three wideband baluns which are suitable for use in the hf spectrum. To the left is a simple air-core balun wound on a plastic form; in the middle is a toroid-core balun; to the right is a ferrite-slug balun.

broadband antenna baluns

A comparison of the impedance characteristics and power-handling capability of three popular types of broadband 1:1 baluns

William I. Orr, W6SAI, 48 Campbell Lane, Menlo Park, California

A balun is an electrical transformer for converting a balanced system to an unbalanced system or vice versa. They come in all shapes and sizes from the midget "ladder transformers" for television receivers to giant ferrite transformers for multi-kilowatt broadcast stations. The baluns that interest the radio amateur are used to match unbalanced coaxial transmission lines to balanced antenna systems.

An inexpensive narrow-band balun may be made with a quarter- or half-wavelength of coaxial line as shown in **fig. 1.** These baluns will cover a single amateur band, but they are of little practical interest if you're using a three-band beam antenna or multi-band dipole.

Various forms of ferrite toroid baluns that promise broadband operation have appeared recently,[1] as well as a simple broadband coaxial-wound balun.[2] This article discusses some of the more common ferrite balun transformer designs and describes a simple and inexpensive **air-core balun** that works well over the 7- to 30-MHz range.

the 1:1 balun transformer

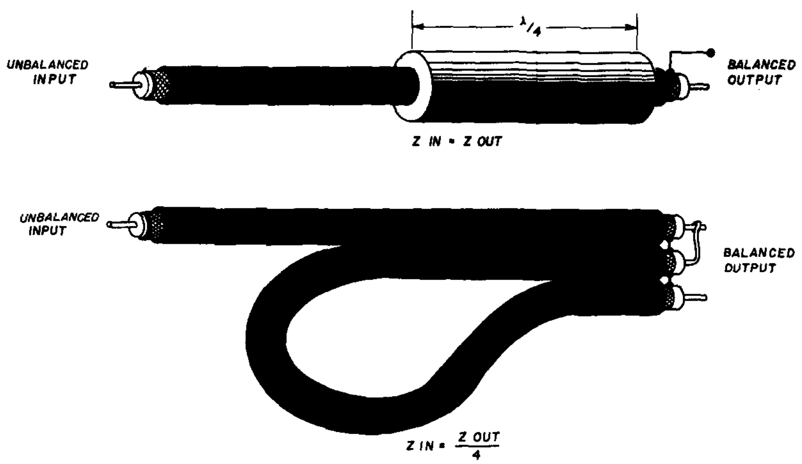
The 1:1 balun is well suited to the problem of feeding a split-dipole radiator with an unbalanced coaxial line. If this important balancing function is left out, it may cause transmission-line radiation and can result in confusing SWR readings when attempts are made to measure the characteristics of the antenna system. For the greatest benefit, a balun should cover the range of 3.5- to 30-MHz so that it can be used with three-band beams as well as "trapped" 80- and 40-meter doublets.' Useful, too, are baluns which cover the "tribander" antenna range of 14 to 30 MHz.

Sophisticated ferrite toroid baluns have been built which span the range of 50 kHz to 500 MHz,[3] and simple linear-coil versions of these exotic devices may easily cover the 80- through 10-meter bands. A well-built 1:1 balun is a noncritical device that provides near-unity transformation; it may be used with either 50- or 70-ohm coaxial transmission lines and most common antennas.

winding) inductor, and may be compared to a two-wire transmission line wound in a coil with an extra balancing winding provided to complete the magnetizing-current path. In effect, the balun is comparable to a transmission line transformer having a 1:1 ratio over the higher-frequency region of operation and to a 1:1 coupled transformer at the lower frequencies.

High-frequency response of the coil balun is largely limited by the distributed (shunt) capacitance and coupling between the windings (both of which are quite critical). The low-frequency response is determined by the primary inductance of the coupled transformer.[4] The most difficult part of the balun transformer to adjust is the distributed capacitance of the windings. Much effort must be expended to reduce this to a minimum value

fig. 1. Narrow-band balancing transformers may be made of lengths of coaxial cable. The upper design provides a 1 to 1 balanced transformation and the lower design, a 4 to 1 transformation. Baluns provide good balance over approximately 0.05% of the operating frequency.



There's more to the balun than meets the eye however, and practical construction information is sorely lacking for these interesting devices. Some simple designs are shown in this article which work well over the h-f range and can be built easily and inexpensively in the home workshop.

The schematic of a 1:1 coil balun is shown in **fig. 2.** The balun consists of a trifilar (three-

without destroying the interturn magnetic coupling.[5]

A coil balun may be constructed with an air core, and designs of this type work well. However, the number of turns required for good low-frequency response are large, and sufficient distributed capacitance exists in a simple balun of this type to limit the range of proper operation to a frequency span of

3 or 4 to 1. If a high-permeability ferrite core is used in the balun, fewer turns are required on the trifilar winding for a given low-frequency response. This reduces the overall distributed capacitance of the winding and improves high-frequency response. A frequency range of 10 or 20 to 1 is common with a balun of this type. The ferrite core, however, is power limited, especially at the high-frequency end of the operating range.*

the ferrite-core toroid balun

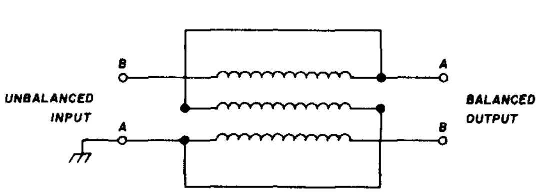
Toroid baluns have been described several times, and variations of the basic design shown in **fig. 2** are available in kit form. Several experimental toroidal baluns were built using available information. An expanded Smith-Chart plot** of one of the best designs is shown in **fig. 3.** The chart illustrates the reactive and resistive components of the balun when terminated in a 50-ohm load and examined with an rf impedance bridge. To plot the chart, a frequency run was made with a signal generator driving the balun through an rf impedance bridge; the bridge readings are transferred to the Smith-Chart. A typical test set-up is shown in **fig. 4.**

The curve for the toroid balun shows that it is not a perfect 1:1 transformer. It presents a termination of 49 ohms at 3.5 MHz and gradually rises to 55 ohms at 14 MHz. Thereafter, the impedance drops to about 44.5 ohms at 29.7 MHz. This balun presents considerable reactance at the lower frequencies,

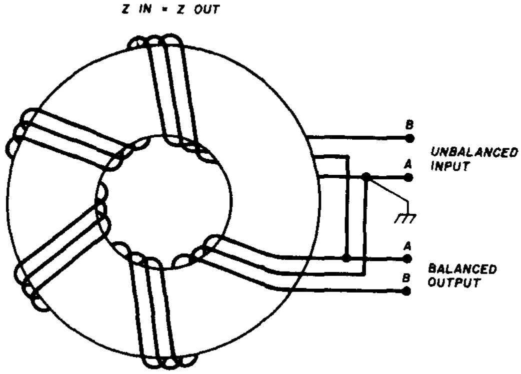
* According to Sosin,[4] the bandwidth is limited at the low-frequency end by the low value of shunt inductance, and at the high-frequency end by a low-pass pi network formed by spurious shunt capacitance and leakage reactance. In order to keep the leakage reactance small, the winding must have a minimum number of turns. Consequently, the ferrite core is very heavily loaded. The power rating of the core depends on the cooling effectiveness, and the temperature rise of the core might become quite high. As the working temperature is increased, a runaway temperature is reached where operation is impractical because of unbalance; ultimately, the balun will be destroyed.

** The Smith Chart used for this series of tests is an expanded type normalized at 50 ohms. The resistive component of the measured impedance falls along the X-axis and the reactive component falls along the Y-axis in the normal manner. (General Radio #5301-7561-NE).

fig. 2. A three-winding transformer provides a balanced 1-to-1 transformation (A). Note that the center winding acts as the balancing coil, completing the magnetizing current path. Connection of balancing winding to transformer winding at the input end must be taken as ground (point A) to preserve optimum balance. The three-winding balun may be used with a toroid core (B).



A

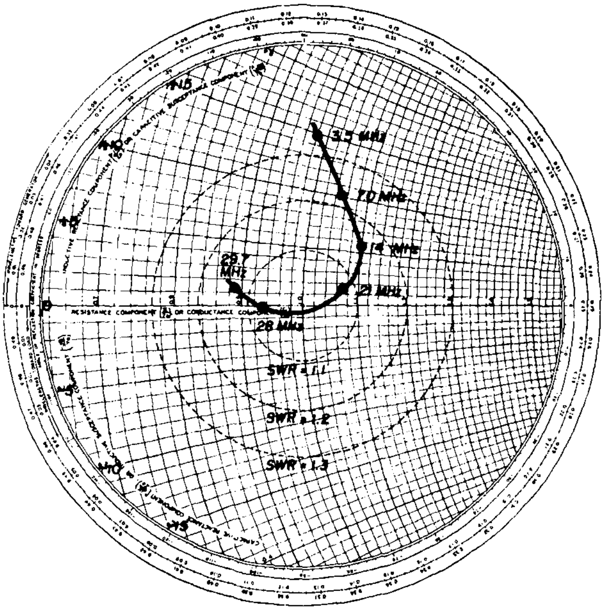


B

resulting in an SWR greater than 1.1 at frequencies below about 19 MHz. Above 19 MHz, balun reactance is slight. This chart shows that, when terminated in a "perfect" 50-ohm load, the balun will introduce a slight SWR (greater than 1.1 but less than 1.35) on a transmission line at frequencies below 19 MHz. Not indicated on the chart is the fact that the balance of the device begins to deteriorate above 30 MHz or so.

In summary, then, a ferrite toroid balun of this design is a good performer above 19 MHz and a fair performer down to above 3.5 MHz. The quality, or excellence of the balun, of course, is a subjective thing and an arbitrary SWR figure of 1.2 was chosen as a practical limit defining balun excellence. A **really good** balun, however, can plot a curve falling with-

fig. 3. Expanded Smith Chart shows response of ferrite-toroid balun plotted with respect to 1.2:1 and a *1.1:1 SWR circles super-imposed* on the chart. Balun consisted of 15 turns number 14 wire bifilar wound on 2.4" diameter, Q-1 toroid. Balun was optimized at h-f end of its range by squeezing and adjusting the *spacing* between adjacent turns and lacing the windings in place.



in the 1.2 SWR circle on the expanded Smith Chart.

Not shown on the chart is the difficulty I encountered in constructing a toroid ferrite balun capable of this degree of performance. Neatness of construction is a virtue, and the coupling, or spacing, between each turn and between the *trifilar* groups of turns is very critical. In the photograph you can see that each trifilar group of wires is tied in place with a length of lacing twine. Unhappily, if the trifilar groupings are too loose on the core, the high-frequency performance of the balun suffers. If, on the other hand, the lacings are too tight and the turns too tightly compressed together, the high-frequency performance suffers equally as before.

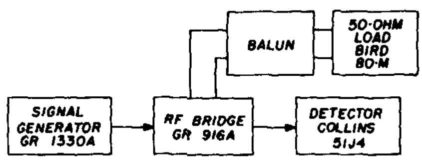
I spent a considerable amount of time adjusting the balun windings while it was connected in the measuring circuit. Only by juggling the windings while watching the rf bridge readings was I able to achieve a satisfactory transformation ratio and acceptable bandwidth. The experience was exasperating in the extreme, and I reached the conclusion that it was virtually impossible to construct a toroid ferrite balun of this type with acceptable characteristics without the assistance of an rf bridge.

The coupling between trifilar windings was very critical and had to be hand-adjusted to a fine degree to make the balun perform above 20 MHz or so. Regretfully, the toroidal construction was cast aside in favor of other designs that could be easily built in the home workshop.

the ferrite-slug balun

I next turned my attention to the ferrite slug balun, a number of which are available commercially in inexpensive versions. A simple trifilar balun was wound on a one-half-inch diameter ferrite core;* measurements were taken and plotted on an expanded Smith Chart as shown in **fig. 5.** The slug balun performed well over the 7- to 50-MHz range (within the 1.2 SWR circle on the chart), and seemed acceptable at 3.5 MHz where the plot fell just outside the 1.3 circle.

fig. 4. Balun tests were conducted with an r-f bridge and balanced load. The r-f bridge was compensated for h-f response to 50 MHz. Resistance and reactance measurements were made directly from the bridge and compensated for system errors.



Wire spacing on the slug core did not seem to be nearly as critical as on the toroid form, and a neat, closewound coil performed very well. Anchoring the winding proved to be a problem; coating the wires with coil dope, Krylon or nail polish increased the distributed capacitance of the balun and disturbed the

* The Newark Electronics Corporation Industrial Catalog number 68 carries a partial listing of Indiana General Corporation Ferrites. A suitable 1/2-inch diameter rod is the Indiana General CF-503 which is 7-1/2" long. (Newark part number 59F-1521). The ferrite may be nicked with a file around the circumference at the desired length and broken with a sharp blow.

transformation above 20 MHz. The solution was to coat the end turns and leads of the assembly and to leave the winding free of adhesive material.

After I had built a few ferrite slug baluns and measured them on the rf bridge, they were tested with a transmitter and a dummy load. The balun with an Indiana General CF-503 slug core readily accepted 700 watts of power up to 14 MHz—the core became only slightly warm after three minutes of operation. Above 20 meters, however, core losses went up, and it was necessary to derate the balun to 500 watts at 21 MHz and 400 watts at 28 MHz. I didn't run any power tests at 50 MHz, but I estimate that the balun is good for 100 watts or so at this frequency. With intermittent voice ssb operation, the power capability could probably be doubled with safety.

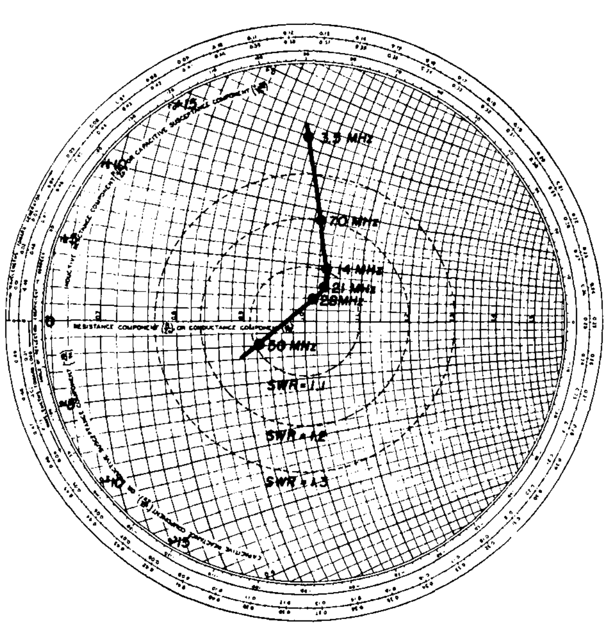


fig. 5. Chart shows plot of ferrite-slug balun with respect to 1.2 and 1.1 SWR circles. This simple, compact balun performed well over the 3.5- to 50-MHz range and the plot fell within the 1.2 SWR circle over the range from 7 to 50 MHz. The balun consisted of 6 turns of number 14 wire on a Q-1 slug and was patterned after a design by W8FYR. This balun provided the widest frequency response of all the baluns tested but was power limited at the h-f end of the range.

the air-core balun

Because of the power limitation and core cost of the ferrite baluns, I decided to explore the capabilities of a simple air-core balun. A suitable design evolved after several failures, and the characteristics of a prototype balun were plotted on an expanded Smith Chart (**fig. 6**). The balun plot fell within the 1.2 SWR circle over a range of 9 to 29.7 MHz and was just inside the 1.3 SWR circle over the 40-meter band. The power capability of the balun was better than 1000 watts at all frequencies within the range of operation. Ease of construction, low cost and simple adjustment plus the improved power capability emphasize the fact that this type of balun is well adapted to home construction.

practical balun construction

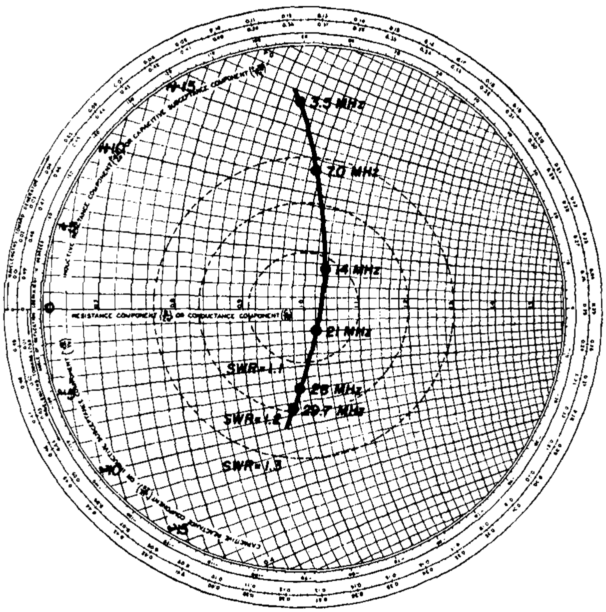
A practical air-core balun for the h-f range is shown in the photograph. It consists of three coils of number 14 Formvar* coated wire, ten turns to each coil. The windings are placed on a 4-inch long piece of 1-1/16-inch outside diameter polyvinyl-chloride (PVC) plastic tubing. This gray, plastic material is commonly used in most areas of the United

* *Formvar* (polyvinyl formal-phenolic resin) coating is superior to plain enamel because of its greater dielectric breakdown strength. *Nyclad* (polyvinyl formal with nylon overcoat) wire has even greater dielectric breakdown strength. It is manufactured by Belden Manufacturing Company. *Nyform* is another trade name for this coating (Anaconda Wire & Cable Company).

States for water pipe, and a small chunk of it can be obtained from your local plumber at little or no cost. The trifilar winding is simple to construct after you get the hang of it, and expertise is readily gained after an experimental winding is made.

Three pieces of wire about 4-feet long are

fig. 6. Chart shows plot of inexpensive air-core balun shown in the photograph. While the frequency response is not as great as that of the ferrite-slug balun, the less expensive air-core balun works well over the range of 3.5 to 29.7 MHz. Response falls within the 1.2 SWR circle over the range of 9 to 29.7 MHz. Balun consisted of ten turns of number 14 Formvar insulated wire on a piece of 1-1/16" piece of plastic pipe, connected as shown in fig. 2A.



cut and smoothed to eliminate bumps and kinks. The wires are placed parallel to one another and the far ends held in a vise. The near ends are scraped clean of insulation and wrapped around 4-40 bolts placed in the PVC form as anchor points. The three wires are then wound side by side on the form as one, until ten trifilar turns are on the form. If you wind carefully and keep reasonable tension, the coil will adhere closely to the form. The other ends of the windings are scraped clean and attached to the proper bolts as shown in the illustration.

The last step is to interconnect the center, or balancing winding. As you can see in the photograph, the center coil cross-connects the outer coils. The terminal connections are reversed in physical position from one end of the coil to the other, and the proper balancing connection may be made by connecting the ends of the center winding to the outer coil winding at each end of the bifilar assembly. Neatness is important, and an evenly wound coil with the turns **just** touching each other will provide greater operational bandwidth than a haywire winding with uneven spots or lumps in the wires. Once the cross connections have been made, the assembly may be held in place by a few drops of epoxy cement, Krylon, or coil dope placed at the **ends** of the windings.

Note that the input terminals of the balun are non-symmetrical from an electrical point of view. That is, **point A** at the input end is taken as ground. The free winding, **point B,** is hot. At the output end, of course, the terminals are balanced with respect to ground. Transposition of the input connections will degrade balancing action. Either end of the unit may be used as the input, of course, provided **point A** is taken as ground.

encapsulating the balun

Air-core baluns of the types discussed here are sensitive to nearby capacitance, and some thought must be given to the problem of protecting the windings from sun, rain and weather without upsetting their electrical characteristics. I tried to encapsulate the baluns in epoxy resin, but the resulting increase in distributed capacitance degraded balun performance to a serious degree at the higher frequencies. A simple solution I finally arrived at was to place the balun in a cylindrical case made from a 2-1/2-inch diameter polyethylene "squeeze bottle" that once held hair shampoo. I cut the ends from the bottle and put in plywood discs with small wood screws. The balun was suspended inside the bottle by the wire leads which were connected to 10-32 bolts placed in the plywood discs. When the unit was completed, it was coated with epoxy resin to waterproof the joints.

A subsequent visit to the local plumber disclosed that there was a "welding" torch available which "welded" PVC pipe with a blast of hot air, using a strip of PVC material as plastic solder. Accordingly, a length of 2-1/4-inch outside diameter PVC pipe was cut to form an outer jacket for the balun. Two end discs were cut from a sheet of the same material. Terminals were placed in the discs, and the balun was wired in place between the terminals. The assembly was then slipped within the larger PVC pipe and "welded" by the plumber with his unique hot-air torch. The result was a neat, compact, waterproof balun assembly ready to mount at the feed point of a beam antenna or hung from the center point of a dipole!

using the balun with your antenna

The air-core balun makes a fine balancing device for use between the coaxial line and the split dipole element of a three-band beam antenna. While nominally designed for a nonreactive 50-ohm load, the balun will happily accept the degree of mismatch presented by the typical amateur antenna. Most three-band beams using trapped elements present a different picture to the transmission line on each of the amateur bands, and rarely is this a "pure" 50-ohm termination.

Typically, such an antenna represents a frequency-sensitive, reactive load whose resistive component falls to about 25 ohms on 14 MHz, 35 ohms on 21 MHz and 45 ohms on 28 MHz. Because of the complex interaction of traps and elements, the chance of achieving a nonreactive 50-ohm load at more than one frequency in one of the three amateur bands is rather remote.

No matter; the operation of the antenna is not dependent to any great degree upon feedline match provided the SWR at the transmitter end of the line is not too great to prevent proper transmitter loading. It is permissible, therefore, to use the balun directly with a multi-band beam without additional matching devices other than those normally associated with proper antenna operation. Therefore, the balun may be used with varying beam terminations, possibly over the range of 15 to 100 ohms or so, while still providing worthwhile balancing and feedline isolation.

low-frequency air-core baluns

During the investigation of air-core baluns, two low-frequency units were built that may be of interest to experimenters. The first covered the range of 2.5 to 15 MHz and consisted of seven trifilar turns of number 14 Formex wire (21 total turns) wound to a length of 1-3/4-inches on a piece of 2-3/8-inch diameter PVC pipe. The design center of this balun was 8 MHz, and the impedance plot fell within a 1.2 SWR circle on the expanded Smith Chart over the range of 3.4 to 15 MHz.

A second balun covered the range of 0.54 to 2.5 MHz. This balun was composed of eighteen trifilar turns of number 14 Formex wire (54 total turns) wound to a length of 3-5/8 inches on a length of 3-1/2-inch diameter PVC pipe. Design center was 1.2 MHz, and the impedance plot fell within a 1.2 SWR circle on the Smith Chart over the range of 0.7 to 2.1 MHz. This balun is well suited for 160-meter work, while the previously mentioned unit is designed for 80- and 40-meter operation. As it turned out, the smaller unit worked well on the 20-meter band as well and was subsequently used on a two-band 40- and 20-meter beam.

conclusion

The simple air-core balun is the easiest to make and adjust and the least expensive of the three balun types discussed in this article. It is capable of working at the full amateur power limit over its design range and greatly simplifies the operation and adjustment of any antenna system. Try one and see; you'll like it!

I'd like to thank Willie Sayer, WA6BAN, for his help in the preparation of this article and for his contribution of the hundreds of feet of copper wire that went into various unsuccessful designs along the way!

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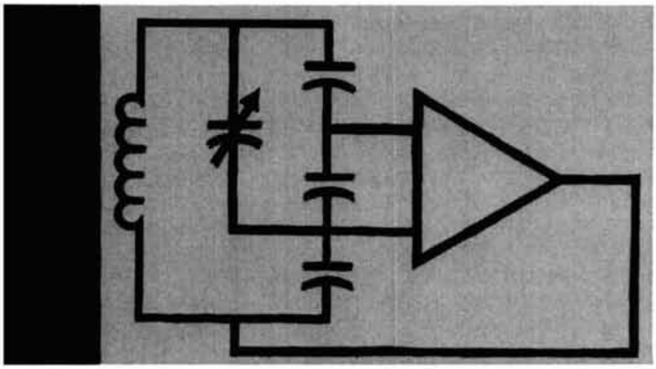


stable transistor vfo's

A discussion of the Vackar and Seiler oscillator circuits

Jim Fisk, W1DTY, RFD 1, Box 138, Rindge, New Hampshire 03461

There has been a lot of interest in the Vackar oscillator lately because of a recent article[1] describing its many merits. Although there hasn't been too much information on this circuit in the American magazines, a wealth of information has been published in the **RSGB Bulletin.** In addition, there have been a number of amateur articles which have used a somewhat similar circuit—the Seiler oscillator.

Actually, both the Vackar and Seiler circuits are closely related to the Colpitts oscillator. The Vackar, named after its inventor, Jiri Vackar, a Czechoslovakian, was originally described in 1949.[2] The Seiler circuit, although almost forgotten, was described in **QST**[3] in 1941. Both of these circuits were designed to minimize loading on the tuned circuit, thereby increasing stability.

Most VFO's in use today use the series-tuned Colpitts or Clapp circuit; interestingly enough, Clapp based his design on the work of Vackar.[5] You can see from **fig. 1** that the Colpitts, Clapp, Vackar and Seiler circuits are very closely related. The Colpitts circuit, of course, is the father of them all. Seiler added a third capacitor in the divider to lessen the load on the tuned circuit. Vackar did much the same thing, but put a variable capacitor across a portion of the tank circuit to increase the tuning range. Clapp went on to simplify the basic Vackar circuit.

Since the Colpitts and Clapp circuits have been covered quite well in the amateur literature,[17-24] the discussion here will be limited to the Seiler and Vackar circuits.

the Seiler oscillator

Until Seiler's article in 1941, most VFO's used the Hartley or high-C Colpitts circuit. The Seiler design permitted the amateur to voltage regulation, and by 1941 standards, the stability was very good.

One of the big advantages of the Seiler circuit is the large capacitors which are placed across the active device—in this case a transistor. These large capacitors tend to swamp out any reactive changes in the transistor and limit the harmonic output, thereby increasing frequency stability. Since capacitors C2 and C3 are usually much larger than C1 or the variable capacitor (Cv) in the Seiler oscillator, the frequency of oscillation may be simplified to:

$$f_{osc} = \frac{1}{2\pi \sqrt{L\,(C1 + Cv)}}$$

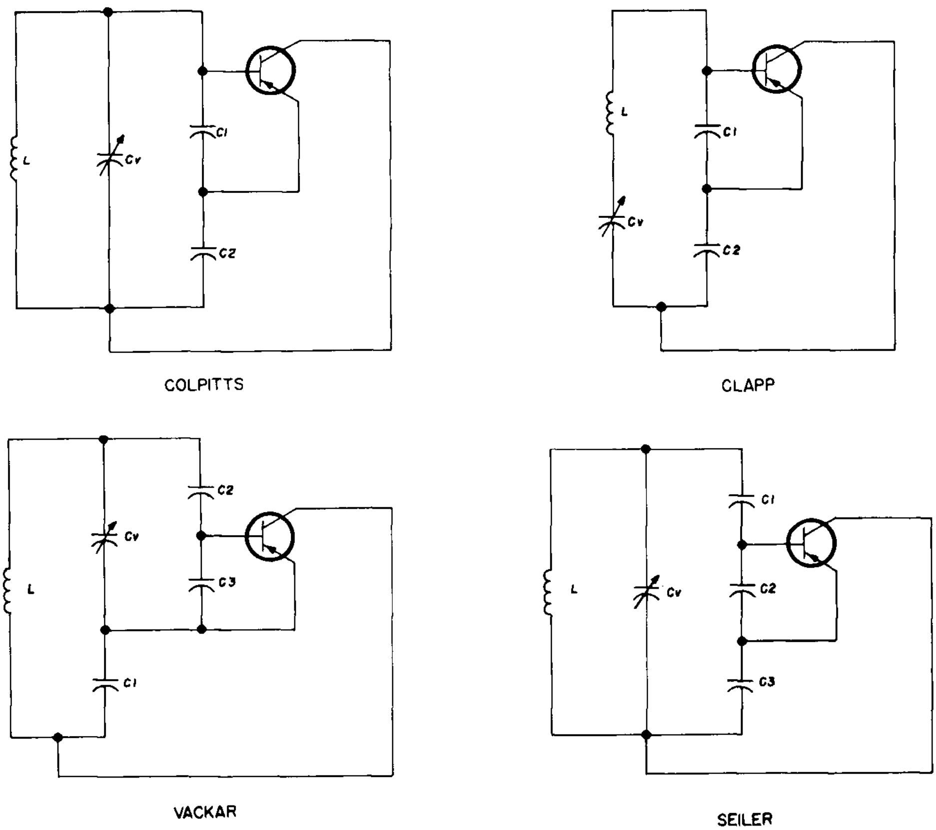


fig. 1. Circuit configurations of the Colpitts, Clapp, Seiler and Vackar oscillators. The Clapp, Seiler and Vackar circuits are derivations of the basic Colpitts circuit.

use a relatively low-C circuit that provided high stability and a tuning range of 1.8:1. A 6F6 was used in the original article, without

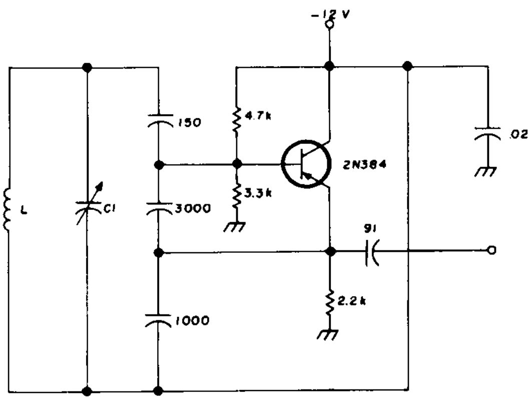
Several vacuum-tube versions of the Seiler oscillator have appeared in the amateur-radio magazines, but in most cases the designers weren't aware that their circuit was an extension of W8PK's original design. In at least one case, the author called his circuit a, "ground-plate Colpitts type."[6]

To my knowledge, the first transistorized version of the Seiler oscillator was W3JHR's "synthetic rock" which was published in **CQ** in 1963.[7] This circuit was extremely popular and subsequently appeared in amateur magazines in England, Germany and South America. W3JHR used an old ARC-5 transmitter as the basis for his VFO; he cut the unit down and used the original variable capacitor and tuning coil to cover the frequency range from 4.9 to 6.1 MHz. Although only the oscillator stage is shown in **fig. 2,** he included a 2N384 emitter-follower buffer for isolation from the next stage.

K9ALD described another transistorized Seiler oscillator for ssb in 1964[8] and claimed exceptionally stable results. His oscillator, designed to cover the range from 4.95 to 5.6 MHz, is shown in **fig. 3.** Because of the relatively low-capacitance characteristics of the 2N2219, the feedback capacitors from base to emitter and from emitter to ground are smaller than those which are usually used in the Seiler oscillator. However, drift was negligible—about 25 Hz after warmup, and that was measured with a digital counter!

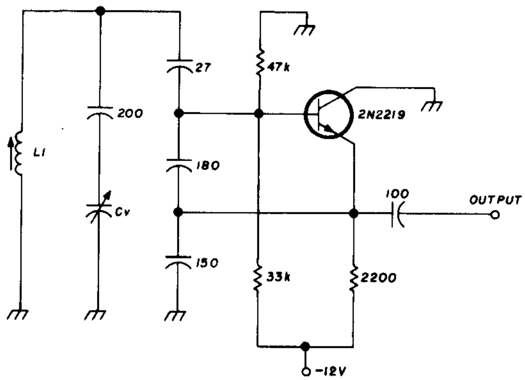
Don't let that 200-pF capacitor in series with the variable capacitor confuse you. It was used to set up the bandspread range of the variable capacitor.

fig. 2. W3JHR's "synthetic rock"—a Seiler oscillator—tunes from 4.9 to 6.1 MHz with tank components from an old ARC-5 transmitter.



Another transistorized Seiler oscillator was described by G3BIK,[9] although he mistakenly identified it as a Vackar. This oscillator used a 2N706 and covered the range from 1.8 to 2 MHz (**fig. 4**). G3BIK reported exceptional stability with this circuit—a change in voltage from 12 to 6 volts results in a 100-Hz change in frequency. He did experience some difficulty with temperature drift, but cured it by using a high-Q coil and silver-mica capacitors and by putting the complete circuit in an enclosed metal box. This doesn't reflect on the Seiler oscillator though—it's good construction practice with **any** VFO!

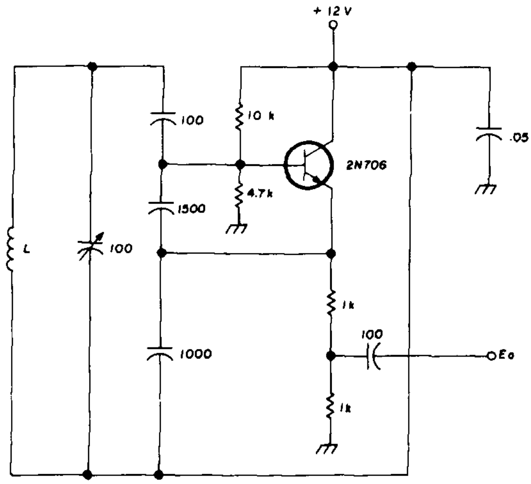
fig. 3. This Seiler oscillator, designed by K9ALD, tunes from 4.95 to 5.6 MHz. Total drift is reported to be 25 Hz. L1 is 2-1/2 turns number 16 on a 1-1/4" ceramic form. Variable capacitor C_v is a 100-pF variable in parallel with an 82-pF silver mica.



Since all the amateurs who have built transistorized Seiler VFO's have claimed such extraordinary results, I thought that an FET would make a good thing better. I was right; the results with the circuit shown in **fig. 5** were nothing short of remarkable! When the circuit was breadboarded on a piece of Vector board, drift was unmeasurable, even with a fresh spring breeze blowing through the window. When the supply voltage was varied from 22 to 9 volts, total drift was less than 1 kHz. This could be cured quite easily by putting a zener diode in the circuit.

The total current drain of this circuit is a little over 4 mA, so a couple of 9-volt transistor-radio batteries would power it for many months of operation. The output is constant within 2 dB over the complete tuning range, 3.49 to 4.01 MHz, so it makes an ideal rf driving source. When it's keyed, there is no chirp or drift; it sounds like it's crystal controlled. It far surpasses any VFO circuit I've ever built, transistor or vacuum tube.

fig. 4. G3BIK's Seiler oscillator covers the frequency range from 1.8 to 2.0 MHz. L1 is 65 turns of number 30 on a 5/8" diameter form.



Seiler design

The design of the Seiler circuit closely parallels the design procedure used for the basic Colpitts oscillator.[10] First of all, choose a transistor that has an f_T several times greater than the frequency you're interested in. Then design a bias network which will put the transistor in the linear operating range. Choose a value of tank tuning capacitance (C_T) from the following formula:

$$C_T = Q/6.28fZ$$

Where C_T is the sum of C_v and C1 (**fig. 1**); **f** is the center of the desired frequency range; **Z** is the impedance of the tank circuit at resonance; and **Q** is the tuned-circuit Q.

For maximum power transfer from the transistor, the tuned-circuit impedance should equal the transistor output impedance and may be approximated from:

$$Z = V_{CE}/I_C$$

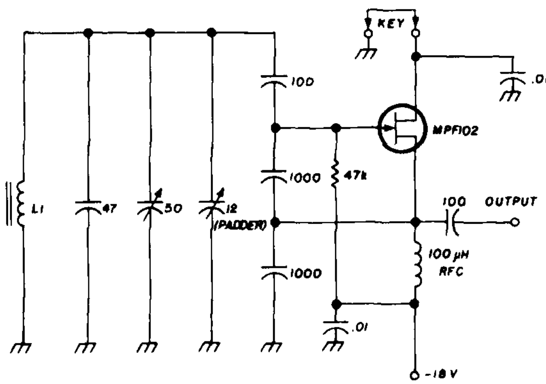
Where V_{CE} is the voltage between the collector and emitter of the transistor and I_C is the collector current.

Choose a value of **Q** as high as possible, because oscillator stability is very closely related to tank-circuit Q. For all practical purposes, the Q of the tank will be determined by the inductance you select, so use the best coil you can. If you have lots of room, air-wound coils are very good; if you're interested in miniaturization, try a ferrite toroid. In any event, when you're calculating for tuned-circuit capacitance, use a value of Q that is attainable in practice.

After you've calculated the total equivalent tank-circuit capacitance that you need, you can choose the coil to resonate in the center of the desired tuning range.

The values of the two large capacitors in the capacitor divider network, C2 and C3 (**fig. 1**), are not critical. However, they should be

fig. 5. Stable Seiler oscillator using an FET. The tuning range of this circuit is 3.49 to 4.01 MHz. L1 consists of 44 turns number 30 on a 1/2" ferrite core (Amidon T-50-2*).



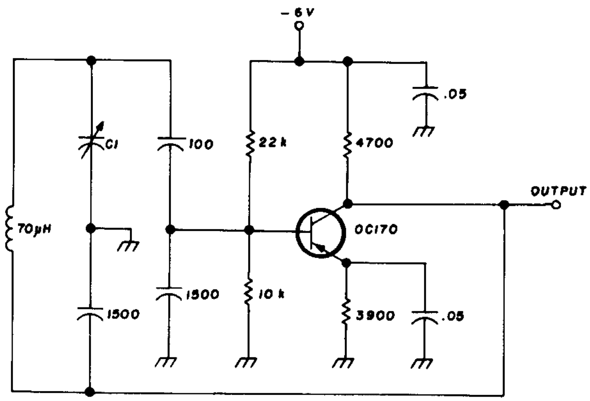
* Amidon Associates, 12033 Otsego Street, North Hollywood, California 91607 (formerly Ami-Tron Associates). T-50-2 ferrite cores are 45c each; minimum order, $1.00. Add 25c for packing and shipping.

quite a bit larger than C1 or the variable capacitor. Typical values range from 150 pF up to several thousand picofarads, depending on the frequency of interest and the gain of the transistor. The rule of thumb to follow here is to use the largest capacitors that will still result in oscillation. If a high-gain transistor is used, these two capacitors are usually equal. If a relatively low-gain device is used, it may be necessary to set the ratio of C3 to C2 less than the current gain of the transistor.

The variable capacitor, C_v, usually consists of a variable in parallel with a padder. The padder can be adjusted so that the variable will cover the desired frequency range. Capacitor C1 determines the amount of drive to the transistor and is relatively small. The best approach here is to start off with about 100 pF at C1 and reduce it until the oscillator ceases to function. Add about 50% to this value as a safety factor for the final value of C1.

This design method will put you in the right ball park with a working oscillator. All that is left is to set the tuning range of the variable capacitor. This is best accomplished on the bench. First, put in a variable that you think will do the job and measure the frequency with your grid dipper. If the circuit covers the frequency range you want, but the tuning range is too broad, reduce the size of the variable and put in some padding capacitors. If the range is about right, but the center frequency is off, change the size of the inductor. With a few minutes work on the bench, you'll have a stable VFO that tunes just where you want it to.

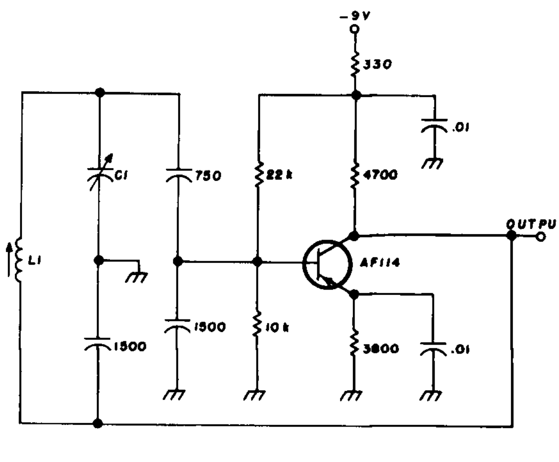
fig. 6. Transistorized Vackar oscillator designed by L. Williams, a British SWL. C1 is a 30-pF trimmer in parallel with a 75-pF air variable.



the Vackar oscillator

The Vackar circuit was another solution to the same problem—to reduce the load on the tuned circuit. In the Vackar, the transistor is again connected across a relatively low impedance and is very loosely coupled to the tuned circut. This oscillator will tune over a frequency range of at least 2.5:1; the output can be made absolutely constant, and, according to Jordan,[1] it has the greatest inherent stability of any known oscillator configuration except for a design with independent

fig. 7. Vackar oscillator design by G5BB for use on 21 MHz. L1 is 19 turns number 22 on a 1/4" form. C1 is a 35-pF air variable in parallel with a 30-pF trimmer.



external load feedback. Those are pretty strong words!

Although the Vackar circuit was originally described in 1949, and publicized, at least in this country, by Clapp in 1954,[4] it has remained virtually unused. W9IK described a vacuum-tube Vackar oscillator built by W9TO[11], and a design appeared in **Radio and TV News,**[12] but that was over ten years ago.

The Vackar oscillator was resurrected when the first transistorized version was published in the **RSGB Bulletin** in July, 1966.[13] This circuit, shown in **fig. 6,** tunes over the frequency range of 2 to 2.5 MHz. The designer reported the prototype "will stay zero beat with a crystal frequency standard for hours."

This article aroused considerable interest in the Vackar oscillator. G3RAE reported[14] that he modified the circuit shown in **fig. 6** for use as a 465-kHz BFO. He increased the inductance to 460 microhenries and changed the tuning capacitor to 100-pF in parallel with a 270-pF fixed capacitor. All other values were the same as shown in **fig. 6.**

Shortly thereafter, G5BB described another transistorized Vackar, this one designed for 21 MHz[15] (**fig. 7**). He experienced some difficulties with temperature drift, but felt they could be cured by putting the circuit in a diecast box. I suspect that replacing the slug-tuned coil with an air-wound inductor would also help.

The latest transistorized Vackar oscillator was described by G. B. Jordan in the February, 1968 issue of **The Electronic Engineer.**[1] He has done a lot of experimental work with the Vackar oscillator and found it to be an extremely stable circuit.

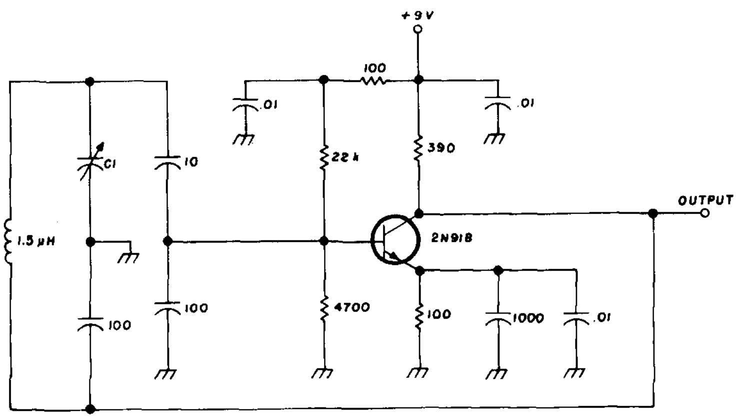
Jordan's circuit, shown in **fig. 8,** is particularly interesting since it was designed to tune from 26.9 to 34.7 MHz, both the CB and 10-meter bands. The output amplitude varied 1.5 dB over the frequency range, and the temperature drift was linear from +20 to +100°F. When he compensated the circuit with N750 capacitors at C1 and C3, temperature drift dropped to 10 Hz per degree F. Further compensation would reduce drift to negligible amounts.

Since I had such good luck with the FET version of the Seiler oscillator, I tried the same thing with the Vackar (**fig. 9**)—again, the results were fantastic. Stability was at least as good as the Seiler; drift was negligible, and the keyed note was crystal clear. I went on to add an FET buffer stage, a 2N706 driver and 1-watt 2N697 final. Still no chirps or drift.

Although this circuit was designed to cover the range from 3.5 to 4.0 MHz, by reducing the number of turns on L1, the same basic design could be used as a remote 5-MHz ssb VFO or 8-MHz VFO for vhf use.

Except for output amplitude stability, could detect **no** difference between the Seiler and Vackar circuits. Perhaps with a counter and a controlled temperature environment, different drift characteristics would be apparent, but in the typical amateur environment, there doesn't seem to be any detectable difference. As far as amplitude stability goes, with the Vackar circuit, the output level

fig. 8. This Vackar oscillator designed by G. B. Jordan tunes from 26.9 to 34.7 MHz. C1 is a 12-pF air variable in parallel with a 6.2-pF silver mica.



changed less than 1 dB over the range from 3.5 to 4 MHz; the Seiler output varied slightly less than 2 dB. This is a pretty small difference.

Vackar oscillator design

As with the Seiler circuit, design of the Vackar is very closely akin to Colpitts design. Since the frequency of oscillation is determined essentially by the value of the variable capacitor and C2, these variable capacitors may be taken as the total tank-tuning capacitance. With this in mind, the tank-tuning capacitance and inductor are chosen by the same method we used for the Seiler circuit. Capacitors C2 and C3 are found from the following formula:

$$C2 = C3 = 3000/f \text{ (MHz)}$$

According to Jordan, this formula yields about optimum oscillator stability compatible with other requirements. Capacitor C1 is adjusted so that the transistor operates essentially class A and is not driven into cutoff or saturation. In the circuit in **fig. 8**, with 10 pF at C1, the peak-to-peak voltage at the junction of the variable capacitor and the inductor was 1-1/2 times the B+ supply. This is a good rule of thumb to go by when you're designing an oscillator of this type.

Most of the authors who have described transistorized Vackar and Seiler VFO's have noticed a tendency for these circuits to oscillate at audio frequencies. Since the feedback loop from the collector to the base of the transistor is through the power supply, the base-bias resistors should be decoupled from the collector resistor by a bypassed resistor as shown in **fig. 8.** Another precaution used by Jordan was to bypass the emitter for both audio and rf, although this may not be necessary.

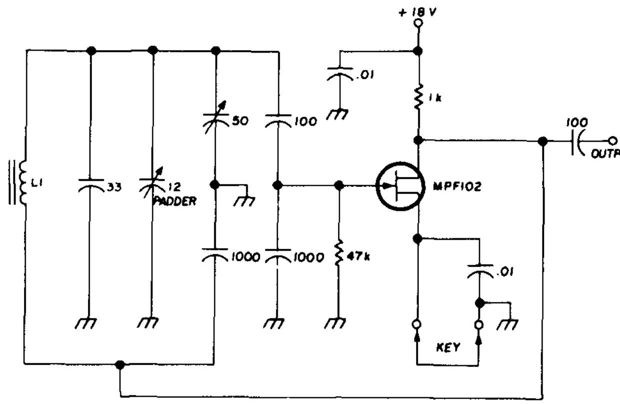


fig. 9. FET version of the Vackar oscillator is extremely stable. L1 is 48 turns number 30 on a 1/2" ferrite core (Amidon T-50-2)

summary

Both the Seiler and Vackar circuits are similar in design and, from my experiences with the FET versions, similar in stability and output. The original tube-type Vackar circuit used high-C tuning whereas Seiler designed for low-C tuning; the high-C was provided by a large trimmer across the main tuning capacitor. There **may** be some advantages to the Vackar circuit for very wide tuning ranges and some advantages to the Seiler when the low-C approach is used, but for amateur VFO's I doubt if there is any significant advantage with either circuit. With both of these circuits, stability is independent of the LC ratio, and not very dependent upon the transistor used.

All of the designers of the circuits shown here have indicated exceptional performance and stability with them. If you have done any experimenting along these lines, I would certainly like to hear about it—both of these circuits have been buried in the literature long enough. They seem ideal for transistor work, easy to design and a good choice the next time you're thinking about a new VFO.

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ham radio

some interesting aspects of increased solar activity

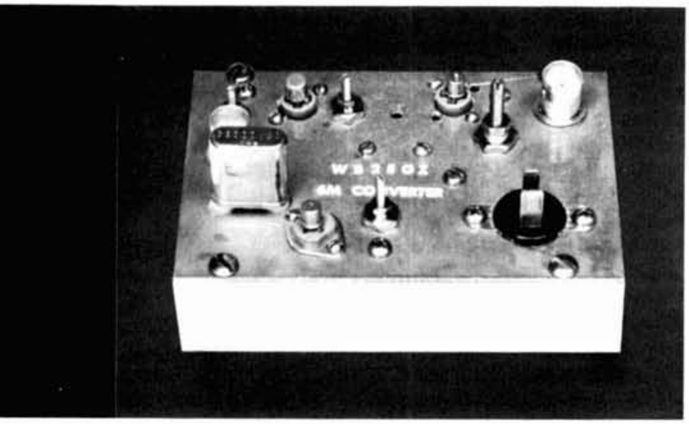
The present upswing in the sunspot number is expected to reach its peak in the very near future, probably at the end of 1968. It is commonly known that an increase in the number of sunspots will result in a marked over-all improvement of short-wave radio communications. However, during periods of increased solar activity, a prolonged deterioration of propagation conditions is very often experienced. This frequent disruption in radio communications is produced by gigantic flares that originate within the sun. Since the number of sunspots and the probability of solar flares are directly related, poor short-wave communications may be often expected during periods of high sunspot numbers.

A solar flare releases electromagnetic radiation, delayed by 8.3 minutes; cosmic-ray particles, delayed from 15 minutes to several hours; and magnetic-storm particles, delayed between 20 and 40 hours. The electromagnetic radiation is in the form of visible light, radio waves, ultraviolet rays, and x-rays; some of the immediate effects are occasional F-layer increase, frequent E-layer increase, and D-layer increase. Cosmic-ray and magnetic-storm particles cause delayed effects, such as magnetic storms, ionospheric storms, auroras and a general increase in cosmic-ray radiation.

Besides the well-known "radio blackouts," solar storms produce an increase in earth currents which may cause drastic power-line voltage variations and over-heating of conductors. Power-line voltage fluctuations as much as 108 to 117 volts have been recorded. Corrosion and conductor vibration in areas of high ionization have also been correlated to magnetic storms. With the increase in system voltages and the increasing importance of system reliability, the nature of space plasmas and their associated phenomena on utility systems present a most important study for future utility system design.

As far as amateur radio is concerned, it must be borne in mind that a high sunspot period means "good DX conditions," but at the same time, you should anticipate severe and frequent short-term communications disruptions. The probability of an actual power-line failure is highly unlikely.

Joe Mikuckis, K3CHP



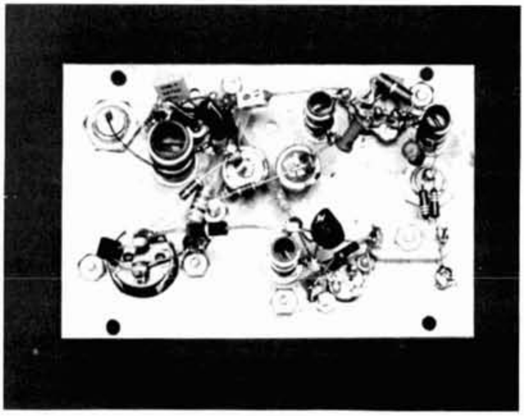
the WB2EGZ six-meter mosfet converter

Construction details for a low-noise, high-gain converter for six meters that out-performs designs using vacuum tubes or bipolar transistors

Don Nelson, WB2EGZ, 9 Green Ridge Road, Ashland, New Jersey 08034

What's this we hear about MOSFET'S? Are they just a laboratory phenomenon? Do they burn-out with the flick of a finger? Are they priced for the idle-rich? Is their frequency response a limiting factor?

Never have I, as an experimenter, been so excited about a device as I am about the MOSFET (metal oxide semi-conductor, field-effect transistor). Immediate success with a simple six-meter converter has prompted my sharing a design which is almost certain to work for anyone with some talent for tinkering.



the MOSFET

Let me digress from the converter for a moment to talk about the MOSFET. Frequently, and possibly more correctly, the device is called an insulated-gate, field-effect transistor (IGFET). The reasoning behind this terminology is that there is no junction between the gate and the channel such as is the case with the junction field-effect transistor (JFET).

Most hams are more familiar with the JFET because of the vast number of magazine articles using the TIS34, MPF102, 2N3819, etc. The MOSFET's used here are similar to the JFET in that they operate in the depletion mode; that is, a negative voltage on the gate reduces the width of the channel, and increases the resistance between the source and drain.*

In the MOSFET, the semiconductor channel is isolated from the gate by a metal-oxide layer, and the change in channel width is controlled by an electrostatic voltage across that layer. The input resistance is considerably higher than a vacuum tube and also higher than the JFET. The feedback capacitance from output to input is considerably lower than that of a tube or JFET. As you will see later, this is a distinct advantage.

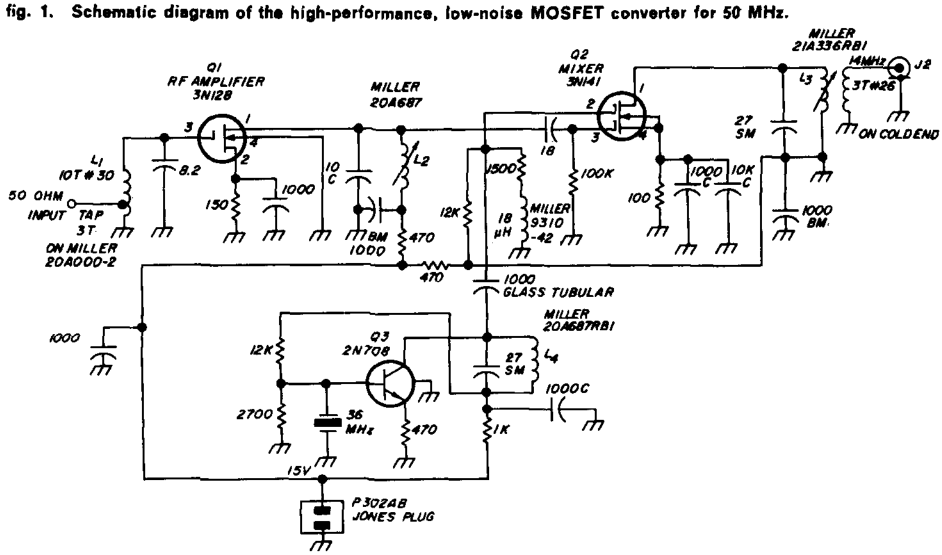
* There is a second kind of MOSFET where the channel width increases with positive gate voltage; this is an enhancement type.

The MOSFET's intrinsic input impedance may work to a disadvantage if the gate has no ground return; voltages which are high enough to destroy the transistor may develop without it. Static burnout, as the condition is called, may also occur by touching a charged body to the open gate. On the other hand, static burnout is almost impossible with any return path for the gate–even several hundred megohms.

A little extra care in handling the MOSFET will pay dividends; remember the following tips:

1. If the leads have to be cut, hold the lead and transistor case with one hand to reduce mechanical shock and possible static discharge.

fig. 1. Schematic diagram of the high-performance, low-noise MOSFET converter for 50 MHz.



2. Never insert or withdraw the transistor when power is applied to the circuit.

3. If the transistor is to be soldered in the circuit, the soldering iron must be grounded (three-wire system).

I have yet to burn out a MOSFET–touch wood!

converter design

Simplicity makes this converter an almost unbelievable circuit. Only three inexpensive transistors are used, and the number of tuned circuits has been minimized. Without a junk box you may pay as much as $25 for parts,

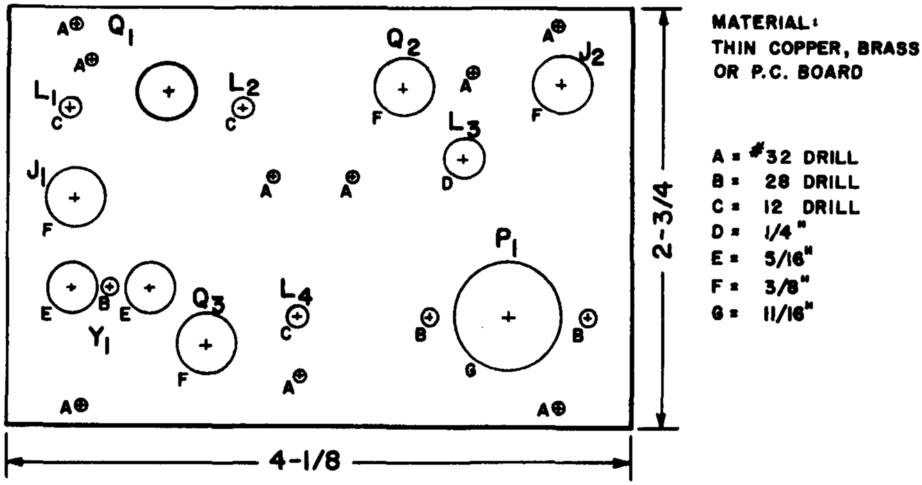


fig. 2. Chassis layout for the 50-MHz MOSFET converter. A full-size drill template is available from ham radio magazine for 25c and a self-addressed, stamped envelope.

but most hams will pay less.

The first stage, an rf amplifier, uses a 3N128 which is an N-channel triode (**fig. 1**). Both the input and output are tuned, but no neutralizing link is needed. The internal feedback capacitance is low enough so that the stage is stable as long as the source (antenna) and load (mixer stage) are properly matched. A trap may be needed to reject interference from Channel 2 if there is a station near you; the 58-MHz trap used in the **ARRL Handbook** Nuvistor converter would be suitable.

A typical noise figure for the 3N128 is 3.5 dB–this is in line with most good transistors, and superior to the Nuvistor. Evidently, the 3N128's I tried are even lower than the advertised figure. Because of the high gain of the 3N128 at 50 MHz, we can get away with only one rf stage. According to reports, the MOSFET is about ten times better than the bipolar transistor with respect to cross modulation and has 25 times the dynamic range. These characteristics compare favorably with tubes.

The mixer is an N-channel tetrode MOSFET, type 3N141. This is the most expensive transistor in the converter and costs $1.55. While tetrodes were originally developed to improve the cross-modulation characteristic of the MOSFET in front-end circuits, the mixer application is equally rewarding.

The construction of the device is similar to two MOSFET triodes in series. That is to say, the drain of one channel is internally connected to the source of the second channel. The gate of the second channel must be biased positive for proper operation by the resistor divider connected to pin 2. That gate also receives the output from the local oscillator, so a choke is necessary in the ground link of the dc divider to prevent rf attenuation.

Gate 1 (pin 3) accepts the output of the rf amplifier which is mixed with the local oscillator to provide the 14-MHz output. This mixer circuit is superior to any transistor circuit, either JFET or bipolar, that I have tried. The noise figure, conversion gain, and cross-modulation characteristics are excellent, challenging the best features of tubes and transistors.

There is nothing sacred about the oscillator circuit. The transistor shown in the photograph is actually a 2N2708, but the RCA40237 is less expensive and an equal performer.

construction

A simplified chassis hole-center layout (**fig. 2**) may be used to reduce construction time. Sockets were used and are recommended. In as much as the MOSFET is a high-impedance device, tanks may be dipped with the transistors in their sockets. Only slight touch-up will be required when the receiver is turned on.

Peaking the oscillator coil may cause hard starting. Should this happen, apply power, detune L_4 until the oscillator starts, and secure the slug at that setting.

testing performance

As you may have guessed by now, I have been impressed by the tube impersonator called a MOSFET. Test equipment was not available for sophisticated measurements of gain and noise figure on the converter, but a few observations were made:

1. The converter is noticeably quieter than the **ARRL Handbook** converter which uses a neutralized 6CW4 Nuvistor.

2. With the noise level set to S1, signals are about 6-dB greater (one S-unit) using the WB2EGZ converter.

3. No overloading or cross modulation has been detected at signal levels where bipolar transistors have failed miserably.

From the experience gained with MOSFET's on six-meters, I'm ready to try some experiments on my favorite band–two meters. If successful, I shall share the results with you.

ham radio

transistor-tube talk

If you're used to tube-terminology, you're probably often confused by transistor terms. Here is a little play on words that can be used to keep them straight. For those of you who are studying for the advanced or extra-class exam, this is a big help if you don't feel at home with transistors.

Let's review some tube terms first. A triode has three parts or elements: cathode, grid and plate. A transistor also has three parts—the emitter, base and collector. If you'll remember the function of each element, the comparison is simple.

The cathode of a tube **emits** electrons and the **emitter** of a transistor is the corresponding element. The key word is "emits." Carrying this a bit further, electrons are **collected** by the plate of a vacuum tube, so the transistor **collector** corresponds to the plate. The key word here is "collects."

This leaves the grid. As you all know, bias controls the action of the tube. The key word is "bias." Sounds like **base** doesn't it? So, *that's it—the base is equivalent to the grid.*

From these simple word similarities, it should be easy to remember that:

1. A grounded-cathode tube cricuit is the same as a grounded-emitter transistor circuit.

2. A grounded-plate or cathode-follower circuit is the same as a grounded-collector or emitter-follower transistor circuit.

3. A grounded-grid tube circuit is the same as a grounded-base transistor circuit.

Just remember that the function of a vacuum-tube element is the key to its transistor equivalent. Score one for the advanced test.

George Haymans, W4NED

next month in ham radio magazine:

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Oscillators are not peculiar to single-sideband. They exist in all ham-radio equipment. Nor does single-sideband use oscillators that are any different, except that they should be extremely stable; the sideband relationships (to one another) have to be maintained consistently throughout a transmitter or receiver. Likewise, when the carrier is re-inserted by the bfo, that oscillator must be steady as a rock and right on frequency, or the recovered voice modulation won't sound much like the original.

There is another reason why you should understand oscillators in single-sideband. There are simply more of them. One fairly elaborate ssb receiver has five oscillators. In a typical exciter there may be that many, too, depending on how many frequency translations there are. At the very least, there will be two or three in a transmitter, and the same in a receiver.

The block diagram in **fig. 1** illustrates a transmitter that uses four different oscillators. Another, of similar design, also has an audio oscillator for A2 transmission and for testing. In **fig. 2** you see a receiver design that uses five different oscillators. In a transceiver, you may find some of the oscillators shown in **figs. 1** and **2** are combined, so that the overall transceiver may have only six or seven oscillators—maybe even fewer.

Somehow, oscillators have gained a reputation for being hard to understand. They are not, provided you are aware of certain principles. When you're trying to make one work that won't, you can simplify your troubleshooting by understanding what makes an oscillator tick.

Fig. 3 shows the four things it takes to make an oscillator. They are: amplification, dc power, feedback, and tuning. The differences among all the many oscillators that exist are in how each of these four jobs is accomplished. You can learn to classify the oscillator type by noticing how each function takes place. For example, a Colpitts oscillator, even though crystal controlled, derives feedback from a capacitive divider network—two capacitors in series, with a feedback tap-off between them. A Pierce crystal oscillator, on the other hand, has the crystal connected between plate (or screen grid) and control grid, providing feedback and tuning simultaneously. The Hartley uses a tapped coil for feedback.

Amplification is handled by a tube or a transistor. The **dc power** is merely to keep the transistor (or tube) working. The method by which these operating voltages are applied is usually the chief consideration whenever you think about or describe an oscillator.

The most important factor, so far as oscillation is concerned, is the **feedback.** Without

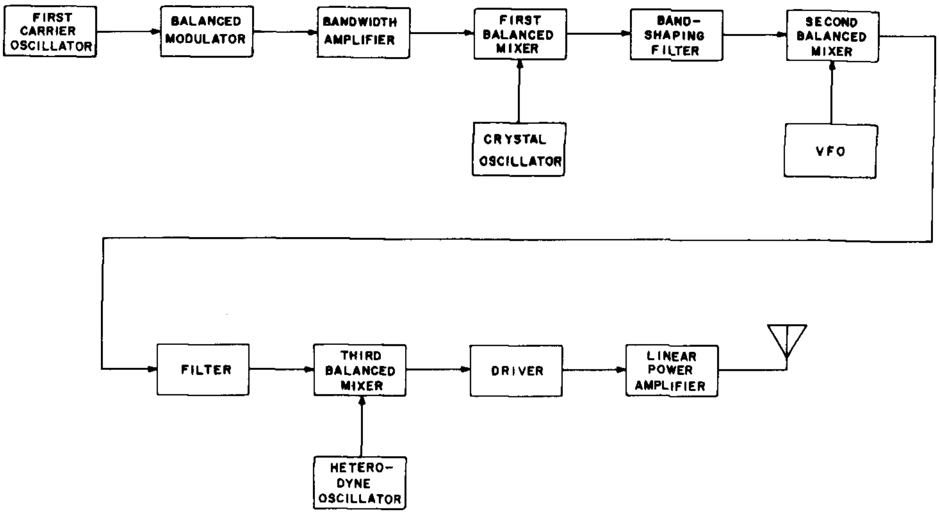


fig. 1. Block diagram of a ssb transmitter with four separate oscillator stages.

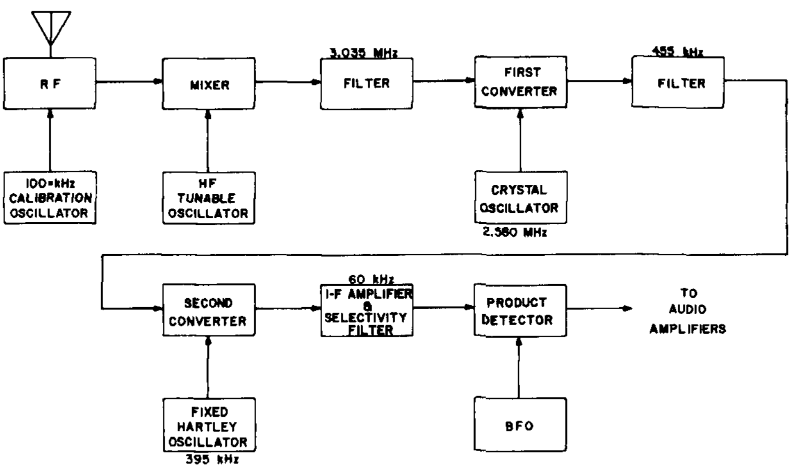
it, the tube and its dc operating voltages would form nothing more than another amplifier. The feedback takes some of the output **signal** voltage of the amplifier stage and feeds it back to the input in such phase that it is re-amplified. The signal is thus self-sustaining. You wouldn't want this action in a normal amplifier tube, but it is the essence of oscillator action.

Finally, the matter of **tuning.** It is of little value to have a circuit oscillate unless it is at some frequency you can use. The form of tuning in the oscillator often determines what kind of oscillator it is—what name it goes by. Tuning also affects how efficient or stable the oscillator is.

Keep in mind, then, that you can learn to recognize any oscillator by its characteristics in each of these four factors: the type of amplification, the method of applying dc operating voltages, the way feedback is developed and applied, and how the oscillator is tuned.

Rather than go into all the different possible combinations of these four requisites, it's more practical to examine typical circuits that use them. We'll begin with the most popular oscillator in all of single-sideband equipment—the Colpitts.

fig. 2. This communications receiver uses five different oscillators.



Colpitts—crystal and variable

The uses for this versatile oscillator are many. In different brands, you'll find it in one form or another as a vfo, as the carrier generator in a transmitter, and as a linear master oscillator (LMO) for transceivers. You'll find it both crystal-controlled and variable in frequency.

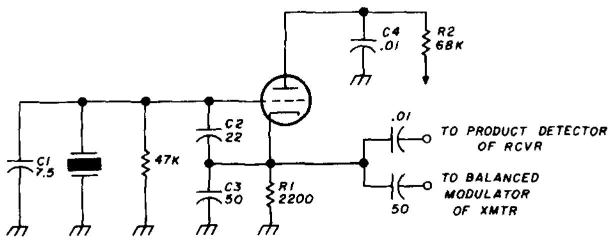
There are several reasons why the Colpitts oscillator is so popular. Mainly, it is stable over a wide range of frequencies. Because a capacitive divider is used, the ratio of feedback voltage remains approximately constant, since the reactance **ratio** between the two capacitors stays the same regardless of frequency change.

Fig. 4 shows the common crystal-controlled version. A triode tube is the amplifying device, although a pentode tube or a transistor could be used just as well. Feedback is developed in capacitive divider C2–C3, and fed to the cathode. The dc connection is typical. Voltage is applied to the plate through R2; the plate is grounded for rf by capacitor C4. If the tube is a pentode, a dc screen supply is provided.

The tube is grid-driven, and output is taken from the cathode. This offers lower output impedance than a plate-output arrangement. In a few models, particularly if a pentode is used, which offers better isolation between input and output circuits, you'll find conventional tuned-tank output arrangements. In the Heathkit linear master oscillator, for example, output is taken from a broadly tuned rf transformer. B+ is fed to the tube through the primary winding of the transformer.

As in all crystal-controlled oscillators, the tuning is accomplished by the crystal itself. The feedback arrangement can easily be designed to force the crystal into operation on an overtone (harmonic), which is desirable in some transmitters and receivers. Sometimes, where cathode bias isn't needed, an rf choke is used in place of the cathode resistor R1. This offers a high impedance to rf, and yet almost no resistance to dc plate current.

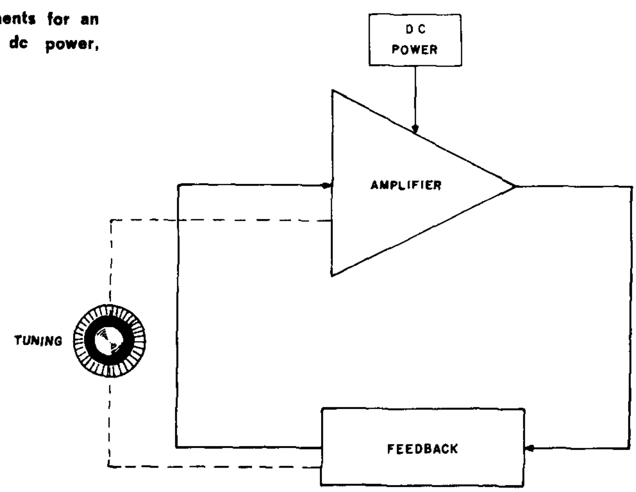
fig. 4. Crystal-controlled Colpitts oscillator.



In some transmitters, the frequency of the crystal is "warped" onto precise frequency by a capacitor—C1 in **fig. 4.** This is done only where frequency is critical, since the "raw" accuracy of a crystal is usually enough for ham work. The capacitor may even be adjustable.

Colpitts oscillators of the tunable variety

fig. 3. The four requirements for an oscillator: amplification, dc power, feedback and tuning.



generally use pentode tubes, which offer better input-output isolation. **Fig. 5** shows one of the most elaborate. Besides the basic tunable Colpitts oscillator, special innovations make this crcuit doubly interesting. The exceptional stability and linear operation of this particular circuit over a range of frequencies makes it particularly attractive for linear master oscillator (LMO) service in transceivers.

The pentode is generally a high-mu type with remote cutoff characteristics—the kind used frequently in television-set i-f strips. The 6CB6 and 6BZ6 are popular for this. In one version, the tube is operated as a tetrode, with positive voltage applied to both screen and suppressor grids.

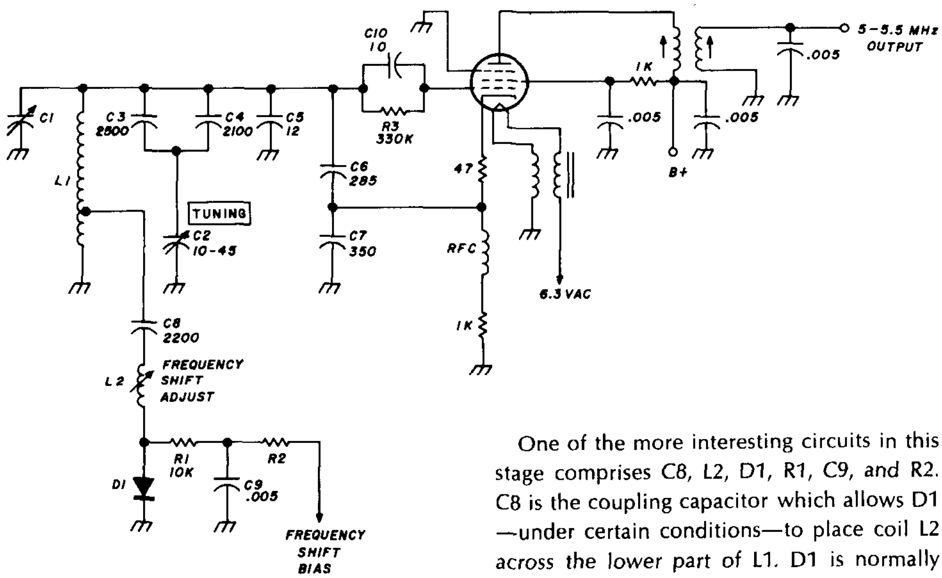
Despite all the elaborate devices for tuning, retuning, coupling, and decoupling, the basic Colpitts configuration is easy to recognize. Capacitors C6 and C7 between grid and ground develop the feedback voltage. The tap to the cathode is the giveaway. An rf choke keeps the cathode well above rf ground, so the feedback can be applied.

An unusual form of grid bias is used in this example, although not in most similar Colpitts circuits. Grid-leak bias is developed in RC network C10–R3.

Capacitor C2 is the main tuning capacitor, and C1 is the trimmer. C3, C4, and C5 are temperature-compensating capacitors; they make sure the oscillator stays at whatever frequency it's set for. To make sure the oscillator does not interact with other rf stages, elaborate decoupling is included. Besides the usual screen-grid and plate-supply decoupling, the filament lead has a bifilar-wound choke. Even when one side of all filaments is grounded, a choke is placed in series with the hot filament lead, with a capacitor to ground.

Output from this version is through a bandpass transformer in the plate circuit. Others use cathode-follower output, and one (in Collins equipment) uses a tapped plate coil and a coupling capacitor.

fig. 5. Variable-frequency oscillator using the Colpitts circuit.

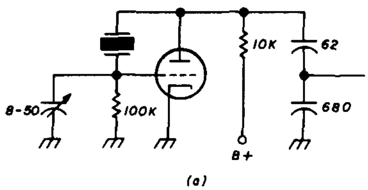


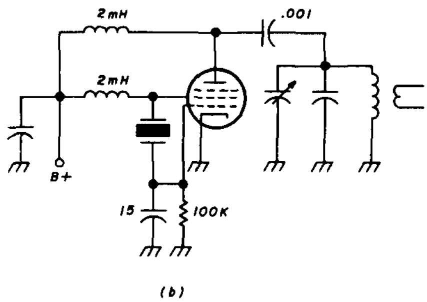
One of the more interesting circuits in this stage comprises C8, L2, D1, R1, C9, and R2. C8 is the coupling capacitor which allows D1 —under certain conditions—to place coil L2 across the lower part of L1. D1 is normally reverse biased and therefore offers a high impedance. When frequency-shift bias is applied at the end of R2, however, the positive voltage makes D1 conduct. While it is conducting, it effectually grounds the lower end of coil L2, thus placing it across L1. This change in inductance shifts the oscillator frequency just enough to switch the receiver or transmitter to the other sideband. Normally, the oscillator runs at a frequency that produces upper-sideband operation. When the frequency-shift voltage is applied, oscillator frequency is lowered and operation switches to the lower sideband.

In practically all versions of the tunable Colpitts oscillator, frequency determination is in the grid circuit. The output is broadbanded. In most cases you'll find the frequency range covered by the oscillator is limited, particularly in ssb equipment. The way output frequencies are developed in single-sideband transmitters (by translation) makes it unnecessary for the carrier-generator oscillator to cover a very wide range.

Summarizing, then, you can see that factor No. 1, amplification, is provided by a triode tube in most crystal-controlled Colpitts oscillators and by a pentode tube in most variable-tuned Colpitts circuits. Factor No. 2, dc power, is generally applied to the plate through a resistor or a transformer winding, even in stages that use cathode-follower outputs. Grid bias may be either by a cathode resistor or by grid-leak bias; in a few it is developed by natural grid current in a high grid resistance. Factor No. 3, feedback, is invariably developed in a Colpitts by a capacitive divider from grid to ground, with the cathode tapped in between the two capacitors. The cathode is kept above rf ground by a resistor or an rf choke. Factor No. 4, tuning, is either by a crystal or a tuned circuit from grid to ground. In the latter case, always keep in mind that the feedback capacitors are in parallel with, and form part of, the tuned circuit. The value of any replacement capacitor in the grid circuit of a Colpitts is quite critical.

fig. 6. Two versions of the Pierce crystal oscillator.





second most popular—the Pierce

This oscillator is popular because of its simplicity and stability. It uses a triode or a pentode, connected normally, with a crystal providing both feedback and tuning. The crystal is connected from plate to grid with a triode, and from screen grid to control grid with a pentode. Because of the accuracy and resonant efficiency of a crystal, a Pierce oscillator holds its frequency well over wide variations of dc input voltage. It isn't likely to drop out of oscillation unless plate or screen voltage becomes **extremely** low.

You'll find the Pierce in both transmitters and receivers; it's often used as a heterodyne oscillator for raising frequency in transmitters, and as a frequency-conversion oscillator in receivers. The simplest version, a triode, is shown in **fig. 6A.** The only elaboration is a frequency-warping capacitor connected between the grid end of the crystal and ground. It permits fine adjustments of the crystal's resonating frequency.

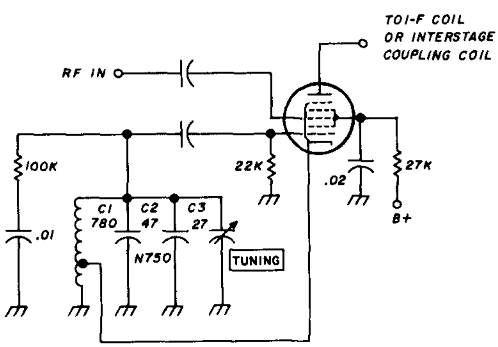
The output of a Pierce oscillator is usually rather strong. This is the reason for the capacitive-divider output network, which gives a ten-to-one reduction in rf voltage fed from this particular oscillator. This version is used in some receivers as a frequency-control oscillator, with output fed to the second mixer, and in at least one transmitter as a heterodyning (frequency-translation) oscillator.

Fig. 6B shows a pentode version of the Pierce oscillator. The dc supply is conventional; some versions use cathode bias while others have the cathode grounded. In either case, the cathode is always kept grounded for rf.

Output is from the plate. Since the tube is a pentode, the plate is isolated from the frequency-control network. The output arrangement shown is a little off-beat; it is called impedance coupling. The choke from plate to B+ is the untuned plate load. A coupling capacitor feeds the rf voltage to the tuned circuit, part of a transformer. Coupling to the next stage is inductive. Another version uses simple RC coupling—a resistor supplies dc plate voltage and acts as output load, with a capacitor coupling the rf signal to the next stage.

Both plate and screen in this stage are fed through rf chokes, which offer some load for rf developed in the plate-current stream of the tube. The screen grid may sometimes have a capacitor tying it to ground, but is

fig. 7. Although this Hartley oscillator is part of a pentagrid converter, the same circuit may be used with an electron-coupled oscillator.



very seldom completely grounded for rf; if it were, feedback couldn't take place from the screen grid to the control grid through the crystal. In the version shown, the screen is not bypassed at all; only a small stabilizing capacitor is connected between the control grid and ground.

There is one version that operates as a cathode follower, with the output tuned circuit in the cathode circuit. Output arrangements have no bearing on the "type" of oscillator. The Pierce gets its identification from the fact that it is controlled by a crystal between the plate and grid. In pentode versions, the screen grid is operating as a plate, not as a screen grid in the usual sense. (That's why it's not thoroughly bypassed for rf.)

the tapped-coil Hartley

This oscillator is distinctly recognizable because the tube's cathode always goes to ground through a tap on a coil (see **fig.** 7). The other end of the coil almost invariably is connected through a capacitor to the grid. The Hartley oscillator is uncomplicated and stable and is used extensively for tunable applications. There is a crystal-controlled version, but it is rarely used in modern ssb equipment.

The version in **fig. 7** is part of a pentagrid converter; the same circuit can be used as an electron-coupled oscillator. The Hartley is found in both receivers and transmitters. In one transmitter, it is the first carrier generator, operating at 60 kHz; in another, the second conversion oscillator, operating at 395 kHz.

The oscillator plate in the tube of **fig. 7** is the double grid, grids 2 and 4. This oscillator plate doesn't have to be left ungrounded for rf, since the control grid modulates the entire electron stream. The rf from the previous stages—from a station or a transmitter stage—is fed in at grid 3. Grid 4 (part of the double grid) acts as a shield for the rf input grid, very much like the screen grid in an ordinary pentode.

The tapped coil that sets up the feedback is always a part of the tuning circuit. The tank capacitors include tuning capacitor C3, temperature-compensating capacitor C2, and main frequency-determining capacitor C1. All affect frequency. In some circuits, C1 may be a trimmer, and occasionally the temperature-compensating capacitor is omitted.

the rest of them

Another simple oscillator used in single-sideband equipment is the tuned-plate-crystal-grid oscillator, sometimes called simply **tpxg.** This one commonly appears as the first receiver oscillator in double- or triple-conversion receivers—named, in that application, the heterodyne oscillator.

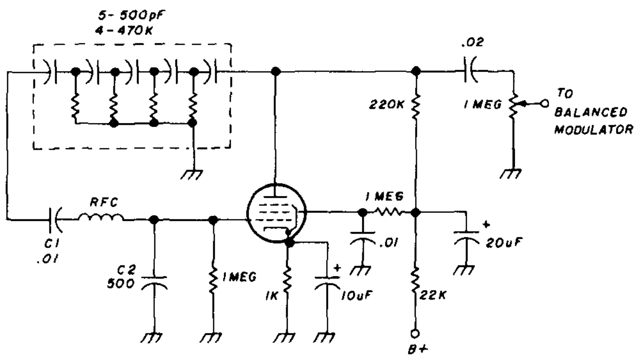
Triodes are always used, because tpxg oscillators depend on interelectrode capacitance for feedback. The screen grid in a pentode would shield out this Miller effect and keep the tube from oscillating. The crystal is connected from grid to ground. A frequency-warping capacitor or coil can be used with the crystal, although it seldom is.

The dc voltages for the tube are conventional. The cathode may be either grounded or above ground (for cathode bias). In most tpxg oscillators, bias is in the form of grid-leak or "contact" bias across a fairly large-value grid resistor.

Output circuits vary just as much as with any other oscillator. Sometimes a broadband coil is used as the load, with a small capacitor coupling the oscillator output. Occasionally, inductive coupling is used, again with a broadband transformer.

This kind of oscillator is especially suitable for overtone operation—running the crystal at (usually) three times its normal frequency. This kind of operation may be necessary in the front end of a ham receiver, and that's why this circuit is not at all uncommon as the up-front heterodyne oscillator. Sometimes, particularly when cathode bias is used, the crystal is separated from the grid by a blocking capacitor. If grid-leak bias is used, there is no need for this.

fig. 8. An 800-Hz audio phase-shift oscillator.



Occasionally, there is reason to use a tone in a single-sideband transmitter—for testing or for A2 code transmission. **Fig. 8** shows an 800-Hz phase-shift oscillator. There are any number of other audio oscillators that can be used, but this one is exceptionally stable and its frequency is independent of output load. This latter characteristic makes it excellent for tone keying.

Feedback is via a printed component circuit (PEC) consisting of five capacitors and four resistors. As they are arranged, they give a phase shift that is almost adequate to sustain oscillation at 800 Hz. Capacitors C1 and C2 and the rf choke complete the job. The result is extremely stable audio oscillation. The output is RC-coupled to a buffer amplifier via a volume control that determines how much modulation will be developed.

what to look for next month

That's the story of oscillators in single-sideband equipment. There are other circuits just as interesting, and often more difficult to understand. We plan to cover most of them in this series on single-sideband.

The method of single-sideband generation in most of today's ssb transmitters is the **filter** method. A balanced modulator, which has already been explained, forms a double-sideband suppressed-carrier signal which is then pushed through a filter that removes one or the other of the sidebands. However, there's another way, called the **phase-shift** method.

Although the phase-shift method is almost never used in commercial ham gear, many readers have wondered about the principles behind it. It is sometimes less expensive than the filter method—particularly at high frequencies, because there is no need for stages of frequency translation. If the suppression ratios were improved, and the circuits made easier to adjust, phase-shift ssb might catch on. Next month, we'll explain how the method works, and give some pointers on making adjustments to this type of ssb generator.

ham radio

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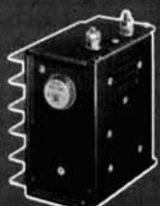

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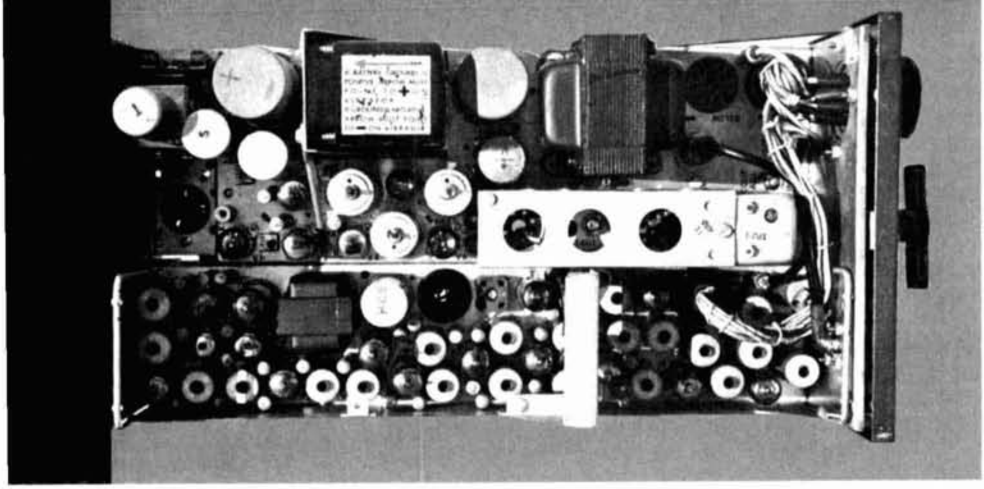


amateur vhf fm operation

An introduction to amateur fm operation on 144 and 432 MHz, including base stations, repeaters and accessories

John Connors, W6AYZ, 920 Sir Francis Ave., Capitola, California 94720

This article was written to introduce you to the wonderful world of amateur vhf fm communications. There are a number of books on the market which will explain all the technical aspects of the subject to you; the purpose of this article is to consider fm seriously as a dependable, local communications mode with many advantages over a-m. You will meet some of the various types of equipment in common use and some of the fascinating mutations developed by commercial and amateur users in their quest for reliability and convenience.

Amateur fm owes its very existence to the commercial fm two-way radio used by the mobile services such as police, fire and taxi. The first equipment that the commercial users used on a large scale was designed for wide-band fm. The transmitter was deviated plus or minus 15 kHz from the center frequency. Most of this early equipment was also designed for a six-volt supply.

Commercial two-way radio caught on big however, and the FCC was forced to alter their requirements to what is now called narrow-band fm; the transmitter is only deviated plus or minus 5 kHz from the center frequency. This rules change provided more channels through closer spacing and made all the old equipment obsolete. To help matters further, the automobile manufacturers decided that twelve-volt ignition systems were more practical than six-volt systems. Result: more obsolete commercial fm equipment. Now, vacuum-tube equipment is being phased out by solid-state units. The result is a lot of low-cost fm equipment for the interested amateur.

why use fm?

As you may have guessed, the first big advantage of fm for the ham is availability. Commercial users couldn't use much of the older equipment, and no one was willing to buy it. As a result, many equipment owners and manufacturers turned to the amateur market as a way of saving some of their original investment. The second advantage is price. For the price of a good a-m transceiver, you can buy four or five fm transceivers with high-quality receivers and transmitters.

The Link decoder. Although these units are stubborn at times, they are often used as a command decoder and work quite well as a selective-call decoder.

For mobile operation, fm units mount in the trunk and are remotely controlled from the front seat. For weak signals, fm is always more understandable than a-m. Receivers won't drift off frequency since since they are crystal controlled. Positive noise-sensing squelch circuits surpass anything found in a-m gear and completely silence the speaker until a signal is received.

Ignition and other forms of interference which cause a lot of trouble with a-m operation don't affect fm; a typical mobile installation rarely needs any noise suppression. Another big advantage is reliability. Commercial equipment is built to run continuously and take a lot of abuse while doing it. Mobile units can bounce around in a trunk for years with no failures, and base stations require little maintenance.

how to get started

You can begin your search for fm equipment and information by writing to the Lynchburg Amateur Radio Club* for a list of active fm nets or groups in your area. The California Amateur Relay Council** will provide legal and technical advice on repeater operation. There are also a couple of books[1,2] and a magazine[3] which are helpful. After you're armed with this information, contact the people in your local area who use the equipment (both amateur and commercial) to find out what is available and where.

Speak to the man who runs the local fm two-way shop. Many times he has a customer who wants to sell obsolete fm equipment; as a favor to his customer he will get you together. Talk to commercial users directly and leave your name and address around, especially at non-governmental businesses. They are not as involved in red tape as the police, fire and county facilities. You may even find someone willing to sell a group of five or ten units at one time. In this case, it's best to have a group of people go together and split the cost. Prices are generally better and this guarantees that you won't be the only fm station in the area. In any case, don't give up. Acquiring the first few units is the hardest part. Once the ball is rolling, and your group expands, you'll find availability is good.

equipment

Before discussing the establishment of your fm operation, a brief rundown on equipment is in order. Two-way fm equipment falls in three major catagories: low band (30-50 MHz), high band (150-170 MHz) and uhf (450

* Lynchburg Amateur Radio Club, 1306 Grove Street, Lynchburg, Virginia.

** California Amateur Relay Council, 51 Norwood Avenue, Kensington, California 94707.

MHz). Low-band and high-band equipment is similar in design and appearance. Equipment for uhf is harder to come by and is generally used for repeater control and backbone links.

High-band equipment is the most popular for a number of reasons. First of all, antennas are less cumbersome and objectionable at the shorter wavelengths. Secondly, television interference has always plagued six-meter activity and two meters is relatively free of those problems. Thirdly, in most cases, two-meter equipment is ready to run as is; equipment that does require modification is taken care of with padding capacitors. Low-band equipment must be moved up beyond the 52.5-MHz band edge for wide-band operation. This is generally no big problem, but it can be quite involved.

In all fairness to six meters, it does provide greater range capabilities and less objectionable mobile flutter than two. This could be a major consideration for simplex operation. In addition, some low-band equipment can be converted to ten meters. This is becoming increasingly interesting for fm with the improved band conditions, and 29.6 MHz is a very active fm channel.

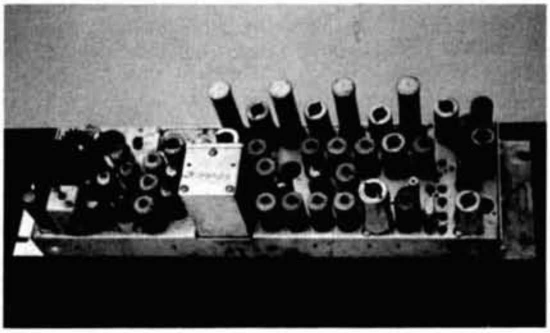
Motorola equipment is quite representative of the trends manufacturers followed over the years. It is also quite popular among hams, so it makes it a good example for discussion. Motorola started out with the **Deluxe** line, a separate transmitter and receiver housed in big, blue containers. They are old, bulky, inexpensive and ever so reliable. Some of these units were made with 110-volt supplies for base station use.

Next came the **Dispatcher** series, commonly called the 5V. These were small, single-case units which had six-volt supplies. Sometimes you'll find one which was converted to 12 volts; the transformers are still available for the 12-volt modification. The receivers in the **Deluxe** and **Dispatcher** lines are not well-suited to multiple-channel work since the same oscillator is used for both high and low i-f injection.

After the **Dispatcher** series, Motorola started its **Research** line which is still being expanded. The 41V became the most popular in this line with its six- or twelve-volt supply and multiple-frequency receiver and transmitter. Some units even had 110-volt supplies for base-station use. The basic unit is slightly larger than the 5V. Besides the 41V, the **Research** line contains a wide variety of transmitters, receivers and power supplies mounted on strip-type chassis. They can be rack mounted or put together in various combinations in a mobile housing. The best way to become familiar with these units is through the **FM Schematic Digest.**[2]

When transistors came into service, Motorola's line of equipment was expanded with solid-state units of all kinds. Hybrid handie-talkies like the one shown in the photograph were partially transistorized at first. Many used rechargeable Nikad battery packs; this makes them very economical for amateur use. Pocket-sized transmitters and receivers followed, but they are still pretty scarce. Motorola's main line of mobile equipment went miniature with the advent of the **Motrac.** This is a hybrid unit with various transmitter powers, multiple-frequency kits and extra gadgets.

A T-44 receiver strip. Excellent for the 450-MHz primary receiver of a repeater.



The other manufacturers have gone the same route over the years. General Electric had their **Preprogress, Progress** and **Master** lines. Link is also used quite a bit by amateurs as is RCA, Comco, Karr, and others. Generally speaking, most manufacturers produced models for both low- and high-band operation in a particular line, but this isn't always true.

establishing an fm operation

There are several very important considerations you and your group must make before becoming deeply involved in fm. First is the problem of choosing a frequency. Before you start buying crystals, stop and consider these points:

Do any other amateur activities frequent the channel you intend to use?

Would it be advantageous for the group to use a frequency in the general-class portion of the band to minimize possible interference? This is especially important for repeater users since the repeater hears a lot more than a ground station.

A homemade test aid for servicing almost any Motorola fm equipment. Adapters for the remaining units are easy to build.

Should you make use of some of the present national fm frequencies as your channels for emergency operation?

It should also be kept in mind that once a number of fm stations are set up on a particular channel, it is nearly impossible to change it. Consult the Lynchburg group regarding the channels being used in your area; you may want to join one of them. Monitor your choice of possibilities first and be sure nothing happens which could make you select another channel.

Once the frequency has been chosen, there is the problem of accurately measuring it. Although the transmitters are crystal controlled, they are adjustable over a few kHz and as Aagaard points out[2], disagreements are sure to arise. Transmitters can be set to the receiver frequency by zeroing the discriminator in the receiver. All discriminators should be zeroed to a common rf carrier. When aligning the reference receiver, use the most accurate signal source available. An accurate frequency meter or counter is a big help in this area.

Point-to-point operation is called local channel or simplex operation and works quite well. For larger coverage, amateurs have gone to repeaters.[4] Repeaters require two methods of control which must be entirely independent. By using dialed tones transmitted to the repeater on the communications channel, secondary or member control is maintained. This is the method used by club members to turn the repeater on and off.

The trustee of the repeater must be able to turn the repeater completely off by using a remote-control system on 220 MHz or higher. His system is only used in emergencies such as equipment malfunctions. This is called primary control. Generally, a 450-MHz fm system is used for primary control because the equipment is more readily available than 220-MHz equipment and takes much less effort to convert.

450-MHz equipment may also be used as a backbone link between two repeaters. This is a two-way relay system in which the audio from one repeater is fed to the other via a 450-MHz link where it is retransmitted on vhf. This allows mobiles or base stations to communicate dependably over great distances. The 450-MHz receivers continuously monitor the channel, and the transmitters are turned on by command from the ground stations. This eliminates any need to monitor the other repeater continuously.

accessories and ideas

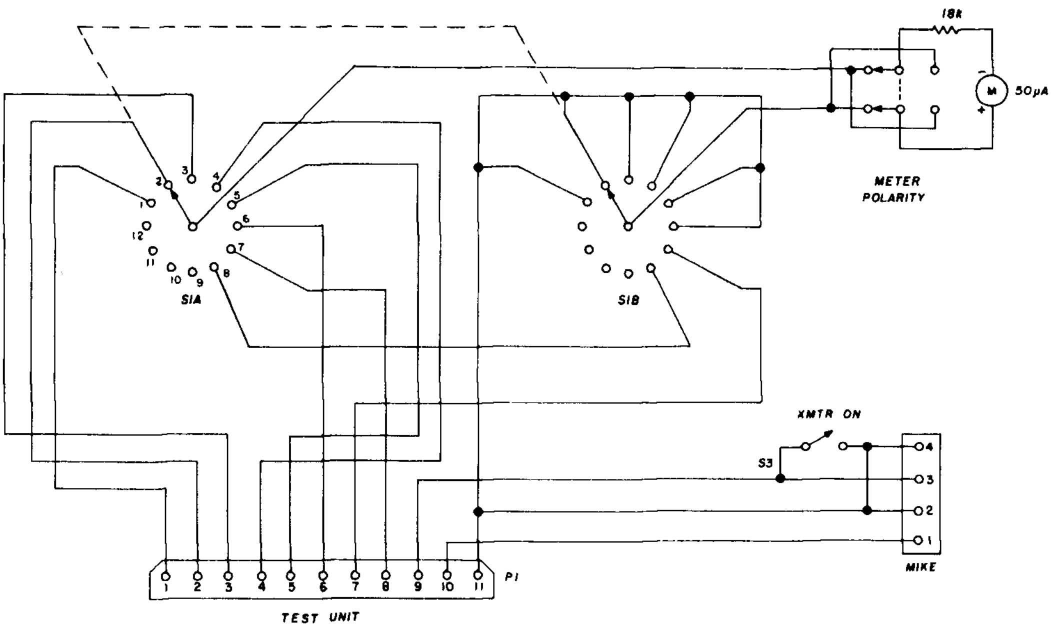
The following are some of the more popular accessories and ideas being used by fm amateurs around the country. This list is by no means complete in scope or content and is offered only as a stimulus to thought.

Tone oscillator. A tone oscillator can be the right arm of an fm amateur. By placing a telephone dial in series with the audio output, it can be used to control a repeater or selective-call system. Generally, provision is made for selecting a number of different preset frequencies with a rotary switch. Special oscillators are used for generating AFSK Teletype and facsimile signals as well as transpond and telemetry signals.

Selective-call decoder. For continuous channel monitoring with the speaker off, a decoder is wired into the base station. The call is placed by dialing a series of digits which add up to ten. This completes a circuit which rings a bell and turns on an indicator lamp. Each channel user with this capability should choose a different four-digit number that adds up to ten such as 1-2-3-4, 1-1-7-1 or 3-4-2-1. Some amateurs transmit a short burst of tone back to the caller to tell him that the alarm did go off. This is called transpond and can even be used to indicate whether or not the party being called is home by transponding with different audio frequencies.

Tone access. Commercial manufacturers make tone-operated squelch systems. Motorola's **Private Line** is a good example. This is somewhat similar to selective call except that it isn't as selective. To open the speaker on your receiver, two conditions must occur simultaneously. First, there must be a carrier present, and second, a short tone burst of a predetermined frequency must occur. The receiver speaker will then enable until the carrier disappears. A small encoder is used at the transmitter and a decoder at the receiver.

fig. 1. Schematic diagram of a homemade test aid for Motorola fm equipment.



Autostart Teletype. For general information bulletins, passing large volumes of information and leaving messages for people not listening, autostart Teletype is very useful. This scheme was discussed in a recent magazine article[5] along with circuits for a complete transistorized system. The most popular machines in amateur service are the Teletype models 26 and 15. The model 26 is a small, quiet unit while the model 15 is a rugged, dependable machine. There are many sources for RTTY gear, and the prices vary, so shop around.

Facsimile. Repeater users soon discover that they are doing a lot of running back and forth exchanging manuals, schematics and so on. Because of the large coverage area of a repeater, one trip to get a schematic can cost a full day. By using facsimile equipment, pictorial information can be passed hundreds of miles in a matter of minutes. While facsimile equipment is less abundant than Teletype machines, these units can be obtained quite readily on the surplus market.

Telephone and desk remotes. Remote control of a base station from another room of the building is quite popular with commercial users. Many manufacturers make a desk-top base station, but it is senseless to run two stations at once. By rewiring an old telephone, a versatile remote can be made for practically nothing. A miniature push-button switch installed in the handset converts it to push to talk; coil cords with five conductors sell for under two dollars. The volume control can be hidden behind the handset cradle and other controls similarly placed. An alternative solution is to mount a speaker and microphone in a small box which can be bolted to the wall in some convenient location. Most amateurs who use remote keep the base station in the shack or garage and use as many remotes as they want in the house. Don't forget to bring in a selective-call wire for the alarm so you will hear it when it goes off.

Typical of equipment available to the ham is this Motorola 5V. They are compact and inexpensive.

Receiving. Most active fm amateurs leave their receivers running continuously day and night. While this does consume some electricity, it makes operation much more pleasant and convenient.

When operating through a repeater, the receiver can be left running while transmitting. This lets you hear yourself coming back through the repeater. If another operator wishes to interrupt or inject a thought, he merely pushes his mike button and the beat note is heard in your receiver. This type of duplex operation makes communications just like talking on the telephone.

repeaters

Besides the normal repeat functions, the following additional features are quite popular with amateur repeaters of all kinds:

Frequency set. By dialing a command, a highly stable crystal-controlled oscillator is enabled. Any station placing a carrier on the input and duplexing can hear the beat note. He can place his transmitter on frequency by zero beating to the reference signal.

Signal-strength monitor. This device may be left on all the time or turned on by command. It delivers an audio beep sequence which indicates proportional signal strength of the carrier present at the repeater's receiver.

Secondary-control cycling timer. This is simply a timer which requires setting within a certain period of time or the repeater is automatically shut off. This is handy for mobiles that inadvertently drive out of range.

CW identifier. Elimination of repetitious voice identification of the repeater is accomplished through automatic CW identification. The usual procedure is to cycle the identifier once when the repeater comes on and once when it goes off as well as every ten minutes in between. Either mechanical or electronic means is employed to generate the MCW tones.

Directional antenna rotation. Some repeaters incorporate facilities for remotely directing antennas to assist in copying weak stations in distant locations. A simpler method is to use separate antennas pointed in the desired direction; they are selected by command.

Emergency repeater or portable power. Some groups will prefer to install an automatic generator at the repeater site for ac power during commercial power failures. Others choose to install a battery-operated repeater which comes on during power failures. The generator has the advantage that normal repeater operation is not affected. However, it requires continuous service as well as maintenance and fuel. The battery-operated repeater gets away from all that, but power capability is limited, and only skeleton operation is possible.

Multifunction decoder. The ability to perform many different remote-control functions upon command is a must for some repeater groups. Some have only two commands, repeater on and off, while others have facilities which can handle up to 1000 different commands. Diodes, relays, transistors and tubes all play an important part in units such as these, and each group must assess its own

A Motorola 41-V. Slightly larger than the 5V and with better features which make it worth owning. Many of these units are coming out of commercial service now.

needs and potentials. For the group just getting started, a simple command decoder is a modified Link or Secode. These can provide enough commands for any club's beginning needs, but you'll soon discover you're only getting by and are actually quite limited.

Alternate receivers and transmitters. Endless combinations of frequencies and modes can be used to avoid conflict with local amateurs who unknowingly fall on the main input channel or for other special purposes. Most popular is a second-channel monitor which listens to another fm channel and "pipes" the audio out over the repeater at reduced level. Many repeater groups are installing facilities for monitoring and transmitting on one or more of the national fm calling frequencies such as 52.525 or 146.94 MHz. These frequencies can be used for traveling mobiles or local co-ordination activities such as interstate traffic handling.

A 450-MHz transmitter from the T-44. Power plug is on left and finals and drivers are under the covers.

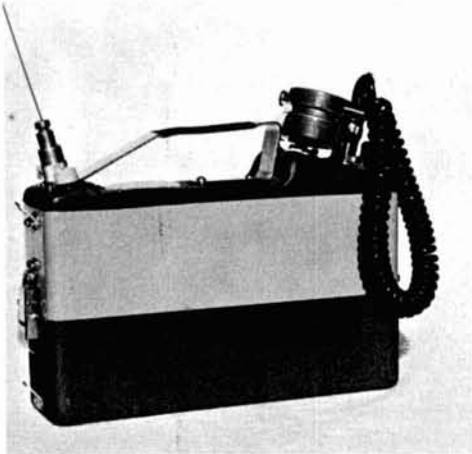
Telemetering. When many commands are available for use, it's difficult to remember which ones are on and which are off. Remote metering via telemetry overcomes this, and there are a number of different approaches. Slow, repeating "beeps" of three different audio frequencies can be read by ear and decoded by counting their position with respect to a sync pulse of a different frequency. Another method generates a dot pattern on an oscilloscope, and intensity modulates the dots for those commands which are on. Amateurs who are interested in television might consider transmitting a television picture of a lamp panel at the repeater site down to the base station.

Tape logging. Repeater logging can be eliminated through the use of recording tapes. A short burst can be made to start the recorder for a predetermined interval of time, or the recorder can run continuously. The advantages and disadvantages of each system are obvious.

Tape-message secretary. A tape recorder will record anything on the repeater input for a predetermined time on command. When another command is given, the message can be played back.

I have deliberately ignored the details of

A battery-operated Handie-Talkie. One watt transmit with rechargeable battery, speaker and microphone.



these ideas since most fm groups will have their own ideas and will want a system engineered to their own needs. This is the best part of fm radio. Transmitters and receivers, the major concern of the low-band ham, become only secondary to the vhf fm operator. His major interest lies in the development of a sophisticated communications system, and fm radio is merely a stepping stone to that goal.

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ham radio

solid-state transmitter switching

If you're tired of holding that PTT switch down, try one of these push-to-talk, push-to-listen circuits described by W2EEY

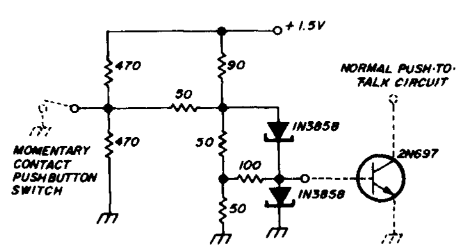
John J. Schultz, W2EEY, 40 Rossie Street, Mystic, Connecticut 06355

Sometimes the simplest gadgets contribute the most to your operating convenience. For example, if you replace the push-to-talk (PTT) mode of operation with a push-to-talk **and** push-to-listen (PTT/L) circuit, you don't have to continually push the mike button during transmit periods.

Amateur operators used to have a simple toggle switch for send-receive switching; push-to-talk was confined to mobile installations. Today, however, transceivers are in the vogue, and push-to-talk operation is used by many stations. The only disadvantage of PTT is that you have to depress the PTT button continuously during transmissions. Your hand can get pretty tired during long operating periods. VOX operation is very convenient, but not all transceivers have VOX built in.

In this article I'll describe some simple ways to convert your rig to push-to-talk and push-to-listen. With this setup, the mike button is pushed momentarily to transmit and then released. When it's depressed again, the rig is switched to receive. The advantages

fig. 1. A tunnel-diode circuit which is the solid-state equivalent of a latching relay.



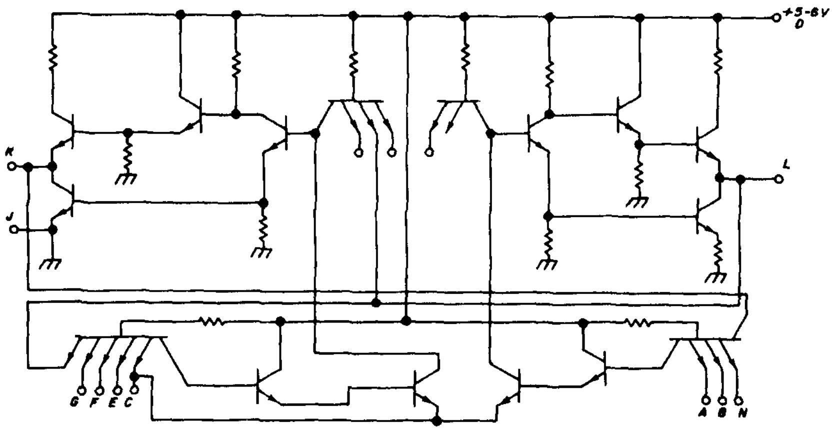
may not appear very great, but try to imagine how much easier many QSO's would be if you didn't have to use a death-grip on the mike continuously!

Although you can use relays or special switches to obtain push-to-talk/-listen (PTT/L) operation,[1] the solid-state circuits described here are a lot more reliable. The use of integrated circuits to replace a relay should interest you even if you don't want a PTT/L circuit in your rig. These switching functions can also be adapted to other uses, such as switching filters or crystals.

solid-state switching conversions

For PTT/L, you have to have a solid-state circuit which will duplicate the action of a "double-push" switch or a latching relay. This can be done electronically with a triggered

fig. 2. Internal circuit of an integrated-circuit J-K flip-flop—this circuit can be used in place of a mechanical latching relay as described in the text.



bistable multivibrator. This term may be confusing, but the basic multivibrator circuit has been used by many amateurs as a CW monitor. The triggered circuit will change "states" (that is, have an output or no output) only after a triggering pulse has been momentarily applied to the input. Each successive triggering pulse changes the state of the multivibrator.

It is fairly easy to convert a free-running multivibrator into a triggered multivibrator. However, succeeding pulse inputs to trigger the circuit have to be opposite in polarity. You can add circuitry so that successive pulse inputs of the same polarity will trigger the multivibrator, but the added components result in some rather complicated circuitry for the simple switching function you need.

tunnel-diode latching circuit

The two tunnel diodes shown in the circuit of **fig. 1** provide the equivalent circuit in a relatively simple form. Each time the input terminal is grounded, the output terminal alternates between a positive 1.5-volt output and a zero-volt output. The output of this circuit cannot be loaded appreciably if it is to function properly. It is better to drive a switching transistor which activates the actual PTT circuit in the transmitter. It can also be used to pickup a SPST relay which then controls PTT action.

There is nothing complicated about the operation or construction of this circuit. If you can buy the diodes reasonably, this circuit is about the simplest electronic latching circuit you can use. For more information on tunnel-diode switching circuits, consult references 2 and 3.

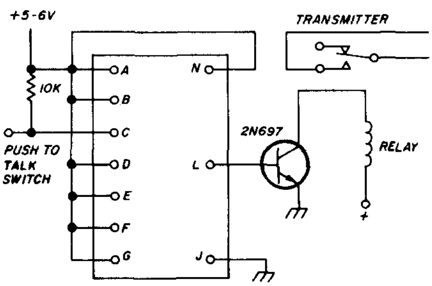
integrated-circuit switch

Another approach to inexpensive solid-state switching involves the use of an integrated-circuit J-K flip flop. The internal circuitry of the IC is shown in **fig. 2.** With this device, negative-going input pulses of the same polarity will produce alternate "on" or "off" states at the output. The integrated circuit I used was a surplus unit available from Solid-State Sales* for $1.20.

Rather than becoming too concerned with the internal circuitry of the IC, let's examine the switching condition that will provide PTT/L operation. If a positive 3 volts is present at all six terminals **EFG** and **ABN**, every time the input voltage at **C** goes from 3 volts to 0 volts (but **not** from 0 to 3 volts), the voltage at **K** and **L** will reverse. For example, if **K** is at 3 volts and **L** is at zero, momentarily grounding **C** will change **K** to zero and **L** to 3 volts.

Fig. 3 shows the J-K flip flop in a PTT/L circuit. The integrated circuit cannot be loaded down too much, so a switching transistor

fig. 3. Connecting an IC and 2N697 relay driver to provide push-to-talk and push-to-listen operation.



is used to control the relay circuit. An NPN transistor is shown here because a positive control voltage is usually used to activate the send-receive relay. If your transmitter happens to use a negative control voltage (very unusual), simply reverse the emitter and collector terminals of the switching transistor. For added flexibility, you can add a bypass switch so that either PTT/L or conventional PTT operation is possible.

There are only two precautions when using this circuit: don't exceed the recommended supply voltage, and make sure the PTT switch provides a good, clean contact. The IC responds extremely fast, and a dirty switch will cause it to change states unexpectedly. Otherwise, its switching action is far more reliable than any mechanical mechanism.

* Solid-State Sales, P. O. Box 74, Sommerville, Massachusetts 02143; order FF-1 J-K flip-flop integrated circuit.

switch replacement

If you feel you have to use a mechanical PTT/L circuit, sometimes the mike switch can be replaced with a so-called "push-push" or "double-push" action switch. These switches will alternately open or close a circuit with alternate depressions of the switch. A double-push switch that will fit in the base of home station microphones is the Cutler-Hammar model 7208-K4. Arrow-Hart and other manufacturers produce similar types. A miniature double-push switch which lends itself to hand-held microphones is the Alco-switch MSP-105D. It is less than 1/2-inch square and costs under $2.00.

For those situations where a momentary action switch can be replaced with a double-push switch, this may be the easiest conversion scheme. However, in most cases, solid-state methods of switching are usually preferable. Not only do they result in push-to-talk and push-to-listen operation with any PTT microphone, with a simple bypass circuit you can have simple push-to-talk operation too.

summary

Push-to-talk and push-to-listen operation is certainly not a major technical innovation. However, it has proved to me to be one of those small operating conveniences that becomes invaluable after it has been used for awhile. Try using push-to-talk and push-to-listen operation for an hour or two, and then go back to plain push-to-talk; the inconvenience you've been putting up with will be quite apparent.

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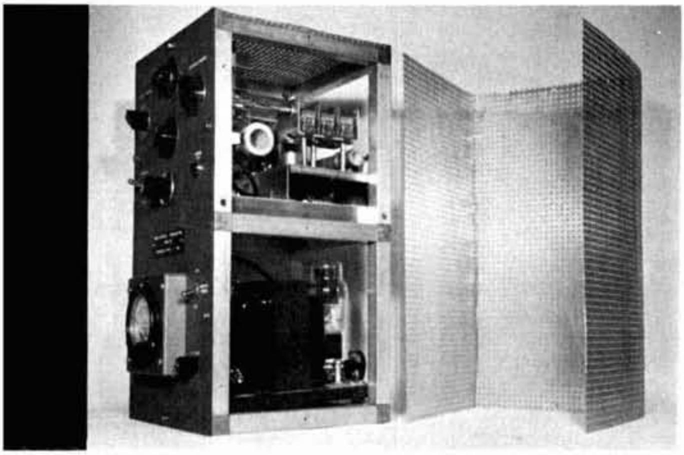


A three-band 80-watt transmitter using modern rack and panel construction.

return to rack-and-panel construction

Here's a construction technique that has all the advantages of the old rack and panel but results in neat, compact designs

Howard S. Pyle, W7OE, 3434 74th Avenue, S. E., Mercer Island, Washington 98040

Grizzled old timers will nostalgically recall the pioneer days of amateur radio when a station was a scattered collection of motley components arranged as fancy dictated. A tuning coil or loose coupler, a crystal detector, perhaps a variable capacitor of sliding metal plates in a grooved wooden frame arranged on a table top constituted the receiver. A massive helix of copper tubing, a huge capacitor of discarded tin-foil-coated, photo plates, a heavy transformer and an awesome rotary gap somehow found space on the floor, the table or a shelf—wherever they would fit—made up the transmitter. Odds and ends of bell wire, lamp cord and copper tubing tied the scattered pieces together electrically and you were on-the-air!

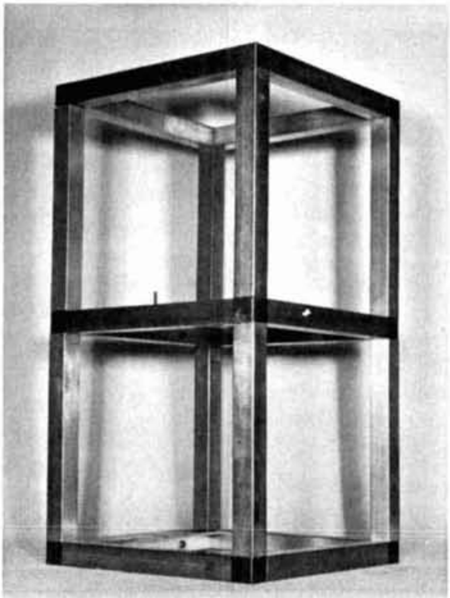
Because of the inconvenience and space-hogging of such arrangements, the receiving elements were soon combined in a more compact group. Generally this took the form of a breadboard, with all the components screwed down. Sometimes a wooden cabinet was used. The tuning coil or loose-coupler was mounted on the cabinet top, rotary variable capacitors were mounted in the box with their shafts sticking out and fitted with homemade scales and typewriter knobs.

Transmitters were another story. A box the size of a coffin was too small to house the massive items making up the more ambitious spark transmitters. Commercial companies began to group their components for shipboard transmitters on slate or hard-rubber panels—one manufacturer even used marble! These panels were mounted on a vertical metal framework of angle iron.

The dawn of the vacuum-tube era ushered in a new day. Receivers rapidly progressed to cabinet-style housings with controls on the front panel. Panels progressed from wood through hard rubber to bakelite, often backed with a metal sheet or tin foil to eliminate body-capacity effects, and finally to all-metal panels. Cabinets weren't far behind, and metal cabinets with matching panels began to appear on the market.

How about transmitters? In the 200-meter days, the components were rather massive because of the necessity for large spacing to avoid the possibility of flash-over with the high voltages involved. A single cabinet was simply impractical. Vacuum-tube transmission significantly reduced the size of transformers, inductors and capacitors. Again the rack-and-panel scheme looked good. Except for the kilowatt stations, the average low-powered ham gear no longer required a floor-mounted rack and panel the size of a small closet.

fig. 1. The basic rack framework is built from snap-together aluminum extrusions and castings.



A simple, easily constructed wooden or metal frame occupying about a square foot of table space and standing only a couple of feet high could be used. The idea rapidly caught on; manufacturers started offering metal racks of various heights, drilled for matching panels. Commercial companies adopted a standard panel width of 19 inches and these were available in heights ranging from 1-3/4 to 24 inches in increments of 1-3/4 inch. Later, cabinet racks became available in various heights up to six feet or so.

People have a strong tendency to follow the leader; if an electronics manufacturer encloses his equipment in an attractive metal cabinet and the design catches on, other designers follow the same general pattern. As a result, today's receivers, transmitters and transceivers are almost invariably housed in handsome, compact metal enclosures. This is fine for the ham who is content to place a nice-looking piece of gear on his hand-rubbed, hardwood operating desk in tasteful surroundings, plug it in, twirl a few dials and get on the air. Most of this equipment is pretty reliable; it will sit there and perform for a long time with a minimum of maintenance. But what about the ham who doesn't want to be a push-button operator? There are a **lot** of them and they like to experiment—try this and that, change a switch, a coil—maybe increase power. They hesitate to butcher a piece of factory gear; modifications generally destroy its resale or trade-in value.

The answer? Homebrew of course! But why stick to convention? Hams have always been known to be ingenious, resourceful and quick to come up with new circuits, new ideas. Then why develop a novel electrical design only to become a conformist in the final stage—the housing? Almost invariably, homebrew equipment winds up with the components buried in the bowels of a shallow metal chassis or mounted on a permanently attached panel.

You have to be a contortionist to wire such an arrangement. Poking a hot soldering iron down in the recesses of a crowded chassis generally produces burned insulation, scorched fingers and a string of cuss words!

Changes and modifications which occur from time to time are worse. Can't things be made so that they present a pleasing appearance, are convenient to assemble, wire and modify? Of course they can.

modern rack-and-panel construction

Let's turn back the hands of the clock a bit —back to the rack-and-panel days of ham radio! However, we are going to do it in the modern mode so that we retain the neat, compact appearance of present-day equipment along with accessibility.

While I was developing a three-band 80-watt transmitter recently, I decided to dip into the past and produce a rack-and-panel job that would compare favorably with the current conception of how ham gear should appear. The result is shown in the accompanying photos.

Your basic unit is the mounting rack. This should be metal. Don't get a sinking feeling envisioning a lot of mitering, hack-sawing, filing, drilling and other strenuous, time-consuming and temper-shortening operations. We've come a long way since we had to be metalsmiths to produce a neat-appearing, substantial job of ham construction.

Take the basic frame shown in **fig. 1;** "Would you believe..." (to paraphrase Maxwell Smart) that cutting the members and assembling this framework consumed just eighteen minutes from the time the raw material was placed in the vise? That's just what it took by the clock! Cutting the aluminum extrusions was like slicing bread; another minute and a few strokes with a file removed the burrs, and the frame members were ready for assembly. With small aluminum castings made especially for use with the extrusions and supplied with springy, toothed locking devices, assembling the final rigid framework was like fastening the snaps down the back of your wife's dress—it was that simple!

Where do you get this kind of material? A good question. There may be others making these aluminum extrusions and castings, but to date I've relied solely on the Ameco Engineering Company.* Their catalog of small aluminum extrusions and castings is available on postcard request. If you're interested in this type of construction, by all means get the catalog. You'll be surprised at the wide variety of assemblies which you can make up; the catalog shows you how as well. For my project, I used 3/4-inch extrusion for the frame with the castings at the corners and mid-sections.

* Ameco Engineering Company, 7333 W. Ainslie Street, Chicago, Illinois 60656.

construction

The frame was made 8-3/4 inches wide by 16-inches high. For the front panel, I cut the notched ends off a standard 8-3/4-inch high rack panel to reduce the height to 16 inches. These panels should be available at your electronic supplier. If not, most of the mail-order electronics houses catalog them. With the exception of toggle switches, a key jack, an indicator light and a fuse holder, **nothing** was permanently attached to the front panel. The variable capacitors, crystal selector and band switches were mounted on a subpanel on the rf baseboard. This arrangement permits removal of either the power supply or the rf deck **without** unsoldering a single wire. By removing a few knobs and mounting nuts, either of the two decks can be taken out of the frame from the back.

What about the rf and power-supply subassemblies themselves? These are also a throw-back—breadboards. I used pieces of 1/2-inch plywood cut to fit inside the frame members as shown in the photographs. The tops were covered with thin sheet aluminum and the exposed plywood edges painted black. Two screws through the boards and tapped into the extrusions hold them in position on the horizontal side members of the frame. Before putting them in the frame, the components were wired and mounted on the breadboards—on the workbench where everything was in plain sight and readily accessible. Terminal strips are used for interconnection between decks with a small wiring harness.

After all the assembly and wiring is completed, the decks are put in position with the control shafts through the front panel, fastened in place, knobs installed, and, after connecting the wiring harness, the rig is ready to go on the air. If there are any changes, adjustments, or modifications required, you slide the rack out of the frame, put it on the bench, and go to work on it in comfort.

While the rf deck may require frequent removal as your ideas change, the power supply deck will ordinarily remain pretty much in place. If you want to completely rebuild the rf deck, simply slide it out, remove the components, throw away the breadboard and make up a new one—what could be simpler?

This was not intended to be a construction article. If the return to rack-and-panel construction appeals to you, work out your own design to accommodate the components you intend to use. Slightly different dimensions and proportions would be used to accommodate an additional deck for a modulator unit; my transmitter was designed for CW only.

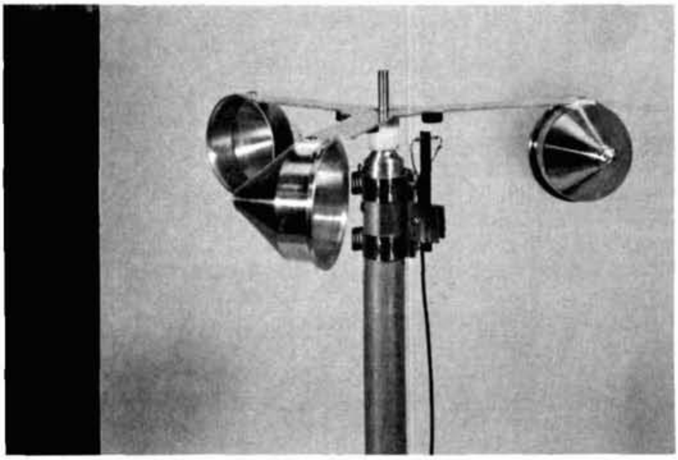
Devise as you plan; for example, the only milliammeter I had available had a long body and required more space behind the main panel than I wanted to spare from the power-supply deck. I simply cut a 4 x 4 x2-inch utility cabinet in two; this gave me an extension ring one-inch deep which moved the meter forward.

The subpanel on the rf deck is a 6-inch square of 16-gauge aluminum, mounted vertically on the front edge of the breadboard. The tuning capacitors, band switch and crystal selector are mounted to this subpanel and permanently wired into the circuits. When the rf deck is placed in position in the rack, the subpanel fits up against the back of the main panel with all shafts protruding through matching holes in the main panel.

As a final step, to suppress TVI and for safety, I enclosed the open areas of the frame in a piece of perforated sheet aluminum. It is available at local hardware and building-supply stores. It is easily cut with small tin snips and easily bent by hand to fit the frame. A few strategically placed 6-32 machine screws tapped into the frame members hold the ventilated shield in place.

Frankly, I'm rather proud of this little piece of rack-and-panel fabrication dug from the distant past. I have a nice-appearing rig, well ventilated, handy to work on and it adds a distinctly professional flavor to my shack—give you any ideas?

ham radio



The anemometer wind head. This unit features a teflon bearing and magnetic pickup for long life.

an amateur anemometer

Here's a simple gadget that will tell you when to crank your tower down

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

Say, beam owner, when the winds are abroad, and you're warmly tucked in the sack, does sleep come easily? The haunting question, "Will I find my antenna farm in a big pile in the back yard?" gnaws at your brain, and sleep is elusive.

The question of just what to do about protecting your antennas against winds has as many answers as there are antenna types and weather variations. One thing is sure, however; if you are to batten-down for a wind storm, you must know that it's coming. The weather bureau furnishes storm warnings, *and by heeding them you won't be caught* with your beam down. However, if the antenna is hauled down every time the small craft come in, you can look forward to a busy year of battening down.

Having your own anemometer is another way of determining, for yourself and in your own exact location, whether the wind warrants the work. By keeping an eye on wind velocity, and adopting some criterion of unsafe levels, you're all set.

You can buy a simple, remote-reading anemometer for as little as $25.00, but the types that are most commonly found in ham shacks cost about $100.00. The anemometers I have had experience with have worked quite well, but have had mechanically weak points about them. Because I'm electronically biased anyway and don't like repairing anemometer wind-heads "in situ," I looked for a simpler type of anemometer.

The unit described here has no sliding electrical contacts or rotary pipe joints; its most complicated mechanical part is the bearing. This mechanical simplicity is complimented by electronic complexity, at least in concept. However, relatively complex electronic systems can now be built easily and inexpensively with modern semiconductors, as this anemometer circuit will demonstrate.

I decided upon a three-cup anemometer configuration; each of the spokes has a small permanent magnet mounted on it. As the magnets rotate past a magnetic reed switch, the switch closes and the associated circuitry puts out three pulses of constant level per revolution. By filtering out the dc value of this pulse generator output (integrating), a voltage is obtained which is proportional to the number of pulses per second. Obviously, this voltage is also proportional to the number of revolutions per second of the three-cup-rotor, since the rotor caused the three pulses per revolution to be generated.

construction

The wind-head is constructed from an aluminum spider 10-1/2 inches in diameter as shown in the photograph; three modified aluminum household funnels are mounted on the ends of the spikes. The funnels, 2-1/2-inch spun aluminum, 39c each at a local variety store, are mounted with 6-32 screws and nuts.

Internal layout of the remote windspeed indicator.

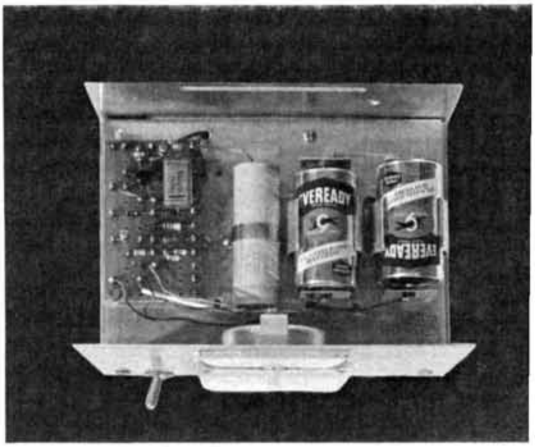
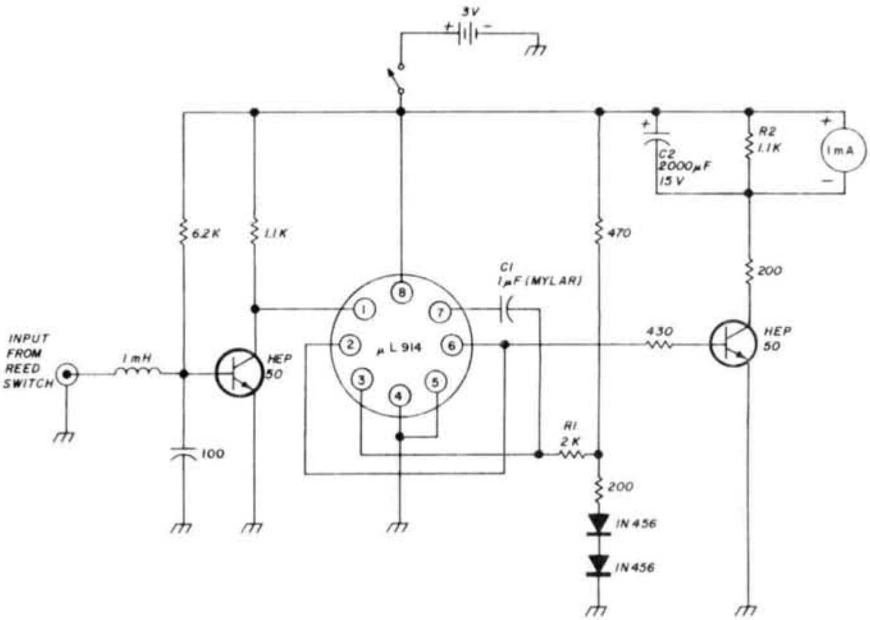
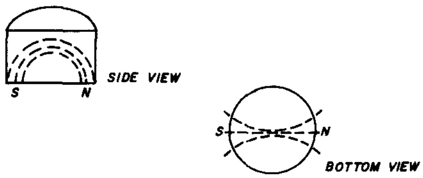


fig. 1. Schematic of the remote windspeed indicator.



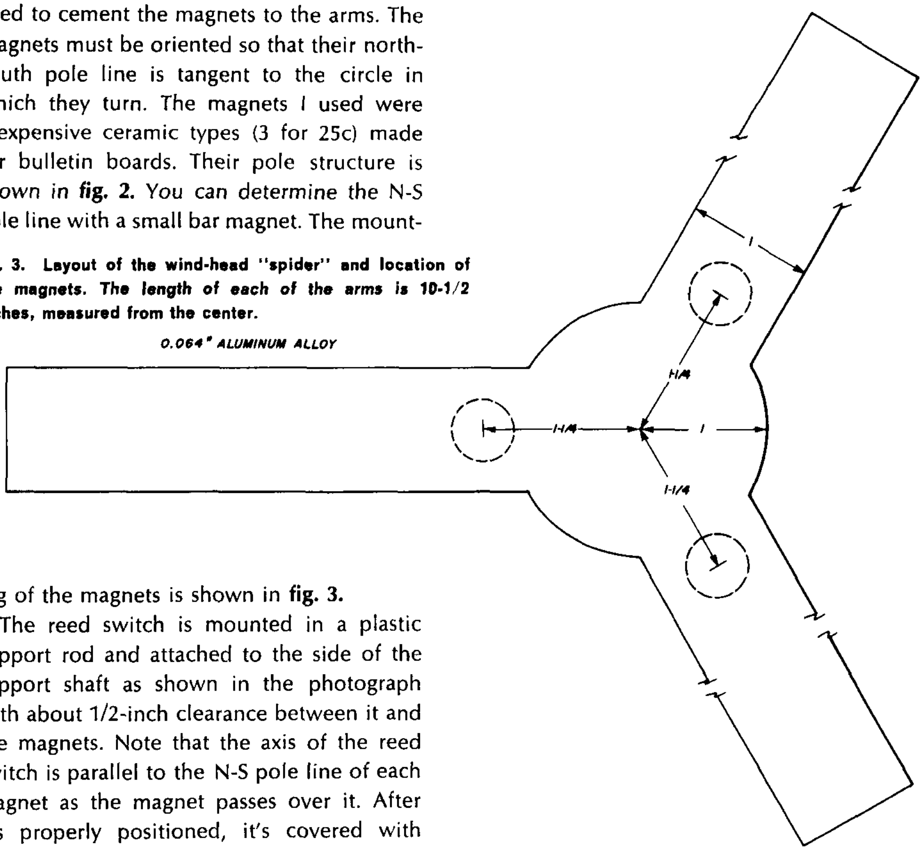
The funnels originally had handles; the hole left after removing the handle was used for mounting to the spider tip. A dab of General Electric RTV (Silastic), widely sold for bathtub and shower caulking, was used to secure the funnel-spider union. The stem of each funnel was also removed and some of the excess metal bent in to close the cone; RTV was used to finish the sealing job.

fig. 2. Pole structure of the miniature bulletin-board magnets used in the anemometer.



Three magnets are attached to the spider arms, 1-1/4 inches from the center. RTV is used to cement the magnets to the arms. The magnets must be oriented so that their north-south pole line is tangent to the circle in which they turn. The magnets I used were inexpensive ceramic types (3 for 25c) made for bulletin boards. Their pole structure is shown in **fig. 2.** You can determine the N-S pole line with a small bar magnet. The mounting of the magnets is shown in **fig. 3.**

fig. 3. Layout of the wind-head "spider" and location of the magnets. The length of each of the arms is 10-1/2 inches, measured from the center.



The reed switch is mounted in a plastic support rod and attached to the side of the support shaft as shown in the photograph with about 1/2-inch clearance between it and the magnets. Note that the axis of the reed switch is parallel to the N-S pole line of each magnet as the magnet passes over it. After it's properly positioned, it's covered with bathtub caulk.

The main bearing was made of Teflon because it is self-lubricating and should stand up in the weather. I felt that a brass sleeve or ball bearing would lose its lubricant in a driving rain. Probably nylon would do as well as Teflon here, but I didn't try it.

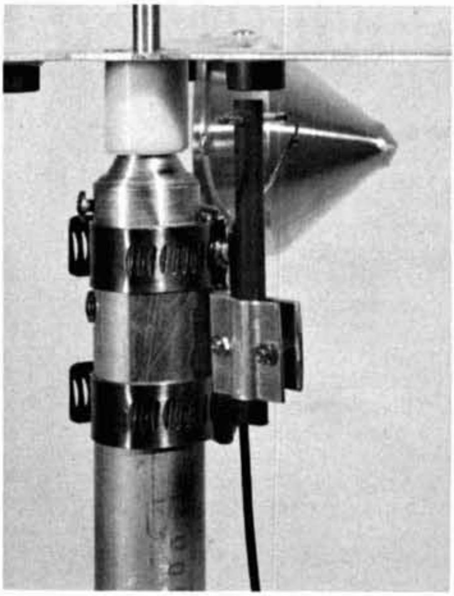
The reed switch is connected to the electronics package through a suitable length of coax—RG-58/U or RG-174/U. The shielded cable was used to keep stray local rf out of the electronics.

The circuit of the indicator is shown in **fig. 1.** It was built in an LMB-WO1A cabinet with self-contained batteries. The pulse length is set by the resistor R, producing a pulse length of about two milliseconds.

calibration

The anemometer sytem may be calibrated fairly accurately by mounting it on your car and making various runs up and down a straight road on a still day. Early Sunday morning seems best for these tests in my area. For best accuracy, your speedometer

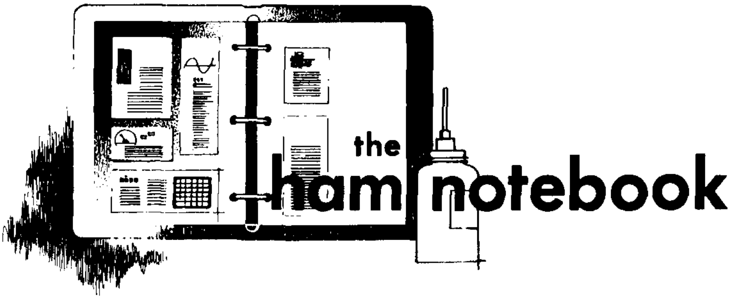
Closeup of the wind head showing the reed switch support and teflon bearing.



should be checked at the AAA or similar facility and the wind head mounted on a 2 x 4 that puts it out **ahead** of the automobile.

ham radio

"Now do you understand what a squelch circuit is, dear?"



coaxial cable supports

The opener flaps on the new aluminum beer and soft-drink cans make very strong supports for coax cable. Bore a small hole in the flap for a screw or a nail.

Don Farrell, W2GA

converting wavelength to inches

It is always exasperating when you have to convert free-space wavelength from meters to inches when you're building an antenna or making a balun. With the help of a simple jingle and a little long division, three-place accuracy is easy:

"Eleven point eight-o-three inches per k-M-z."

Here's how it works for 432 MHz (3/4 meters):

$$\frac{11.803 \text{ in/kMz}}{.432 \text{ kMz}} = 27.321 \text{ inch}$$

For coax it's:

$$\frac{11.803 \text{ (in/kMz)}}{\text{Velocity constant x frequency (kMz)}} = \text{coax (inches)}$$

WA6SXC

s-meter readings

If you have ever wondered what the S-meter readings actually indicate, the following chart may be of some help. This chart is based on an input signal of 50 microvolts at S-9 and 6-dB steps between each S-unit.

s-meter reading	signal strength (μV)
1	0.18
2	0.37
3	0.75
4	1.5
5	3.1
6	6.25
7	12.5
8	25.0
9	50.0
9 + 10 dB	158
9 + 20 dB	500
9 + 40 dB	5,000
9 + 60 dB	50,000
9 + 80 dB	500,000

That 80 over S9 report you just got means that you have a half-volt signal into the other fellow's receiver.

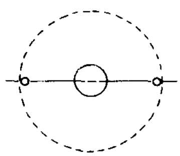
Jim Fisk, W1DTY

Motorola MPS transistors

Plastic transistors carrying MPS numbers below MPS6500 are made by Motorola and are similar to 2N transistors carrying the same number. MPS stands for Motorola Plastic Silicon, and numbers over 6500 are special transistor types.

W2DXH

punching aluminum panels



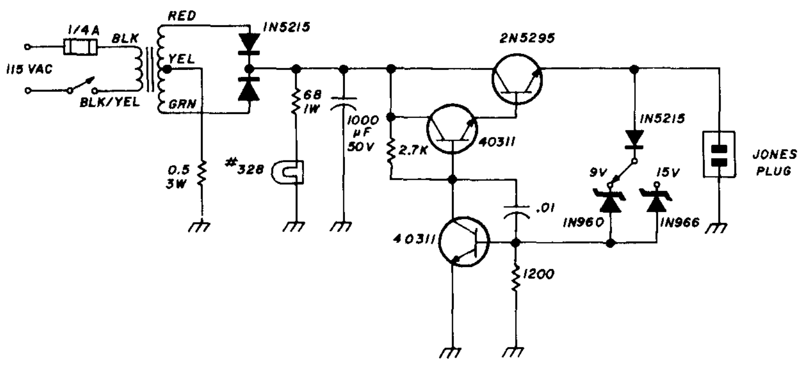
After breaking my share of Greenlee chassis punches, I have found a way of using them on 1/8" aluminum panels. First, drill your starting hole; insert the drive screw; screw on the cutter; and rotate the cutter by hand to scribe a circle. Then scribe a line through the circle; drill two small holes just **inside** the circle where the points of the cutter touch the panel. These two holes allow the cutter to shear the metal rather than punching through it with "brute force."

Joe Kofron, W7DIM

soldering fluxes

There may be some confusion regarding the use of "soldering paste" mentioned by VE3GFN *in his article on page 74 of the* March 1968 issue of **ham radio.** Although Mike used the term "soldering paste" once modified with the term acid-free, I'm sure he doesn't refer to No-Korode and similar fluxes. These paste fluxes are suspensions of zinc-chloride and ammonium chloride, aqueous solutions in grease. They are excellent fluxing agents for most common metals other than stainless steel, but the residue that is left after soldering is highly hydroscopic. Reaction of water with the residue produces hydrochloric acid. Obviously, this is no material to use with electronics equipment. The inorganic residue is not affected by low heat and requires about 1300°F to be boiled off. It is difficult to remove by washing.

Dave Heller, K3HNP



WB2EGZ's low-voltage power supply. The transformer is a Triad 91X or equivalent.

a low-voltage supply

It doesn't take a big power supply with meters, fancy panels and a big transformer for most of the work around the shack. The relatively simple unit shown here is compact, inexpensive, and handles many of my needs, including the broad category of a second supply.

On the premise that one of two voltages will operate most solid-state amateur converters, receivers and transmitters, a two-voltage supply was devised. Either 9 or 15 volts is available and regulated at any current up to 1 ampere. The series pass transistor is a 2N5295—a low-cost RCA plastic unit, but a TO-66 type, such as the RCA 40310 or 2N3054 is suitable if you can't find a 2N5295.

Any small chassis may be used, but my unit was mounted in a 4 x 2-1/4 x 2-1/4-inch Minibox. The power transistor is heat-sunk with insulating washers and thermal compound to the minibox. Wiring is not critical. You can obtain other fixed voltages by using a 400-mW zener diode of the desired voltage.

Don Nelson, WB2EGZ

tilt your rig

Modern operating practice for receivers, transmitters and transceivers calls for the cabinets to be slightly tilted. However, most equipment is shipped with four equal-length legs.

To tilt your gear slightly, measure the diameter of the legs at the front of the rig. Then buy some rubber crutch tips from the dime store or your hardware dealer. These will raise the front of the rig sufficiently to allow easier operation. If they're properly fitted to diameter, they slip on and off easily and provide a modern appearance for your operating desk. Cost? 30c!

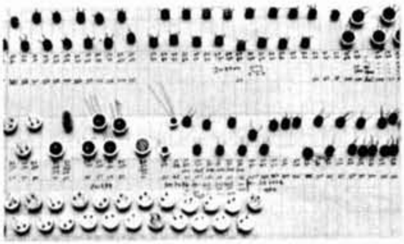
George Haymans, WA4NED

small parts trays

The flat aluminum trays used for TV dinners are divided into compartments and make excellent trays for holding small parts and screws while you're building or repairing ham gear.

Don Farrell, W2GA

transistor storage



Finding a place to store transistors that have measured characteristics can sometimes be a problem. Try this: lay several pieces of double-backed masking tape across a piece of cardboard as shown in the photograph. Then, stick the transistors to the tape and write their characteristics just below. You can remove and replace the transistors many times if you use this method.

Tom Lamb, K8ERV

some considerations about speech processing in amateur equipment

J. R. Fisk, W1DTY, RFD 1, Box 138, Rindge, New Hampshire 03461

Since the inception of voice-modulated radio communications, engineers have recognized that speech processing was absolutely essential so you could get optimum use of the system without exceeding its peak-power limitations. The schemes that have been used to accomplish this restriction of peak excursions have fallen into two general categories: agc or alc control, or clipping. The agc system uses feedback to control the gain of one or more amplifier stages, thereby keeping them within their linear operating range.

Rather complicated agc systems are used by every broadcast station in the United States to maintain the average modulation level within prescribed limits. In addition, most modern amplifiers which are designed for amateur use incorporate a feedback system to prevent overmodulation, and keep the modulation level up.

Unfortunately, the "clipping" system of speech processing has earned a poor reputation because of misuse and a general misunderstanding of its advantages and limitations. The important differences between the two approaches is time. The agc system uses feedback with its associated time constants; the clipping method has no time constants other than the attack time of the device that does the actual clipping.

Each system has definite advantages and disadvantages. In general, with a properly adjusted and operating agc-alc system, you can never overmodulate your transmitter. In addition, the modulation level will be maintained within the range of the agc circuit. Essentially then, the agc circuit generally keeps the system operating within its linear range and acts as an emergency brake in case of overmodulation.

audio clipping

Clipping systems have advantages and disadvantages not inherent in the agc system. Due to the absence of time constants or long attack times, the amplitude clipper can effectively change the peak-to-average power content in the speech waveform. This is the primary benefit we're all trying to achieve. A linear system modulated with a speech waveform whose average power content has been improved will show the same improvement in average output power. However, there are definite disadvantages to the simple clipper technique.

Clipped audio frequencies generate a host of harmonic products which fall within the audio band. In normal a-m transmission, 4 to 6 dB of straight audio clipping is generally considered the most you can use before the disadvantages of high distortion outweigh the improvement in averaged radiated power. Under poor operating conditions, however, this can be a very acceptable technique.

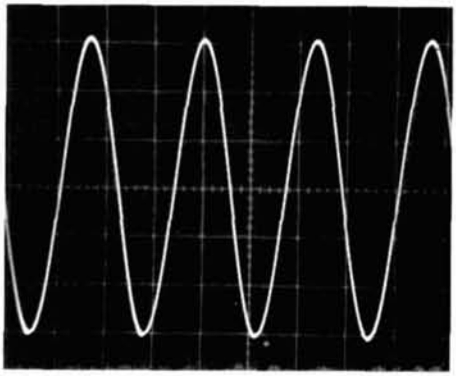
Another disadvantage of audio clipping is that audio processed in this way should not be used to modulate a ssb transmitter. Neither phasing nor filter-type exciters provide the phase linearity required to prevent the audio harmonics from recombining with the fundamental signals. This results in amplitudes that are higher than those present before clipping. *A good ssb transmitter with properly operating alc will decrease its average power output in order to accommodate the abnormal peaks generated in the exciter by harmonic-rich audio.* The system not only suffers from increased distortion due to clipping, it does not provide any benefits of an improved average-to-peak modulation ratio.

Elaborate filter techniques and clipping at rf (which eases the filter problem) have been used to improve this situation, but these systems are clipping three signals at once: the lower sideband, the upper sideband and the carrier. These signals are spaced only by the value of the audio frequency at any given instant; hence their intermodulation products still generate unwanted signals within the up-converted audio band.

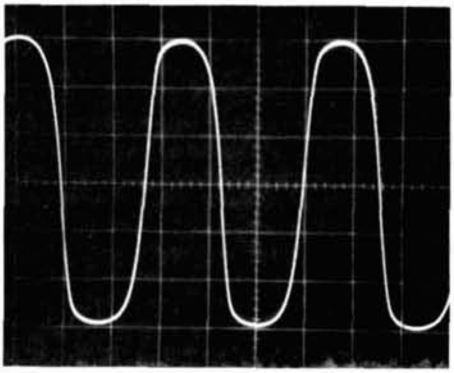
With these considerations in mind the next step should be obvious; a speech-processing technique that provides the benefits of instantaneous clipping without the disadvantages of harmonic distortion.

rf clipping

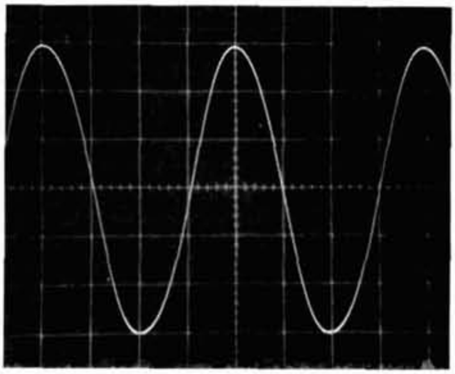
One answer is rf clipping. This is essentially nothing more than clipping the rf or i-f ssb signal, not the audio. If the single sideband signal is clipped, harmonic products are generated as with audio, but the closest



Pure sine wave at 700 Hz.



Output from a commercial speech clipper with 15 dB of clipping. Note the flattening of the audio peaks.



Output from the Comdel CSP-11 with 15-dB clipping. Note that the output of this speech processor closely resembles the input waveform.

fig. 1. Input and output audio waveforms using a commercial speech clipper and the Comdel CSP-11.

one is removed by at least the value of the i-f frequency. With this approach, the harmonics fall outside the audio band and are easily removed by filtering. The presence of intermodulation products tends to broaden the bandwidth of the signal, so an additional ssb filter is required.

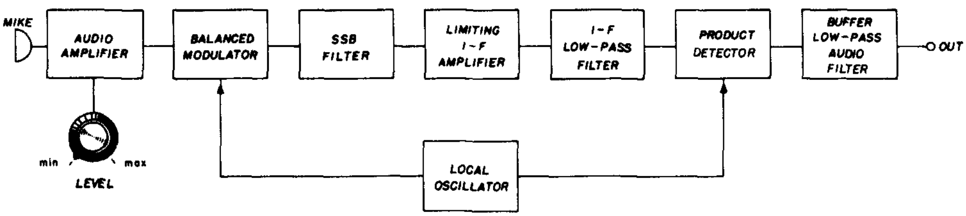
The output signal contains all the original audio information and has an improved average-to-peak power content as much as 15 dB (30 times). This obviously changes the quality of the transmission, but very little distortion is noticed. There is no loss of intelligibility "in the clear" as with a straight audio-clipping circuit, so the rf-clipping circuit may be left in the system permanently.

Modifying existing equipment to incorporate rf clipping is a little bit tricky. For one thing, the additional filter has to track the existing ssb filter very closely, and in practice, this is difficult to achieve. Also, additional gain has to be provided in the right place, since just turning up the audio gain control will cause overloading somewhere—usually in the first balanced modulator.

The Comdel CSP-11, illustrated in block form in **fig. 1**, is effectively a closed-circuit ssb system incorporating i-f clipping and avoids these difficulties. You can see that there is no frequency error because the same oscillator is used for both generation and demodulation of the ssb signal. The audio output of the system is instantaneously peak limited, yet free from harmonic distortion. For best operation, 15- to 20-dB clipping is recommended. The apparent power gain, as confirmed in numerous tests, is often as high as 10 dB at the receiving end.

The circuitry required to accomplish this type of speech processing is quite complex. But power ratio, lack of harmonic content, a fixed known peak audio-input level, and a specifically tailored 3-kHz audio response are well worth the effort.

fig. 2. Block diagram of the Comdel CSP-11 speech processor.



Comdel CSP-11 Specifications

Frequency response:	**500-2500 Hz**
Signal-to-noise ratio:	**36 dB minimum**
Input impedance:	**0.5 megohms**
Output load:	**not less than 6000 ohms**
Input level at limiting point:	**10 mV peak**
Output level at limiting point:	**40 mV peak**
Power requirements:	**9 volts at 18 mA**
Battery life:	**300-500 hours**
Size and weight:	**5-1/2 x 3-1/4 x 7-1/2 inches; 32 ounces**
Price:	**$120.00 postpaid**

* Comdel, Inc., Beverly Airport, Beverly, Massachusetts 01915.

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2. S. E. Stuntz, W1RXX, "Premodulation Clipping and Filtering," *QST*, November, 1950, p. 22.
3. W. K. Squires, W2PUL, E. T. Clegg, W2LOY, "Speech Clipping for Single Sideband," *QST*, July, 1964, p. 11.

ham radio

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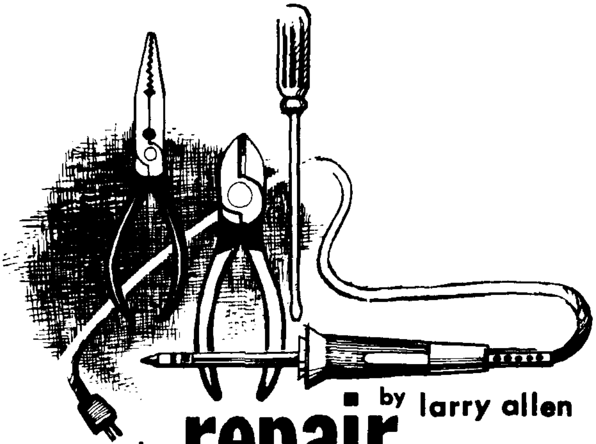


by larry allen

the repair bench

ham receiver alignment

Just about a month ago, a young college student from down the block telephoned to ask if I could help him. It seems Jeff had built an inexpensive shortwave receiver kit and couldn't get much out of it. Oh, he got some noise, but it was a far cry from the listening he was planning to do.

He brought it over, and we put it on my bench and turned it on. It was a general-coverage receiver, and we could get a few stations in the broadcast band, but very little anywhere else. The top band, which went on up to 30 MHz, was completely dead, even with a beam I have.

I ran through it real quick with the signal tracer and found the i-f gain poor. Usually these kits come with i-f cans prealigned, so I asked him if he had messed with the alignment screws. He had. The instruction book gave some adjustment instructions, and he had tried to go through them. There wasn't a screw in the i-f or rf section he hadn't turned. I could see I had my work cut out for me.

My young friend, who aspires to become a novice, had committed a sin that is often committed by adults who should know better. He had attempted to align a sensitive, selective receiver without either knowing how or having the equipment to do it with.

In the first place, you need a small screwdriver and an alignment tool that will fit the i-f slug, an rf/af signal generator, similar to the one I talked about in this column last month, and a meter. For good alignment, that generator needs to be fairly accurate. Even better, a heterodyne frequency meter can be used as a source of highly accurate signals. A lot of hams have the old surplus BC-221—I still have mine sitting around. A meter like the Lampkin MFM freq meter is okay for this, too. Anyway, make sure your signal source is accurate. If you have to, check its dial calibration at each of the several WWV or WWVH frequencies, using any receiver that is working. Later, I'll tell you how.

The signal generator output cable is usually terminated in its characteristic output impedance. If not, you can add a resistor of that value across the output leads. In case you don't know the output impedance of your generator, use a 50-ohm resistor. Use a .001-μF blocking capacitor, in series with the output lead between the resistor and the set, to make sure no dc reaches the resistor. The sketch shows how.

For an indicating meter, I prefer a vtvm, which I connect to the avc line of the receiver. A few hams and service technicians prefer to use a VOM, set to its "output" function, which puts a capacitor in series with the test lead. They use this as an indicator by hooking it across the speaker or headphone output to monitor the audio developed. The effects of alignment tuning are much broader visualized on this kind of indicator, but the system works.

Alignment has two purposes. One is to adjust all the rf and i-f tuned circuits so that they pass the correct frequencies as efficiently as possible. In elaborate ham receivers, alignment may even involve some traps to make sure that certain frequencies—such as an upper or lower sideband—are rejected; trap circuits also help steepen the skirts of a band-pass response curve.

The second purpose of alignment is to make sure all the oscillators are operating at the correct frequency, to assure correct calibration of the receiver's dial. Dial calibration is pretty important for both shortwave listening and ham reception. In a simple receiver like the one young Jeff brought by, this part of the alignment can become quite difficult. However, there are ways to overcome the problems, and I'll mention them later.

lining up the back section

Before you start aligning any shortwave receiver, let it and your test instruments warm up at least a half-hour to stabilize—an hour is better. Stability is important.

The first step is to "calibrate" the detector and the final i-f transformer. The accuracy of the signal used for this step is critical; the effectiveness of succeeding steps depends on *this adjustment being made correctly. If the* receiver is a multiple-function rig, set the switch for a-m reception. The whole set will be easier to align in this mode. You can clip the vtvm dc—probe to the output of the a-m detector—common lead to chassis, of course.

Connect the signal source at the input (grid or base) of the very first stage of the last or low i-f. Set its frequency very precisely. If the receiver uses a nontunable selectivity filter in conjunction with the low i-f, getting the *right* frequency will be simplified if you feed the signal in before the filter. Feed in *only enough of the signal to cause an indica*tion on the meter. Too much will make the tuning so broad you can't really tell when you have peaked a tuned circuit.

Popular kit-type signal generator suitable for receiver alignment.

Start with the transformer winding nearest the detector. Work your way back toward the input of the i-f section. When you get back to the input transformer of the section, peak it as best you can. It may be a little broad, because of the connection from the signal source. Later, when you have the signal *source connected further toward the front* of the receiver, be sure to come back and re*peat this one adjustment; you'll usually find* the true peak slightly different.

Go through the i-f strip twice. You want to be very sure it's aligned correctly. If this is the last i-f of a double- or triple-conversion receiver, the frequency may be as low as 50 or 60 kHz; on the other hand, it could be as high as 2 or 3 MHz. In Jeff's receiver, it was 455 kHz. Transformers for that frequency are inexpensive and plentiful.

the middle i-f

This part of the receiver differs considerably from model to model. If the receiver is *double-conversion, it may be called the high* i-f, being the only one other than the low i-f. It may be a broad-banded stage, if the tuning is done **after** it. (Examples are the Heathkit SB301 and the Collins 75S-1. Both use a crystal-controlled heterodyne oscillator for first conversion and a tunable **linear master oscillator** (LMO) for the second.) In expensive receivers, a bandwidth filter may be used for this i-f instead of tuned circuits; it is not adjustable.

Generally speaking, the **best** place to feed in the test signal is at the grid of the mixer preceding the i-f strip you're about to align. *This islolates the output cable of the signal* generator, and eliminates the need to repeak the first input slug.

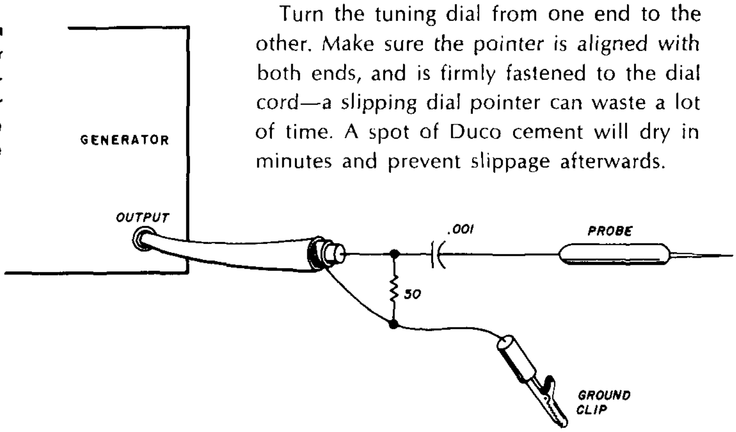
the low-cost front end

One problem with an inexpensive receiver is poor image rejection. An image, as you may know, is a signal on the other side of the local oscillator frequency from the desired signal, exactly as far from the local oscillator as the desired signal is. In other words, it is a signal *that, when mixed with the local oscillator,* also produces the i-f of the receiver. The image response is always separated from the desired signal on the dial by exactly **twice** the i-f frequency. With a 455-kHz i-f, for example, the image is 910 kHz away from the desired signal. When you are receiving rf frequencies in the neighborhood of 20 and 25 MHz, an image is comparatively close, percentagewise —less than 1 MHz away. It is not easy for the preselector tuned circuit to block out the un*wanted image. In fact,* unless the Q of the preselector circuit is unusually high, good image rejection in a low-cost receiver is virtually impossible.

This means, then, that the oscillator in such a receiver is hard to get calibrated correctly, because you can't tell if you're picking up the signal at the image or at the fundamental on the receiver dial. If you work very carefully, however, you can surmount this obstacle and do a really good alignment job.

Start with a long warmup—both generator and receiver. You want as much stability as is possible. The vtvm is the best indicator for this step; the VOM across the speaker isn't really sensitive enough. You are going to depend on the meter to help you separate fundamental reception from image reception. As a general rule, use only enough signal—fed to the antenna terminal of the receiver—to cause an indication on the meter. Any more will distort the avc action of the set, and make accurate alignment difficult.

This is how you connect a probe to the output of your signal generator. The resistor terminates the generator cable in a 50-ohm load; the capacitor isolates it from the dc supply in the receiver.



Make it a rule always to start with the highest band. In some receivers, adjusting the high bands affects low-band adjustments. In any case, it's a good idea to start with the high band—get the tough part done first.

There are three steps to each phase of front-end alignment, once you have all the i-f's precisely adjusted. The first step is calibrating the high-end dial frequency, with the oscillator trimmer capacitor. The second is adjusting the low-end dial frequency, usually by adjusting a slug in the oscillator coil. There is interaction between these two adjustments; you have to go back and forth several times. It is very important that you make sure you do not align either end with an **image** signal. The third step is alignment of the rf tuned circuits. There may be more than one rf adjustment. The instruction manual that comes with your receiver will tell.

In preparation for the actual adjustments, make yourself a chart of their locations. Figure them all out **before** you start sticking a screwdriver into them. During the alignment your attention should be on the frequencies and on peaking the adjustments; you have no time to be figuring out where each one is. Label them with a pencil if you can. Do anything to avoid touching the wrong trimmer, because you might then have to begin all over.

Turn the tuning dial from one end to the other. Make sure the pointer is aligned with both ends, and is firmly fastened to the dial cord—a slipping dial pointer can waste a lot of time. A spot of Duco cement will dry in minutes and prevent slippage afterwards.

Now for the first adjustment: the high-end oscillator adjustment for the top-most band. Set the rf generator, modulated, to 30 MHz. Your first job is to identify the image so not to confuse it with the main signal. Tune back and forth in the neighborhood of the high end of the band, and you will hear signals at two points. Tune in one with the receiver dial, very cautiously and carefully, tuning for a maximum meter indication. Then do the same for the other. Notice which dial position produces the higher meter reading. That one is the fundamental.

See where the dial pointer is. If it is not indicating 30 MHz exactly, you'll have to readjust the oscillator trimmer capacitor for that band. Be sure you have the right one. If the dial is off very far, there is only one way to bring the dial reading into proper position without confusion: Turn the dial just the tiniest bit in the direction to correct its reading, but not so far you lose the sound or the meter indication. Then adjust the trimmer to make the reading strong again. Next, move the dial a little closer to the correct setting, until you almost lose signal again. Then again peak the trimmer. In this manner, you can slowly "walk" the trimmer and dial right onto the correct frequency setting without losing the proper signal and inadvertently zeroing in on the image frequency.

Next, you have the same job to do at the low end of the same band. This might be around 15 kHz, for example. Set the generator to precisely that frequency. Tune the receiver around the low end until you find the fundamental frequency; again, use your meter indications to make sure you don't have the image tuned in. Then, adjusting the slug in the oscillator coil for that band, slowly "walk" the signal onto the correct 15-MHz spot on the dial.

When you tune back to the high end of the dial, you'll find the frequency has shifted slightly, especially if you had to do much adjusting at the low end. Again, tune in the fundamental 30-MHz generator frequency, being sure it's not the image, and "walk" the trimmer setting until the dial is accurate. Repeat at the low end and repeat at the high end. Final adjustment should be at the high end, because the oscillator slug has less effect on the over-all frequency.

Before you move to the oscillator adjustment for the next band, make the rf adjustments for this one. There may be a high-end and a low-end adjustment in the rf section, in the more elaborate receivers. Otherwise, there will only be a high-end trimmer or two to adjust. Again, be sure the signal you're feeding in and tuned to is the fundamental one. You don't have to "walk" the adjustments in the rf section. Just tune the dial for maximum indication on the meter. Then tune the trimmers—and slugs, if there are any for low-end adjustment—for maximum.

Next, go to the band next below in frequency. Go through the same procedure: First, the high-end oscillator adjustment, "walking" the dial setting into proper position. Then the same for the low-end—and then back and forth between the two until both ends are accurate. Finally, peak the rf adjustments. You'll find that separating the fundamental from the image becomes much easier as you get down in the lower bands, because the 910-kHz (or whatever it is) signal has a wider spread on the dial. In the lowest band, usually the broadcast band, you will have no trouble at all; the image is half the dial length away.

Finish by aligning each band all the way down to the lowest, repeating the procedure already outlined. When you are finished, if you really care about calibration, accuracy, and sensitivity, start with the high band and double-check the high- and low-end frequency settings.

You may want to check the **true** calibration of the receiver, to overcome any inaccuracies the signal generator may have, especially in this highest band. A good test is to tune in the National Bureau of Standards station, WWV, at 15 MHz. You'll have to do this at a time of day when the band is open. If you can, tune also at 20 MHz and 25 MHz. You may not be in the right locality for best reception at those frequencies, but you can check them whenever propagation permits. See if the receiver dial is correct. If you find the dial is not accurate, make the correction only with the oscillator **trimmer.**

Make the same WWV test in the lower bands, using the 10-MHz and 5-MHz WWV signals. Remember to make corrections only with the oscillator trimmer; **do not** change the oscillator slug. Some night, you can also check at 2.5 MHz, using WWV or WWVH.

The broadcast band is easy to check out, because broadcast stations must be very close to correct frequency. Tune one at the high end and correct the dial calibration with the oscillator trimmer. Pick one at the low end and correct it with the oscillator slug. As you did with the generator, go back and forth to get each precise.

verifying generator accuracy

Probably the handiest way to do this is with a freq meter. The simplest way is just to feed the outputs of the generator and the freq meter into a receiver. It doesn't really matter whether the receiver is in alignment or not, since all you are actually doing is using the receiver as a detector to detect the beat between the two.

Set the frequency meter precisely for whatever frequency you want to check—say, 20 MHz. Set the generator there, too. Tune the receiver until you can hear the signals beating together. Don't use an antenna. Swing the generator dial until you hear the whistle caused by the beat between the generator and the frequency meter signal. Swing it slowly back and forth until you find the exact zero beat between the two. See whether the generator dial actually rests at 20 MHz. You can plot any inaccuracies at intervals of about 5 MHz, and use the graph as a correction factor when you're calibrating a receiver dial.

Another way to check accuracy of the generator is with the receiver and WWV (or WWVH). Just tune in at the 2.5-, 5-, 10-, 15-, 20-, and 25-MHz signals. Then check to see if those corresponding signals from the generator are accurate on the generator dial. A zero beat is your guide to precise tuning.

ham radio

simple untuned crystal mount

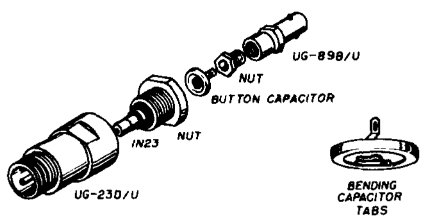
Many times in amateur UHF and microwave work you need an untuned crystal mount for detection of small levels of rf energy. Usually a small diode and bypass capacitor are simply haywired into the circuit, but this method usually causes some problems. First of all, if the frequency of operation is high enough and the lead lengths are too long, a lot of the available energy will be radiated. Furthermore, the parasitic reactances, as a result of the lead lengths associated with the capacitor and diode, can cause some rather mysterious results.

This crystal mount is based upon the use of two standard coaxial cable fittings, a type-N jack, the UG-23D/U, and a type-BNC jack, the UG-89B/U. Both of these fittings are available at reasonable prices. To build the mount, discard the braid-clamping washer and rubber gasket from the type-N connector. Then take the female pin and carefully squeeze the large end so that it is a snug fit around the pin of a 1N23-type diode.

Ream out the type-N cable-retaining nut so that a 1000-pF button capacitor may be force fit into the opening. Bend one of the tabs on the capacitor over so it will provide a spring contact to the diode when the nut is screwed into the connector. Bend the other tab so it comes straight up from the surface of the capacitor.

Remove the cable-retaining nut from the BNC connector, and place it on top of the type-N nut. Now, solder the whole works together, the N and BNC nuts and the feedthrough capacitor. Make sure that the N nut has been reamed out sufficiently so the BNC nut sits flush and level. The easiest way to solder the parts together is on an electric stove or hot plate.

After this assembly has cooled down, solder a short piece of wire about 5/8 of an inch long to the upright tab on the button capacitor. Place the female pin from the BNC connector



over the end of the wire and put the BNC connector on to test for proper wire length. The wire should be trimmed so that the end of the female pin is flush with the center insulator in the connector. When you find the right length, solder the female pin to the wire.

To use the completed mount, connect a sensitive dc microammeter across the BNC connector, apply some rf energy to the type-N connector, and you're in business. In most UHF and microwave work, the type-N connector will fit right in with existing equipment.

Jim Fisk W1DTY

One of the more highly publicized bugs is this "007" sugar-cube mike. It is completely self-contained and will transmit up to several hundred feet.

electronic bugging

and the

ham

The true story behind the "electronic bugging" headlines

Robert M. Brown, K2ZSQ/W9HBF, 5611 Middaugh Avenue, Downers Grove, Illinois 60515

Surprising though it may seem, very few surveillance devices are more complex than those shown in this article. For the most part, these simple devices reflect the vast majority of gadgets employed today. Exceptions are custom-built designs used by the CIA and a few other federal branches who have the funds available to develop more advanced (and generally higher-powered) bugs for specific applications. If you can ignore the mass-media spy syndrome ("Get Smart," "U.N.C.L.E.," etc.), you are well on your way.

Basically, the bugs break down into two major types: the audio-microphone group using connecting wires, and self-contained rf transmitters. Countless variations exist, yet these are the exception rather than the rule. Quite naturally, the microphone-types are the least expensive since they aren't nearly as complex as the transmitters and require a bit more installation time. One company that specializes in low-cost mike configurations is Consolidated Acoustics of Hoboken, New Jersey. Perhaps the largest direct-mail solicitor, Consolidated offers mike kits to put together everything from wall-listening devices to parabolic-dish long-range snoopers and also offers inexpensive telephone induction systems. These normally make use of a Philmore-type pickup coil placed near the phone sidetone coil. Output is coupled into a nearby audio amplifier, recorder, or rf transmitter tuned to the fm music band. While a big outfit in terms of sales, Consolidated's offering is pretty simple in concept. Audio amplifiers, crystal mikes, cabling, and recorders comprise the bulk of equipment sold, and this is fairly illustrative of their competitors, too.

The more recent outpouring of tunable fm band transmitters, however, poses a more serious threat to the potential victim. While pretty much short in range capability (few travel more than 300 yards at 100 MHz), countless forms are taken, since the tiny one-way devices can be hidden practically anywhere. Although phone bugging is very big right now, these transmitters have turned up behind pictures, inside ashtrays, disguised as diaries, in pen desk sets, and in table lamps. While not elaborate in design circuitry, they're assuredly strong in imaginative application.

Common bugs. To the left is the model 003; a parallel-connected fm phone bug with a 1/4-mile range. In the middle is a model 001 series-connected phone bug with a 1/2-mile range powered by the telephone. To the right is a model 003A, a room transmitter similar to the 003 with a built-in microphone.

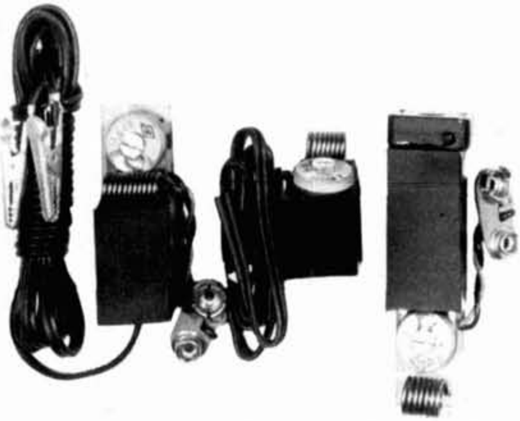


Photo courtesy L. N. Schneider

Feeding from both sides (microphone-wire, and transmitting) the electronic tailing business emerges. The assortment of car bugs and bumper beepers now saturating the marketplace seems to be a combination of several techniques, with heavy emphasis on rf transmission. Interestingly, these devices are found as voice-bugs, strategically located under the dash and powered by the ignition system with an antenna coupled to the car radio whip, and as pulsed-tone beepers, emitting a constant a-m or fm signal interspersed with a 400-Hz note, antenna trailing just above the road surface. Regardless of method, the tracker assumes the identity of a ham or CB'er, using a vehicle well-equipped with a directional loop antenna, or phased whips coupled to a receiver under the dash. Complex triangulating systems are frequently employed with the aid of other vehicular operatives linked together with a CB set and zeroing in on the target. Yet, even the single agent can approximate distance and direction by looking for a null between the two phased antennas and noting S-meter readings.

While it has been said that telephone bugs have been the biggest boon to the surveillance industry, it is the tailing devices which have had the greatest application to the largest number of U.S. private investigative firms, since they cut required manpower enormously and enable safer tails (ones in which the target car does not have to be in direct sight of the operative).

Even this grouping is not exotic in terms of equipment function or design. From an amateur standpoint, in fact, the majority of devices now in use are rather behind the times. Very few employ IC's, and even fewer make use of tunnel diodes or FET's, although basic solid state long ago replaced vacuum-tube types. The exception to this is the 117L7GT a-m room bug made in Florida and designed to be permanently installed in the wall of a freshly-built apartment or home. This type is constantly on, drawing power from the household currents and transmitting on a frequency just above the tuning range of conventional a-m radios. It is good for the life of the tube, normally several years, since plate current is resistively dropped below the amateur norm. Most of the circuits employed in transmitting devices are straight from an old **Popular Electronics** or **Radio-TV Experimenter,** with certain improvements and changes made in the tanks and power supplies.

transmitting eavesdrop "plants"

I think we can safely assume that the experienced ham already has a good deal of working knowledge on audio amplification, types of miniature microphones, etc., normally used in direct-line taps and other forms of wired bugs, so for this reason we can skip into the more interesting field of rf transmitting types. As can be seen in some of the circuits shown here, these mini-transmitters are far from complex. The vast majority transmit with outputs ranging from 50 to about 250 milliwatts and seldom contain more than three semiconductors. Yet, determinate upon frequency of operation, the range expectancy can vary significantly.

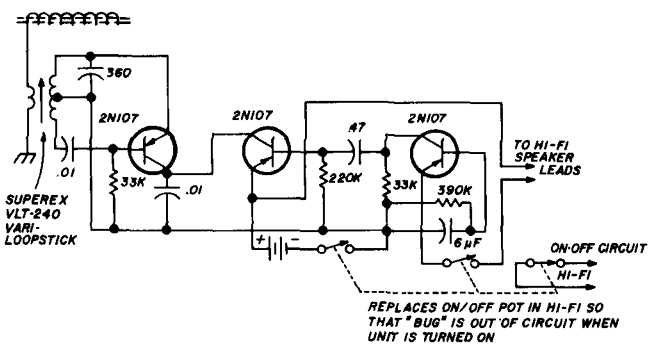


fig. 1. This a-m room bug can be concealed in a hi-fi, tv or radio cabinet with the speaker as the mike and the line cord as the antenna. *Signal is tuned in between* 500 and 700 kHz on a standard broadcast receiver.

Most room bugs and a good number of wired-in phone transmitters are powered by Mallory Duracells and the like, require little maintenance, are relatively drift-free, and offer a life expectancy of two to three weeks of constant operation. Often, tiny hearing-aid variety mercury cells will be used too, although the power input to the final transistor (and resultant DX) is proportionately less. Few circuits employ more than 12 Vdc, with most in the 6- to 9-volt area.

Frequency of operation is the key to the questionable success of the modern eavesdropper. Obviously, if he uses standard a-m or fm frequencies, he runs the risk of accidental interception by the very party he's trying to overhear. A great number of private individuals though, dabble in snooping with inexpensive mail-order devices use the 88- to 108-MHz band, centering their transmitters at 89 MHz. For the most part, however, these are small-time operators, and, judging by the places the ads appear, curious youngsters. Although a professional may begin with such a device, he invariably turns later to a rig capable of transmitting either just outside one of these bands, or on a different frequency range altogether. Consequently, anyone even slightly interested in this aspect of electronic eavesdropping must be prepared for just about anything.

A group of nine operative bands are used in 99% of the transmitting bugs, breaking down pretty much like this:

1. Just below the a-m broadcast band,

2. Just above the a-m broadcast band but below 160 meters,

3. An unused channel on the 27-MHz Citizens' Band,

4. 30 to 36 MHz fm,

5. 42 to 49 MHz fm,

6. 70 to 74 MHz fm,

7. Just below the fm music band (below 88 MHz),

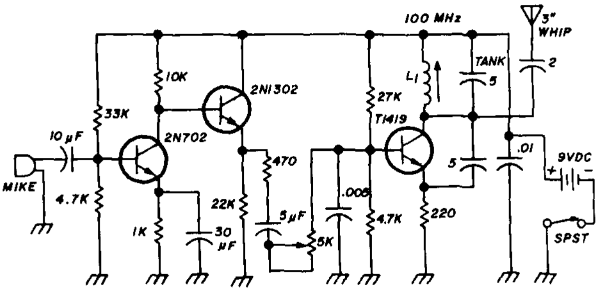
8. Just above the fm music band (above 110 MHz),

9. 150 to 174 MHz fm.

By and large, the most popular range of frequencies falls in category 7, about 1.5 MHz below the bottom of the fm broadcast band. The reason for this is twofold: one, any transistor portable FM radio can be detuned to capture 86.5-MHz signals and, two, the antenna-length requirement is quite minimal (usually on the order of 3 inches and in the form of #28 wire). Additionally, fm operation at these frequencies is generally interference-free and not troubled appreciably by ignition pulses. It has been estimated that 50% of the professional (law-enforcement, detective agencies, etc.) market for such equipment falls into this band, and more than 80% of the gear sold over the counter or by direct mail to the general public.

To a somewhat lesser extent, category 8 can also be grouped with these bugs, because the same equipment is generally tunable over a 25-35 MHz range (easily hitting above 108 MHz), although it is not as frequently employed. One of the reasons for this is that *commercial-aircraft* frequencies have been twice "hit" unintentionally by eavesdroppers and *monitored* by the FAA. Subsequently, vague warning letters arrived from the FCC, and many of the surveillance houses promptly dropped all references to above-the-fm-band operation in their promotional literature. One company, Jones Equipment, of southern California, discontinued their product entirely.

fig. 2. This circuit is the backbone of the commercial spy equipment industry. With a *tunable* output, this set is generally pocket-sized and will transmit well over 50 feet with a whip antenna cut to the 88- to 100-MHz fm band. L1 is 3-1/2 turns number 26 enameled on a 0.3" diameter ferrite core, 1/4" long.



The result has been a recent trend away from anything above 89 MHz.

While a-m broadcasters have been around for years, and new transistor circuits are popping up at an average of one every three months in electronics publications, they are nowhere near as popular as you might expect. Except for permanent-type installations in furniture, such as hi-fi's, TV's, and the like and rugged designs built into the home during construction, the tendency is to pass this one up altogether in favor of hf and vhf. In spite of this, however, it would be foolhardy to rule this possibility out during a debugging investigation, since you can never be sure. Generally, though, the transmitter is capacitively coupled to the household wiring or to the telephone lines to achieve the required antenna length, and can be rapidly located with this in mind.

Professional "kits," as they are called by federal purchasers (such as the Bureau of Narcotics, Internal Revenue, Customs Bureau, FBI, etc.), more often than not consist of larger transmitters in the 1/2- to 6-watt category which are crystal-controlled in the 30- to 50- and 150- to 174-MHz bands. These bugs often take the form of the "left-behind" attaché case, although at least one is known to have been secreted into a picture frame.

Another band popular with law-enforcement and professional security people is the 70-MHz area, although custom-built fm receivers required for monitoring are available from only three suppliers. Generally, this equipment has a greater transmit range (frequently to 15 miles) and is retrieved as insurance against ultimate detection and for re-use at a later date.

The great proportion of bumper beepers and other tailing aids also falls into this three-band frequency range, although an increasing number are cropping up on the 27-MHz CB band due to the inexpensive availability of pre-wired transmitter printed-circuit boards from such sources as Radio Shack, Round Hill Associates, Lafayette Radio, etc. These transmitters, of course, range anywhere from 100 milliwatts to 5 watts input, although the greatest majority are in the 250 mW area.

Although it has been known to happen (a 1965 case in Los Angeles), the likelihood of an eavesdropper using a ham radio band is nearly nil. The reason is the poor availability of commercial flea-power oscillators for the amateur vhf bands, at least when contrasted with the burgeoning CB marketplace. Additionally, the chances of accidental interception by a monitoring operator might trigger an unofficial *investigation, particularly since* eavesdropping transmitters are usually at work over extended periods of time.

Stability is another factor that varies considerably from one device to another. For the most part, L/C tanks control output frequency with very few crystal-controlled bugs. For this reason, the eavesdropper selects a spot on the receiver with ample room both sides of the carrier to allow for drift, however slight. Over extended periods of time, battery drain will cause frequency "jumps" in addition to gradual drift which must be contended with. This can work, though, to the benefit of the countermeasure people, since accidental jarring of the unearthed bug (jogging frequency at the same time) will probably be read at the other end as a normal transmitter characteristic. Too frequent occurrences like this, however, are dead giveaways. It should be noted that diode rectifying fm oscillators powered by phone-line currents seldom follow this trend, and, therefore, should be treated with care. Aside from minor frequency shifting, these configurations are relatively stable.

more exotic bugging devices

While it is true that the following devices have received more publicity than those previously described, it should also be noted that their use is nowhere near as extensive in the field. One such animal is the tunnel-diode transmitter, discussed at length in a recent issue of **Electronics World.**[2] This configuration has been developed by R&D shops filling in during slack periods with "custom-engineered" bugs for law-enforcement customers concerned with microminiaturization and increased range. One type produces fm modulation by using the audio signal to change the anode bias of the tunnel. This affects the resonant frequency sufficiently to create an fm signal in step with voice frequencies. Best of all, it takes only 10 tiny components in addition to the L/C circuit to do it.

Another TD application not yet beyond the drawing boards is the "free-power" transmitting bug, which uses the tunnel to rectify rf derived from a local high-power broadcast station. In operation, the tunnel follows a tuned circuit and is in turn followed by a hefty storage capacitor. In practice, however, not enough power has been generated in this fashion to power most fm transmitter circuits used by the eavesdroppers.

The advent of transistorized VOX, however, has been a boon to the private detective agencies plagued with high manpower costs and low-budget clients. NYC's Manny Mittleman has designed a device which is preset to respond to only normal room sounds such as footsteps, doorknob turning, voices, etc. In the presence of such sounds, the VOX completes the mercury cell circuits and actuates the transmitter. This item is just the ticket for motel-type plants, since it can be placed in the room days ahead of schedule, "in advance of whatever action he is interested in," according to Mittleman.

Carrying this further, some agencies make use of a "double-VOX" system that extends the concept to the monitoring post. Using a broad, constantly running receiver (in case the remote transmitter shifts a bit in frequency), the VOX mechanism is placed between the receiver output (usually squelched by preset) and a Concord-variety tape recorder

fig. 3. The much-publicized spike mike can look like this, or have the mike element and audio amplifier separated by a short cord. Since this bug works on a conductance basis, it can be driven into a door or a plaster wall. Transformer is a standard miniature output type, 500 ohms center tapped to 8 ohms; only one-half of the primary winding is used.

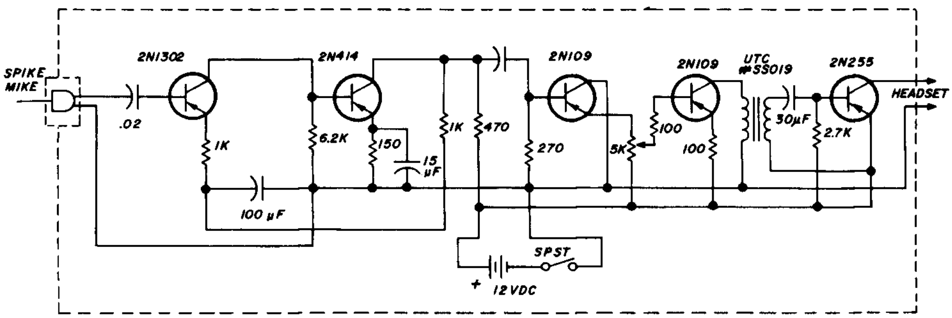


Photo courtesy C. H. Stoelting Co.

This transmitter has a range up to two miles and may be completely concealed in the eavesdropper's clothing. The cuff-link mike is in the upper right.

with long recording-time capability. When the receiver "hears" the room noise, it starts the recorder. In addition to permitting a system unattended by agents, it furnishes the client with an unedited, near-continuous tape of what's been happening.

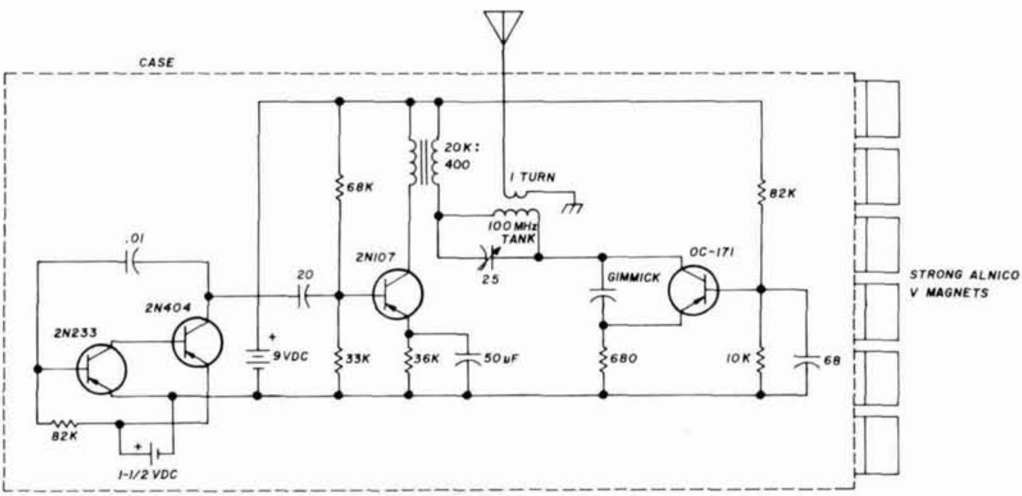
Perhaps the most widely publicized, however, has been the "harmonica bug," a unique circuit that doesn't use rf transmission at all. Designed to be planted in the telephone

table 1. This milliampere-hour chart can be extremely helpful in determining the life of an unearthed "bug". To ascertain maximum power life, divide "mA hours" by the current drain of the bug. Example: a 2-mA bug powered by a 9-volt #146 battery would have 175 hours bug life.

mercury cell life chart

battery type	mA hours	at drain of (mA)
1	1000	35
3R	2200	42
4R	3400	63
9	2400	50
12	3600	62
42R	14000	250
133	1000	35
146	350	3
163	500	10
164	500	10
165	500	10
177	160	5
233	2200	42
312	36	2
400	75	2
401	800	25
450R	350	3
502R	2400	50
520	130	5
601R	1800	30
625R	250	5
630	350	3
640	500	10
675R	160	5

fig. 4. Here's a popular tracking device which is often used with a second operative at a different location for triangulation purposes. It's a screeching fm bumper beeper which emits a shrill audio tone near the top of the 88- to 100-MHz fm band. Antenna is a 3" whip. Transmitter is attached inside the bumper or under the gas tank with magnets. L1 is 5 turns number 14, spaced 3/4" on a 3/8" diameter form.



where room conversation is to be overheard, the eavesdropper merely dials the number of the bugged phone from any telephone in the Direct Dialing System, blows a 500-hertz harmonica note into the phone just before the bell at the other end rings, and presto! Instant eavesdrop.

Consisting of a subminiaturized Bramco-Controls-type resonant-reed decoder relay and a miniature single-stage audio amplifier, Generally installed in the base of the phone itself, this eavesdrop "ultimate" sells anywhere from $699 to $1000, depending upon supplier.

Although microminiaturization has given us the sugar-cube mike, fountain-pen transmitter, etc., it is well to remember that these tiny transmitters are limited in terms of range capability. The famed martini-olive, disclosed in a Senate Judiciary Subcommittee on Ad-

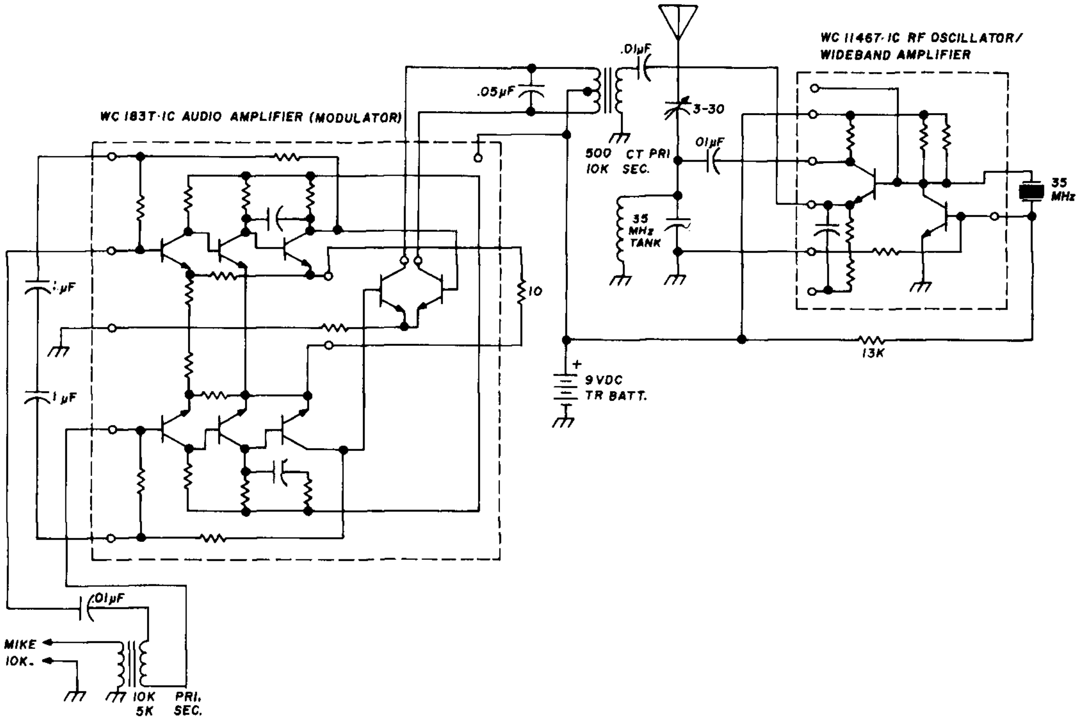


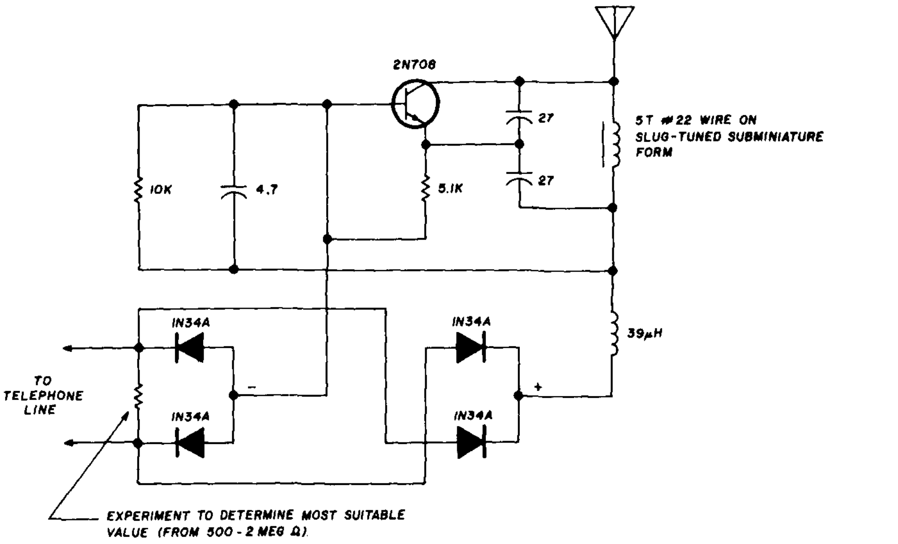
fig. 5. Professional eavesdroppers pay upwards of $200 for this bug which uses IC's for ultra-compactness. With an output of 50 milliwatts at 35 MHz, the listener only needs a 30- to 50-MHz fm monitor receiver and a dipole.

this sophisticated bug is permanently wired across the phone lines. When the decoder picks up the 500-hertz trigger note, the relay is actuated, simultaneously deactivating the bell-ringing circuit and transferring the mike line to the audio amplifier, which in turns feeds information back to the eavesdropper.

Should someone else dial the number during this period, he merely gets a busy signal. Should the victim desire to use the telephone himself, the eavesdropper simply hangs up just before the victim picks up the phone receiver. If timing is good, no one is the wiser.

ministrative Procedures and Practice session under the chairmanship of Senator Edward V. Long, turned out to have a range of only 20 feet. In spite of the sensation it created in the press, the bug was a custom job not suitable for actual use since submersion in a dry martini would quickly put it out of commission. Other microminiature designs are similarly referred to by professionals as "toys" geared for sale to the general public on their gimmick value. The smallest, known as the "007," measures 1 x 3/4 x 1/4 inches.

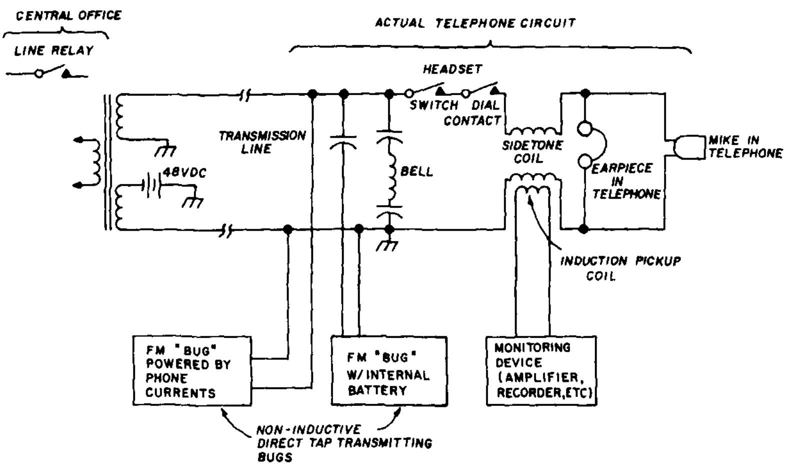
From this point on, discussions of exotic fig. 6. Known as the drop-in transmitter, this item is one of the hottest circuits around. It's built onto the back of a standard telephone carbon mouthpiece with subminiature components. The eavesdropper merely unscrews the existing carbon button and replaces it with this baby. Hot wax is poured over the circuitry to hold it in place.



bugs take on an air of the future. Long-range parabolic microphones, while effective in certain circumstances, are unwieldy and easily spotted. The Electro-Voice tubular shotgun mikes (**not** à la Les Crane) are similar monstrosities not well suited to practical snooping. Additionally, audio-filtering systems are not fully developed to the extent necessary to extract passing automobile noises, etc., from the resultant pickup.

This brings us to the much-discussed laser beam eavesdropping, perhaps the furthest of all from reality at this point. Experts in laser research feel that it will take a minimum of 20 years before any tangible results are realized, although such media as the TV spy shows and **Esquire** magazine would lead you to believe quite the opposite. While it is true that micro-reflectors consisting of optically invisible Angstrom-thick reflective paint have been developed, its use as a window reflector for laser snooping is pure conjecture right now. And as indicated earlier, audio filtering techniques are far from the ultimate,

fig. 7. Telephone tapping is popular because it's simple. This diagram shows three ways a bug can be hooked up.



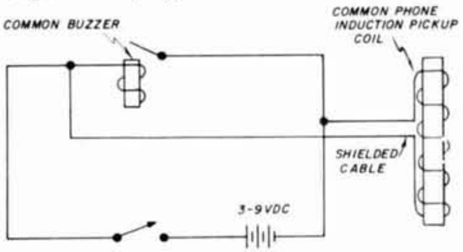
although Miles Wireless Intercom, Ltd., of NYC is said to have perfected a system (primarily for plastic "Sonaband" recording purposes) guaranteed to separate voices from typewriter clatter, cars, air conditioners and overhead airplanes.

electronic debugging equipment

In addition to having a working knowledge of what he's up against, an amateur reader concerned with detecting and/or defeating electronic bug plants should know something about the so-called professional bug locators often selling for prices many times their component cost.

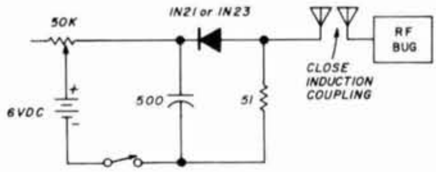
By and large, the biggest selling countermeasure item is a variation on the tried-and-true field-strengh meter. Often going for prices up to $250, bandswitching FSM's offer the debugging man a means of observing the signal on a meter. They also permit earphone monitoring to insure that the tuned-in "blip" is indeed a bug. Most FSM's are sold as "bug locators" (R.B. Clifton's $98 model is called the "Hound Dog") and contain at least one stage of amplification. Unfortunately, however, this procedure is frequently beyond the scope of the typical non-electronics type and few manufacturers, who often simply relabel Lafayette instruments, offer clear instructions for the user.

fig. 8. Cheap and dirty jamming device induces battery-powered buzzer hash into the telephone through induction, although many users prefer direct capacitive coupling to the line.



Another instrument uses a TD as a broadband rf detector that operates as an audio oscillator when triggered into operation by the presence of a low-level rf signal. The user only has to adjust the potentiometer until the device is just on the verge of breaking into oscillation; it can also be used as a sensitivity control to insure against triggering from strong local broadcast stations. Similar in appearance to the Radar Sentry gadgets that clip to your auto visor, these signallers also come in a beep-light configuration for mounting over doors or on desks to catch the attaché-case types. A specialty of the Dee Company, about $250 will buy one.

fig. 9. Simple vhf noise generator is an effective bug-defeater if placed close enough to an unearthed fm bug. Simply wrapping the antenna wires creates enough hash to disrupt the bug's oscillator.



The CPO/keying monitor selling in ham circles for under $15 is frequently sold to countermeasure people at prices up to 10 times that much. Essentially operating on the same triggering-concept as the TD instrument, this one uses a telescoping whip antenna for pickup and rectifies the signal with a conventional diode, filtered, and fed to an audio oscillator, amplifier, and loudspeaker.

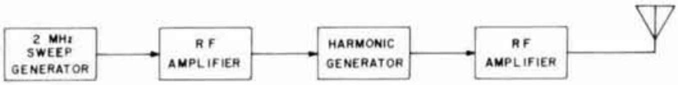
By far the most effective device now employed in countermeasures, however, is the

With one stage of transistor amplification and a sensitivity to 600 MHz, this field-strength meter is guaranteed to "get the goods."

Photo courtesy R. B. Clifton

feedback detector. Although it isn't available through many commercial outlets, it appears to be a "specialty" of Security Electronics and R&S Research, both leaders in good lines of position to close in on the instrument and pinpoint its location. Good feedback detectors run about $150 and come with an rf gain control, earphone jack and meter switch.

fig. 10. Block diagram of an effective defeater/jammer. A 2-MHz sweep generator circuit sweeps 1 MHz each side of center. This is amplified to drive a harmonic generator, thereby sweeping through the spectrum from 1 MHz to beyond 400 MHz. Result is complete blanketing over so wide a frequency range that few bugs escape obliteration.



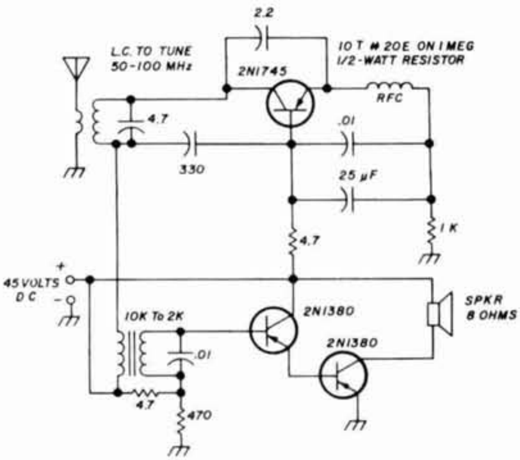
debugging kits. While new to the eavesdropping marketplace, the feedback detector is old hat to hams. Basically, it is a broadband (nearly untuned) super regenerative circuit that functions somewhat like a Heath Sixer or Twoer receiver section. The debugging man only has to tune slowly across the band–which may run 35 to 120 MHz–and listen for the bug's signal.

While such a device will also pick up TV, commercial fm broadcasts and the like, in the presence of a nearby transmitting bug it will screech in the true feedback tradition. Once the bug is revealed, the operator can simply switch from the loud-speaker to an S-meter

It is claimed that the Antibug Mark III "effectively jams all commonly-used electronic eavesdropping transmitters—including the telephone tap." It is basically a souped-up white-noise generator.

Photo courtesy Dectron Industries, Inc.

fig. 11. This portable broadband superregen is ideal for defeating hidden fm bugs since the regeneration is generally much more intense than the bug's own signal. In addition to wiping out the center carrier frequency, it will obliterate several MHz on each side.



illegal antibug jammers

While it's ethical to hire a countermeasure man to unearth the suspected bug, it is frequently much less expensive to simply buy a single jamming device guaranteed to render "all kinds of electronic surveillance devices virtually harmless." While illegal from an FCC point of view, these instruments can be turned on and off at will and do wonders for the paranoid corporate executive.

Known as "wiretap traps" and "antibugs," these gadgets are generally souped-up white noise generators that wreak havoc on bugging equipment, to say nothing of nearby radios and TV sets. Since they eliminate the need for

Once a bug has been found, the victim should consider the pros and cons before deciding to take one of the following moves:

Feed the bug wrong information purposely designed to make the eavesdropper show his hand.

Defeat its effectiveness by jamming; this often also forces the eavesdropper's hand.

Conduct a search to locate the monitoring post and/or eavesdropper.

Turn the matter over to a private detective agency (and lawyer) before tampering with the device.

Call the local police department now that evidence is at hand.

Carefully drain batteries without affecting bug's operation to accelerate the "death" of the device and move up the replacement time.

Defeat effectiveness by turning on running water (shower) or placing a radio in front of bug.

Notify FCC local office to reveal monitoring post without bringing in local police. FCC may take initiative in contacting authorities, but is discreet.

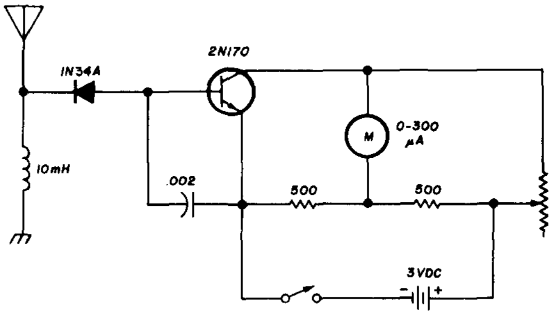
Remove device entirely.

visual and electronic detection techniques, however, they command good prices, usually from $225 to $350.

Other types include ac-powered versions of the super-regenerative feed-back detector. A single tube variety I experimented with used a single tube with about 100 Vdc on the plate. This little gadget put forth sufficient regeneration on the 88- to 108-MHz fm band to completely knock out a commercial 20,000-watt broadcast station at a distance of only 1/2 mile from the jammer. And this was accomplished using only a 3-inch link of hookup wire as an antenna. Similar designs employed as bug-killers could totally wipe out a low-powered fm listening device at the listening end.

Crude spark-gap transmitters, the ultimate in hash generation, are occasionally employed today, but they are not mass-marketed for obvious reasons. In use, the spark-gap is placed fairly close to a source of high-level corporate conferences and powered by dry-cell batteries. By remote-control switching from any convenient point in the building, the spark-gap is actuated during periods of sensitive speech.

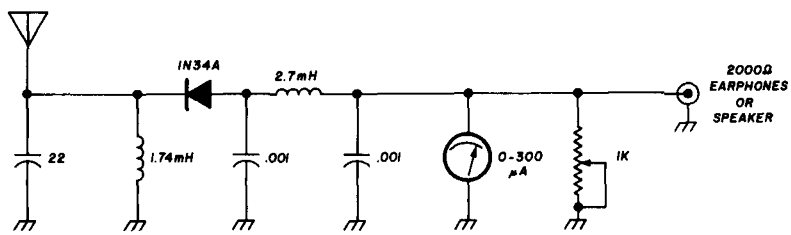
fig. 12. The basic field-strength meter is the backbone of the bug-detection industry, although it is frequently souped up for added sensitivity.



what the law says about transmitting bugs

On September 19, 1966, Congressmen Moss and Gallagher introduced legislation aimed at the ultimate destruction of the surveillance

fig. 13. Circuit used most often in $100 bug detectors. An amateur with a well-stocked junk box can put one together for less than five dollars.

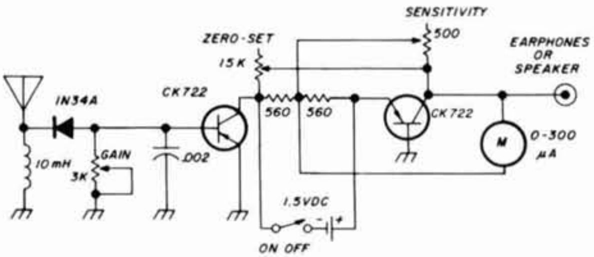


equipment industry (H.R. 17826 and 17827):

"A bill to prohibit the shipment in commerce of electronic eavesdropping and wiretapping devices."

The legislation, if enacted, would give exception to "any department, agency, or in-

fig. 14. This simple two-stage field-strength meter is about as sophisticated as you'd care to go, since further amplification is unnecessary. In fact, with the circuit you may pick up local radio and tv broadcasts unless the gain is reduced



strumentality . . . authorized to use such devices by Federal statute." This would take effect 180 days after passage of the bill. These bills were referred to the Committee on Interstate and Foreign Commerce, where they remained as the 89th Congress closed.

Earlier, the FCC adopted certain amendments to its Rules on April 8, 1966, designed to prohibit eavesdropping. Though entered as a specific regulation (Part 2, Subpart H, Section 2.701), the FCC spelled out the same ruling in Part 15:

"No person shall use, either directly or indirectly, a device required to be licensed . . . for the purpose of overhearing or recording the private conversations of others unless such use is authorized by all persons or parties engaged in the conversations."

Further, this exception was noted:

". . . This section shall not apply to operations of any law-enforcement officers conducted under lawful authority."

In Commission Chairman Rosel H. Hyde's 1966 year-end wrap-up statement, it was noted that since this rule change was adopted, the FCC investigated eight cases of alleged electronic invasions of privacy. A query I made to Commission Secretary Ben F. Waple, however, succeeded only in learning that such matters are "internal" FCC affairs and regarded "as confidential and not for release." Obviously, however, the FCC cannot apprehend all violators since the vast majority of bugging equipment is used only for short periods of time and is of an extremely low-power nature.

what the law says about telephone devices

Although no legislation is currently pending, it is hoped by proponents of anti-bugging that Senate investigations may permit some proposal to be worked up in 1968. The only agency that can now become involved is the FCC, which holds as a rule violation of Section 605 the "unauthorized interception" of phone conversations by direct wiretaps, or induction-coupling. Yet, for the Commission to take action, it must have evidence on hand that the

This bandswitching field-strength meter tunes from 25 to 250 MHz but reaches up to 450 MHz untuned. It will function over 400 hours with the internal mercury cell.

Photo courtesy W. J. S. Electronics

gleaned information has been clearly divulged or in some way "beneficial."

As phone-patch enthusiasts are well aware, many telephone companies have policies prohibiting attachment of **any** foreign device to its property. An illustration can be provided by this Wisconsin Telephone Company policy:

> "No equipment, apparatus, circuits, or device not furnished by the telephone company shall be connected with the facilities furnished by the telephone company, whether physically, by induction, or otherwise, except as provided in this tariff."

The tariff permits connection only of radio equipment of the Armed Forces, mobile telephone systems, and the major U.S. railroads.

on your own

Since hams are generally more interested in circuit technology of new breeds of devices, I have attempted to emphasize this aspect of eavesdropping rather than illustrative

Master bugger Fred Gluckman of Security Electronics demonstrates how an fm phone bug can be detuned to confuse the counter-measures investigator.

The following list covers all known major and minor manufacturers and distributors of eavesdropping equipment. Complete details on equipment types, prices, and street addresses can be found in "The Electronic Invasion" published by John F. Rider Publisher, Inc., New York.

Baker Electronics Co., Greencastle, Indiana
Britton Enterprises, Don, California and Hawaii
George F. Cake Co., Berkeley, California
R. B. Clifton Co., Miami, Florida
Consolidated Acoustics, Hoboken, New Jersey
Continental Telephone Co., Inc., New York, New York
Criminal Research Products, Inc., Conshohocken, Pennsylvania
Dectron Industries, Inc., Van Nuys, California
Dee Co., Houston, Texas
Dehart Electronics, Sarasota, Florida
Ekkotronics Co., Milwaukee, Wisconsin
Fargo Co., San Francisco, California
Fudalia & Associates Electronic Surveillance Devices, Toronto
Kel Corporation, Belmont, Massachusetts
Martel Electronics Sales, Inc., New York, New York
Micro Communications Corp., Los Angeles, California
Miles Wireless Intercom, Ltd., New York, New York
Mittleman, Manny, New York, New York
Mosler Research Products, Inc., Danbury, Connecticut
R & S Research, Inc., Houston, Texas
S.A.C. Electronics, Los Angeles, California
Saber Laboratories, San Francisco, California
Security Electronics, New York, New York
Sierra-Tronics, Nevada
Silmar Electronics, Inc., Miami, Florida
Spindel, Bernard B., Holmes, New York
Steckler Sales Co., New York, New York
Telephone Dynamics Corp., North Bellmore, New York
Telmar, New York, New York
Tri-Tron, Inc., Dallas, Texas
Tron-X Publications, Hollywood, California
Wireless Guitar Co., New York, New York
W.J.S. Electronics, Hollywood, California

As the author has not had the opportunity to visit the places of business or purchase equipment from all the companies represented he cannot vouch for authenticity of product claims or equipment reliability.

This feedback detector sweeps over the frequency range from 6 kHz to 10,000 MHz with a broadband fm receiver configuration.

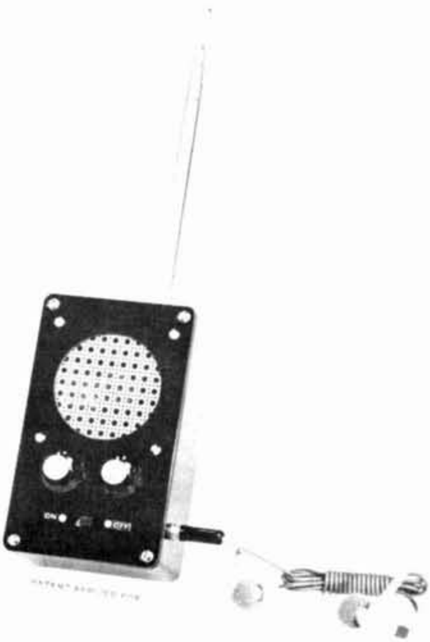


Photo courtesy R&S Research, Inc.

case histories showing where bugs have been unearthed, who has been indicted, and what corporations are involved. For much the same reason, this report has taken on an objective, factual approach and not one interjected with moral overtones.

Electronic invasions of privacy will continue to be part of the American way of life in the years to come, despite federal, state, and local efforts to suppress its growth. It is too well-entrenched now in U.S. business to do much more than go underground.

ham radio

references

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2. "Electronic Eavesdropping," *Electronics World*, April 1967, page 23.
3. "The Electronic Invasion," John F. Rider Publishers, Inc., 1967.
4. "The Intruders," published by Frederick A. Praeger, 1967.
5. "The Eavesdroppers: Fallout from R&D," *Electronic Design*, June 21, 1966.

sporadic-E propagation predictions

Some of the best vhf propagation conditions of the year occur in early summer. Here are some forecasts of sporadic-E openings in June

Vic Frank, WB6KAP, 12450 Skyline Boulevard, Woodside, California 94062

Although high-frequency propagation over paths greater than 2500 miles will be the primary emphasis in the months ahead, I am kicking off the propagation column with sporadic-E predictions for June, 1968. The curve in **fig. 1** shows the percentage occurance of sporadic-E measured at Point Arguello, California, during the first half of June, 1967, and is indicative of the sporadic-E propagation you can expect this year.

These curves show critical-frequency sporadic-E propogation versus time of day. The critical frequency is the highest frequency at which sporadic-E reflections were obtained with a **vertical** sounder.

Four critical-frequency contours are shown: 7, 9, 11 and 13 MHz. The critical frequency contour of 7 MHz corresponds to a range of 625 miles on 28 MHz; the 9-MHz critical frequency indicates a range of 470 miles on 28 MHz or 1400 miles on 50 MHz. The critical frequency contour of 11 MHz corresponds to a range of 800 miles on six meters; and a 13-MHz critical frequency corresponds to 625 miles on 50 MHz. For a sporadic-E opening on two meters, the critical frequency must go up to 24 MHz. The corresponding range on six meters would be 250 miles.

In summary, six meters will probably be open to distances between 1000 and 1400 miles more than half the days of the month, but you shouldn't miss many openings by sleeping between 0200 and 0600.

Two meters should open up to distances of 1250 to 1350 miles at least once during the month. The reflection point will probably be south of 38° north latitude between 0900 and 1500 local time at the path midpoint. Unfortunately, two-meter openings may not be noticed because of lack of activity at the proper places. More beacon transmissions and noon-time schedules over distances between 1200 and 1500 miles would help.

summary of high-frequency propagation

80 and 40 meters. On these two bands, summer-time noise levels and absorption will limit propagation to darkness paths. Since the north pole is in continuous daylight, no propagation is expected over the pole. This is not without merit—foreign broadcast stations will cause less interference than they do during fall and winter.

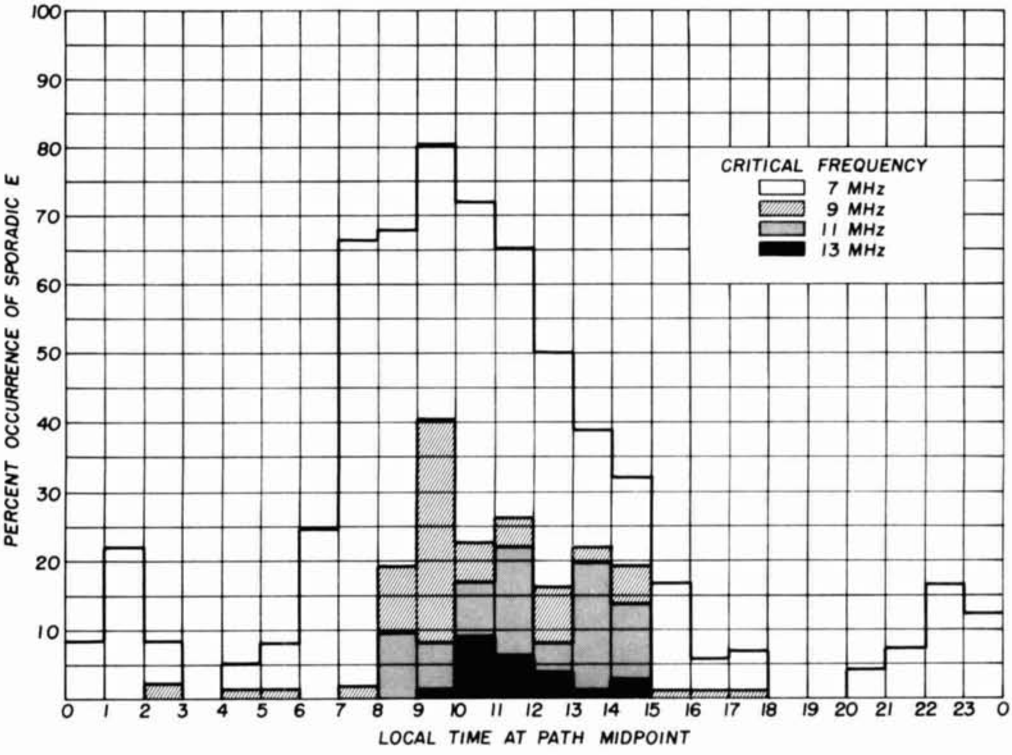
20 meters. Twenty will be primarliy a night-time band. The maximum usable frequency should be above 14 MHz for all but polar paths during the pre-dawn hours.

15 meters. Fifteen should be open during day-light and evening hours to directions south of east and west. Short skip may be prevalent because of sporadic-E.

10 meters. Ten should be open up from the southern half of the United States toward the south. Short skip sporadic-E propagation will be prevalent. Double-hop sporadic-E will permit occasional communications up to 2500 miles.

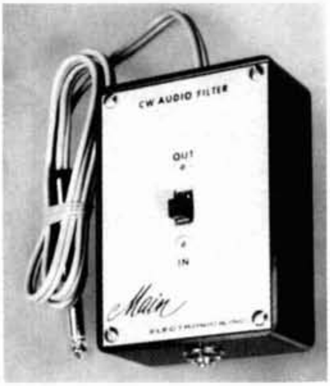
ham radio

fig. 1. Percentage occurrence of sporadic-E measured with a vertical sounder at Point Arguello, California during the first half of June, 1967.



new products

Main cw audio filter



If you are irritated by the QRM level on the CW bands these days, this new device will be of interest to you—the new Main Electronics high-selectivity CW audio filter. This unit offers very high selectivity for CW reception on all transceivers and receivers. To use the CWF-1, you merely plug into the 2- to 4-ohm audio output of your receiver and plug your headphones into the CWF-1. A switch is provided for taking the filter in or out of the circuit as interference dictates.

The passband of the filter is 120 Hz wide at the 6-dB points and 200 Hz wide at the 10 dB points. This is achieved by the use of high-Q toroidal inductors in a four-pole filter circuit. The output is designed to match 2000-ohm headphones. The filter not only separates the wanted signals out of the QRM, it also improves the signal-to-noise ratio when receiving weak CW signals which are close to the noise level such as in vhf DX work.

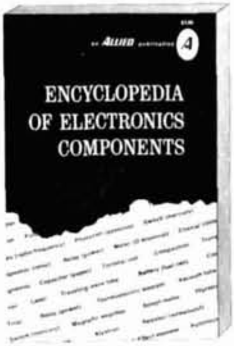
The CWF-1 Audio Filter is 2-7/8-inches wide, 1-5/8-inches high and 4-inches deep. A descriptive brochure is available upon request; $19.95 from Main Electronics, Inc., 353 Pattie, Wichita, Kansas 67211.

Raytrack 50-MHz Converter

Raytrack Company has introduced a new six-meter converter using FET's in both the rf and mixer stages. These transistors give high immunity to cross modulation and a 3-dB typical noise figure. A 15-dB nominal gain is claimed. Features of the *Horizon VI* include a trap for TV Channel 2 and a built-in power supply. Crystal switching from the front panel permits a choice of expanded coverage to operating band segments. An output jack is also provided in the crystal oscillator circuit to permit transceive operation with your transmitter.

This converter has both a 150-ohm input and output impedance. It is designed to operate over the frequency range from 50 to 54 MHz with an output from 14 to 18 MHz. It is built on a fiberglass chassis and weighs only 18 ounces. The *Horizon VI* is priced at $59.95 by the Raytrack Company, 211 Springhill Drive, Columbus, Ohio 43221.

electronic components encyclopedia

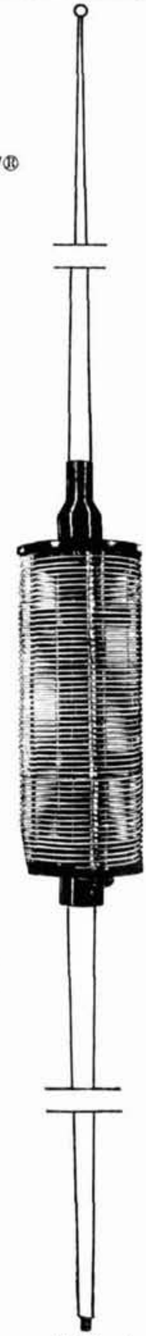


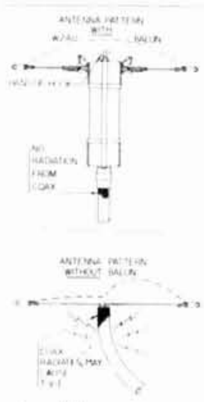
A new encyclopedia of electronic components recently put out by Allied Radio alphabetically lists, describes and illustrates the basic electronic components currently in use. This book is virtually an electronics text that provides an understanding of individual units used in electronic devices and systems in one reading. Descriptions are completely non-technical. Each component is identified, and its use is carefully explained. In addition, any special handling or installation requirements are covered.

This is a handy reference book for anyone in electronics and is an interesting and useful aid to amateur radio operators, experimenters and students. One dollar postpaid in the USA. For more information, write to Allied Radio Corporation, 100 North Western Avenue, Chicago, Illinois 60680.

new Lafayette catalog

Lafayette has just announced its new 1968 Summer Catalog #684. This catalog is available free upon request and has the latest electronics and home entertainment equipment. It includes Lafayette's equipment plus many other major manufacturers, plus values in power tools for the home workshop, marine accessories and a complete line of amateur radio equipment, test equipment and citizens band two-way radio. It may be obtained free by writing to Lafayette Radio Electronics Corporation, P. O. Box 10, Department HR, Syosset, Long Island, New York 11791.





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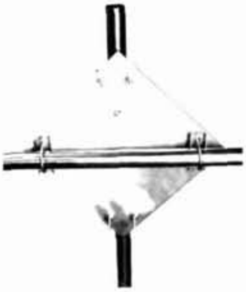

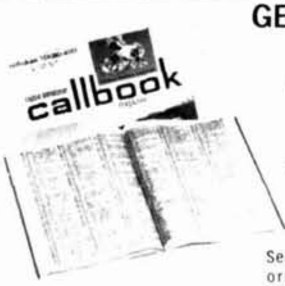

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